DOCUMENT RESUME

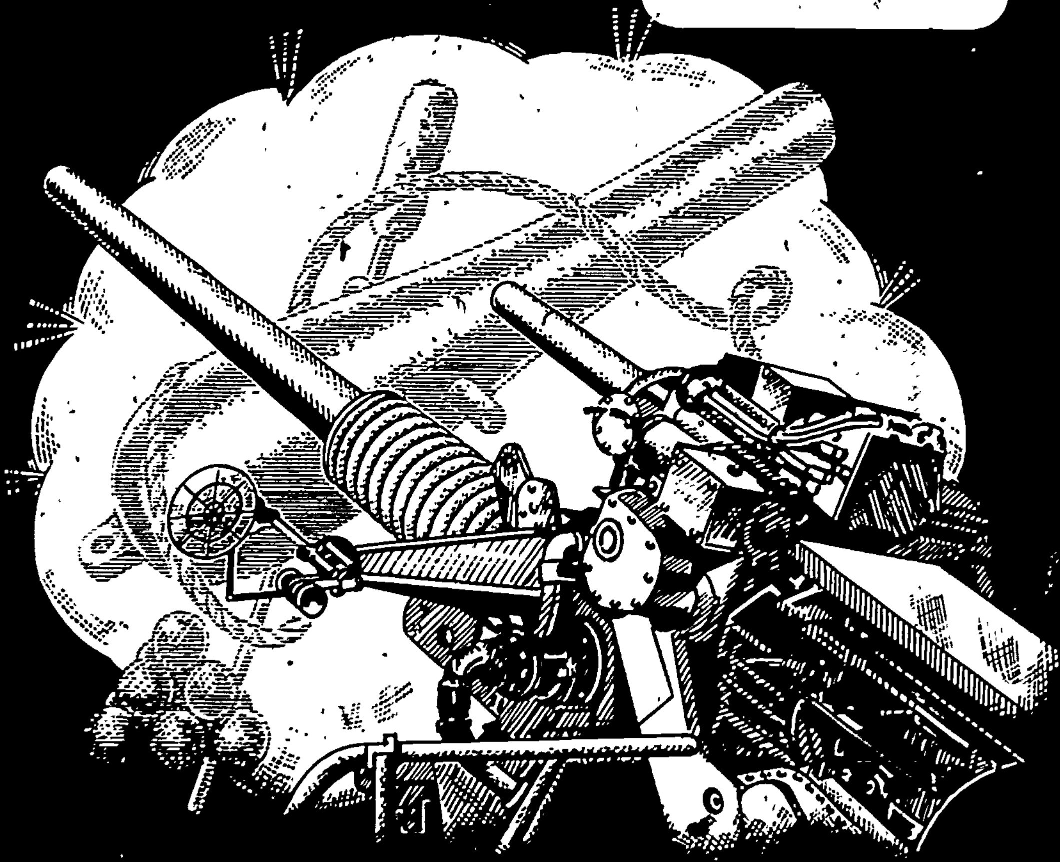
ED 109 343 CE 004 124

TITLE Gunner's Mate G 3 and 2; Rate Training Manual. Revised.
INSTITUTION Naval Education and Training Command, Pensacola, Fla.
REPORT NO NAVEDTRA-10185-B
PUB DATE 74
NOTE 530p.
AVAILABLE FROM Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (Stock Number 0502-LP-050-9260; No price given)

EDRS PRICE MF-$0.92 HC-$27.29 PLUS POSTAGE
DESCRIPTORS Course Content; Electromechanical Technology; Employment Qualifications; Equipment Maintenance; Equipment Utilization; *Instructional Materials; Job Skills; *Manuals; Military Personnel; *Military Science; Military Service; *Military Training; Occupational Information; Promotion (Occupational); Seamen; Skill Development
IDENTIFIERS *Gunners Mate; Navy; Weaponry

ABSTRACT

The rate training manual has been prepared for men of the regular Navy and of the Naval Reserve for the purpose of advancement to increase knowledge in the various aspects of the Gunner's Mate rating (G 3 and 2). Chapters 1 through 14 deal with the following topics: the requirements of the Gunner's Mate G Rating, explosives and pyrotechnics, ammunition and magazines, small arms and machineguns, landing party equipment and demolition materials, basic mechanisms, electrical and electronic circuit analysis, electrohydraulic power drive fundamentals, gun mounts, breech mechanisms, rocket launchers and projectors, fire control problems, fire control instruments and techniques, and maintenance. Numerous illustrations and diagrams are interspersed throughout the document. A subject index is appended. (BP)



GUNNER'S MATE G 3 & 2

2

NAVAL EDUCATION AND TRAINING COMMAND

RATE TRAINING MANUAL NAVEDTRA 10185-B

PREFACE

The primary purpose of naval training is to produce an efficient naval fighting force which can ensure the Navy victory at sea. Quality training will ensure superior readiness of personnel. A victorious Navy is dependent upon the superior readiness of its personnel.

This rate training manual provides the technical knowledge and skill requirements necessary to prepare personnel to perform tasks in the operation, maintenance, and repair of gun mounts, rocket launchers, and small arms.

This training manual was prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training. Technical assistance was provided by the Gunner's Mate School, Great Lakes, Illinois; the Naval Ordnance Systems Command, Washington, D.C.; the Remington Arms Company, Inc., Bridgeport, Connecticut; and the Naval Tactical Doctrine Activity, Washington, D.C. Technical reviews, comments, ideas, and suggestions from the foregoing activities have been most helpful.

Stock Ordering No.
0502-LP-050-9260

Revised 1974

PUBLISHED BY

NAVAL EDUCATION AND TRAINING SUPPORT COMMAND

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON, D C: 1974

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

CONTENTS

CREDITS

The illustrations listed below are included in this edition of Gunner's Mate G 3 & 2 through the courtesy of the designated source. The forwarding of these illustrations for use in this manual is gratefully acknowledged.

Source	Figures
Remington Arms Company, Inc.	4-44, 4-45, 4-46 4-47, 4-48A, 4-48B

CHAPTER 1

THE GUNNER'S MATE G RATING

This training manual has been prepared for men of the regular Navy and of the Naval Reserve, not only for the purpose of advancement in rating but also to increase your knowledge in the various aspects of the Gunner's Mate rating. This knowledge includes technical training in the maintenance, operation, and repair of hydraulics, maintaining and trouble-shooting electrical and electronic circuits, and the skills necessary for the maintenance and repair of the mechanical components of gun mounts, and rocket launchers. The Gunner's Mate qualifications used in the preparation of this manual are contained in the Manual of Qualifications for Advancement, NAVPERS 18068-C, and will not be repeated in this manual. It is recommended that you study the GM section of NAVPERS 18068-C to gain an understanding of the skills and knowledge required of a Gunner's Mate.

This manual has been organized to give you a systematic understanding of your job. For information about the material covered in the manual, refer to the chapter subject matter outline. Study the subject matter of this manual carefully, it will not only help you toward advancement but expand your knowledge of naval ordnance, and this knowledge will benefit you in your desire to become a more proficient technician and benefit the Navy by utilizing the skills of a proficient craftman.

By increasing your knowledge and skills in the field of ordnance, the rewards and responsibilities through advancement in rate increase. The satisfaction of getting ahead in your chosen career, plus higher pay, greater prestige, and more interesting and challenging work are goals to be achieved through advancement in rate. By increasing your skills the Navy benefits in combat readiness and you gain satisfaction by becoming more proficient in your job.

Your contribution to the Navy depends upon your willingness and ability to accept increasing responsibilities as you advance in rate. When you assume the duties of a GMG 3, you begin to accept certain responsibilities for the work of others. As you advance in your career, you accept responsibilities in military matters as well as the occupational requirements of the GMG rate.

Your responsibilities for military leadership are about the same as those of petty officers in other ratings since every petty officer is a military man as well as a technical specialist. Your responsibilities for technical leadership are special to your rating and directly related to your work as a GMG. The operation and maintenance of a ship's weapon system requires team work. It requires a special kind of leadership ability that can be developed only by personnel who have a high degree of technical competence and deep sense of personal responsibility. Strive to improve your leadership ability and technical knowledge through study, observation, and practical application.

THE ENLISTED RATING STRUCTURE

The two main types of ratings in the present enlisted rating structure are general ratings and service ratings.

GENERAL RATING identifies broad occupational fields of related duties and functions. Some general ratings include service ratings; others do not. General ratings are applicable to both regular Navy and Naval Reserve personnel.

SERVICE RATING identifies subdivisions or specialties within a general rating. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Regular Navy and Naval Reserve personnel may both hold service ratings.

THE GUNNER'S MATE RATING

The Gunner's Mate rating is not the oldest rating in the Navy but it rates near the top. The rating was established in 1797. Paygrades in the rating at that time are not defined since the records for that period are practically nonexistent. However, the paygrade of Gunner's Mate, Chief was established by General Order No. 36 of May 1864. It was not until February 1894 that the pay grades of first, second, and third class petty officers were established by General Order No. 409. In July 1903 the rating of Turret Captain was established in the paygrades of Chief and first class. Turret Gunner's Mates in the lower ratings were general GMs up to and including second class petty officer. At the first class level they became Turret Captains.

The Gunner's Mate rating structure was quite stable from around the turn of the century to World War II. During World War II, the Gunner's Mate rating acquired two new specialties, namely an Armorer and Powderman.

After World War II (1947), the post war rating structure was established and implemented in 1948. This change established the GM General Service rating in paygrades E-4 through E-7. At the same time, three Emergency Service ratings were established in paygrades E-4 through E-7; for the GMA (Armorer), GMM (Mounts), and at paygrades E-6 and E-7 for GMT (Turrets).

Note: The rating of Turret Captain was disestablished and incorporated into the GM rating as GMT (Turrets).

In May 1958 the paygrades of E-8 and E-9 were established. These paygrades applied to the GM rating for both the General Service and Emergency Service ratings.

Another change came about in the Gunner's Mate rating structure in April 1961. The paygrades of E-8 and E-9 were redesignated from General Service rating to General rating. The paygrades for the Emergency Service ratings of GMA (Armorer), GMM (Mounts), and GMT (Turrets) were disestablished. Two Service ratings in paygrades E-4 through E-7 were established Gunner's Mate G (Guns) and Gunner's Mate M (Missiles).

The Gunner's Mate G (Guns), GMG, rating includes the duties of operating, repairing, and maintaining all types of guns, rocket launchers, certain types of missiles launchers, and their associated magazines and ammunition and/or handling equipment. In general, the GMG has to be able to make detailed electrical, electronic, hydraulic, and mechanical systems and servosystems casualty analyses. He must be able to maintain ammunition handling equipment, inspect and maintain magazine sprinkler systems, and maintain rocket, projector, and gun ammunition magazines.

The duties of the Gunner's Mate M (Missiles), GMM, rating involves the maintenance, testing, and firing of missiles and their associated launching equipment and magazines.

During 1961 the Secretary of the Navy approved the disestablishment of the Nuclear Weaponsman (NW) rating and the retitling of the rating to GMT and including it as a third service rating from paygrades E-4 through E-7. This action developed the GM rating structure as it appears today; Gunner's Mate Guns (GMG), Gunner's Mate Missiles (GMM), and Gunner's Mate Technician (GMT).

The Gunner's Mate T (Technician), GMT, rating has the responsibility of maintaining, stowing, repairing, and adjusting all types of nuclear weapons, including nuclear warheads. Recently the ASROC launching groups have been added to the responsibilities of the GMT rating.

The GMT rating is separated from the other two GM ratings up through the paygrade of E-9. The remaining two service ratings, GMG and GMM, remain separated up to and including E-7. At the E-8 and E-9 levels they are combined into the general ratings of Gunner's Mate Chief Senior (GMCS) and Gunner's Mate Chief Master (GMCM).

This means that the E-7 Gunner's Mate G, to advance, must be prepared to supervise the maintenance of launching systems. In other words, a E-7 GMG taking an exam for E-8 will be examined on the qualifications expected of the GMM in addition to those qualifications in his own rating.

Because of the many different and highly complex weapon systems now in service in the fleet, the GMG rating is subdivided into classes. Each class is assigned a Navy Enlisted Classification (NEC) number. The purpose of these codes is to assist in identifying personnel in a rating when a broad definition (such as GMG) is not enough. Code numbers are assigned to personnel with specialized skills and training. Examples of such codes are GM-0876, assigned to Gunner's Mates who have graduated from the Gun Mount 5"/54 Mk 42 Mod 9 maintenance course, and GM-0877, the number given to the GMGs who have graduated from Gun Mount 5"/54 Mk 45 Mod 0 maintenance course. A complete list of the codes is found in the Manual of Navy Enlisted Classifications, NAVPERS 15105 (latest revision).

GMG Billets

The GMG rating is conventionally classed as a seagoing rating. This is not to say that the GMGs never get shore duty; they do. Each ship regardless of its purpose supports some type of weapon system. You, as a GMG, will primarily be concerned with the gun systems on board ship. To maintain these weapons, you must become proficient in your rating. This can be achieved through constant study and, of course, practical experience. Most of the billets (duty assignments) for the GMG rating are on combatant ships. These ships range from the destroyer escort types to the large attack carriers.

The list of billets to which you may be assigned as a GMG 3 or GMG 2 is too long to list here. We can, however, give some examples. On a combat ship, you normally will be assigned to one of the gun batteries. In most cases you will be an assistant who will work under the supervision of a more senior petty officer. If you are a striker, your work will be closely supervised. As you advance, supervision will diminish and you will be allowed to show more initiative in performing your work. The more you advance in rating, the more your responsibilities for the supervision of others will increase.

As a GMG 2 on a destroyer, you may be in charge of one of the gun mounts. Your job would include supervision of its crew, as well as coordination of your mount with the others in the battery. Either a GMG 3 or GMG 2 may be in charge of a rocket launcher or projector. Or you may be put in charge of the ship's small arms and landing force equipment. Aboard a carrier, Gunner's Mates have responsibility for the ship's magazines. There your duties might include maintenance of the magazine sprinkler systems, temperature controls, and magazines themselves.

Aside from your occupational or professional duties, you will be required to perform certain military functions, as do all ratings in the Navy. The military duties include manning battle stations, watch standing, and other assignments related to the requirements for naval operations, management, and security. In this manual we are concerned primarily with your professional (technical) duties so we will not go into the military aspects of your rating.

YOUR PART IN NAVAL LEADERSHIP

The Navy has a continuing program of moral leadership and character education to ensure that naval leadership is maintained at a consistently high level. The Navy stresses moral responsibility and personal example.

As a petty officer you will have an important practical part to play in your shipboard leadership program. You may be in charge of a group of strikers which will put you in a position of leadership. Your two responsibilities in this position will be to accomplish the mission and to care for your men. The principles and techniques of leadership are discussed in Military Requirements for PO 3 & 2, NAVEDTRA 10056-C.

Assume for a moment that your mission aboard ship is to maintain a gun mount, and that you have strikers to assist you. A big part of your job is to learn everything you can about the mount and to pass on your knowledge to your men. Technical competence is a major aspect of good leadership. But being a skilled technician is not enough. You must inspire your strikers to do their work as efficiently as possible.

A point worth mentioning at this time is, never become so engrossed in your own competence that you won't listen to suggestions. Even a striker may come up with a suggestion for performing a function that is a much easier and better method than the one you have been following. Remember; no one is infallible.

A national characteristic of the American fighting man is that he wants to know why he is called upon to do certain tasks. You must explain to your men the importance of their work and how it affects the overall fighting efficiency of your ship. Make the smallest mechanical task take on the nobility of a cause. During exercises or drills make them feel they are winning a war, not just turning knobs on equipment. Keep in mind that they are the men who will fight by your side in combat. When led with courage, spirit and intelligence, they will fight as willing and as efficiently as any fighter in the world. But it is up to you to provide inspiration so that it will seep down to them.

To inspire your strikers and others, you must be of strong moral character. Some of the character traits you can develop by conscientious study and practice are loyalty, integrity, and quiet confidence.

Loyalty is one of the most essential factors of leadership. Experienced officers and petty officers agree that they would rather have a loyal man who is not necessarily an excellent worker than a disloyal man who does excellent work. Loyalty to country, to the Navy, to your ship, to your division, to your chief, to your senior petty officer, and to the men who work with and for you—these are the prime requisites of leadership. The surest way to get the respect and loyalty of your men is to be loyal yourself.

Everytime you feel the urge to criticize the handling of your ship's affairs, stop short. You are a part, and an important part, of your ship. How can you expect your strikers to be loyal if you are not?

Deal with your men squarely and honestly. If you do, you will win and hold their respect. Be dependable. This mark of integrity involves keeping promises promptly. A reputation of being a "square shooter" is worth every effort on your part. Help to build this reputation early by not tolerating "gun-decking" or other methods of falsifying reports.

Good leaders have a quiet self-confidence (not an arrogant or cocky manner) based on thorough knowledge of the job and a belief in their own ability. Confidence begets confidence. If you have confidence in yourself, you can inspire confidence in your men and those around you.

Gunner's Mates are often selected to lead or take charge of many military functions. Over the years, Gunner's Mates have earned the reputation of being good military men and good leaders. In today's Navy, he still holds this reputation by following examples of the men before him—as others will follow you.

ADVANCEMENT

Sometimes, as you study and work for advancement, the task ahead may seem extremely difficult and not worth the trouble. At times you may feel like dropping out. If you ever feel this way, stop and consider the many advantages of attaining a higher rate. First, when you sew on your new rating badge or the second stripe, you gain more authority along with the added responsibility you soon will be given. Of course, you also get a raise in pay to compensate you for assuming more demanding duties. That rating badge or extra stripe also elevates you in the eyes of your shipmates and assures you of more privileges. Last but not least, you have the personal satisfaction of attaining your goal. That is, by increasing your knowledge in your speciality you contribute more to your shipmates and the Navy by being better qualified to perform your job as a GMG. Then too, you have attained another step in the promotion ladder.

Incidentally, you may wonder why the Navy goes to such lengths to inspire and assist you in advancing. The answer is rather simple—perhaps selfish. Every time you advance, in fact, everything you learn makes you more valuable to the Navy. With each advancement you improve your skill and increase your value to the Navy by becoming a better technician. The things you have learned can be utilized in teaching men in lower ratings. The Navy already has an investment in you, and in the interest of protecting and profiting from that investment, it is willing to invest still more money and effort in making you a better sailor. As you advance, you have a better opportunity to improve your leadership qualities and to show by example the moral character of all good leaders.

HOW TO QUALIFY FOR ADVANCEMENT

Although minor changes may occur from time to time in the requirements for advancement, ordinarily you must:

1. Spend a certain amount of time in service and in your present grade.

2. Complete the required military and professional nonresident career courses.

3. Demonstrate your ability to perform the tasks listed in the Record of Practical Factors, NAVEDTRA 1414/1.

4. Be recommended by your commanding officer after the petty officers and officers supervising your work indicate that they consider you capable of carrying out the duties of the next higher rate.

5. Pass a written examination on the professional and military qualification standards for advancement.

Figure 1-1 details the requirements for advancement of active duty personnel. Figure 1-2 gives the same information for inactive duty personnel.

Because qualifications for advancement change, check with your division officer or training officer to make sure that you know the latest quals.

Advancement is not automatic. Although you have met the requirements, including passing the written examination, you may not be able to "sew on a crow" or add a stripe. The number of men in each rate and rating is controlled on a Navy-wide basis. The number of men who may be advanced is limited, therefore, by the number of vacancies that exist.

A final multiple is a combination of scores based on the examination grade, and scores computed for the length of time in service and in pay grade, awards held, and past performance.

ELIGIBILITY REQUIREMENTS FOR ADVANCEMENTS:

a. Practical factors/performance tests

a. Navy training course

c. Service school

d. Citizenship/security clearance

e. Performance mark minute 3.0 or no one GOL, UNM, UNS during period equal to 1/2 TIR required for advancement to E-6 in eval blocks 3, 5, or 7

f. Proper path of advancement

g. Meet special or physical requirements if applicable

h. Not be involved in circumstances which render ineligibility for advancement

i. Fulfill service requirements of TIS and SIPG by terminal eligibility date

j. Military/leadership exam

k. Recommended by C.O.

All of the information above (except the examination score and High Quality Bonus Point (HQP) factor) is submitted to the Naval Examining Center with your examination answer sheet. After grading, the examination scores, for those passing, and the HQP Factor (additional points awarded for those who previously passed the examination but were not advanced) are added to the other factors to arrive at the final multiple. A precedence list, which is based on final multiples, is then prepared for each pay grade within each rating. Advancement authorizations are then issued, beginning at the top of the list, for the number of men needed to fill the existing vancancies.

HQP FACTOR

The HQP factor, formally the Passed but not Advanced (PNA) factor, is awarded on the basis of Final Multiple scores (FMS's) from past examinations. A maximum of three points can be accrued each examination cycle. After five examination cycles, candidates will be eligible for a maximum of 15 points.

HOW TO PREPARE FOR ADVANCEMENT

In preparing for advancement, you must study the qualifications for advancement, the required rate training manuals, and other specified material. Additionally, you must work on the practical factors. You will need to become familiar with (1) The Manual of Qualifications for Advancement, (2) Applicable rate training manuals, (3) Bibliography for Advancement Study, NAVEDTRA 10052, and (4) the Record of Practical Factors. The following sections describe and give you some practical suggestions on how to use these publications in preparing for advancement.

Quals Manual

The Manual of Qualifications for Advancement, NAVPERS 18068C, gives the minimum occupational and military qualification standards for advancement to each pay grade within each rating. This manual is usually called the "Quals Manual," and the qualifications themsevles are often called "quals". The qualification standards are of two general types: (1) military qualification standards and (2) occupational qualification standards.

MILITARY STANDARDS are requirements that apply to all ratings rather than to any one particular rating. Military requirements for advancement to third class and second class petty officer rates deal with military conduct, naval organization, military justice, security, watch standing, and other subjects which are required of petty officers in all ratings.

E-4 time in service requirements changed by DOD effective 1 July 1975 for advancement to E-4 TIS requirements are increased from 21 months minimum to 2 years.

REQUIREMENTS *	E1 to E2	E2 to E3	# E3 to E4	#† E4 to E5	† E5 to E6	† E6 to E7	† E7 to E8	† E8 to E9
SERVICE	4 mos. service-or completion of Recruit Training.	8 mos. as E-2.	6 mos. as E-3.	12 mos. as E-4. 3 years time in service.	24 mos. as E-5. 6 years time in service.	36 mos. as E-6. 8 years time in service.	36 mos. as E-7. 8 of 11 years time in service must be enlisted.	24 mos. as E-8. 10 of 13 years time in service must be enlisted.
SCHOOL	Recruit Training. (C.O. may advance up to 10% of graduating class.)		Class A for PR3, DT3, PT3, AME 3, HM 3, PN 3, FTB 3, MT 3,			Class B for AGC, MUC, MNC.††		
PRACTICAL FACTORS	Locally prepared check-offs.	Record of Practical Factors, NavEdTra 1414/1, must be completed for E-3 and all PO advancements.						
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.					
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.					
EXAMINATIONS **	Locally prepared tests.	See below.	Navy-wide examinations required for all PO advancements.			Navy-wide selection board.		
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)		Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NavEdTra 10052 (current edition).					Nonresident career courses and recommended reading. See NavEdTra 10052 (current edition).	
AUTHORIZATION	Commanding Officer		NAVEDTRAPRODEVCEN					

* All advancements require commanding officer's recommendation.
† 1 year obligated service required for E-5, and E-6; 2 years for E-7, E-8, and E-9.
\# Military leadership exam required for E-4 and E-5.
** For E-2 to E-3, NAVEDTRAPRODEVCEN exams or locally prepared tests may be used.
†† Waived for qualified EOD personnel.

Figure 1-1.—Active duty advancement requirements.

REQUIREMENTS *	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	4 mos.	8 mos.	6 mos.	[illegible] mos.	24 mos.	36 mos. with total 8 yrs service	36 mos. with total 11 yrs service	24 mos. with total 13 yrs service
TOTAL TRAINING DUTY IN GRADE †	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
PERFORMANCE TESTS			Specified ratings must complete applicable performance tests before taking examination.					
DRILL PARTICIPATION	Satisfactory participation as a member of a drill unit in accordance with BUPERSINST 5400.42 series.							
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)	Record of Practical Factors, NavEdTra 1414/1, must be completed for all advancements.							
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)	Completion of applicable course or courses must be entered in service record.							
EXAMINATION	Standard Exam		Standard Exam required for all PO advancements. Also pass Military Leadership Exam for E-4 and E-5.				Standard Exam. Selection Board.	
AUTHORIZATION	Commanding Officer		NAVEDTRAPRODEVCEN					

* Recommendation by commanding officer required for all advancements.
† Active duty periods may be substituted for training duty.

Figure 1-2.—Inactive duty advancement requirements.

OCCUPATIONAL STANDARDS are professional requirements directly related to the work of each rating.

Both the military requirements and the occupational qualifications are divided into two subject matter groups called PRACTICAL FACTORS and KNOWLEDGE FACTORS. Practical factors are things you must be able to to DO. Knowledge factors are things you must KNOW to perform the duties of your rating.

In most subject matter areas, you will find both practical quals and knowledge quals. In some subject matter areas, you will find one or the other. It is important to remember that there are some knowledge aspects to all practical factors, and some practical aspect to most knowledge factors. Therefore, even if the Quals Manual indicates that there are no knowledge factors for a given subject matter area, you still may expect to find examination questions dealing with the knowledge aspects of the practical factors listed in the subject matter area.

Occasionally, changes are made to every set of quals. When this manual was printed, it covered the current set of quals, but by the time you begin your study, the quals may have changed. Naturally, you will be examined on the basis of the latest requirements. For this reason, well before examination time, check the Quals Manual to make sure that new quals not covered here or by other study material have not been added.

You are required to pass a Navywide military/leadership examination for E-4 or E-5, as appropriate, before you take the occupational examinations. These examinations are administered on a schedule determined by your commanding officer. Each examination consists of 100 questions based on information contained in Military Requirements for Petty Officers 3 & 2, NAVPERS 10056, and other publications listed in Bibliography for Advancement Study, NAVEDTRA 10052. Candidates are required to pass the applicable military/leadership examination only once.

The Navywide occupational examinations for pay grades E-4 and E-5 will contain 150 questions related to occupational areas of your rating.

If you are working for advancement to second class, remember that you may be examined on third class qualifications as well as on second class qualifications.

Record of Practical Factors

Before you can take the servicewide examinations for advancement, there must be an entry in your service record to show that you have qualified in the practical factors of both the military qualifications and the occupational qualifications. The RECORD OF PRACTICAL FACTORS, NAVPERS 1414/1, mentioned earlier, is used to keep a record of your practical factor qualifications. This form is available for each rating. It lists all practical factors, both military and occupational. When you demonstrate your ability to perform a practical factor, appropriate entries are made in the DATE and INITIALS columns.

When changes are made to the Manual of Qualifications for Advancement, revised forms of NAVPERS 1414/1 are provided as necessary. However, extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the Quals Manual. The Record of Practical Factors also provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum qualifications for advancement.

Until completed, the NAVPERS 1414/1 usually is held by your division officer; after completion, it is forwarded to the personnel office for insertion in your service record. If you are transferred before qualifying in all practical factors, the incomplete form should be forwarded with your service record to your next duty station. You can save yourself a lot of trouble by making sure that this form actually is inserted in your service record before you are transferred. If the form is not there, you may be required to requalify in the practical factors.

NAVEDTRA 10052

Bibliography for Advancement Study, NAVEDTRA 10052 (revised), is a bibliography listing required and recommended rate training manuals and other references to be used by personnel working for advancement. As such, it is important that you become familiar with it.

The required and recommended references are listed by pay grade. If you are working for advancement to third class, study the material listed for that rate. If you are studying for second class, however, study the material for both second and third class because you may be examined on third class subjects as well as those for second.

In using NAVEDTRA 10052 you will notice that some rate training manuals are marked with an asterisk (*). Any manual marked in this way is MANDATORY—that is, it must be completed at the indicated rate level before you can be eligible to take the servicewide examination for advancement. Each mandatory manual may be completed by (1) passing the appropriate nonresident career course that is based on the mandatory training manual; (2) passing locally prepared tests based on the information given in the training manual; or (3) in some cases successfully completing an appropriate Navy school.

Do not overlook the section of NAVEDTRA 10052 which lists the required and recommended references relating to the military qualification standards for advancement. Personnel of ALL ratings must complete the mandatory military requirements training course for the appropriate rate level before they can be eligible to advance.

The references in NAVEDTRA 10052 which are recommended but not mandatory should also be studied carefully. ALL references listed in NAVEDTRA 10052 may be used as source material for the written examinations at the appropriate rate levels.

NAVEDTRA 10052 is revised and issued once each year, usually in March. Each revised edition is identified by a letter following the NAVEDTRA number and by a date. When using this publication, be sure that you have the most recent edition.

Rate Training Manuals

Rate training manuals are designed to provide you with information that you need to advance. There are two general types, RATING manuals and SUBJECT MATTER manuals. A rating manual, (for example, this one) gives information directly related to the occupational qualifications of one rating. Subject matter manuals or BASIC manuals give information that applies to (is basic to) more than one rating, for example, Basic Electricity.

Rate training manuals are revised from time to time to keep them up to date technically. The revision of a rate training manual is identified by a letter following the NAVEDTRA number. You can tell whether any particular copy of a training manual is the latest edition by checking the NAVEDTRA number and the letter following this number in the most recent edition of List of Training Manuals and Correspondence Courses, NAVEDTRA 10061. NAVEDTRA 10061 is actually a catalog that lists all current training manuals and nonresident career courses; you will find this catalog useful in planning your study program.

Each time a rate training manual is revised, it is brought into conformance with the official publications and directives on which it is based; but during the life of any edition, discrepancies between the manual and the official sources are almost certain to arise because of changes to the latter which are issued in the interim. In the performance of your duties, you should always refer to the appropriate official publication or directive. If the official source is listed in NAVEDTRA 10052, NAVEDTRAPRODEVCEN uses it as a source of questions in preparing the fleetwide examinations for advancement. In case of a discrepancy between any publications listed in NAVEDTRA 10052 for a given rate, the most recent material will be used.

The following suggestions may help you to make the best use of this manual and other Navy training publications when you are preparing for advancement.

1. Study the military qualifications and the occupational qualifications for your rating before you study the training manual, and refer to the quals frequently as you study. Remember, you are studying the manual primarily to meet these quals.

2. Set up a regular study plan. It will probably be easier for you to stick to a schedule if you can plan to study at the same time each day. If possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.

3. Before you begin to study any part of the manual intensively, become familiar with the entire book. Read the preface and the table of contents. Check through the index. Look at the appendixes. Thumb through the book without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.

4. Look at the training manual in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a pretty clear picture of the scope and content of the manual.

As you look through the manual in this way, ask yourself these questions:

- What must I learn about this?

- What do I already know about it?

- How is this information related to information given in other chapters?

- How is this information related to the qualifications for advancement?

5. When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material that you can cover at one time will vary. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying any unit, chapter, section, or subsection—write down the questions that occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how this information ties in with your own past experience.

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without looking at the training manual, write down the main ideas that you have gotten from studying this unit. Don't just quote the book. If you can't give these ideas in your own words, the chances are that you have not really mastered the information.

9. Use nonresident career courses whenever you can. These courses are based on rate training manuals or on other appropriate texts. As mentioned before, completion of a mandatory rate training manual can be accomplished by passing a nonresident career course based on the rate training manual. You will probably find it helpful to take other nonresident career courses as well as those based on mandatory manuals. Taking a course helps you to master the information given in the training manual, and also helps you see how much you have learned.

10. Think of your future as you study rate training manuals. You are working for advancement to third class or second class right now, but some day you will be working toward higher rates. Anything extra that you can learn now will help you both now and later.

SOURCES OF INFORMATION

Besides training manuals, NAVEDTRA 10052 lists official publications on which you may be examined. You should not only study the sections required, but should become as familiar as possible with all publications you use.

One of the most usefule things you can learn about a subject is how to find out more about it. No single publication can give you all the information you need to perform the duties of your rating. You should learn where to look for accurate, authoritative, up-to-date information on all subjects related to the military requirements for advancement and the occupational qualifications of your rating.

PUBLICATIONS YOU SHOULD KNOW

Some of the publications described here are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, be sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made. Studying canceled or obsolete information will not help you to do your work; it is likely to be a waste of time, and may even be seriously misleading.

NAVORDSYSCOM Publications

As you might expect, the publication most often referred to in this manual as a source of amplifying information is the Ordnance Pamphlet (OP). OPs are the basic type of technical publications issued by the Naval Ordnance Systems Command (NAVORDSYSCOM). The equipment OP (which is the one you will most generally use) provides detailed instructions on operational theory, physical description of components, installation, maintenance, repair, and safety precautions for each item of ordnance equipment. Any change to the original OPs are issued by

NAVORDSYSCOM. Changes issued to the fleet are numbered, and a record of all changes is listed on a change record sheet posted in the front of every OP.

The OPs needed for your equipment will be aboard. If you feel a need for additional information, you can consult OP O, the index of OPs, for the titles and numbers of other publications, and then request them.

The manufacturer's technical manuals furnished with some items of equipment are valuable sources of information on operation, maintenance, and repair.

Another publication you should become familiar with is the OD (Ordnance Data). An OD is a kind of catchall. It is used for publishing advance information or instructions on ordnance equipment installation and alignment data, parallax data, and other miscellaneous information, such as tables of weights and dimensions. Formerly, ODs were used for publication of test and inspection data; Ordnance Reports are now used for this purpose. ODs are numbered consecutively by the issuing agency. ODs, like OPs, are listed in OP O.

One OD that is required reading for you, and for all other Gunner's Mates, is OD 3000, Lubrication of Ordnance Equipment. It is the one OD that your ship's library of ordnance publications must not be without.

INSTRUCTIONS issued by the NAVORDSYSCOM are another source of information referred to in this manual. The purpose of these instructions is to pass out the details concerning the command's policy in matters of operation and maintenance.

NOTE: As of 1 July 1974 NAVORDSYSCOM and NAVSHIPSYSCOM were integrated into one command; NAVSEASYSCOM. Wherever NAVORDSYSCOM or NAVSHIPSYSCOM appear in this manual, substitute NAVSEASYSCOM.

NAVEDTRA Publications

Some of the NAVEDTRA (formerly BUPERS) publications that you will need to study or refer to as you prepare for advancement have already been discussed earlier in this chapter. The basic courses, published by Chief of Naval Education and Training (formerly Chief of Naval Personnel) will be referred to frequently in the manual. These include:

Basic Electricity, NAVPERS 10086-B
Basic Electronics, NAVPERS 10087-C
Military Requirements for Petty Officer 3 & 2, NAVPERS 10056-C
Blueprint Reading and Sketching, NAVPERS 10077-C
Basic Machines, NAVPERS 10624-A
Tools and Their Uses, NAVPERS 10085-B
Fluid Power, NAVPERS 16193-B

Large changes have been made in some of the revisions so be sure you have the latest revision of each book.

Since you will be working closely with Fire Controlmen and Gunner's Mates (Missiles), you may find it useful to consult the rate training manuals prepared for those ratings.

Naval Ship Systems Command (NAVSHIPSYSCOM)

Gun systems and ammunition magazines must be installed and maintained to comply with ship's rules. These are given in NAVSHIPS Technical Manual, consisting of chapters, many of which are in pamphlet form. Use the table of contents to locate a particular chapter, and then use the index at the end of the chapter to find the topic you want.

The electricity used in your division is supplied by the ship, and ship's rules and regulations must be observed. These too, are given in the NAVSHIPS Technical Manual, along with some detailed instructions on care and repair of components.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Training films are listed in the United States Navy Film Catalog, NAVAIR 10-1-777 (formerly NAVWEPS 10-1-777) published in 1969. Copies may be ordered in accordance with the Navy Stock List of Publications and Forms, NAVSUP 2002. Monthly supplements to the Film Catalog are distributed to catalog holders.

When selecting a film, note its date of issue listed in the Film Catalog. As you know, procedures sometimes change rapidly. Thus some films become obsolete rapidly. If a film is obsolete only in part, it may sometimes be shown effectively if, before or during its showing, you carefully point out to trainees the procedures that have changed.

CHAPTER 2

EXPLOSIVES AND PYROTECHNICS

One of the most important developments in the history of ordnance was the discovery of explosives. In this chapter we will give you a brief history and discuss the characteristics, uses, and handling of explosives currently used by the United States Navy. We discuss what the term explosives means and then we go into some details of various explosives and pyrotechnics used in Navy weapons.

EXPLOSIVES

To understand the composition and function of a complete round of ammunition, a basic knowledge of the characteristics and uses of military explosives is necessary. The demands for ammunition capable of fulfilling the many requirements of the Navy necessitates the employment of several kinds of explosives. Each explosive performs in a specific manner. Thus, the explosives (bursting charge) used to burst a forged steel projectile would not only be an unsuitable propelling charge for ejecting and propelling projectiles and missiles, but also would be highly dangerous. Similarly, the explosives used in initiators, such as in primers and fuzes, are so sensitive to shock that only small quantities can be used safely.

Personnel not familiar with ammunition, or untrained in its use and handling, normally are afraid of the possibility of an explosion. However, when handled in accordance with the prescribed regulations, ammunition is relatively safe. Safety regulations are set forth in numerous publications such as U. S. Navy Regulations, Ordnance Publications (OPs), pertinent instructions, etc. Many of the regulations and precautions embody the lessons learned as result of actual disasters. They must be obeyed without exception and cannot be changed or disregarded.

OP 4, Ammunition Afloat, defines the word explosives, if used without further qualification, as those substances or mixtures of substances which, when suitably initiated by flame, spark, heat, electricity, friction, impact, or similar means, undergo rapid chemical reactions resulting in the rapid release of energy. The release of energy is almost invariably accompanied by a rapid and pronounced rise in pressure. The rise in pressure usually, but not necessarily, is a consequence of the rapid generation of gas in much larger volume than that originally occupied by the explosive.

An explosion is defined as a practically instantaneous and violent release of energy. It results from the sudden chemical change of a solid or liquid substance into gases. These gases, expanded by the heat of the chemical change, exert tremendous pressure on their containers and the surrounding atmosphere.

CHARACTERISTICS

There are three important characteristics of explosive reactions: they liberate heat; they produce large increases in pressure, usually by liberation of large quantities of gas; and the reaction takes place in a comparatively short time.

HEAT.—An explosive reaction is always accompanied by the liberation of heat. The amount of heat is representative of the energy of the explosion and, hence, its potentiality for doing work.

PRESSURE.—High pressure accompanying an explosive reaction is caused by the formation of gases which are expanded by the heat liberated in the reactions. The work which the reaction is capable of performing depends upon the volume of the gases and the amount of heat liberated. The maximum pressure developed and the way in which the energy of the explosion is applied depend further on the velocity of the reaction.

VELOCITY.—An explosive reaction differs from ordinary combustion in the velocity of the reaction. For example, if gases are evolved slowly, they are dispersed without causing any appreciable increase in pressure. Velocity is one of the characteristics that distinguishes high explosives from low explosives. Although the power of an explosive is affected greatly by the quantity of gas and heat evolved, the rate at which they are given off is of prime importance. This rate is designated the velocity of explosion or the velocity of detonation.

Sensitivity

Sensitivity, which is of great importance in military explosives, may be defined as the ease with which an explosive can be detonated. Explosives must be safe to handle and, in some cases able to withstand severe shock before the start of the chemical reaction or detonation. The strength of the impulse required to detonate or set off an explosive may vary considerably. Some may be detonated by the slightest touch; others require a violent blow and cannot be set off in the open by a flame.

EXPLOSIVE TERMS

Terms defined here are some that you should know to understand the following discussions.

High explosives: High explosives are substances whose reaction is a high detonation that is most readily initiated by a blow or shock and proceeds as a wave phenomenon propagated at a speed of the order of the velocity of sound in solids. The amount of exposed surface has little effect on the time required for complete reaction.

Low explosives: Low explosives are substances whose decomposition involves a rapid burning or deflagration that is most readily initiated by direct heat or flame and proceeds as a thermal wave, the speed of which is markedly slower than the velocity of sound. Low explosive burning is confined to exposed surface, thereby providing a means of regulating the time for total reaction. The extent of exposed surface has considerable effect on the burning time of low explosives.

Brisance: Shattering ability of high explosive. When it is desired that a projectile explode to scatter lethal fragments, an explosive is one in which the maximum pressure is attained so rapidly that the effect is to shatter material surrounding it or in contact with it.

Stability: Ability of an explosive to remain unaffected by storage conditions. Some explosives (like propellant powder) decompose with age, even under the best of conditions, and require frequent checking.

Power: When applied to an explosive, refers to the extent of its ability either to inflict damage or to activate another explosive. Power may be measured by energy, peak pressure, or momentum of the shock wave from the explosion.

Loading properties: The adaptability of an explosive to loading requirements is an important factor in fixing its range of usefulness. Projectiles of the Navy are pressloaded with a granular explosive. Cast explosives are used for mines, depth charges, bombs, and warheads.

Hygroscopicity: Tendency of a material to absorb moisture. Because moisture reduces the sensitivity of an explosive, or affects it adversely in other ways, explosives must be protected to prevent deterioration.

CLASSIFICATION

At one time, explosives were commonly divided into two categories, designated high explosives and low explosives. High explosives were those which could be made to detonate and whose use depended on this characteristic. Low explosives were those which could be made to burn only by application of heat or flame, and whose use depended on their characteristics, usually that of burning in a rapid, controllable, and reproducible manner. In military applications, the term high explosive is still used but with a somewhat different meaning. Many of the explosives formerly called low explosives are now called propellants, but the term propellant is not synonymous with low explosive.

Classification of explosives thus far has been based on characteristics. A more practical classification from the standpoint of the Gunner's Mate is based on their military use. These classifications are:

1. Propellants.
2. Initiating explosives.
3. Booster explosives.
4. Burster high explosives.

Propellants

The primary function of a propellant is to provide a pressure that, acting against an object to be propelled, will accelerate the object to the required velocity. This pressure must be so controlled that it will never exceed the strength of the container in which it is produced, such as guns, rocket motor housings, pyrotechnic pistols, line throwing guns, etc. In addition, propellants must be comparatively insensitive to shock.

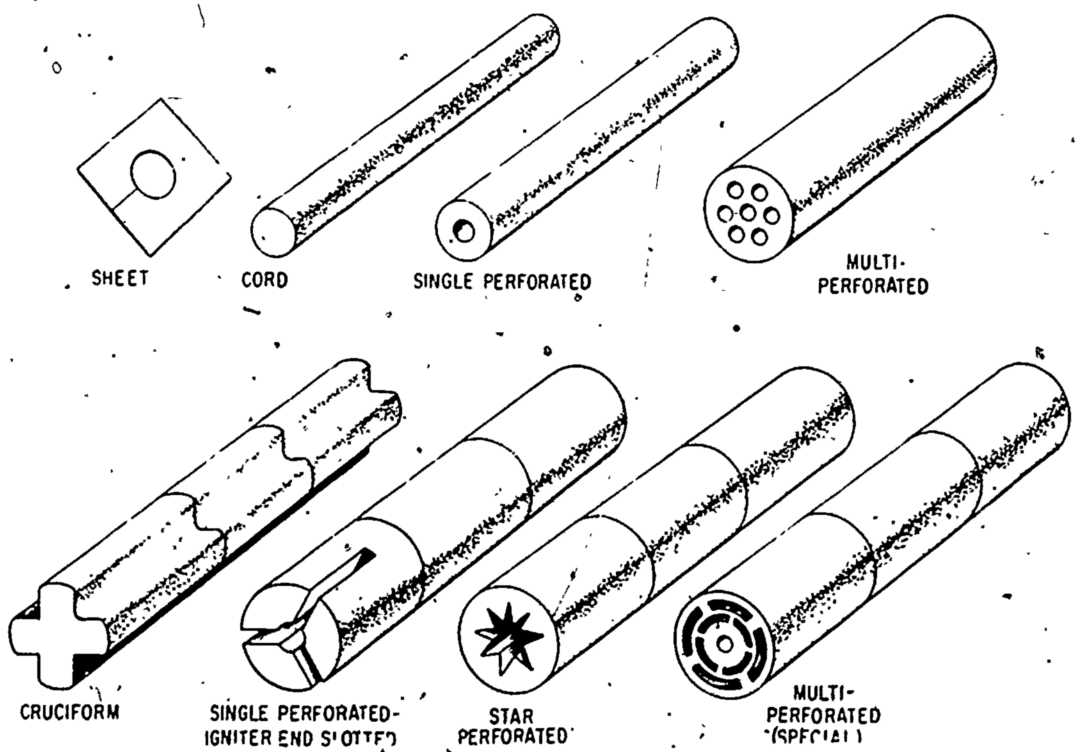
Propellants may be either liquid or solid in form. Many solid propellants have a nitrocellulose base. Various organic and inorganic substances are added to the nitrocellulose base during manufacture to give improved qualities for special purposes.

Propellants can be classified by such terms as single-base, double-base, multi-base, and composite. Single-base propellants contain only one explosive ingredient, nitrocellulose. Double-base and multi-base propellants contain one or more explosive ingredients in addition to nitrocellulose. Multi-base propellants which contain three explosive constituents are often called triple-base powder. Composite propellants are compositions that contain mixtures of fuel and inorganic oxidents but do not contain a significant amount of nitrocellulose or nitroglycerin. There are also combinations of composite and double-base propellants.

Solid propellants are manufactured in the form of flakes, balls, sheets, cords, or perforated cylindrical grains. They are made in various shapes to obtain different types of burning actions. The cylindrical grains are made in various diameters and lengths, and with varying numbers of holes or perforations. (See fig. 2-1.) The different types of burning actions are regressive, neutral, and progressive. A propellant is said to be regressive burning when the surface area of the grains decrease as they burn. An example of a neutral burning grain is a single perforated grain whose inner surface increases and whose outer surface decreases as it burns. The result of these two actions is that the total surface remains the same. As a multiperforated grain burns, its total burning area increases since it burns from the inside to the outside at the same time. Thus, it is called progressive burning.

Initiators

Initiating explosives are those explosives which serve to ignite propellants and are used in



53.144

Figure 2-1.—Shapes and forms of propellant grains.

the caps of primers and to initiate the reaction of high explosives. Initiating explosives explode or detonate when subjected to heat, impact, or friction. There is, however, considerable difference among them with respect to the type and strength of the initiating force required, the amount of heat given off, and the shock produced by the explosion. Currently used initiating explosives are lead azide, lead styphnate, tetracene, and diazodinitrophenol.

PRIMERS.—A primer is a device used to initiate the burning of a propellant charge by means of a flame. It may consist of a small quantity of extremely sensitive high explosive. Usually, primers are classified in accordance with the method of initiation such as percussion, electric, friction, chemical, etc. A percussion primer, upon being struck by the firing pin of a gun, will detonate and produce the flash of flame needed to ignite the propellant charge. All primers function in a similar manner when initiated. Primers may also be used to initiate detonators.

DETONATORS.—Detonators are used in initiating high explosive bursting charges as opposed to propellants. They are similar to primers inasmuch as they also contain a small quantity of extremely sensitive high explosives. Detonators are also classified in accordance with the methods of initiation.

Auxiliary Explosives

Large propellant charges and relatively insensitive disrupting explosives require an intermediate charge so that the flame or shock of the initiating explosive may be increased to ensure proper reaction of the main explosive charge. The intermediate or auxiliary explosive used with propellants consist of a quantity of flame-producing black powder sufficient to engulf the propellant grains. The auxiliary explosive used with disrupting explosives is called a booster and consists of a quantity of more sensitive high explosive, such as tetryl or granular TNT. A booster increases the shock of the detonator to a degree sufficient to explode the disrupting explosive.

BOOSTER.—An auxiliary explosive, when used with a burster charge, is called a booster. It consists of a moderately sensitive high explosive. Boosters are necessary because of the relative insensitivity of the main charge. (NOTE: Explosives used as boosters in large projectiles may serve as burster charges in smaller ones.)

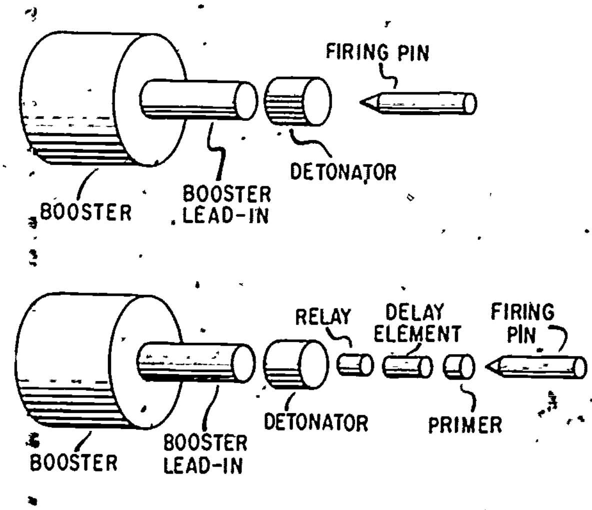
The basic high explosive train consists of the detonator, booster, and burster charge. However, high explosive trains are often compounded by the addition of auxiliary boosters, time delays, and primers. Such a train might be as follows—primer, delay pellet, detonator, booster, auxiliary booster, and main burster charge. However, this example is the extreme. (See fig. 2-2.)

Burster High Explosives

The burster charge for projectiles or various type bombs, mines, torpedo warheads, and other bomb-type ammunition is always a high explosive. Burster charge substances must fulfill certain requirements for military use. In general, they must do the following:

1. Be insensitive enough to withstand the shocks of handling, of being fired from a gun, and of impact against armor—only in armor piercing projectiles.
2. Have a maximum explosive power.
3. Have stability to withstand adverse storage conditions.
4. Produce proper fragmentation—only for fragmentation weapons.
5. Be inexpensive and easy to manufacture from readily available materials.

The substance most nearly fulfilling all of these conditions might be considered the best burster explosive; however, the specific purpose to be served must be considered. For example,



53.153

Figure 2-2.—Typical high explosive trains.

a burster charge used in a projectile must fulfill all of the foregoing conditions, whereas a mine or torpedo warhead filler need not be so insensitive as to withstand armor impact. However, for mines and torpedoes, the tendency of the burster explosive not to absorb moisture and its maximum power would be the most important characteristics. Thus, compromises have to be made to a certain point, provided no safety factor requirement is overlooked.

High explosive charges are loaded into their containers by one of three methods: cast-loaded, pressloaded, and extrusion. Cast loading is performed by pouring the substance as a liquid into a container and letting it solidify. Explosives having no liquid form must be press-loaded, or pressed into their container. The combining of certain explosives results in plastic mixtures that can be loaded only by the extrusion method.

SERVICE EXPLOSIVES AND THEIR USE

Service explosives as used in the Navy are varied and are constantly undergoing changes. However, there are certain basic explosives that have become fairly standard throughout the Navy. A few of the more pertinent explosives and their uses are discussed in the following paragraphs.

BLACK POWDER

Black powder is the oldest explosive known. The ingredients in black powder include saltpeter (potassium nitrate or sodium nitrate), charcoal, and sulphur. It ignites spontaneously at about 300° C (572° F) and develops a fairly high temperature of combustion (2300° to 3800° C).

The chemical stability of black powder is practically unlimited when stored in airtight containers; but it deteriorates irregularly when exposed to moisture, which it absorbs readily.

Black powder is not affected by moderately high temperatures, and it is not subject to spontaneous combustion at ordinary storage temperatures. It is highly flammable and very sensitive to friction, shock, sparks, and flame. When ignited, it is extremely quick and violent in its action.

Uses of Black Powder

The range of use of black powder has decreased with the development of new chemical compounds but, where smoke is no objection, black powder is considered by many to be the best substance available for transmitting flame and producing a quick, hot flame.

Currently black powder is used by the Navy for the following purposes:

1. Delay elements in fuzes.
2. Ignition charges for smokeless powder, for primers in guns of all calibers, and for rocket or guided missile igniters.
3. Impulse charges for surface torpedo tubes and depth-charge projectors.
4. Black powder charges for training, saluting, and signaling.

SMOKELESS POWDER

These are low, or burning, explosives which are used to give a specified velocity to the delivery of missiles such as gun projectiles, rocket projectiles, torpedoes, and depth charges. Relatively slow, controlled decomposition is required to provide time for the force of the evolved gases to act without the destruction of the projecting equipment.

The basic component of modern smokeless powder is vegetable fiber (generally cotton), molded into grains and dried. The resulting powder is a low explosive which will burn instead of detonating. It is used almost exclusively as the propellant for gun and rocket ammunition. The powder is generally considered to be of three types: single-base, double-base, and multi-base.

Smokeless powder is obviously a more effective propellant than black powder, and is far less sensitive, tricky, and dangerous to handle. It has the following characteristics:

1. Burns evenly.
2. Noncorrosive; it does not react to metals.
3. Gives off large quantities of gas during burning, which is highly desirable in a propellant.
4. Leaves little residue or ash.
5. Is somewhat hygroscopic and tends to deteriorate as it becomes moist.

There are certain volatile ingredients in smokeless powder which tend to evaporate when the powder is exposed. It must be stored in airtight, moisture-proof containers. Powder magazines should therefore be checked daily for condition of powder containers, for maintenance of proper temperature, and for evidences of deterioration of powder.

Excessive heat has an unfavorable influence upon the stability of smokeless powder. At temperatures below 60° F, the stability is not appreciably affected. The rate of decomposition begins to rise at temperatures above 70° F, becoming relatively high at 100° F, and dangerously accelerated at temperatures above 110° F. Precautions must therefore be taken to ensure the maintenance of a uniformly low temperature in magazines where smokeless powder is stowed.

SPD. Smokeless powder with the index designation SPD consists of colloided nitrocellulose and diphenylamine, which is the stablizer. This is the powder commonly known as "pyro" powder by the United States Navy and has been used in standard service ammunition.

SPDN. Smokeless powder with the index designation SPDN is composed of nitrocellulose and dinitrotoluene, to which is added dibutylphthalate to control the potential of the powder and to aid in plasticization. This composition also contains diphenylamine, which acts as the stabilizer.

SPDF. Smokeless powder with the index designation SPDF is a modification of the basic composition of either SPD or SPDN made by the addition of a coolant or flash inhibitor, generally potassium sulfate. This combination of materials results in a flashless charge for the gun in which the powder is designed for use. SPDF powder is highly effective for full charges in 5-inch and smaller guns and reduced charges in several major caliber guns.

SPDB. A blend of stabilized SPD powder. The blend was originally devised to provide an index of ample size for a ship's service allowance but the letters are now assigned to a lot made to utilize small remnants for service or training exercise purposes. A blend of large-web and smaller-web powder (of not too great difference) may be made to produce an equivalent intermediate web to satisfy desired ballistics.

SPDE. Smokelss powder containing lead carbonate for decoppering purposes and otherwise similar to SPD powder.

SPDW. Reworked powder made from ground stabilized SPD smokeless powder regrained. It is generally used for training exercises. Many indexes are satisfactory for service ammunition, and service stable life experience with lots manufactured in recent years has not been much less than nonreworked powder.

SPC. A recently perfected cool burning, single-base smokeless powder of special nitrated nitrocellulose, containing centralite as a stabilizer.

SPCA. Smokeless powder of albanite type double-base containing DINA as substitute for nitroglycerin and with centralite as a stabilizer. It is white in color and has not been extensively manufactured.

SPCF. A single-base smokeless powder, similar to SPC powder, but containing ingredients added during manufacture to render the powder flashless.

SPWF. Reworked flashless powder made from ground stabilized SPD smokeless powder to which certain compounds were added during remixing.

BALLISTITE

Ballistite is a double-base powder used as a rocket propellant. It is composed of nitrocellulose, nitroglycerin, and diphenylamine which acts as a stabilizer. It burns with a considerable amount of flash and smoke, and generates a great volume of gas. Ballistite burns progressively but at a slower rate than gunpowders. The rate of burning is dependent upon the composition and physical characteristics of the powder grain, the temperature of the powder grain before ignition, and the pressure during reaction. It is produced in various shapes to fit the rocket motor housing, and is ignited by the flash of a black powder charge which, in turn, is ignited electrically. Obvious disadvantages are the telltale flash and black smoke.

NACO (NAVY COOL)

NACO is a rather recent development in the field of Navy gun type propellants. The basic formula is a typical single-base, but it is manufactured from low-nitration nitrocellulose to provide cool, clean burning without the use of soot-producing coolants. NACO compositions also provide decoppering action of the gun barrel by an alloying process.

NACO powder burns at a lower temperature than other conventional gun powders. The reduced heat lessens gun barrel erosion thereby lengthening barrel life.

Another important characteristic of NACO is its reduced muzzle flash making the powder desirable for night firing as well as daytime use.

Currently NACO is being operationally used in the 5"/54 gun mount.

INITIATING EXPLOSIVES

The explosives used as initiating explosives are the primary high explosives mentioned previously in this chapter. The high explosives are used in varying amounts in the different primers and detonators employed by the Navy, and therefore differ considerably in sensitivity, brisance, and the amount of heat given off. The explosives discussed in this section are lead azide, lead styphnate, tetracene, and diazodinitrophenol (DDNP).

Lead Azide

Lead azide has a high ignition temperature and is less sensitive to shock and friction than mercury fulminate. The brisance of lead azide increases as the pressure applied to it increases.

Lead azide is poisonous, slightly soluble in hot water and in alcohol, and highly soluble in a dilute solution of nitric or acetic acid in which a little sodium nitrate has been dissolved. Lead azide reacts with copper, zinc, cadmium, or alloys containing such metals forming an azide which is more sensitive than the original lead azide. Lead azide does not react with aluminum, and detonator capsules for lead azide are made of this metal. The hygroscopicity of lead azide is very low. Water does not reduce its impact sensitivity, as in the case with mercury fulminate. Ammonium acetate and sodium dichromate are used to destroy small quantities of lead azide. Lead azide may be used where detonation is caused by flame or heat. The velocity of detonation is approximately 17,500 fps. Its color varies from white to buff. Lead azide has become the most widely used in detonators of major-caliber base detonating fuzes, or point detonating fuzes, and of auxiliary detonating fuzes. It is also used in priming mixtures.

Lead azide is completely stable in storage even at elevated temperatures.

Lead Styphnate

There are two forms of lead styphnate. the normal, which appears as six-sided monohydrate crystals; and the basic, which appears as small rectangular crystals. Lead styphnate is particularly sensitive to fire and the discharge of static electricity; when dry, styphnate can be readily ignited by static discharges from the human body. The longer and narrower the crystals, the more susceptible the material is to static electricity. Lead styphnate does not react with metals. It is less sensitive to shock and friction than lead azide. Lead styphnate is slightly soluble in water, and methyl alcohol and may be neutralized by a solution of sodium carbonate. The velocity of detonation is approximately 17,000 fps. The color of lead styphnate varies from yellow to brown. Lead styphnate is used as a component in primer and detonator mixtures. It is stable in storage even at elevated temperatures.

Diazodinitrophenol

Diazodinitrophenol (DDNP) is a yellowish brown powder. It is soluble in acetic acid, acetone, strong hydrochloric acid, and most of the solvents but insoluble in water. A cold sodium hydroxide solution may be used to destroy it. DDNP is desensitized by immersion in water and does not react with it at normal temperatures. It is less sensitive to impact but more powerful than lead azide. The sensitivity of DDNP to friction is approximately the same as that of lead azide.

DDNP is used with other materials to form priming mixtures, particularly where a high sensitivity to flame or heat is desired.

DDNP is stable in storage even at elevated temperatures.

BOOSTER EXPLOSIVES

The explosives used as booster explosives consist of a moderately sensitive high explosive. However, they are generally more sensitive than those high explosives used as burster explosives. As high explosives used for booster purposes, they fall in the intermediate range of sensitivity.

Tetryl

Tetryl is a derivative of methyl-analine and is classified as a nitroaromatic compound. Tetryl is a fine crystalline material practically insoluble in water, but soluble in acetone, ammonia, ether, carbon tetrachloride, and benzol. Tetryl melts at about 130° C. Heated above its melting point, it undergoes gradual decomposition, and explodes when exposed to a temperature of 60° C for 5 seconds. Tetryl will corrode steel when in the dry or moist state. It is practically nonhygroscopic (after proper drying), but moisture does interfere with its effectiveness. Tetryl is chemically stable at ordinary temperatures. It is more sensitive, to shock or friction than TNT and more powerful than TNT. Tetryl is more sensitive to detonation by lead azide than TNT and is readily exploded by penetration of rifle bullet. Tetryl can be initiated from flame, friction, shock, or sparks; burns readily; and is quite likely to detonate if burned in large quantities. The velocity of detonation of tetryl is approximately 24,000 fps. When pure, tetryl is light -

yellow, but is usually gray after loading because of the graphite mixture used in the loading process.

Tetryl is sensitive to mechanical shock, and is used as a booster charge between the lead azide detonator and the high explosive bursting charge. Tetryl is also used as a filler in small-caliber projectiles. Tetryl is loaded in pellet form, the pellets being pressed after being mixed with small quantities of graphite which serve to lubricate it while it is being pressed.

Tetryl is poisonous when taken internally and causes dermititis on contact with skin. Precautions are therefore necessary when handling and packing the dry material. Special precautions must be taken to prevent ignition or explosion by friction or blows resulting from rough handling. Tetryl should be kept dry and protected from high temperature and sparks.

FILLER (BURSTER) EXPLOSIVES

There are several high explosives currently used by the Navy as fillers for bombs, torpedoes, mines, and projectiles. The principal explosives are TNT, RDX, and explosive D. These explosives, when combined in various percentages and combinations, produce numerous high explosives with varying degrees of sensitivity, brisance, rate of detonation, and other pertinent characteristics. The principal explosives and some of the more common derivative explosives are discussed in the following paragraphs.

Trinitrotoluene (TNT)

Trinitrotoluene is a crystalline substance. The importance of trinitrotoluene as a military explosive is based upon its relative safety in manufacture, loading, transporation, and storage, and upon its powerful, brisant, and explosive properties. Manufacturing yields are high and production relatively economical. Chemical names for TNT are trinitrotoluene and trinitrotol and other commercial names are Trilit, Tolite, Trinol, Trotyl, Tritolo, Tritone, Trotol, and Triton.

It is toxic, oderless, comparatively stable, nonhygroscopic, and relatively insensitive. When pure, it varies from white to pale yellow in color and is known as grade A TNT. When the proportion of impurities is much greater, the color is darker, often being brown, and is known as grade B TNT. It may be ignited by impact, friction, spark, shock, or heat. TNT does not form sensitive compounds with most metals. The melting point varies between 80.6° C for grade A (refined TNT) and 76° C for grade B (crude TNT). TNT does not appear to be affected by acids but is affected by alkalies (lye, washing soda, etc.), becoming pink, red, or brown, and more sensitive. Like most other explosives, but to a greater extent, it is adversely affected by sunlight becoming darker in color and deteriorating in melting point and purity. It is practically insoluble in water, but soluble in alcohol, carbon tetrachloride, ether, benzene, carbon disulphide, acetone, and certain other solvents. The velocity of detonation is approximately 22,300 fps.

TNT may be cast into burster charges for projectiles, bombs, depth charges, warheads, mines, and rocket heads. TNT is normally combined with other high explosives to form burster charges. Cast TNT is rather difficult to detonate. It usually requires a booster charge of refined, granular TNT or tetryl to ensure complete high-order detonation. For fuzes and boosters, a refined, granular TNT is used.

In a granular or crystalline form, and when unconfined, TNT burns freely and may burn without detonation. However, there are a few instances on record of large quantities detonating after having burned for a while. Thin-walled ammunition such as bombs, depth charges, mines, warheads, and similar ammunition containing TNT burster charges; containers of bulk TNT; and demolition charges are subject to sympathetic detonation or detonation en masse. This property makes it necessary to separate TNT storage from other types of explosive storage, especially fuzes and detonators, and from fire hazards which may initiate a detonation. Contrary to the beliefs of many, TNT is not so insensitive that it can be treated roughly with impunity. Instances are on record where small globules have been detonated by scraping them with a knife and where a pipe plugged with TNT detonated when hammered.

Exudate has been known to separate from cast TNT. It may appear pale yellow to brown in color and vary in consistency from an oily liquid to a more viscous one. The amount and rate of separation depend primarily upon the purity of the TNT and secondarily upon the termperature of the storage place. Grade B (low-melting point) TNT may exude considerable liquid and generate some gas. This exudation is accelerated with an increase in temperature.

Pure TNT will not exude since exudate consists of impurities which have not been extracted in the refining process. Exudate is a mixture of lower melting isomers of TNT, nitrocompounds of toluene of lower nitration, and possible nitrocompounds of other aromatic hydrocarbons and alcohols. It is flammable and has high sensitivity to percussion when mixed with absorbants. Its presence does no appreciable harm to the stability, but somewhat reduces the explosive force of the main charge. In some ammunition, an inert wax pad is used in the loading operation and in some cases waxy material may ooze from the case. It should not be confused with the TNT exudate described above. This material should, however, be tested for TNT to confirm its actual composition.

TNT exudate, when mixed with a combustible material such as wood chips, sawdust, or cotton waste, will form a low explosive which is highly flammable and ignites easily from a small flame. It can be exploded in a manner similar to a low grade of dynamite, but the main danger is its fire hazard. Accumulation of exudate is considered a great risk, both explosive and fire, and should always be avoided by continual removal and disposal of the exudate as it occurs. Frequent inspection of all cast TNT ammunition should be made to see that exudate is not present.

The exudate is soluble in acetone or alcohol. One of these solvents (taking care to provide adequate ventilation) or clean hot water should be used to facilitate removal and disposal of the exudate. Under no circumstances should soap or other alkeline preparations be used to remove this exudate, as the addition of a small amount of hydroxide, caustic soda, or potash will sensitize TNT and cause it to explode if heated to 160° F.

Tritonal

Tritonal is composed of 80 percent TNT and 20 percent aluminum powder. Tritonal is noncorrosive, toxic, and possesses satisfactory storage properties. Its melting point is 81°C, and it is soluble in acetone. Velocity of detonation is approximately 18,000 fps. The color is gray.

Tritonal is used primarily in anti-swimmer devices. Tritonal is cast, segregation of the aluminum being prevented by a pellet loading technique.

Composition A

Composition A is a wax-coated, granular explosive, consisting of 91 percent RDX and 9 percent plasticizing wax. The wax content is sufficient to desensitize the mixture and lubricate it enough to allow it to be pressed into projectiles.

Composition A-3 is not melted or cast. It is nonhygroscopic and possesses satisfactory storage properties. The melting point of composition A varies from 200° C to 230° C. Composition A is appreciably more brisant and powerful than TNT as is indicated by its velocity of detonation of approximately 27,000 fps. Its color may be white or buff, depending upon the color of the wax used to coat the powdered RDX.

Composition A is used as a filler in projectiles which contain a small burster cavity such as anti-aircraft projectiles. Three varieties of composition A have been developed, designated composition A-1, A-2, and A-3. They can also be used as compressed fillers for medium-caliber projectiles.

Composition B

Composition B-1 is a mixture of 59 percent RDX, 40 percent TNT, and 1 percent wax. Composition B-2 is a mixture of 60 percent RDX and 40 percent TNT. The TNT reduces the sensitivity of the RDX to a safe degree and lowers the melting point, thereby allowing the material to be cast-loaded.

Composition B might be detonated at low or high order depending on case material by bullet impact. The total energy of blast in air of composition B is about 116 percent of that of TNT. Composition B is nonhygroscopic and remains stable in storage. It has an extremely high shaped charge efficiency. The velocity of detonation is approximately 24,000 fps and its color is yellow to brown.

Composition B has been used as a more powerful replacement for TNT in loading some of the rifle grenades, and some rocket heads. It can be used where an explosive with more power and brisance is of tactical advantage and there is no objection to a slight increase of sensitivity.

Composition C

Composition C-3 is one of the composition C series that has now been replaced by C-4, especially for loading shaped charges. However, quantities of composition C-1 and composition C-2 may be found in the field. Composition C-1 is 88.3 percent RDX and 11.7 percent plasticizing oil. Composition C-3 is 77 percent RDX, 3 percent tetryl, 4 percent TNT, 1 percent nitrocellulose, 5 percent MNT (mononitrotoluol), and 10 percent DNT (dinitrotoluol). The last two compounds, while they are explosives, are oily liquids and plasticize the mixture. The essential difference between composition C-3 and composition C-2 is the substitution of 3 percent tetryl for 3 percent RDX, which improves the plastic qualities. The changes were made in an effort to obtain a plastic, putty-like composition to meet the requirements of an ideal explosive for molded and shaped charges that will maintain its plasticity over a wide range of temperature and not exude oil.

Composition C-3 is about 1.35 times as powerful as TNT. The melting point of composition C-3 is 68° C, and it is soluble in acetone. The velocity of detonation is approximately 26,000 fps. Its color is light brown.

HBX—HBX-1, HBX-3, H-6

The HBX group of explosives are an important segment of the explosives used by the Navy. They all contain a mixture of composition B, TNT, aluminum, composition D-2, and calcium chloride in varying percentages to meet the requirements of their principal use.

The explosive HBX-1 is not a manufactured product but is a cast mixture of the foregoing compositions. HBX-1 is used primarily in mines.

HBX-3 is composed of the same compositions as HBX-1 but in different percentages. The primary use of HBX-3 is in mines and torpedo warheads.

H-6, a later development in the family of HBX explosives, is composed of the same compositions as the other HBX explosives with again a difference in percentage of the ingredients. It is used in bombs and missiles and is a cast filler but is considered superior to the other HBX compositions.

The explosive HBX is noncorrosive and chemically stable. Tests indicate that prolonged exposure to unusually high temperatures may cause the loss of a small part of the wax used as a desensitizer. This wax may appear as exudate; however, the wax is not explosive and should be cleaned off by normal means. The melting point of HBX varies from 80° C to 90° C. HBX has a velocity of detonation of approximately 24,300 fps, and a color of slate gray.

Explosive D

Explosive D or ammonium picrate is a high explosive usually derived by nitration of phenol followed by ammoniation of the produced picric acid. In bulk, explosive D appears in the form of finely divided crystals. Explosive D stains human hair and skin yellow. It has two major disadvantages:

1. Its melting point is too high for it to be melted and cast; therefore, it must be loaded by pressing.

2. If not entirely free of traces of unammoniated picric acid, it reacts with certain metals such as lead, potassium, copper, and iron to form sensitive compounds and must be protected from direct contact with such metals. The color varies from yellow to orange brown. Explosive D is soluble in water and alcohol. Its melting point is 265° C. Explosive D is not hygroscopic when dried to specified moisture content (0.2 percent). It is very difficult to detonate and difficult to ignite. The principal use of explosive D is as a burster charge for large caliber projectiles. While its powers and brisance are slightly inferior to those of TNT, it is much more insensitive to shock and will stand impact on armor plate without deflagrating. The velocity of detonation is approximately 21,300 fps.

OTHER HIGH EXPLOSIVES

High explosive compounds are often mixed with the principal explosives to produce combination explosives such as ammonium nitrate, nitroguanidine, and picric acid.

Ammonium Nitrate

Ammonium nitrate is a crystalline powder varying in color from almost white to brown. It has a melting point of 170° C. It usually cannot be detonated by heat or friction but may be exploded by heavy booster explosives. It also may be exploded by relatively light initiation if it has been sensitized by certain impurities, among which are many carbonaceous materials. Ammonium nitrate is not flammable at normal temperatures. In fires involving large quantities of ammonium nitrate, the material becomes explosive hazard. The explosive hazard is accentuated by conditions of partial confinement and buildup of a certain degree of pressure in the gases of decomposition. When ammonium nitrate is in contact with copper-bearing metal, it may form sensitive compounds. When granulated in a special form or coated with certain noncombustible materials, ammonium nitrate is widely used as an efficient nitrogenous fertilizer.

Nitroguanidine

Nitroguanidine is a powerful high explosive which, when incorporated in propellants in appreciable quantities, results in a propellant that burns in a gun with a temperature so cool that no muzzle flash is produced.

Nitroguanidine, under moderate temperature and humidity, is acceptably stable. It is comparable in strength to TNT and its sensitivity is somewhat less than that of TNT. The velocity of detonation of nitroguanidine is approximately 24,400 fps. The color is white to yellowish.

Dynamite

Dynamites and blasting gelatins are explosives procured from commercial sources. Their sensitivity and keeping qualities are of a different order than those of standard military explosives. Therefore, special conditions for handling and storage are mandatory. Dynamite is more hazardous in storage than other high explosives because:

1. It may exude nitroglycerin which is a greater fire and explosion hazard than other types of exudate.
2. It deteriorates more rapidly than other high explosives. Therefore, it is a policy not to store dynamite and blasting gelatins in large quantities at naval activities handling ammunition or explosives, except with specific approval.

PYROTECHNICS

Pyrotechnics is a Greek word for fireworks. The Navy uses fireworks not for celebration, but for illumination, marking and signaling. An example is the illuminating projectile or starshell (SS) used to illuminate targets for gunfire. A starshell actually is a pyrotechnic device although it is encased in a projectile body of standard external shape, and is fired from a standard rifled gun.

In the following sections we discuss pyrotechnics launched by hand or from special projectors, or simply held by hand. All the pyrotechnics we study here are intended for signaling.

The Navy issues pyrotechnics not only for use aboard its surface combat ships, but also for use by aircraft, submarines, motor torpedo boats, merchant ships and for use ashore. However, we discuss only those issued as ship's pyrotechnics. For the others, see the OPs on pyrotechnics (at present OPs 1511, 2213, and 2793).

The pyrotechnic units we describe are—

1. Marine location markers
2. Signal lights, and the pyrotechnic pistols and projectiles used in firing them
3. Distress and hand signals
4. Navy lights.

MARINE LOCATION MARKERS

Marine location markers are of two general types—those for day use (Mk 1 Mod 3) and for night use (Mk 2). The marker for daytime use spreads a patch of bright yellow dye on the water; the night type burns with a yellow flame for 45 to 55 minutes. Both types are used to indicate the point of discharge of depth charge barrages and to provide a reference point for further antisubmarine attack. (A Mk 1 Mod 2 marker, still occasionally used, has green dye.)

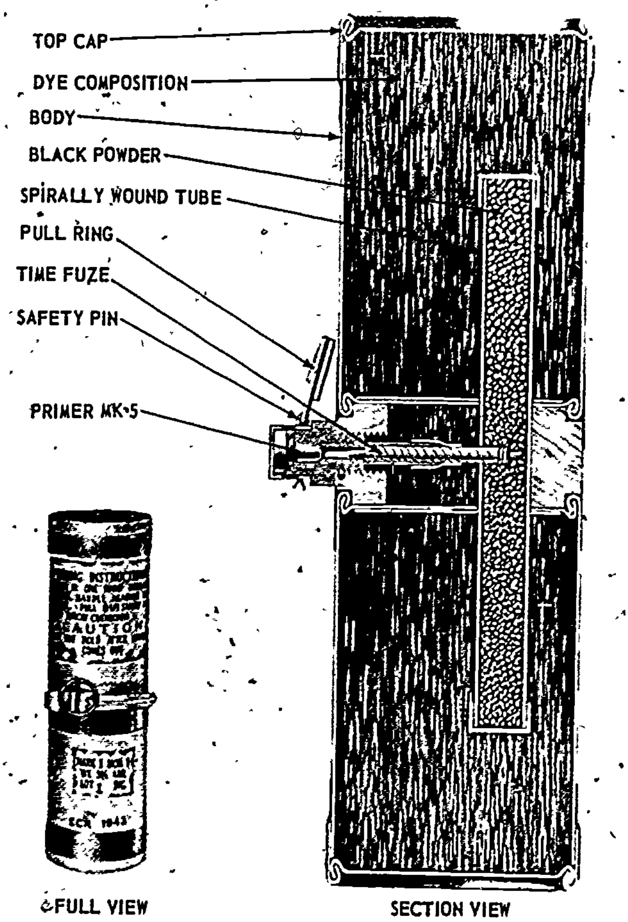
Strictly speaking, the marine location markers Mk 1 Mod 2 and 3 are not pyrotechnics. Their displays are not produced by burning pyrotechnic compositions. These devices do, however, contain explosive charges that serve to burst the outer container. The markers are covered in this section because of their loose relationship to pyrotechnics.

Marine location Marker Mk 1 Mod 3 (fig. 2-3) is a cylindrical waterproofed container about 12 inches long and 3.5 inches in diameter. When you pull the ring attached to the safety pin and release the safety lever, the primer ignites the time fuze. Fifteen seconds later the black powder charge bursts the two dye containers and scatters the dye. The marker is dropped about 25 yards from the actual point where the depth charge itself was launched so that the depth charge's "boil" when it bursts will not dissipate the slick of dye. Never pull the pin until the marker is to be launched. After the pin is pulled, keep the safety lever firmly against the marker body until it actually leaves your hand.

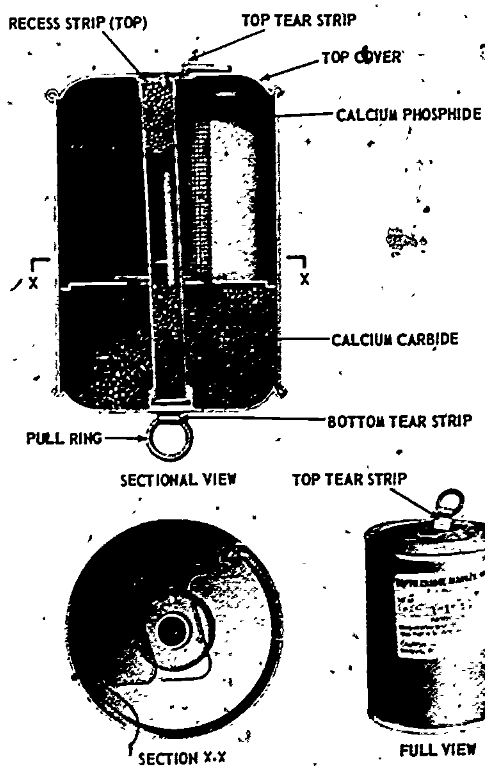
WARNING: If the marker is accidentally dropped after the pin has been pulled, clear the area. DON'T try to retrieve the marker and make it safe again; it cannot be done.

If exposed to moisture, the dye in the marker cakes and doesn't spread very well in the water. The markers should, therefore, be kept dry.

The Mk 2 (night) marker is a sealed metal cylinder 7 inches high and 5 inches in diameter, shown in figure 2-4. It contains two chemicals; one of them is calcium carbide, the stuff that was used back in the horse-and-buggy days for carriage lamps. When wet, calcium carbide gives off acetylene, a gas that smells evil but burns



83.107
Figure 2-3.—Marker, location, marine Mk 1.



83.108
Figure 2-4.—Marker, location, marine Mk 2.

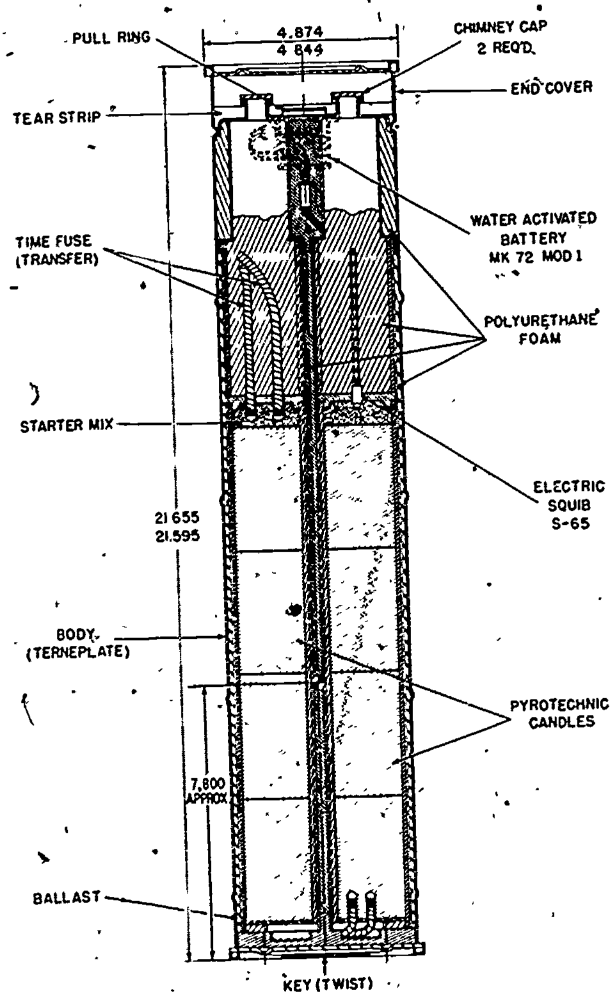
well. The other chemical (calcium phosphide) when wet, gives off a gas that ignites by itself, without help from matches, ignition charges, or the like. The calcium phosphide ignites the acetylene, which burns with a white flame.

To operate the marker, pull the rings on the marker to open the holes allowing water to reach the chemicals. Then throw the marker overboard, allowing a short time lag to avoid the depth charge "boil". The flame should appear in 45 to 50 seconds. DON'T remove the tear-strip rings until ready to cast the marker overboard. NEVER handle or carry the markers by their tear-strip rings.

Night depth charge markers (Mk 2) should be inspected while in stowage for damaged tear strips. Markers with damaged strips should be disposed of immediately as unserviceable.

SMOKE AND FLARE MARKERS

For night or day reference marking on the ocean's surface, Marker, Location, Marine Mk 58 Mod 0 is used chiefly by aircraft patrols in ASW but also is used for search and rescue operations, man-overboard marking, and similar applications. It can also be dropped over the side from surface ships. It is approximately 21 1/2 inches long and weighs about 12 3/4 pounds. It contains a battery squib, some starter mix, two pyrotechnic candles, and a transfer fuse between the two candles. Before launching, the tear tapes over the water port must be removed so that the sea water can enter to activate the battery. The battery current then energizes the electric squib which ignites the starter mix, which in turn lights the pyrotechnic candle. When the first candle has burned out in about 20 minutes, the second candle is started by the transfer fuze. Figure 2-5 illustrates this marker.



83.189

Figure 2-5.—Marker, location, marine Mk 58 Mod 0.

Several other types of markers are in use, but the present modifications require launching from aircraft to provide the force needed to rupture the dye marker or to activate the smoke and fire marker.

The Aircraft Smoke and Illumination Signal Mk 6 (fig. 2-6) is a pyrotechnic device that is launched from surface craft only to produce a day or night floating reference point. One of its principal particular uses is as a man-overboard marker. It was previously approved for launching from low performance aircraft as a long-burning marker but has been superseded for these purposes by Marine Location Marker Mk 58.

This device consists of a wooden body with a flat, die-cast metal plate affixed to one end to protect it from water impact damage and to maintain it in the correct floating attitude. There are four flame and smoke emission holes in the opposite end, each capped and sealed with tape. The pull wire ring, also at the emission end, is likewise covered with tape.

The Mk 6 signal has a direct-firing ignition system. Ignition results from pulling the pull ring. The pull ring is pulled by hand, and the device is thrown into the water immediately. The pull wire ignites a 90-second delay fuze which ignites the quickmatch at the top of the first of four candles. The quickmatch ignites the first candle starting mix which, in turn, initiates burning of that candle. Expanding gases of combustion force the cap and tape from the emission hole, allowing smoke and flame to be emitted. When the first candle is nearly burned out, a transfer fuze carries the ignition to the quickmatch of the next candle in series. This process continues until all four candles have burned. The yellow flame and gray-white smoke are produced for a minimum of 40 minutes.

After the tear strip on the shipping container has been removed, the following rules shall apply:

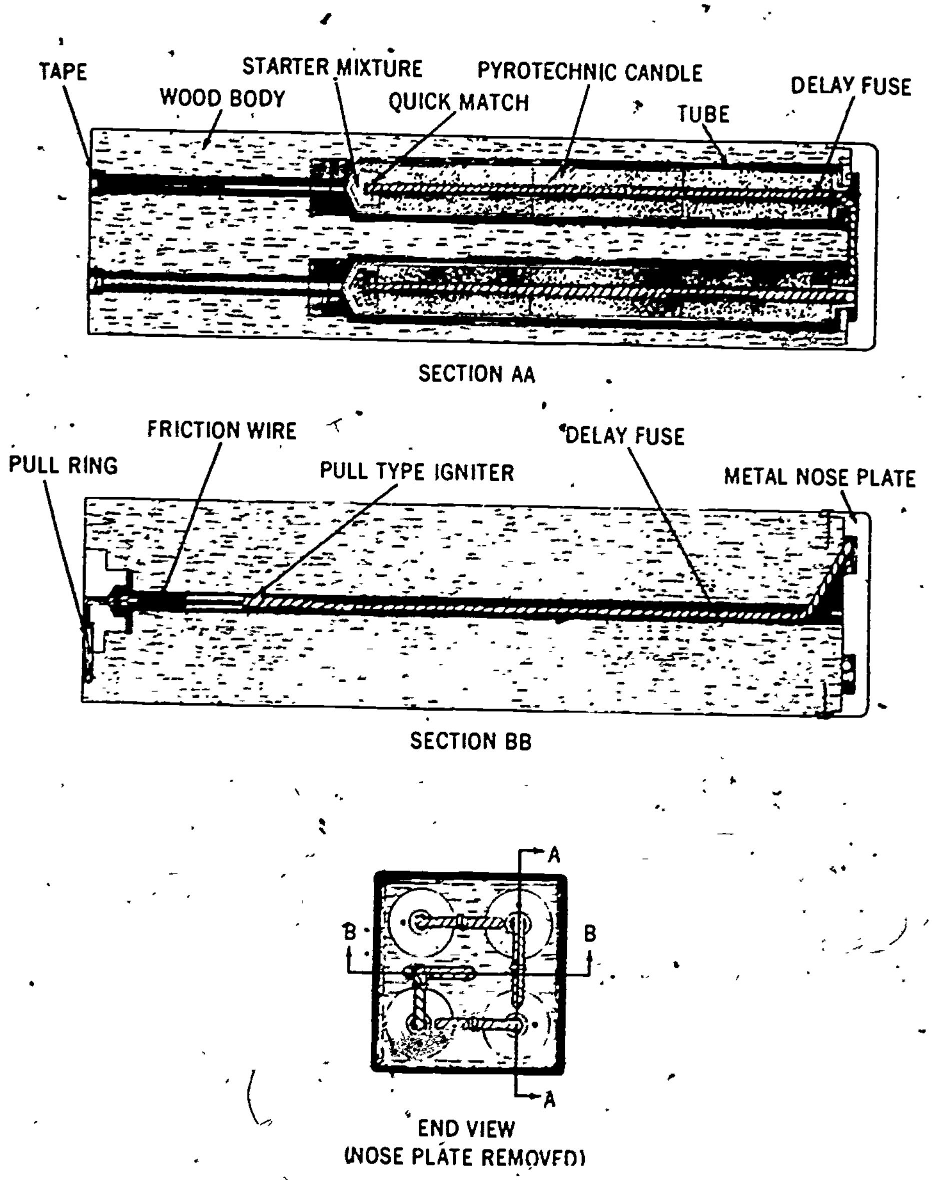
1. The tape over the pull ring shall not be disturbed until immediately before hand launching the signal. This tape not only prevents an accidental pull on the pull ring, but also protects the igniter assembly from moisture which might render the signal useless.

WARNING: This signal is initiated by the physical movement of a friction wire through ignition compound. Extreme care must be taken to prevent tension of the pull ring during all handling operation.

2. If this device is prepared for launching and is not launched, the pull ring must be securely retaped into position at the top of the signal without exerting any pulling force on the pull-wire igniter.

3. Under no circumstances shall these signals be stowed or restowed with their pull rings exposed or with any wires, strings, or other material of any kind joined to their pull rings.

All safety precautions pertaining to this signal shall be observed. In addition, the following specific rules apply:



83.203

Figure 2-6.—Aircraft smoke and illumination Signal Mk 6.

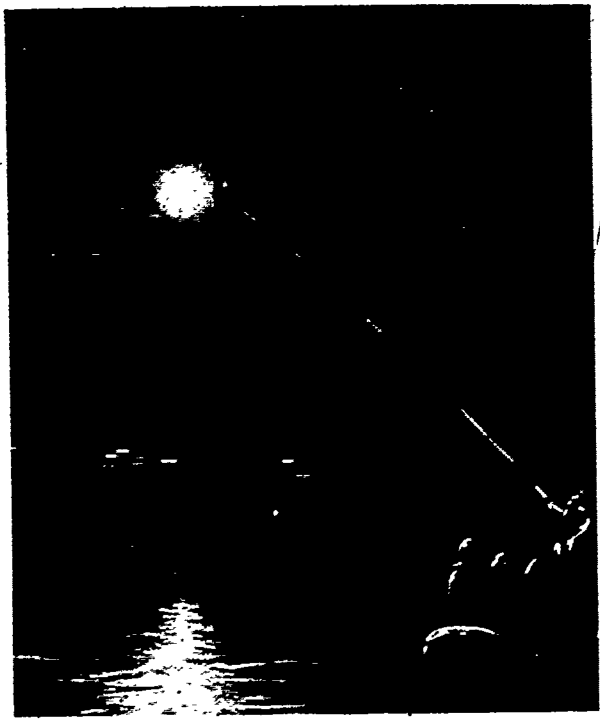
1. Do not remove the tape over the pull ring until immediately before launching.

2. The Mk 6 signal must be thrown over the side immediately after pulling the pull ring. This device contains a maximum 90-second delay element between initiation and candle ignition.

3. In all handling, extreme care must be taken to avoid pulling on the pull ring. Any slightest movement of the friction igniter may start the ignition train.

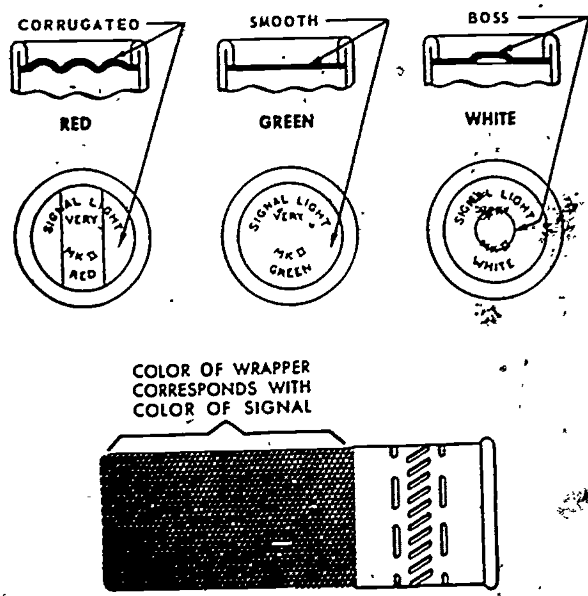
SIGNAL LIGHTS

Signal lights, often called Very lights (not because they are very light, but because that is what they were called by the French who originated them) are similar in appearance to a standard shotgun cartridge. When fired from the proper pistol or projector, a burning star (somewhat like a star from a roman candle) shoots high into the air, as shown in figure 2-7.



83.109

Figure 2-7.—Projected signal light.



83.110

Figure 2-8.—Markings on signal light Mk 2 Mod 0 (Very light).

The Mk 2 signal light is available in three colors—red, green, and white. Each cartridge has a percussion primer and a propelling or expelling charge of ten grains of black powder, which projects the burning star to a height of about 200 feet. The star charge is a tightly packed cylinder wrapped with a quick match (a fast-burning fuze) which ignites it when fired. The star charge is separated from the expelling charge by a shock-absorbing wad of hard felt. The cartridge is closed by a wad which is so marked that color of the star can be determined by feeling it, as shown in figure 2-8.

The red star may be identified by its corrugated closing wad, the green star has a smooth closing wad, and the white has a small conical boss on its closing wad. Each of the three colors may also be identified by the corresponding color of the paper on the cartridge.

The burning time for each of the stars is approximately 6 seconds.

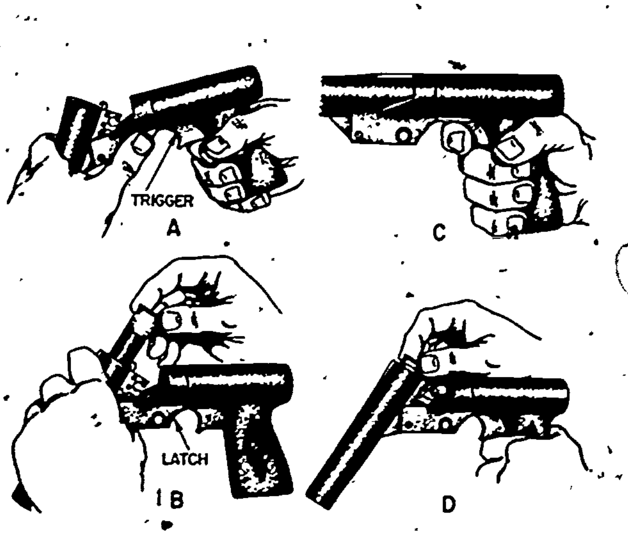
The lights are available in combination kits known as Service Box, Signal Pistol Mk 5; and Reserve Box, Signal Pistol Mk 5. Unless packed in kits, signal lights are packed in a metal can in units of tens, and 100 cans (1000 signals) are packed in a wooden case for shipment.

Signal lights are fired from signal Pistol Mk 5. Signal Pistol Mk 5, for use with signal light Mk 2, is a single-barrel, breech-loading pistol, 11 inches long. Metal parts are mounted on a plastic frame. A cartridge belt (Mk 1) and holster are issued for use with the pistol. Figure 2-9 shows how to use the pistol.

1. To load the pistol, depress the latch button below the barrel. At the same time pull the barrel downward, as in part A of the figure. Then insert the signal light shell (as in part B of the figure). Push the barrel upward again until it latches closed. The pistol is now ready to fire.

2. To fire the pistol, aim it upward at the desired angle but clear of other ships or personnel. Pull the trigger, as shown in figure 2-9C. Keep your elbow slightly bent, when firing, to absorb the shock of recoil and prevent the pistol from knocking itself out of your hand.

3. To extract the expended shell, break the pistol open again (Step A), and pull the shell out of the chamber, as in figure 2-9D.



83.111
Figure 2-9.—Operation of signal pistol Mk 5.

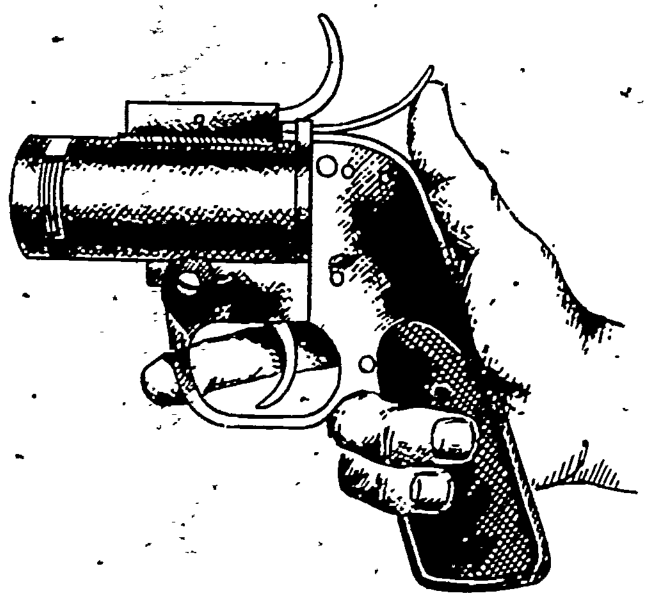
The pistol Mk 5 must be kept in serviceable condition at all times. Clean it thoroughly after each use. Wipe down all parts with a cloth impregnated with light machine oil. After assembly, wipe the exposed parts with a dry cloth. Swab the barrel with a cloth dampened with acetone or other solvent to remove powder residue.

When loading or firing pyrotechnic pistols, NEVER point them in the direction of other personnel or vessels.

NEVER use Signal Pistol Mk 5 with ammunition other than that authorized for use with it. Conversely, signal lights should never be fired from shotguns, or from projectors other than those authorized.

PYROTECHNIC PISTOL AN-M8

A pistol similar to the Mk 5 signal pistol is Pyrotechnic Pistol AN-M8 (fig. 2-10). It can be used with a number of signal lights of shotgun-shell shape. Some of these shells have paper cases and some have aluminum cases. Aircraft illumination Signal M 11 is fired only to denote aircraft distress, but other signals that can be fired from the AM-M8 pistol are used for signal and identification purposes, and may be fired from aircraft or surface ships. The use of the different colors of signals was outlined in the text Seaman, NAVTRA 10120-E, particularly with regard to their use in lifeboats.



83.190
Figure 2-10.—Pyrotechnic pistol M8, tripping breech lock.

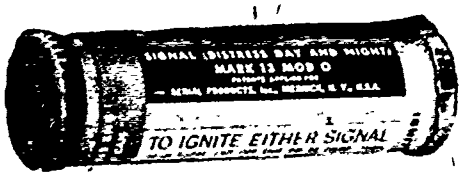
DISTRESS SIGNALS

The Distress Signal Mk 13 Mod 0 provides by day a pillar of smoke, and by night a fiery light. It's a mighty comforting thing to have in a life raft or life vest.

The Mk 13 Mod 0 signal (fig. 2-11) is a metal cylinder about 5-1/8 inches long and 1-5/8 inches in diameter. It weights between 6 and 7 ounces. One end contains a canister which, when ignited, produces orange smoke for about 18 seconds. The other end contains a pyrotechnic flare pellet that will burn 18 to 20 seconds.

Each end of the metal tube is enclosed by a soldered cap with a pull ring through which you can put your finger. When you pull the cap loose, a brass wire attached to its inside surface moves through a cap coated with a composition that ignites by friction, setting off either the flare or the smoke canister (depending on which ring you pull). The metal caps of the signal are covered with paper when issued, you must remove the paper before the pull rings are accessible.

The signal body carries illustrated instructions for use. The flare end has embossed projections extending around the case to identify it as the end to use at night. When you use the signal, point it away from the face and hold it at arm's length at a 30° angle after it ignites. After one end of the signal has been used, douse



3.246

Figure 2-11.—Distress signal Mk 13 Mod 0.

the signal to cool the metal parts. Keep it so that, if necessary, the other end can be used. Each end is separately insulated and water proofed. NEVER try to use both ends at once. When using the smoke signal, keep it to leeward.

These signals are shipped in wooden boxes containing 100 units. They are also available in metal cans containing four units for stowage in life boats, inflatable boats, etc. Avoid rough handling and stow in a cool, dry place in accordance with standard pyrotechnic stowage rules.

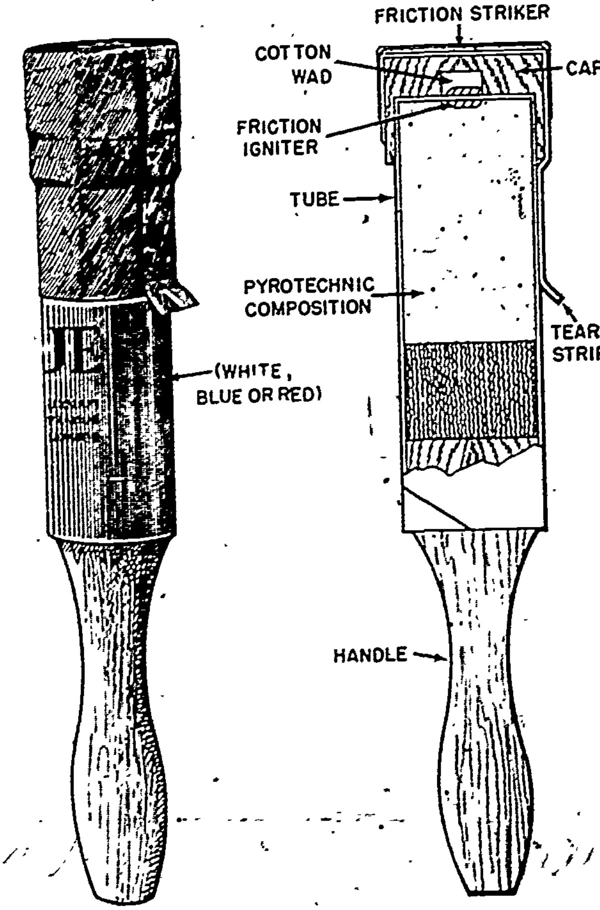
NAVY LIGHTS

Navy lights are hand torches that burn with a brilliant light visible at night up to 3 miles away. They come in two colors, blue and red: Navy blue light Mk 1 Mod 1 burns between 60 and 90 seconds; Navy red light Mk 1 Mod 0 burns between 150 and 180 seconds. The two lights are similar in appearance and construction (fig. 2-12).

Navy lights consist of a paper tube which contains the pyrotechnic substance with a wooden handle at one end and, at the other end, a cover with an exterior coating of abrasive like that on the scratching side of a safety match box. A tear strip protects the cover's exterior. The upper end of the paper tube, beneath the cover, is capped by a fabric impregnated with igniting compound similar to that on the head of a safety match.

To ignite the Navy light, tear off the protective strip, remove the cover, and scrape the inverted cover across the top of the paper tube. When you do this, it's advisable to hold the light pointing away from you at an angle of about 45° to avoid contact with hot particles falling off the pyrotechnic candle. Hold the light at that angle while it burns.

Navy red lights Mk 1 Mod 1 are shipped in metal containers with 6 or 12 lights packed in each. Navy blue lights Mk 1 Mod 1 are also shipped as part of the reserve box, signal



83.112

Figure 2-12.—Navy lights.

pistol Mk 5. Since these lights deteriorate when exposed to moisture, do not remove them from their containers until ready for use. For the same reason, keep them away from water or moisture. Lights that have been left in open containers for more than 6 months should be turned back to the nearest ammunition depot or magazine at the earliest opportunity. Lights that have become chemically encrusted, or which give off an acetic acid (vinegar) odor, should be disposed of immediately. Put them in a weighted sack and dump them overboard.

PYROTECHNIC KITS

Signal lights and Navy lights are issued not only by themselves but also as kits. These kits are assembled around the Mk 5 signal pistol

The Mk 5 signal pistol service box contains two pistols, a set of spare parts for the pistols, two holsters, a cartridge belt, and 50 each of red, white, and green cartridges. These kits are the ones most commonly found aboard ship.

SAFETY

No matter how dangerous the work, familiarity is apt to lead to carelessness. All personnel involved in the inspection or care of explosives, propellants, and pyrotechnics must exercise the upmost care to ensure that regulations and instructions are rigidly observed. As a GMG 3 or 2, you should carefully supervise those under you, and frequently warn them of the necessity of using extreme caution in the performance of their duties. No relaxation of vigilance should ever be permitted. The following safety precautions must be observed when working with explosives.

Whenever ammunition or explosives are being received, transferred, or stowed, the work should be supervised by an officer or petty officer who is thoroughly familiar with the rules for care and handling of explosives. He must make sure that all persons engaged in the work are properly impressed with the necessity for exercising the greatest care.

All ammunition, explosives, and powder must be protected from abnormally high temperature. If so exposed, they must be handled in accordance with current instructions (permissible maximum storage temperatures are prescribed by the Naval Ordnance Systems Command.)

Black powder is one of the most dangerous explosives and must always be kept segregated. Only such quantities as meet immediate needs may be taken from the magazines. A container of black powder may not be opened in a magazine, nor in the vicinity of a container in which there is any explosive.

Ballistite and smokeless powder which has been wet from any cause must be regarded as dangerous for dry stowage. Such propellants are to be handled in accordance with current instructions.

Electric igniters or detonators, electrically fired rocket motors, or electric fuzes may NOT be located in the same compartment with, or within 5 feet of, radio apparatus or antenna leads.

Pyrotechnics contain material of an extremely dangerous nature. Special precautions for certain pyrotechnics are prescribed in the section relating to the specific item. The following general precautions should be observed at all times.

Pyrotechnics should be handled carefully. Rough handling may cause immediate functioning, or may damage the item so it will not function properly at the time desired. Pyrotechnics are more easily ignited than rounds of explosive ammunition and the burning is usually difficult to extinguish. Some types of pyrotechnic ammunition are more dangerous than other types of service ammunition, and proper functioning is important.

Functioning of pyrotechnics is affected by moisture so they should be stowed in a dry, well-ventilated place. Most pyrotechnics are packed in moisture-proof containers and the seal of such containers should not be broken until just before the item is to be used. Pyrotechnics exposed to moisture should be segregated until an examination has proven they are safe and serviceable.

Whenever possible, pyrotechnics should be stowed in the boxes or watertight containers in which they were supplied, and should be separated according to type, color, and lot number.

Pyrotechnics should not be stowed where the direct rays of the sun can strike them, and they should be protected from excessive and variable temperatures. The temperature in stowage spaces should be below 100° F. The main reason for this temperature limitation is that many pyrotechnic items incorporate commercial percussion-type primers containing fulminate of mercury which deteriorates rapidly at temperatures exceeding 100° F.

Aboard ship, smoke-producing pyrotechnics should be stowed above deck if possible because it is difficult to combat fires in these materials when they are stowed where the smoke produced is not blown away. Water-activated items should be stowed separately. If water is used to fight a fire, the water may spread the fire by activating the pyrotechnics. Smoking or carrying lighted cigarettes, cigars, or pipes is not permitted in the vicinity of pyrotechnics. Matches and other flame or spark-producing articles should not be carried near places where pyrotechnics are stowed.

When a cartridge type pyrotechnic misfires, make at least two more attempts to fire it. If it still fails to fire, the pistol or projector may be unloaded after waiting a minimum of 30 seconds. Because of the nature of pyrotechnics, most types deteriorate in a shorter period of time than other types of service ammunition. The oldest serviceable pyrotechnics available should be issued first to ensure the continuing availability of fresh stock.

Pyrotechnic material shall always be kept segregated in regular pyrotechnic stowage spaces if such are provided, or in pyrotechnic lockers on upper decks. When handling or loading pyrotechnics, the number of units exposed or removed from stowage at one time should be kept to a minimum.

Flares are more dangerous as a fire hazard than many types of ammunition because they are so easily activated and because of the great heat developed by the burning illuminant candle. Extreme care is necessary in stowage, use, and handling. Flares exposed to excessive moisture or mechanically damaged by rough handling must be returned to ammunition depots or dumped overboard. Never disassemble flares nor remove parachutes or other components nor leave them in aircraft indefinitely grounded.

Deteriorated or damaged pyrotechnics shall be disposed of as soon as such a condition is discovered, either by dumping in deep water or by returning to a shore station. Pending disposition, such devices shall be carefully segregated.

Note the following safety precautions in the use of Navy lights:

1. Select carefully the place at which the lights will be burned because burning particles dropping from the lighted candles can start fires.
2. Always hold the light up at an angle of 45° and point it to leeward while it's burning.

Additional information on the methods and safe handling and disposing of high explosive exudate, powdered high explosive residue, and damaged explosive components is in OP 3347, United States Navy Ordnance Safety Precautions. This publication was developed for operating forces located both ashore and afloat and replaces chapter 20 of OPNAV 34P1, United States Navy Safety Precautions.

The scope of OP 3347 is restricted to explosive and nonexplosive ordnance material and equipment. All personnel in ordnance type ratings and strikers for such ratings have the responsibility of enforcing the proper methods and the safety precautions related to all types of ordnance material and equipment. All ordnance personnel must remain alert at all times to avoid a tragic situation brought about by carelessness or by ignorance or misuse of ordnance explosives and ammunition. Read and study OP 3347.

CHAPTER 3

AMMUNITION AND MAGAZINES

In the preceding chapter you learned about the raw materials that are used to make up explosives and pyrotechnics. In this chapter we will study Navy gun-type ammunition including its construction features and function. We identify the types of projectiles and fuzes used in the Navy and explain the color coding system used to identify ammunition.

We also discuss magazines and their sprinkling and alarm systems. We explain the safety precautions to be observed when operating and testing magazine sprinkling systems. In the last section of this chapter we discuss safety precautions for handling, and stowing gun ammunition and rockets.

Since ammunition is a major subject of this chapter, we will first supply a definition or explanation of ammunition.

Ammunition: A contrivance charged with explosives, propellants, pyrotechnics, initiating composition, or nuclear, biological, or chemical material for use in connection with defense or offense, including demolitions. The definition, when broadly applied, pertains to any case or contrivance (a mechanical device or appliance) charged with explosives. Ammunition is classified as follows:

1. Gun ammunition:
   a. Separate-loading (bag)
   b. Separated
   c. Fixed
   d. Small-arms (in reality a subclass of fixed ammunition)
2. Bomb type ammunition:
   a. Torpedo war heads
   b. Aircraft bombs
   c. Depth charges
   d. Mines
3. Pyrotechnic ammunition
4. Rocket ammunition
5. Impulse ammunition
6. Demolition charges and components
7. Guided missiles

GUN AMMUNITION-PROPELLING CHARGES

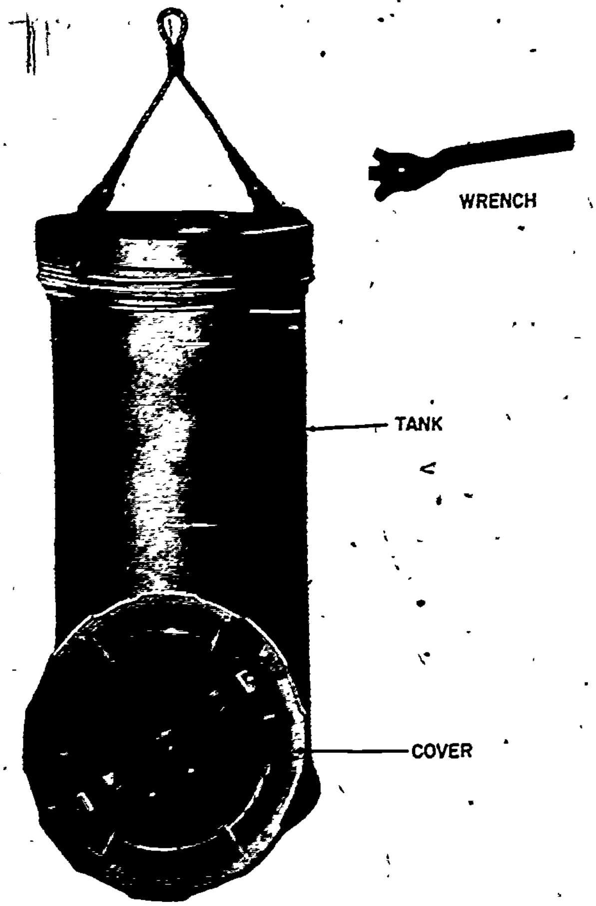
Propelling charges for gun type ammunition no longer fall into two categories. The last U. S. Navy ships carrying turret guns using bag type ammunition have been placed in an inactive status, therefore bag ammunition will not be discussed. As of this writing, all gun equipped Navy ships in the active fleet use case type ammunition. In case type propelling charges, the propelling charge and primer are contained in a cylindrical metal cartridge case. This ammunition is of two types, fixed and separated. In fixed ammunition the primer, propelling charge, and projectile are assembled into a single unit which may be loaded into the gun in a single operation. In separated ammunition, the primer and propelling charge are contained in a cartridge case as a separate plugged unit, with the projectile a complete, separate unit. Small arms ammunition is fixed, but will be taken up elsewhere in this manual.

CASE TYPE PROPELLING CHARGES

A complete round of separated ammunition consists of two pieces; a projectile, and a cylindrical metal cartridge case sealed by a cork or plastic plug. Separated ammunition is used in 5, 6, and 8-inch guns. Separated ammunition cases are kept in airtight tanks (fig. 3-1) until they are to be fired.

A complete round of fixed ammunition is one piece, with the cartridge case crimped to the base of the projectile. Fixed 3-inch rounds are kept in tanks, but smaller calibers are stowed in airtight boxes, several rounds to a box.

The insides of both the fixed and separated ammunition cartridge cases are quite similar. Figure 3-2 and 3-3 show the main components of both type cartridge cases. The primer's base fits into the base of the case so that the gun's firing pin lines up with and contacts it when the breech is closed. When a primer can be set

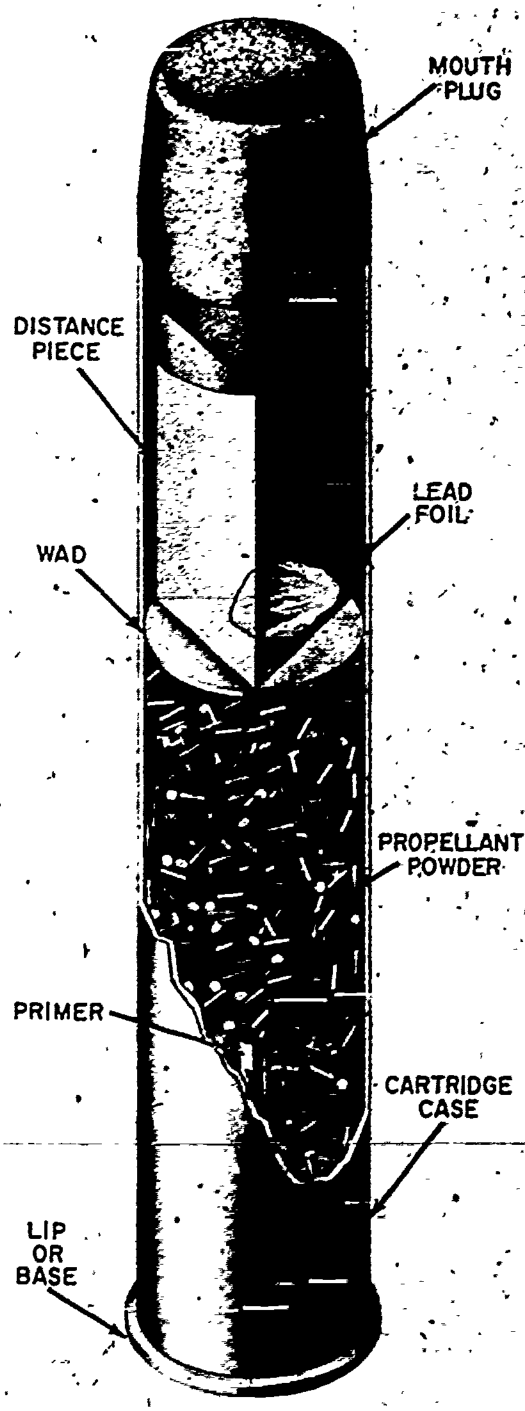


84.8
Figure 3-1.—Powder tank, cover, and wrench.

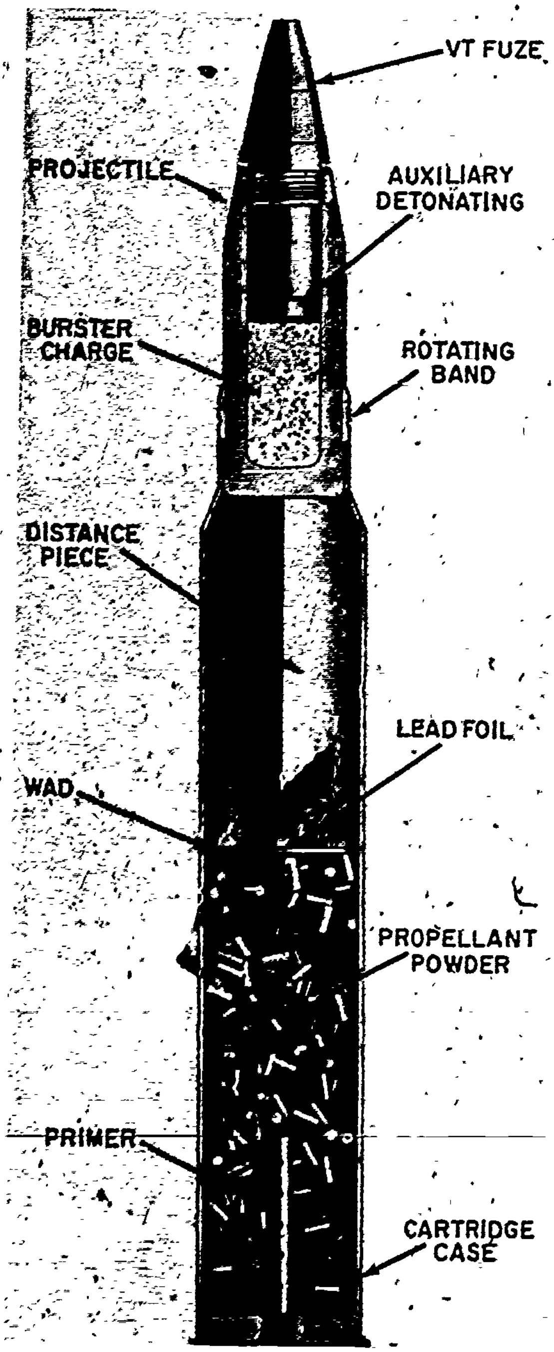
off either by an electric firing current or by the mechanical impact of the firing pin, it is called a combination primer. A black powder ignition charge runs the full length of the primer's perforated stock or tube, and does for the case type propelling charge what the ignition pad does for the bag type charge. This type primer is called a case combination ignition primer.

Case ammunition with combination primers are in service, but the majority of ammunition 3-inch and larger caliber being issued to the fleet is assembled with electric primers.

So that guns using separated ammunition may be cleared in the event of a casualty of the electrical firing system, short charges (bore clearing charge) will continue to be assembled with percussion or combination primers.



84.9(84A)A
Figure 3-2.—Typical cartridge case for separated ammunition, sectional view.



84.9(84A)A

Figure 3-3.—Typical round of fixed ammunition, cartridge case assembled with projectile, sectional view.

WARNING: You are NOT authorized to disassemble service ammunition to get at primers, nor to disassemble live primers. The explosive compounds in them, as you should have learned from the preceding chapter, are exceedingly touchy. Even if a primer hasn't enough wallop to blow you to bits, it can certainly deprive you of a finger or an eye, and it can easily set off more powerful charges. Under proper supervision you may, of course, use test primers, designed for the purpose of checking the functioning firing mechanisms and circuits.

Remember to play safe with primers when they're assembled into their charges, too. Handle separated ammunition cartridge cases, when they're out of their tanks, with base UP so that you won't accidentally set the case down on the deck, where a rivet head can set off the primer. Similarly, load them into their hoists base up.

Now let's look at the case in figure 3-2 again. When the gun fires, the case expands under the powerful pressure of the burning propellant gas, then must contract again afterward so that it can be removed from the chamber. It must not stick to the chamber walls nor may it crack. For a long while, only seasoned brass cases could be relied on to perform correctly. During World War II, when the supply of brass became critical, metallurgists developed a special steel that served adequately and has since almost completely replaced brass.

Steel is cheaper and is being constantly improved. But whatever cases are made of, used cases are generally called "fired brass." Steel cartridge cases are no longer reloaded and reused, however, since the cartridge tanks are required for reuse the fired brass may be returned in the empty tank for the fired brass scrap value.

Immediately after firing, stand ejected cases (5-inch and larger) on their bases to permit residual gases (small amounts left over after firing) to escape completely. Then replace the cases in their tanks. Other fired brass should be replaced in the original containers, tagged, and stowed.

In the center of the base of the case is the threaded hole for the primer. The case tapers slightly toward the forward end so that it can be withdrawn from the chamber without binding. A rim at the base is engaged by the gun's extractors. In fixed ammunition, the case often has a bottle neck in which the projectile is crimped.

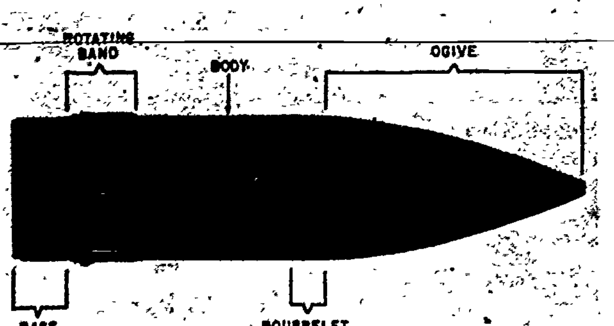
The propellant powder in the case is the 7-perforation kind we have already studied. (Small-caliber grains have one perforation.) The powder is weighed out with great precision and loaded into the case at the ammunition factory. Since it does not take up all the space inside the case, and since it would be dangerous for the powder to have a lot of room to rattle around in, it is tightly packed and sealed under a cardboard or pyralin wad. The wad is kept tight by a triangular cardboard distance piece. The distance piece bears up against the plug that closes the mouth of the case. In fixed ammunition, the case is sealed by the projectile base.

A small amount of lead foil included in each propelling charge functions upon firing by clearing the bore of the metal fouling that scrapes off the projectile rotating band onto the rifling as the projectile passes through the barrel.

PROJECTILES

From your study of Seaman, NAVEDTRA 10120-F, you learned the purposes of the external parts of projectiles such as the ogive, bourrelet, and rotating band, you also learned that the projectile's shape is designed to obtain the desired flight characteristics for stability and for minimum air resistance. Before explaining the classification, types, and general construction of projectiles, we'll review some of the basic information about the external parts of projectiles studied in the Seaman manual.

The body of the projectile is formed so that the forward end, called the ogive (fig. 3-4), is pointed, permitting the projectile to push its way through the air with a minimum of drag. Just aft of the ogive and ringing the projectile body is a highly finished surface called the bourrelet (fig. 3-4). It is slightly larger in diameter than the projectile's body; the purpose of the bourrelet is to support and steady the forward end of the projectile as it passes through the gun bore.



110.45
Figure 3-4.—External features of gun projectile.

Toward the rear of the projectile is a band of fine copper, slightly larger than the gun's bore. This band is called the rotating band. Its purposes are to (1) engage the rifling of the gun and impart rotation to the projectile when it is fired; (2) keep the projectile firmly seated in the gun, preventing the projectile from sliding back when the gun is elevated; and (3) seal the bore to prevent propellant gases from escaping around the forward part of the projectile.

CLASSIFICATION OF PROJECTILES

A projectile is most commonly classified by the size of the gun in which it is used. In addition to designations of bore diameter, such as 20MM, 3-inch, or 16-inch, the length of the gun bore in calibers is also used as a means of classification. Thus a 3"/50 projectile is one used in a bore length of 50 times 3 inches, or 150 inches. Projectiles are also classified by their service use and by their purpose and construction.

Classification By Service Use

For economy and for safety, gun ammunition is assembled and classified as follows:

1. Service: Ammunition for use in combat. The projectiles carry explosive, illuminating, or chemical payloads.
2. Target and Training: Ammunition for training exercises. The projectiles are comparable in weight and shape to those of service ammunition but are of less expensive construction and normally contain no explosive. VT NON-FRAG projectiles are an exception in that they are for training purposes and do have a combinat[illegible] black powder-pyrotechnic color burst eleme[illegible].
3. Dummy or Drill: Any type of ammunition assembled without explosives, or with inert material substituted for the explosives, to imitate service ammunition. The ammunition may be made of metal or wood. Dummy or drill ammunition is used in training or exercising personnel or in testing equipment. It is normally identified as dummy cartridges, dummy charges, or drill projectiles. Drill projectiles may not be fired from any gun.

Classification By Purpose And Construction

Projectiles are classified by their tactical purpose as one of the following types: penetrating, fragmenting, and special purpose. Since targets differ in design and purpose, projectiles must also differ in their construction to make them more effective. If you were to cut open for purpose of inspection, the different types of projectiles listed above (other than small arms) you would find that their construction and characteristics are common. Because of this, projectiles are also classified by their construction.

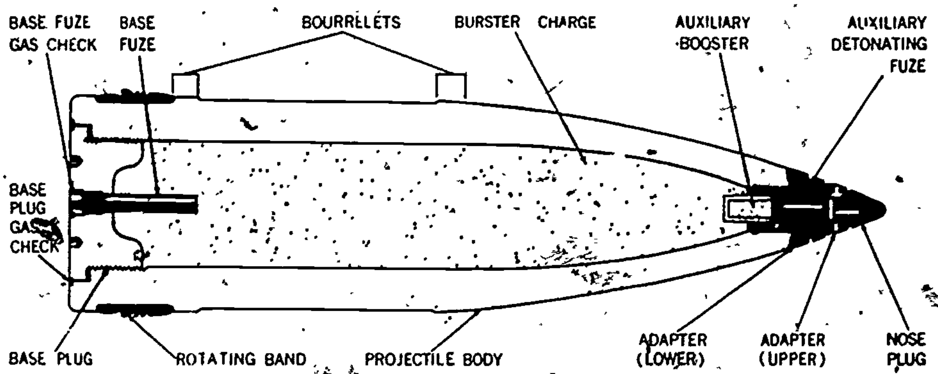
1. Thin-walled projectiles, designed to inflict damage by blast effect and by fragmentation (breaking up into small high-speed fragments). These projectiles have relatively thin walls and a large cavity for the bursting charge. The types of thin-walled projectiles are—

a. High-capacity (HC) (fig. 3-5) for use against unarmored surface or land targets. They are usually fuzed to function upon striking the target.

b. Antiaircraft (AA) (fig. 3-6) designed to burst in air for use against aircraft. They are usually fuzed to function either upon approaching the target (VT or proximity fuze), or at a certain pre-set time after firing (time fuze).

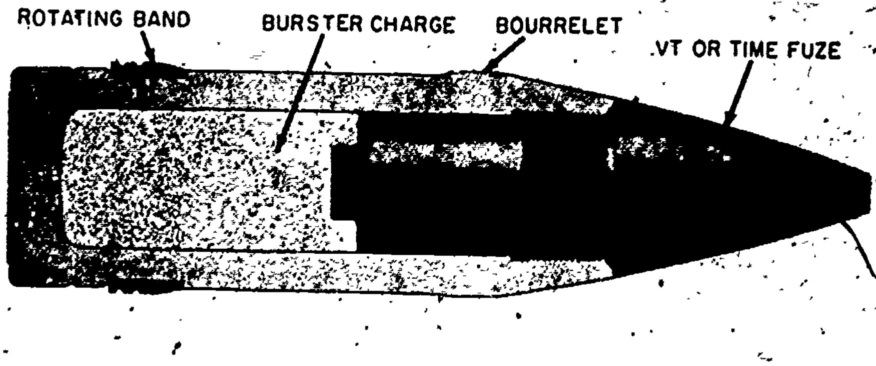
c. Antiaircraft common (AAC) (Fig. 3-7) projectiles are equipped with fuzes that detonate either upon impact, or a set time after firing. These projectiles can be used against surface or land targets.

d. High-explosive (HE) projectiles (fig. 3-8) for use against un-armored surface or land



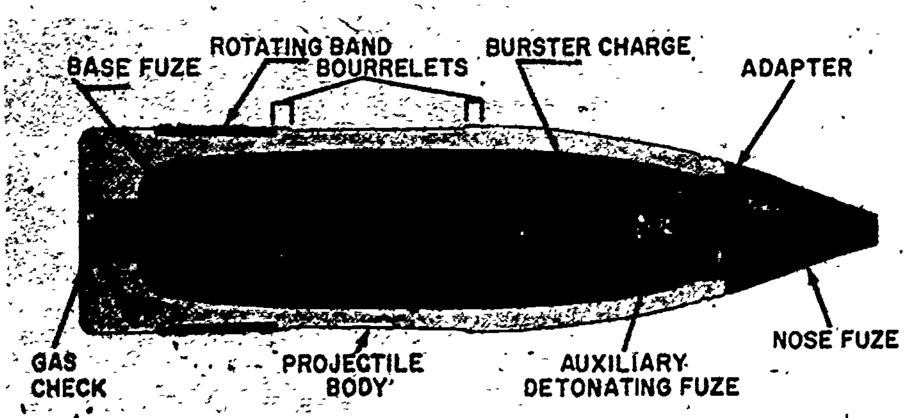
84.296

Figure 3-5.—Typical high capacity projectile, sectional view.



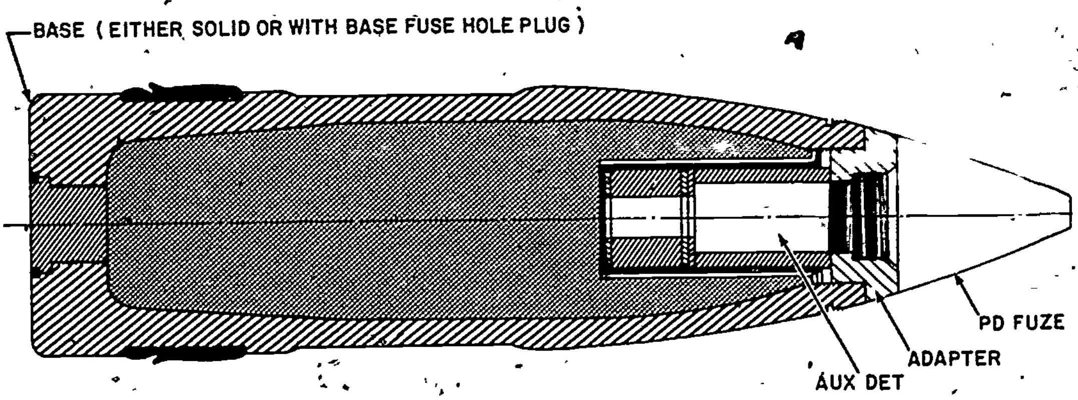
84.297

Figure 3-6.—Typical antiaircraft projectile, sectional view.



84.298

Figure 3-7.—Typical antiaircraft common projectile, sectional view.

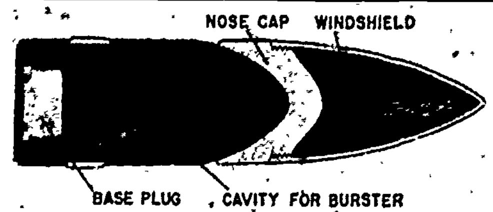


84.348

Figure 3-8.—High-explosive (HE) projectile.

targets when fuzed with PDF (HE-PDF) or used in the AA role when fuzed with MTF (HE-MTF). To achieve fuze action MTFs must be set on a time setting between 5 and 45 seconds and never on "safe"; PDFs must be set "ON". Note the lack of BDF backup.

2. Armor-piercing (AP) projectiles, designed to penetrate resistant obstacles like heavy armor plate, thick concrete, or the like, and then to explode. As you can see in figure 3-9 an AP projectile body has thick walls, a relatively small cavity for the burster charge, a nose cap, and a thin metal windshield. To function effectively, an armor-piercing projectile must keep its burster charge intact until it has penetrated its

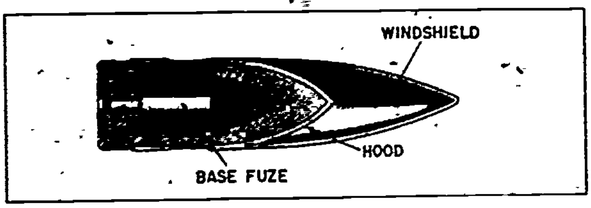


84.10.1

Figure 3-9.—3-inch armor piercing projectile, cross section.

target. The projectile body of tough steel backs up the hardened but somewhat brittle steel nose cap, which is so shaped that it will dig into and cut through an armorplated target, rather than bounce off (ricochet). However, in flight the blunt nose cap, which is shaped for penetration of armor not for streamlining, would give the projectile the ballistics of a brick. Hence the windshield, which collapses upon impact with the target, is screwed on to give the exterior of the projectile a satisfactory ogival shape.

NOTE: Figure 3-9 does not show the burster charge or the base fuze used to set it off.



.84.10.3

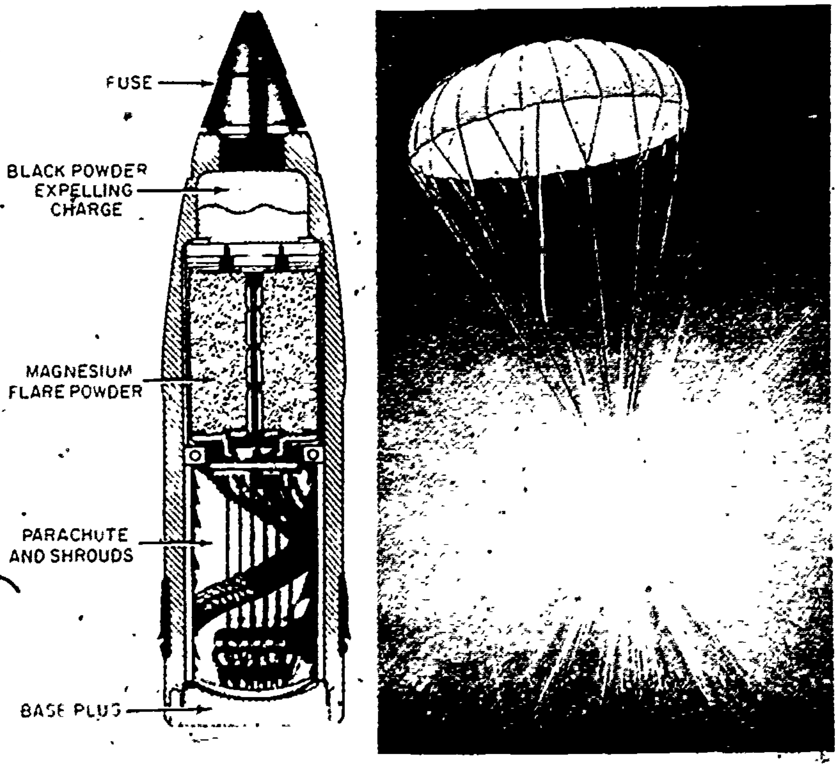
Figure 3-10.—3-inch common projectile, cross section.

3. Common (COM) projectile, a compromise between the AP and thin-walled types (fig. 3-10). The walls, though sturdy enough to penetrate thin armor, still permit a cavity large enough to carry a sizeable bursting charge. Common projectiles, 5-inch and larger, may have windshields.

4. Special-purpose projectiles, which include all those types that are not listed and classified above. Special-purpose projectiles are not intended to inflict damage by explosion or fragmentation. Their purposes depend on type, as follows:

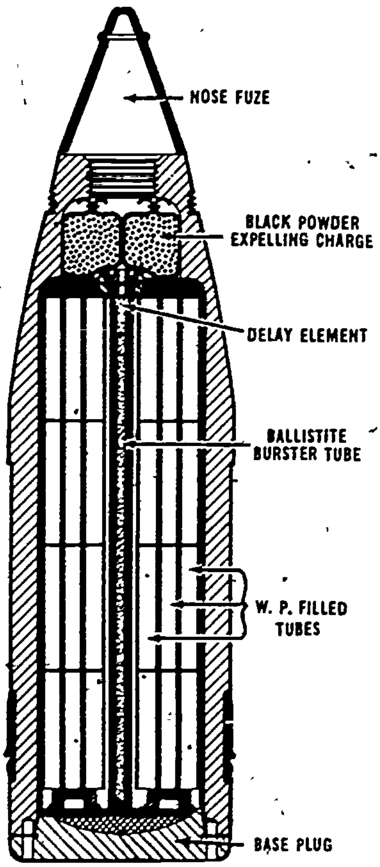
a. Illuminating projectiles, often termed star shells (SS). These are used for illuminating a target in darkness, at a predetermined instant, while the projectile is in flight, the time fuze ignites a black or smokeless powder charge. The charge expels the parachute and flare from the base of the projectile and lights the flare, which burns with a brilliant light as it descends, supported by the parachute (fig. 3-11).

b. Chemical projectiles include a number of different types, depending on purpose—those with various types of war gases, and smoke projectiles. Smoke projectiles (one is shown in cross section in fig. 3-12) are by far the most common. They



110.47.1:84.11.1

Figure 3-11.—Illuminating projectile.



110.47.3

Figure 3-12.—Smoke (WP).

contain tubes of white phosphorous (WP) and black-powder or Composition A3 burster charge, which scatters the white phosphorous over a wide area when it explodes. The WP projectile is used primarily for spotting, and to harass the enemy.

c. Target projectiles (fig. 3-13), the use of which is indicated by the name, are similar in shape, weight, and balance to the corresponding service projectiles of the same caliber. Usually they are inert loaded, and older models may have a tracer.

d. Nonfragmenting (NONFRAG) projectiles (fig. 3-14) are a special type used for AA training exercises. The projectile is inert loaded, but does have a small black powder expelling charge. When activated by a VT fuze, the expelling charge will blow the base out of the projectile, producing a distinctive gray cloud. The projectile continues its flight past the target. Theoretical hits are calculated by observing the bursts.

e. CHAFF (ex-Window) projectiles (fig. 3-15) are loaded with metal foil strips and a small burster charge. When exploded at high altitude, the scattered strips hinder enemy radar operation.

f. Drill projectiles (fig. 3-16) are used to exercise gun crews in loading drills and for testing ammunition hoists and other ammunition handling equipment. They are made of economical but suitable metals, and are designed to simulate the represented service projectile in size, form and weight. They may be solid or hollow. If hollow, they may be filled with an inert material to bring them to the desired weight. This latter type is closed with a base or nose plug or both, as appropriate.

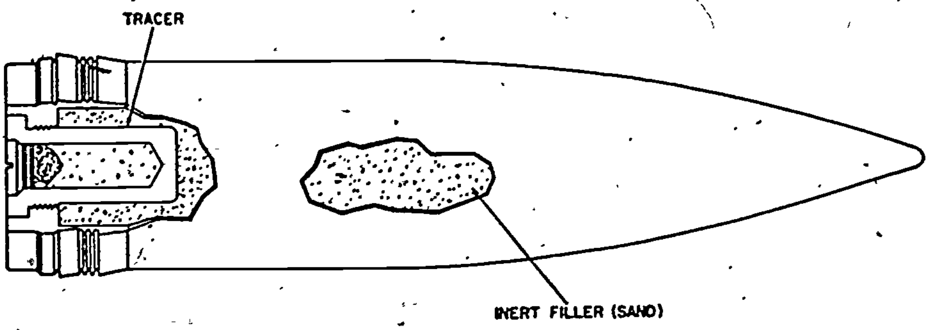
Many types of projectiles, especially 40-mm and smaller are fitted with tracers (fig. 3-13) that burn during projectile flight, leaving a bright trail of light, for use in spotting. Tracers are especially valuable in antiaircraft fire control. In 40-mm ammunition, the tracer may be installed so that when it burns down to its end, it detonates the burster charge. The advantage of this self-destroying feature is obvious when AA projectiles are fired at such elevations that they might fall on friendly forces.

ROCKET ASSISTED PROJECTILES

The 5"/38 Rocket Assisted Projectile, (RAP) is fired from guns at the same initial velocity as standard projectiles. The primary use for RAP is against personnel and light-material shore targets. Its secondary use is against enemy shipping. at extended ranges. The RAP round is an addition to, rather than a replacement for, existing gun-type ammunition. Operational skill and maintenance level required aboard firing ships will be the same as for existing type gun systems. RAP will remain in the fleet indefinitely as an extended range gun-fire projectile.

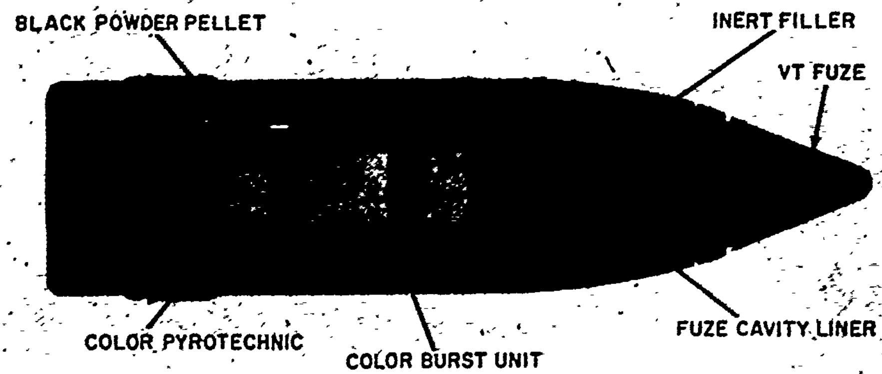
RAP Description

Each RAP round consists of a projectile and a gun cartridge (full charge). The projectile consists of a solid-propellant rocket motor with a delayed ignition element, an explosive filler warhead, and either a controlled variable time fuze (CVT) or a point detonating fuze (PD). Cartridges used to fire RAP are the same as



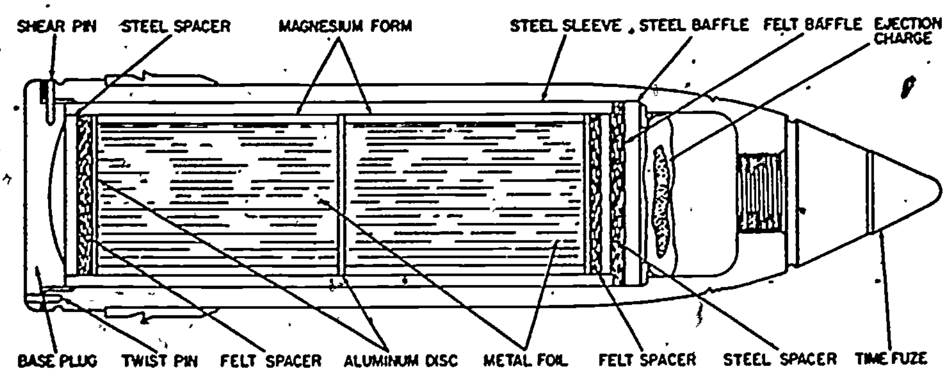
84.300

Figure 3-13.—Typical target projectile, sectional view.



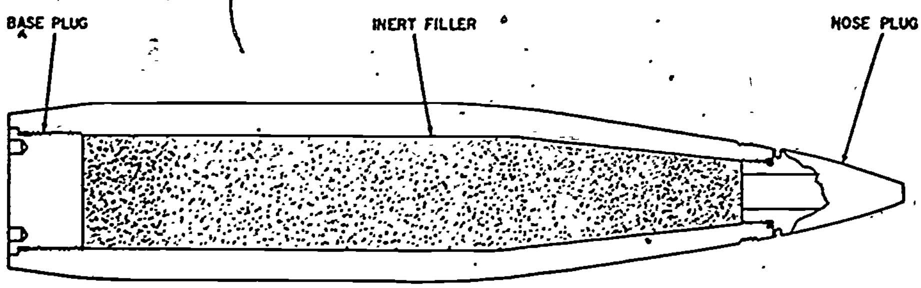
84.301

Figure 3-14.—Typical nonfragmenting projectile, sectional view.



84.302

Figure 3-15.—Typical CHAFF projectile, sectional view.



84.303

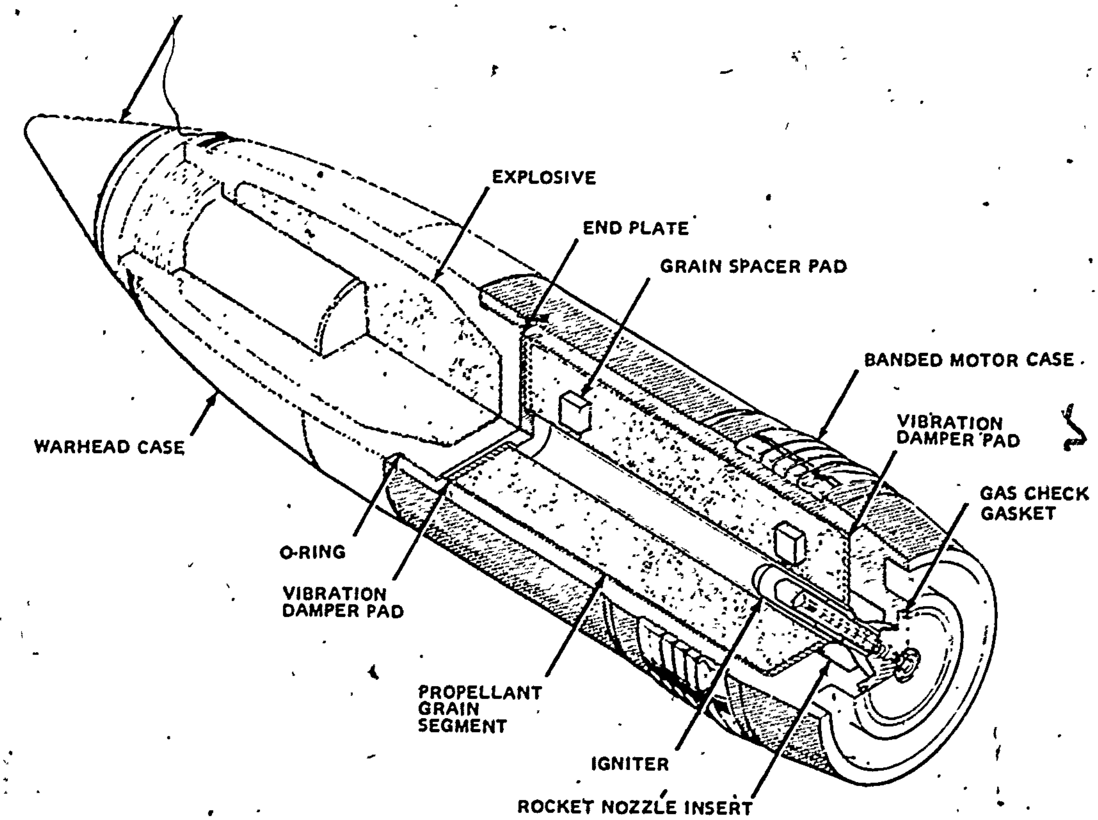
Figure 3-16.—Typical drill projectile, sectional view.

those used for standard 5-inch projectiles. Figure 3-17 is a cutaway view of the 5"/38 RAP projectile.

RAP Operation

The basic concept of a solid-fuel rocket assisted projectile was generated by German rocket scientists during WW II, but the idea was not developed beyond the initial stages until early 1960.

Ignition of the boosted rocket-motor is achieved with the Mk 279 igniter. The igniter is a gun-gas-triggered, percussion-activated delay igniter which is sealed into the motor case



84.304

Figure 3-17.—5"/38 rocket assisted projectile (RAP) Mk 57 Mod 0, cutaway view.

base with a gas check gasket and is blown out upon motor ignition.

Gun chamber pressure develops when the projectile is fired, this pressure flexes a belleville spring which strikes a percussion primer assembly in the base of the projectile. The primer in turn ignites a pyrotechnic delay column which burns for a finite period of time (23 sec. for a 5"/38 RAP). After the delay period the delay column burns the ignition charge which ignites the rocket motor to increase the velocity of the projectile. The 5"/38 RAP booster burns for 1.6 sec. Figure 3-18 shows the details of the ignition element used in the RAP projectile.

HANDLING.—During handling of a RAP, a drop in excess of 24 inches on the base of the projectile, in which a deck pin, (rivethead) bolt, or miscellaneous object strikes the center hole of the igniter with sufficient force, can actuate the igniter. In this event, ignition of the rocket motor may be delayed 20 to 30 seconds.

All personnel should immediately evacuate the area. Do not attempt disposal prior to rocket motor ignition. After a delay of at least one (1) minute following rocket motor burn out, the projectile should be disposed of immediately by dumping.

Handle RAP projectiles carefully at all times. Avoid jarring or dropping. Stowage conditions for RAP projectiles must meet the same requirements applicable to standard projectiles.

In view of the similarity in appearance between standard and RAP projectiles and dissimilarity of impact points, positive and correct identification by handling crews becomes a major safety factor. For example, a gun crew could be under the impression that they are firing RAPs over the heads of our assault forces, when actually they are firing standard projectiles into the midst of the very force it is supporting. Use extreme caution during all firing operations.

FUZES

In the preceding chapter you learned that the burster charge of a projectile is relatively insensitive, and requires an explosive train, beginning with a very small amount of sensitive initiating explosive, to get the projectile to accomplish successfully its mission of destruction.

The component that sets off the projectile bursting charge is the fuze. No matter how complicated or simple its construction or function, that is what the fuze is for.

Fuzes can be classified by functions as follows:

1. Time fuzes function a predetermined length of time after the projectile is fired. The exact time is set, before the projectile is loaded into the chamber, by a mechanical fuze setter on the

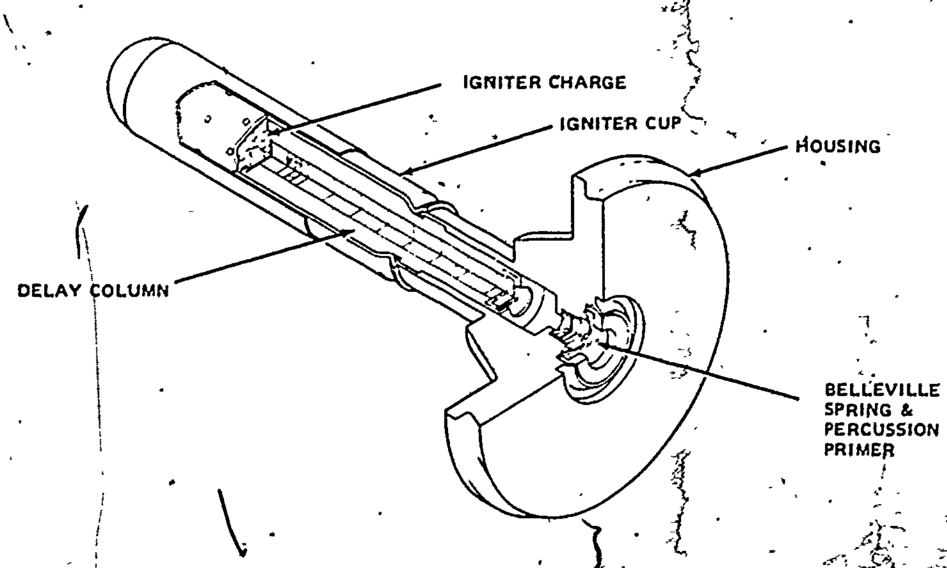


Figure 3-18.—Ignition element Mk 279 Mod 0, cutaway view.

mount. Or you can set the fuze with a special fuze wrench. The interval between the instant the fuze is set, and the instant the projectile is fired, is dead time. No matter when, how, or by what it is set, the timing mechanism of a time fuze won't function until the projectile is fired.

2. Proximity or VT fuzes are energized after the projectile is fired, and function when the projectile approaches closely to the target.

3. Percussion or impact fuzes function either as the projectile strikes the target or (especially an AP projectile) after the projectile penetrates. Some fuzes (non-delay type) function immediately on contact with any thin material (for example, the thin sheet metal skin of an aircraft). Fuzes for armor-piercing projectiles, however, always incorporate a slight delay to keep the burster from going off until after penetration.

4. Combination fuzes now under development incorporate both time and percussion features— that is, the fuze may go off either on impact, or after the time set, whichever occurs first.

5. Auxiliary fuzes, as the name implies, operate only with other fuzes. In gun projectiles, they form part of the explosive train, and pass on the explosion initiated by another fuze (located in the projectile nose) to the main bursting charge.

The nature of the fuze mechanism depends, of course, on what type fuze it is. All fuze mechanisms depend on certain forces either to start their functioning, or to keep them functioning. These forces develop either when the projectile is fired, when it flies through the air, or at the end of the flight. In the sequence of their development, these forces are called setback, centrifugal force (caused by spin), creep, and impact. They are worth explaining.

All objects have a property known as inertia. For our purpose we can say that inertia means resistance to change in motion. A moving ship, for example, tends to keep going even with engines stopped. (And it would keep going indefinitely if it weren't for the fluid friction of the water it floats in, and obstacles in its way.) A ship dead in the water tends to remain so, and it takes mighty efforts by its propulsion machinery to get it under way.

In 1687, in a Latin treatise on natural philosophy entitled Principia, Sir Isaac Newton described this characteristic behavior of material things in the statement of his First Law of Motion:

"Every body tends to remain at rest, or in uniform motion in a straight line, unless compelled by external force to change."

Why bring up Newton and his laws of motion when we're discussing fuzes? The reason: Every one of the forces that acts on a projectile fuze— from firing to impact—is an effect of inertia.

Let's begin with setback (fig. 3-19A). When the propelling charge of the round fires, the fuzes and projectile are at rest. As the hot gases expand, pressure in the chamber builds up, and forces the projectile to move forward. But because of inertia, every particle of the projectile and fuze tends to stay where it is. The effect—well, have you ever been in a jalopy whose hot-rod driver tramps on the throttle as soon as he sees the light turn green? Your head snaps back as the car jerks forward. The same thing happens in the projectile and its fuze, except that the acceleration— and the setback effect—are thousands of times greater. As an example of its application to fuzes, setback is used in mechanical time fuzes to unlock the clockwork mechanism.

As the projectile rotating band is twisted by the gun bore's rifling, the projectile spins. You know how spinning develops centrifugal force (fig. 3-19B)—a tendency to fly directly away from the center of rotation. (This is another effect of inertia. A moving object tends to keep moving— in a straight line. Centrifugal force is caused by a revolving particle's tendency to move in a straight line rather than in a circle.) As an example of its application in fuzes, centrifugal force, instead of woundup spring (as in conventional clockwork), is used to operate the clockwork in most mechanical time fuzes. Centrifugal force is also used to assist in readying (arming) the fuze to function when it strikes or approaches the target.

Creep (fig. 3-19C) is another effect of inertia. Like anything else that moves through the air, a projectile in flight moves against air resistance, which tends to slow it down. Its supersonic speed creates shock waves and turbulence, which increases this frictional slowing. But the slowing-down effect is applied to the exterior of the projectile. The parts inside aren't overcoming any air resistance, so they don't tend to slow down. You can notice this effect as it applies to yourself if you ride in an automobile in which the brake (simulating air resistance) is being applied lightly. You tend to lean forward. Similarly, movable parts in a fuze tend to creep forward as the projectile plows through the air that slows it down. In many types of fuzes, creep force is used to align the fuze firing mechanism so that it will function on impact.

Impact (fig. 3-19D) is probably the most obvious application of the general principle of

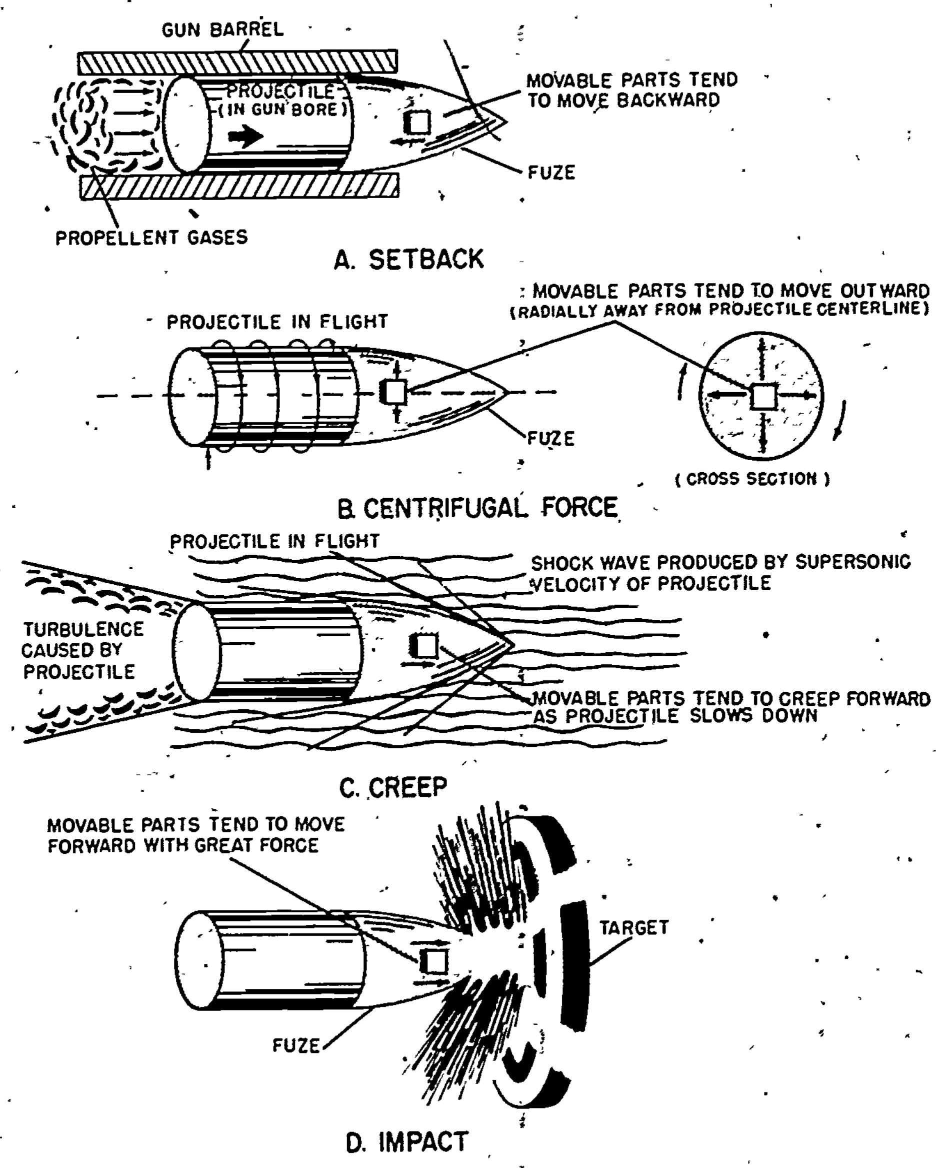


Figure 3-19.—Forces that work on fuzes.

inertia to fuzes. When the projectile strikes, it comes to a stop. But the movable parts inside the fuze tend to keep right on going. You can use the force developed by this tendency to drive a firing pin against a percussion cap to initiate the explosive train. Some people think of impact as a kind of creep—but in a very violent form. In principle, it's true that creep and impact are related, but they are quite different in degree, and are used differently in fuze mechanisms, so it's best to consider them separately. Fuzes are operated also by more conventional energy sources.

Time fuzes for larger caliber projectiles are driven by springs because the relatively slow rotation of these projectiles doesn't produce enough centrifugal force to run the clockwork reliably. Older time fuzes (no longer in use) consisted of slow-burning powder trains of adjustable length, rather than clockwork. The powder was ignited by setback which drove a firing pin into a percussion cap.

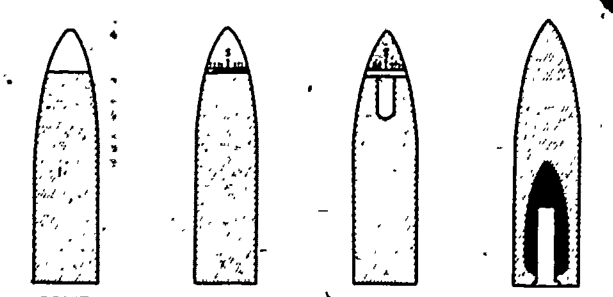
Proximity fuzes in projectiles are miniature radio transmitters and receivers, powered by tiny battery cells. The cells are activated by setback. When the projectile approaches closely to a target, the radio waves sent out by the transmitter are reflected back to the receiver in sufficient strength to close a circuit that initiates fuze action.

Most projectile fuzes use a small detonating charge to set off the explosive train. These are detonating fuzes. Some fuzes, however, are called ignition fuzes because they are designed to produce a flame that will set off an explosive sensitive to flame (usually black powder).

Fuze nomenclature often indicates the physical location of the fuze in the projectile (fig. 3-20). Thus we have point or nose fuzes, and base fuzes. (Fuzes in bombs and other projectiles may be located elsewhere, too.)

In general, proximity, time, and percussion fuzes are in the projectile nose. Auxiliary detonating fuzes are located just behind the nose fuze. In AP projectiles (in which the hardened cap makes no provision for nose fuzes), the fuze is in the base. In some projectiles, to provide greater versatility for selected targets a nose and a base fuze are provided. The nose fuze can be inactivated at the gun for base fuze initiation. When the nose fuze is activated, the base fuze functions as a back up for greater reliability.

A fuze is intended not only to explode the burster charge at the right time; it is intended also to prevent explosion at the wrong time. A fuze is armed when it is made ready to function. When (as for example, before firing) it is set so as not to function, it is safe.



84.13

Figure 3-20.—Fuze locations.

Fuzes have safety features to protect those who handle ammunition. These safety features may be put out of action by the time the projectile reaches the enemy. Some of the features are canceled by hand or mechanically before the gun is loaded. Others depend on the forces developed by the actual firing to arm the fuze. Fuzes that are armed only after the projectile leaves the gun muzzle are called BORESAFE. Projectiles 40mm and larger are usually boresafe, projectiles 20mm and smaller generally are not. This is important for you to remember when handling smaller caliber fuzed ammunition.

IDENTIFICATION OF AMMUNITION

Distinguishing colors and markings are necessary to properly identify ammunition, ammunition components, and ammunition containers. Identification of Ammunition, OP 2238, latest revision, serves as a guide for identifying by color, markings, and lettering all types of Navy gun ammunition, Navy rockets, projector charges, guided missiles, underwater ordnance, bombs, demolition material, and pyrotechnics.

COLOR CODING

In the color coding system for 3-inch and larger projectiles, the colors are applied as overall body colors, as appropriately colored circumferential bands, or as a combination of colors when the need exists, in accordance with figure 3-21. Nose fuzes and rotating bands are not painted; however, when a dummy nose plug or projectile adapter is assembled with the projectile, it is painted. When circumferential bands are used, the first (or forward) band begins at the base of the nose fuze or the tip of the projectile nose. It is equal in width to half the caliber but does not exceed three inches. When a second band is used, it is placed immediately behind the forward band and is equal to 1/4 the caliber but does not exceed 1-1/2 inches. Figure 3-22 illustrates the location of colors and markings on various type projectiles. Projectiles are further marked to indicate characteristics such as the presence and the color of a tracer, a dye load, a color burst unit, or a chemical filler, according to the following:

1. The presence and the color of a tracer is indicated by three T's in the same color as the tracer. The letters are located on the ogive of the projectile.

Color	Interpretation
Service Ordnance	
Yellow	High Explosive
Brown	Low Explosive or Propellant
Gray	Toxic or Irritant Agents
Gray with red band(s)	Irritant Agent
Gray with dark green band(s)	Toxic Agent
Black	Armor Piercing
Silver/Aluminum	Counter-Measures
Light Green	Smoke-Producing or Marker
Light Red	Incendiary or Highly Flammable
White	Illuminating
Training Ordnance	
Bronze	Drill/Inert/Dummy
Blue	Practice/Target
Orange	Exercise/Recoverable
Non-Significant Colors	
Olive Drab	All Ordnance
Black	For Lettering
White	For Lettering

84.306

Figure 3-21.—Interpretation of new color-coding system.

2. Projectiles having a windshield which contains a dye load are marked with three D's in the same color as the dye load. The letters are located on the ogive of the projectile.

3. Projectiles containing a color burst unit are marked with three C's in the same color as the color burst unit. The letters are located on the ogive of the projectile.

4. Projectiles having a chemical filler are marked with 1/2 inch wide red or green bands as indicated in figure 3-21.

5. A projectile assembled with a mechanical time fuze normally is painted with a white stripe 1/4-inch by 2-inches, shown in figure 3-22, which is longitudinally placed on the projectile adjacent to the stationary setting lug or groove of the fuze. If the background color is light, the stripe will be black.

In addition to the above markings, chemical projectiles are marked with the symbol for the chemical agent. For toxic or irritant agents, the symbol is marked in the same color as the bands denoting the type of agent. For a projectile containing a white phosphorus smoke filler, the symbol color is light red. The symbol is located on the ogive of the projectile just behind the nose fuze.

Lettering

Projectiles of 3-inch caliber and larger are lettered on the body by the manufacturer with the following information:

1. Caliber and type of projectile.
2. Mark and Mod of projectile.
3. Manufacturer's initials or symbol.
4. Projectile body lot number.
5. Year of manufacture.
6. Inspector's stamp.

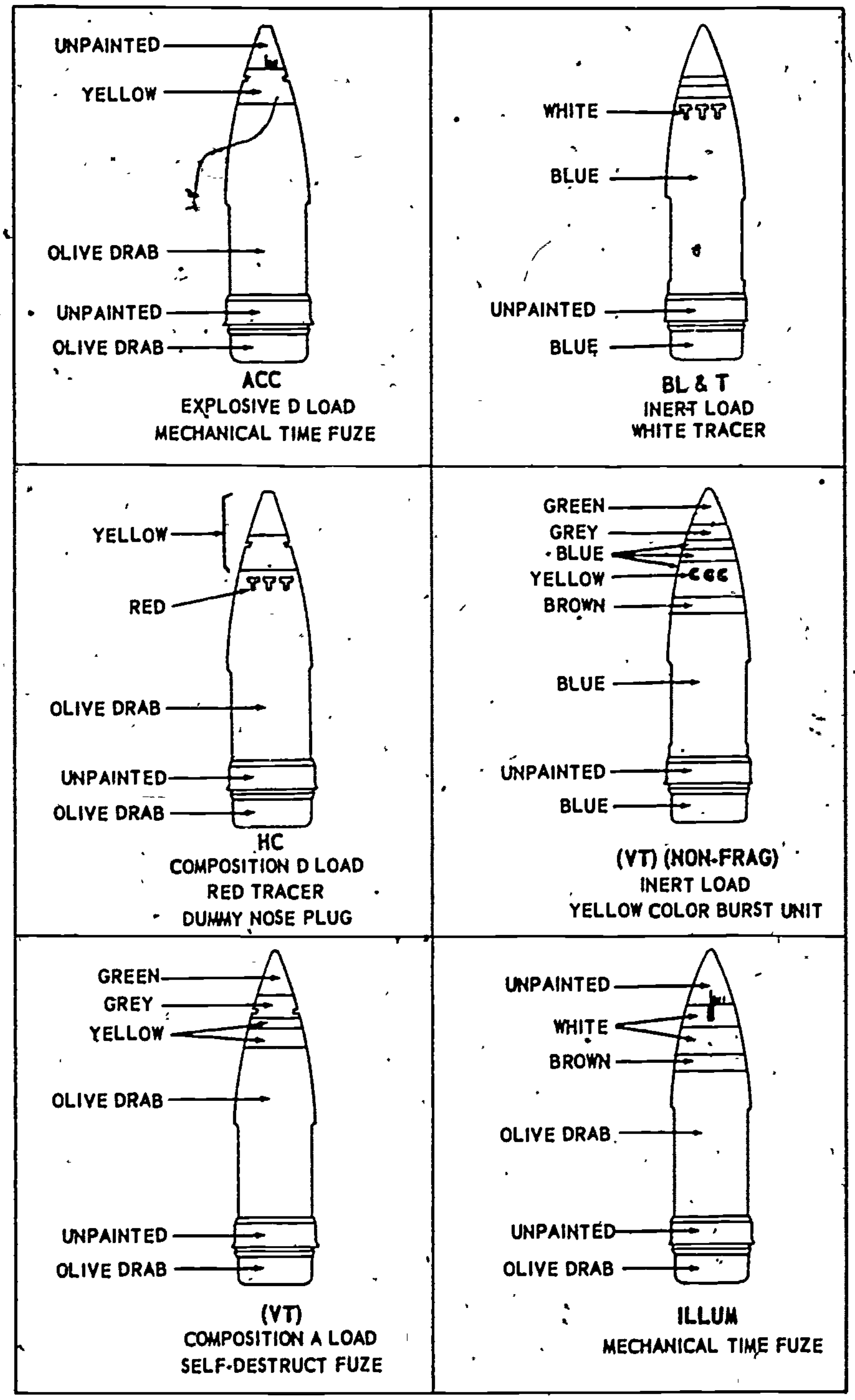
The same information is die-stamped on the rotating band of the projectile body along with the inspector's initials and stamp. Projectiles containing base plugs are die-stamped with the serial number, the drawing number, and the piece number on the base plug.

The loading activity applies lettering longitudinally on the body of the projectile from just below the forward bourrelet and extending to the rotating band. The following colors are used for lettering:

Projectile Type	Color
AP, COM, VT, HC, AA, AAC	Yellow
Countermeasure, Window Smoke (other than WP)	Black
VT (Non-FRAG, Illum, Target Practice)	White
Smoke (WP)	Light Red

The following information is typical of that applied to projectiles by the loading activity, when applicable:

1. Caliber, type of projectile and filler (for service projectiles only).
2. Ammunition lot number.



C84.307.1
C84.307.2

Figure 3-22.—Typical color coding for 3-inch and larger projectiles.

3. Mark and Mod of projectile.
4. Mark and Mod of nose fuze, SD or NSD if applicable.
5. Mark and Mod of ADF, if applicable.
6. Mark and Mod of BDF, if applicable.
7. Mark and Mod of Illuminating load or Window load, if applicable.
8. Mark and Mod of gun for which the projectile was designed.
9. FSN (Federal Stock Number) including NALC (Navy Ammunition Logistics Code).

Figure 3-23 illustrates designated areas for lettering 3-inch and larger projectiles.

GUN AMMUNITION LOT NUMBERS

In view of the large quantities of ammunition now being handled by shore activities and fleet units, a readily usable identification system has been established for gun type ammunition to simplify recognition and reports. The system, in the form of an ammunition lot number, is lettered on each assembled complete round or component of gun or rocket ammunition.

The lot number system consists of an Ammunition Lot Number symbol, ALN, (a two or three-letter prefix), a one-to four-part numerical group, a one- to three-letter group, a final numeral group and sometimes a one or two letter suffix.

The prefix designation identifies the size and type of ammunition. A prefix designation having a final letter "R" denotes renovated items.

Following the prefix is a numerical group. This group indicates the sequential lot number of a particular type of ammunition item produced by an activity during the calendar year. This group consists of numbers 1 through 9999:

The next group of letters identify the ordnance activity that assembled the ammunition item.

The final numerical group following the suffix group are the last two digits of the calendar year of assembly.

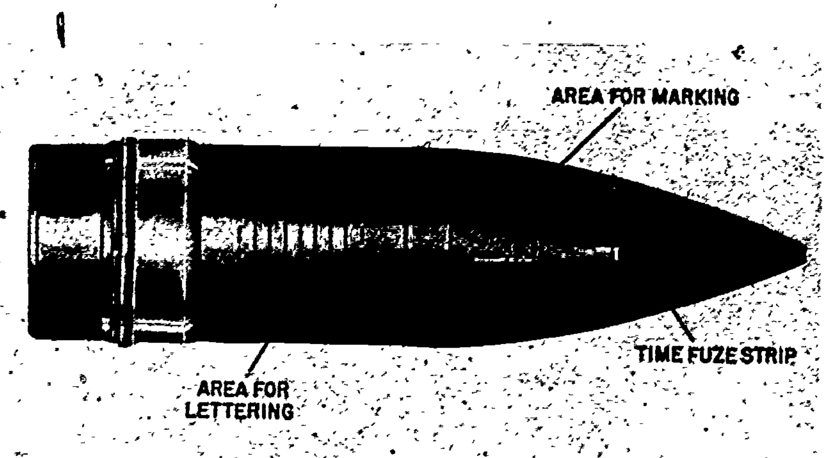
In summary, the lot number ALN-BER-245-HAW-70 is broken down to clarify the foregoing information.

1. ALN—Ammunition lot number symbol.
2. BER—BE identifies the ammunition as a 5"/38 AA common projectile. The "R" indicates a renovated ammunition lot.
3. 245—245th lot of AAC projectiles assembled.
4. HAW—Naval Ammunition Depot Hawthorne-assembly activity.
5. 70—Assembled during 1970.

A letter is often noted following a lot number. Example: BER-5-GU-59A. The suffix indicates some type of screening or other work not requiring a rework lot number. The suffix DOES affect the status of a lot from a serviceability standpoint. For example: BER-5-GU-59 is listed in OD 17190 as unserviceable; this does NOT affect lot BER-5-GU-59A which is a serviceable lot. Since this letter suffix system is relatively new in Navy lot systems, note it carefully.

ACTION AFTER INVESTIGATION

During 1969 the U. S. Navy experienced several catastrophic explosions on its ships.



84.308

Figure 3-23.—Stenciling for 3-inch and larger projectiles.

As a result of ensuing investigations, several pertinent facts were disclosed. It was determined that an apparent lack of understanding existed regarding the inspection of ammunition. Gunnery personnel were not familiar with the principle of the gas check system in the base of projectiles. Shipboard personnel were not familiar with the gun ammunition lot number system and the Notice of Ammunition Reclassification in OD 17190. Results of the investigation indicated that increased understanding was required.

From the foregoing it can be seen that all GMGs 3 & 2 should make every effort to increase their knowledge of gun type ammunition by seeking out and studying all available OPs, ODs, and instructions. Gaining this knowledge is not only beneficial to you in self satisfaction but in knowing the proper procedures in the care and handling of ammunition and the steps to be taken in emergencies.

An important point to remember is, ammunition in any form is dangerous unless it is properly tended. Any deviation from authorized procedures can lead to problems. Minor unauthorized acts can establish a train of events which can eventually cause a magazine to blow. Therefore, it is imperative that ordnance personnel follow standard operating procedures exactly; if any doubt exists—contact the nearest ammunition facility for guidance.

SHIPBOARD EXAMINATIONS

NAVORD has directed the mandatory inspection of 5-inch, 6-inch, and 8-inch high explosive loaded projectiles of gas check seals (GCS) prior to issue by NAVORD activities or overseas ammunition issuing activity. This GCS inspection by experienced ammunition personnel includes SIGHTING (1) that the GCS is not missing, (2) that the GCS is symmetrical and properly seated, (3) that it is not cracked, cut or torn, and (4) that the BDF (Base Detonating Fuze) or BFHP (Base Fuze Hole Plug) is flush or slightly below the projectile base. After inspection, issuing activities ashore certify a good GCS by applying a suffix, either A or B in accordance with OD 17190 as appropriate, on the projectile and the data card.

To safeguard against damage during subsequent handling and the possibility of sabotage, the firing ship should, prior to use, examine each 5-inch, 6-inch, and 8-inch high explosive loaded projectile for proper gas check seal. Ordnance personnel should also check ammunition to see that waterproof protecting caps are properly installed, nose fuzes are properly seated and not loose; upper nose caps of fuzes are intact and that complete rounds can be identified by lot identification number. This system of identification is simple but it requires study to understand and must be followed to be effective. (Figure 3-24 illustrates projectile components).

MAGAZINES

The term "magazine" applies to any compartment, space, or locker which is used, or intended to be used, for the stowage of explosives or ammunition of any kind.

The term magazine area includes the compartment, spaces, or passages on board ship containing magazine entrances, which are intended to be used for the handling and passing of ammunition. The term is also used to denote areas adjacent to, or surrounding, explosive stowages, including loaded ammunition lighters, trucks, and railroad cars, where applicable safety measures are required.

Magazines are arranged with regard to facility of supply, the best obtainable protection, and the most favorable storage conditions.

MAGAZINE TYPES

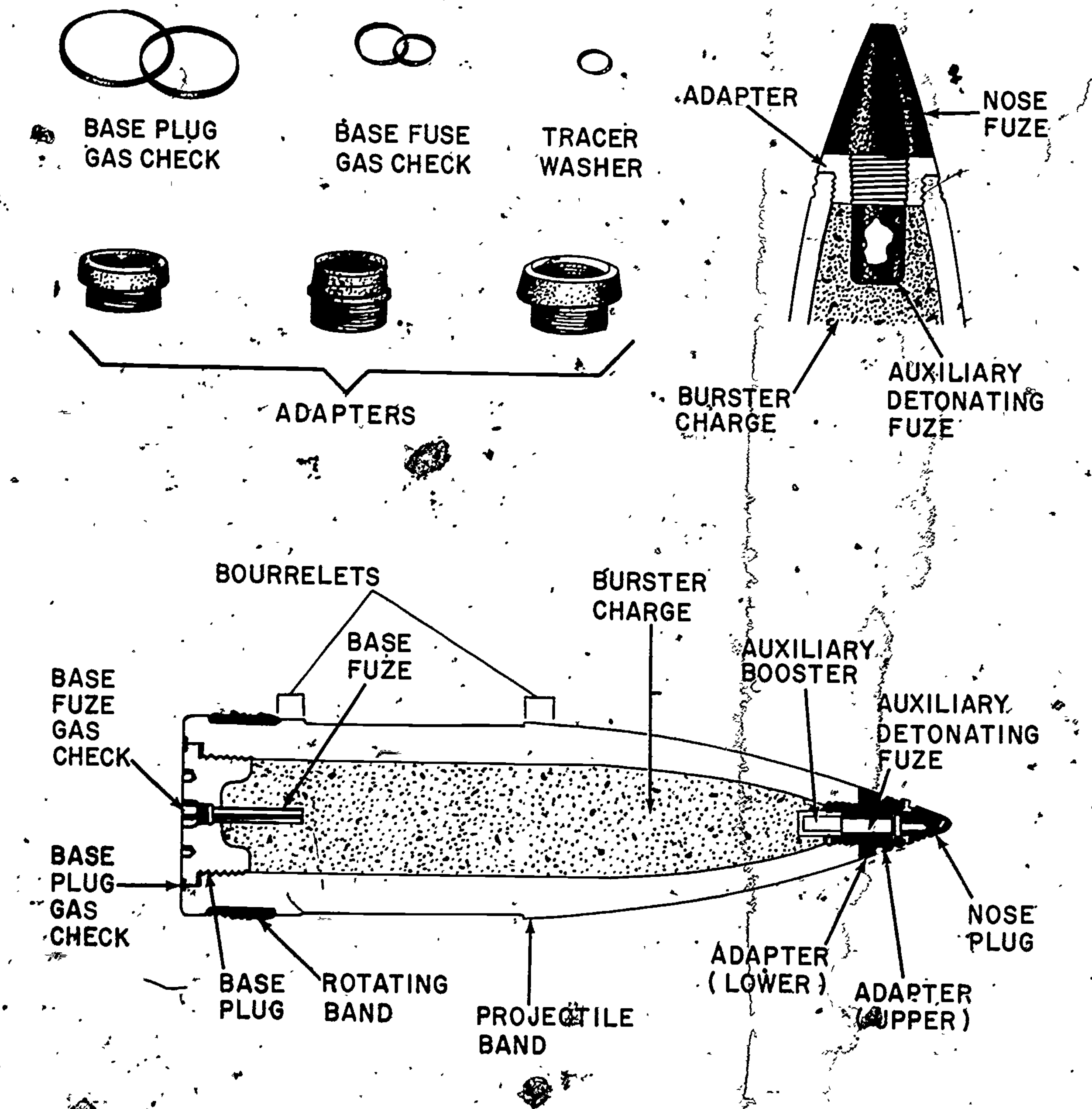
There are many different types of magazines provided on ships. Each magazine is designed specifically for the type of ammunition it is to contain. For our purpose, however, we will be concerned with only three types—primary magazine, ready service magazine, and ready service stowage.

Primary Magazines

Primary magazines are designed as ammunition stowage spaces, generally located below the main deck, and, insofar as is practicable, below the water line. They are adequately equipped with insulation, ventilation, and sprinkling systems. These spaces must be provided with fittings so that they may be locked securely. Primary magazines accomodate a vessel's complete allowance of ammunition for peacetime operation.

Ready Service Magazines

Ready service magazines are spaces physically convenient to the weapons they serve. They



84.296(53C)

Figure 3-24.—Typical projectile components.

provide permanent stowage for part of the ammunition allowance. Normally they are equipped with insulation, ventilation, and ammunition sprinkling systems, and should be secured by locking. The combined capacities of primary and ready service magazines are normally sufficient to stow properly the allowance for war and emergencies.

Ready Service Stowage

Ready service stowages are those ammunition stowage facilities in the immediate vicinity of the weapon served. They include weather deck lockers, bulwark (gun shield) racks, and 5-inch upper handling rooms. This stowage normally is filled only when the weapon is to be fired. There is little security for ammunition in such stowage, and it provides the least favorable protection from the elements.

All magazines are marked by appropriate label plates showing the compartment number and the types of ammunition to be stowed therein. Insofar as is practical, magazines are designed to hold a single type of ammunition.

MAGAZINE DESIGNATIONS

The following designations are given for magazines whenever a single-purpose stowage is practical.

1. Powder magazines
2. Fixed-ammunition magazines
3. Small arms magazines
4. Warhead lockers
5. Projectile magazine or rooms
6. Bomb magazines
7. Fuze magazine
8. Detonator lockers
9. Pyrotechnic magazine or locker

While stowage of a single type of ammunition in individual magazines is desirable, it is not always possible due to space limitations. Where a ship's mission requires carrying various types of ammunition, stowage of more than one type in one magazine is acceptable. Current NAVORDSYSCOM instructions authorize certain mixed stowage in magazines which maintain a single purpose designation.

Authorization of such stowage is at the discretion of the operational commander. Such mixed stowage does not include pyrotechnics which have been removed from containers, or fuzes and detonators which are not integral parts of, or assembled within, the ammunition. These items must be stowed in accordance with the current instructions related to the particular items.

Where mixed stowage of ammunition is necessary, take precautions to ensure that the various types of ammunition are segregated within the magazine and that each type is suitably marked for ready identification.

MAGAZINE SECURITY

In peacetime, all magazines, explosive lockers, ready service lockers and all areas such as ammunition hoists leading into magazine spaces are kept closed and locked, except when they are opened for inspection, for ventilating purposes, for testing, or for authorized work. These spaces are not entered unnecessarily and are opened only when authorized by the weapons officer who is responsible for ensuring that the spaces are locked when the purpose has been accomplished.

Magazines are intended for the stowage of ammunition and for this only. It is no place for the stowage of empty paint or grease cans, oily waste rags, or similar fire hazards. What goes for material also goes for men. No one but those authorized should ever be permitted in a magazine. Even they should be there only when they have business there. A magazine is no place to sit around and "shoot the breeze".

The commanding officer is the custodian of all magazine keys. He may, however, designate certain persons under his command to have custody of duplicate keys. Each morning keys are drawn by a responsible Gunner's Mate for the purpose of inspecting magazines and taking magazine temperatures.

Security of Nuclear Weapons Magazine

Nuclear weapons, because of their strategic importance, public safety considerations, and political implications, require greater protection than their security classification alone would warrant. The special shipboard installations required for the safety and security of these weapons varies with the type of ship and weapon involved. As a GMG your association with nuclear weapons will be limited. However, it is possible that because you are in the Gunner's Mate rating, you might be called upon to take part in a ship's safety and security program for nuclear weapons.

The following discussion provides a basis for determining the minimum security requirements for nuclear weapon spaces. The definitions listed below are those used throughout the Navy in connection with nuclear weapons.

a. Access: Applied to nuclear weapons, physical access which permits the opportunity to cause a nuclear detonation.

b. Exclusion Area: A security area which contains one or more nuclear weapons or one or more components of a nuclear weapon system. The nature of the area is such that mere entry constitutes access to the nuclear weapon or permits the arming, launching, or firing of a weapon.

c. Limited Area: A security area containing one or more nuclear weapons or one or more components of a nuclear weapon system that allow the arming, launching, firing or releasing of a weapon. Within this area, guards or internal controls, depending on the nature of the activity, can prevent access by unauthorized persons to the nuclear weapon or can prevent the arming, launching, or firing of a weapon.

d. Nuclear Weapon: Any complete assembly of its intended ultimate configuration which, upon completion of the prescribed arming, fuzing, and firing sequence, is capable of producing the intended nuclear reaction and release of energy.

SAFETY STANDARDS.—Safety and security are considered to be synonymous when it comes to nuclear weapons. The main objective is to prevent an inadvertent or deliberate nuclear accident or incident. The standards governing the installation of safety equipment and facilities for protecting the nuclear weapons must be in accordance with the criteria set forth in current NAVSHIPS and OPNAV instructions.

Some of the standard requirements for surface ships are:

1. A security station must be provided at the main entrance to a nuclear weapon space or space complex.

2. Hatches used as secondary personnel entrances to nuclear weapons spaces must be dogged in such a manner as to be operable only from within the secured space.

3. Two padlocks or combination locks must be installed on the main entrance to a nuclear weapon space or space complex. Prior to, and after installation, the key and combinations to the locks are classified SECRET.

4. Separate security lockers must be provided for stowing removable warhead components. Where space is available, these lockers must be mounted in an exclusive or limited area. Where space is not available, the location is determined on an individual basis depending on the weapon system, the type of ship, and the item to be stowed.

5. A security alarm system (circuit FZ) is required for all nuclear weapon spaces and space complexes except for special weapon spaces on aircraft carriers. Security protection for these spaces is provided by a Marine detachment. The purpose of the FZ alarm system is to detect unauthorized entry into spaces containing nuclear weapons. A master control panel, usually located in damage control central, controls the operation of the FZ alarm circuit. The master control panel is locked and the keys classified SECRET.

Installation requirements for the FZ circuit vary with the ship type and weapon system. Minimum requirements for the ASROC system call for the FZ circuit to be installed in the following areas:

a. Main personnel entrances to exclusion and limited areas.

b. Other personnel entrances to exclusion areas located above the main deck which open to the weather decks. This safeguard prevents unauthorized use of these entrances for personal convenience and natural ventilation.

INSPECTION OF MAGAZINES

The periodic (daily, weekly, fortnightly, monthly, bymonthly, quarterly, semiannual, or annual) inspections of magazines and their contents must be conducted aboard ship and ashore in accordance with instructions contained in applicable publications.

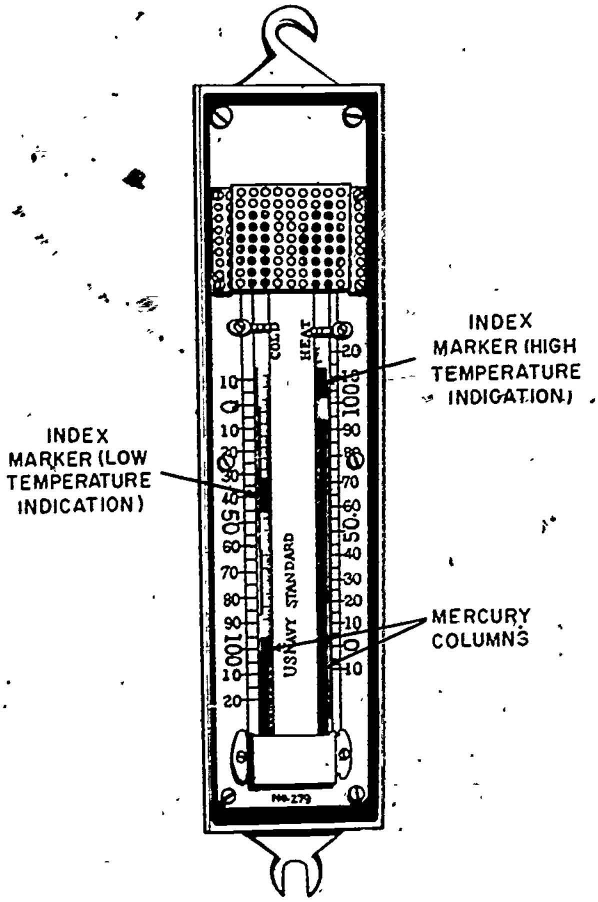
Magazine Temperature

The main item of a daily routine inspection is to check and report the temperature of the magazine. (Temperature is the most important single factor that affects powder stability.) Temperature readings normally are taken once a day. A thermometer capable of indicating the highest and lowest temperature reached since the last inspection is used. The thermometer, commonly called a maximum-minimum thermometer, (fig. 3-25) is a U-shaped mercury-filled glass tube with two bulbs. Present temperature can also be read by noting the level of mercury in either arm of the tube. (Both sides should read approximately the same.) The temperature recorded in the pictured instrument is approximately 95°, which would call for some drastic action if it were actually on a magazine bulkhead.

Maximum temperature is read by noting the position of the bottom edge of the little steel index marker against the right-hand scale, which increases upward. (The picture shows it at just over 100°, another excessive temperature, for a magazine.)

Minimum temperature (here a little over 45°) is read on the left-hand scale against the bottom edge of the little steel marker. The minimum scale increases downward.

To zero the instrument, a small horseshoe magnet is run against the glass tube to draw each steel index marker down to the level of



5.65
Figure 3-25.—Maximum-minimum thermometer.

the mercury. Zero the thermometer on both sides after you have recorded the maximum and minimum readings.

Magazines should be equipped with two maximum-minimum thermometers—one in the coolest part of the magazine, and one in the warmest. Others may be used where it is considered necessary to have additional data on parts of the magazine that may get too warm—bulkheads near the steam lines, for example.

Since powder, under usual stowage conditions, deteriorates continuously, even if slowly, it will eventually become dangerous. It is just a matter of time—fortunately, a good long time, under normal circumstances; but temperature readings are not enough to keep track of the powder's stability. Records of the powder's age and chemical characteristics are needed and the powder must be kept continuously under test to verify its condition.

Records of Magazine Inspections

Like other maintenance procedures, magazine inspections and ammunition surveillance operations are performed periodically according to a prescribed schedule. The magazine inspections and surveillance operations presently prescribed for all United States naval vessels are listed in OP 4.

Written records must be kept of all maintenance operations, whether they are routine or not. As far as magazine inspections and ammunition surveillance are concerned, the most common written records are the magazine temperature record (fig. 3-26A) and the daily magazine temperature report form (fig. 3-26B).

The magazine temperature record is a card posted in each magazine. Every day you enter on it the maximum and minimum temperatures recorded for the previous 24 hours in that magazine. The card is replaced every month, and the old one is turned over to the weapons officer.

The daily magazine temperature report summarizes the results of magazine inspections for the whole ship. This form includes not only spaces for entering the highest and lowest magazine temperature, but also for reporting the condition of the magazines and their ventilating device, and (under remarks for miscellaneous) nondaily routine work.

The daily magazine temperatures are transferred from the record cards to a magazine log which is a permanent record of all magazine temperatures. A separate section of the magazine log should be set aside to record the results of the monthly sprinkling systems tests.

Magazines are considered to be in normal condition if inspection shows the following to be true:

1. Magazines and magazine areas are well insulated as protection against abnormal high temperatures.

2. Magazines are dry, well ventilated, and in good repair.

3. Magazine doors can be secured against unauthorized entry.

4. The interior of the magazine is clean and orderly with contents so grouped as not to exceed prescribed heights and quantities.

A

MAGAZINE TEMPERATURE RECORD
SND GEN 90 (REV 11-48)

COMPARTMENT	THERM. NO.	MONTH
A 304 M	279	APRIL

DATE	MAXIMUM	MINIMUM	INITIAL
1	84	72	RAC
2	82	70	RAC
3			
4			
5			
6			
29			
30			
31			

PAPO NorVa 11-2-48 99014(Job) 8M

B

DAILY MAGAZINE TEMPERATURE
DD, DE CLASSES

NOTE: To be submitted to O.O.D. by 1130 daily

U.S.S. T. E. TREMENDOUS — DATE 1 APR. 63
MAXIMUM 84° — IN A-304 M
MINIMUM 69° — IN A-204 M
INSPECTED MAGAZINE'S CONDITION OK
INSPECTED MAGAZINE VENTILATION CONDITION OK
INSPECTED SMOKELESS POWDER SAMPLES CONDITION OK
CONDUCTED WEEKLY TEST OF MAGAZINE SPRINKLER SYSTEMS
DATE 1 APR 63
REMARKS TEST OF MAGAZINE SPRINKLER SYSTEMS SATISFACTORY

SIGNATURE (GMC or GM in Charge) L. Barber — SIGNATURE (Gunnery Officer) L. B. Benson

DESLANT FORM 8000-7 (Rev. 11/55)

5.66

Figure 3-26.—Magazine records—A. Magazine temperature record. B. Daily magazine temperature.

5. The atmosphere in and around the magazine is free from excessive ether-alcohol fumes.

6. The temperature does not show readings above 100° F. (Maximum and minimum temperature readings are recorded and reported to the OOD.)

7. Requirements outlined on applicable stowage charts are met.

8. Containers are in satisfactory condition.

9. Contents of the magazines are identified and segregated by lot numbers.

10. Loose rounds, damaged containers, paint, oils, waste, rags, dunnage not in use, and other prohibited articles are not present in any magazine.

11. Magazines are properly identified by placards, inside and out.

12. Ammunition, explosives, and loaded components are not stowed outside appropriate and designated magazine areas.

13. Boxes and other containers are securely closed.

14. Firefighting equipment is in operating condition.

The inspection afforded shipboard magazines is basically the same for magazines ashore. Those responsible for ammunition ashore must be familiar with all instructions and procedures governing the inspection and maintenance of all ammunition and magazine areas. All magazines should be inspected in detail every day. Where this is impossible due to lack of personnel, one or more magazines which are representative of each group or type of magazine must be inspected daily. The results of any and all inspections are recorded in the magazine logs over the signature of the person making the inspection.

There are several matters which are not common to shipboard magazines, but which do apply to magazines ashore. One is that a definite firebreak is necessary around all the magazines. It must be of prescribed width and should be kept free of rubbish and other flammable materials at all times. Another is that all ammunition, explosives and components thereof, must be stowed in the designated and appropriate magazines. They cannot be stowed in buildings used for other purposes. The requirements for normal magazine conditions for magazines ashore are the same as those for aboard ship.

If any abnormal or hazardous condition is found to exist, the matter should be reported at once to the commanding officer and prompt corrective measures should be taken. Facts pertaining to any abnormal conditions must be entered in the deck log.

Special Inspection Requirements

ROCKETS.—Rockets are usually stowed with their heads and motors packaged in separate magazines. A limited number of rockets complete with fuze may be stowed temporarily in ready-service lockers. The inspection requirements for the motors are similar to those for ballistite. Most rocket heads have no special inspection requirements. However, rocket heads over 200 pounds gross weight are classified as bomb type ammunition and must be inspected as such.

INITIATING DEVICES.—Fuzes, primers, detonators, and similar initiating devices should be inspected to ensure that they are properly segregated in identified logs according to type, enclosed in suitable tightly closed containers, and well protected from moisture.

SMALL-ARMS AMMUNITION.—Small arms ammunition must be inspected to determine that full boxes are properly marked and sealed, intact, and that the lids or covers of partially filled boxes are securely closed and appropriately marked.

PYROTECHNICS AND CHEMICAL AMMUNITIONS.—Pyrotechnics and chemical ammunition frequently are characterized by a definite, stated length of life, beyond which deterioration may be expected.

The inspector should, therefore, examine the markings closely for dates of manufacture and expiration dates of storage. He should also ensure that containers are not rusty, corroded, or leaking, that they are tightly sealed, and the contents protected against moisture. Special fire extinguishing agents and equipment, if required, should be examined to assure their availability and serviceability. Gas masks or other protective equipment, if required, should be available and serviceable.

WHITE PHOSPHOROUS.—White phosphorous (WP) loaded ammunition stowage should be separate from other ammunition stowage.

Stowage spaces for WP loaded ammunition should be topside, away from ventilation intakes and in a place convenient for jettisoning. They shall be protected from direct sunlight, rain, spray or other conditions that may cause corrosion to ammunition containers.

White phosphorous ammunition must be stowed where temperatures can be maintained below 100° F., because WP melts at 110° F. To satisfy this condition, it may be necessary to stow WP below decks. In such a case, separate stowage is preferable, however, the selected stowage space shall be capable of being rapidly and completely flooded by means of a sprinkler system.

All WP projectiles and rocket heads shall be stowed base down to prevent them from becoming unbalanced should the WP filler melt and subsequently solidify.

Loaded WP ammunition should be handled carefully so it may retain its air-tight seal.

White phosphorous will spontaneously ignite in air. If combustion occurs in a confined space the oxygen content of the atmosphere in the space will not be sufficient to support life. Further high concentrations of the vapors evolved by burning WP are irritating to the eyes, nose, throat, lungs, and skin.

White phosphorous vapors and fires can best be controlled by complete immersion of leaking item of WP ammunition in a tank of water kept available in the area. Vapors and fires can be controlled by application of low velocity water spray; however, WP will re-ignite when water has dried from it. Exposed WP shall be kept wet until all traces are washed or scraped overboard.

When readiness so requires, WP projectiles may be stowed in upper handling rooms. Because of the susceptibility of WP to high temperature and the danger of vapor escaping to adjacent personnel spaces and vent systems, upper handling room stowage should be used for short periods of time, preferably only immediately before firing.

MAGAZINE SPRINKLING SYSTEM

Sprinkling systems are used for emergency cooling of, and firefighting in, magazines, ready service rooms, ammunition and missile handling areas, turrets, and some enclosed mounts. A magazine sprinkling system consists of a network of pipes secured to the overhead and connected by a sprinkling system control valve to the ship's salt water fire-main. The pipes have small holes which are arranged so that the water forced through them showers all parts of the magazine or ammunition and missile handling areas. A modern sprinkling system can wet down all exposed bulkheads at the rate of 2 gallons per minute per square foot and can sprinkle the deck area at the rate of 4 gallons per minute per square foot. Magazine sprinkling systems are designed so that they are capable of completely flooding their designated spaces within an hour. To prevent unnecessary flooding of adjacent areas, all compartments equipped with sprinkling systems are watertight. Upper deck handling and ready service rooms are equipped with drains that limit the maximum water level to a few inches. Magazines are completely enclosed; if flooded, they would be exposed to the full firemain pressure. The firemain pressure on most ships is considerably higher than the pressure that magazine bulkdheads could withstand; therefore, magazines are equipped with exhaust ventilators that are located in the bulkhead near the overhead. An exhaust ventilator is a pipe with a check valve that permits pressure release (usually to the topside). Since the diameter of the pipe is large enough to allow water to flow out as fast as it flows in, no excess pressure can build up in the magazine compartment.

On newer ships, magazines are also equipped with small, capped drainpipes located in the bulkhead near the deck. The caps may be removed in the adjacent compartment to drain flooded magazines.

In their complexity, the sprinkling system control valve and associated components vary with the type of ship, type of stowage, and type of ammunition or missile stowed in the magazine. In ready service areas of combat ships and in certain magazines of auxiliary ships, a simple globe valve or gate valve is ~~installed~~ for sprinkling the magazine. ~~This~~ valve is manually controlled by a handwheel or some other mechanical device located outside the stowage or handling area. The control valve is connected to the handwheel by mechanical linkage (reach rods). On combat ships, magazines are normally divided into groups. The sprinkling of each group is controlled by a master group control valve. This valve can be manually operated or can be hydraulically controlled from one or more remote control stations. A typical magazine sprinkling system remote control, showing two types of hydraulic main control valves, is shown in figure 3-27. This hydraulic sprinkling system is the older type system you will still find in the fleet.

There are three types of hydraulic controlled sprinkling systems: the oil operated dry type, salt water operated dry type, and salt water operated wet type. Since all three of these types of systems may be installed aboard the same ship and the testing procedure is slightly different in each case, it is important to follow the testing instructions.

Oil Operated Sprinkling System

The hydraulic sprinkling system main control valve shown in figure 3-28, and the valve not connected in the system in figure 3-27, is a modified version of the valve connected in the system. This is a piston-operated globe valve, normally held closed by spring pressure acting on the piston and firemain pressure acting on the disk. When hydraulic pressure enters the underside of the piston, a force is created that overcomes both spring tension and firemain pressure, lifting the valve disk off its seat and allowing salt water from the firemain to flow through the control valve to the sprinkling system piping. The valve is closed by spring action when the hydraulic pressure is vented from under the valve piston. In an emergency, the control valve can be manually opened by means of a ratchet wrench.

It should be noted that this control valve has a test casting and flushing adaptor built into the dry side of the control valve body. The older type control valve has no flushing and test casting built into its body; therefore, a special flushing and test casting is installed on the dry side of the valve.

In the older type control valve hydraulic pressure is ported to the top of the valve, hydraulic pressure is down (schematically) to open the valve. The functions of this hydraulic sprinkling control valve are similar to those of the modified valve. The modified valve is opened hydraulically by pressure being exerted to the bottom of the valve piston, whereas in the older type control valve, fluid pressure is exerted on top of the valve piston to open the valve. Another difference is in the control valve closing springs. The modified control valve has one spring assembled inside the valve casing and the older type has two springs located outside the valve casing.

An oil supply tank, located at each remote control station, provides the hydraulic fluid for

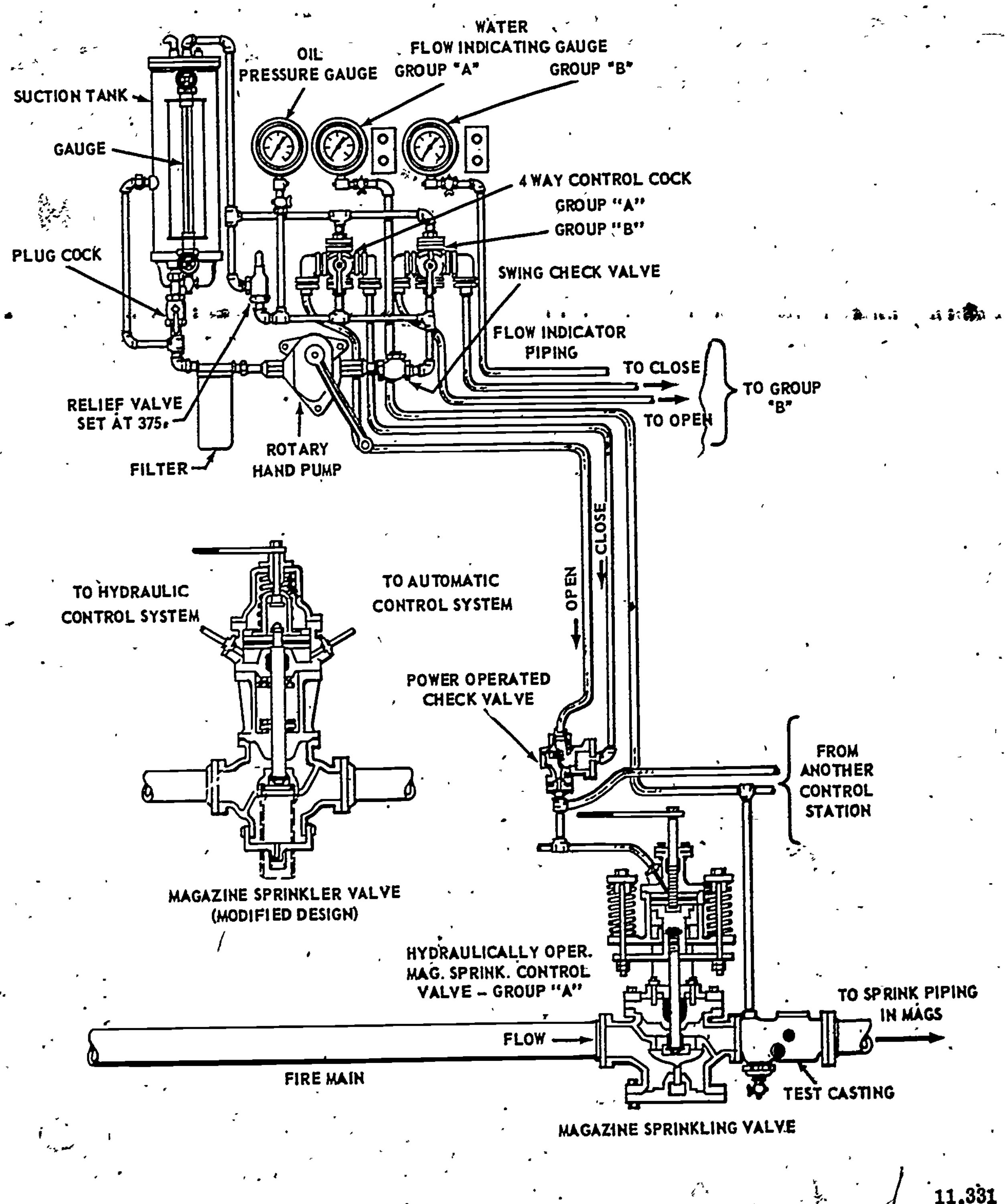
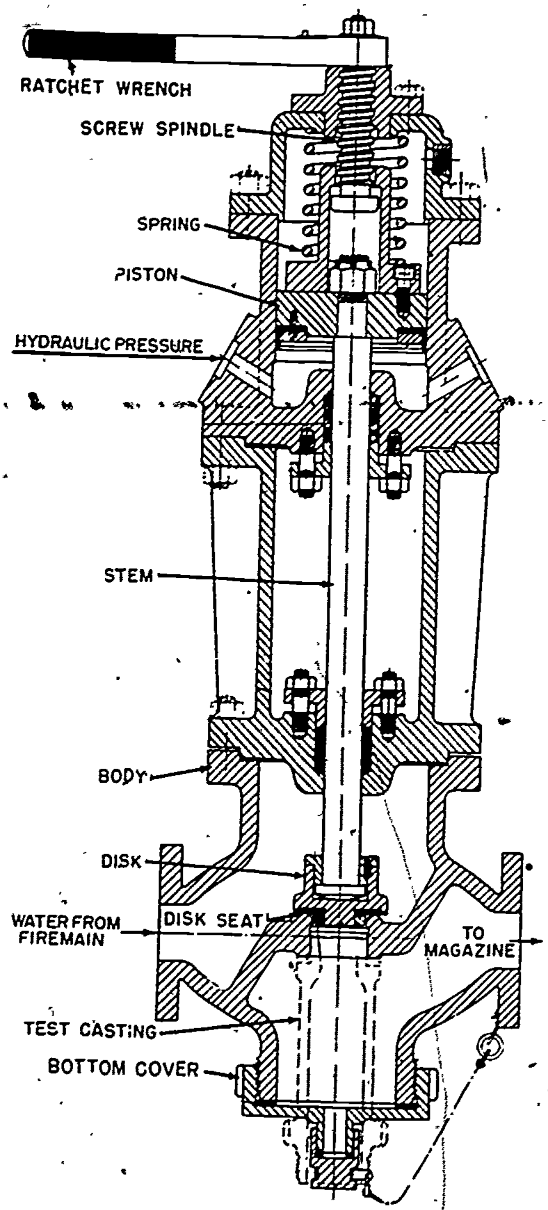


Figure 3-27.—Hydraulically operated magazine sprinkling system.



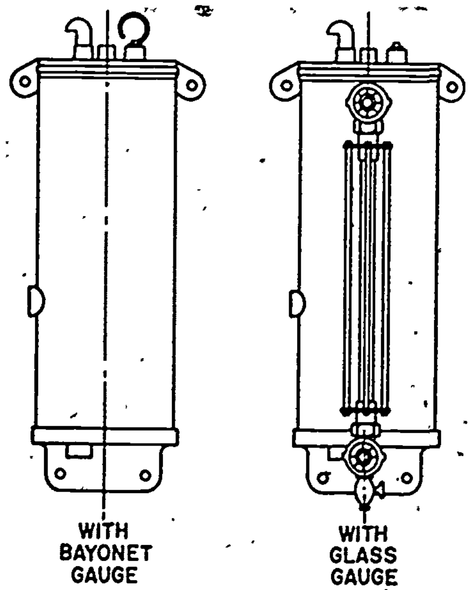
11.324

Figure 3-28.—Hydraulically operated control valve (modified design).

operating the sprinkling system control valve. The average tank holds approximately 2 gallons of hydraulic fluid. The size of each tank depends on the size and number of valves to be operated from the remote control station. The types of tanks are similar, except for the oil level indicators.

Each remote control station has an oil pressure gage installed which indicates the hydraulic pressure developed by the hand pump. In addition, some control stations also have water gages installed which are connected to the dry side of the control valve and which provide pressure indication only when the magazine is being sprinkled. In one type of tank a dipstick is used; in the other a sight glass is installed. Refer to figure 3-29.

On some ships, light indicators are installed at the remote control stations to indicate whether

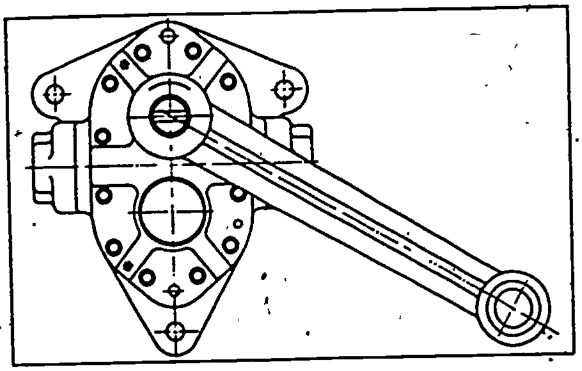


84.309

Figure 3-29.—Types of oil supply tanks.

the sprinkling system control valve is open or closed. The lights are controlled by switches installed on the sprinkling control valve. Normally, either water gages or indicating lights are used; however, a few ships have both devices installed at each remote control station.

The hand pump, shown in figure 3-30, is made of bronze. It is a rotary gear type of pump which, when rotated clockwise, provides the hydraulic pressure required to operate the sprinkling system. The pump handle is removable and is normally stowed on the bulkhead at the remote control station.



84.310

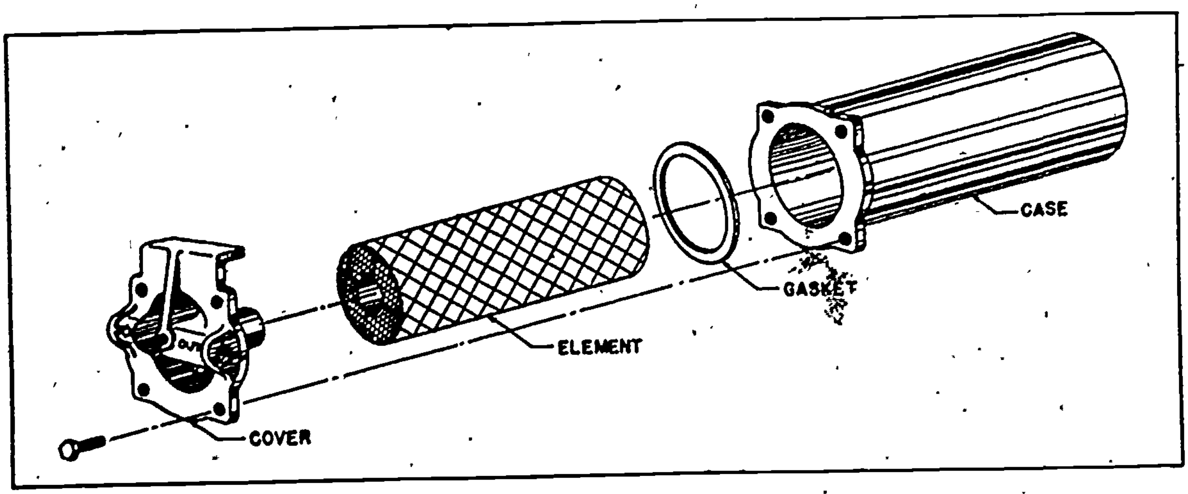
Figure 3-30.—Hand pump.

The filter assembly is located in the hand pump intake line at the remote control station. (Refer to figure 3-31.) The assembly filters out the particles of foreign matter from the hydraulic fluid, thus preventing damage to the equipment and possible interference in the sprinkling system's operation. The filter element should be replaced at each overhaul.

A spring-loaded, swing check valve is located in the pump output line. The valve prevents the system pressure from escaping through the pump to tank.

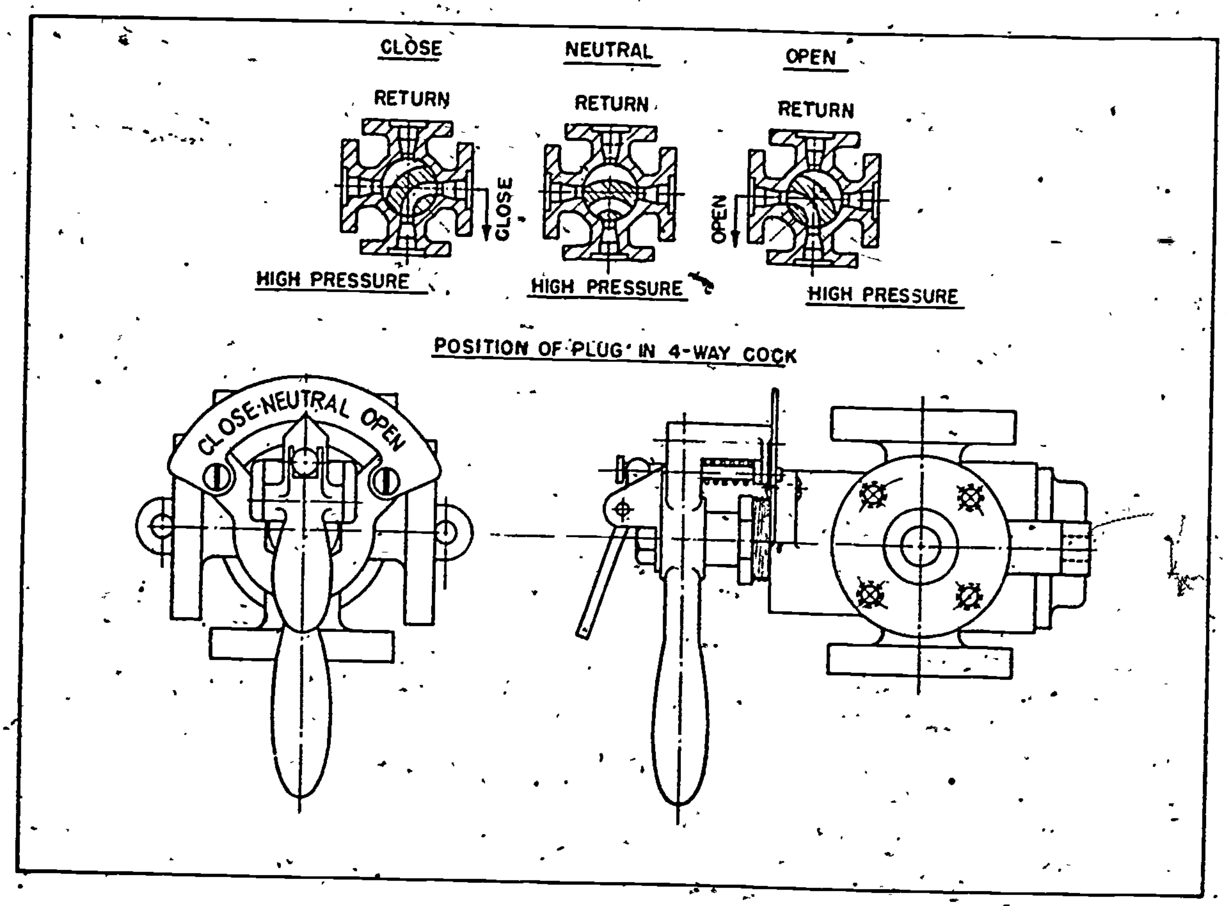
SPRINKLING CONTROL VALVE.—A 4-way control valve, shown in figure 3-32 is located in the pump output line, between the swing check valve and the power operated check valve. This valve controls the fluid flow through four hydraulic lines. The valve body (cock) is arranged so that the pressure port (pump output) can be directed either to the open port or close port of the sprinkling system. Simultaneously, the port (open port or close port) which is not connected to pressure is connected to the return (tank). When the 4-way valve control handle is positioned to NEUTRAL, the pressure port is blocked and the close port and open port are connected to tank. A spring-loaded relief valve is located in the pump output line. The spring is adjusted to limit the pump output pressure to 375 psi. If the pressure in the system exceeds this amount, the relief valve lifts to bypass the excess hydraulic fluid to tank.

The power-operated check valve is located between the 4-way control valve and the hydraulic sprinkling system control valve. The check valve either connects the pump output to the piston of the sprinkling system control valve or allows the hydraulic fluid from the sprinkling system to return to tank. When the 4-way control valve is positioned to OPEN and the pump handle is turned, hydraulic fluid from the pump is connected to the power-operated check valve. The pump pressure lifts the poppet, and the fluid



84.311

Figure 3-31.—Hydraulic filter assembly.



84.312

Figure 3-32.—Four-way control valve.

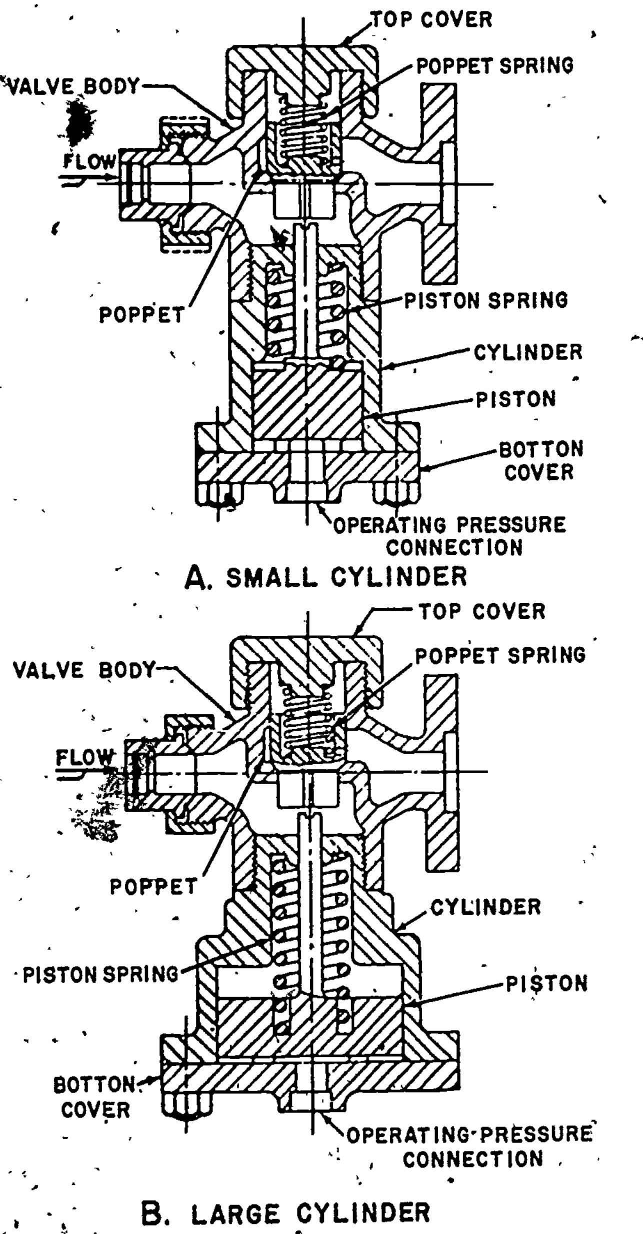
is ported to the sprinkling system control valve. As soon as the pump is stopped, the poppet is spring-returned to its seat, thus blocking the hydraulic fluid to the sprinkling system control valve and holding the control valve open. To close the sprinkling system control valve, the 4-way valve must be positioned to CLOSE, and the hand pump must be operated again. The pump output is directed to the port of the power-operated check valve which is located below (schematically) the piston. The hand pump volume moves the piston up and forces the poppet off its seat, allowing the trapped hydraulic fluid from the sprinkling system control valve to return to tank, thereby enabling the spring in the sprinkling system main control valve to seat the disk.

The small cylinder, power-operated check valve, shown in figure 3-33A is designed for oil operation only, while the large cylinder check valve shown in figure 3-33B may be either oil or water operated.

Test castings are used with both the old and modified types of sprinkling system control valves. The test castings are always located on the dry side of the control valves. They provide a means of checking the sprinkling system without flooding the magazine. The castings also allow flushing of the sprinkling system.

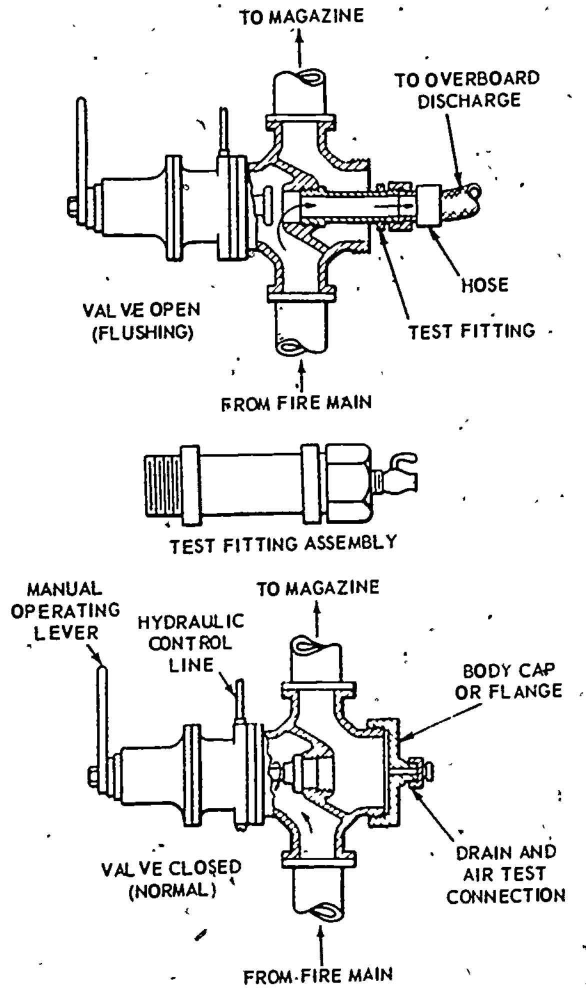
Test Fittings

The test fitting assembly for the sprinkling system modified type of main control valve is shown in the illustration in figure 3-34. Note that the test fitting is threaded into the control valve after the body cap has been removed. When the cap of the test fitting is removed, a hose can be



84.349

Figure 3-33.—Power operated check valves.



5.69

Figure 3-34.—Test fitting for sprinkling system testing and flushing, modified type.

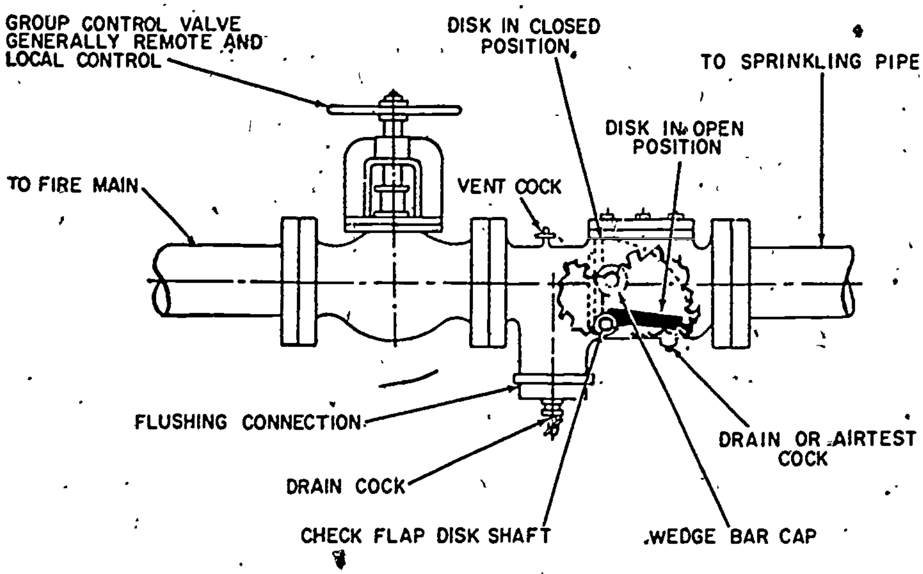
connected to the fitting for flushing the sprinkling system.

The test casting shown in figure 3-35 is used with the old type of main control valve. The disk (flapper) is closed, and a wedge bar is inserted into the casting to hold this disk closed before the sprinkling system is tested or flushed. (The illustration shows a simple, manually operated sprinkling system main control valve.)

The following is a description of operational procedures for sprinkling a magazine which becomes overheated due to a nearby fire. It is assumed that the sprinkling is controlled from a remote control station.

To set up the control station, the hand pump handle must be installed and the 4-way control valve must be positioned to OPEN, as indicated on the nameplate of the valve.

CAUTION: Some control stations may sprinkle two magazine groups; therefore, these control stations are equipped with two 4-way control



5.68

Figure 3-35.—Sprinkling system test casting, old type.

valves. Care must be taken to ensure against sprinkling the wrong magazine.

Moving the 4-way control valve to the OPEN position connects hand pump output to the underside of the poppet in the power-operated check valve. By rotating the hand pump, oil pressure moves the poppet up thereby allowing oil to be transmitted to the sprinkling control valve piston.

When the piston in the main control valve has moved its maximum allowed distance, pressure in the hydrualic system reaches 375 psi and any further hand pump output is bypassed through the relief valve to the supply tank.

When the pump is stopped, the poppet in the power-operated check valve will seat thereby blocking fluid flow to the sprinkling control valve piston thus holding the main control valve open.

To close the sprinkling system main control valve, position the 4-way control valve to CLOSE, and rotate the hand pump in a clockwise direction. Hand pump output is now ported to the power-operated check valve piston causing the poppet to lift off its seat.

As soon as the poppet lifts, the hydraulic fluid which was holding the sprinkling system control valve open is vented to tank and the sprinkling system main control valve is closed by spring action.

CAUTION: Take care to keep the pump rotating and to maintain 375 psi on the hydraulic gage until the salt water gage (if installed) indicates zero.

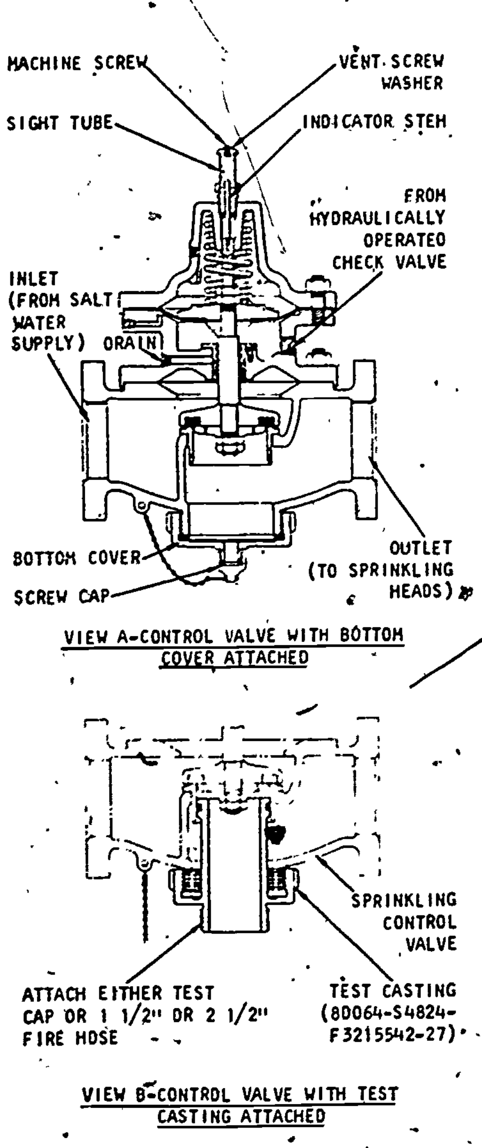
When the sprinkling system main control valve is closed, the 4-way control valve must be positioned to NEUTRAL. In this position, the 4-way valve blocks the pump output port and connects both the open port and the close port to tank.

The sprinkling system just described is found mainly in the ammunition magazines of older ships. On newer ships and on most redesigned ships, the ammunition magazines, special weapon spaces, missile magazines, and missile handling spaces use firemain water pressure (90 psi) to operate the sprinkling system main control valve. This salt water actuated system eliminates the oil supply tank, hand pump, check valve, and relief valve.

Salt Water Sprinkling System

The main control valve in the salt water system shown in figure 3-36 functions similarly to the valve operated by hydraulic fluid except that the salt water operated valve cannot be opened or closed mechanically and contains a sight tube that indicates the condition (open or closed) of the valve.

This valve can be activated either by a manual control valve or automatically through



84.314

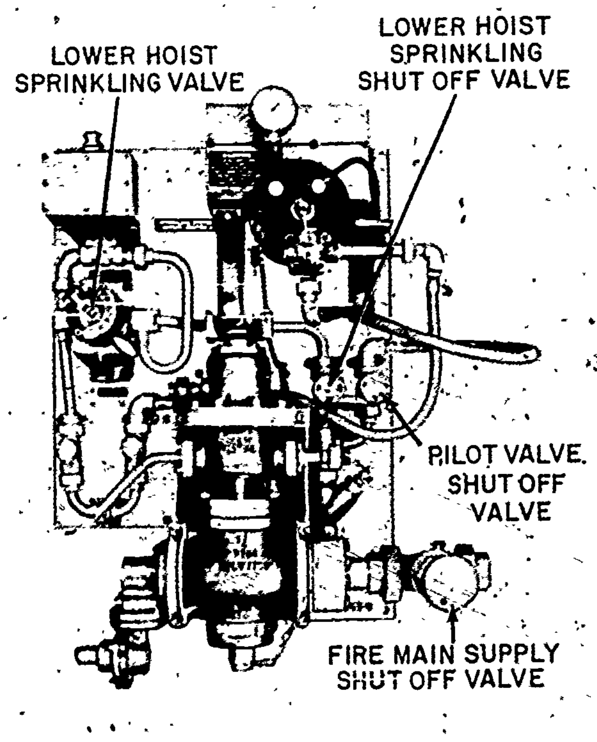
Figure 3-36.—Salt water operated sprinkling (main) control valve.

heat sensing devices acting on a pneumatic released pilot (PRP) valve. Activation by either method will allow firemain pressure to be admitted to the bonnet chamber of the main control valve. Spring pressure holding the main sprinkling control valve closed is overcome by the firemain pressure to open the valve and direct water to the sprinkling heads. Deactivation of the system is accomplished by properly positioning the respective control valves which direct water to a power-operated check valve, opening it, and allowing water to drain from the main sprinkling control valve bonnet and spring pressure to close the valve.

The latest improvement in automatic sprinkling systems is the use of firemain pressure to activate a wet type system. In this system, the normally dry section between the main control valve and the sprinkling heads is filled with nonpressurized fresh water. The dry side of the system is kept filled with fresh water by the use of a fresh water tank. A combination valve and sprinkling head replace the open orifice type of spray head. The sprinkling head valve is supplied from an accumulator-type, 20-gallon fresh water tank. Actuation of the PRP valve or operation of the manual 3-way valves cuts off the 50 psi accumulator tank and releases the water pressure on the sprinkler head valves. At the same time, the main control valve is released and sprinkling begins immediately.

Control Panel

The sprinkling system control panel, shown in figure 3-37, is located in the ammunition handling room and is the parent control station for automatic sprinkling of the lower ammunition



84.350

Figure 3-37.—Sprinkling system control station D.

hoists and carrier room of the 5"/54 gun mount. Main components on the panel consist of a manually controlled sprinkling valve, a pneumatically released pilot (PRP) valve, and the sprinkling main control valve. The sprinkling system may be activated by manually positioning the manual control valve or by the PRP valve which is activated automatically by heat sensing devices.

Automatic Control Devices

Some gun magazine sprinkling systems are equipped with automatic control devices. These automatic control devices are actuated by heat sensing elements located in the magazine area.

The automatic control device actuates the same sprinkling system main control valve which is operated by the hydraulic remote and local control stations. The device can be designed to actuate when a rapid rise of temperature occurs or when the heat exceeds a fixed temperature.

The earliest application of automatic control for sprinkling systems (rate-of-rise) consists of the use of one or several heat actuated devices (HADs), installed in the magazine or ammunition stowage space. The HAD is connected by a 1/8-inch insulated tubing to a pneumatically released pilot valve which controls the operation of a jacking cylinder; the jacking cylinder, in turn, controls the operation of the sprinkling system main control valve. The rate-of-rise device and associated hydraulic system are shown in figure 3-38.

The design of the rate-of-rise (primary) system for the automatic control device is based on the following principles:

1. Air expands when heated.
2. Expansion of air in a closed container produces pressure.
3. Pressure can be converted to mechanical energy.

The rate-of-rise device is designed to open the magazine main (group) control valve when the device absorbs heat from fire at a rapid rate in or near the protected compartment to create within the automatic control device a definite volume of pressure in a given time.

When the heat is absorbed by the device at a slower rate than the one mentioned in the preceeding paragraph, the system does not function since provision is made within the PRP valve to allow for normal temperature changes within the compartment.

The gate valve is locked open, except during servicing of the sprinkling system. The strainer is of special wye type, with fine perforations (slots) in a Monel basket. A drain cock is provided in the strainer body to drain the sediment accumulated from the firemain water supplied to the PRP valve.

The jacking cylinder connects the oil in the hydraulic system which operates the main control valve and the water from the firemain which is the activating medium for the automatic control device. The oil side (small diameter) and water side (large diameter) of the cylinder contain, respectively, a piston with hydraulic cup packings suitable for oil service and another piston with packings suitable for salt water service. Both pistons are connected in tandem.

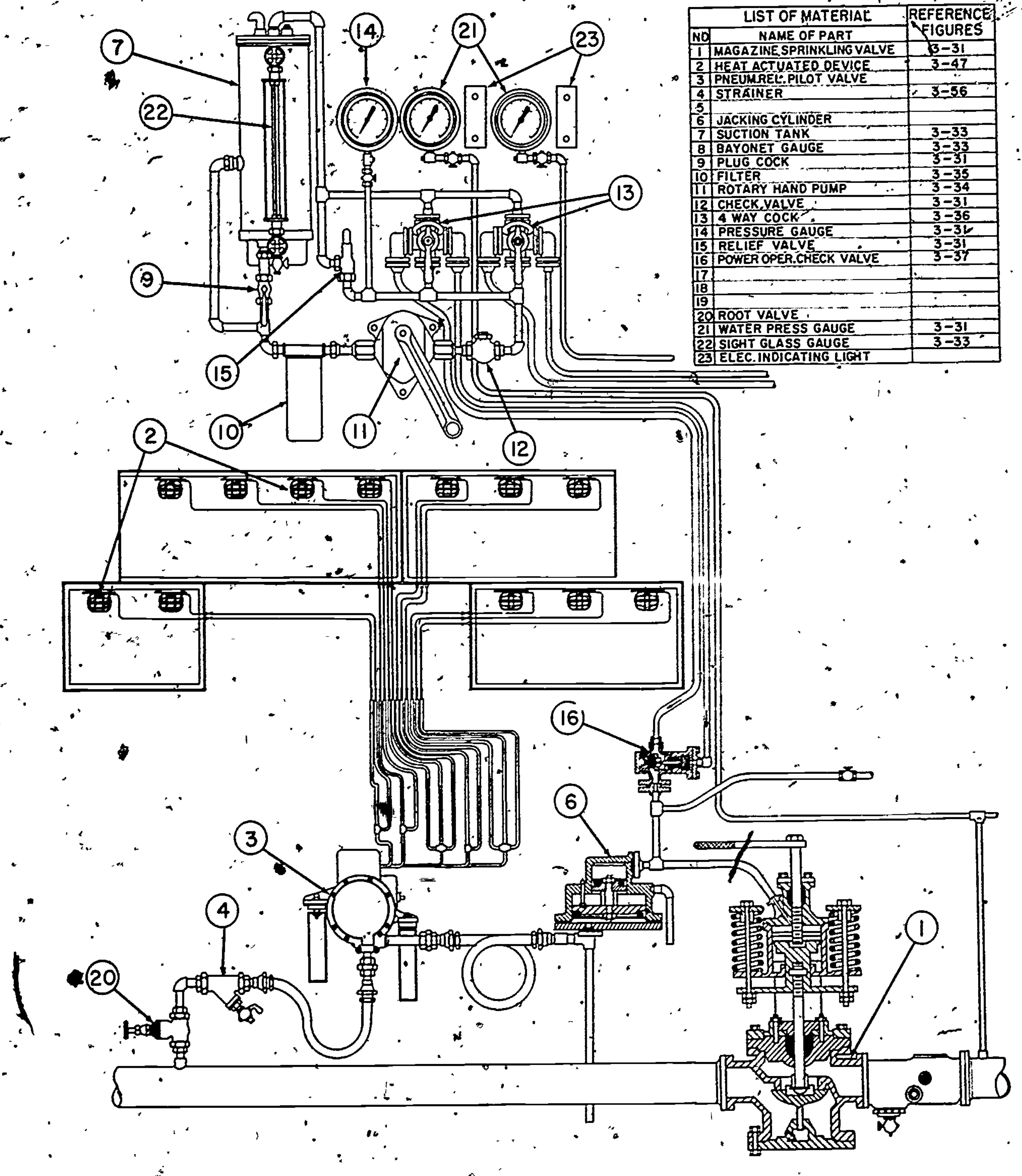
The water side of the cylinder is so designed that, when a water pressure of 40 psi is applied to the water piston, sufficient pressure is transmitted by the oil piston to overcome the spring force and water pressure acting on the valve disk of the sprinkling system main control valve.

The jacking cylinder is equipped with an indicator which provides visual indication of the piston positions. A vent installed between the pistons in the body of the jacking cylinder provides draining when a leakage occurs past either piston.

The early model jacking cylinder contains a leadoff fitting and a tail pipe which are installed on the water side of the jacking cylinder to permit release of water during resetting of the PRP valve after the automatic control device has been actuated. A small hole in the leakoff fitting would prevent the jacking cylinder from lifting if a leak should develop in the PRP valve.

The PRP valve shown in figures 3-39 and 3-40 releases water from the firemain to the large-area side of the jacking cylinder when the temperature rate-of-rise in the protected compartment exceeds a preset level.

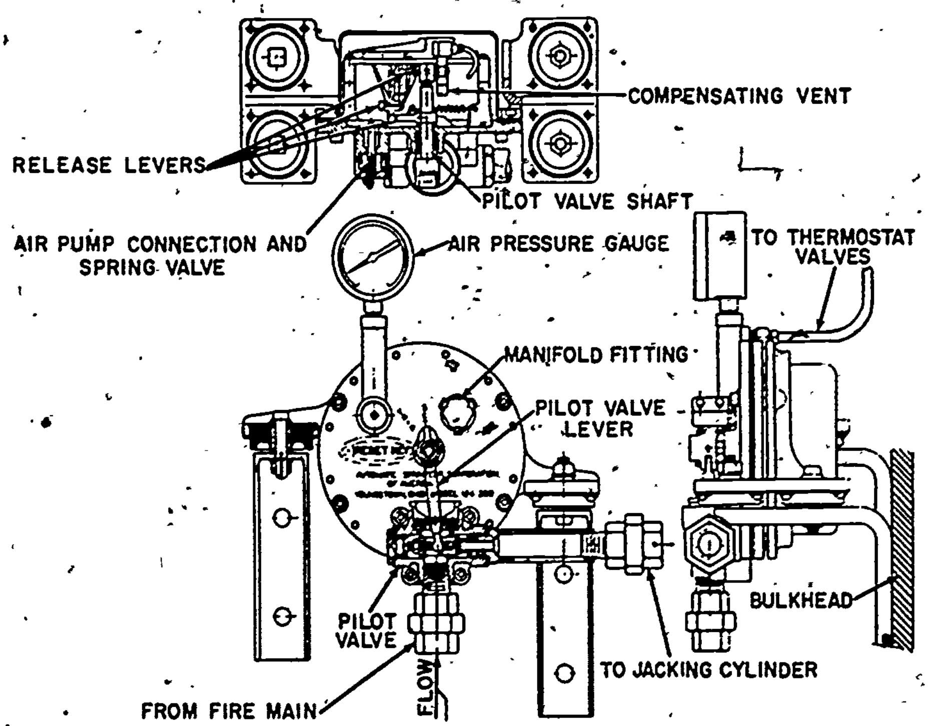
The PRP valve assembly shown in figure 3-40 consists of a bronze case which encloses a release diaphragm, chamber, linkage, springs, and a pilot valve shaft and levers. The shaft and levers are connected to the PRP which opens and closes to control firemain input to the jacking cylinder. The shaft and levers are arranged so that any sudden pressure increase causes the diaphragm to extend into the diaphragm chamber and to trip the operating lever out from under the fulcrum lever. When the fulcrum lever is released, the pilot valve is opened by spring action.



LIST OF MATERIAL		REFERENCE FIGURES
NO	NAME OF PART	
1	MAGAZINE SPRINKLING VALVE	3-31
2	HEAT ACTUATED DEVICE	3-47
3	PNEUM.REL. PILOT VALVE	
4	STRAINER	3-56
5		
6	JACKING CYLINDER	
7	SUCTION TANK	3-33
8	BAYONET GAUGE	3-33
9	PLUG COCK	3-31
10	FILTER	3-35
11	ROTARY HAND PUMP	3-34
12	CHECK VALVE	3-31
13	4 WAY COCK	3-36
14	PRESSURE GAUGE	3-31
15	RELIEF VALVE	3-31
16	POWER OPER. CHECK VALVE	3-37
17		
18		
19		
20	ROOT VALVE	
21	WATER PRESS GAUGE	3-31
22	SIGHT GLASS GAUGE	3-33
23	ELEC. INDICATING LIGHT	

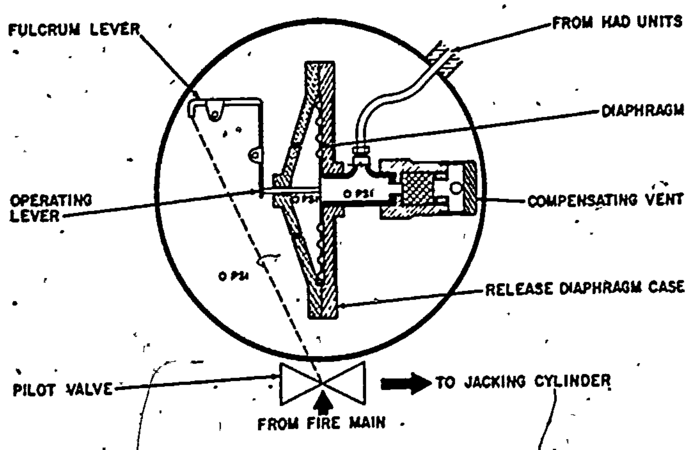
84.318

Figure 3-38.—Hydraulic and automatic thermo-pneumatic rate-of-rise control systems for operating magazine sprinkling control valves.



84.319

Figure 3-39.—Three views of the pneumatically released pilot valve (PRP).



84.320

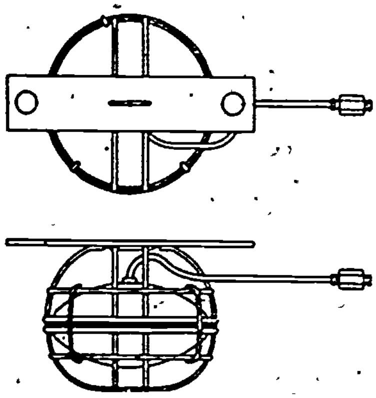
Figure 3-40.—Pneumatically released pilot valve (PRP), schematic.

Slow changes in pressure from the HAD are equalized by the compensating vent which is installed in the PRP case. This vent consists of a carefully calibrated leak in a special stainless steel fitting.

HAD Units

The heat actuated device (HAD), shown in figure 3-41, is a pneumatic thermostat which

71



84.321
Figure 3-41.—Heat actuated device (HAD).

consists of a hollow brass chamber whose capacity is about 14 cubic inches. The HAD is located in the protected compartment and creates the pressure necessary to actuate the PRP valve when the rate-of-rise of the temperature in the protected compartment becomes excessive.

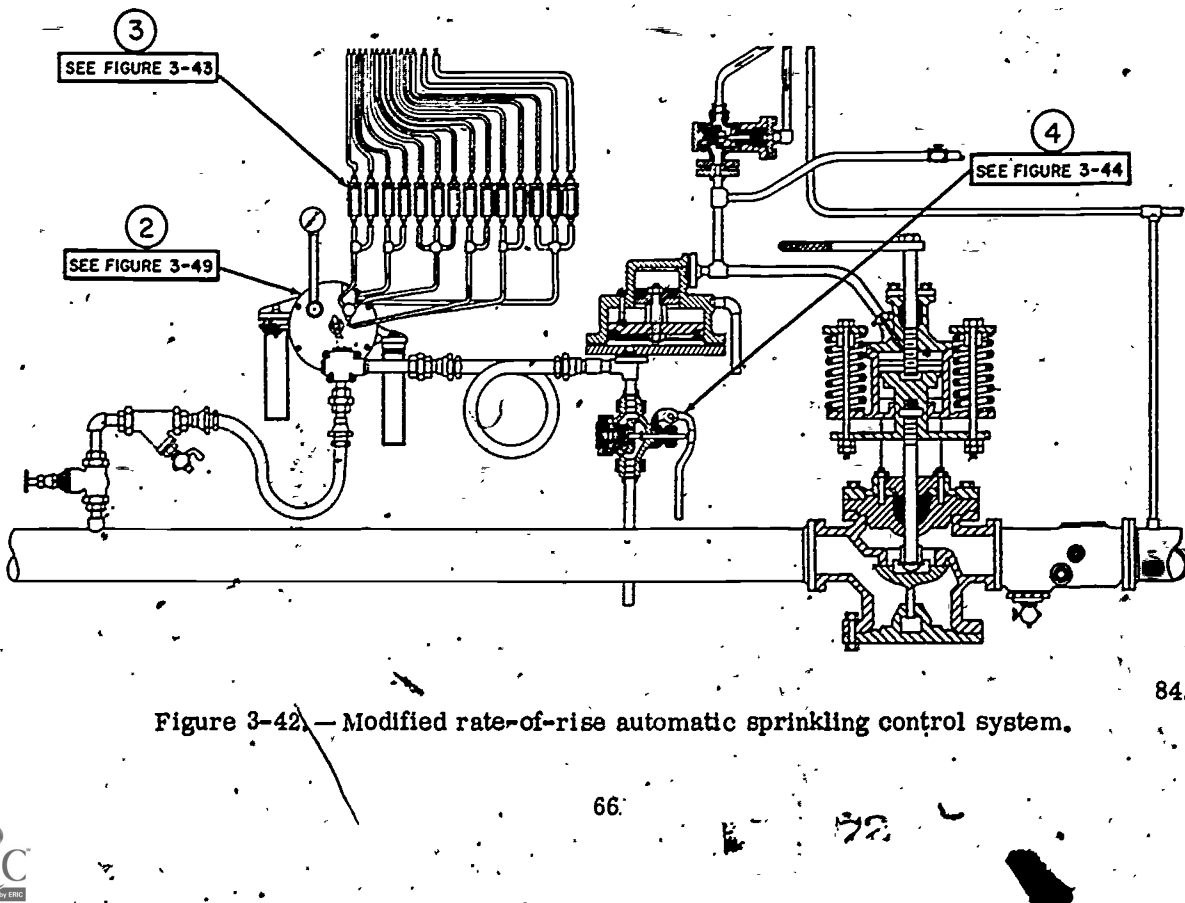
The excessive heat is absorbed by the HAD and is utilized to heat the air trapped in the system. The heated air expands and creates a pressure which is transmitted through 1/8-inch tubing to the PRP diaphragm.

One or more HADs are installed on the overhead of each compartment protected.

A modified model of a rate-of-rise automatic sprinkling control system is shown in figure 3-42 and contains the following improvements:

1. A minimum of two HADs in each compartment protected.
2. A modified design PRP valve.
3. A circle seal check valve in each transmission line between the PRP valve and the HAD.
4. A lever operated drain valve in the salt water side of the jacking cylinder.

A PRP valve has been modified to include an air charging valve, and a reset key. The air gage and charging valve are installed to provide a means of pressurizing the automatic control device to test for leaks. An air pump is also provided with the special tools for use in the pressure test. The PRP reset key is provided for the resetting of the PRP valve operating mechanism after the valve has been tripped.



84.322
Figure 3-42.—Modified rate-of-rise automatic sprinkling control system.

A spring-loaded circle seal check valve shown in figure 3-43 is installed in the air tubing of each HAD, and is designed to check against sudden changes in pressure in one direction and to open when pressure is applied from the opposite direction. The valve housing contains a restricted bypass orifice that equalizes pressure in the system so that pressure created in one HAD is restricted to the diaphragm chamber of the PRP valve assembly instead of pressurizing the entire system. (The direction of air flow is shown in figure 3-43.)

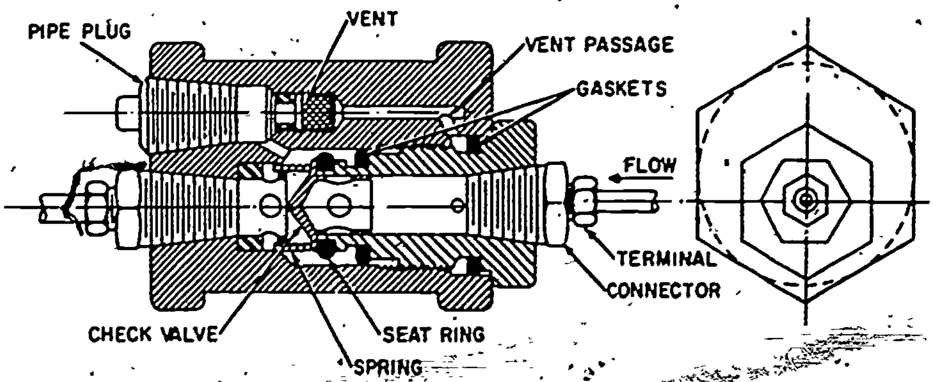
A lever operated drain valve, shown in figure 3-44, is installed in the salt water side of the jacking cylinder. This valve is self-closing. When opened, it drains the water side of the jacking cylinder.

After the PRP valve has been reset, the lever operated drain valve must be manually opened before the jacking cylinder returns to its normal position and allows the sprinkling system main control valve to close.

A 0.098-inch hole, located in the bridge wall of the lever operated drain valve, prevents premature sprinkling of a magazine by salt water leaking from the PRP valve.

Another of the newer automatic sprinkling control systems is shown in figure 3-45. This system incorporates the following features:

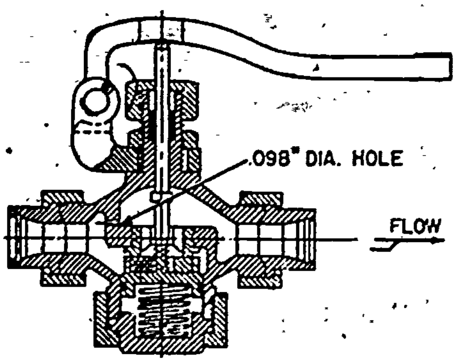
1. A fixed temperature unit (FTU) for each HAD in the protected compartment.
2. Additional expansion loops in the tubing from the HADs.



84.323

Figure 3-43.—Circle seal check valve.

3. A water switch in the dry side of the sprinkling system.
4. A modified type of sprinkling system main control valve.



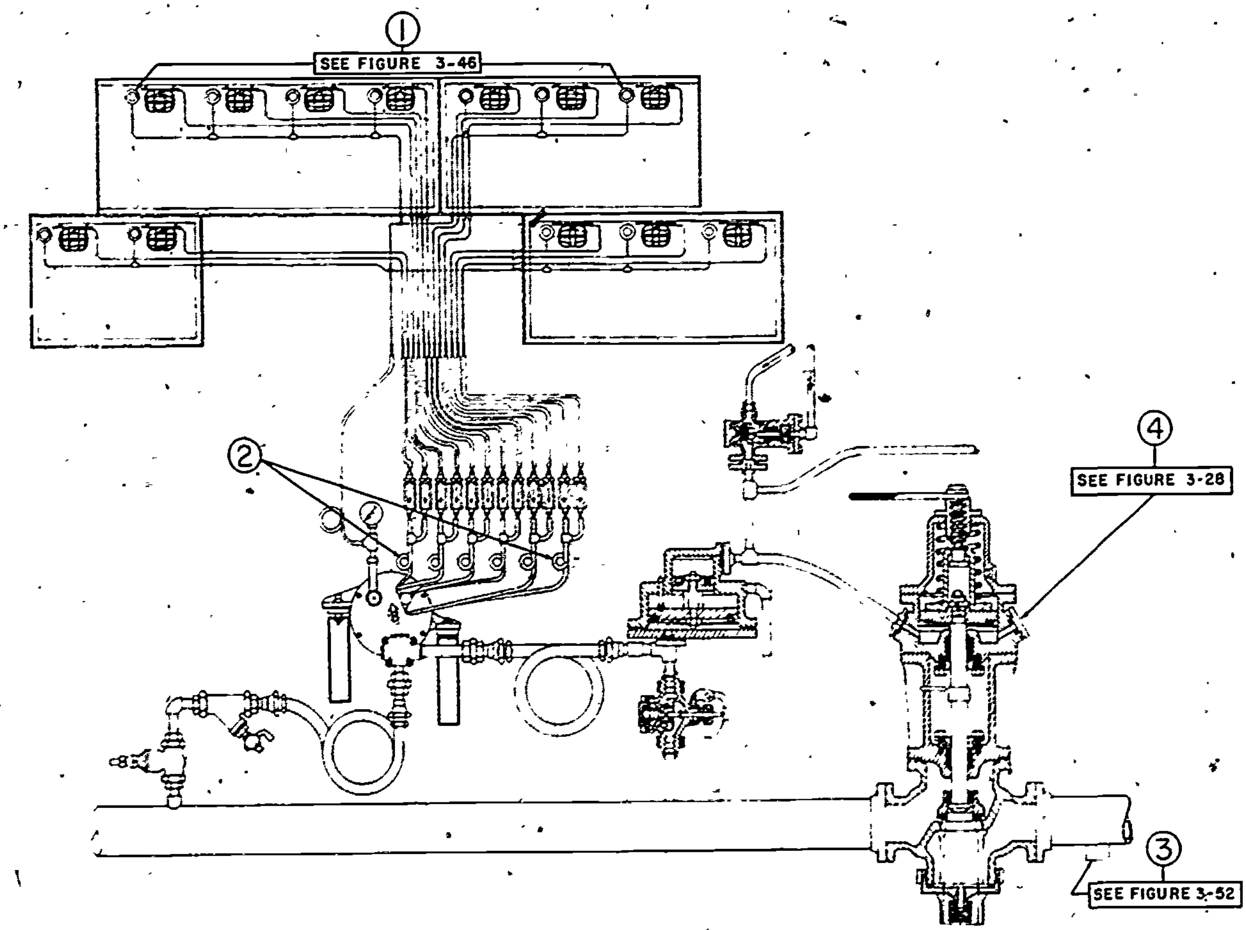
84.324

Figure 3-44.—Lever operated drain valve.

Fixed Temperature Unit

The design of the fixed temperature (secondary) system used with the automatic control device is based on the same principles as the design of the rate-of-rise system plus the following:

1. Pressure can be converted to mechanical energy.
2. Heat can be converted to mechanical energy.



84.325

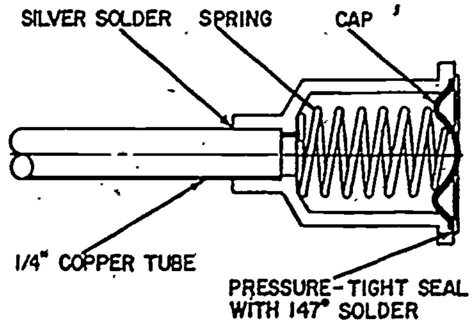
Figure 3-45.—Hydraulic and automatic thermo-pneumatic rate-of-rise and fixed temperature control systems for operating magazine sprinkling control valves.

The fixed temperature units (FTUs) actuate the automatic control device when the temperature reaches a predetermined value.

NOTE: The temperature rise must be slow, otherwise the HAD unit will actuate the automatic control device before the FTU can function.

An FTU consists of a spring-loaded cap held in place by indium solder. (Refer to figure 3-46.) This solder is made of a material that melts at the predetermined maximum setting for the protected compartment. When the FTU cap is freed, the pressure in the PRP valve case is released, causing the automatic control device to actuate.

A schematic of the automatic control for the sprinkling system in figure 3-45 is provided in figure 3-47. It is assumed that the temperature in



84.326

Figure 3-46.—Fixed temperature unit (FTU).

the protected compartment rises at a slow rate. As the temperature rises, the HADs respond by transmitting the heat in the form of air pressure to the PRP diaphragm. Since the air pressure rise is slow, it is equalized within the PRP diaphragm case by the compensating vent, thus preventing the PRP valve from being actuated. However, when the temperature in the protected compartment reaches the predetermined maximum level, the FTU opens and vents the air pressure built up in the diaphragm case, causing the PRP valve to trip.

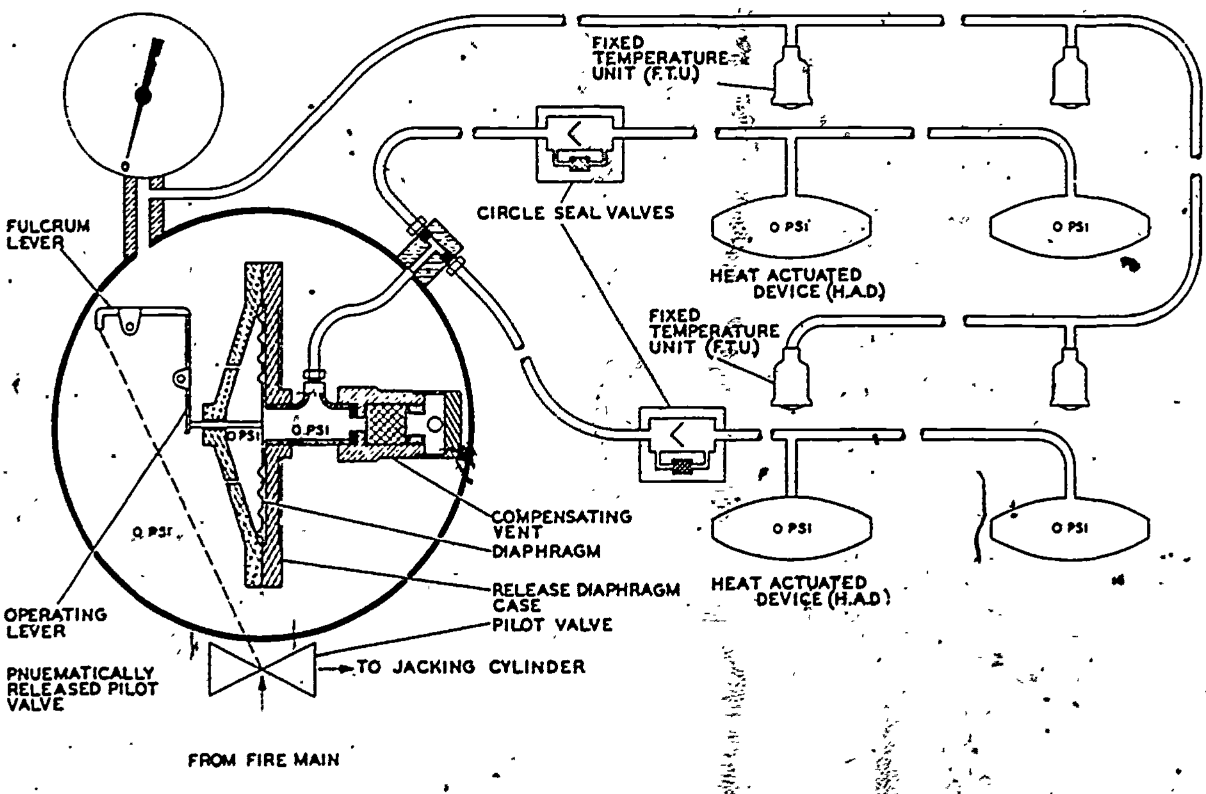
Thermosylphon Device (TSD)

The latest control device for an automatic sprinkling system combines the features of a HAD and an FTU. This device, known as the thermosylphon heat sensing device, is used in many of the newest types of sprinkling systems. These systems include the salt water actuated type shown in figure 3-36, and the wet type described earlier in this topic.

The thermosylphon heat sensing device consists of a bellows normally enclosed in a mesh cage. The bellows are expanded and held by a fusible link against spring pressure. The device, shown in figure 3-48, automatically actuates a PRP valve when there is a rapid temperature rise or when the fusible link melts.

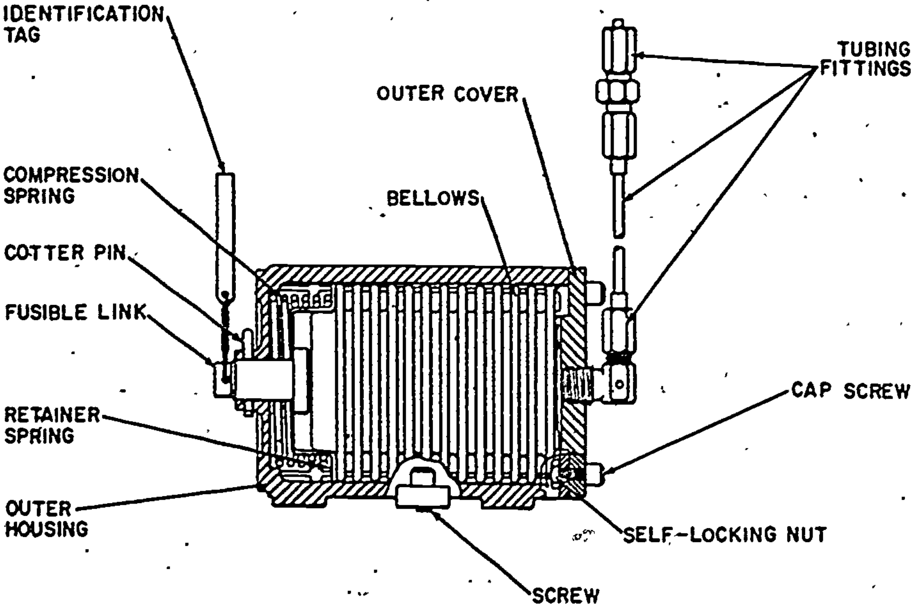
When a rapid temperature rise occurs in a magazine or ready service area, the resultant sudden pressure increase in the bellows is transmitted to the PRP valve causing it to activate the sprinkling system. Normal temperature changes also cause air in the bellows to expand and contract. However, these normal pressure changes are vented by a small orifice in the PRP valve.

When the temperature in a magazine or ready service area reaches a predetermined value, it causes the fusible link to melt, releasing the compressed spring and causing the bellows to collapse. As the bellows collapse, a pressure is developed that actuates the PRP valve.



84.237

Figure 3-47. —Sprinkling system automatic control system, schematic.



84.328

Figure 3-48.—Thermo-sylphon heat sensing device.

CHECKING SPRINKLING SYSTEM

Once a week check for valve leakage in the magazine sprinkling system. This involves the sprinkling control valve and the drain line from the local control panel.

To check the sprinkling control valve, simply remove the cap from the bottom cover of the valve. If there is no leakage, replace the cap. Otherwise, close the shutoff valve in the 3/8-inch salt water control line leading to the remote control panel, close the shutoff valve in the 3-1/2-inch salt water supply line, repair as required, replace cap, and open the shutoff valves.

Verify that there is no leakage from the drain line that leads from the local control panel (identified by a "To Drain" plate at bottom-left of panel). To check for leakage, the adjacent union coupling can be unscrewed. If there is any leakage, determine which valve is leaking (by systematically opening and closing the various shutoff valves until the leaking valve is pinpointed). Close the two main shutoff valves as in the preceding paragraph, repair or replace as required, and open all the shutoff valves.

TESTING SPRINKLING SYSTEM

Once a month (1) airtest the pneumatic lines in the sprinkling system for tightness and operability of the heat sensing devices, and (2) test the sprinkling system for proper operation of the valves.

Once every quarter (1) airtest the dry lines for unobstructed flow between the sprinkling control valve and the sprinkling heads, (2) flush the associated firemains for unobstructed flow, (3) clean the salt water strainers, and (4) clean the drain hole in the sprinkling control valve.

Airtest (Tightness)

To airtest the sprinkling system monthly for tightness and operability of the heat sensing devices, proceed as follows:

1. Obtain the following equipment.
   a. A test casting
   b. A spanner wrench
   c. A hand pneumatic pump
   d. Either a 1-1/2- or 2-1/2-inch fire hose or a test cap (2-1/2—7-1/2 N. H. thread) having a petcock

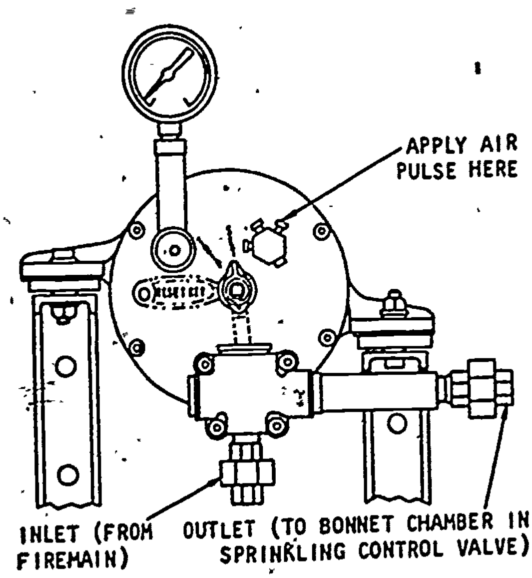
e. A small container in which to catch salt water

2. Using the spanner wrench, remove the bottom cover of the sprinkling control valve. Then screw in the test casting, as shown in figure 3-36B.
3. To the threaded end of the test casting, attach either the fire hose or, if available, the test cap. If the fire hose is used, hang its drain end overboard.
4. Close the normally locked-open globe valve in the 3-1/2-inch salt water supply main.
5. Connect pneumatic handpump to air valve on PRP valve (figure 3-49).
6. Slowly pressurize system until a pressure of at least eight ounces is reached. Because of the slow passage of air through the vents, some additional pumping of air may be required before obtaining a balance.
7. Stop pumping and hold pressure for five minutes. The pressure should not drop during this period—even the slightest drop in pressure is serious, for it indicates a leak which may prevent the automatic operation of the system at time of fire. If the gage does not retain eight ounces of pressure for five minutes, first check to make sure that the fitting on the hose line for the pneumatic pump is not the type that holds the air valve open, thereby permitting the pressure to escape. Then look for a leak by applying soap suds to the fittings near the PRP valve (see Note below) and subsequently at the fittings near the heat sensing devices. Do not use movable jaw wrench when tightening fittings.
NOTE: If the leak is within PRP valve, replace this valve with a new unit. Do not open this valve under any circumstances. Turn in defective valve to nearest Naval stocking activity. Repeat airtest with replacement valve.
8. To test the action of the heat sensing devices, punch the air valve fully open. The sudden release of pressure in the PRP valve case and pneumatic lines should trip the sprinkling control valve; accordingly, water will flow into the test casting. (This simulates the condition created when the bellows of a heat sensing device collapse as the result of the fusible slug melting).
9. Wait about two minutes (see Note below), and then reset the tripping mechanism on PRP valve by gripping the reset lever with the reset key and turning the lever to SET (figure 3-49). Be sure that the lever latches at SET before removing reset key.

NOTE: The reason for the two-minute wait is to allow time for the pressure to equalize on both sides of the valve diaphragm. Until the pressure is equalized, the valve will not latch at SET. If after two minutes the valve does not set, again slowly pressurize the system as in Step 6, wait five minutes, and then punch the air valve wide open. Again wait two minutes, and then reset. If the valve still fails to reset (or will not trip to begin with), replace the PRP valve with a new unit. DO NOT OPEN THIS VALVE UNDER ANY CIRCUMSTANCES. Turn in defective valve to nearest Naval stocking activity. Airtest replacement.

10. Open globe valve in the 3-1/2-inch salt water supply main lock open.

NOTE: If the monthly operational check or the quarterly flushing (below) are to be performed immediately following, do not perform Step 11 at this point. However, if there is to be any time lapse between conducting these tests, immediately carry out Step 11 to keep the sprinkling system in a functional condition.



84.329

Figure 3-49.—Pneumatically released pilot valve.

11. IMPORTANT: Remove the fire hose, or test cap, from the test casting on the sprinkling control valve. Have a small container available to catch salt water trapped within test casting. Then remove test casting, check to see that there is no leakage past valve seat, and screw on the bottom cover to the valve, using the spanner wrench.

Finding and Correcting Leaks in Automatic Control Systems

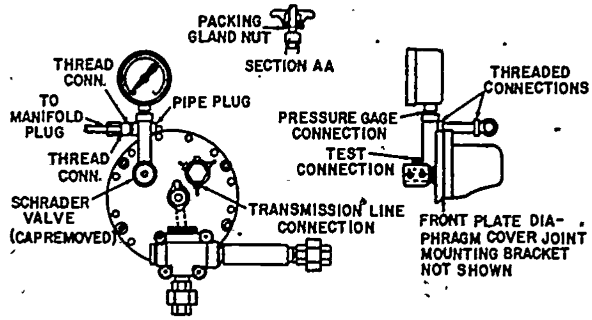
In recent reports from ships in the fleet, it has been noted that technical assistance has been requested for magazine sprinkling systems because the automatic control system would not hold pressure during the monthly PMS test. The only reason for the automatic control system's inability to hold pressure is a leak in a system component.

The automatic (thermo-pneumatic) control system is a closed system. Since the system's operation depends on pressure, it must be tight at all times. Any leak in the system will render it inoperative. The system's function is to actuate the magazine sprinkling system in response to either a rapid rate of rise in temperature or a slow rise to a predetermined temperature. A detailed description of the automatic control system is presented in NAVSHIPS 0348-078-1000, Magazine Sprinkling System Instruction Book.

During the monthly PMS test, the automatic control system's tightness is verified by pressurizing it to at least 8 ounces per square inch and ensuring that it holds that pressure for 5 minutes. If the system does not hold pressure, it must be considered inoperative. Accordingly the leak or leaks must be found and corrected as soon as possible.

The following is a checklist of locations where leakage can occur. In checking these locations refer to figure 3-50.

1. Schrader valve.
2. Transmission tubing connections and test connection at the manifold on the front of the PRP valve.
3. Pilot valve packing gland.
4. Pressure gage connection.
5. All joints of nipple and tee connected to rear of PRP valve pressure gage.
6. Circumferential joint where the PRP valve diaphragm cover joins the front plate.



LOCATION OF POSSIBLE LEAKS FROM PRP VALVE

84.351

Figure 3-50. — Location of possible leaks from PRP valve.

7. Circle seal check valve inlets and outlet connections and by-pass orifice plug.
8. Any joint or connection in the transmission tubing or any area in the transmission tubing where the rockbestos insulation has been damaged.
9. Heat actuated devices (HADs) and fixed temperature units (FTUs).
10. Sylphon type heat sensors.

Before checking any of the heat sensing devices, check the tightness of all system connections.

The wrench provided with the automatic control system tool kit should be used to "snug-up" all fittings. No adjustable wrenches are to be used because they may round off corners of fittings. When "snugging-up", use restraint to avoid damaging the fittings or transmission tubing. To check tightness of the PRP valve packing gland nut, insert a 1/16-inch blind punch (at a flat angle) into one of the tightening holes on the gland nut shoulder and exert a slight pressure in a clockwise direction.

Extreme care must be exercised in tightening the gland nut to prevent overtightening which may cause the packing to bind on the pilot valve shaft and prevent the PRP valve from tripping. After all the connections have been checked, repeat the tightness test. If the system does not hold pressure, it will be necessary to find the leak by using leak detection compound, FSN 9G-6850-621-1920, or a soap solution made with warm water and any common hand soap.

The leak detection procedure entails maintaining a pressure of 16 to 20 ounces per square inch in the automatic control system by using the hand pump, applying the leak detection compound or soap solution to all locations from which leakage can occur, and watching for the formation of bubbles which indicate the leak.

Finding leaks can be a tedious and time consuming task. The task must be performed with deliberation because if it is hastily done, a leak may be overlooked which will necessitate performing the entire procedure again.

The following leak procedures are recommended as an aid to leak detection:

1. With the hand pump, maintain 16 to 20 ounces per square inch pressure in the automatic control system at all times while checking for leaks.
2. If leak detection compound is used, apply it as directed on the bottle. If using a soap solution, apply a liberal amount of solution using rapid brush strokes to promote a heavy lather. A leak is shown by the continuous formation of bubbles in the lather.
3. Check the soundness of the Schrader valve first. Pressurize the system to the required pressure, and apply a liberal amount of solution around the Schrader valve, and quickly remove the hand pump. Rapidly apply more solution to the valve stem and watch for bubbles. A leak from the Schrader valve does not preclude leakage from other locations. The remainder of the system can be checked as long as pressure is maintained by the hand pump.
4. Always start your search for leaks at the PRP valve and work outward to the circle seal check valves, all tubing connections and outward to the heat sensing devices.

When the leak has been located, take immediate corrective action (except as noted in the final paragraph of this section).

A word of caution here, however, about leakage at threaded connections. Never overtighten flared fittings on the PRP valve packing gland because this can cause the PRP valve to be inoperable. Teflon tape can be used as a sealant on larger threated connections such as pressure gage stem on pipe plugs; however, do not use pipe dope on any joint. Where leakage from a flared fitting cannot be corrected by tightening, cutting and re-flaring the tubing may be necessary by using the tools provided in the tool kit and following the instructions contained in Section 6 of the Magazine Sprinkling Instruction Book.

Leakage from a Schrader valve can often be corrected by replacing the valve stem (core) which is merely threaded into the valve. A stem extractor tool or pair of thin needle nose pliers can be used to remove the old stem and screw in the new one. Unfortunately, the stem extractor tool and replacement valve stems are not carried in the Navy Supply System. However, they can be purchased at any bicycle shop or auto supply store. If the tool and replacement stem are not available at the time a Schrader valve leak is detected, it is recommended that the PRP valve be replaced and the defective Schrader valve be repaired at the earliest opportunity. Repeat the PMS tightness test after corrective action to ensure that all leaks have been found.

In the following instances, immediate corrective action cannot usually be effected due to the necessity of obtaining replacement components.

1. Leakage from bellows of a sylphon type heat sensor cannot be repaired, replace the heat sensor.
2. Leakage from a flared fitting when there is insufficient slack to permit cutting and re-flaring, install new tubing.
3. Leakage from damaged transmission tubing, install new tubing.

Operational Test, New System

Test the sprinkling system monthly for proper operation of all the valves.

Proceed as follows:

1. Obtain the following equipment:
   a. A test casting
   b. A spanner wrench
   c. A hand pneumatic pump
   d. Either a 1-1/2- or 2-1/2-inch fire hose or a test cap (2-1/2—7-1/2 N. H. thread) having a petcock.
   e. A small container in which to catch salt water.
2. Using the spanner wrench, remove the bottom cover of the sprinkling control valve. Then screw in the test casting, as shown in figure 3-36.
3. To the threaded end of the test casting, attach the fire hose and hang its drain end overboard.
4. Check the water pressure gages on the remote control panel. These gages should indicate at least 70 psi water pressure.

5. Test the PRP valve with the hand pneumatic pump. Apply a pulse of air of approximately 8 ounces as shown in figure 3-49. This should trigger the PRP valve tripping mechanism. If the indicator valve rises to the top of the sight tube (figure 3-36A), it can be assumed that the PRP valve is functional and that the sprinkling control valve opens normally (should not pound or chatter). If not, see "Unscheduled Maintenance Procedures—Servicing Sprinkling System."
6. Wait about two minutes (see Note below), and then reset the tripping mechanism on PRP valve by gripping the reset lever with the reset key and turning the lever to SET (figure 3-49). Be sure that the lever latches at SET position before removing reset key. NOTE: The reason for the two-minute wait is to allow time for the pressure to equalize on both sides of valve diaphragm. Until the pressure is equalized, the valve will not latch in the SET position. If after two minutes the valve does not set, again apply an 8-ounce air pulse, wait another two minutes, and then reset. If the valve still fails to reset (or will not trip to begin with), replace the PRP valve with a new unit. DO NOT OPEN THIS VALVE UNDER ANY CIRCUMSTANCES. Turn in the defective valve to the nearest Naval stocking activity.
7. Turn the manual control lever on the remote control panel to STOP. The stem on the sprinkling control valve should drop below the sight tube, and water should drain through the hydraulically operated check valve. If the stem does not drop, see "Unscheduled Maintenance Procedures—Servicing Sprinkling System."
8. Turn the manual control lever on the remote control panel to AUTO. Drainage through the hydraulically operated check valve should stop. If not, see "Unscheduled Maintenance Procedures — Servicing Sprinkling System." NOTE: If the test cap rather than the fire hose is attached to the test casting on the sprinkling control valve: before proceeding to step 9, open the petcock on the cap and drain into container the salt water trapped by test casting. Close petcock when drained.
9. Turn the manual control lever on the remote control panel to START. If the indicator stem on the sprinkling control valve rises to the top of the sight tube, it can be assumed that the manual control valve on the remote control panel opens normally.

   NOTE: Before proceeding to Step 10, see note under Step 8.

10. Test the manual control valve on the local control panel in the same manner as the manual control valve on the remote control panel was tested in Steps 7, 8, and 9.
11. IMPORTANT — Remove the fire hose (or test cap) from the test casting on the sprinkling control valve. (In removing the fire hose, have a small container available to catch salt water trapped within the test casting.) Then remove the test casting, check to see that there is no leakage past valve seat, and screw on bottom cover to valve, using the spanner wrench.

Operational Test, Old System

To conduct operational tests under the old system, proceed as follows:

1. Obtain the following equipment:
   a. A wedge bar
   b. A flapper-valve wrench
   c. A spanner wrench
   d. A bucket in which to catch salt water
   e. A set of sound-powered phones
   f. Magazine keys
2. Using the spanner wrench, remove the wedge bar cap (fig. 3-35). Place a bucket under the drain cock and open the cock.
3. Close the flapper-valve (disk) with the flapper-valve wrench (fig. 3-35), and push the wedge behind the closed flapper-valve (disk). Make sure that the flapper-valve is securely closed (wedged by the wedge bar).
4. Instruct the man at the remote control station via sound-powered telephone to open his group control valve for the group being tested.
5. When a solid stream of water issues from the drain cock, indicating that there is no obstruction in the system, instruct the man at the remote control station to close the group control valve.
6. When all the water has drained from the drain cock, remove the wedge bar and open the flapper valve (disk), and replace the wedge bar cap.

Testing personnel must be sure to leave the system completely ready to function after testing. An inspection of all magazine areas should be conducted several hours after testing to ensure there is no leakage from any valves.

In hydraulic operated sprinkler systems, failure of the hydraulically operated control valve may be caused by low oil levels. Check the oil level frequently and replenish when necessary. Be sure to use the specified oil, and pour it through a filter or 200-mesh wire screen.

Airtest (Unobstructed Flow)

To airtest the sprinkling system quarterly for unobstructed flow between the sprinkling control valve and the sprinkling heads, proceed as follows:

1. Remove the screw cap on the bottom cover of the sprinkling control valve, and attach the ship air supply line and an air gage to the cap.

   Caution: Be sure to hold air pressure at about 5 psi, because too high a pressure will unseat the valve and send salt water into the dry line and sprinkler heads.

2. Blow air through the piping at about 5 psi.
3. Check each of the sprinkling heads for the passage of air. If air does not pass freely through any of the heads, replace and retest.
4. Detach air line, replace screw cap, and flush the firemain as instructed below.

Flushing

To flush the firemain, proceed as follows: Note: Perform only in areas where the sea water is clean. Also, when operating in tropical waters, flush firemain more often than once every three months.

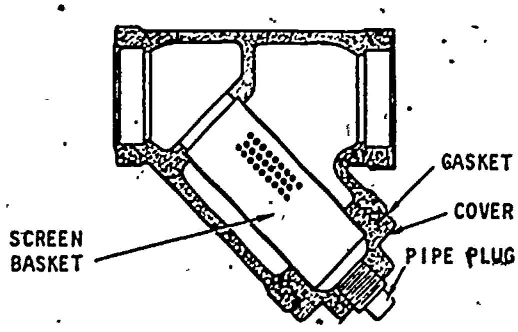
1. Obtain the following equipment:
   a. A test casting or wedge bar
   b. A spanner wrench
   c. A 1-1/2 or 2-1/2-inch fire hose
   d. A small container to catch valve drainage.
2. With the spanner wrench, remove the flushing connection of the sprinkling control valve (fig. 3-35) for the old system and the test casting (fig. 3-36) for the new system.
3. Insert a wedge bar (old system) or a test casting (new system). Attach a fire hose to the threaded end of the flushing connection or test casting and hang the drain end of the hose overboard.
4. Open the group control valve and allow it to stay open under full firemain pressure until the lines are clear of sea growth and shell particles. When clear water runs from the hose for five minutes or more, it can be assumed that all lines are clear.
5. The procedures for stopping and securing the sprinkling system are the same as those followed when conducting operational tests.

Checking/Cleaning Strainers

After flushing firemains, check the four salt water strainers that are in the sprinkling system.

Following are the procedures for checking and cleaning a strainer:

1. Shut off salt water supply by closing globe valve adjacent to strainer.
2. Hold small container beneath strainer; then remove strainer plug, and catch drain water.
3. Remove strainer cover and screen basket inside (fig. 3-51).
4. If screen basket appears dirty, gently brush it with a wire brush to remove accumulated material. If brushing does not clean screen basket, treat according to shipboard procedures.
5. Replace basket, cover, and plug. When replacing basket, be sure that its upper end is properly seated in its recess before



84.330

Figure 3-51.—Strainer for sprinkling system.

tightening retaining cover. Also check gasket for signs of deterioration. Install new gasket if necessary.

6. When all parts have been replaced, tighten plug and cover securely so assembly is watertight. Then open adjacent globe valve.

7. Although it is not a part of the strainer, the drain hole also should be cleaned at this time to guard against plugging with dirt, scale, or other foreign matter (fig. 3-51).

Note: For information on sprinkling system trouble diagnosis and remedies, refer to NAVSHIPS 0348-078-1000.

SPRINKLING ALARM SYSTEMS

Several types of warning devices or systems are used onboard ships, and one of them is the alarm system activated by the water switch on the dry side of the sprinkling system main (group) control valves. The alarm indicates by sound or by light when the main control valve is leaking.

Another type of alarm system used is actuated by heat. The alarm sounds when the temperature in an ammunition storage area rises to the danger point. Due to this warning, the temperature can be reduced before sprinkling becomes necessary.

A new alarm system now in use is the pry-a-larm. This system functions according to an entirely different principle: The trigger of the pry-a-larm detector is activated by minute particles of combustion. NOTE: Formation of combustion particles occurs in all types of fires and even in smoldering or overheated materials. The small combustion particles are invisible, but they are usually present before there is any other evidence of a fire; the larger particles are visible in the form of smoke. However, most of the particles are too small to be seen by the naked eye.

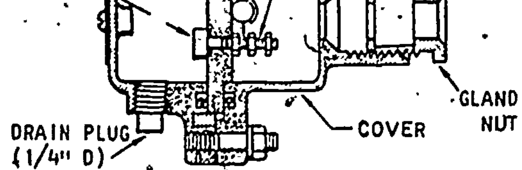
The advantages of the pry-a-larm system are as follows:

1. The early warning provided by the pry-a-larm system often permits safe evacuation of the endangered area and gives the damage control party time to fight the fire while the fire is still small and controllable.
2. The system may be adjusted (calibrated) to ensure proper operation, regardless of its location onboard ship.
3. The electrical circuit associated with the pry-a-larm system is a standard two-wire circuit. Because of the low current used, a thin walled conduit can be used.
4. Any failure of wiring or of other essential parts is immediately indicated on a trouble board located in the damage control central.

Testing Alarm Systems

On a periodic basis, sprinkling system alarm circuits should be tested. These tests involve checking the electrical continuity of the switch circuits. The leakage alarm (water switch) shown in figure 3-52 is activated by water. When water enters the switch housing, the contacts of the switch are shorted and the alarm is energized. To test this type of switch, proceed as follows:

1. Notify all personnel concerned that a test of the alarm system is being conducted.
2. Obtain a bulb-type battery filler, and a small container in which to catch water.
3. Partly fill syringe with fresh water.
4. Remove drain plug on water switch (fig. 3-52) and place syringe stem flush against the drain opening. Slowly squeeze the syringe to force enough water into switch housing until the two contacts are shorted. This will energize the leakage alarm located in the ships damage control central.
5. When verification from DC central has been received that the alarm system is working properly, drain the switch housing and replace drain plug.



84.331

Figure 3-52.—Sprinkling system water switch SIZ 2.

Moisture within the switch housing can cause the alarm system to be activated. Ensure that the water switch (leakage alarm) is completely dry after testing.

AMMUNITION HANDLING AND SAFETY

The utmost care and prudence must be exercised in supervising handling, inspecting, testing, preparing, assembling, and transporting all types of ammunition. Men tend to become careless and indifferent when continually engaged in work with explosives and, as long as nothing occurs, are inclined to drift gradually into neglecting the necessary precautions. Nothing but constant vigilance on the part of the officers and petty officers in charge will ensure the steadfast observance of the rules and regulations which experience has taught to be necessary.

Safety is everyone's responsibility. Awareness of danger, knowledge of how danger can be avoided, and constant vigilance are the three basic requirements to prevent accidents when working with explosives. If a thorough understanding of the basic ideas behind the precautions is developed, unsafe conditions can be recognized and corrected and further suitable action can be taken instinctively when the unexpected occurs. Safety precautions pertaining to the handling of and working with explosives may be found in OP 4, Ammunition Afloat, OP 1014 Ordnance Safety Precautions, Their Origin and Necessity; and OP 3347 United States Ordnance Safety Precautions.

Safety precautions, rules, and regulations for handling explosives should be made the subject of frequent review, and the necessity for strict compliance with these precautions should be firmly fixed in the minds and habits of all hands involved in handling explosives so they will react in an emergency to the instruction previously received.

Attention is especially invited to the fact that in the early stages of the use of explosives, experience was gained at a great price—not only in dollars, but in human lives. No relaxation should be tolerated since this tends to create the impression that the rules are arbitrary.

Handling ammunition should be reduced to the minimum to prevent the occurrence of leaky containers, damaged tanks and cartridge cases, loosened projectiles, torn powder bags, etc., and thereby reduce the chances of accidents. The number of men allowed in the vicinity of explosives should, as far as is practicable and depending upon the requirements of the operation, be reduced to the minimum for properly performing the work at hand. It frequently happens that unnecessarily large working parties are assembled for handling live ammunition. Every effort and known precaution has been taken to make ammunition safe for handling under all known conditions. However, do not assume that an accident will not happen. Unnecessarily subjecting personnel to the effects of any accident is unwarranted.

There is a great amount of ammunition being handled at the present time. Much of this ammunition consists of new types which require precautions and handling methods that older, well-known types of ammunition do not require. These new explosives, some of which are more sensitive and powerful than explosives that were used before, are now being used extensively. They are not so sensitive, however, as to be unsafe to handle if the safety orders and precautions are observed. Even the least sensitive explosive may detonate if subjected to rough and improper handling. In handling explosives in any form, the fact must be borne in mind that they are potent and were meant to explode. Also, it must be remembered that they are intended to destroy the enemy, not our own ships and forces.

An explosion can result from improper handling of ammunition. Explosions, however, are not the only result of improper handling. Rough handling may damage ammunition to such an extent that it will not function as intended. Obvious reasons for avoiding such damage are:

1. A fighting ship's sole purpose is to destroy the enemy.
2. A fighting ship depends upon ammunition to accomplish its purpose.
3. A fighting ship without ammunition cannot defend itself and is a liability to its own forces in battle.
4. A fighting ship having ammunition that will not function is a fighting ship without ammunition.
5. The few minutes required to remedy a misfire or gun stoppage may be sufficient time to permit an enemy aircraft to attack successfully.

The following orders and precautions are excerpts from U. S. Navy Regulations and NAVORD manuals:

The Commanding Officer shall see that the officers and crew are instructed in the safety orders and all requirements regarding the care, stowage, handling, and examination of explosives, inflammables, and fuels as laid down in Navy Regulations and NAVORD manuals. He shall be responsible that all proper, necessary, and prescribed precautions are taken relative to the care, stowage, handling, and inspection of explosives, inflammables, and fuels on board ship.

The Weapons Officer shall be held responsible for the efficiency of the armament and all appurtenances connected therewith, and for the cleanliness and good condition of all ammunition stowage spaces and ordnance workshops, and of all ordnance storerooms not turned over to the supply officer of the ship. In addition, the Weapons Officer shall make or cause to be made such inspections, examinations, and tests thereof as may be prescribed. He shall also be responsible for the instruction of the officers and crew in the safety orders, and all regulations regarding the care, stowage, handling, and examination of explosives as laid down by Navy Regulations. In each part of the ship where ammunition is stored or handled or where weapons' appliances are operated, such safety orders as apply shall be posted in conspicuous places, of easy access, and the personnel concerned shall be frequently and thoroughly instructed and drilled in them.

All personnel in the naval service shall be carefully and frequently instructed in the safety precautions, methods of handling, stowage, and uses of all ammunition with which the vessel, aircraft unit, or station may be supplied. All persons must distinctly understand that their safety as well as the safety of others depend upon the intelligence and care exercised by themselves and by their fellow workers.

No one shall be permitted to undertake the inspection, preparation, or adjustment of live ammunition until he thoroughly understands his duties and the hazards involved.

New and inexperienced personnel must not be permitted to work alone, but shall be under direct and continual supervision of skilled and experienced persons.

Only careful, reliable, mentally sound, and physically fit persons shall be permitted to work with or use explosives or ammunition.

Personnel engaged in working with explosives or ammunition shall be limited to the absolute minimum number required.

Visitors and spectators, unless accompanied by an officer or for training purposes, shall not be permitted in a magazine, filling house, nor in the immediate vicinity of handling or loading operations of explosives or ammunition.

Anyone with information concerning defective ammunition, ammunition containers, or handling devices, or with information concerning rough and improper handling, or willful or accidental violation of the safety precautions, however slight, shall immediately report such information to his immediate superior. Persons found guilty of wilfull violation of the safety precautions and instructions relating to explosives or ammunition shall be punished; in the case of naval personnel, by appropriate disciplinary action; and in the case of civil employees under the Navy Department, by immediate dismissal.

The instructions pertaining to handling and stowage of ammunition prescribed in this portion of the text are of a general nature only, but shall be strictly observed, where applicable, by all naval activities afloat and ashore. It is difficult to cover every possible emergency which may arise and which, if improperly handled, may have serious results. When carrying out these instructions and the safety precautions contained in Navy Regulations, an attempt should be made to grasp the ideas upon which these instructions and regulations are based. Thus, if incidents occur which are not known at the time of their promulgation, the proper action may be taken instinctively. Additional instructions for the guidance of naval ammunition, mine depots, and shore magazines are contained in OP 5, Ammunition and Explosives Ashore. More detailed information will also be found in ordnance publications, or will be furnished by NAVORD upon request.

All personnel in the naval service whose duty it may be to supervise or perform work in connection with the inspection, care, preparation, or handling of explosives shall exercise the utmost care that all regulations and instructions are rigidly observed. No relaxation of vigilance with respect to handling will be permitted.

Whenever ammunition or explosives are being received, transferred, stowed, or prepared, the work should be supervised by an officer who is himself familiar with the rules concerning the care and handling of explosives, and who sees that all persons engaged are properly impressed with the necessity for exercising the greatest care. As stated before, any repeated, familiar work, no matter how dangerous, is likely to become perfunctory and to lead to carelessness; therefore, safety in the handling and in the stowage of explosives and ammunition demands constant vigilance and intelligent, close supervision to prevent accidents.

When embarking and discharging ammunition, the paramount consideration is safety and reliability; the receipt, discharge, preparation, and stowing of ammunition and explosives shall never be treated as a competitive evolution with regard to speed and methods.

Whenever the guns of a vessel are fired, the fire hose shall be connected and pressure shall be maintained on the fire main. This does not require water to be running through the hose.

Except in the case of an emergency, live ammunition and explosives should not be received or discharged from the ship or lighter at night.

A red flag shall be prominantly displayed during daylight on a ship (usually at the foretruck) when ammunition and explosives are being received or discharged. A red flag shall be flown in the bow of all boats, lighters, and other craft, and on-station rolling stock while loading and transporting ammunition and explosives.

Uncovered lights, matches, flame-producing devices, fires, and smoking shall not be permitted in the vicinity of exposed ammunition or explosives, nor in or near magazines containing explosives.

Magazines, lighters, and cars containing ammunition or explosives shall be kept securely closed and locked or guarded, except when required to be open for ventilation, cooling, inspection, or handling of the contents, in which case a responsible person must be in charge of the magazine or conveyance.

Ammunition or explosives for shipment by a common carrier must be marked and labeled in accordance with the Department Of Transportation regulations for the transportation of explosives and other dangerous articles, or in accordance with the United States Coast Guard.

As far as is practicable, explosives and ammunition offered for shipment by a common carrier shall also be packed to comply with the foregoing regulations, although these regulations state that:

"Shipment of explosives offered by the Army and Navy Departments of the United States Government may be packed, including limitations of weight, as required by their regulations."

Copies of these regulations, with specifications for shipping containers, will be found at all naval stations, ammunition dépots, and usually in all freight offices.

A permanent record shall be kept by naval activities of the car numbers of common carriers and the names of vessels loaded with explosives or ammunition.

The shipment by mail of explosives or ammunition in any form is forbidden.

Prior to taking ammunition and explosives aboard from a lighter, boat, truck, or car, or before a conveyance which has been loaded leaves the shipper, an inspection shall be made of its condition and security, and the contents of the conveyance shall be checked against the invoiced quantities. A report of shortages, errors, defects, and discrepancies shall be made.

Ships and shore stations receiving ammunition in leaky containers or showing evidence of rough or improper handling shall at once fully investigate the circumstances leading to this situation and submit a complete report to the Naval Ordnance Systems Command.

Lighters, boats, trucks, and railroad cars containing ammunition or explosives shall not be allowed to remain loaded any longer than is necessary. Such conveyances shall be guarded, and, as far as is practicable, isolated from private property in accordance with the station, port, municipal, Department of Transportation or other applicable regulations.

After unloading every conveyance shall be swept clean of loose explosives, ammunition, and dangerous refuse. This material must be destroyed or disposed of in a safe and proper manner.

If artificial light is needed for the examination or handling of ammunition or explosives, only carefully placed electric floodlights, approved magazine lanterns, or flashlights will be used.

Every precaution shall be taken to prevent ammunition or explosives from falling into unauthorized hands or from being stolen. Attention is invited to the fact that many state laws make it a felony for an individual to possess ammunition or explosives without proper authority.

Ammunition and explosive containers shall not be tumbled, dragged, thrown, or dropped on each other, or on the floor or deck. Bale hooks shall never be used on containers.

Projectiles should not be rolled, but should be handled by trucks, projectile tongs, and slings, whenever possible. When such methods are not feasible, sufficient dunnage shall be laid down and projectiles shall be rolled by hand and not be allowed to bump into each other, harming fuzes, damaging or loosening windshield caps, tracers, fuzes, bourrelets, rotating bands, and identification markings.

Ammunition, explosive containers, and projectiles must be hoisted and lowered slowly, and landed gently on a cushion of mats or old mattresses in order to prevent damage, leaks, and the loosening of windshields and caps on projectiles, etc. Ample time should be allowed for proper removal after the landing of a hoist.

Slides may be used for comparatively small or light containers capable of being readily handled by hand, provided:

1. That there is no drop at the end of the slide.
2. That containers are handled slowly enough and with sufficient care to permit steadying near the end of the slide and to allow removal without danger of striking other containers.
3. That thick cushions of mats or old mattresses are placed at the discharge end of the slide.

Heavy containers may be discharged or loaded by means of slides, provided that restraining lines are used to ease them down, and that the requirements as to the height of the discharge end and use of cushioning mats specified in the preceding paragraphs are met.

Barrels, drums, or kegs containing explosives and ammunition containers shall never be rolled, but shall be carried by hand or transported on trucks.

Care shall be taken not to obliterate or deface markings, labels, and tags on containers of ammunition or explosives. Inspect to see that the markings are intact.

Proper facilities shall be employed for the handling of ammunition and explosives. Where proper and ample means are not available, ships and stations shall improvise or take the necessary steps to obtain all necessary equipment for the safe handling of explosives and ammunition.

Blocks, lines, nets, shackles, slings, and projectile tongs or carriers, hooks, winches, hoists, conveyers, etc., must be frequently examined and repaired or replaced, as necessary, to ensure freedom from possible failure with the resulting danger of an accident. Brakes and controllers of hoisting motors shall be in efficient operating conditions, and hoisting speeds shall be so regulated that there will be no danger of jams or parting of lines. Sufficient trained personnel must be stationed for the safe operation of all hoists.

Any ammunition or explosive containers received or found in a damaged condition, or damaged or dropped in handling, shall be returned to an ammunition depot, or to other sources of ammunition supply, for forwarding to a depot. Powder tanks are so constructed that they will remain airtight only as long as the gaskets hold.

Care must be taken in handling powder tanks not to dent the body, open the seams, or loosen the top or bottom rings or covers which will permit exposure of the powder to the atmosphere. Periodic inspections must be made to ensure that tanks have not been improperly handled or stowed. In handling powder tanks, dents are frequently caused by the use of cargo nets, by rolling the tanks along decks and over obstructions, by allowing the bodies or rings to strike projections when hoisting or lowering, or by dropping them. When powder tanks are opened for inspection, the gaskets and general airtight condition of the tank should be observed. It is impossible to give a standard method for handling powder tanks, but, in general, they should be hoisted and lowered with care, carried along decks by hand, or transported by truck.

Some examples of the careless handling of powder tanks follow. A vessel turned in her service allowance of ammunition to a depot for overhaul. While the powder was aboard the ship, the reports of surveillance tests gave 60 days and the same index ashore gave 50 days, showing that the powder was, apparently, entirely satisfactory for continued use afloat for a number of years. However, during the overhaul, a number of leaky tanks were discovered and the tests on the powder taken from them gave a less than six-day surveillance test. Carelessness on the part of the personnel resulted in the unsatisfactory condition of these tanks. Many instances are on file in NAVORD where sister ships have turned in their service allowances for overhaul, one requiring practically no repairs and the other requiring most extensive repairs and replacement material. The investigation into the poor condition of one ship's outfit disclosed the fact that the powder tanks had been transferred from ship to lighter by dumping them down a chute. The only explanation for such utter disregard of existing instructions can be found in the failure of the personnel to appreciate the significance of their carelessness.

There are other serious conditions which arise from leaky powder. Powder in leaky containers will not only give different ballistic results from those determined on proof, but will give erratic results, to the serious inconvenience of fire control. The serious nature of permitting ammunition to deteriorate so that it becomes not only ineffective but dangerous and erratic in battle should be obvious to every person who participates in the teamwork necessary to produce the correct answer in battle; namely, "hits per gun per minute."

Smokeless powder in leaky containers shall be landed for replacement at the earliest practicable moment after discovery, unless a surveillance test shows it to be in normal condition, and that the container can be repaired.

When ammunition is being embarked or discharged from a ship, a cargo net should be rigged between the ship and dock, or conveyance, to catch any ammunition that may be dropped. The cargo net should be covered with a tarpaulin if the pieces being handled are small enough to pass through the mesh of the cargo net. Cargo nets alone should not be used for transferring empty or filled tanks or other ammunition containers likely to be damaged. In hoisting and lowering ammunition containers with cargo nets, a rigid wooden platform or base should be fitted in the net upon which the containers can be placed, stacked, or piled upon their stowage rings in such a manner as to prevent shifting and bumping each other, or exerting pressure upon their sides.

The wooden platform (or base) shall be made of good solid wood, strong enough to bear the load with a wide margin of safety, and sufficiently rigid so as not to bend under the load. It may be made rigid by the addition of heavy beading around the edges of the upper side. This beading serves a second useful purpose by preventing the containers or pieces from sliding off the platform, and by holding tanks in place so that they remain stacked.

The platform must be of a width greater than the length of the cartridge or powder tank, if the tanks are to be stacked, so that the weight of the tanks will be borne by the stacking rings. It may be squared or circular in shape and should not be of such width or diameter that the net will not extend well around the load to be hoisted. For general use, the square platform is preferred.

The advantages of using a square-type platform lie in the fact that it may be used with most types of ammunition that can be handled by hand. Cartridge or powder tanks may be stacked so that they interlock and the weight is borne by the stowage rings. Or projectiles may be laid on their sides; the beading serves as a check for the stacks and prevents the load from sliding off the platform. There are, however, some disadvantages in using the square-type platform. It is cumbersome and difficult to handle and has corners which may protrude through the net and hang up on obstructions. The sides of the net will not extend up far enough to completely cover all high loads.

The square-type platform shall be placed as near the center of the net as is practicable, with the sides of the platform diagonal to the sides of the net. This will cause the load to land level when suspended and permit the corners of the net to be pulled well up the side of the load. Loads that are not interlocked shall never be stacked so high that the bottom of the top layer is higher than the lowest part of the sides of the net.

The net shall be lined with canvas if the pieces handled are small enough to pass through the mesh of the net.

The projectiles shall be alternately placed on the platform to provide an even stowage, and placed so that the noses and the bases are together. This is important in order to prevent the point of a projectile from possibly striking the tracer in the other projectile, with the subsequent danger of igniting the tracer. Particular care shall be taken to prevent the projectiles from rolling or shifting. If the platform is not completely loaded, the projectiles should be placed so as to balance the load.

Although the square-type platform is preferred, the circular-type (pie plate) may be used in cargo nets when transferring ammunition or empty containers. The advantages of the circular platform lie in its ease of handling, and in the fact that it has no corners to protrude through the net to catch obstructions. Also, its shape permits the forming of the net around the entire load when hoisted. As in the use of the square platform there are disadvantages in using the circular platform. It is not normally used with projectiles or cartridge tanks, because the cargo must be stood on end which increases the likelihood of its toppling or sliding if the load is tilted.

In using the circular-type wooden platform, place it as near the exact center of the net as is practicable, so that the load will hang level when suspended. A canvas lining should be used in the net if the pieces being handled are small enough to pass through the mesh of the net.

If powder cartridge tanks or projectiles are to be loaded in sufficient number on a platform, it will be necessary to stand them on end. Some means must be taken to prevent their toppling over. This may be done by lashings, or by placing a second cargo net down on top of the load. When a second net is used with projectiles, push it down to force the projectile noses up through the net.

Ammunition and empty containers in palletized unit loads may be transferred in cargo nets without the use of a platform. The unit load or pallet shall be placed as near the center of the net as is practicable and with the sides of the pallet diagonal to the sides of the net.

A modified salmon board may be used in transferring ammunition and empty containers. Rope slings are provided to pull the netting up around the load. When loaded with cases, the spreader bars will act as clamps to hold the load solidly in place. The platform must be wide enough to permit stacking the tanks so that the weight will be borne by the stowing rings.

When ammunition is handled with wire nets, heavy canvas should be used in the net to prevent sparks and to protect the paint and markings. Use some means to keep the projectiles from being damaged by their being crushed together when hoisted.

If the projectiles have windshields and/or caps, special care must be taken to prevent their being loosened or damaged in any way.

In the case of emergency, where a platform is not available and the use of cargo nets in transferring tanks is necessary, a suitable substitute for a platform may be made by using four lengths of heavy timber to form a frame of such width as to permit stacking the tanks properly, with the ends of the tanks resting on two of the sides of the frame. In the event that this is not possible, take action to prevent damage to the tanks, and line the net with a heavy tarpaulin to prevent the ends of the tanks from becoming entangled in the mesh of the net. A heavy mat placed in the net will lessen the tendency of the net to squeeze the load.

When cargo nets, without platforms, are used in transferring projectiles (5- and 6-inch), they should be of the close-mesh type and heavy tarpaulin placed in them to prevent the projectiles from being forced out through the mesh. The projectiles should be stacked on their sides in a single tier in the center of the net. If more than one tier is used, they will be crushed together in the center when the load is lifted. The maximum load handled in a rope cargo net should not exceed 2400 pounds.

The following specifications for an ammunition chute, or slide, are taken from U. S. Coast Guard Regulations:

Chutes for loading and unloading explosives shall be constructed of smooth, planed boards, not less than one inch thick, with side guards of the same material four inches high. Assembly shall be made with brass screws only. D-shaped wooden strips or runners not more than six inches apart, running lengthwise on the chute, shall be fastened to the upper surface of the slide by means of glue and wooden dowels extended through the bottom of the chute. No metalic fasteners used in construction shall protrude above or beyond the inner face of the chute. Four lashing rings shall be provided, one at each corner of the chute, for the purposes of securing during use.

The strips on the surface of the slide serve to reduce friction and to keep cartridge tanks and similar pieces in the center. The slide will have a tendency to creep when in use, due to the weight of the ammunition and the movement of the ship; consequently, it should be well secured to prevent its being upset or dropping off the side.

If cargo mats or old mattresses are not available for dunnage, some substitute must be used, such as folded cargo nets, folded tarpaulins, or hawser or line, flemished or faked down.

Never slide projectiles down a slide nose-first, unless a restraining line is used. The base of the projectile should be toward the lower end of the slide. Ammunition containers that have a removable lid should, if possible, be handled with the lid toward the high end of the slide.

Eyebolts are available in two sizes, a larger size for use with 16-inch projectiles, and a small size for use with eight-inch projectiles.

The eyebolts fit into socket holes in the base plug of projectiles, two holes being provided in major caliber projectiles.

Eyebolts are used in supplying projectiles to the guns in some turrets and used in the emergency supply of projectiles to eight-inch turrets. They may be used in loading projectiles if projectile carriers are not available for use. However, the eyebolts should not be used if carriers are available because of the difficulty in landing the projectiles without damaging windshields and caps.

The greatest care must be exercised in handling loaded and fuzed projectiles. A loaded and fuzed projectile which has been dropped from a height exceeding five feet must be set aside and turned in to an ammunition depot. Such a projectile must be clearly marked to show its condition and must be handled with the greatest care. Upon receipt at a naval ammunition depot, it must be defuzed and the fuze scrapped. Fuzes are designed and manufactured so that a fuzed projectile may be dropped without causing a fuze to function, but additional drops or the shock of firing may cause a fuze action. Rotating bands on projectiles for separated ammunition have non-fringing lips which are easily damaged. Particular care is required to prevent damage to the band.

The standard projectile carrier should be used at all times on projectiles of calibers larger than eight inches, unless emergencies arise which justify the risk using improvised slings. Carriers are provided for projectiles of 6"/47 (and larger) caliber.

Extreme care must be taken in handling projectiles fitted with caps and/or windshields to prevent loosening the cap or windshield. The caps and windshields shall be protected from jolts and stress when being handled manually or with handling devices. Slings which support a part of the weight of the projectile on the cap or windshield should not be used.

A skip box (cargo box) is an ideal device for handling ammunition that is light enough to be handled by hand. It furnishes complete protection from stresses or crushing effect when properly loaded. In loading the skip box, the load must not be piled higher than the sides or pieces may slide off or be subjected to pressure by the slings. Navy yard skip boxes are usually available for use when loading ammunition while moored to a Navy yard dock.

If the box is not completely filled with projectiles or containers, the load shall be placed in the box so that it is evenly balanced and precautions must be taken to prevent the projectiles from shifting or tumbling. The hook points of the sling on the skip box should be outboard to prevent their disengaging when the sling is slacked.

Fuzes that are not permitted to be stowed in assembled bombs or other types of ammunition must be well removed from high explosives. Fuzes are dangerous to handle, assemble, and disassemble; unskilled personnel must never undertake such work.

Detonators are sensitive to shock, dangerous to handle, and require special stowage spaces. Detonators requiring separate stowage must be well removed from all high explosive stowages.

When detonators or blasting caps (both electric and nonelectric) are received in a shipment for stowage aboard ship, carry them aboard by hand and place them in their assigned stowage space prior to removal of the balance of ammunition from the lighter, truck, or other conveyance used. They must not be placed in a cargo net or sling load of ammunition.

If the quantity of detonators is so large as to make transfer by hand impractical, load them on a skip box or some other similar contrivance that will assure protection from crushing and damage. Cargo nets alone, or any similar contrivance without platforms to prevent crushing, must never be used. Coast Guard regulations limit the weight of any one hoist load of detonators to 1000 pounds. Detonators should never be transferred by means of a slide.

Detonators should be transported, if practicable, in a conveyance that does not contain other types of ammunition explosives. If this is not practicable, the detonators should be at least 10 feet from other live ammunition or explosives. If the distance is less than 10 feet, a barrier of two-inch planks on four-by-six framing shall be interposed between them, and bags of sand piled around the detonators, if available. If the load includes inert material such as bombs tails, depth charge pistols (except the Mk 7-1 and extenders), or other less hazardous types of ammunition i.e., small arms without explosive bullets or pyrotechnics, this material may be placed between the detonators and the high explosives or munitions containing high explosives.

In peacetime, fuzes or detonators must not be placed with a shipment, load, or lot of bomb-type ammunition or other high explosive material, but must be forwarded in a separate shipment. In wartime, however, detonators can be shipped in the same car or truck as boosters or warheads provided certain precautions, as laid down by the Interstate Commerce Commission, are observed.

The purpose of the section on ammunition handling and safety is to point out some of the more important regulation, safety orders, and precautions observed in handling ammunition. Current safety instructions issued by NAVORD SYSCOM and United States Navy Regulations reflect all the current safety regulations necessary and prescribed for all types of ammunition and explosives. It is the responsibility of all personnel in the GMG rating to be up-to-date on all safety precautions related to handling, stowage, and use of all types of ammunition associated with the vessel or station to which he is assigned.

CHAPTER 4

SMALL ARMS AND MACHINEGUNS

Strictly defined, the term "small arms" means any firearm cal. .60 inch or smaller. As far as you are concerned (there are no .60 cal. weapons in the Navy) this means that all weapons from the .22 cal. pistol up through the .50 cal. machinegun are small arms. Such weapons are carried aboard ship primarily to equip personnel assigned to the landing party, and certain watch standers or sentries for the ship's internal security.

As a third class, you will be concerned with pistols, rifles, and shotguns. Second class gunner's mates must know the .50 cal. and M60 (7.62) machineguns. Your responsibility in the field of small arms is twofold. First, you must know how to assemble, disassemble, overhaul, and repair small arms. Second, you must be able to train other personnel in the operation, safe handling, and the care and cleaning of small arms.

As the majority of small arms are of Army issue, you will find that the best reference publications for these items also come from the Army. Army technical manuals (TMs) are especially useful to the small arms repairman. Army field manuals (FMs) are prepared for the man in the field—the man who is going to shoot the weapon. You should have a complete set of these publications in your armory. An index of Army FMs is found in Army pamphlet 310-3. The index for TMs is Army pamphlet 310-4. OD 39397 also lists Army publications and Navy ordnance publications pertaining to small arms.

Another important tool in the identification of parts and maintenance of small arms are the Maintenance Requirement Cards (MRC's). These you will use in the maintenance and upkeep of all small arms.

Before we begin our study of the individual weapons, let's examine some of the quirks in small arms nomenclature. For the most part, terminology pertaining to the weapons themselves is fairly standard. This is because the Navy has adopted most of the Army's system of identification. For example, the Army uses the letters M and A instead of mark and mod. This means that "Carbine M1A2", in Navy language is the same as "Carbine Mk 1 Mod 2".

Much of the confusion surrounding small arms terminology lies in cartridge or round designations. Perhaps you know how the gage of shotguns is determined, but what is the difference between .30-06 and a .30-30 round of ammunition? Actually, a .30-30 means that the cartridge has a caliber of .30-inch and contains 30 grains of propellant powder. The .30-06 cartridge, for which the M1 rifle (former Navy standard issue) is chambered, also has a caliber of .30-inch but the numbers -06 in this case mean the round was standardized in 1906.

The diameter of a shotgun's bore is referred to as the "gage" of the shotgun. Gage is not a measurement of inches or millimeters. Instead, it means the numbers of lead balls of that particular diameter required to make a pound. For example, if you measured the diameter of the bore of a 12-gage shotgun, you would find it to be 0.729 inch. If you were to make a number of lead balls of this diameter and weigh them, you would find that 12 of them would make a pound.

So, the larger the bore of a shotgun, the smaller the gage number. A 16-gage shotgun has a smaller bore than a 12-gage.

CYCLES OF OPERATION

In every weapon there is a cycle of operation. This cycle is a group of actions which take place upon the firing of one round and which must occur before the firing of the next round. In the automatic small arms currently used by the Navy, the sequence or manner of accomplishing these actions may vary between weapons of different design, however, they are always performed.

There are eight steps in the cycle of operation; they are shown in figure 4-1.

FEEDING

This action places a round in the receiver just to the rear of the chamber. In its simplest form it amounts to putting a cartridge by hand in the path of the device which will chanber the round. Most often feeding is accomplished by a spring-loaded follower in a magazine or clip.

Magazines have a limited capacity which cannot sustain the continuous rate of fire required by machineguns. Therefore machinegun ammunition is belted, and the rounds are fed to the rear of the chamber by cam and lever action.

CHAMBERING

This action is required to ram a new round into the chamber. Again in its simplest form, this amounts to placing the round there by hand. In military weapons chambering takes place as the forward moving bolt strips the round from the feed mechanism and forces it into the chamber. The bolt closes on the cartridge and the extractor snaps into the extracting groove machined around the base of the cartridge case.

LOCKING

This action holds the bolt in its forward position for a short period of time (after firing) to prevent the loss of gas pressure until the bullet has left the muzzle of the gun. For low-powered weapons, it is possible to seal the breech for a short time by merely beefing up the weight of the bolt. The bolt does start to move upon firing, but, if sufficiently heavy, it will not move far enough to release the gases until their pressure has been satisfactorily reduced. This method is used on submachine guns.

FIRING

Firing occurs when the firing pin strikes the primer of the cartridge.

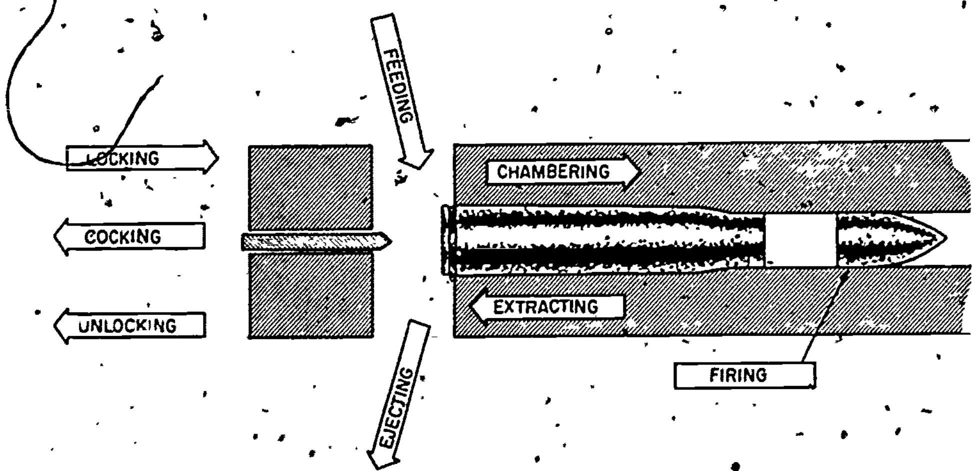
UNLOCKING

Unlocking occurs after the firing of the round. Actions for unlocking are just the reverse of those required for locking. For most rifles the first movement of the bolt is a rotating one, disengaging the locking lugs.

After this the bolt moves to the rear. In the straight blowback type bolt there is no camming action, the cartridge is held in the chamber until the gas pressure overcomes the inertia of the heavy bolt, forcing it to the rear.

EXTRACTING

This is the process of pulling the empty case back out of the chamber. The extractor (normally a small hooked piece of metal encased in the bolt) snaps over the rim of the cartridge case when the round is chambered. As the bolt moves rearward after firing, the extractor hauls out the empty brass.



84.235(84)

Figure 4-1.—The eight steps in the cycle of operation.

EJECTION

It is not only necessary to pull the cartridge case out of the chamber, but also to throw it free of the receiver. This action is called ejection and is created by placing a small projection on one side of the receiver so that as the bolt and case move to the rear the case will strike the projection and be expelled from the weapon. This method is used in the .45 cal. pistol. Another method of accomplishing this step is to incorporate a spring-loaded ejector in the face of the bolt. In this arrangement the case is flipped from the weapon as soon as its forward end clears the chamber. This method is used in the M14 rifle.

COCKING

Cocking is the retraction of the firing mechanism (firing pin and hammer) against spring pressure so that there will be sufficient energy to fire the cartridge in the next cycle of operation. The firing pin, hammer, or in some cases, the bolt itself, are held in a cocked position by a piece called the sear.

Again, firing is initiated by squeezing a trigger. This movement trips the sear, releasing the firing mechanism (firing pin, hammer or, in automatic weapons, such parts as the bolt group or slide), causing it to move forward with enough force to discharge the round.

AUTOMATIC AND SEMIAUTOMATIC FIRING SYSTEMS

A semiautomatic weapon unlocks, extracts, ejects, cocks, and reloads automatically, However, the trigger must be pulled each time to fire a round. By this definition, the .45 cal. "automatic" pistol is actually semiautomatic. A fully automatic weapon keeps firing as long as the trigger is kept pulled.

Two examples of weapons that can be fired both automatically and semiautomatically are the 7.62mm M14 rifle and the 5.56mm M16A1 rifle.

SMALL ARMS OPERATING PRINCIPLES

Automatic and semiautomatic weapons are classified on the basis of how they obtain the energy required for operation. Fundamentally, small arms obtain the energy from the forces that accompany the explosion created when a round of ammunition is fired. The use of these forces does not reduce the effectiveness of the weapon, but utilizes otherwise wasted energy.

There are three primary methods in which the wasted energy can be used to operate the weapon. Figure 4-2 shows the three methods in which the pressure from the exploding cartridge is used to operate a weapon. They are gas operated, recoil operated, and blowback operated.

Gas Operated

In gas operated weapons, a portion of the expanding powder gases behind the bullet are tapped off into a gas cylinder located beneath the barrel. (The hole connecting the barrel and cylinder is near the muzzle end.) As the bullet passes this hole, gases enter the cylinder, strike a piston, and push this piston rearward. The piston is connected by a rod to an operating mechanism of the weapon, such as the bolt. The piston carries the bolt aft with it, unlocking, extracting, ejecting, and cocking the weapon.

Recoil Operated

As a round is fired, high pressures develop behind the bullet and force it down the barrel. The force behind the bullet is also directed rearward against the breech. If the barrel and bolt are secured to one another, the entire force of recoil is felt on the shooter's shoulder. But, by designing the barrel and breech assembly so

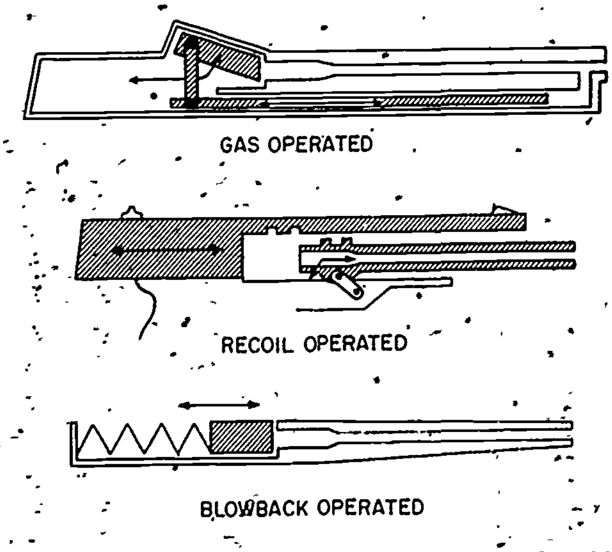


Figure 4-2.—Types of operating systems.

that they can slide in the frame or receiver, the energy of the rear moving assembly can be used to compress springs, move levers, etc, necessary to complete the cycles of operation.

Generally, in recoil operated weapons, the barrel and the bolt move rearward together for a short distance. Then the barrel is stopped and the bolt (now unlocked) continues to the rear against spring pressure until the empty case is ejected. The force of recoil is also used to cock the weapon and compress the spring, returning the bolt to its firing position and chambering a new round in the process. The .45 cal. pistol is an example of a recoil operated weapon.

Blowback Operated

There are similarities between recoil and blowback operated weapons. But there are several major differences. In recoil operation, the bolt and barrel are locked together until the bullet has left the barrel, and most of the recoil thrust is spent. The combined thrust of the recoiling barrel, bolt, and some other parts are used to operate the weapon. In blowback (inertia) operation, however, the bolt is not locked to the barrel and in most cases the barrel does not recoil. The bolt is held closed by spring pressure and the mass of the breechblock. The initial blow of the exploding cartridge starts the bolt moving rearward, but the weight of the bolt is such that it does not allow the chamber to be entirely opened until the round has left the bore. Action by a recoil spring returns the bolt to the closed position, chambering a new round.

Thus the weight of the breechbolt is an important factor in the design and operation of a blowback operated weapon. When used with low powered ammunition, it is a suitable arrangement. A military rifle however, using the standard .30 cal. cartridge and the blowback action would require a 27-pound breechblock.

Besides the submachineguns, many types of so-called "pocket automatic" pistols and .22 cal. automatic rifles use blowback operation.

HANDGUNS

There are two handguns used by the Navy today—the .45 cal. automatic pistol and the .38 cal. Smith and Wesson revolver. The .45 cal. automatic is the standard service pistol used by sentries, watchstanders, and some members of the ship's landing party. The .38 cal. revolver, because of its lighter weight, is frequently issued to flight personnel, instead of the .45 cal. pistol.

Handguns are characterized by their short range and small magazine capacity, and their purpose – which is generally defensive in nature.

.45 CALIBER AUTOMATIC PISTOL

During the uprising of the Moro tribes in the Philippines during the early 1900's, it was found that the fanatic tribesmen often were not stopped when hit by bullets from the .38 cal. sidearms then used by American troops. This lack of stopping power was one of the factors which led to the adoption in 1911 of the .45 cal. automatic pistol as the official military sidearm.

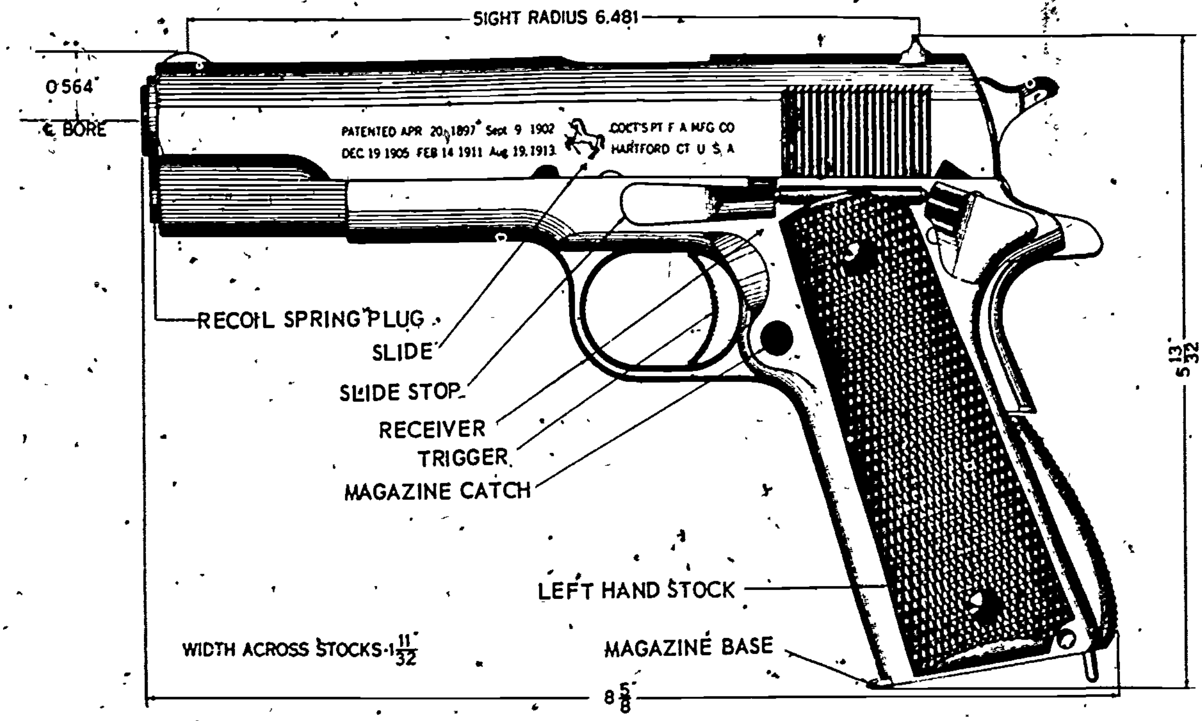
The .45 cal. automatic pistol, often called the "Colt", was designed and patented by John M. Browning who was probably the world's greatest inventor of automatic weapons. The original model 1911 differs only in minor detail from the current model 1911A1. Operation of the two models is identical. Figure 4-3 shtws the pistol with nomenclature for some of the external parts.

The caliber .45 pistol M1911A1 is a recoil-operated, semiautomatic, magazine fed, self-loading handgun with fixed sights. It is often called an "automatic pistol", but based on our previous definition, it is a true semiautomatic weapon. The magazine holds seven rounds when fully loaded; one round is fired with each squeeze of the trigger. Rifling in the barrel is left hand twist (the only Navy weapon with left hand rifling). Empty, the pistol weighs approximately 2-1/2 pounds. It has a maximum range of a little over 1600 yards, and an effective range (in the hands of troops) of about 50 yards.

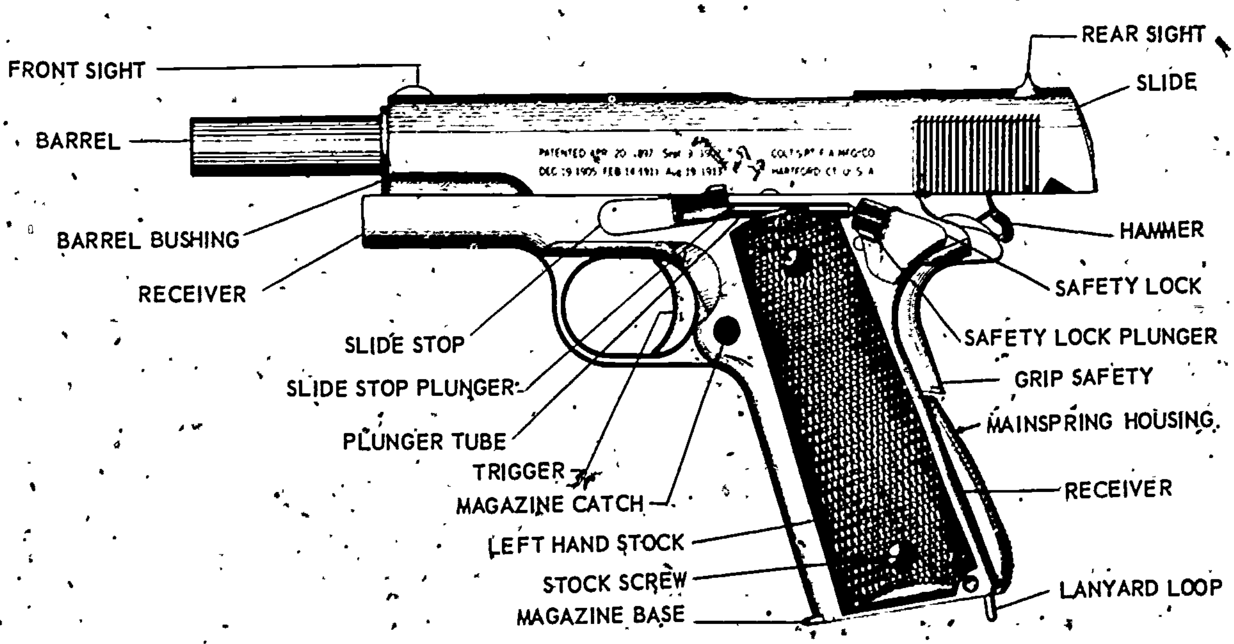
DISASSEMBLY

Care of the pistol includes daily preventive maintenance, prefiring cleaning, and postfiring cleaning. For daily maintenance the pistol need not be disassembled but, for the prefiring and postfiring cleaning, the pistol should be disassembled.

There are two phases of disassembly for the pistol, general disassembly (field stripping) and detailed disassembly. General disassembly (fig. 4-4) is the disassembly necessary for normal care and cleaning and after the weapon has been fired. This is the extent of disassembly that is generally explained to personnel such as watchstanders. The detailed disassembly of the receiver group



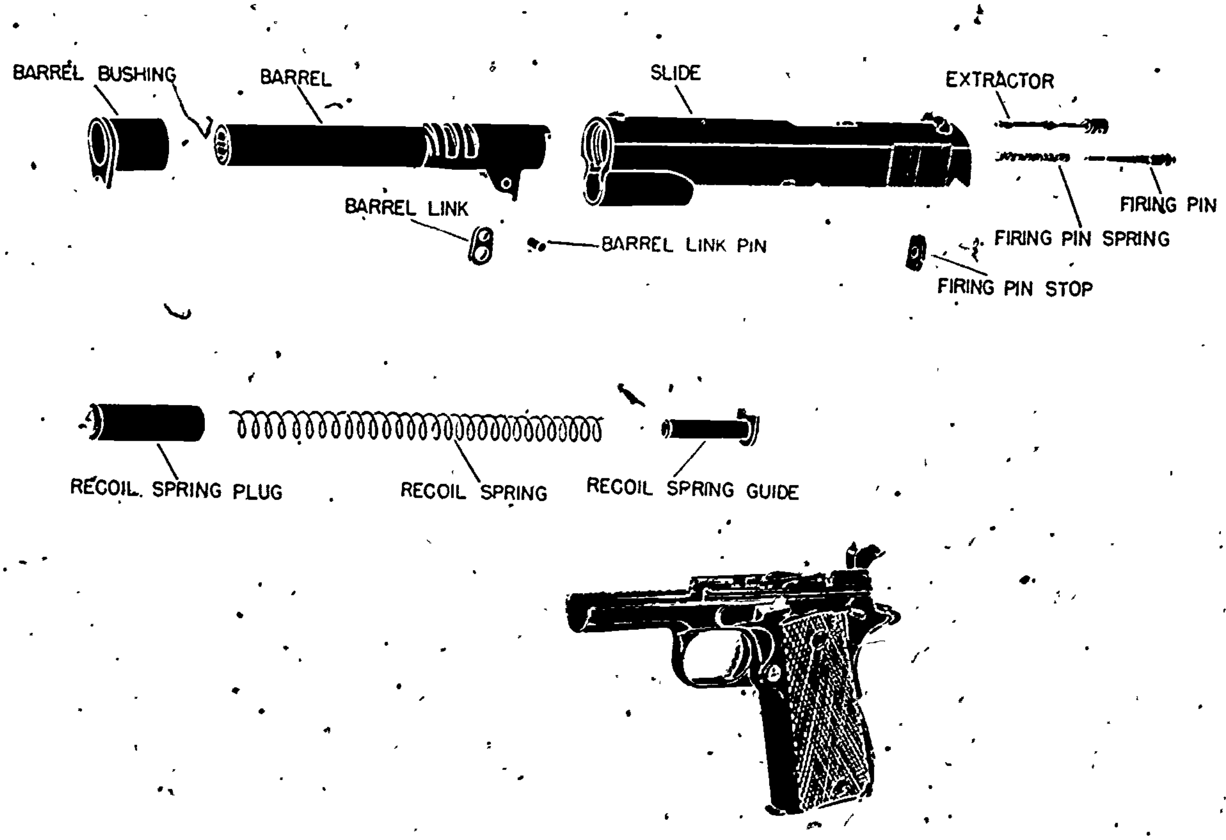
A



B

17.42

Figure 4-3.—Automatic pistol, caliber .45, M1911A1. A. Slide closed. B. Slide open.



17.42.1

Figure 4-4.—The pistol in a field stripped condition.

(Fig. 4-5) is the job of the Gunner's Mate during periodic cleaning and repair.

To do a good job of cleaning and repair, it is essential that you know the names of the parts of the weapon. The nomenclature of parts of the pistol should be learned while practicing disassembly and assembly. As each part is removed and replaced, the nomenclature is repeated until known. While studying the disassembly and assembly of the pistol, refer to the illustrations showing the parts by name and description. Become thoroughly familiar with them and their function. Knowing the names of the parts also will help you understand the operation of the weapon.

General Disassembly (field stripping)

Prior to performing any work on the pistol, remove the magazine and pull the slide to the rear and inspect to see that the weapon is clear. Then perform the following steps:

1. Cock the hammer and put the safety lock in its up (SAFE) position. Depress the recoil spring plug and turn the barrel bushing about a quarter turn clockwise. This releases the tension on the spring. Allow the spring to expand slowly, under control, to prevent injury or loss of parts. Turn the recoil spring plug counterclockwise and remove it from the recoil spring. Move the safety lock back down to its FIRE position.

2. Draw the slide to the rear until the half-moon recess (on the slide) is directly above the projection on the slide stop. Push out the slide stop from right to left.

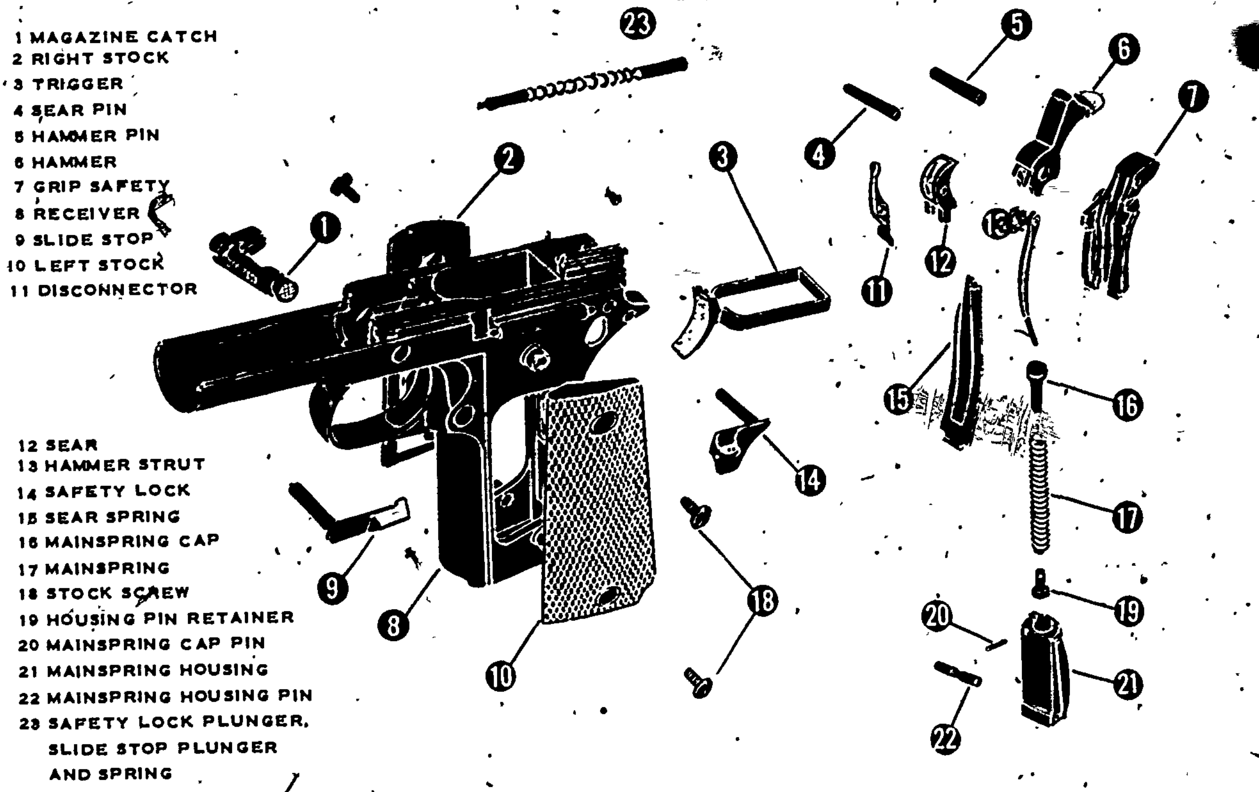
3. Turn the pistol upside down and draw the receiver to the rear, disengaging it from the slide. Lay the receiver down.

4. Draw the recoil spring and its guide to the rear and out of the slide.

5. Take the barrel bushing out of the slide by turning it counterclockwise as far as it will go, then lifting up.

6. Lay the barrel link forward and pull the barrel out of the muzzle end of the slide.

7. Take out the firing pin. To do this, press in on the rear of the firing pin with any pointed object until you can slide out the firing pin



17.42.2

Figure 4-5.—Receiver group.

stop. Keep your fingers over the firing pin, allowing the spring tension to ease; then lift both firing pin and spring from the slide.

8. Pry the extractor out of the rear of the slide.

Detailed Disassembly of the Receiver Group

Disassembly of the receiver group into its individual parts as seen in figure 4-5 is done as follows:

1. The hammer should still be in its cocked position. Move the safety lock up and down, at the same time pulling it outward from the receiver. (Do not use any tool to pry the stop out.) With the safety lock removed, squeeze the trigger, and allow the hammer to EASE FORWARD.

2. Remove the mainspring housing pin. This step requires a good deal of force, so the receiver must be placed on a sturdy supporting surface. The end of the safety lock pin can be used to push the mainspring housing pin out.

3. Remove the mainspring housing. Take out the grip safety and the sear spring.

4. Using a drift pin, punch out the hammer pin; then lift the hammer from the receiver.

5. Drift out the sear pin from right to left, and let the sear and disconnector drop out into your hand.

6. Press the magazine catch in until flush with the left side of the receiver. Then, using the short leaf of the sear spring, turn the magazine catch lock one quarter turn counterclockwise. Lift the magazine catch from the right side of the receiver.

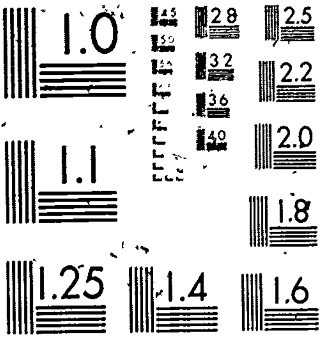
7. Remove the trigger from the rear of the receiver.

8. Remove 4 stock screws and left and right stocks.

ASSEMBLY

Assembly of the weapon is also covered in two phases: First the receiver group is assembled. At the end of this phase the weapon is in a field stripped condition. Then the field stripped weapon is assembled.

96



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

Both phases of assembly are done by performing the disassembly procedures in reverse order. Here are four hints which should be helpful in assembling the pistol—

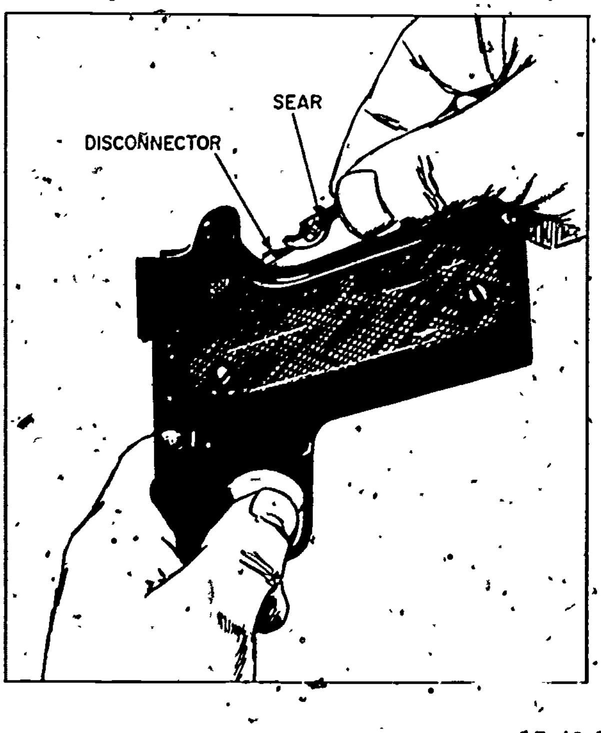
1. All pins go in from left to right.
2. Place the sear and disconnector in as one unit, fitted together as shown in figure 4-6.
3. When you place the sear spring in position, have the mainspring housing ready to slide up about three quarters of the way into the receiver to hold the spring in place.
4. Make sure that the hammer strut is actually fitting well down into the mainspring cap before sliding the mainspring housing into place. Sometimes the hammer strut will catch on top of the cap instead of properly seating in the cap's recess.

SAFETIES

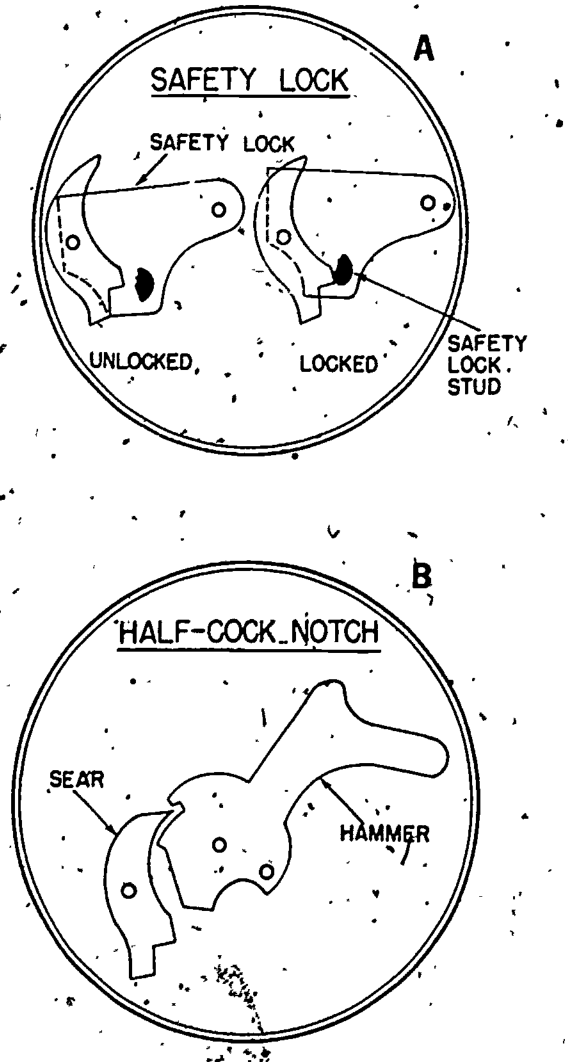
There are four safety devices on this pistol. The two manual safeties are the safety lock (sometimes called the thumb safe) and the half-cock notch. The two automatic safeties are the grip safety and the disconnector. Although the disconnector is classed as a safety, it is not considered a positive safety as are the three safeties mentioned above since it is designed to cause the pistol to fire semiautomatic fire and cannot be controlled by the shooter.

The safety lock positively locks the slide in the forward position. In addition, a stud on the safety lock (fig. 4-7A) blocks the shoulders of the sear to prevent any movement of the sear out of the full-cock notch of the hammer.

The half-cock notch is the notch just above full-cock notch. It has a lip which prevents movement of the sear from that notch when pressure is applied to the trigger. (See figure 4-7B.)



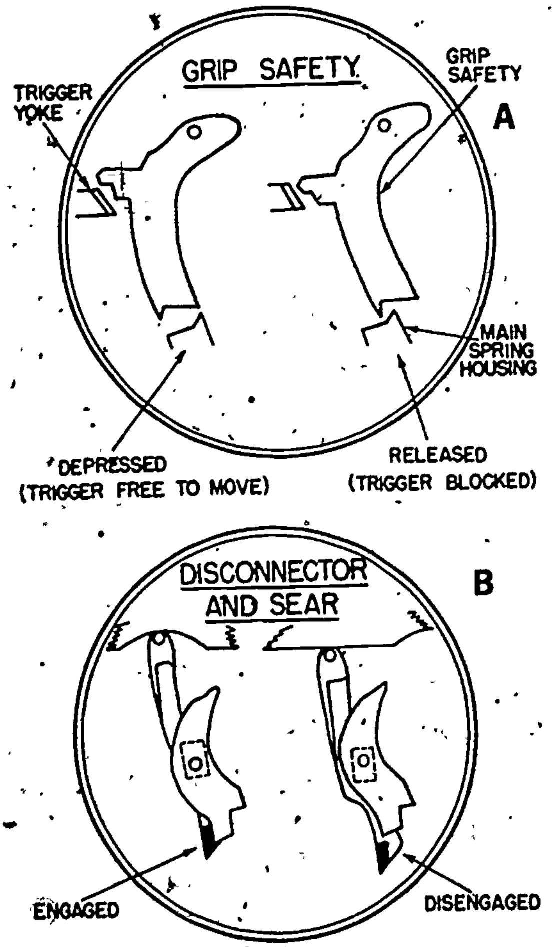
17.42.3
Figure 4-6.—Replacing the sear and disconnector.



17.42.4
Figure 4-7.—Manual safeties.

The grip safety (fig. 4-8A) indirectly stops any movement of the sear by blocking trigger movement. If the trigger cannot be actuated, the sear cannot move, and the hammer will not fall.

The disconnector (fig. 4-8B) prevents firing unless the slide is fully forward and locked. When the slide is forward, the disconnector rides up into a recess on the underside of the slide. The spade of the disconnector (dark area) bears against lugs on the sear. When the trigger is pulled, the trigger yoke pushes back against the disconnector spade which transmits the motion to the sear, rotating the sear nose out of the full-cock notch of the hammer, and the weapon fires. At any time the slide is not fully forward, the nose of the disconnector is forced downward. In this condition the disconnector spade does not contact the sear when the trigger is pulled. When the trigger is pulled, the disconnector will be pushed to the rear but the sear remains in position, holding the hammer to the rear.



17.42.5

Figure 4-8.—Automatic safeties.

CYCLE OF OPERATION

Refer to figure 4-3 as we explain the functions of the pistol. We will assume that a loaded magazine is in the weapon, a round is in the chamber, the grip safety is depressed, the trigger has been squeezed, and the round ignited. The cycle of operation now begins.

As the gases from the burned powder expand, the bullet is forced down the barrel while the same force is directed rearward against the slide. The slide and barrel are locked together at this point, and both are forced aft. The barrel link is attached to the stationary receiver, so the barrel is moved downward as well as to the rear. As the barrel locking ribs are disengaged from the recesses in the slide, unlocking is completed.

As the slide moves aft in recoil, the extractor pulls the empty case along with it. Extraction is completed when the cartridge clears the chamber.

Ejection occurs when the cartridge strikes the stationary ejector, pivots on the extractor, and flips from the weapon through the ejection port.

Cocking began as soon as the slide started its recoil movement. The hammer is moved rearward and the hammer strut is pushed down against the mainspring, compressing it. When the slide strikes the recoil spring guide collar, its rearward movement is stopped. The recoil spring then causes the slide to begin its forward movement. The hammer follows the slide for a short distance. Then the sear, which bears against the hammer through the action of the sear spring, enters the full-cock notch of the hammer and holds it in a cocked position.

Feeding starts as soon as the slide, moving to the rear, clears the top of the magazine. The magazine follower, under pressure from the magazine spring, forces the top round against the lips of the magazine. This places the top cartridge in position to be picked up by the face of the slide during its forward movement.

Chambering occurs when the forward moving slide pushes a new round into the chamber. As the bullet is pushed up the ramp into the chamber, the base of the cartridge slides up the face of the slide. As this happens the groove on the base of the cartridge is engaged by the hooked extractor.

After chambering, the slide continues forward a small distance, pushing the barrel ahead of it. As the barrel moves, it pivots up and forward on the barrel link. The locking ribs on the barrel enter the locking recesses in the slide, thereby locking the two together.

Firing will start the cycle all over again. When the grip safety is depressed and the trigger is squeezed, the trigger yoke presses against the disconnector, which pushes aft on the sear. The sear rotates on its pin, disengaging from the notch on the hammer. The mainspring pushes up on the hammer strut, rotating the hammer forward. The hammer strikes the firing pin which, in turn, strikes the cartridge primer.

.38 CALIBER SMITH AND WESSON REVOLVER

You will find the .38 cal. S & W revolver (fig. 4-9) in armories ashore, where it is used by men assigned to guard or police duties. Because it is lighter than the .45 cal. automatic, the .38 is frequently issued to flight personnel. This weapon has about the same maximum and minimum ranges as the .45 cal. automatic-1600 and 50 yards, respectively. Figure 4-10 shows the revolver disassembled to the extent usually required for normal care.

Operation

In this discussion, operation of the revolver is limited to loading, firing, and unloading. To load the revolver, the cylinder must be swing out by pushing forward on the thumb piece and applying a little pressure on the right side of the cylinder. The thumb piece will not release the cylinder if the hammer is cocked.

NOTE: The cylinder should not be flipped out sharply because this can cause the crane to be bent, throwing the cylinder out of timing.

Insert a round in each of the cylinder's 6 chambers, and swing the cylinder back into position. The weapon is now loaded and ready to be fired.

The revolver can be fired by single or double action. For single action firing, the hammer is pulled back with the thumb to the full-cock position for each round. This action also rotates the cylinder. The hammer is held in the cocked position by the sear until released by the trigger. In double action firing, pulling the trigger causes the hammer to be raised to nearly its full-cock position. The hammer strut will then escape the trigger, and the spring-loaded hammer will fall and strike the cartridge. In double action firing, the cylinder is rotated by pulling the trigger. Since it requires slightly less trigger pull for single action, this method should produce better accuracy.

The empty cartridges are ejected by swinging out the cylinder to the left and pushing the ejector plunger toward the rear of the cylinder.

There are two built-in safeties on this revolver—the hammer block and the rebound slide. The hammer block prevents the hammer from going far enough forward to strike the cartridge primer when both the hammer and trigger are in the forward or uncocked position. Thus, if the revolver were dropped or otherwise struck on the hammer, the round would not be fired. The rebound slide actuates the hammer block to prevent the hammer from traveling far enough to strike the primer should the hammer slip from the thumb while being manually cocked.

Disassembly and Assembly

To disassemble the revolver:

1. Push forward on the thumb piece (fig. 4-9A) which actuates the cylinder latch, and swing the cylinder out to the left. With a small screwdriver remove the sideplate screw (No. 1 in Fig. 4-9B), located directly under the cylinder. This screw retains the crane (or yoke) of the cylinder and ejector group.

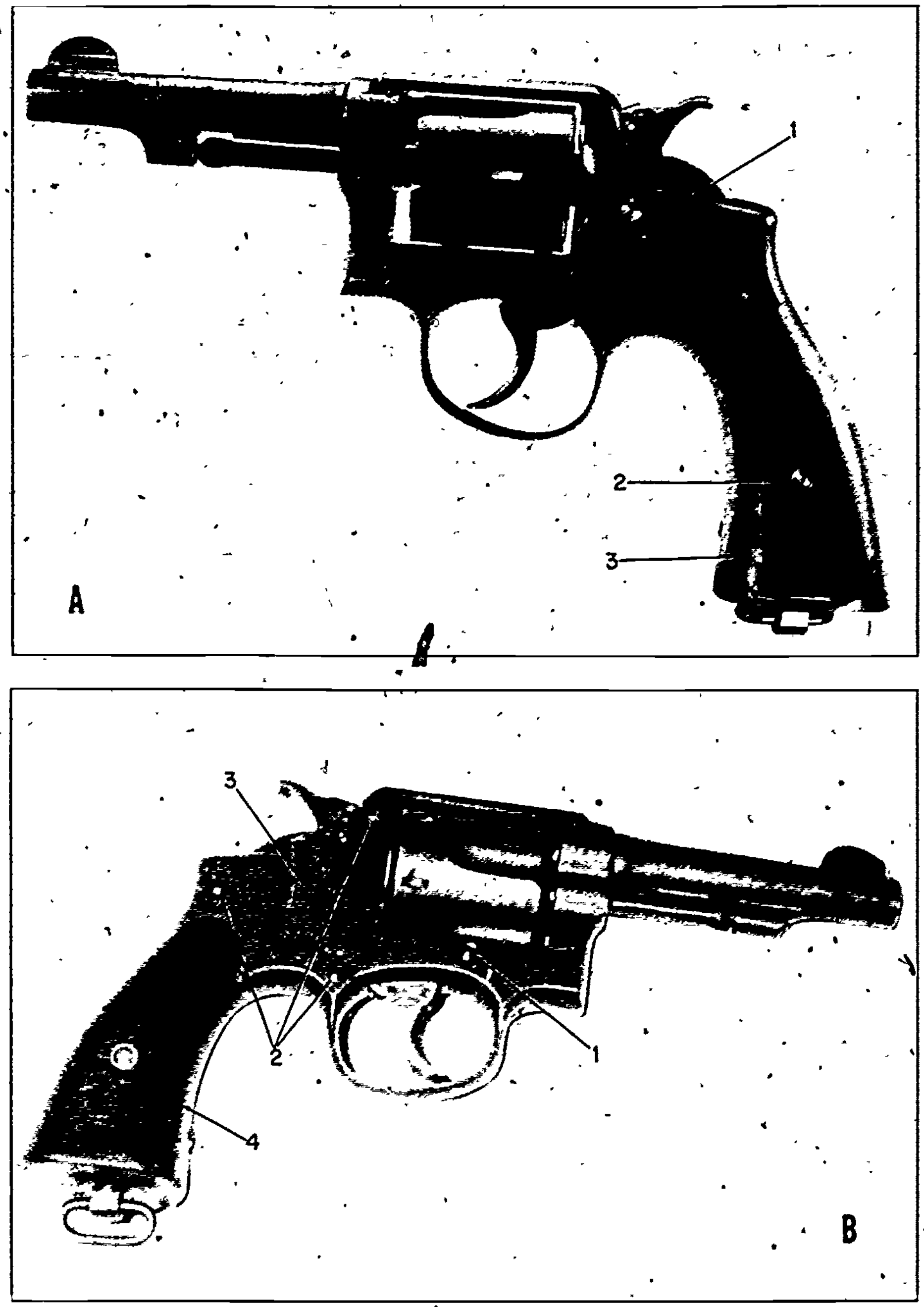
2. Remove the cylinder and extractor group by pulling the cylinder forward.

3. Remove the three remaining sideplate screws (No. 2 fig. 4-9B).

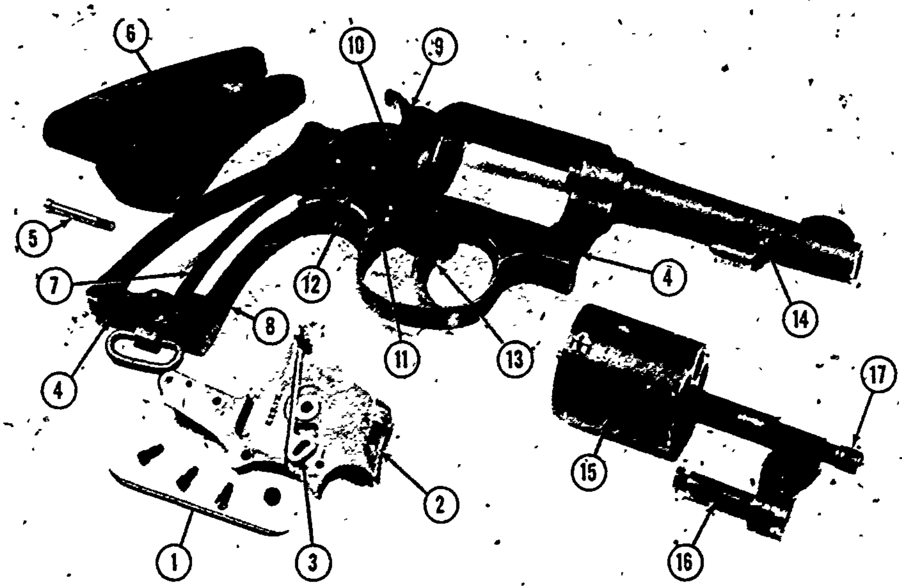
4. Remove the sideplate. Do not pry the sideplate off. Use a wooden handle to tap the plate and frame until the sideplate loosens from the seating.

5. Remove the stock screws and lift off the stocks.

The disassembled weapon appears as shown in figure 4-10. The parts can be inspected and lubricated as necessary.



84.241
Figure 4-9.—Smith and Wesson revolver, caliber .38 special. A. Left side: 1. Thumbpiece (cylinder release). 2. Stock screw. 3. Stock. B. Right side: 1. and 2. Sideplate screws. 3. Sideplate. 4. Stock.



84.241.3

Figure 4-10.—Smith and Wesson revolver, caliber .38; right side view with cylinder and ejector group, side plate, and stocks removed. 1. Sideplate screws. 2. Sideplate. 3. Hammer block. 4. Frame. 5. Stock screw. 6. Stocks. 7. Mainspring. 8. Mainspring strain screw. 9. Hammer. 10. Sear. 11. Rebound slide. 12. Hammer block pin. 13. Trigger. 14. Barrel. 15. Cylinder. 16. Crane or yoke. 17. Ejector plunger.

To assemble the weapon, first remove the hammer block (No. 3 of fig. 4-10) from the sideplate. Place the hole in the hammer block over the hammer block pin (No. 12 in fig. 4-10) so that the "L" projection of the hammer block will fit between the hammer and frame. The remaining parts are installed following the reverse order of disassembly.

SHOULDER WEAPONS

Shoulder weapons are designed to be held with both hands; they are braced against the shoulder to absorb the force of recoil and to improve accuracy. Included in this group are the M14 and M16A1 rifles.

THE M14 RIFLE

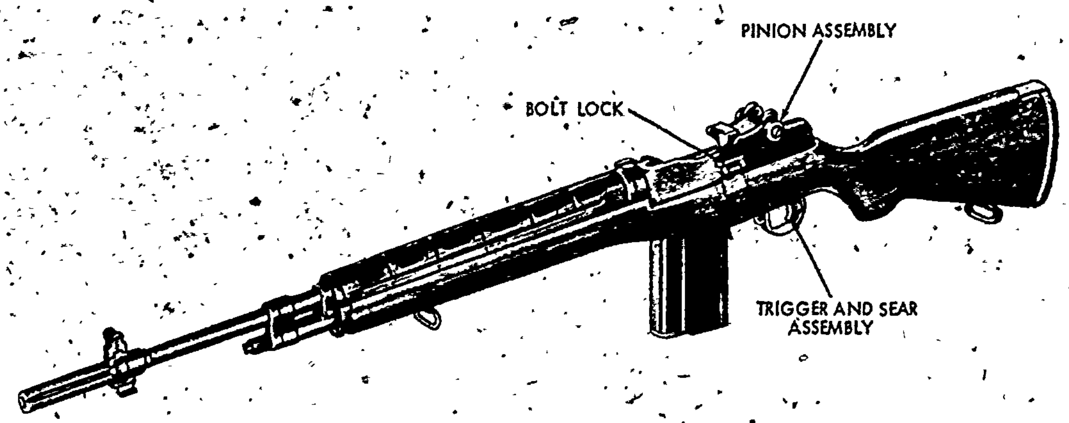
The M14 rifle (fig. 4-11 and 4-12) is a lightweight, air-cooled, gas-operated, magazine-fed shoulder weapon. It is designed primarily for semiautomatic fire, or full automatic fire at the cyclic rate of 750 rounds per minute. The rifle is chambered for 7.62mm cartridges and is designed to accomodate a 20-round cartridge magazine, the M2 rifle bipod (fig. 4-13), the M76 grenade launcher (fig. 4-14), and the M6 bayonet (fig. 4-15).

M14 RIFLE CONTROLS

Figure 4-16 shows the "selector". You position it as in A for automatic fire (fig. 4-16A), as in B for semiautomatic fire (fig. 4-16B). Figure 4-11 shows the "trigger and sear assembly." In firing for semiautomatic fire you squeeze the trigger for each round fired. For automatic fire you squeeze the trigger and hold.

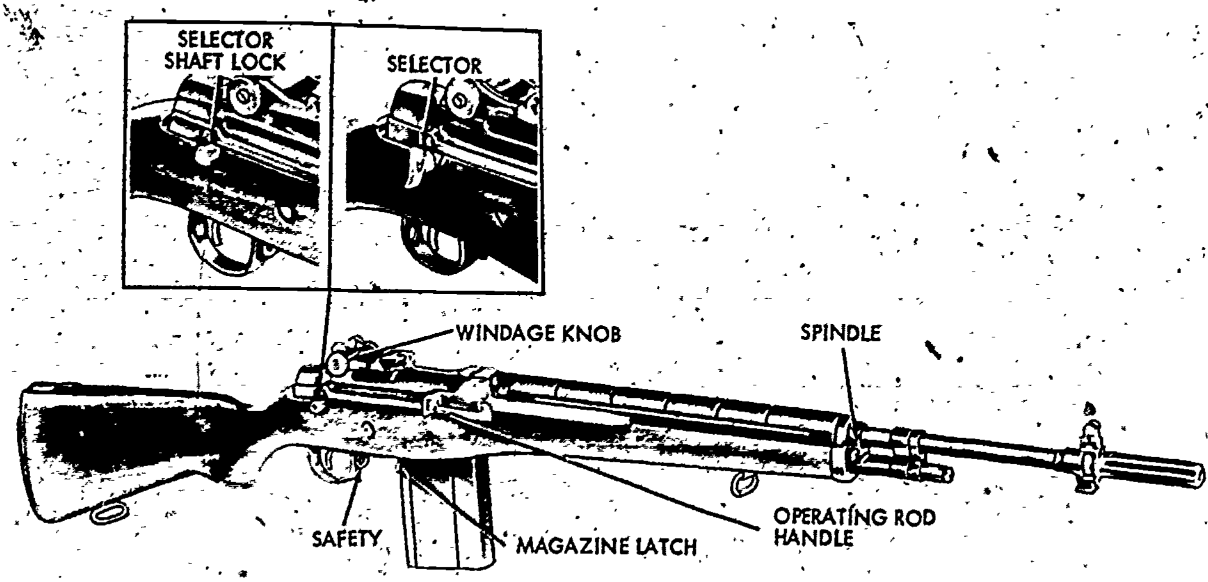
NOTE: Most of the M14 rifles issued to the Navy will not be equipped with the automatic selector, so only semiautomatic fire will be possible.

The "safety" is shown in figure 4-12. To prevent firing, you press it back from in front of the trigger guard. To permit firing, you press it forward from inside the trigger guard. The safety is placed in the safe position before the operating handle is pulled to the rear to cock the rifle.



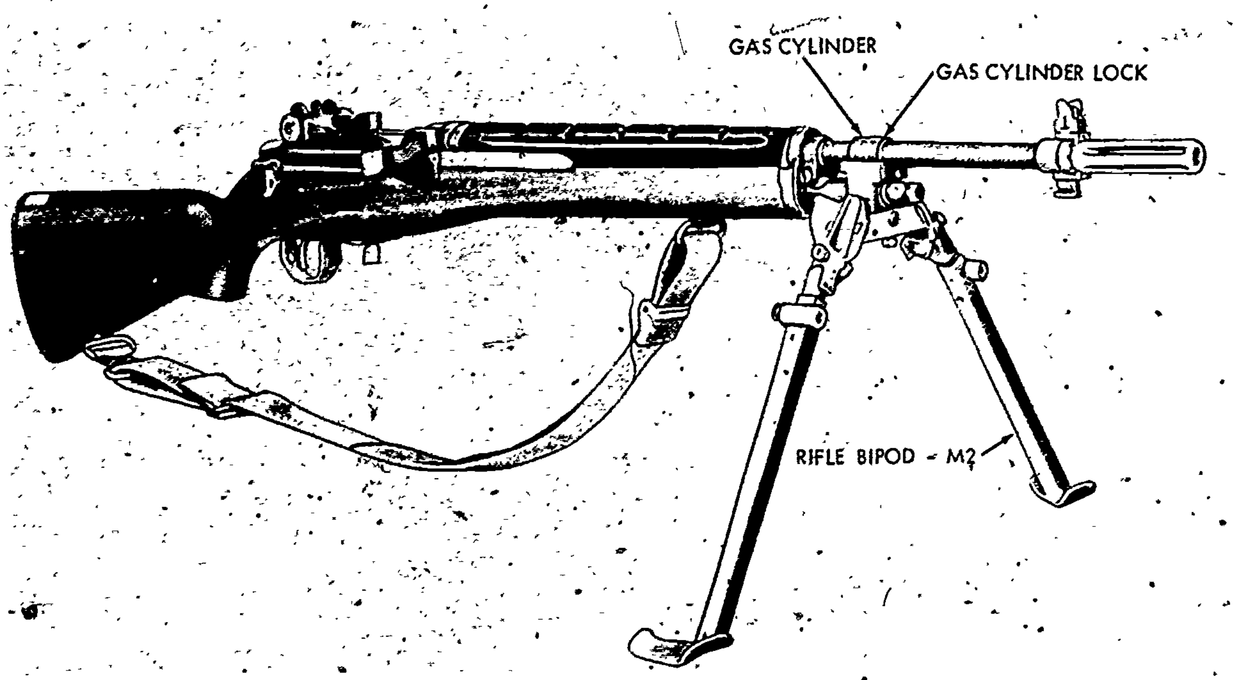
29.316

Figure 4-11.—7.62-mm rifle M14 and controls-left front view.



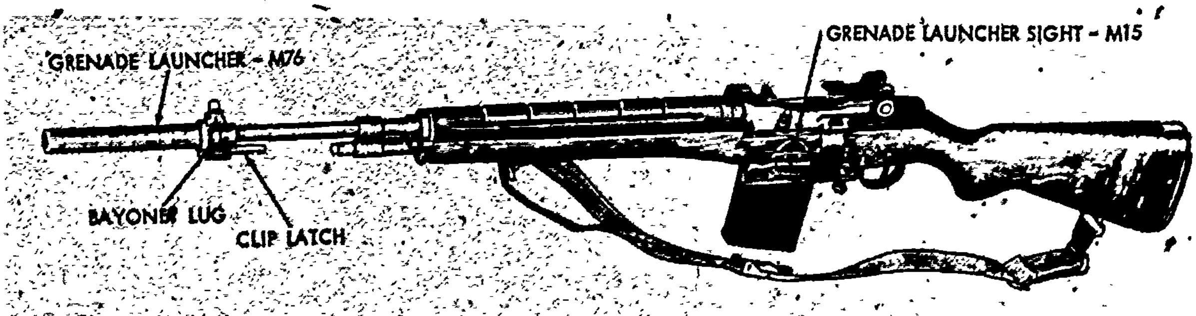
29.331

Figure 4-12.—7.62-mm rifle M14 and controls-right front view.



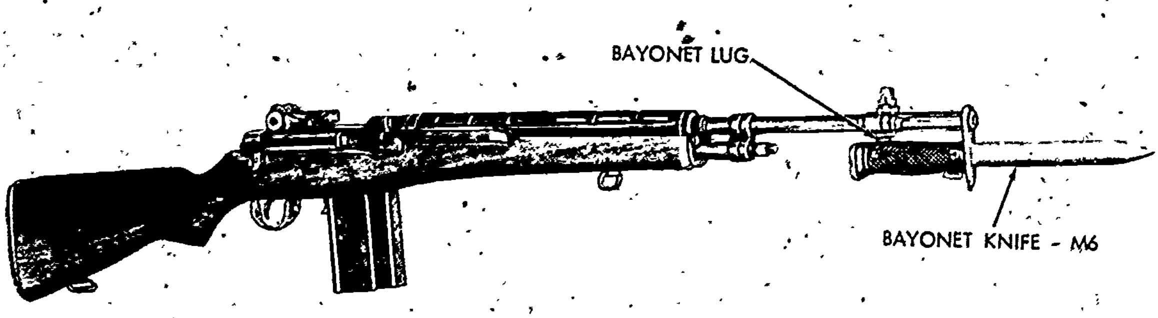
29.332

Figure 4-13.—7.62-mm rifle M14 with bipod installed.



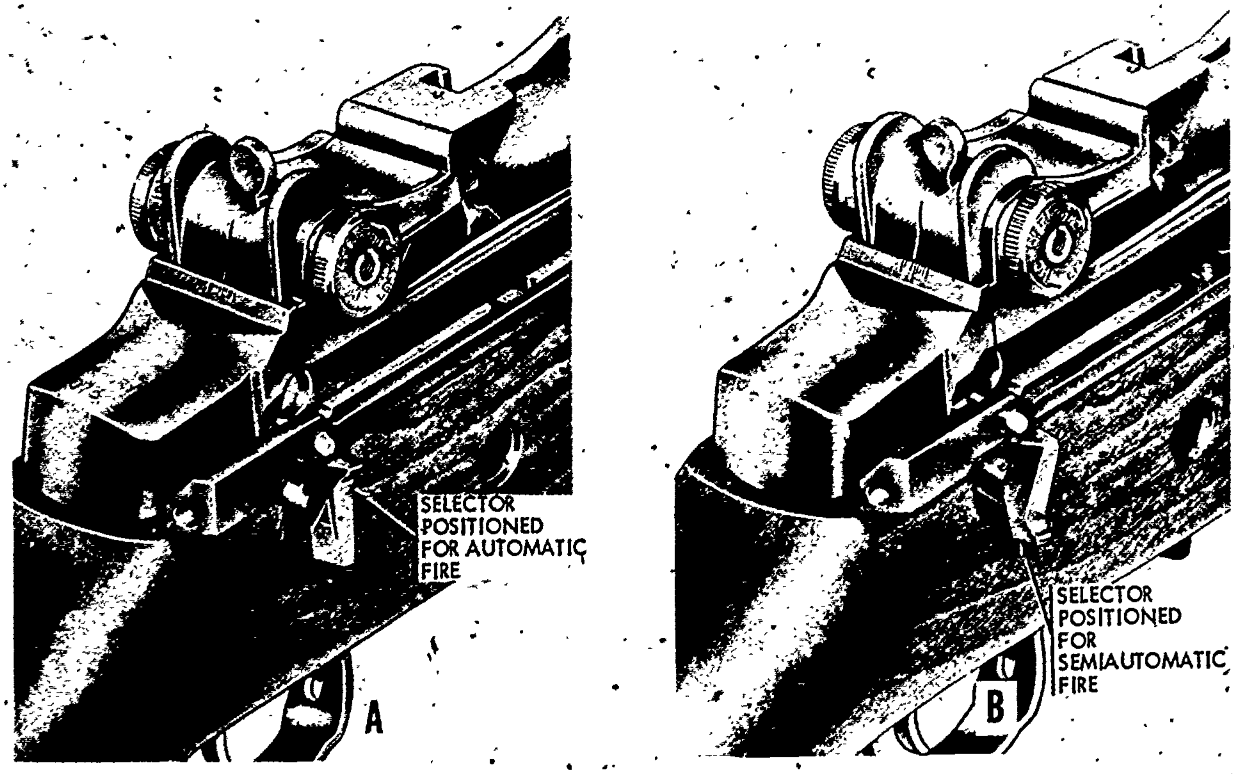
29.333

Figure 4-14. – 7.62-mm rifle M14 with grenade launcher M76 and grenade launcher sight M15.



29.334

Figure 4-15.—7.62-mm rifle with bayonet-knife M6.



29.335

Figure 4-16.—Selector for automatic and semiautomatic fire.

The rifle is cocked and operated manually by the use of the "operating rod handle" (fig. 4-12). First you install a loaded magazine, or reload an empty magazine already in the rifle. To install a loaded magazine, insert front end of loaded magazine into magazine well until the front catch snaps into engagement; then pull rearward and upward until the magazine latch locks magazine into position (fig. 4-17). To reload an empty magazine in the rifle, first push safety into safe (back) position. Then draw the bolt assembly all the way back, depress the bolt lock (fig. 4-11), and ease the bolt forward against the lock. Then insert 5-round cartridge clips as shown in figure 4-18. Four 5-round clips will fully load the magazine. Release bolt lock by drawing bolt rearward, and close bolt. As the bolt assembly closes, the top cartridge in the magazine is forced into the chamber.

In the procedure of reloading an empty magazine in the rifle, the rifle cocks when you draw back the bolt assembly. When you insert a loaded magazine in the rifle, however, the rifle is uncocked and you must cock it to fire. To do this, you move the operating rod handle (fig. 4-12) all the way to the rear and release. This permits the force of the magazine spring to position the top round in path of the bolt after the operating rod has moved the bolt to its rearward position. As the operating rod moves the bolt forward, the bottom face of the bolt engages the base of the cartridge, ramming it forward, feeding, chambering, and locking it in the barrel.

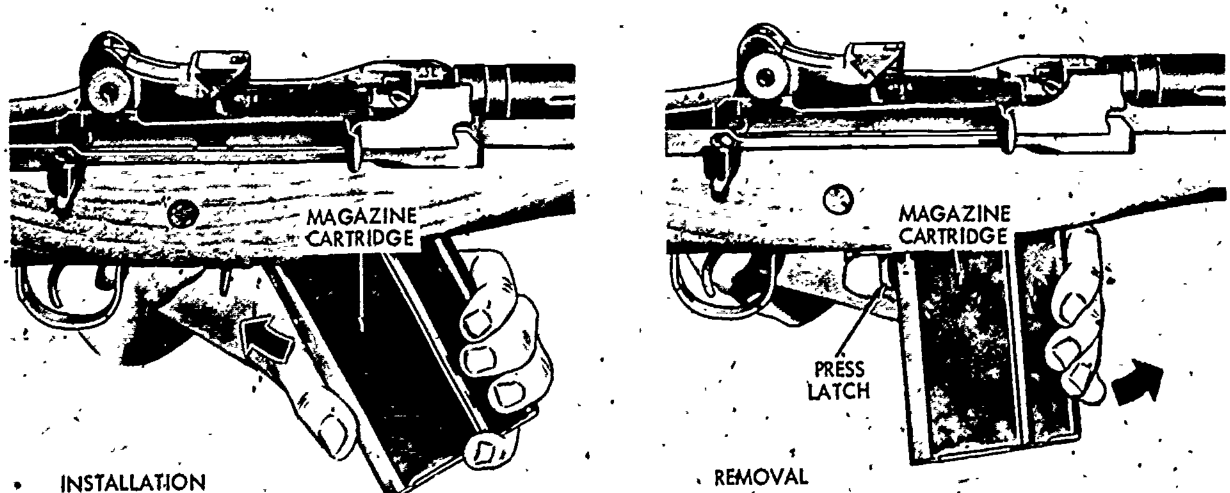
The "gas spindle valve" (fig. 4-19) controls the gases used in firing the rifle as follows: When the slot of the spindle valve is in vertical or on position (fig. 4-19, upper view), the valve is open, and directs gases to the operating piston for ordinary functioning of the rifle. When the slot is in horizontal or off position (fig. 4-19, lower view), the spindle valve is closed. This permits full pressure of gas to be utilized in propelling a rifle grenade.

The rear sight controls consist of a "windage knob" (fig. 4-12) and a "pinion assembly" (fig. 4-11). The function of the windage knob is to adjust the sight laterally. To move the sight to the right, turn knob clockwise; to the left, counterclockwise. The pinion assembly adjusts the sight aperture vertically. Turn pinion clockwise to raise, counterclockwise to lower.

FIRING THE M14 RIFLE

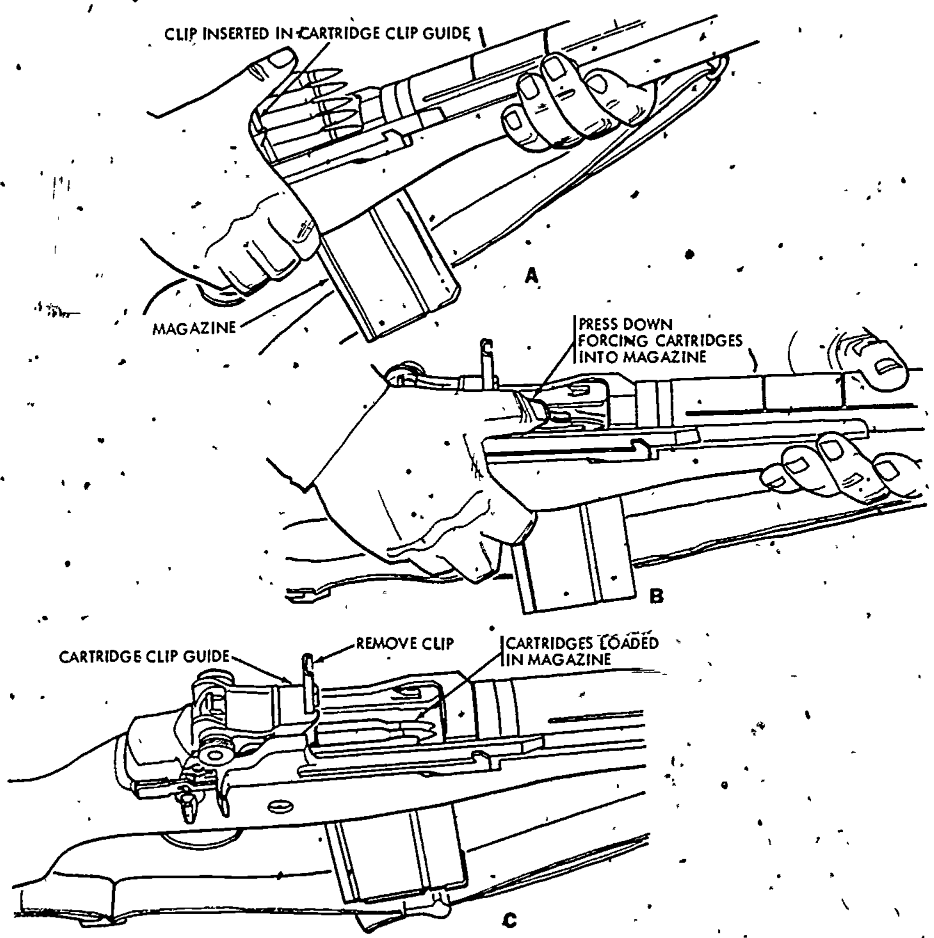
It may be that the command desires that there be no automatic fire. If that is the case, the selector on your rifle will be removed, and a "selector shaft lock" (fig. 4-12) inserted, so that the rifle is capable only of semiautomatic fire.

For a rifle equipped with a selector shaft lock, you simply push the safety forward, and then fire a round with each squeeze of the trigger.



29.336

Figure 4-17.—Installation and removal of magazine.



29.337

Figure 4-18.—Loading magazine through cartridge clip guide.

For semiautomatic fire of a rifle equipped with a selector, you position the selector for semiautomatic fire, and then fire a round with each squeeze of the trigger.

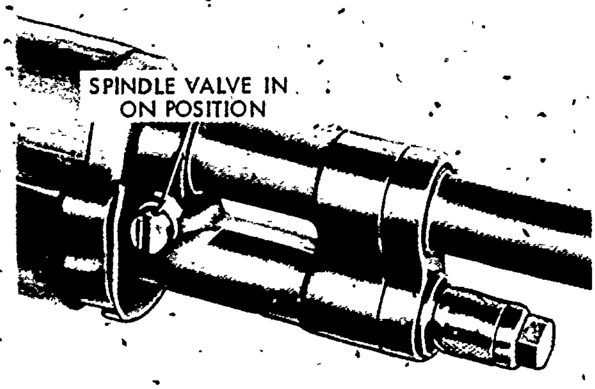
For automatic fire with selector, you proceed as follows:

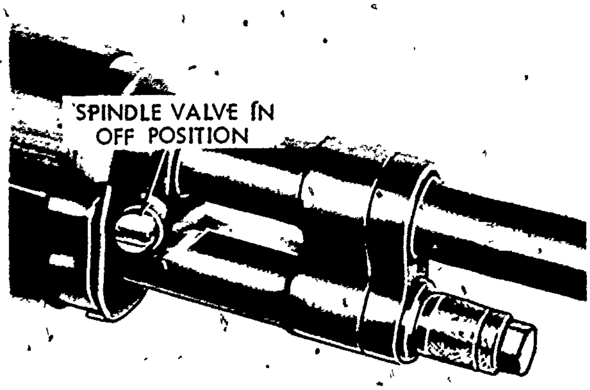
1. Position selector for automatic fire.
2. Push safety forward.
3. Squeeze trigger, and rifle will fire automatically as long as trigger is squeezed and there is ammunition in the magazine. Release trigger to cease firing.
4. After the last round is fired, the magazine follower (spring-driven plate in the magazine that forces cartridges upward as rounds are expended and cases ejected) actuates the bolt lock, locking the bolt in rearward position. When an empty magazine is removed and a loaded one inserted, release bolt lock by retracting the operating rod thereby drawing the bolt rearward, then close the bolt. As the bolt assembly is closed, the top cartridge in the magazine is pushed forward into the chamber.

UNLOADING THE M14 RIFLE

To unload the M14 rifle, proceed as follows:

1. Push the safety to safe (back) position.
2. Grasp magazine with thumb on magazine latch, and squeeze the latch to release it. Push the magazine forward and downward to disengage it from the front catch, and then remove from magazine well, as shown in right-hand view of figure 4-17.





29.338

Figure 4-19.—Gas spindle valve—on and off positions.

3. Pull the operating rod handle all the way to the rear.

4. Inspect the chamber to ensure it is clear.

5. Lock the bolt carrier to the rear by depressing the lower portion of the bolt catch, and return the charging handle forward.

The rifle is clear ONLY when no round is in the chamber, the magazine is out, the bolt carrier is to the rear, and the selector lever is on the SAFE setting.

FIELD STRIPPING THE M14 RIFLE

Figure 4-20 shows how the M14 rifle breaks down into 7 "group assemblies." You should be able to disassemble the rifle to this extent, for cleaning, lubrication, and maintenance. This procedure is called "field stripping" the rifle. The names of the group assemblies are as follows:

1. Magazine
2. Firing mechanism
3. Stock with butt plate assembly
4. Hand guard assembly
5. Operating rod and connector group
6. Bolt assembly
7. Barrel and receiver group.

To withdraw the firing mechanism (no. 2 in fig. 4-20) from the stock, proceed as follows:

1. Remove magazine.

2. Place safety in safe position AFTER ASCERTAINING THAT RIFLE IS COCKED.

3. Disengage hooked end of trigger guard from firing mechanism housing.

4. Swing trigger guard away from stock (but do not rotate more than 90 degrees), and pull straight away from stock to draw out firing mechanism.

To remove stock with butt plate assembly after removing firing mechanism, proceed as follows:

1. Separate stock with butt plate assembly from rifle by grasping the receiver firmly with one hand and striking the butt of the stock sharply with the palm of the other.

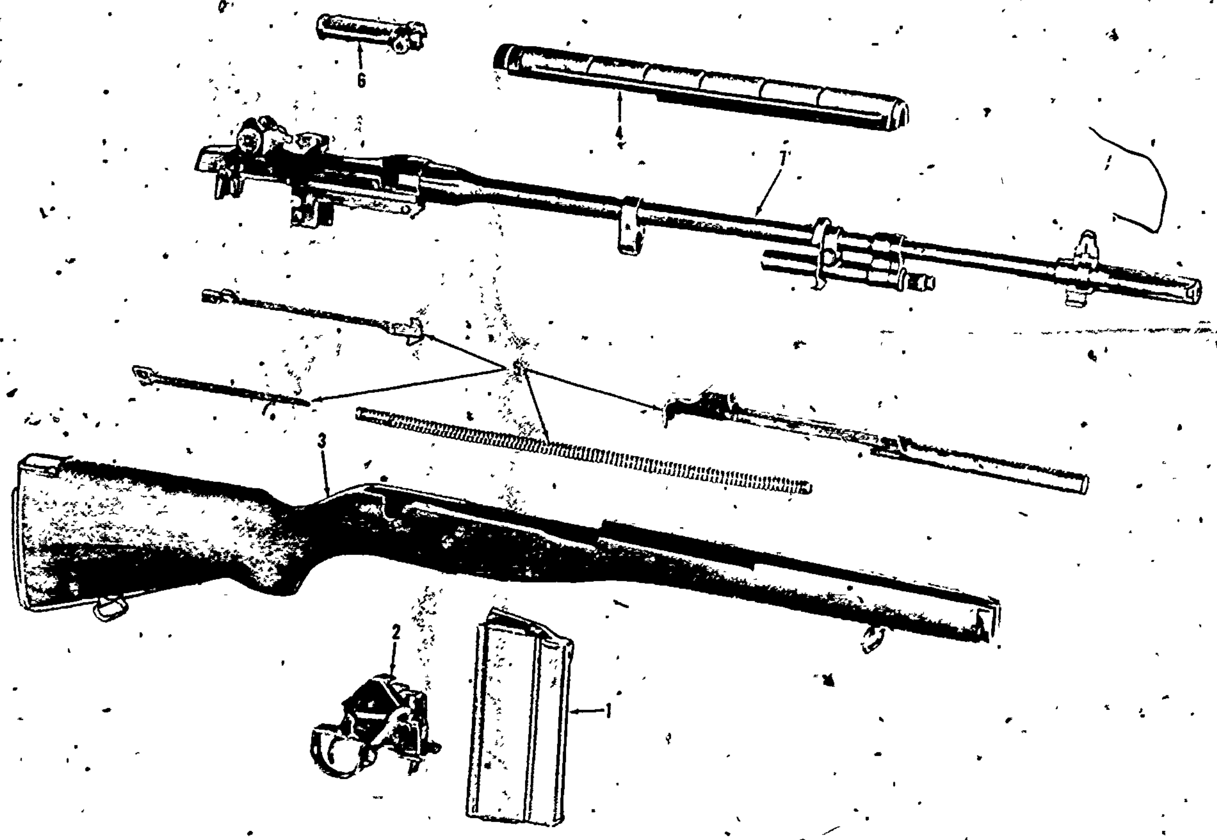
2. Lift stock from barrel and receiver group.

To separate the operating rod and connector group from the barrel and receiver group, proceed as follows:

1. Depress the rear sight to lowest position, and turn barrel and receiver group on its side with connector assembly upward.

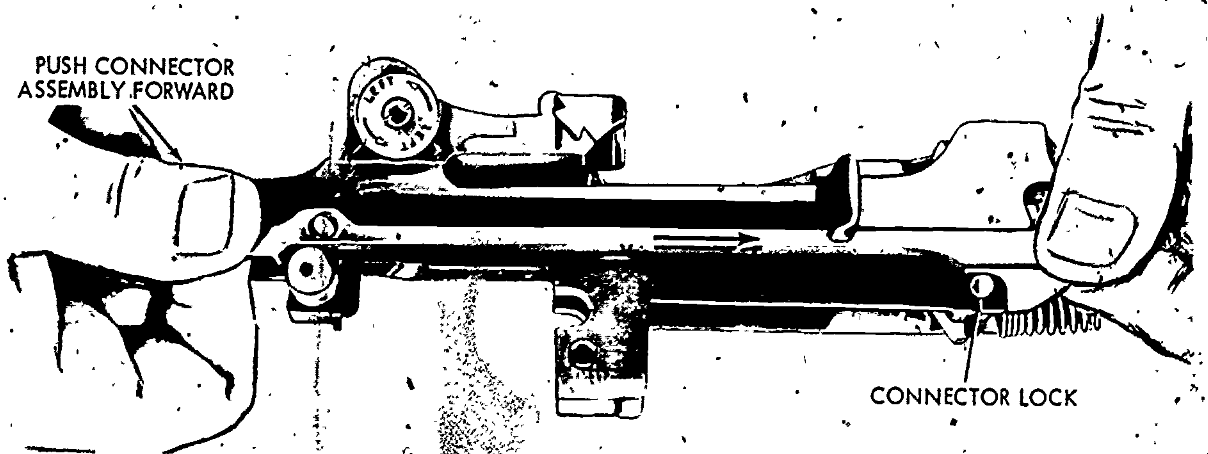
2. If the rifle has a selector, press in and turn selector until the face marked A is toward the rear of the sight knob, and the projection forward is at an angle of about 35 degrees. Then press forward on connector assembly and remove as indicated in steps 3 and 4.

3. If the rifle has a selector shaft lock, press forward on rear of connector assembly with right thumb as shown in figure 4-21, until the front end can be lifted off the connector lock.



29.339

Figure 4-20.—Group assemblies of the M14 rifle.



29.340

Figure 4-21.—Disengaging connector assembly.

4. Rotate the connector assembly about 35 degrees clockwise, until the slot at the rear is aligned with the elongated stud on the sear release (see fig. 4-22); then lower the front end of the connector assembly and lift it off the sear release.

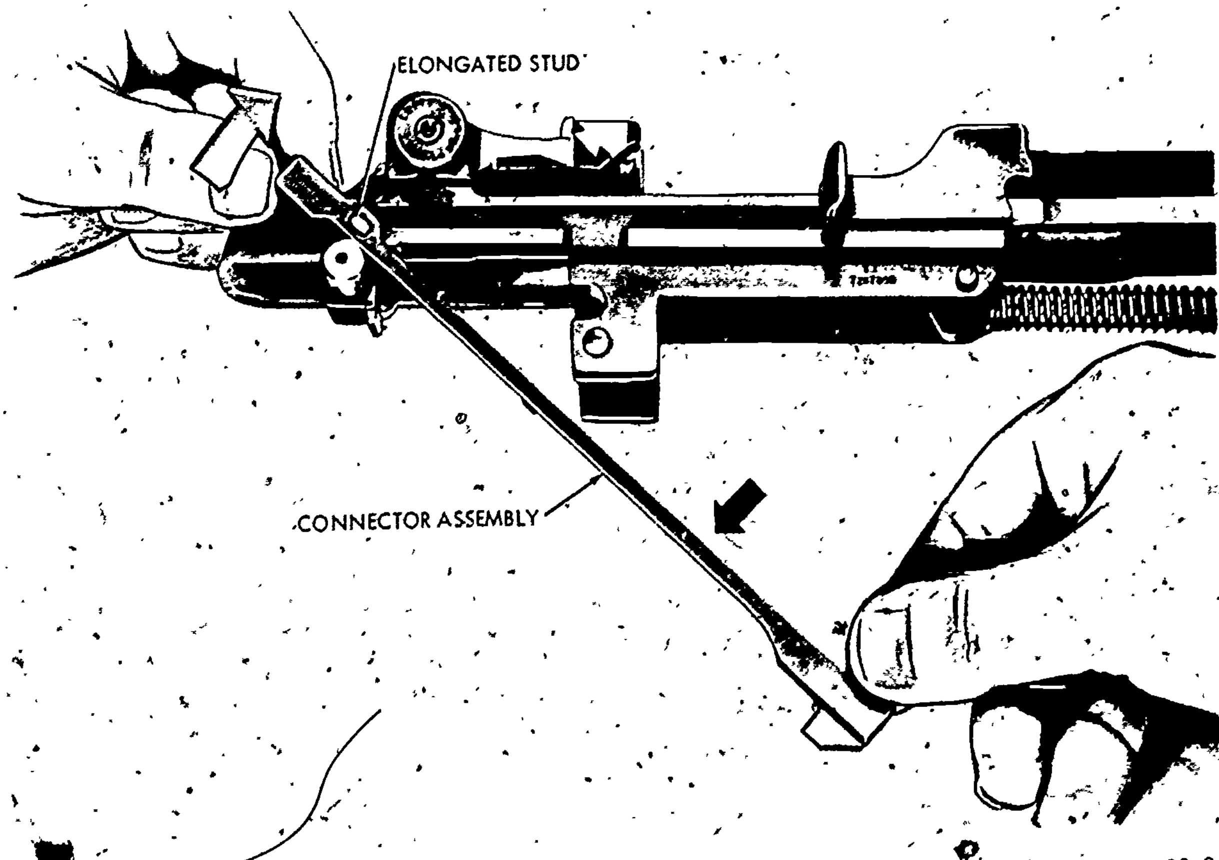
The next step is to remove the operating rod spring guide (no. 2 in fig. 4-23), the operating rod spring (no. 3 in fig. 4-23), and the operating rod (no. 4 in fig. 4-23), as follows:

1. With the barrel and receiver group upside down, pull forward on operating rod spring, relieving pressure on the connector lock pin. Pull lock outward to disconnect the operating rod spring guide.
2. Remove operating rod spring guide and operating rod spring. Turn barrel and receiver group right side up.
3. Retract operating rod until key on its lower surface coincides with notch in receiver. Lift operating rod free and pull to rear, disengaging it from operating rod guide.

To remove the bolt after removal of the operating rod, grasp the bolt roller that engages with the operating rod and slide it forward. Lift upward and outward to the right with a slight rotating motion and remove bolt from receiver.

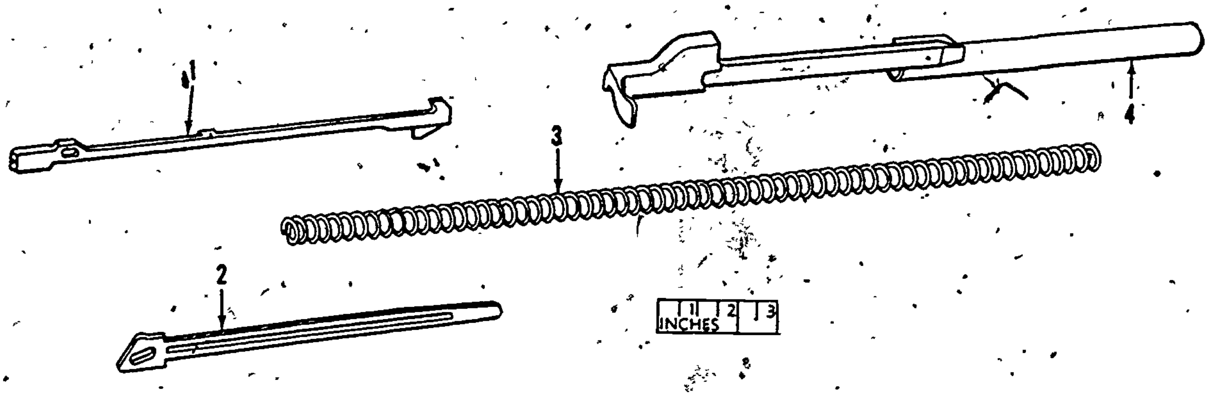
GRENADE LAUNCHER M76

The grenade launcher M76 (fig. 4-24) is an extension to the M14 rifle. The barrel of the launcher contains 9 annular grooves numbered 6 to 1 and 2a, 3a, and 4a. These are used to obtain different ranges when firing grenades by placing the grenade at different positions on the barrel. On the muzzle end, bottom portion of the launcher, is a clip-type retainer spring used to



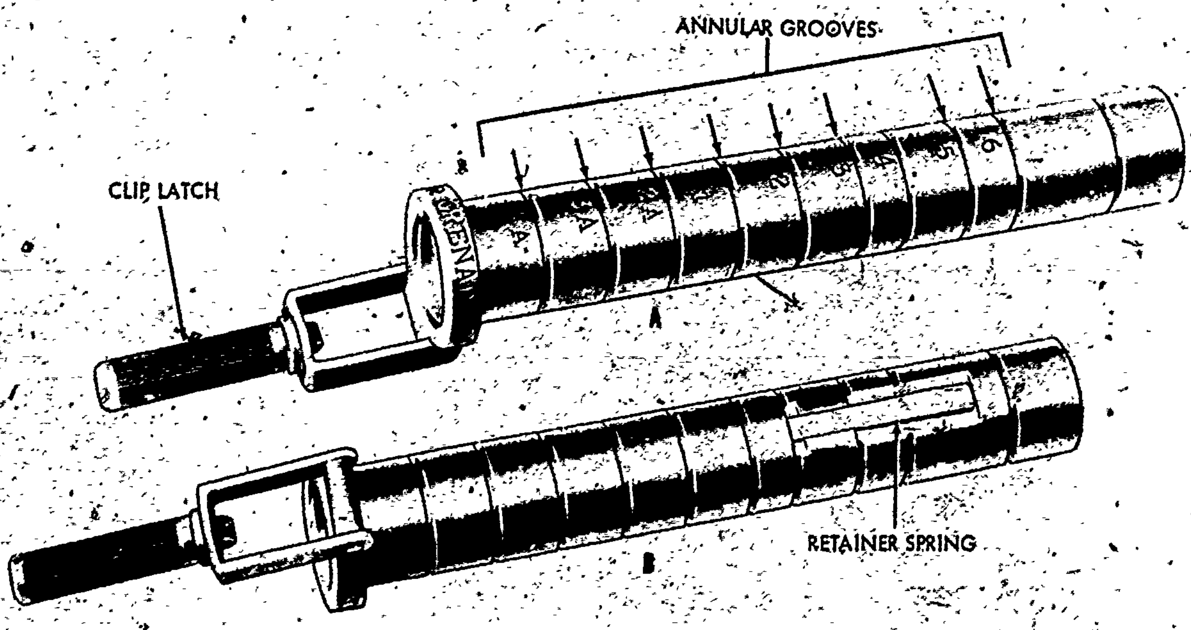
29.341

Figure 4-22.—Removing connector assembly.



29.342

Figure 4-23.—Component parts of operating rod and connector group.



29.318

Figure 4-24.—Grenade launcher M76.

hold the grenade on the launcher at a desired position.

Figure 4-14 shows the grenade launcher installed on the rifle. To accomplish this, install barrel end of launcher containing clip latch to flash suppressor. Push clip latch rearward, securing it to bayonet lug of the flash suppressor.

The grenade launcher sight M15 (fig. 4-14) provides an angular measurement of elevation for firing rifle grenades and can be used for both low angle (direct firing) and high angle firing. Figure 4-25 illustrates the procedure for installing the sight. First install sight to mounting plate, aligning notches of plate with click spring tips of the sight as shown in A, figure 4-25. Turn clockwise (B in fig. 4-25) until a sight mark lines up with 0 degrees on mounting plate.

Two identical sets of calibrations are located on the lip of the mounting plate. Each set is calibrated in 5-degree intervals from 0 degrees to 60 degrees elevation, and each is numbered in 10-degree intervals. The under edge of the lip is serrated to engage the click spring of the sight bar assembly. Each click is a 5-degree change in elevation. The sight bar assembly consists of a 13-centimeter (about 5-inch) sight bar with a front sight post, a rear peep sight mounted on a sight leaf, a leveling bubble, and an elevating screw.

The front sight post and the rear peep sight are used when firing direct fire. They are just like the sights on the rifle—that is, you sight through the rear peep sight over the front sight post at the target. At the rear of the peep sight there are four 1-degree graduations, used to make from 1-degree through 4-degree changes in elevation. Five clicks of the elevating screw (each click indicates an elevation change of 12 minutes) mean a 1-degree change in elevation.

For high-angle fire the front sight post, rear peep sight, and elevating screw are not used. Instead, the sight bar assembly is rotated until the index line on the sight body bracket is aligned with the appropriate degree setting on the mounting scale plate. When you are in firing position, you raise or lower the rifle until the level bubble is centered in the vial. The vertical angle of the bore is now equal to the angle you set on the sight.

The M15 grenade sight can be adjusted horizontally as well as vertically. When correctly adjusted, the aiming point of the direct-fire sights and the point of impact of the grenade will just about coincide. You orient the grenade sight to the rifle sights by the following procedure, known as "zoning" the grenade sight. Set the rifle sights at zero elevation and windage, place the rifle in a stationary rest, select a distant aiming point (150 meters/164 yards or more,)

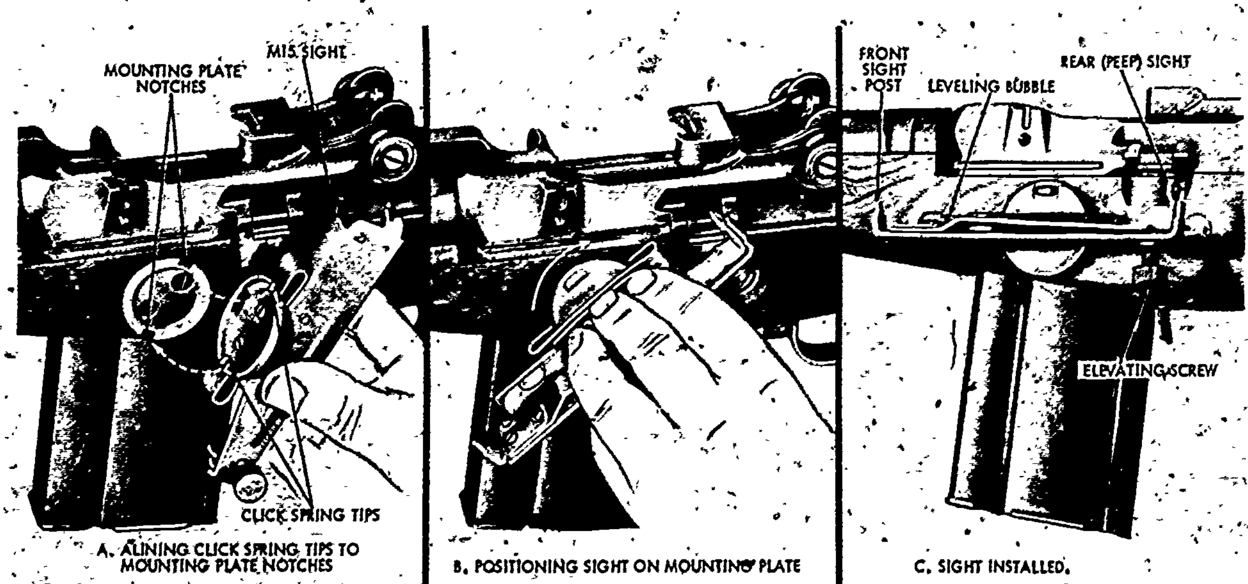


Figure 4-25.—Installation of grenade launcher sight M15.

and adjust the rifle so that the rifle peep sights are on the aiming point. Then set the peep sight of the grenade sight at 0 degrees elevation, by turning the elevating screw a sufficient number of clicks to align the sight body bracket with the top or 0-degree graduation on the rear of the peep sight, and by rotating the sight bar assembly until the index line on the sight body bracket corresponds to the 0-degree setting on the mounting scale plate.

Horizontal adjustment is made by loosening the two sight leaf screws. Move the peep sight the desired distance either to the right or left, and then firmly tighten the two sight leaf screws.

For vertical adjustment sight through the grenade sight and note whether the sight is pointed above or below the aiming point. Remove the grenade sight bar assembly from the mounting scale plate and loosen the two capscrews on the inside of the sight body bracket. To raise the point of aim of the grenade sight, turn the sight body clockwise in relation to the sight body bracket. To lower the point of aim, turn the sight body counterclockwise in relation to the bracket. Tighten the two capscrews and replace the sight bar assembly on the rifle. Verify the point of aim of the grenade sight. Repeat this process until the grenade sight is set on the same aiming point as the rifle sight.

GRENADE FIRING WITH THE M14

Before placing the grenade on the launcher, you load the rifle with the 7.62-mm rifle grenade cartridge M64. Do not remove the safety pin of the grenade until you are ready to fire. To remove the pin, grasp the grenade with the left hand and remove the pin with the right hand. Inspect the grenade again to ensure that the safety lever is not bent. A bent safety lever permits abnormal movement of the striker. If abnormal movement has occurred, unlock and fire the rifle immediately.

After the safety pin is removed, the safety lever is held in place by the arming clip of the adapter. When the grenade is fired, the arming clip tends to remain in place because of inertia. The arming clip strikes the small extension on the bottom of the arming clip retainer. Because this extension is made of brittle metal, the force of the arming clip against it will break it and allow the arming clip to fall free. This action releases the safety lever and allows the fuze to function. After the normal delay interval, the fuze will function and the grenade will explode.

Positions for Low Angle Fire

You may fire rifle grenades at low angle, direct fire targets from the standing, kneeling, and prone positions. Except in the prone position, fire the rifle with the butt against the right shoulder. This allows you to see the target through the rear peep sight over the front sight post of the M15 sight. Do not fire from the shoulder when in prone position because, in this position, your body cannot move back to absorb the recoil. Use a butt rest when firing from the prone position. Even in the other positions, fire from the shoulder only when your body can move freely with the recoil.

Do not use the sling when firing at low angle, direct fire targets using the M15 sight. Hold the rifle firmly with the left hand near the upper sling swivel and the right hand at the small of the stock. Hold the left elbow well underneath the weapon and exert pressure to pull the butt of the rifle snugly into the right shoulder or against the butt rest. Hold your right thumb alongside the right side of the stock, not around the top of the small of the stock. Keep your head slanted slightly to the left, well away from the sight, to prevent possible injury when the rifle recoils.

For standing position fire, face the target, execute a half right face, and spread your feet a comfortable distance apart (about 30 inches). Rotate the rifle on its right side, receiver away from you, so that when you grasp it with your left hand, your fingers will be well over the top. Your left hand should be at least 2 inches below the upper sling swivel to ensure that the swivel will not recoil against your hand.

Without changing the grip of your left hand, rotate the butt of the rifle into your right shoulder. The fingers of your left hand should now be well over the top of the rifle, and your left elbow should be well underneath the rifle. Do not allow the rifle to cant to either side. Hold your right elbow at the height of your right shoulder or above to form a pocket for the butt of the rifle.

Place your right hand at the small of the stock with your right thumb alongside the right side of the stock. Slant your head slightly to the left so that you can see through the sight, but DO NOT PLACE YOUR EYE CLOSE ENOUGH TO THE SIGHT TO HAVE IT HIT DURING THE RECOIL. Lean into the rifle with your left leg bent and your right leg straight but not stiff. Lean forward with the whole body, not just with the part above the hips. This will allow your whole body to rock back as it absorbs the recoil. Track a moving target by pivoting evenly and smoothly at the waist.

For kneeling position fire, face the target, execute a half right face, and kneel on your right knee with the lower part of your left foot pointing generally toward the target. Do not sit on your right heel and do not use your left knee to support your left elbow. Such positions make it difficult to track a moving target. Place the rifle to the shoulder in the same manner as for the standing position. Lean well forward so that you can rock back with the recoil. Track a moving target by pivoting evenly and smoothly at the waist.

For grenade firing with the M14 the prone position has several disadvantages, and it should therefore be used only when necessary. You must use a butt rest, such as a tree stump or a hole in the ground because, if you fired the rifle from the shoulder in the prone position, you could not rock back to absorb the recoil. Besides, it would be difficult to see throug the M15 sight or to track a moving target. When you assume the prone position, place the butt of the rifle against any handy rest and your right forearm over the top of the butt of the rifle to hold it in the firing position. Do not allow the rifle to cant to either side.

Positions for High Angle Fire

You may use either the kneeling or the sitting position for high angle fire.

For the kneeling position, face the target and kneel on your right knee, keeping the left foot pointed in the direction of the target. Because you do not track moving targets with high angle indirect fire, you may sit on your right heel and use your left knee to support your left elbow. Place the butt of the rifle on the ground against your right knee. Grasp the rifle near the upper sling swivel with your left hand and at the small of the stock with your right hand. Your right thumb should be against the right side of the stock.

Rest your weight on your right heel. After placing the correct sight setting on the sight, lower the rifle and sight along the barrel toward the target to obtain the correct deflection. Then raise the rifle muzzle slowly until the leveling bubble is centered in its vial. Lower your head before firing to prevent any blow-back from striking you in the face.

For the sitting position you face the target and sit down, keeping your right leg flat on the ground and pointed toward the target. Cross your left leg over the right knee so that your left knee will support your left elbow. Place the butt of the rifle beside your right hip. Grasp the rifle near the upper sling swivel with your left hand and at the small of the stock with your right hand. Your right thumb should be against the right side of the stock. You may then sight for deflection, center the leveling bubble, lower your head, and fire when ready.

GUN MAINTENANCE

The cleaning, preservation, and care given an M14 rifle are determining factors in the operation and shooting accuracy of the weapon. You have undoubtedly heard that "an ounce of prevention is worth a pound of cure". This can aptly be applied to the maintenance of not only the M14 rifle but to all ordnance weapons and equipment. To properly maintain this weapon, a system of preventive maintenance must be employed. If the 3-M system has been implemented on your ship or station, the maintenance procedures as set forth on the Maintenance Requirement Cards (MRCs) must be followed. If the 3-M system has not been implemented, the procedures outlined in TM 9-1005-223-12 may be used as a guide in setting up your procedures.

Preventive maintenance is the systematic care, inspection, and servicing of material to maintain it in a serviceable condition, prevent breakdowns, and assure operational readiness. To maintain the M14 rifle in a state of readiness, the weapon must be serviced (including lubrication) each time it is used and periodically when in stowage.

Inspections of the weapon are an important part of preventive maintenance. Inspections to see if items are in good condition, correctly assembled, secure, not worn, and adequately lubricated apply to most items in preventive maintenance procedures.

Cleaning and Care

Immediately after firing, thoroughly clean the rifle bore with a stiff wire bore brush saturated with MIL-C-372 bore cleaning solvent. Ensure that all surfaces, including the rifling, are well coated with the compound. After cleaning with MIL-C-372, swab the bore with flannel cleaning patches, making certain that no trace of burned powder or other foreign substance remain in the bore, then apply a light coat of PL special, general purpose lubricating oil.

Clean chamber with a special cleaning brush. The brush is attached to a special ratchet into which is inserted a section of cleaning rod that is used as a handle.

The steps in cleaning the chamber are as follows:

1. Remove the magazine.
2. Apply a light coat of CR to the chamber.
3. Withdraw the bolt to the rear engaging bolt lock, and hold bolt lock in the open position.
4. Insert brush into the chamber.
5. Pull operating rod rearward, release bolt lock, and ease the operating rod and bolt fully forward, seating brush in the chamber.
6. Move handle of the ratchet base from side to side several times.
7. Grasp the operating rod to release tension on brush and remove brush from the chamber.
8. Wipe CR compound from the chamber and apply a light coat of PL special, general purpose lubricating oil to the chamber and close bolt.

Make certain all metal parts have been cleaned with SD, dry cleaning solvent P-D-680, and dried thoroughly. Apply a light coat of preservative, PL special, general purpose lubricating oil. Apply a light coat of rifle grease lubriplate 130A to the following surfaces:

1. Locking lugs of bolt, operating lug, and recesses.
2. Bolt guide.
3. Anti-friction roller on bolt.
4. Operating rod guide groove on side of the receiver.

THE M16A1 RIFLE

The rifle, M16A1 (fig. 4-26), is a 5.56-mm (about .22 caliber) magazine-fed, gas-operated, air-cooled shoulder weapon. It is designed for either semiautomatic or full automatic fire through the use of a selector lever.

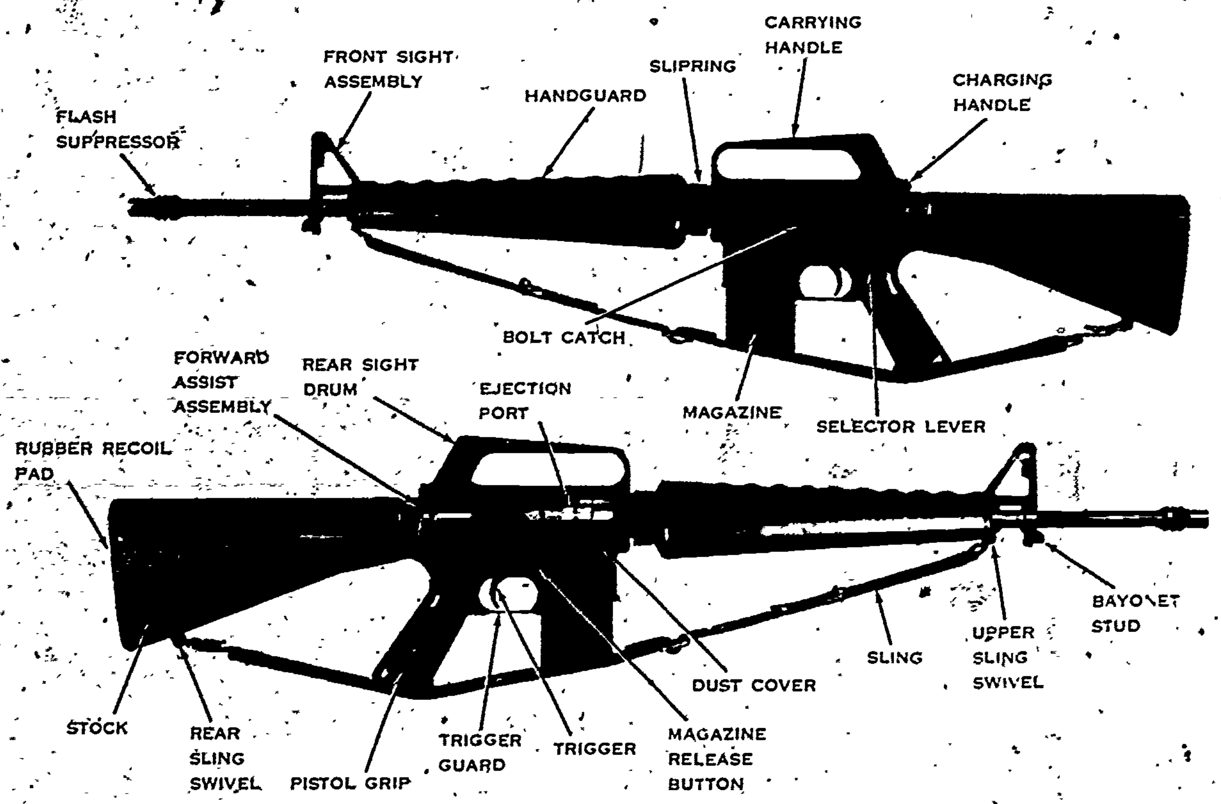


Figure 4-26.—Rifle, 5.56-mm, M16A1, left and right side views.

The M16A1 rifle offers grenade launching capabilities. Grenades launched from the rifle include pyrotechnics and signal devices for communications, harassing agents, and high explosive ammunition against enemy personnel, bunkers, and armored vehicles.

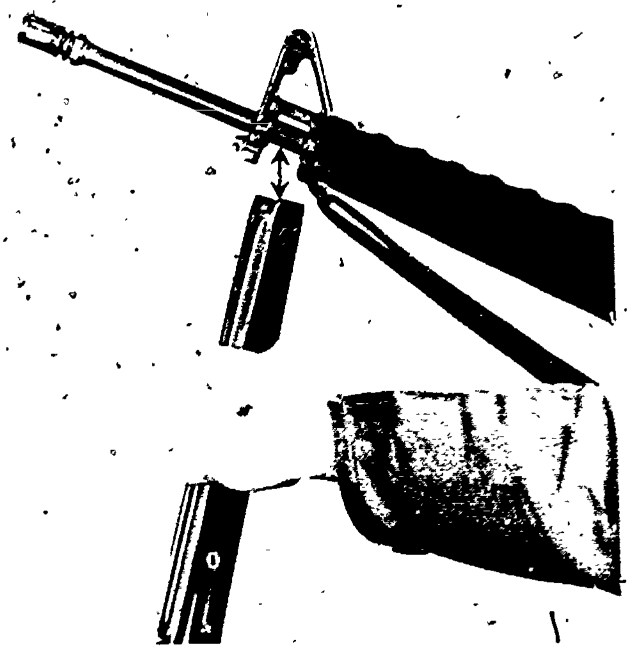
CAUTION: When firing pyrotechnics and rifle grenades, observe the following restrictions:

a. Pyrotechnics and rifle grenades will not be fired with the butt of the weapon against the shoulder or any other part of the body.
b. Firing over the heads of friendly troops should be avoided.
c. Under no circumstances should the M19A1 or M19A2 signal parachute illumination, or the M64 signal ground smoke, be launched from the M16A1.

The following grenades are authorized for use with the M16A1 rifle with the use of additional accessories:

a. Rifle Grenades.
   (1) M19A1 WP.
   (2) M22A2 smoke series.
   (3) M23 smoke streamer series.

A "clothespin" bipod shown in figure 4-27 is used in the prone and foxhole positions. The bipod is attached to the barrel directly beneath the front sight between the bayonet lug and the front sling swivel.



84.352
Figure 4-27.—Attaching "clothespin" bipod to M16 rifle.

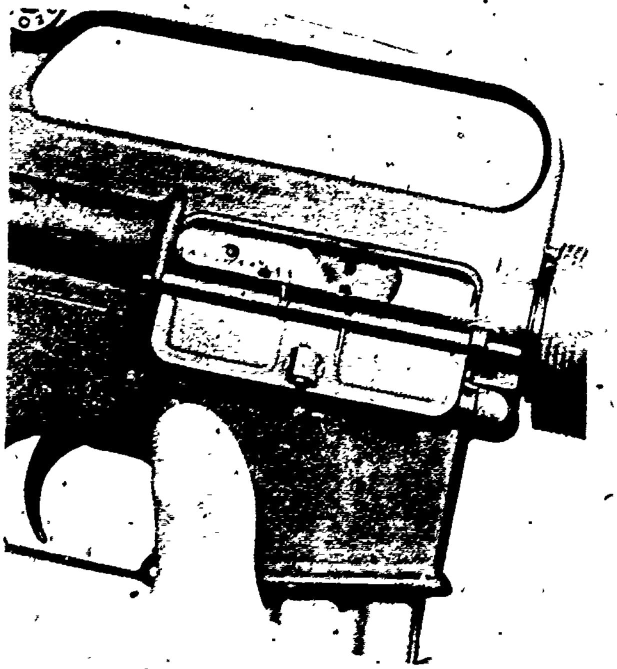
CLEARING THE M16A1 RIFLE

The first consideration in handling any weapon is to make it safe by clearing it. To clear the M16A1 rifle, place the butt against the right thigh and proceed as follows:

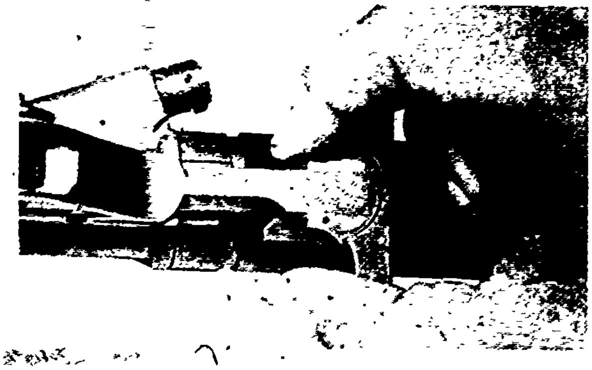
1. Attempt to point the selector lever toward SAFE, the position shown in figure 4-28. If the weapon is not cocked, the selector lever cannot be pointed toward SAFE. If this is the case, do not cock the weapon at this time; instead, go on to the next step in clearing.

2. Remove the magazine as shown in figure 4-29. Grasp it with the right hand (fingers curled around the front of the magazine, thumb placed on magazine catch button), apply pressure on the magazine catch button with the thumb, and pull the magazine straight out of the weapon.

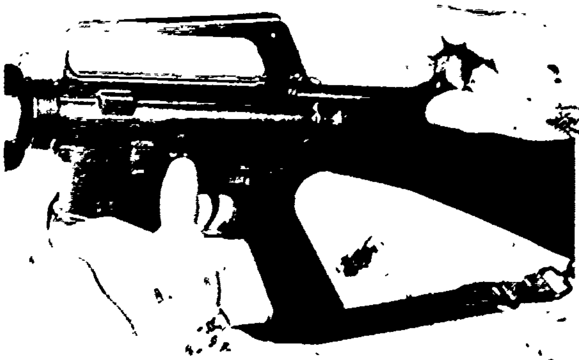
29.346
Figure 4-28.—Selector lever pointing to SAFE.



29.347
Figure 4-29.— Removing the magazine.



29.348
Figure 4-30.— Pulling the charging handle rearward.



29.349
Figure 4-31.— Locking the bolt open.

3. Lock the bolt open as shown in figures 4-30 and 4-31. Grasp the charging handle with thumb and forefinger of right hand, depress the charging handle latch with right thumb, and pull to the rear (fig. 4-30). When the bolt is at the rear, press the bottom of the bolt catch with the thumb or forefinger of the left hand (fig. 4-31). Allow the bolt to move slowly forward until it engages the bolt catch, and return the charging handle to its forward position.

4. Inspect the receiver and chamber of the weapon by looking through the ejection port to ensure that these spaces contain no ammunition.

5. Check the selector lever to ensure that it points toward SAFE, and then allow the bolt to go forward by depressing the upper portion of the bolt catch.

CAUTION: The selector must be in the SAFE position to prevent damage to the automatic sear.

FIELD STRIPPING THE M16A1 RIFLE

The individual GM is authorized to disassemble the M16 to the extent called "field stripping." Field stripping can be accomplished without supervision and is adequate for normal maintenance. As the weapon is disassembled, the parts should be laid out on a table or other clean surface in the order of removal, from left to right. This makes assembly easier because the parts are assembled in the reverse order of disassembly. Nomenclature (the names of the parts) should be learned as the weapon is disassembled and assembled to enable the Gunner's Mate to better understand the function of parts in the weapon.

The steps in field stripping are as follows:

1. Remove the sling and place the rifle on a table or flat surface, muzzle to the left.

2. Keeping the muzzle to the left, turn the weapon on its right side. Use the nose of a cartridge to press the takedown pin (fig. 4-32)

29.350

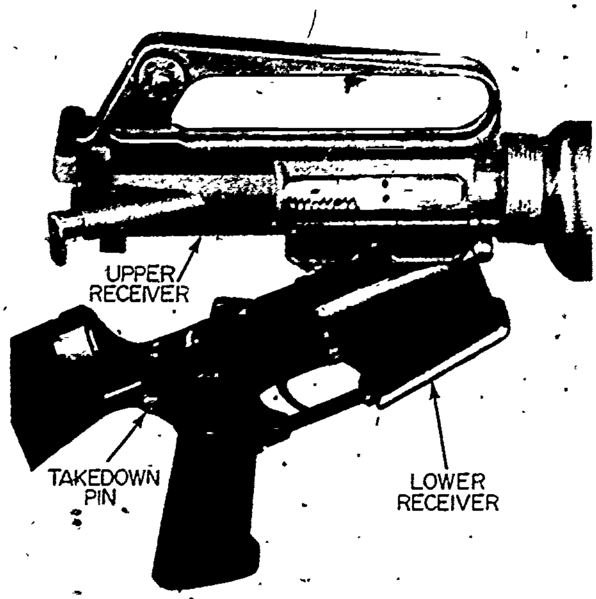
Figure 4-32.—Pressing takedown pin to the right.

until the upper receiver swings free of the lower receiver (fig. 4-33). CAUTION: The takedown pin does not come out of the receiver.

3. Again using the nose of a cartridge, press the receiver pivot pin (fig. 4-34). Separate the upper and lower receiver groups (fig. 4-35) and place the lower receiver group on the table. CAUTION: The receiver pivot pin does not come out of the receiver.

4. Pick up the upper receiver group; keep the muzzle to the left. Grasp the charging handle, pressing in on the latch, and pull to the rear (fig. 4-30) to withdraw the bolt carrier from the receiver. Grasp the bolt carrier and pull it from the receiver (fig. 4-36). When the bolt carrier is removed, the charging handle will fall free of its groove in the receiver (fig. 4-37). Place the receiver on table.

5. To disassemble the bolt carrier group, press out the firing pin retaining pin by using the nose of a cartridge (fig. 4-38). Elevate the front of the bolt carrier and allow the firing pin to drop from its well in the bolt (fig. 4-39). Rotate the bolt until the cam pin is clear of the bolt carrier key and remove the cam pin by rotating it 90 degrees (1/4-turn) and lifting it out of the well in the bolt and bolt carrier (fig. 4-40). After the cam pin is removed, the bolt can be easily removed from its recess in the bolt carrier (fig. 4-41).

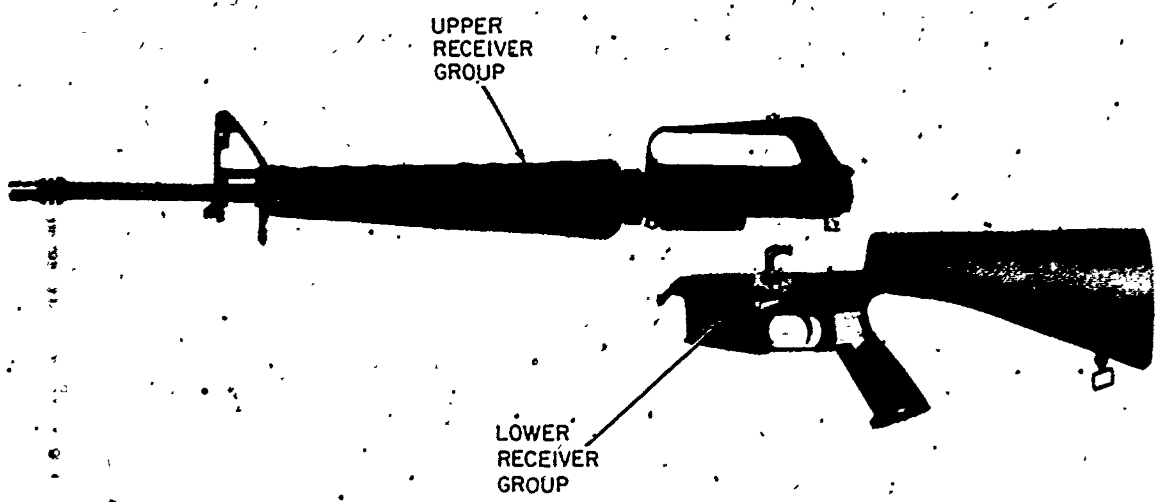


29.351

Figure 4-33.—Breaking upper receiver away from lower receiver.

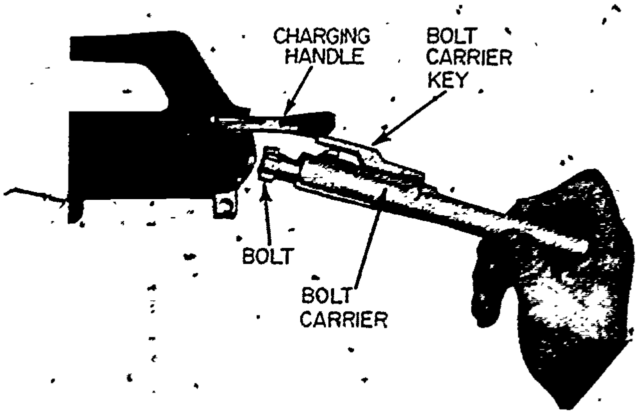
29.352

Figure 4-34.—Pressing out receiver pivot pin.



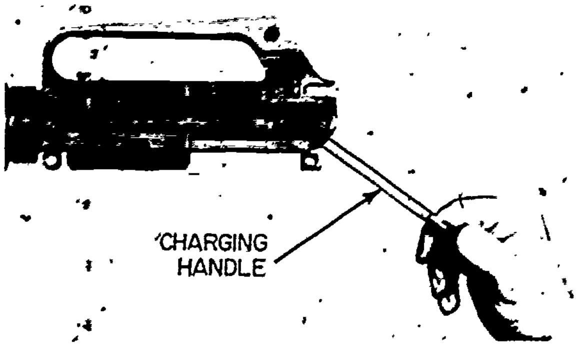
29.353

Figure 4-35.—Upper and lower receiver groups.



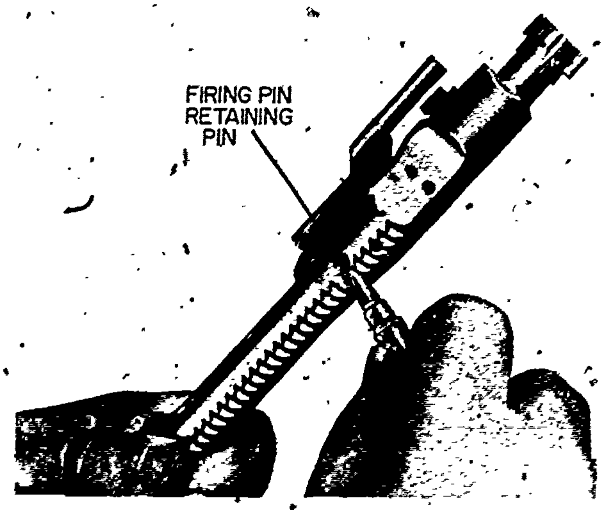
29.354

Figure 4-36.—Removing bolt carrier from receiver.



29.355

Figure 4-37.—Removing the charging handle.



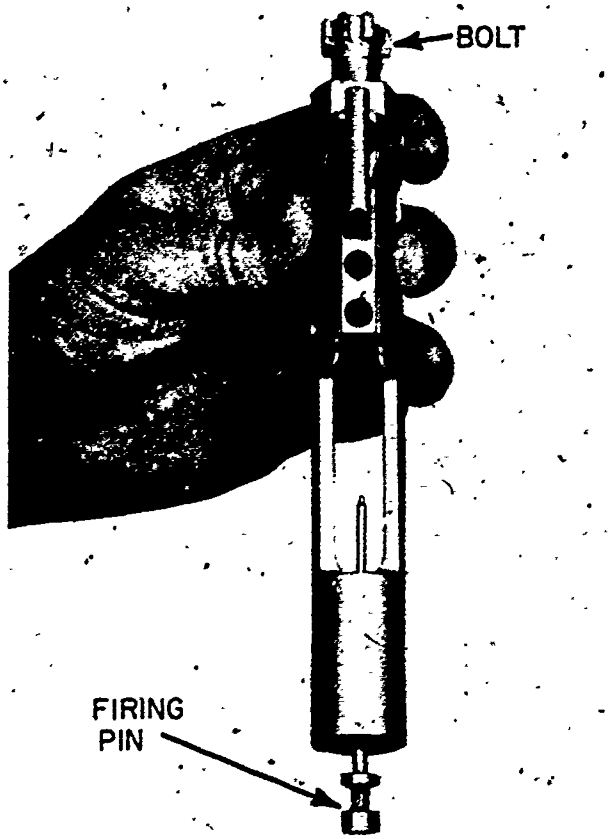
29.356

Figure 4-38.—Pressing out firing pin retaining pin.

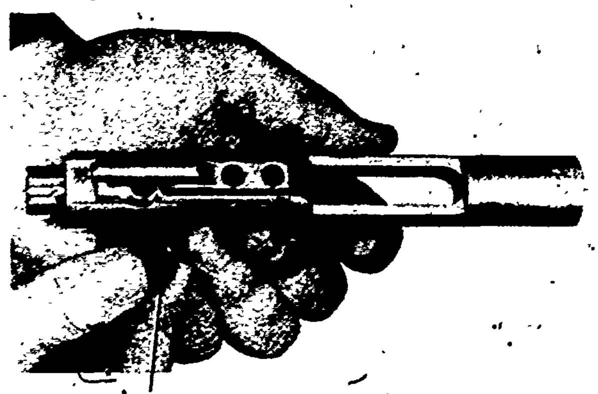
OPERATING THE M16 RIFLE

Loading the Magazine

The magazine has a capacity of 20 rounds and may be loaded with any amount up to that capacity. The magazine follower has a raised portion generally resembling the outline of a



29.357
Figure 4-39.—Removing the firing pin.



29.359
Figure 4-40.—Removing the cam pin.

29.358
Figure 4-41.—Removing the bolt.

cartridge. Cartridges are loaded into the magazine so that the tips of the bullets point in the same direction as the raised portion of the follower (fig. 4-42).

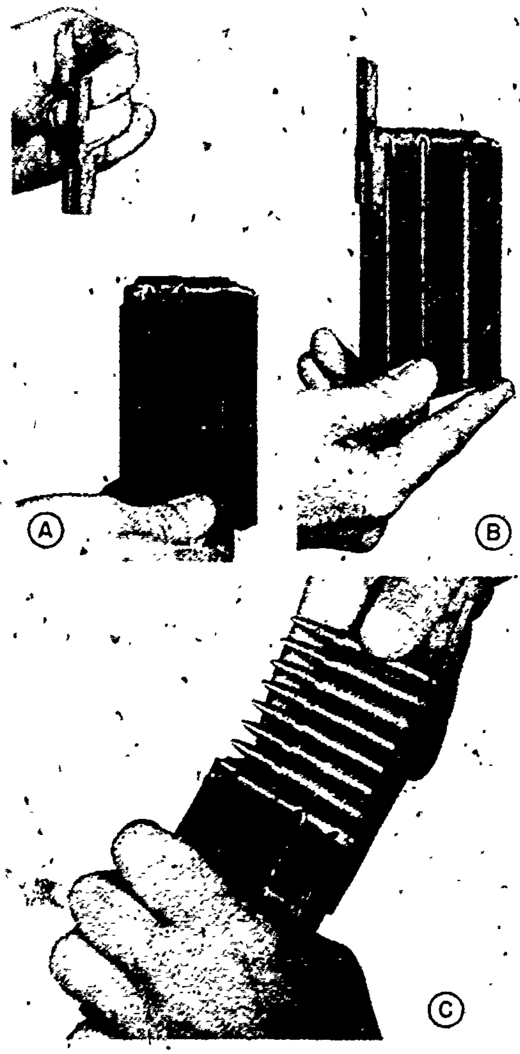
A magazine charger and magazine charger strip (fig. 4-43) are provided to facilitate loading of the magazine. The magazine charger is connected to the magazine and fully seated. The charger strip is inserted into the magazine charger until fully seated. Pushing on the top cartridge will force cartridges into the magazine.

Loading the Rifle

With the hammer cocked, place the selector lever on SAFE. The magazine may be inserted with the bolt either open or closed; however, you should learn to load with the bolt open. This reduces the possibility of a first-round stoppage and saves the time required to chamber the first round by pulling back the charging handle.

Open the bolt and lock it open as previously described. Hold the stock of the rifle under

29.360
Figure 4-42.—Loading cartridges into magazine.



84.353
Figure 4-43.—Loading cartridges into magazine with magazine loading strip and charger.

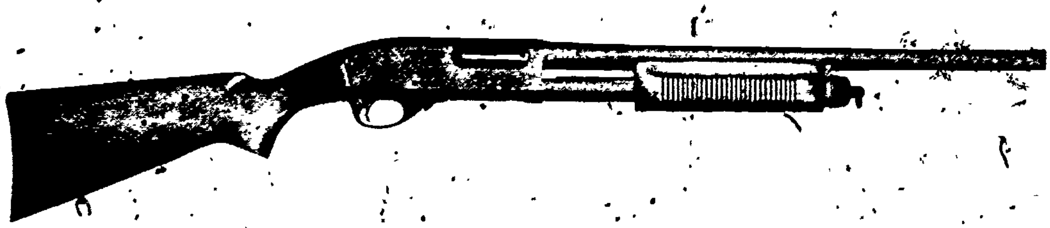
the right arm with the right hand grasping the pistol grip, and point the muzzle in a safe direction. With the left hand, insert a loaded magazine into the magazine feedway. Push upward until the magazine catch engages and holds the magazine. Rap the base of magazine sharply with the heel of the hand to ensure positive retention. Then release the bolt by depressing the upper portion of the bolt catch as previously described. The bolt, as it rides forward, will chamber the top round.

If you load the rifle with the bolt closed, you chamber the top round by pulling the charging handle fully to the rear and releasing it. NOTE: Do not "ride" the charging handle forward with the right hand. If the handle is eased forward from the open position, the bolt may fail to lock. If the bolt fails to go fully forward, strike the forward assist assembly (fig. 4-26) with the heel of the right hand.

Unloading the Rifle

To unload the rifle and make it safe, place the selector lever on SAFE, press the magazine catch button and remove the magazine, pull the charging handle to the rear, inspect the chamber to ensure it is clear, lock the bolt carrier to the rear by depressing the lower portion of the bolt catch, and return the charging handle forward.

The rifle is clear (and therefore safe) ONLY when no round is in the chamber, the magazine is out, the bolt carrier is to the rear, and the selector lever is on the SAFE setting.



84.354

Figure 4-44.—Remington M870 shotgun.

GUN MAINTENANCE

A clean, properly lubricated, and maintained M16 rifle will function properly and fire accurately when needed. To keep the rifle in good operating condition, it must be properly cared for and maintenance performed according to set procedures. The procedures for the care and cleaning of the rifle can be found on the 3-M System Maintenance Requirement Cards (if implemented) or in the Army's FM 23-9. Maintenance of the M16 rifle is generally the same as for other small arms previously discussed. The bore and chamber must be kept free of residue and foreign matter. Inspect, while cleaning and lubricating, all sliding or working surfaces for burrs, cracks or worn areas (repair or replace as necessary) and lubricate with a thin film of lubricant. Remove dirt, rust, grit, gummed oil, and water as these will cause rapid deterioration of the inner mechanism and outer surfaces.

SHOTGUNS

Shotguns used by the armed forces are not specialized military weapons but civilian models procured for certain use such as guard work and skeet shooting. The armed forces use a variety of makes and models of shotguns. The Navy, however, has adopted the Remington M870 as its standard shotgun.

In this section we will take up the functioning, construction features, and maintenance inspection of the standard issue shotgun you will most likely encounter in the fleet—the Remington Model M870 (fig. 4-44).

REMINGTON SHOTGUN M870

Now let's go into a little detail on the M870 shotgun used by the Navy for guard work and skeet shooting. This is a manually operated, pump action, magazine fed (tubular), shoulder type weapon.

Technical Description

Length of shotgun	41-3/4 inches (approx)
Length of barrel	21 inches (approx)
Magazine capacity rounds	4
Shell (gage)	12
Ammunition	12 gage 2-3/4" Standard velocity and 2-3/4" Magnum shot shells
Safety	Cross bolt type
Fore-end	Plain Beaver tail style

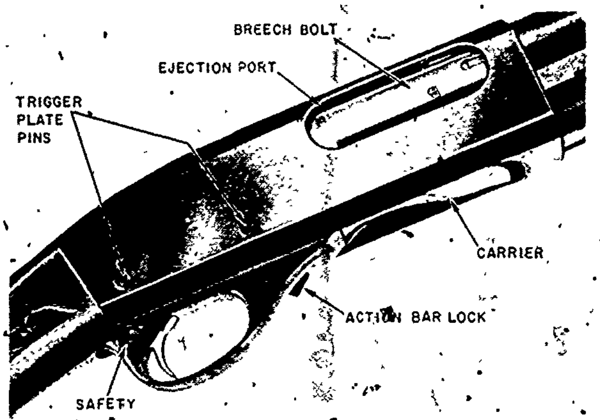
Functioning of Remington M870

Safety—Before loading or unloading, push safety (fig. 4-45) across rear of trigger left to right to ON SAFE position. Red band on safety will not show.

Fire position—Push safety across to FIRE position. Red band marking will show. Trigger can then be pulled to fire the gun.

Single load—Push safety ON SAFE. Press in the action bar lock (fig. 4-45) and pull the fore-end fully to the rear. Place shell into open ejection port upon downthrust carrier. Slide fore-end toward the muzzle to load shell into the barrel chamber and lock action closed.

Magazine load—Push safety ON SAFE. Slide fore-end completely forward to close the action. Turn gun bottom upward and press shell against carrier then forward fully into the magazine. Make sure that the rim of the shell snaps past shell latch to prevent shell from sliding back



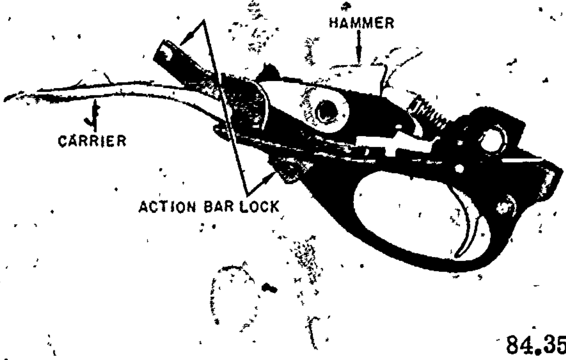
84.355

Figure 4-45.—Remington M870 receiver nomenclature.

over carrier. Should this occur, forcefully open action or, if necessary, remove trigger plate assembly (fig. 4-46) if gun is cocked to remove shell.

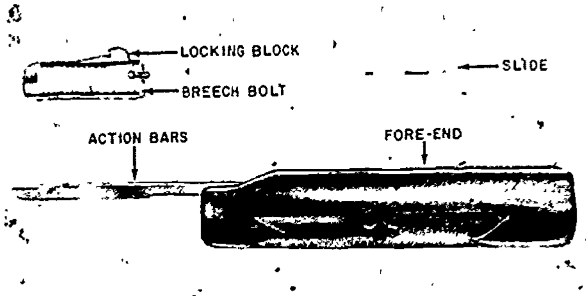
Load barrel from magazine—Shells can be fed from loaded magazine by simply pumping the fore-end. Press in the action bar lock (fig. 4-45) if the gun is cocked. Pump the fore-end back and forth to open and close the action.

Unload gun—Push safety ON SAFE. Press in the action bar lock; pull fore-end (fig. 4-47) slowly rearward until front end of shell from barrel is even with ejection port in receiver. Lift front of shell outward and remove from ejection port. Continue pulling fore-end back fully until next shell releases from magazine. Roll gun sideways to allow released shell to drop from ejection port. Close action by pushing



84.356

Figure 4-46.—Remington M870 trigger plate assembly.



84.357

Figure 4-47.—Remington M870 fore-end assembly.

forward on fore-end. Continue this same method until magazine and gun are empty.

CAUTION: Open action and check shell chamber in breech and magazine to make sure no rounds remain in gun.

Unload barrel only—Push safety ON SAFE. Press in the action bar lock and pull fore-end rearward until front end of shell from barrel is even with front end of ejection port. Lift front end of shell from receiver as described previously. A shell with different powder and shot combination may then be placed in chamber and action closed without disturbing shells in the magazine.

Remington M870 Operating Cycle

To fully understand an operating cycle of the shotgun M870, it is necessary to know the names and general function of the gun's parts. To become more familiar with the parts during our discussion of an operating cycle, refer to figure 4-48A, the individual parts breakdown, and figure 4-48B, the accompanying parts list.

The entire operating cycle of the shotgun M870 is completed by pulling the trigger, sliding fore-end rearward to open action, and forward again to close the action. The fore-end is mounted on double action bars and is fully controlled and operated by the shooter.

Assuming the magazine is loaded and one shell is in the chamber and locked, the gun is ready to fire. The firing cycle is as follows:

FIRING—With the cross bolt safety pushed to fire position (red band showing), the gun is fired by pulling the trigger. The top part of the trigger rotates forward carrying the right connector, in ready position, forward against the sear. This movement pivots the sear out of engagement with the hammer. The released hammer with force from the spring loaded hammer plunger strikes the firing pin which is pinned in the breech bolt and spring retracted. The firing pin strikes the primer and ignites the powder charge. During the upward movement of the hammer, it engages the action bar lock just before it strikes the firing pin. Downward movement of front of the action bar lock is restrained until pressure against it is briefly released by the shooter as his arm recoils rearward. When action bar lock is released, forward end of the action bar lock is lowered from its position at rear of left action bar and the rear section rises and lifts the left connector which lifts the right connector from contact with the sear. This completes the "lock" or firing mechanism firing cycle. The action bar lock serves a two-fold purpose. It serves as a safety feature that disconnects the trigger assembly and sear until a shell is fully seated in the chamber and the breech mechanism again is ready for firing and locks the action closed.

After pulling the trigger, pulling the fore-end rearward will open the action and accomplish Unlock, Extract, Eject, Cock and Feed cycles.

UNLOCK—The inition rearward movement of the fore-end, after shell has been fired, carries the slide to rear of the breech bolt. As the breech bolt passes to the rear, the slide cams the locking block from recoil shoulder of barrel. This movement unlocks the action and cams the firing pin to the rear where it is locked and prevented from protruding through the bolt face.

EXTRACT—Continued rearward movement of the fore-end opens the action. The breech bolt moves back and the fired shell is extracted from the chamber. The extractor claw, which overhangs the bolt face, grips rim of shell tightly as extraction progresses. Pivot pressure is exerted on rear of extractor by extractor plunger and spring.

EJECT—As the extracted shell clears the chamber, its base engages a shoulder on rear of the ejector spring, which is located on left side of receiver. This pivots the shell so its front end is ejected first through the ejection port.

COCKING—Before ejection occurs, the breechbolt in its rearward travel forces the hammer down against the coiled hammer spring to engage the sear. Sear spring pressure locks the sear in a notched position against the cocked hammer.

FEEDING—The final movement of fore-end carries the slide, breech bolt assembly, and locking block to the rear of the receiver. Termination of this rearward stroke also permits the left action bar to cam the left shell latch, in turn releasing the first shell from the magazine. The released shell is forced from the magazine by a spring loaded follower. The carrier receives the released shell. Meanwhile, the right shell latch which was cammed into the magazine way by the right action bar during extraction cycle, intercepts base of the second shell.

With a shell resting on the depressed carrier, forward movement of the fore-end will close the gun's action and complete the loading and locking cycles.

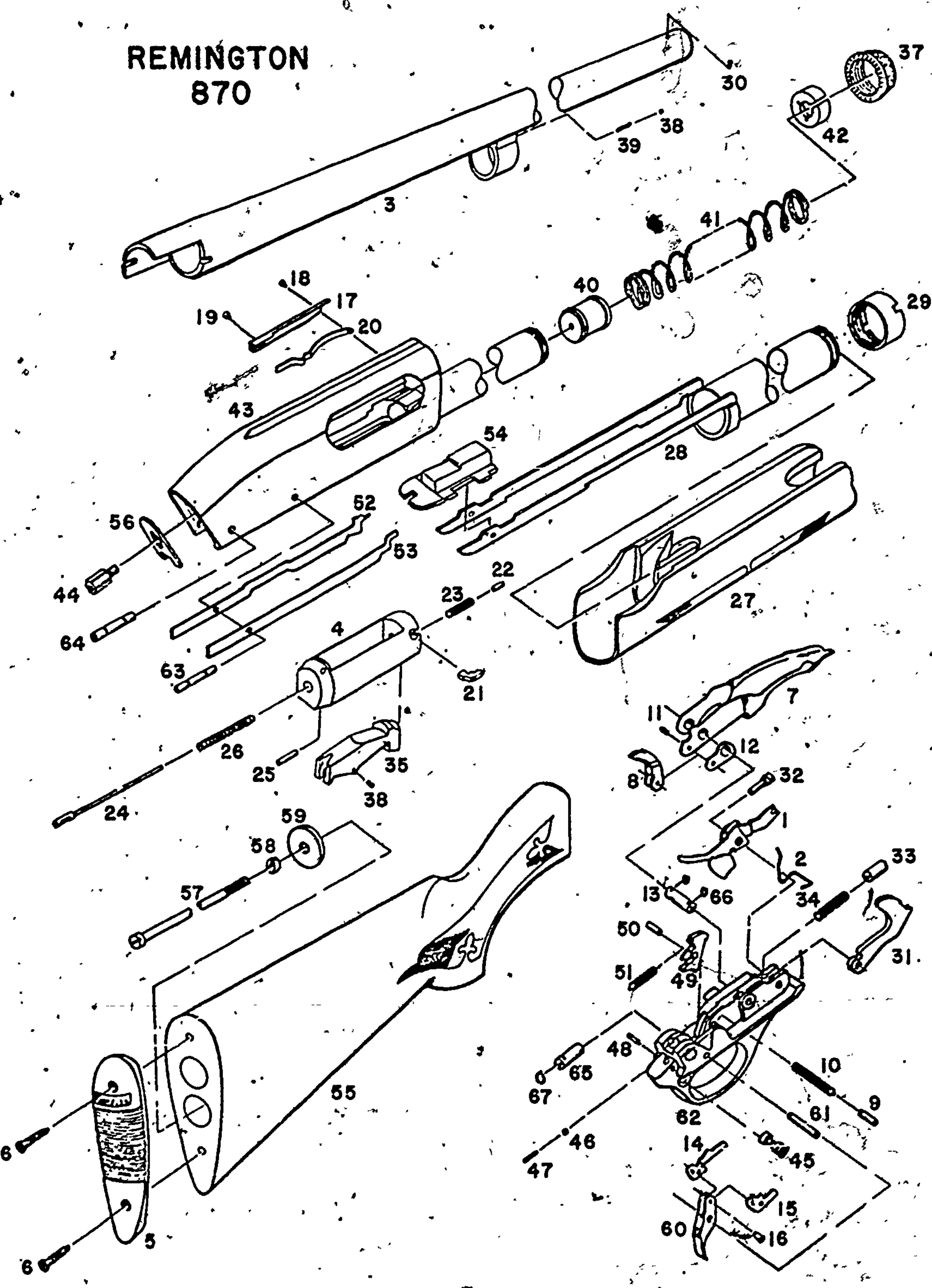
LOADING—Forward movement of the fore-end will carry with it the slide, breech bolt, and locking block. The carrier dog is engaged by the slide, pivots the shell carrier upward, and places a shell in the path of the returning breech bolt. As the bolt continues to advance, it depresses the ejector spring and the shell is picked up and loaded into the chamber. The carrier dog is released by the passing slide, forced up by the carrier dog follower, and pivots the carrier from path of the loading shell. The following shell from the magazine, being retained by the right shell latch, is released by the camming action of the returning right action bar. At this point the shell is intercepted and held by the left shell latch until the next feeding cycle.

LOCKING—When the shell is fully in the chamber, the action closes and the bolt is against the shell base. The slide continues to travel within the bolt and cams the locking block into recoil shoulder of the barrel. The locking block secures the breech bolt firmly and is supported by the slide as it completes its forward travel. With the locking block fully seated, the passage through the locking block allows protrusion of the firing pin through the bolt face.

MAINTENANCE

The following discussion on maintenance of the shotgun M870 will cover only action necessary for routine maintenance of the weapon. More detailed information may be obtained from the manufacturer's pamphlet.

Before any disassembly of the shotgun M870 is attempted, be sure no shells remain in the chamber or magazine.



84.358

Figure 4-48A.—Remington M870 individual parts breakdown.

View No.	NAME OF PART	View No.	NAME OF PART
1	Action Bar Lock	36	Locking Block Stud
2	Action Bar Lock Spring	37	Magazine Cap
3	Barrel Assembly, 12 Ga. PLAIN, 20" (includes Barrel, Barrel Guide Ring, Barrel Guide Pin Front Sight (Steel), Magazine Cap Detent, Magazine Cap Detent Spring)	38	Magazine Cap Detent
4	Breech Bolt, 12 GA.	39	Magazine Cap Detent Spring
	Breech Bolt Assembly, Complete, 12 Ga., (includes Breech Bolt, Extractor, Extractor Plunger, Extractor Spring, Firing Pin, Firing Pin Retaining Pin, Firing Pin Retractor Spring, Locking Block Assembly, Slide)	40	Magazine Follower, 12 Ga.
5	Butt Plate	41	Magazine Spring
6	Butt Plate Screw	42	Magazine Spring Retainer
7	Carrier	43	Receiver Assembly, 12 Ga. (includes Receiver, Ejector, Ejector Rivet, Front; Ejector Rivet, Rear; Ejector Spring, Magazine Tube, Barrel Support)
	Carrier Assembly, (includes Carrier, Carrier Dog, Carrier Dog Pin, Carrier Dog Washer)	44	Receiver Stud
8	Carrier Dog	45	Safety
9	Carrier Dog Follower	46	Safety Detent Ball
10	Carrier Dog Follower Spring	47	Safety Spring
11	Carrier Dog Pin	48	Safety Spring Retaining Pin
12	Carrier Dog Washer	49	Sear
13	Carrier Pivot Tube	50	Sear Pin
14	Connector, Left	51	Sear Spring
15	Connector, Right	52	Shell Latch, Left, 12 Ga.
16	Connector Pin	53	Shell Latch, Right, 12 Ga.
17	Ejector, 12 Ga.	54	Slide
18	Ejector Rivet, Front	55	Stock Assembly (includes Stock, Grip Cap, Grip Cap Screw, Butt Plate, Butt Plate Screws (2)
19	Ejector Rivet, Rear	56	Stock Bearing Plate
20	Ejector Spring	57	Stock Bolt
21	Extractor	58	Stock Bolt Lock Washer
22	Extractor Plunger	59	Stock Bolt Washer
23	Extractor Spring	60	Trigger
24	Firing Pin		Trigger Assembly (includes Trigger, Connector, Left; Connector, Right; Connector Pin)
25	Firing Pin Retaining Pin	61	Trigger Pin
26	Firing Pin Retractor Spring	62	Trigger Plate, R.H. (Right Hand Safety)
	Fore-end (Wood only) 12 Ga.		Trigger Plate, L.H.
27	Fore-end Assembly, 12 Ga. (includes Fore-end, Fore-end Tube Assembly, Fore-end Tube Nut)		Trigger Plate Assembly, R.H. (includes Action Bar Lock Action Bar Lock Spring, Carrier, Carrier Dog, Carrier Dog Follower, Carrier Dog Follower Spring, Carrier Dog Pin, Carrier Dog Washer, Carrier Pivot Tube, Connector Left; Connector right; Connector Pin, Hammer, Hammer Pin, Hammer Pin Washer, Hammer Plunger, Hammer Spring, Safety, Safety Plunger, Safety Spring, Safety Spring Retaining Pin, Sear, Sear Pin, Sear Spring Trigger, Trigger Pin, Trigger Plate, R.H.; Trigger Plate Pin Bushing, Trigger Plate Pin Detent Springs, From (2); Trigger Plate Detent Spring, Rear)
28	Fore-end Tube Assembly (includes Action Bar, Left; Action Bar, Right; Fore-end Tube)		Trigger Plate Assembly; (L.H. Safe)
29	Fore-end Tube Nut	63	Trigger Plate Pin, Front
30	Front Sight (Plain Barrel)	64	Trigger Plate Pin, Rear
	Front Sight (Vent Rib) Steel Bead	65	Trigger Plate Pin Bushing
	Front Sight Retaining Pin (for use on Vent Rib Steel-Sight)	66	Trigger Plate Pin Detent Spring, Front
31	Hammer	67	Trigger Plate Pin, Pin Detent Spring, Rear
32	Hammer Pin		
	Hammer Pin Washer		
33	Hammer Plunger		
34	Hammer Spring		
35	Locking Block Assembly (includes Locking Block, Locking Block Stud)		
	Locking Block Assembly (oversize)		

84.359

Figure 4-48B.—Remington M870 parts list.

BARREL — To remove and clean the barrel, push the safety to SAFE. Open the action, unscrew the magazine cap, and pull barrel from the receiver. Replace magazine cap on the end of the magazine tube. To clean the barrel, use a cleaning rod with a lightly oiled cloth. If powder fouling remains in the barrel, use a powder solvent to scrub the bore. After using solvent, wipe clean and re-oil very lightly. Replace the barrel by removing the magazine cap, insert barrel in receiver, and replace the magazine cap.

TRIGGER PLATE ASSEMBLY — With the safety pushed ON SAFE, cock the action. Tap out the front and rear trigger plate pins (fig. 4-48A). Lift rear of the trigger plate from receiver, then slide rearward to remove from the gun. The trigger assembly will be cleaned as a unit by brushing with a solvent. Wipe dry and re-oil very sparingly. When replacing the plate assembly in the gun, make sure the action bar lock (fig. 4-46) enters the receiver easily and operates in position.

FORE-END ASSEMBLY UNIT- Push the safety ON SAFE. Close the action, remove the magazine cap and barrel. Reach into bottom of receiver and press the left shell latch inward. Remove fore-end by sliding forward off the magazine tube. After the fore-end assembly has been removed from the gun, the breech bolt parts and slide may be lifted from ends of the action bars.

NOTE: The top right edge of slide may bind on bottom front edge of ejector port in the receiver. To free the slide, push downward on front end of the bolt.

It is not necessary to disassemble the bolt for routine cleaning. Brush with solvent to clean, then wipe dry.

Assembly of the weapon is done in reverse of disassembly. There are, however, set procedures to follow to facilitate the assembly.

When assembling the fore-end parts, the gun must be cocked. During this assembly, place slide in the correct position on ends of the double action bar. Place the breech bolt assembly, which includes the attached locking block assembly, over slide on the action bars. Insert end of action bars into matching grooves in the receiver. Move the fore-end slowly until contact is made with the front end of right shell latch. Press front right shell latch into side of the receiver and continue moving the fore-end past this latch until contact is made with the left shell latch. Press the front of left shell latch in to allow fore-end assembly to pass and move freely into the receiver. Assemble barrel to the receiver and tighten firmly with the magazine cap. This completes the assembly of the shotgun.

LINE THROWING GUN

The line-throwing gun (fig. 4-49) is the only gun in the Navy that fires a projectile of small arms caliber that is not intended as a weapon. The gun is also unique among those we have taken up in this chapter in that it is not of Army origin. It is used only by the Navy and the reference publication for it is OP 546.

The line-throwing gun is used to pass a small line from ship to ship or from a ship to the beach. A projectile, with one end of the line attached, is fired from the gun by the impulse of a blank cartridge. This small line serves as a messenger for the larger lines of refueling rigs, high lines, breeches buoys, mooring lines, etc.

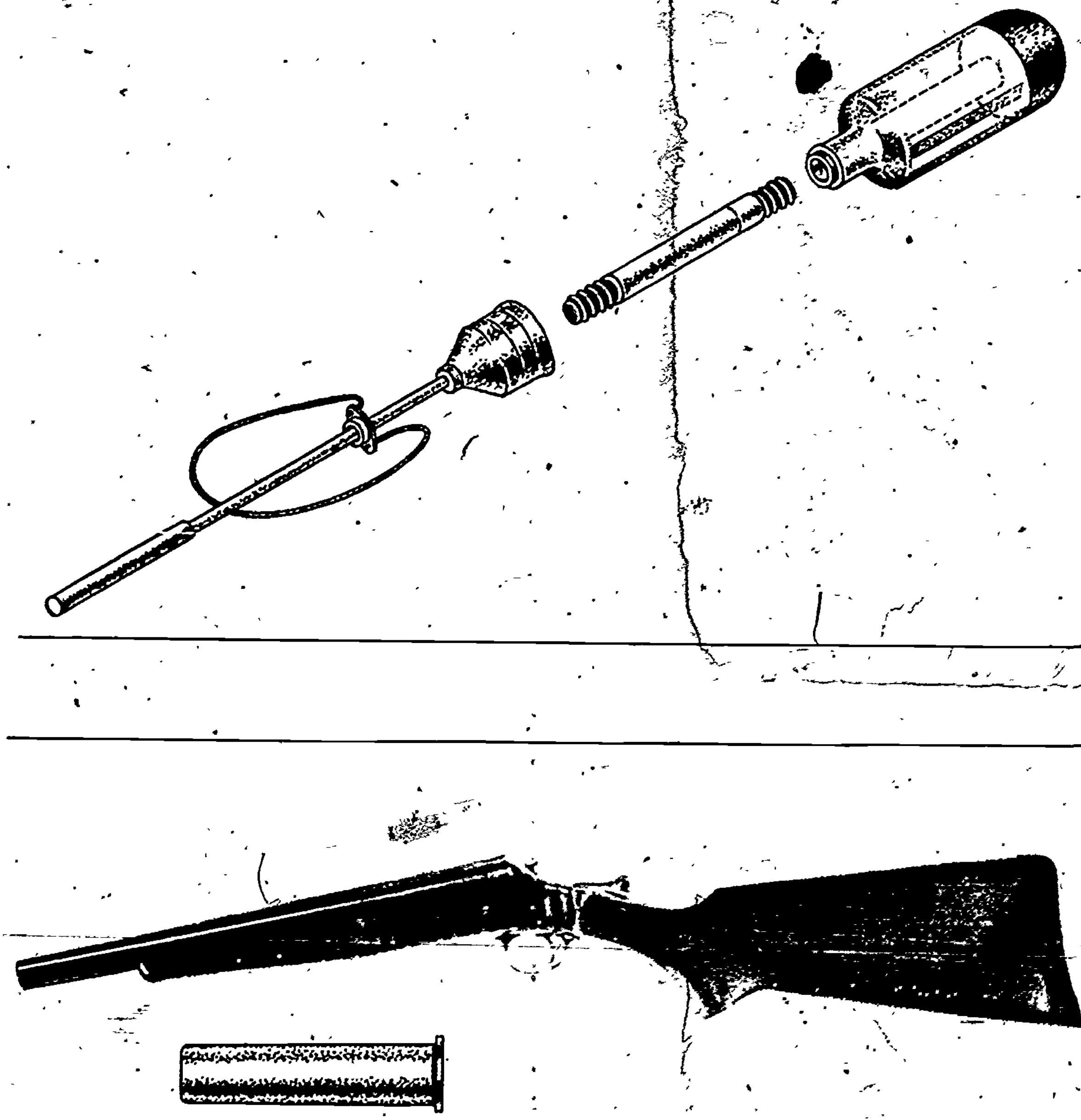
The gun is single shot, smooth bore (.45 cal.), with a short barrel of tip-down action hinged to the frame. It is ruggedly constructed, and the breech is heavily reinforced to withstand the relatively high chamber pressures.

The shot line is made of nylon with a minimum (when new) breaking strength of 125 pounds. It is wound on a wooden spindle in such a way that, when the spindle is removed for firing, it will pay out without fouling. The ammunition is a blank 45-70 cartridge loaded through the breech of the gun while the projectile is loaded through the muzzle.

The projectile (fig. 4-49) is made up of three major units: a buoyancy chamber, an illuminating unit, and the rod. The buoyancy chamber is a plastic bottle-shaped cylinder fitted onto the front of the rod. It serves to keep the projectile afloat. The illumination unit is essentially a small flashlight which is enclosed in the buoyancy chamber. It is especially useful during night operation for obvious reasons. The rod is the part of the projectile that goes in the gun's muzzle. The nylon shot line is attached to a slide on the rod. If the rod gets scratched, burred, or slightly bent, use fine emery cloth to get it back into shape. DO NOT fire any projectile that fails to enter the bore freely.

FIRING THE GUN

Before firing the caliber .45 line-throwing gun, certain precautions are necessary.



84.250

Figure 4-49.—Caliber .45 line-throwing gun and projectile.

177

1. Before loading, select an outboard firing position clear of rigging, ship's structure, or any obstacles on which the line may become fouled.

2. All loading and firing operations are to be performed at the rail, with the gun pointed outboard in a safe direction.

3. Open the breech and inspect the bore to see that it is thoroughly clean and dry, and slip the projectile into the muzzle to see that it moves freely. The projectile must move freely its entire length of the travel in the bore. Excessive friction produces dangerously high chamber pressure and reduces range.

It takes two men to safely fire the line-throwing gun unless the special cannister is used. One man holds the coiled line and the other fires the gun. Assuming that the projectile has been properly prepared, follow this procedure:

Both men station themselves at the rail, the man holding the coiled line to leeward of the shooter. On a ship underway this precaution normally puts the man with the gun forward of the man holding the line.

If the line has not yet been attached to the projectile, do it now. Knock out the wooden spindle; pull enough line from the center of the coil and tie it to the slide on the projectile. Don't pull out any more line than is necessary for this operation.

Try the projectile in the bore of the gun. It must pass through freely. Now take the projectile out of the bore.

Standing at the rail, open the breech by pressing the unlocking lever to one side.

Insert a cartridge into the breech.

Close the breech.

Insert the projectile rod into the bore as far as it will go.

Brace the gun firmly against the shoulder. Cock the gun by pulling back on the hammer until it reaches the full cock position.

Aim the gun. At short ranges the gun is fairly accurate. At long ranges, however, you will have to elevate your aim and use "Kentucky windage" to lead the target. The path of the projectile and line are seriously affected by wind. Also, the projectile is relatively slow moving, so target speed is a factor in aiming the gun. About the only firm rule we can lay down here is that your shot should be placed well clear of personnel on the receiving ship. Fire the gun.

When the man holding the coiled line sees that the projectile has definitely crossed the other ship, he squeezes the coil, halting any further paying out of the shot line.

Take a bight in the line and secure what is left in the coil with it. Bend your shot line to whatever running lines are going to be sent over to the receiving ship.

Your interest in the proceedings now is largely one of trying to get your shot line and projectile sent back with the rig.

Note 1: In the event of a misfire, keep the gun braced against your shoulder and pointed in a safe direction. Recock and attempt to fire again. If repeated attempts to fire fail, wait one minute before opening the breech and removing the cartridge. Take a quick look at the primer to see if it has been struck by the firing pin; if so, deep six it.

The firing pin of the line-throwing gun is a short, free-floating type. It is a good idea, before you shoot, to elevate the gun and jiggle it to bring the firing pin out toward the hammer as far as it will go.

Note 2: When shooting the gun, do NOT lay your thumb on top of the stock immediately behind the breech unlocking lever. Instead, lay it alongside the frame. The recoil of a line-throwing gun is such that, if you hold it incorrectly, the unlocking lever can pinch or even penetrate your hand. And there is the possibility that if your hand is placed so as to interfere with the unlocking lever's rearward movement, the lever may be cammed to one side, unlocking the breech. In this case, recoil may be accompanied by a rapid unintentional disassembly of the gun.

Maintenance

Authorized disassembly of the line-throwing gun is limited to the following steps:

1. Remove the foregrip by pulling it down firmly, releasing the spring snap which secures the grip to the barrel.

2. Remove the barrel by opening the breech and pushing back on the barrel, disengaging it from the frame.

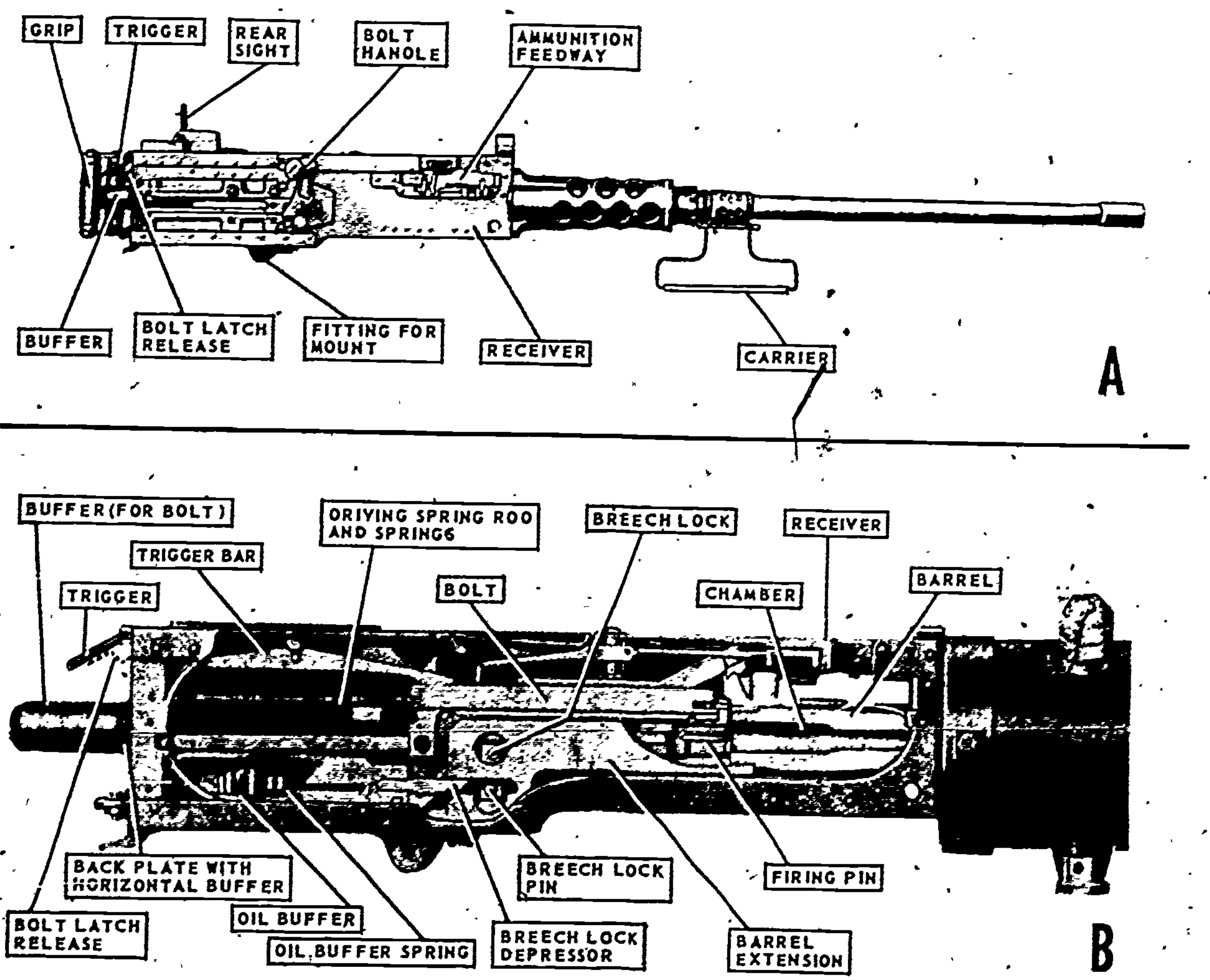
The gun is reassembled by reversing the foregoing steps.

When the gun is stored in the armory, it is kept lubricated with a light oil, as are all small arms. When it is to be fired, however, the bore must be completely cleaned and dried by running patches through it. Also, between consecutive firings, a dry patch should be run through the bore to remove all powder residue from the previous shot. The line-throwing gun is known for its kick, and anything causing the projectile to bind in the bore adds dangerously to the gun's recoil.

BROWNING MACHINEGUN CALIBER .50, M2

Browning machineguns (abbreviated BMG) are standard Army weapons used by the Navy in the air, ashore, and afloat. The caliber .50 BMG now used by the Navy and Army is the M2, which may be equipped with either of two different kinds of barrels—air-cooled (for aircraft use), or air-cooled heavy barrel (HB). Although the caliber .50 HB (fig. 4-50) is not used as extensively as it once was, it is still found on many combat ships and on certain types of landing craft. (The .50 caliber MGs are still important as aircraft armament, but you're not likely to have to deal with such installations. Therefore, we will not take up the air-cooled aircraft caliber .50 BMG.)

The mechanisms and the principles of operation of the caliber .50 BMG will be taken up in this section of the chapter. For the detailed



84.112

Figure 4-50.—Browning machinegun, caliber .50 HB, M2. A. Exterior. B. Cutaway view.

information on the caliber .50 BMG refer to the Army's FM 23-65.

The main characteristics of the caliber .50 BMG, M2 are as follows:

Weight of receiver group	56 lb
Weight of barrel	26 lb (approx)
Total weight of gun, complete, on tripod mount, M3	126 lb (approx)
Maximum range (M2 ball)	7400 yards
Maximum effective range	2000 yards
Cyclic rate of fire	450-500 RPM (approx)
Muzzle velocity (M2 ball)	2930 fps
Length of gun overall	65 in. (approx)
Length of barrel	45 in.

GENERAL DESCRIPTION

The Browning machinegun, caliber .50 HB, M2, is a belt-fed, recoil-operated, air-cooled machinegun. The gun is capable of semiautomatic, as well as automatic fire.

By repositioning some of the component parts, the gun is capable of alternate feed (ammunition can be fed from either the right or left side of the receiver); however, under most circumstances, the gun is fed from the left side. A disintegrating metallic link belt is used in feeding. In preparation for firing, the first round requires manual operation.

The force for recoil operation of the weapon is furnished by the expanding gases and is controlled by various springs, cams, and levers.

Air cooling of the weapon is permitted through maximum exposure to the air of the barrel and receiver. Perforations in the barrel support allow air to circulate around the breech end of the barrel and help to cool the parts. The heavy barrel is used to retard early overheating.

DISASSEMBLY AND ASSEMBLY

There are two classifications of disassembly and assembly of the caliber .50 BMG: general and detailed.

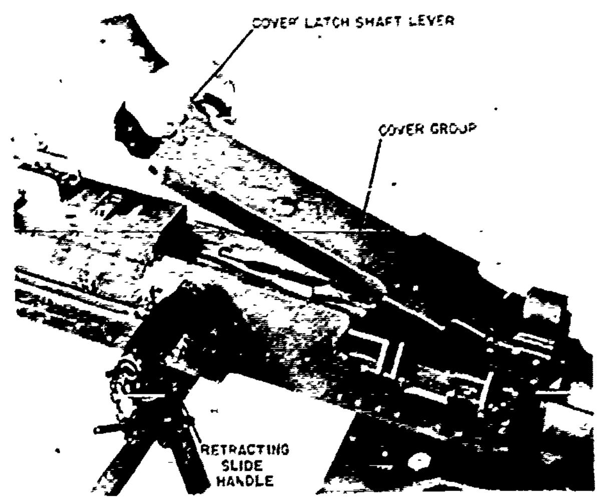
The general disassembly and assembly is what you as a GMG are expected to know. This includes removal of groups from the gun to the extent required for limited cleaning or replacement of groups.

Detailed disassembly and assembly includes the removal of all component parts from each group for cleaning, minor repairs, or replacement of parts.

We will present information here only on the general disassembly and assembly. If it becomes necessary that you need information on the details necessary for you to do detailed disassembly and assembly of the caliber .50 BMG, refer to the Army's FM 23-65.

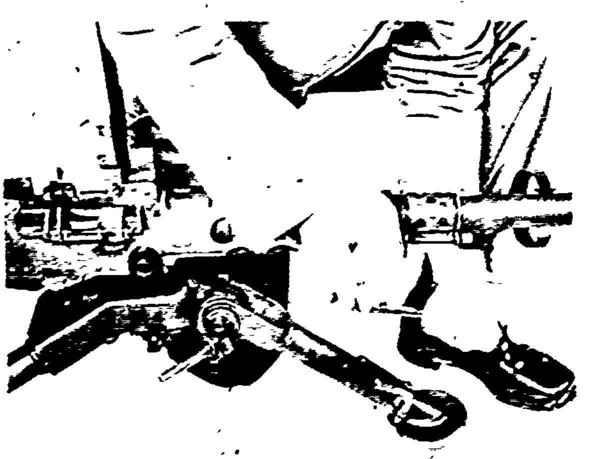
Barrel. Turn the cover latch shaft lever and raise the cover group (fig. 4-51). Grasp the retracting slide handle with the right hand, palm up; pull the recoiling parts to the rear until the lug on the barrel locking spring alines with the 3/8-inch hole in the right sideplate of the receiver (just below the feedway exit). The barrel can be turned only when the lug is alined with the 3/8-inch hole. Unscrew the barrel from the barrel extension, and remove the barrel from the receiver (fig. 4-52). Be careful not to damage the threads, or barrel locking notches.

CAUTION: Do not allow the bolt to slam forward with the barrel removed. Damage to parts will result from this action.



84.360

Figure 4-51.—Raising the cover.

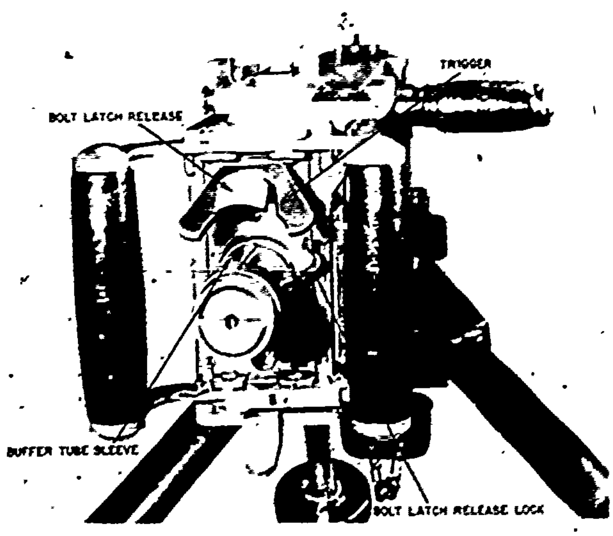


84.361
Figure 4-52.—Removing the barrel.

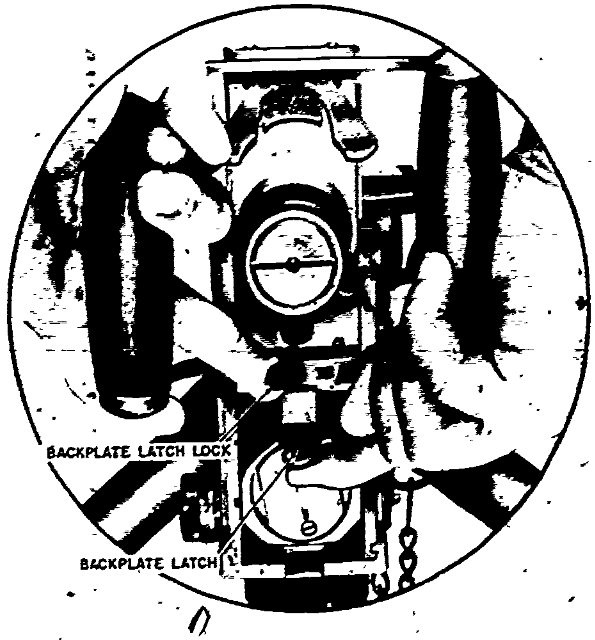
Backplate. Ensure that the bolt latch release (fig. 4-53) is up, free of the bolt latch release lock. If it is not, push down on the bolt latch release and turn the buffer tube sleeve clockwise, or to the right, until the bolt latch release lock is free of the bolt latch release (fig. 4-53). The bolt must be forward before the backplate is removed. If the bolt is to the rear, push down on the bolt latch release to let the bolt go forward. The backplate latch lock and latch are below the buffer tube. Pull out on the latch lock and up on the latch; remove the backplate by lifting it straight up (fig. 4-54).

Driving spring group. The inner and outer driving springs and driving spring rod are located next to the right sideplate, inside the receiver (fig. 4-55). Push in on the head of the driving spring rod and turn to the left to remove the driving spring rod retaining pin from its seat in the right sideplate. Pull the driving spring group to the rear and out of the receiver. A slight pressure is exerted on the driving springs when the bolt is forward, however, never attempt to cock the gun while the backplate is off and the driving spring rod installed. If the backplate is off and the driving spring group is compressed, the retaining pin on the driving spring rod can slip from its seat and injure anyone behind the gun.

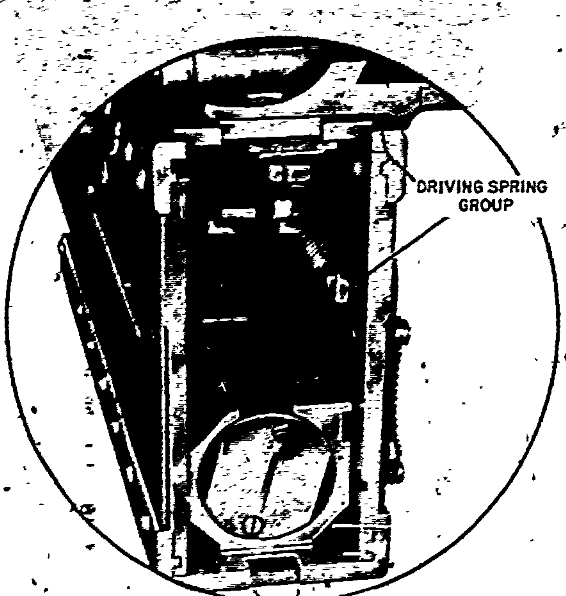
Bolt stud. Grasp the retracting slide handle and give it a quick jerk, halfway to the rear, to free the bolt from the barrel extension and move the bolt halfway to the rear. Aline the collar on the bolt stud with the clearance hole in the bolt slot on the right sideplate, and remove the bolt stud to the right (fig. 4-56). If the bolt



84.362
Figure 4-53.—Bolt latch release lock free of the bolt latch release.

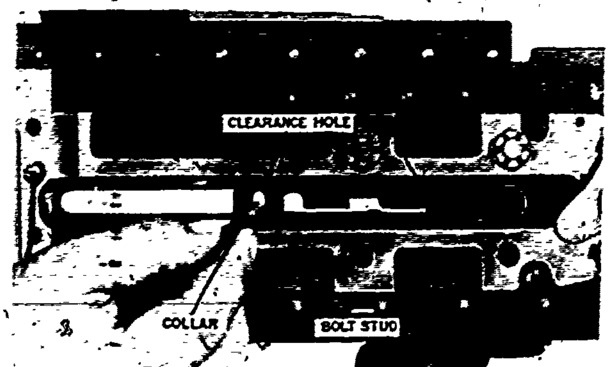


84.363
Figure 4-54.—Removing the backplate.



84.364

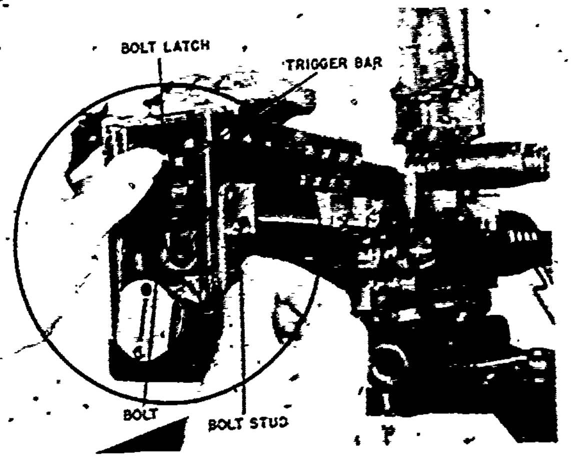
Figure 4-55.—Driving spring group with the driving spring rod retaining pin in its seat in the right sideplate.



84.365

Figure 4-56.—Removing the bolt stud.

is accidentally moved all the way to the rear, the bolt latch will engage in the bolt latch notches in the top of the bolt. If this occurs, raise the bolt latch (left of the trigger bar) and push the bolt forward to aline the bolt stud with the clearance hole (fig. 4-57).

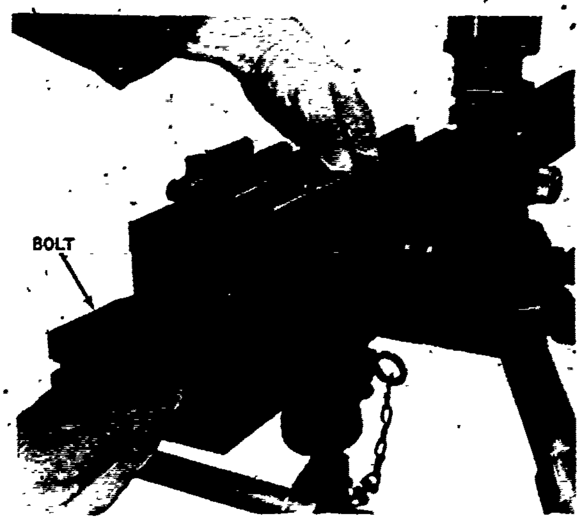


84.366

Figure 4-57.—Freeing the bolt.

Bolt. After freeing the bolt, slide it from the rear of the receiver (fig. 4-58). Place the bolt down on its right side (with the extractor arm up), so the extractor will not fall from the bolt.

Oil buffer group and barrel extension. Insert the drift of a combination tool, or other pointed instrument through the hole in the lower rear corner of the right sideplate. Push in on the oil buffer body spring lock. At the same time, place one hand on the receiver and push the



84.367

Figure 4-58.—Removing the bolt from the receiver.

barrel extension group and oil buffer group to the rear (fig. 4-59). Remove the oil buffer group and barrel extension group from the receiver. Separate the two groups by pushing forward on the tips of the accelerator (fig. 4-60).

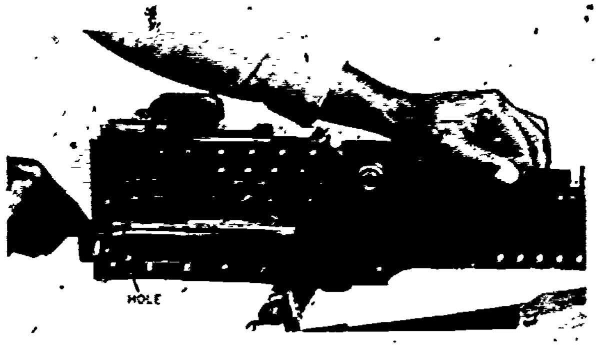
Oil buffer assembly. Pull the oil buffer assembly from the rear of the oil buffer body group. The oil buffer assembly will not be disassembled (fig. 4-61). This completes the general disassembly for limited cleaning and replacement of groups. Figure 4-62 shows the major groups after general disassembly.

To assemble the gun, replace the groups in the reverse order of removal of disassembly. To make assembly easier, there are certain procedures to follow that we will cover here.

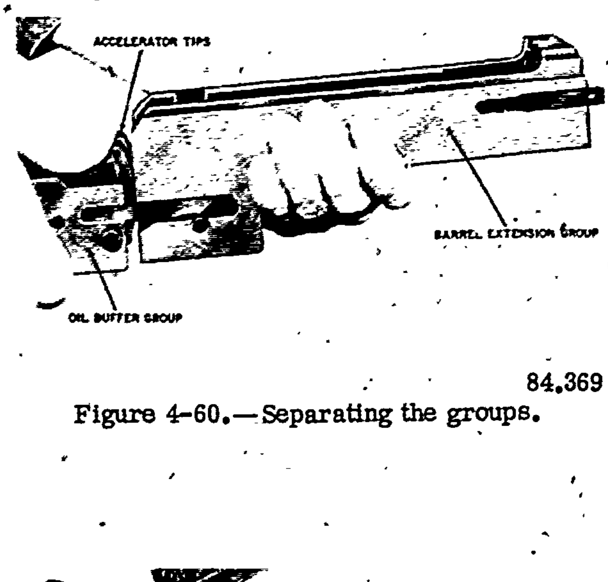
Oil buffer assembly and oil buffer body group. Replace the oil buffer assembly in the oil buffer body group, with the key on the spring guide to the right. This key must fit in its slot in the right side of the oil buffer body. Turn the oil buffer tube until the screwdriver slot (in the rear of the tube) is vertical, the arrow pointing to the right. The stud on the tube lock will now engage the serrations in the oil buffer tube. To keep the tube from turning, push the oil buffer assembly fully forward (figs. 4-63 and 4-64).

Oil buffer group and barrel extension group. To join the two groups together, hold the oil buffer group in the right hand, with the index finger supporting the accelerator. Join the notch on the shank of the barrel extension group with the cross groove in the piston rod of the oil buffer assembly. At the same time, aline the breech lock depressors with their guideways in the sides of the barrel extension, ensuring that the tips of the accelerator are against the rear end of the barrel extension (claws against the shank) (fig. 4-65). Push the groups together. As they rotate to the rear, press down on the tips of the accelerator to ensure positive locking of the groups. Place the groups in the receiver, and push them forward until the oil buffer body spring lock snaps into position. When the parts are properly locked in place, the oil buffer tube should protrude about 1-1/8-inches from the rear of the oil buffer body group.

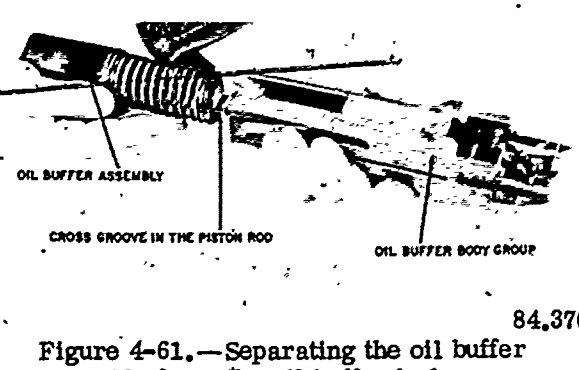
Bolt. Place the bolt in the receiver, with the top of the cocking lever forward and the extractor down (fig. 4-66). Push the bolt forward into the receiver. At the same time, look through the slot in either sideplate. As the front end of the bolt approaches the tips of the accelerator, press down



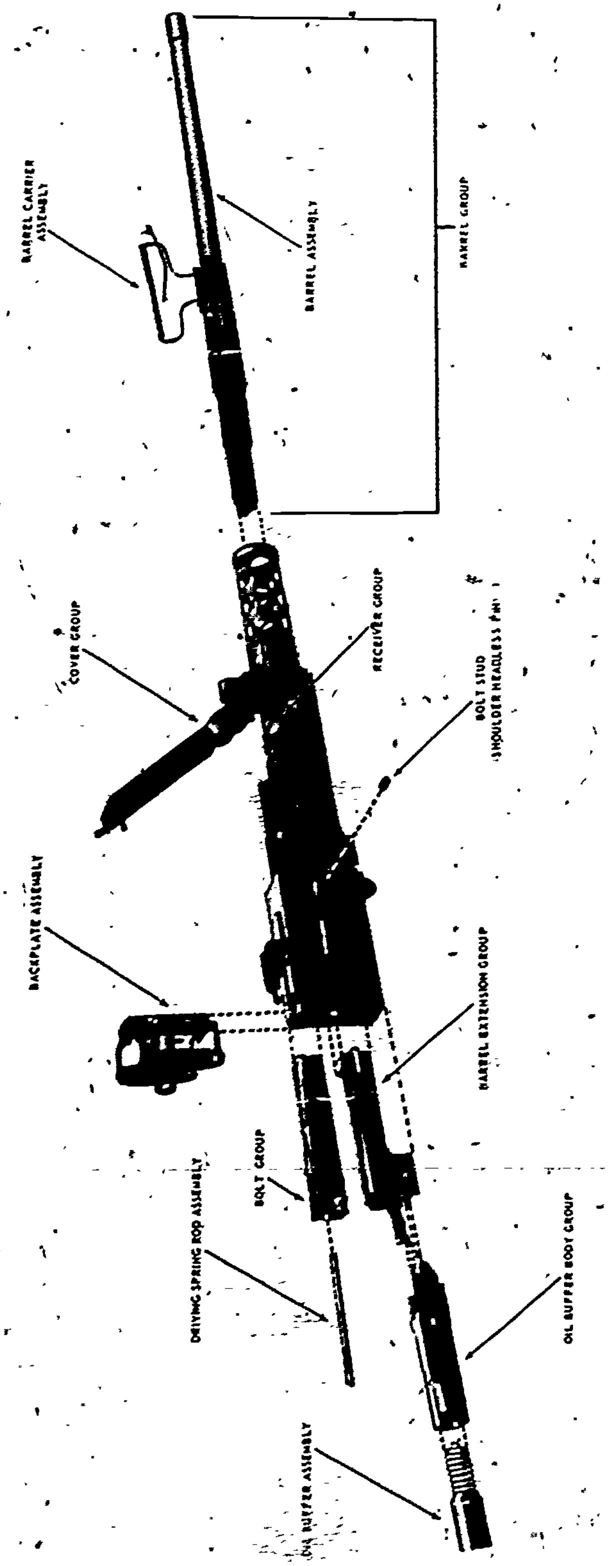
84.368
Figure 4-59.—Removing oil buffer group and barrel extension group.



84.369
Figure 4-60.—Separating the groups.

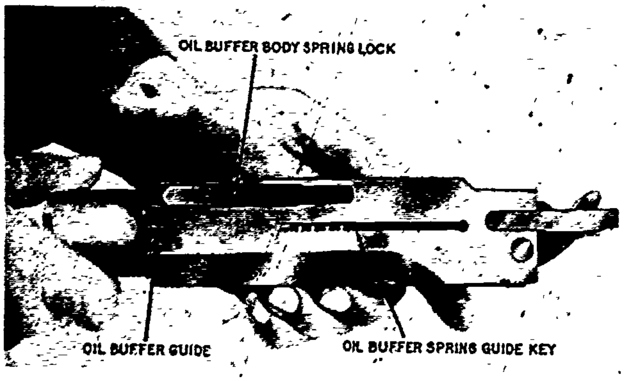


84.370
Figure 4-61.—Separating the oil buffer assembly from the oil buffer body group.

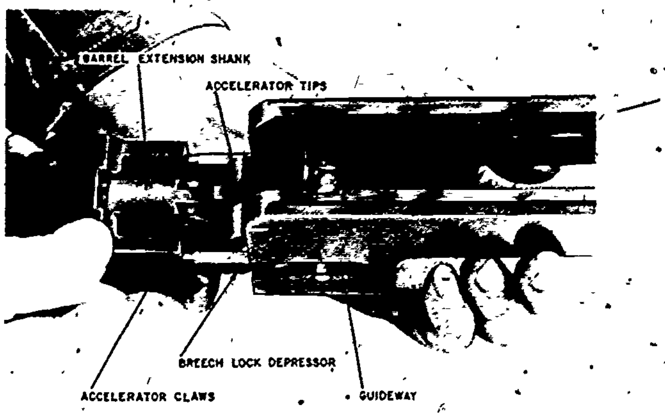


84.371

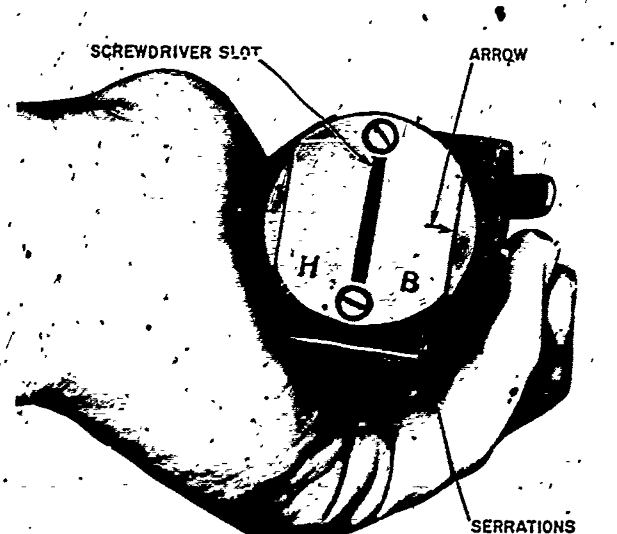
Figure 4-62.—Major groups.



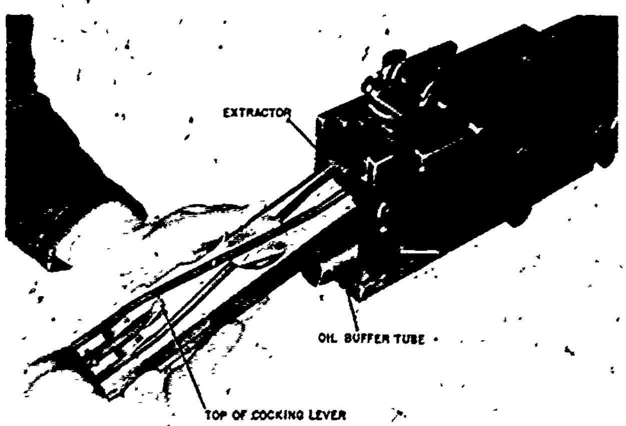
84.372
Figure 4-63.—Replacing the oil buffer assembly.



84.374
Figure 4-65.—Joining the barrel extension group and oil buffer group.



84.373
Figure 4-64.—Replacing the oil buffer assembly.



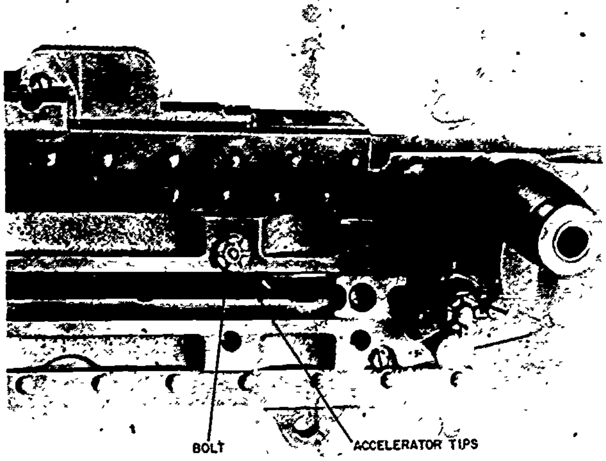
84.375
Figure 4-66.—Replacing the bolt.

on the rear end of the bolt to let the front end clear the accelerator tips (fig. 4-67). Raise the rear of the bolt and continue to push the bolt forward until the bolt latch engages the notches in the top of the bolt; raise the bolt latch and push the bolt into the receiver. The barrel extension, oil buffer, and bolt groups may be returned to the receiver together (fig. 4-68).

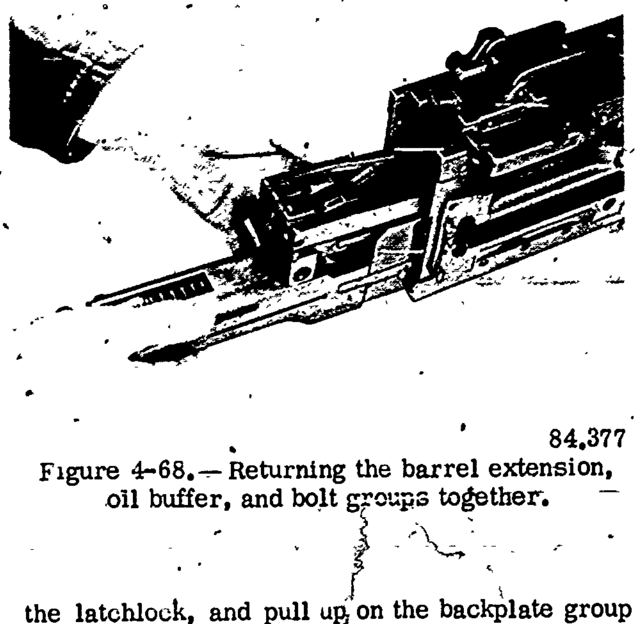
Bolt stud. Position the bolt to return the bolt stud. Ensure that the collar of the stud is inside the right sideplate.

Driving spring group. Push the bolt all the way forward. The oil buffer tube is now inside the receiver. Place the end of the driving spring rod in its hole in the rear of the bolt, and push the driving spring group forward. Press in and to the right on the head of the driving spring rod, and place the retaining pin in its seat in the right sideplate.

Backplate group. Hold the backplate with the latch down and the trigger up; place the backplate guides in their guideways. Hold out on the latchlock, and tap the backplate into position until the latch snaps into place (fig. 4-69). Release



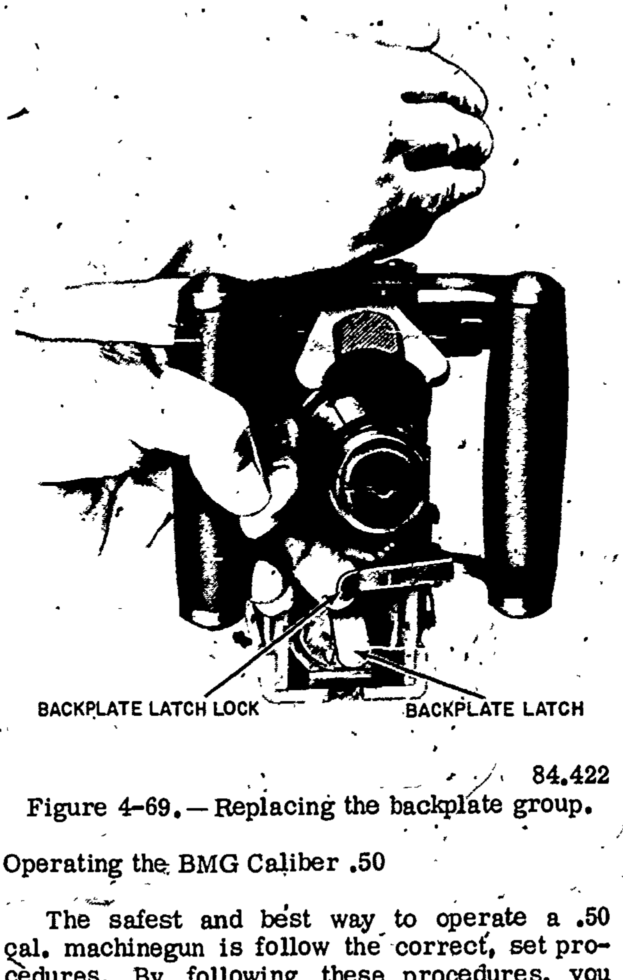
84.376
Figure 4-67.—Bolt clearing the accelerator tips.



84.377
Figure 4-68.—Returning the barrel extension, oil buffer, and bolt groups together.

the latchlock, and pull up on the backplate group to see that it is firmly in place. (If the end of the oil buffer tube prevents return of the backplate, the oil buffer body spring is not properly seated).

Barrel. Pull the retracting slide handle to the rear until the lug on the barrel locking spring is visible through the 3/8-inch hole in the right sideplate. Screw the barrel all the way into the barrel extension; then unscrew the barrel two notches. Close the cover. This completes the general disassembly and assembly.



84.422
Figure 4-69.—Replacing the backplate group.

Operating the BMG Caliber .50

The safest and best way to operate a .50 cal. machinegun is follow the correct, set procedures. By following these procedures, you prevent damage to the gun and possible injury to you or others in the area. The operating procedures of the caliber .50 BMG include loading or unloading the gun, clearing the gun, or allowing the bolt to go forward.

On the command to "half-load", the double loop end of the ammunition belt is inserted in the feedway until the first round is held by the belt holding pawl. The retracting slide handle is then pulled all the way to the rear and released. With the bolt latch release lock positioned to engage the bolt latch release, the bolt and retracting slide handle will move forward under pressure of the driving spring group, thus half-loading the gun. However, if the bolt latch release is up and free of the bolt latch release lock, the bolt latch will hold the bolt to the rear. Now, push the retracting slide handle all the way forward (before releasing the bolt); then press down on the bolt latch release to let the bolt go forward.

The procedure for fully loading the gun is the same as for half-loading, except that the operation is repeated.

To unload the gun, the bolt latch release is unlocked, the cover latch release is turned, and the cover is raised. The ammunition belt is lifted from the gun. The bolt is pulled to the rear and the chamber and T-slot are examined to see that they hold no rounds. After this examination, the bolt is allowed to go forward, the cover is closed and latched, and the trigger is pressed.

The procedure for clearing the gun is the same as for unloading except that in clearing the gun, the bolt is latched to the rear, the bolt is not released, and the cover is not lowered.

Functioning of the Caliber .50 BMG

Disassembly and assembly affords an opportunity to learn the nomenclature of parts which each GMG should take advantage of. In this section we will discuss the functions of the parts. You must learn how these parts function to reduce most of the stoppages encountered, and enable you to keep the gun in working order.

Each time the gun is fired, the parts inside the gun work in a given sequence. These movements are controlled by various springs, cams and levers.

There are eight basic steps in a cycle of operation. These steps don't necessarily follow in sequence because one or more steps may occur at the same time.

Following are the steps in the functioning of the caliber .50 BMG:

1. Feeding. The action of placing a cartridge in the receiver approximately in back of the barrel, ready for chambering.
2. Chambering. A new round is placed in the chamber.
3. Locking. The bolt is locked to the barrel and barrel extension.
4. Firing. The firing pin is released igniting the primer of the cartridge.
5. Unlocking. The bolt unlocks from the barrel and barrel extension.
6. Extracting. The empty cartridge case is pulled from the chamber.
7. Ejecting. The empty cartridge case is ejected from the receiver.
8. Cocking. The firing pin is withdrawn into the cocked position.

Feeding

Figure 4-70 shows the feeding mechanism parts set up for both right and left hand feeding. Refer to this figure and those following to follow the feeding cycle as we discuss the two phases of the feeding cycle.

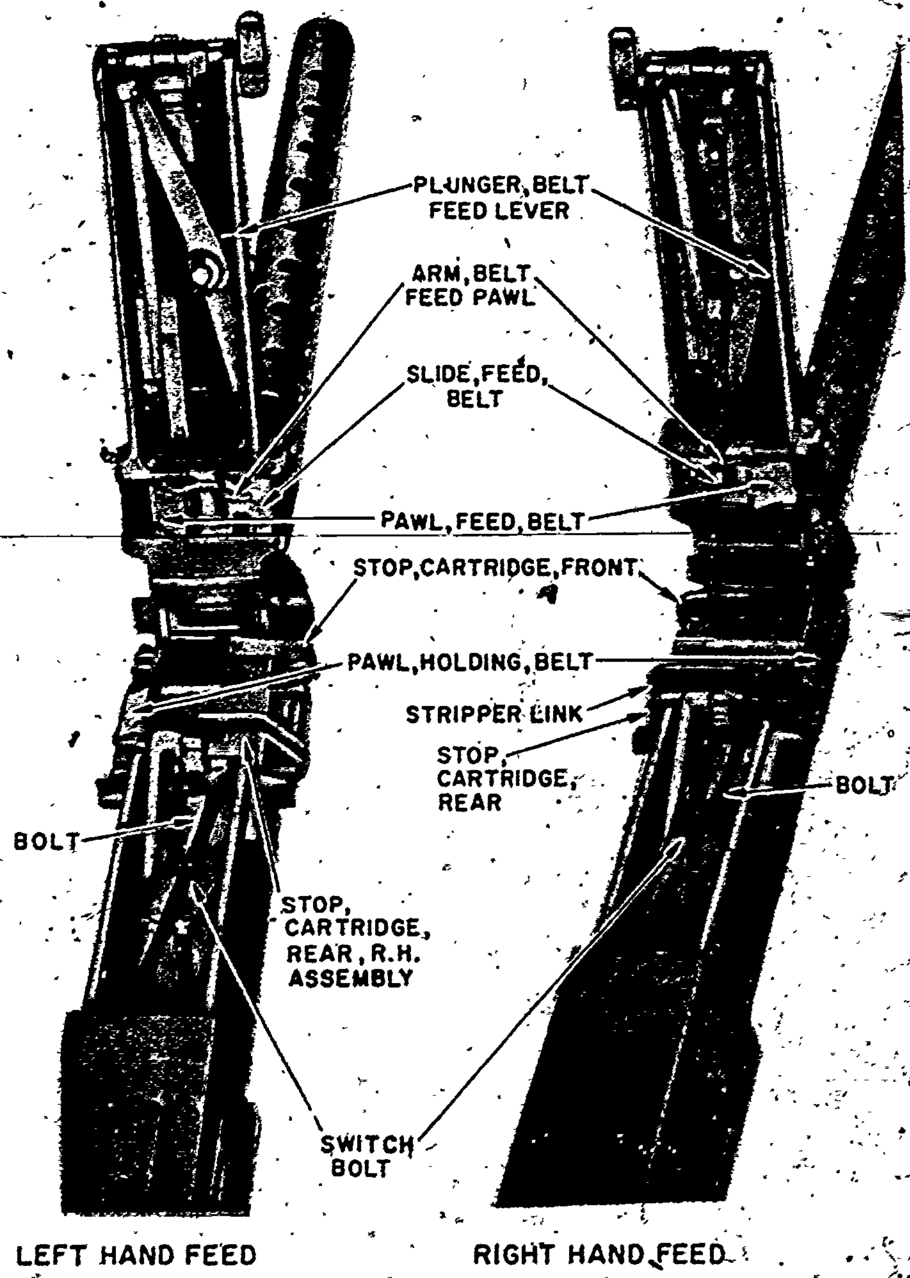
In the first phase, when the bolt is fully forward, the belt feed slide (figs. 4-71 and 4-72) is in the cover; the ammunition belt is held in the feedway by the belt holding pawl (figs. 4-71 and 4-72). As the bolt moves to the rear, its cam groove guides the belt feed lug, pivoting the lever, and moving the feed slide out the side of the cover (fig. 4-73). The belt is held stationary by the belt holding pawl, while the belt feed pawl rides up over the link holding the first round (fig. 4-74). The feed slide moves out far enough to the left to allow the belt feed spring to force the pawl down behind the first round (fig. 4-75). Forward movement of the bolt moves the bolt feed lever which, in turn, moves the slide back into the receiver. The belt is pushed in by the belt feed pawl. The next round rides over the belt holding pawl, compressing its spring until the next round has passed (fig. 4-76). When the bolt is fully forward, the slide is back in the cover; the first round is engaged by the extractor.

The second phase of feeding entails withdrawing a new round from the belt. The extractor grips the first round in the feedway and, as the recoiling parts move to the rear, withdraws it from the ammunition belt. Initially the grip of the extractor is held secure by the downward pressure of the cover extractor spring (fig. 4-77).

As the bolt continues to the rear, the cover extractor cam forces the extractor down, causing the cartridge to enter the T-slot in the bolt (fig. 4-78). As the extractor is forced down, the extractor lug, riding along the top of the extractor switch, forces the rear end of the extractor switch downward. Near the end of the bolt rearward movement, the extractor lug overrides the end of the switch and the switch snaps into position.

Chambering

As the bolt moves forward, the new round is held by the T-slot and the extractor assembly. The extractor stop pin permits the extractor assembly to go down far enough to aline the new round with the chamber (fig. 4-79). As the bolt continues forward, the new round is chambered, and this action takes place—the extractor lug rides up on the extractor cam, compresses the



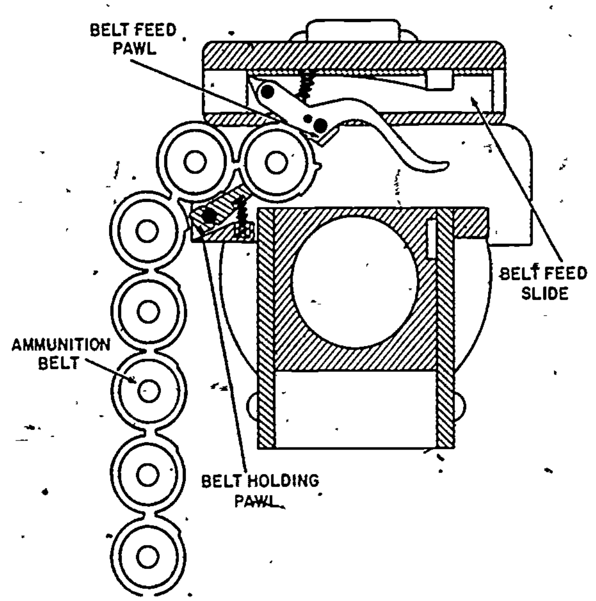
84.114

Figure 4-70.—Browning machinegun, caliber .50 HB, M2. Feeding mechanism parts set up for left-hand and right-hand feeding.

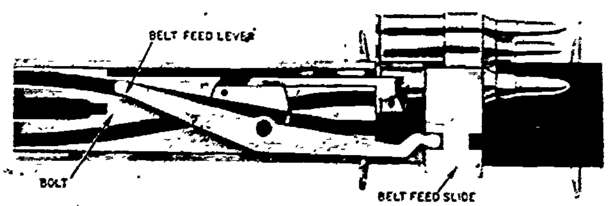
cover spring, and through pressure of the spring, snaps into the groove in the next cartridge.

The following information is presented as a review of an operating cycle of the caliber .50 BMG.

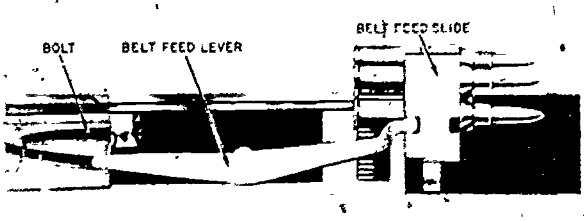
You can follow most of the cycle by referring to figure 4-50B. Assume the chamber is loaded, the gun cocked, and the bolt latch released. The trigger is depressed, the firing pin strikes the primer, the propelling charge goes off, and the



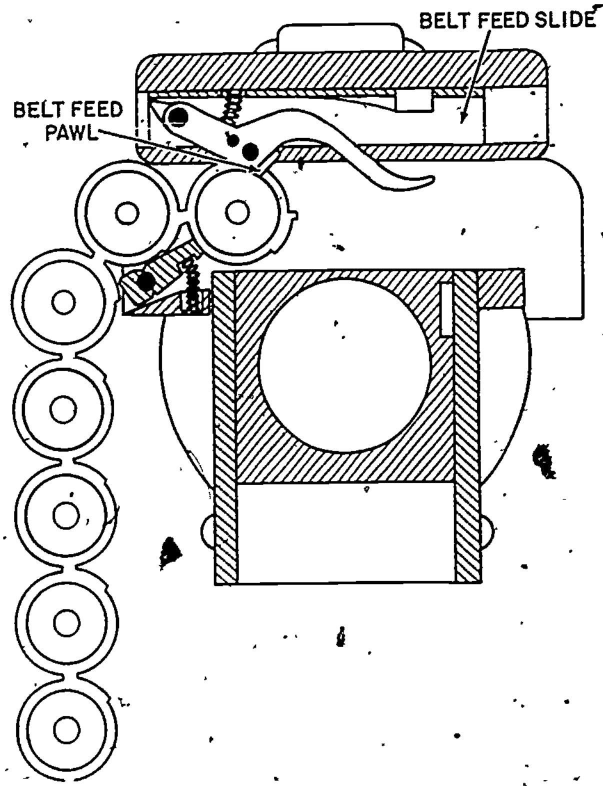
84.378
Figure 4-71.—Feeding—bolt fully forward, belt feed slide in the cover and ammunition belt held in the feedway by the belt holding pawi (rear view).



84.379
Figure 4-72.—Feeding—bolt fully forward, belt feed slide in the cover and ammunition belt held in the feedway by the belt holding pawl (top view).



84.380
Figure 4-73.—Feeding—belt feed slide moving out the side of the cover.



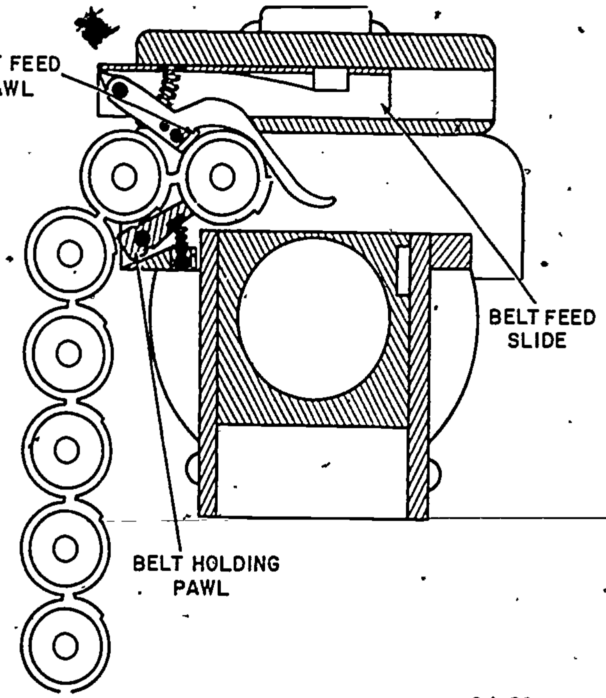
84.381
Figure 4-74.—Feeding—belt feed pawl riding over the first round.

recoiling parts start rearward. After 3/4 inch of recoil, the breech lock is cammed down to release the bolt from the barrel extension which strikes the accelerator, is brought to a stop by the oil buffer, and is locked in recoil position by the accelerator.

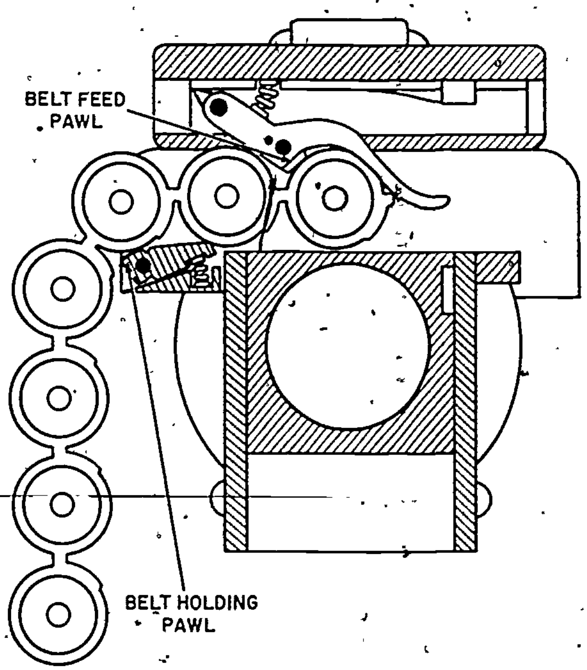
Meanwhile the bolt, kicked all the way to the rear by the accelerator, rebounds against the upper buffer, and counterrecoils, unlocking the barrel extension from the receiver. When the breechblock reengages, the barrel extension locks to the bolt and both move forward together into battery. The cycle repeats when the firing pin sets off the next cartridge.

GUN MAINTENANCE

The importance of a thorough knowledge of how to care for, clean, and preserve the machinegun cannot be over-emphasized. Proper care, cleaning, and preservation determine whether or not this gun will shoot accurately and function properly when needed. The bore and chamber must be



84.382
Figure 4-75.—Feeding—belt feed pawl behind the first round.

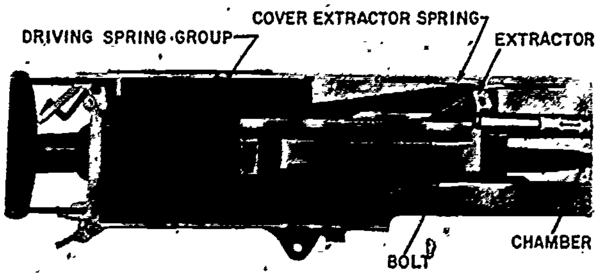


84.383
Figure 4-76.—Feeding—belt feed slide moving inside the cover, with the belt feed pawl behind the first round.

kept in perfect condition to ensure accurate fire. Because of the close fit of working surfaces and the high speed at which the gun operates, it is important that the receiver and moving parts be kept clean, well lubricated, and free from burrs, rust, dirt, or grease. This ensures proper, efficient functioning of the gun.

To ensure proper care of the machinegun, it is necessary to establish standard operating procedures concerning frequency at which the gun is to be cleaned. This can be done by the use of the 3-M system Maintenance Requirement Cards (MRCs) (if implemented) or by using TM 9-1005-213-10 to set up your maintenance procedures. Under combat conditions, it may be necessary to clean the gun where it is mounted; however, when possible, the gun should be disassembled, cleaned, and oiled in a clean, dry location, where it is least exposed to moisture, dirt, etc. Be particularly careful to remove all sand or dirt which, if not removed, act as an abrasive on moving parts causing excessive wear, sluggish operation, or malfunction. Do not oil parts excessively. Excessive oil solidifies and causes sluggish operation or complete failure.

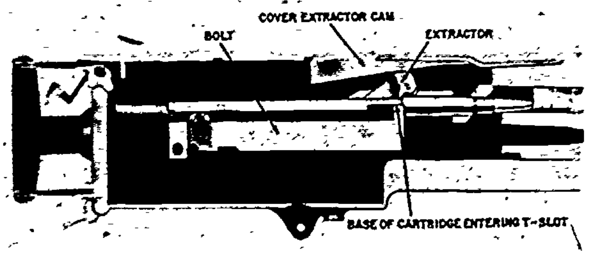
Each gun should be cleaned as soon after firing as possible, and each time it is taken to the field and returned. Under combat conditions,



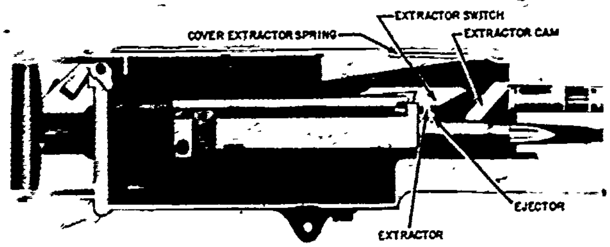
84.384
Figure 4-77.—Feeding—withdrawing the first round from the feedway.

the gun should be cleaned and lightly oiled daily. Under ideal conditions, where the gun is not used and is stored in a clean, dry place, it may only be necessary to inspect, clean, and lubricate the gun once a week.

For more detailed information on the prescribed cleaning materials, lubricants, and rust preventives to be used in the caliber .50 BMG maintenance refer to the Army's FM 23-65.



84.385
Figure 4-78.—Feeding—cartridge entering the T-slot in the bolt.



84.386
Figure 4-79.—Chambering—new round alined with the chamber.

INSPECTION AND GAGING OF BMG CALIBER .50 HB, M2

Inspection. Check the general appearance of the weapon. Pull the bolt to the rear, release, and check for smooth operation. Check the cover latch; be sure the spring has enough tension to keep the cover securely latched. Raise the cover and check the functioning of the cover detent pawl. Move the belt feed lever from side to side, and make sure the belt feed mechanism moves in its full travel in both directions. When you inspect the bolt, check the extractor and ejector, and look for corrosion. Check the back plate latch and lock.

After gaging, test the action of the gun mechanism by feeding several dummy cartridges assembled into a belt (with new belt links) through the gun, operating the gun mechanism by hand.

Gaging. In the caliber .50 Browning machinegun, headspace is measured from the face of the bolt to the base of the chambered cartridge. Tight (insufficient) headspace will cause poor timing of locking and unlocking and consequent damage to the barrel extension, bolt, or breechblock. Excessive headspace leaves too much play between bolt and barrel, and may result in ruptured cartridge cases and possible injury to the gunner.

In the gaging and adjustment of headspace the HEADSPACE AND TIMING GAGE (Army No. 535/217) is used. Headspace must be checked before firing, and adjusted, if necessary. Here is the procedure:

1. Raise the cover. Retract the recoiling parts and screw the barrel all the way into the barrel extension, then unscrew the barrel two notches.

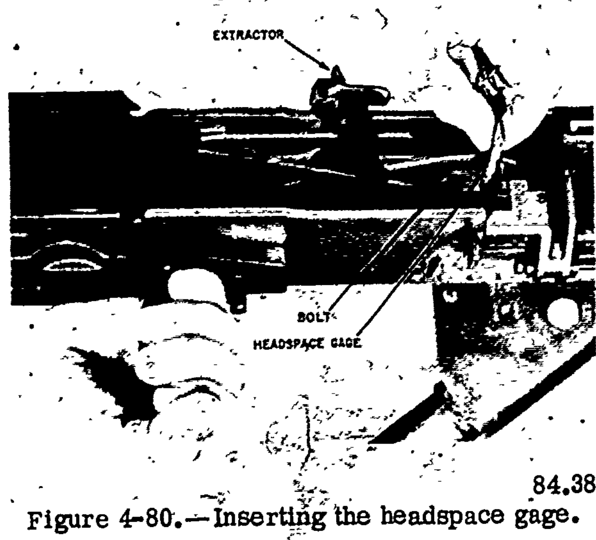
2. Cock the gun; pull the retracting slide handle all the way to the rear, then return it to its most forward position. Press the bolt latch release and allow the bolt to go forward.

Note. Be careful not to depress the trigger, since this will cause the firing pin to be released.

CAUTION: The firing pin should never be released with the gage in the T-slot as this could damage the firing pin and gage.

3. Pull the retracting slide handle back until the barrel extension is about one-sixteenth of an inch from the trunnion block. This will ensure that the locking surfaces of the breech lock and the bolt are in proper contact. This prevents the driving spring group and weight of the parts from giving a false determination (fig. 4-80).

4. First, insert the GO end of the headspace gage in the T-slot, between the face of the bolt and the rear end of the barrel. If the GO end of



84.387
Figure 4-80.—Inserting the headspace gage.

the gage enters freely down to the center ring of the gage, then attempt to insert the NO GO end of the gage. If the GO end enters, and the NO GO end does not enter, correct headspace is set.

5. If the GO end of the gage does not enter freely, headspace is too tight. When this condition exists the barrel must be unscrewed one click (notch at a time checking with the gage after each click), until the GO end of the gage enters freely. To complete the adjustment, attempt to insert the NO GO end of the gage; if it does not enter, correct headspace is set. Remember, to unscrew the barrel, or to screw the barrel into the barrel extension, the lug on the barrel locking spring must be alined with the 3/8-inch hole in the right side plate.

6. If the NO GO end of the gage enters the T-slot, headspace is too loose. The barrel must be screwed into the barrel extension (one click at a time) checking with the gage after each click, until the GO end enters and the NO GO end does not.

7. Remove the gage.

Timing is the adjustment of the weapon so that firing takes place when the recoiling parts are between .020 and .116 inches out of battery to prevent contact between the front end of the barrel extension and the trunnion block. Timing is correctly set when the following conditions are met.

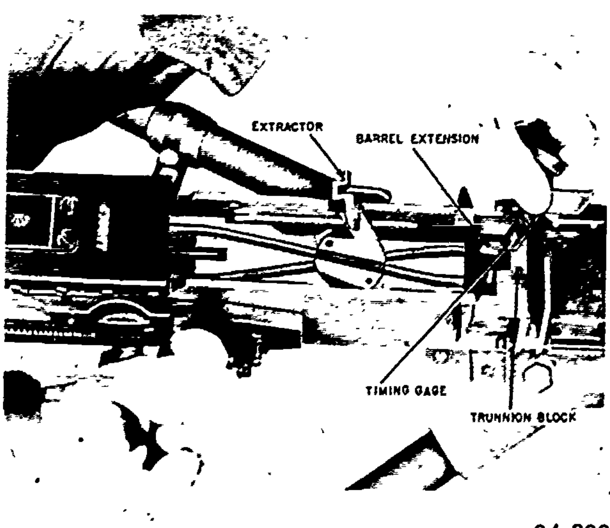
1. The recoiling parts are locked together.
2. Firing takes place just before the parts are in battery (fully forward).
3. When the gun fires on the FIRE gage, and does not fire on the NO FIRE gage. Timing must be checked and/or set each time headspace is set, or whenever timing is questionable.

The following procedures are to be followed in checking and/or setting timing.

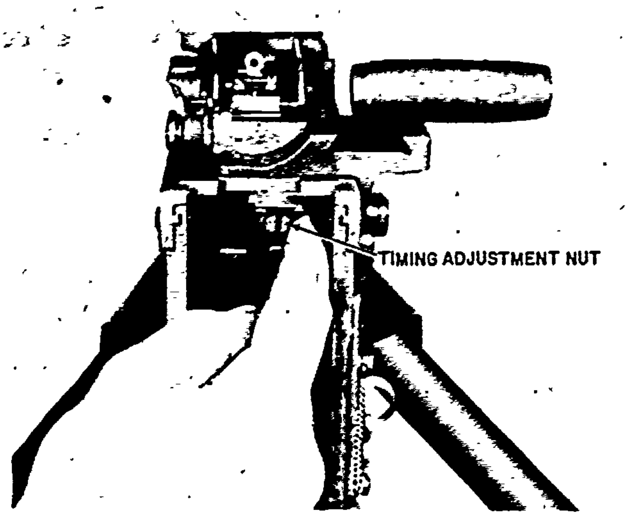
1. Ensure that the gun has correct headspace adjustment.
2. Cock the gun; pull the retracting slide handle all the way to the rear and return it to its most forward position. Press the bolt latch release and allow the bolt to go forward.

Note. Do not depress the trigger.

3. Raise the extractor and pull the retracting slide handle back until the front end of the barrel extension is about one-fourth of an inch from the trunnion block.
4. Insert the NO FIRE timing gage between the barrel extension and the trunnion block, placing the beveled edge of the gage on the barrel notches (fig. 4-81).
5. Let the barrel extension close slowly on the gage.
6. Depress the trigger firmly, attempting to release the firing pin. The firing pin should not release. If the firing pin does release, the gun is timed to fire too early.
7. To correct for this, pull the retracting slide handle to the rear, allow the bolt to go forward. Insert the cap gage, remove the backplate and screw the timing adjustment nut to the left until it rests on the trigger lever (fig. 4-82). Press "up" firmly on the trigger lever attempting to fire. Rotate the timing adjustment nut to the right one notch at a time, each time pressing up firmly on the trigger lever, attempting to fire the weapon.
8. When the firing pin is released, turn the timing adjustment nut two additional notches to the "right" and replace the backplate.
9. Recock the weapon and allow the bolt to go forward. Insert the NO FIRE gage between the trunnion block and the barrel extension and attempt to fire the weapon by depressing the trigger. The weapon should not fire. If the weapon does fire, a mechanical defect exists.
10. Replace the NO FIRE gage with the FIRE gage and attempt to fire. The weapon should fire.
11. When all of the above procedures have been completed, the weapon is correctly timed.



84.388
Figure 4-81.—Inserting the timing gage.



84.389

Figure 4-82.—Rotating the timing adjustment nut to the left.

THE 7.62-MM M60 MACHINEGUN

The M60 machinegun (fig. 4-83) is used primarily as a supporting element of a rifle company. The weapon is used both offensively and defensively to support the rifleman and provide him with a heavy, controlled and accurate fire that is beyond the capability of the individual small arms. The weapon can effectively engage predetermined targets under all conditions of visibility.

A most significant design feature of the M60 machinegun is fixed headspace which enables the barrel to be changed in only three seconds. This allows rapid cooling, and accounts for the M60s increased rate of fire over other earlier machineguns.

GENERAL DESCRIPTION AND DATA

The M60 machinegun is a belt fed, gas operated, air cooled, automatic weapon. Ammunition is fed into the gun by a disintegrating metallic split-link belt. Its operation is similar to that of the M14 rifle, in that the trapped gases from the previous exploding cartridge provide the energy required to load and fire the next round. Initially the weapon is fired from the bolt open position. When the trigger is squeezed, the operating rod and bolt move forward, chambering and firing the first round. This action will continue automatically as long as there is ammunition and the trigger is held to the rear.

The M60 has an overall length of 43.5-inches and weighs approximately 23-pounds. The barrel, which is chrome lined, measures 25.7-inches with the flash suppressor. It has four lands and grooves, with a uniform right hand twist of one complete turn every 10-inches.

Ammunition for the M60 is the standard NATO cartridge which can be fired at a sustained rate of 100-rounds per minute for 10-minutes, after which the barrel must be changed. On rapid fire, the M60 can deliver up to 200-rounds per minute for two minutes, before the barrel must be changed. The cyclic rate of fire is 500-600 rounds per minute, with a barrel change required every minute. Muzzle velocity is 2700 feet per second with a maximum range of 3500 meters (4000 yards). The maximum effective range is 1100 meters (1200 yards).

The major groups and assemblies of the M60 machinegun, along with an index to the groups, are shown in figure 4-84. Figure 4-83 shows the gun mounted on a bipod. It may also be mounted on tripod mount M122 (fig. 4-85). The method of installing the gun on the tripod mount is shown in figure 4-86.

LOADING AND FIRING

Ammunition for the machinegun is fired from a metallic, split-link belt containing 100 rounds. At one end of the link belt there is a double link, that is started into the gun. Figure 4-87 shows the steps in loading and firing the M60 machinegun.

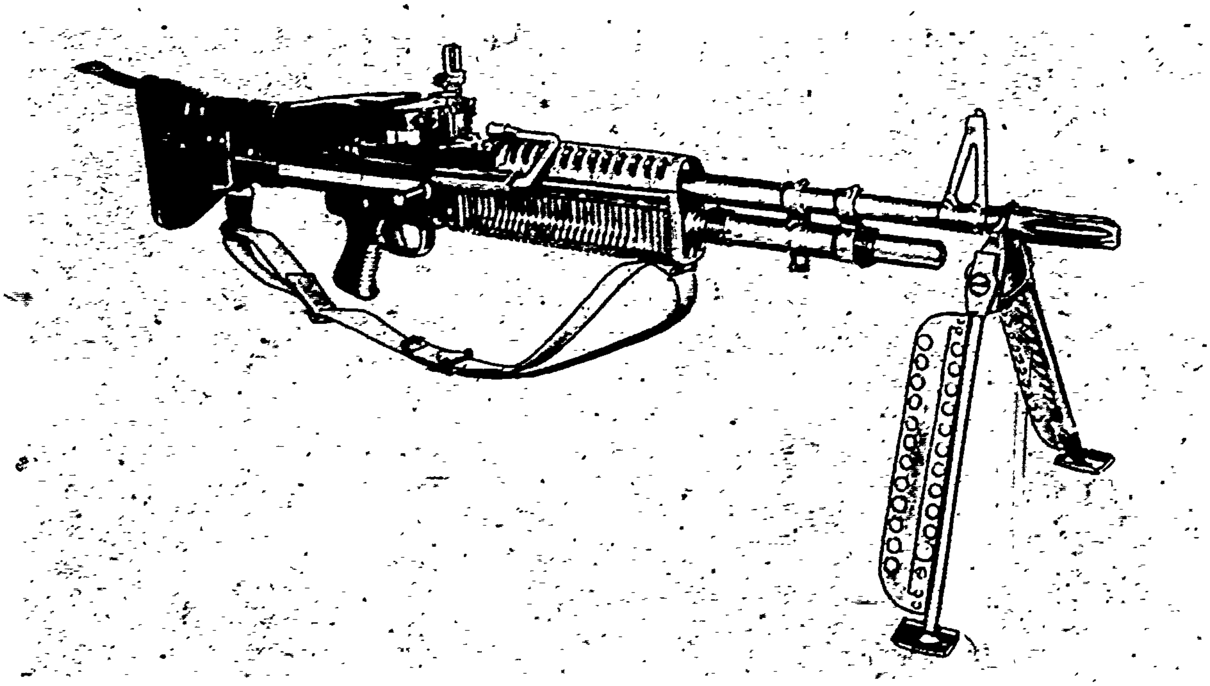
CASUALTIES

Runaway Gun

A broken or worn sear may cause the casualty called "runaway gun," a situation in which the gun continues to fire after the trigger is released. When this casualty occurs, you hold the fire on the target until feeding stops or the ammunition is expended. You then notify maintenance personnel at once.

Ruptured Cartridge Case

A cartridge case may rupture so that the forward portion remains in the chamber and only the rear portion is extracted. When a rupture of this type occurs, a new round will be fed into the chamber, and the following may occur:



45.578

Figure 4-83.—7.62-mm machinegun M60.

1. Incomplete chambering, because the live round cannot be seated fully. It may be compressed enough to cause detonation, with possible damage to the gun, injury to personnel, or both.

2. A round driven into the ruptured case without detonation. You remove this round by the following steps. (a) Retract bolt and move safety to S position. (b) Insert cleaning rod in muzzle end of barrel, set against nose of cartridge, and tap rod gently to eject cartridge from chamber.

To remove a ruptured cartridge case from the breech, you use the ruptured cartridge case extractor shown in figure 4-88. You insert the ruptured cartridge case extractor through the case, insert the cleaning rod from the muzzle end of the barrel, and drive out the case by tapping the rod lightly.

Misfire, Hangfire, and Cook-Off

A misfire is a complete failure to fire. A hangfire is a delay in functioning of a propelling charge—that is, a situation in which the primer in the cartridge case, after being struck by the firing pin, does not detonate the propelling charge immediately, but does detonate it after an interval. NOTE: A misfire must be treated as a hangfire until it is established that the round will not at some time detonate.

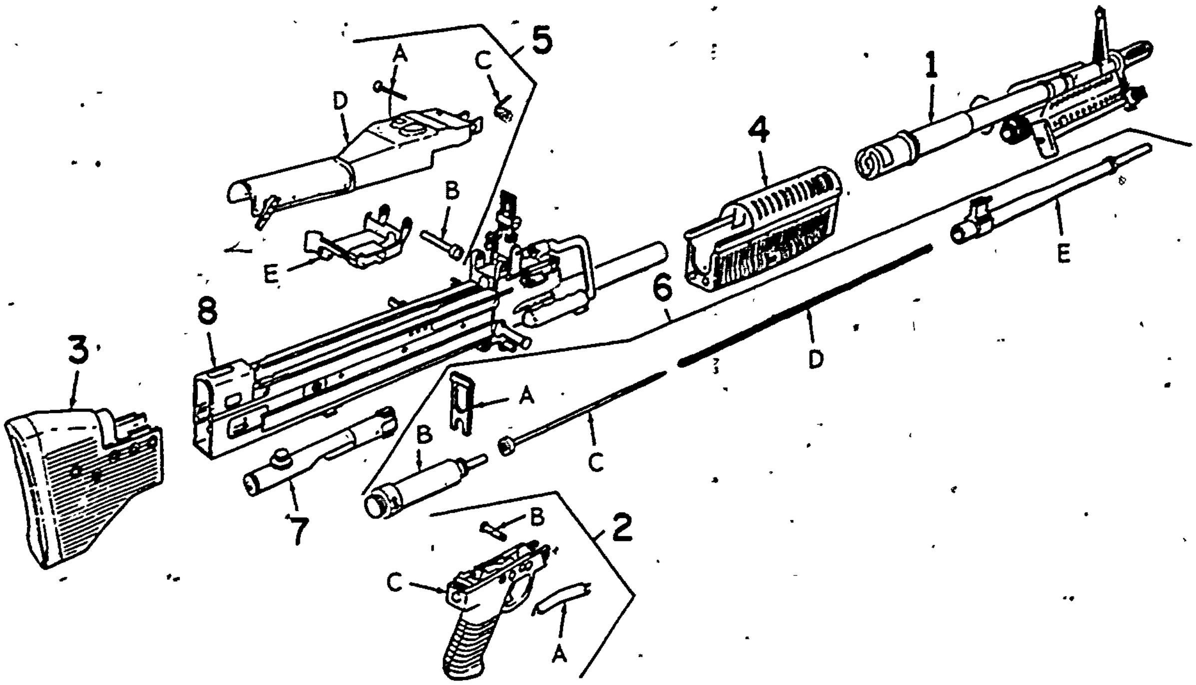
A cook-off is the firing of a chambered round caused by the heat of the hot barrel. A cook-off may occur as long as 5 minutes after the round has been chambered.

If a stoppage (failure of a round to fire, and consequent stoppage of feed) occurs, it may be either a misfire or a hangfire, and should be treated as a hangfire. Wait 5 seconds, and then pull the cocking handle all the way back, ensuring that it stays back.

If this procedure ejects the chambered round, relay the gun on the target and attempt to fire. If the weapon does not fire, it must be cleared by qualified personnel and the ammunition inspected to determine the cause of the stoppage.

If pulling back the cocking handle fails to eject the chambered round, move the safety to S (safe) position, remove ammunition and links, and inspect the receiver, chamber, and extractor.

If there is a round in the chamber, move the safety to F (fire) position and attempt to fire.



1. Barrel assembly with bipod assembly
2. Trigger mechanism grip group
   A. Leaf spring
   B. Retaining pin
   C. Trigger mechanism grip assembly
3. Shoulder gun stock
4. Forearm assembly
5. Cover assembly and cartridge tray assembly groups
   A. Hinge pin latch
   B. Hinge cover pin
   C. Spring
   D. Cover assembly
   E. Cartridge tray assembly
6. Buffer assembly and operating rod assembly groups
   A. Retaining buffer yoke
   B. Buffer assembly
   C. Driving spring guide assembly
   D. Spring
   E. Operating rod assembly
7. Breech bolt assembly
8. Receiver group

29.373

Figure 4-84.—Major groups and assemblies of M60 machineguns.

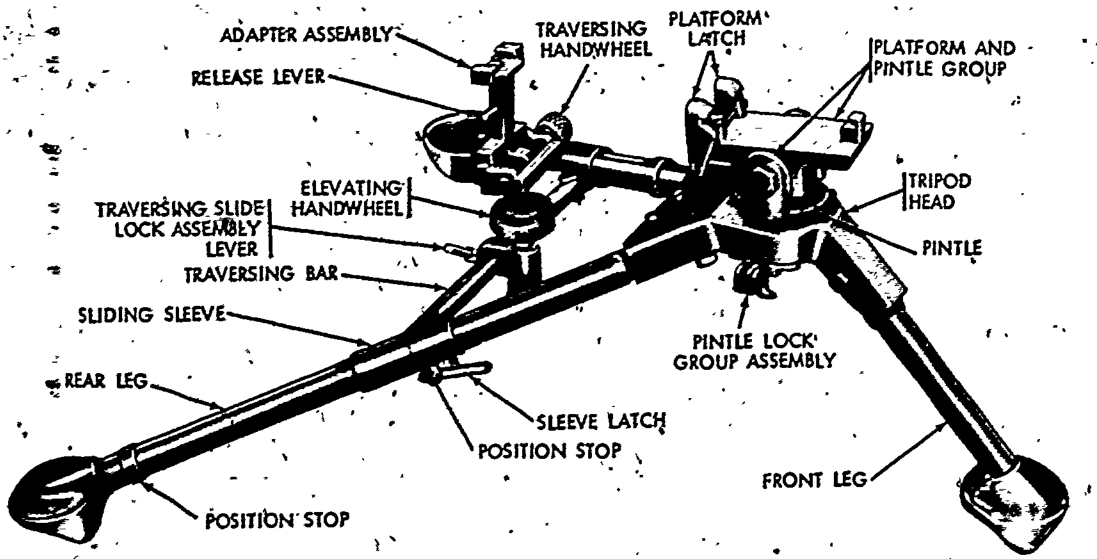
If the round fires and the case is ejected, reload the gun; relay on the target, and continue firing.

If the round in the chamber does not fire and the gun is hot enough to cause a cook-off (if 200 rounds were fired within the previous two minutes, it may be hot enough), wait five minutes with the bolt in forward position. Then remove the round, reload, relay on the target, and attempt to fire. Disregard the 5-minute wait if the gun is not hot enough to cause a cook-off.

Double Feed

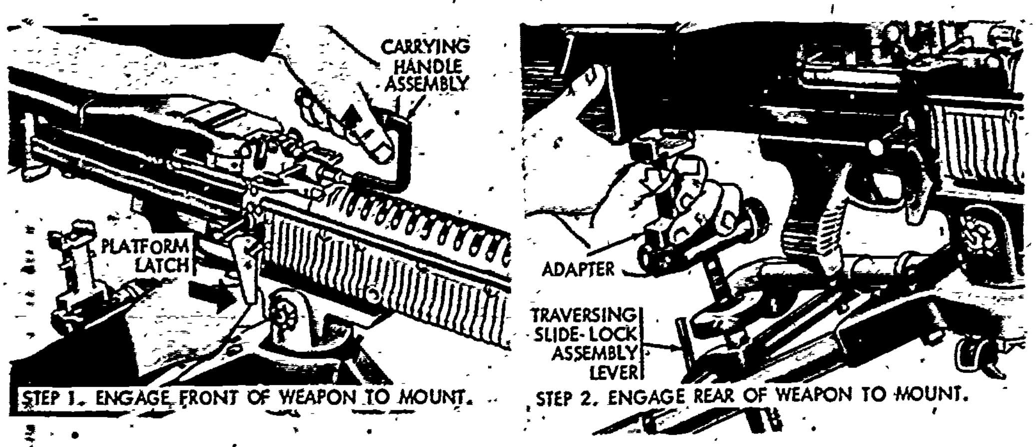
"Double feed" is a situation in which a live round is fed into a chambered spent case or chambered live round.

When the gun fails to extract a spent case, the bolt automatically recoils, picks up the next (live) round, and feeds it into the chambered case. The force may compress the live round enough to detonate it, with damage to the gun and injury to personnel.



29.374

Figure 4-85.—Machinegun tripod mount M122.



29.375

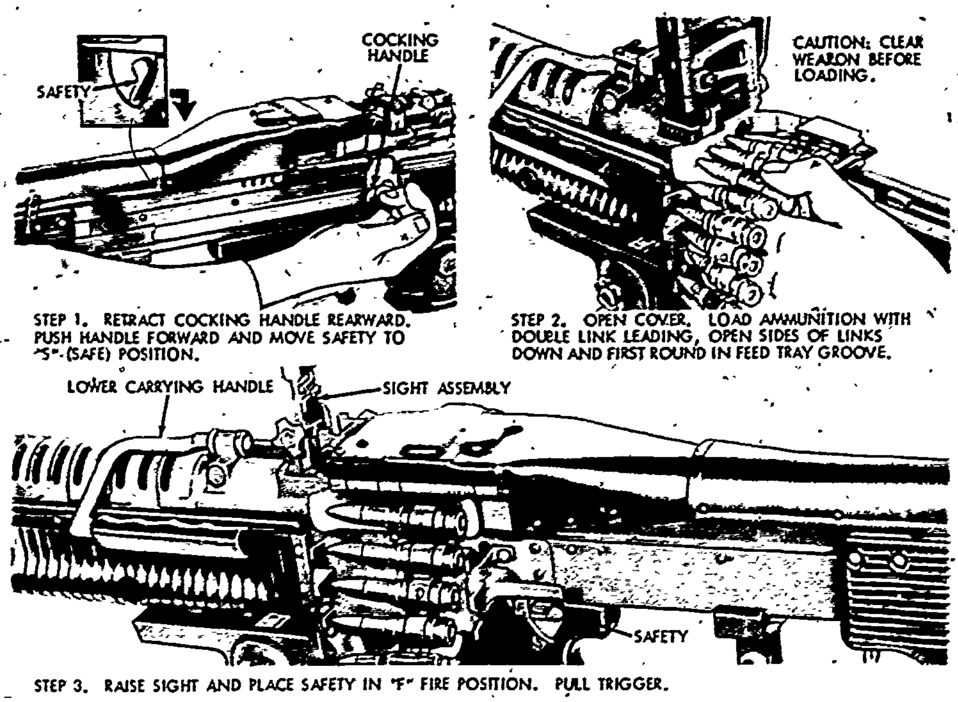
Figure 4-86.—Installing M60 machinegun on tripod mount.

Double feed into a live round will not occur automatically because when a round fails to fire, the bolt does not recoil, but remains in forward, closed position. The correct procedure here is to proceed as described for a hangfire. If, instead of doing this, you charge the gun manually and pull the trigger, the next round will be fed into the primer in the base of the chambered live round, causing one or both rounds to detonate, with damage to the gun and injury to personnel.

WARNING: If there is belted ammunition on the feed tray and a live round in the chamber, NEVER retract the bolt and allow it to go forward.

FIELD STRIPPING

The steps in field stripping the M60 machinegun are shown in figure 4-89 through 4-95. White arrows shown on illustrations indicate disassembly, black arrows indicate assembly.



29.376

Figure 4-87.—Steps in loading and firing the M60 machinegun.

THE 40-MM GRENADE LAUNCHER M79

The grenade launcher M79 (figs. 4-96 and 4-97) is a single-shot, break-open fire weapon. It is breech loading and chambered for a 40-mm metallic cartridge case with internal primer. Cartridges used with the grenade launcher M79 are shown in figure 4-98.

CONTROLS OF THE M79 GRENADE LAUNCHER

The safety (fig. 4-99) is in SAFE position when pulled all the way back, in firing position when pushed all the way forward.

The barrel locking latch (fig. 4-99), when pushed all the way to the right, permits the breech end of the barrel to be swung up into open position. The grenade launcher cocks as it opens.

The rear sight assembly is shown in figure 4-100.

In figure 4-99, the trigger guard is shown in lowered position. It can be released for setting to one side or the other by pushing back the cylindrical housing at the front. This makes it possible for a man wearing heavy gloves or mittens to fire the grenade launcher.

OPERATING THE M79 GRENADE LAUNCHER

Preparation for firing—Check the bore to be sure that it is free of foreign matter or obstructions. Check all ammunition to be sure proper type and grade is being used. Check the launcher to be sure that it is properly cleaned. Inspect for malfunction and other defects.

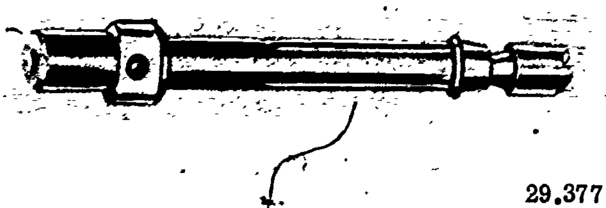
Loading—Point muzzle of launcher at the ground and clear the area of all personnel.

Move barrel locking latch all the way to the right and break open the breech. If safety is not already on SAFE, this procedure will cause it to move to SAFE, provided that you move the barrel locking latch its FULL LIMIT OF TRAVEL.

Insert the projectile portion of the ammunition into the chamber opening (fig. 4-101) and push the complete round forward into the chamber until the extractor contacts the rim of the cartridge case.

Close the breech.

Firing—The launcher is fired from either standing or prone position. In the standing position the butt is placed against the shoulder



29.377

Figure 4-88.—Ruptured cartridge case extractor.

(fig. 4-102). In the prone position the butt is placed against the ground (fig. 4-103).

A detailed discussion of sight-setting is beyond the scope of this course. However, to engage targets at ranges from 50 to 80 meters (165-265 feet), the rear sight frame assembly is placed in the lowered (called the "battle sight") position (fig. 4-102). Longer ranges are fired with the rear sight frame in upright position (fig. 4-103), and the sight aperture bar set at the approximate target range of the scale.

When firing grenades at targets within battle sight ranges (50-80 meters or 165-265 feet), the operator must be in a protected position. Targets which are within 80 meters (265 feet) of friendly troops must not be fired upon.

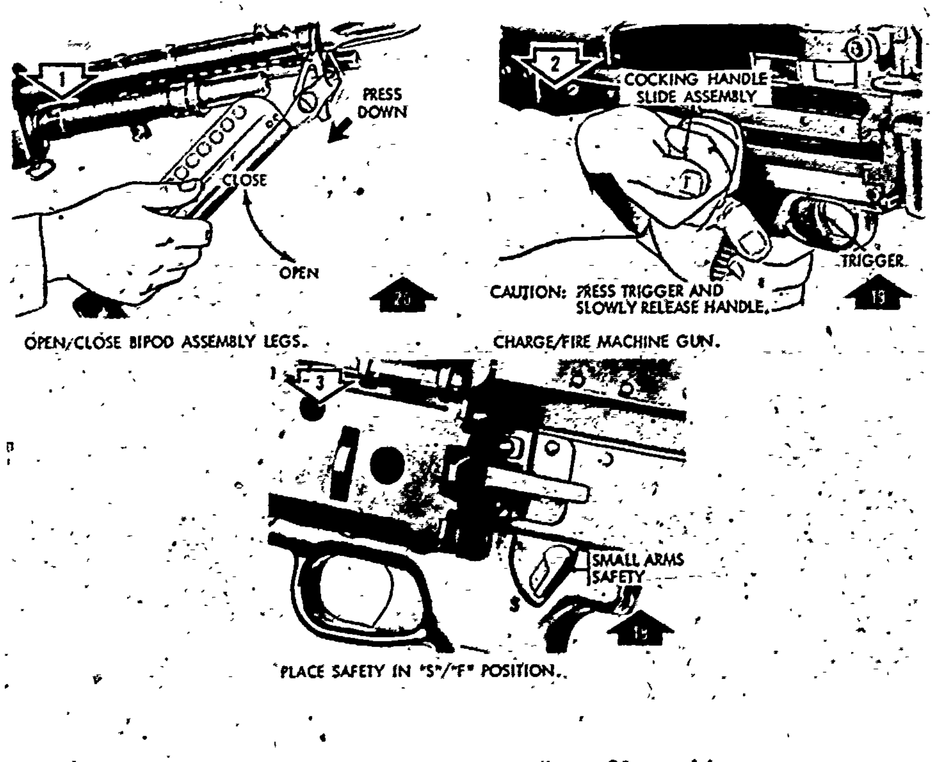
FIELD STRIPPING THE GRENADE LAUNCHER M79

Field stripping the grenade launcher M79 consists of separting the fore end assembly from the barrel and receiver group, and separating the stock from the receiver group.

To remove the fore end assembly, first use the wrench assembly shown in figure 4-104 to remove the machine screw shown in the same figure. Then pull front end of fore end assembly away from barrel, as shown in figure 4-105, until the lug on the rear sight base is clear of hole in upper surface of fore end bracket. Keeping lug clear of hole, pull forward on fore end assembly until it is free of receiver assembly.

To remove the barrel group from the receiver group, first open barrel locking latch and open breech. Then, holding stock and receiver stationary, move the barrel rearward in the receiver until it is disengaged from fulcrum pin as shown in figure 4-106. Separate barrel from receiver group.

To separate the stock from the receiver group, use combination wrench assembly as



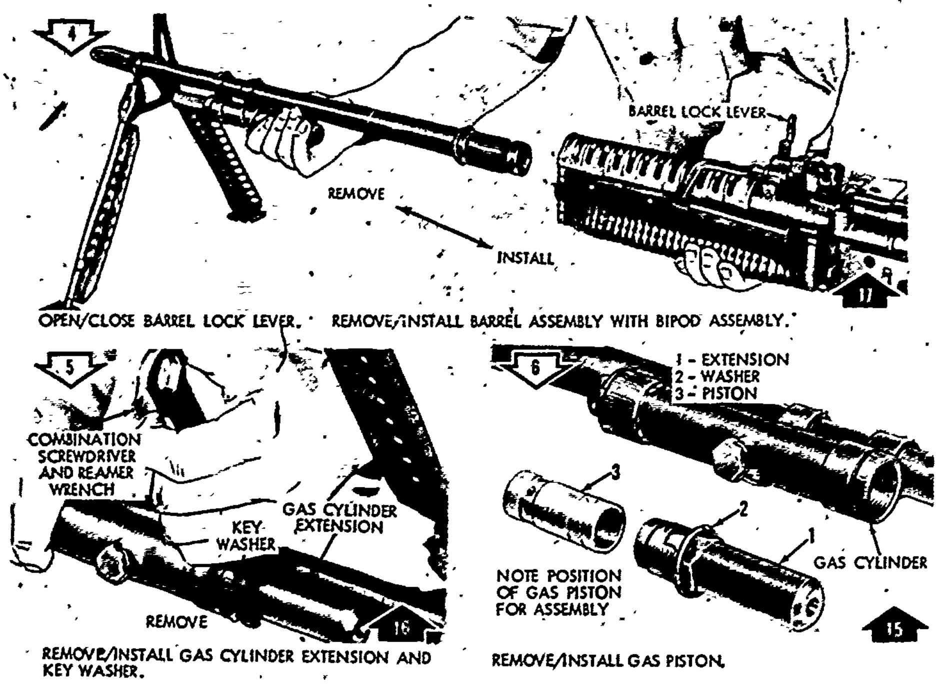
OPEN/CLOSE BIPOD ASSEMBLY LEGS.

CHARGE/FIRE MACHINE GUN.

PLACE SAFETY IN "S"/"F" POSITION.

29.378

Figure 4-89.—Field stripping the M60 machinegun.



29.379

Figure 4-90.—Field stripping the M60 machinegun—continued.

shown in figure 4-107 to remove pan-headed machine screw which secures stock to receiver group. Separate stock from the receiver group.

SAFETY PRECAUTIONS

Small-arms safety precaution, like all safety precautions, are largely a matter of common sense. Every gun should be considered loaded until proven otherwise by examination; never trust your memory or anyone else's memory in this respect. TO THINK a gun is unloaded can be fatal. Be positive.

NEVER point a firearm at anyone or anything you do not intend to shoot, or in any direction where accidental discharge might do harm. When checking operation or releasing spring tension, point the weapon upward or in some safe direction before pressing the trigger. Never place the finger inside the trigger guard unless ready to fire.

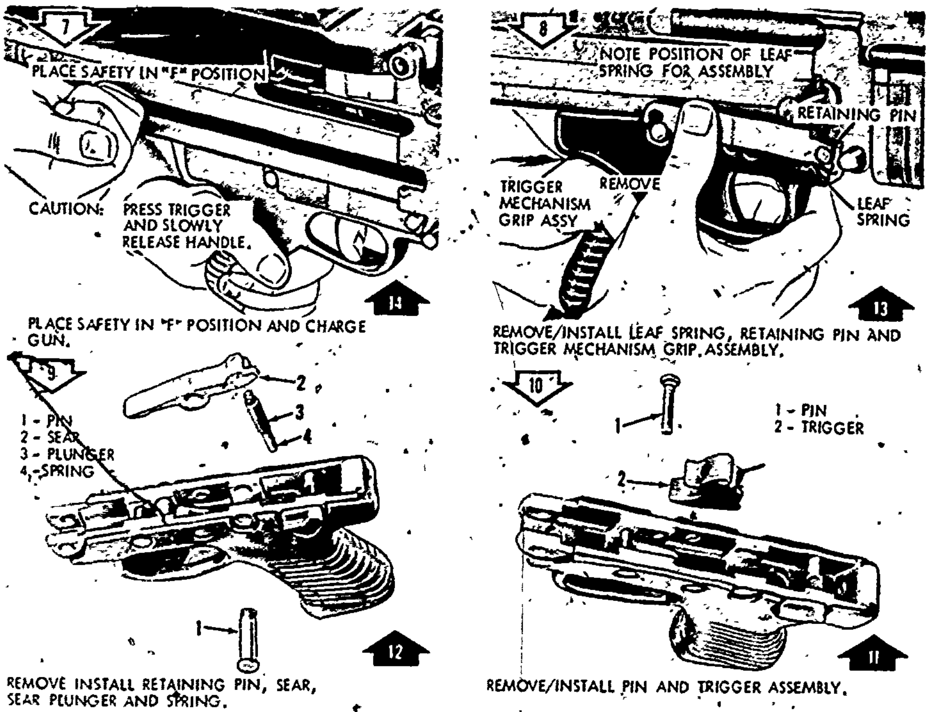
Do not work on a weapon you do not thoroughly understand. Ask a senior ordnanceman or other qualified personnel to instruct you if possible; otherwise refer to the proper technical publication. Never use force in disassembling and assembling small arms. They are so constructed that undue force is unnecessary if parts are properly assembled or removed.

Safety features should be frequently tested for proper functioning. For obvious reasons, an inoperative safety device is more dangerous than no safety device at all.

In weapons with detachable magazines, always remove the magazine as the first step in unloading or clearing a stoppage. It should be noted that with ALL magazine-fed weapons, the shape, position, and condition of the magazine lips are extremely critical and, if dented, will interfere with proper feeding of the cartridge into the chamber. The majority of stoppages in magazine-fed weapons is due to faulty magazines and consequently care must be taken when handling them not to cause damage.

Before loading ammunition into the weapon, check for dirt, oil, grease, malformation, loose bullets, or other defects.

Check the bore prior to firing to be sure it is free of foreign matter or obstructions. If during firing there is any indication of misfire or weak charge, make sure the bullet is not lodged in the



29.380

Figure 4-91.—Field stripping the M60 machinegun—continued.

bore. An obstructed bore will cause a serious accident when the next round is fired.

To minimize danger from hangfire, wait 10 seconds after a misfire, then clear the weapon quickly. If the weapon cannot be cleared quickly and the barrel is hot, DANGER OF COOKOFF EXISTS. Leave the round in the chamber, point the weapon in a safe direction, and allow it to cool before removing the misfired round.

SPECIAL PRECAUTIONS FOR PISTOLS AND REVOLVERS

Automatic pistols in the hands of inexperienced or careless persons are largely responsible for the saying "It's always the unloaded gun that kills." It is a fact that many accidental deaths and injuries are due to a mistaken belief that removing the magazine of a pistol (or other magazine fed weapon) is all that is necessary to unload it. Nothing could be further from the truth. To completely unload a pistol or other magazine fed weapon and render it safe to handle, it is necessary to not only remove or empty the magazine, but also to MAKE ABSOLUTELY CERTAIN THE CHAMBER IS EMPTY. The only way this can be done, when handling the caliber .45 pistol, is to pull back the slide and inspect the chamber either visually or by feel if it is dark. This should be done AFTER the magazine is removed, and with the muzzle pointed upward. Of course, if the chamber is loaded, the round will be extracted and ejected when the slide is operated. "I didn't know it was loaded" is never an excuse for the accidental discharge of a weapon—especially for the ordnanceman.

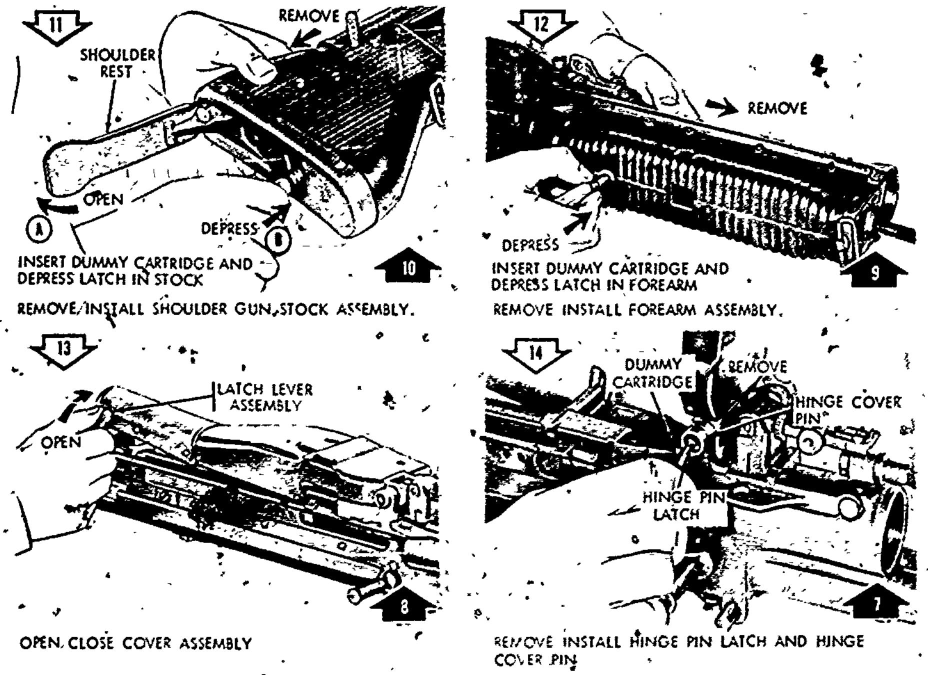
When handling revolvers, a simple visual inspection is sufficient to determine if any chambers in the cylinder are loaded.

Keep hammer fully down when pistol or revolver is not loaded.

When the pistol is cocked, keep the safety lock in the ON position until ready to fire.

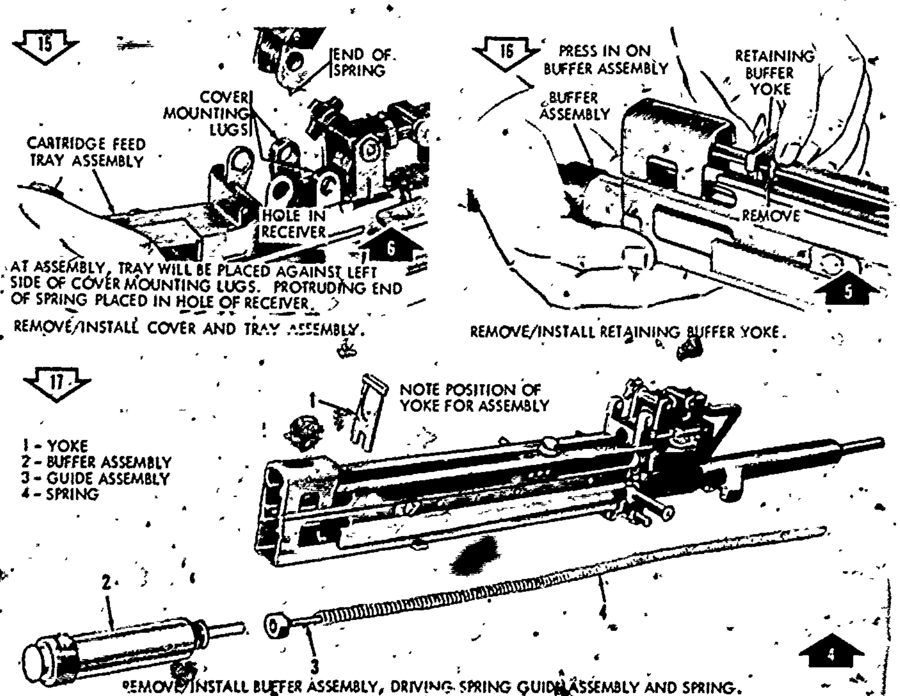
Let's review briefly some of the safety precautions that apply to the handling of ALL small arms:

1. Never point a weapon at anyone unless you intend to kill him.



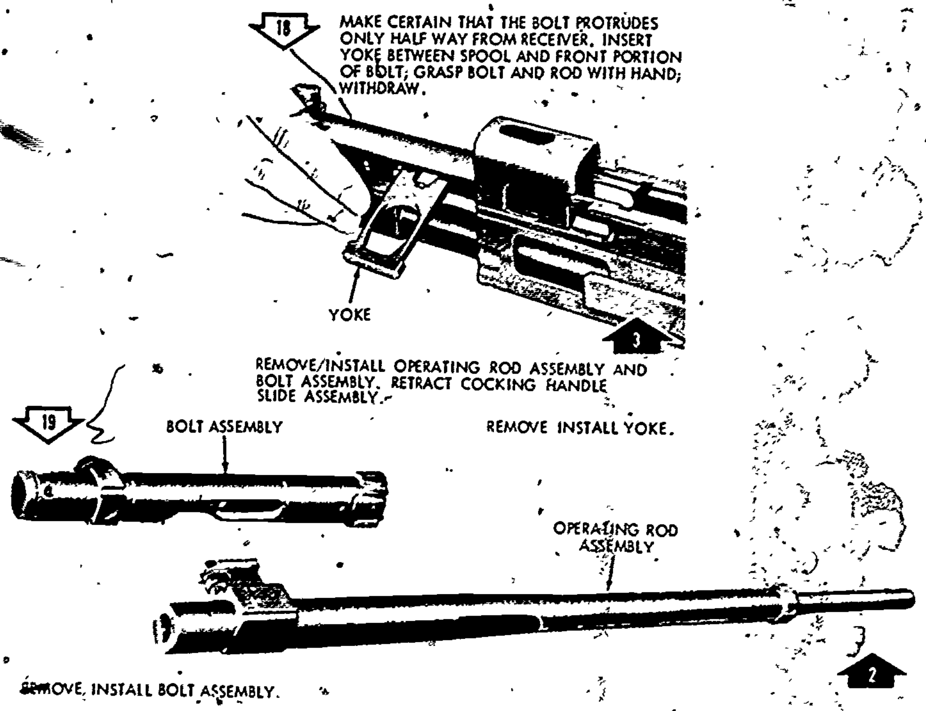
29.381

Figure 4-92.—Field stripping the M60 machinegun—continued.



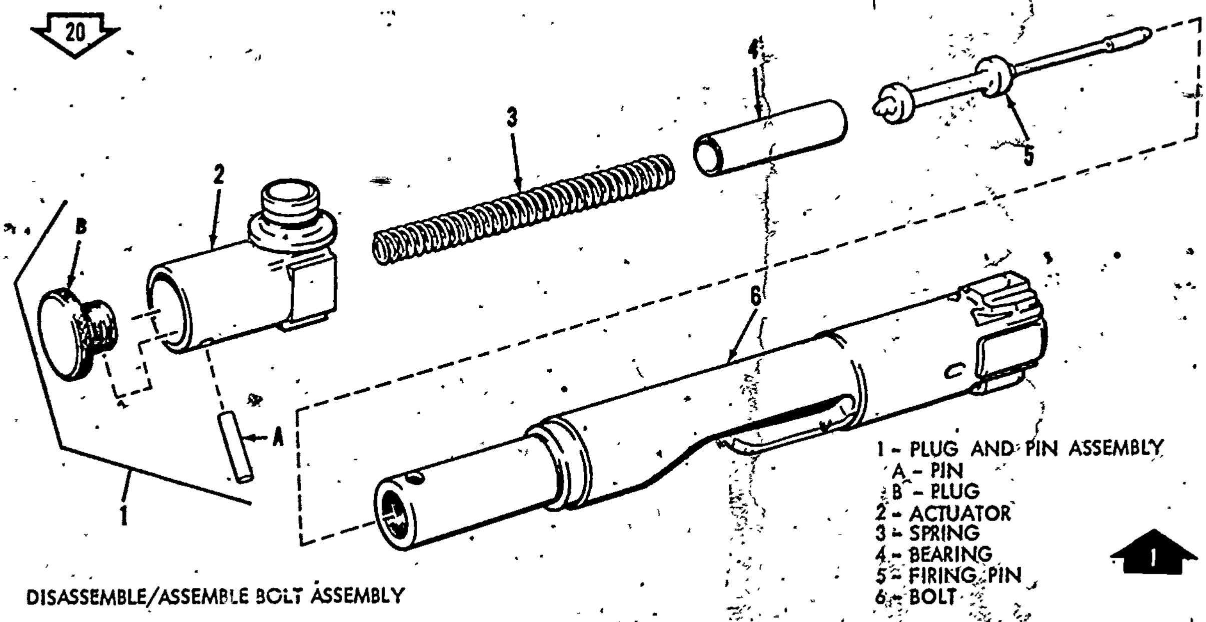
29.382

Figure 4-93.—Field stripping the M60 machinegun—continued.



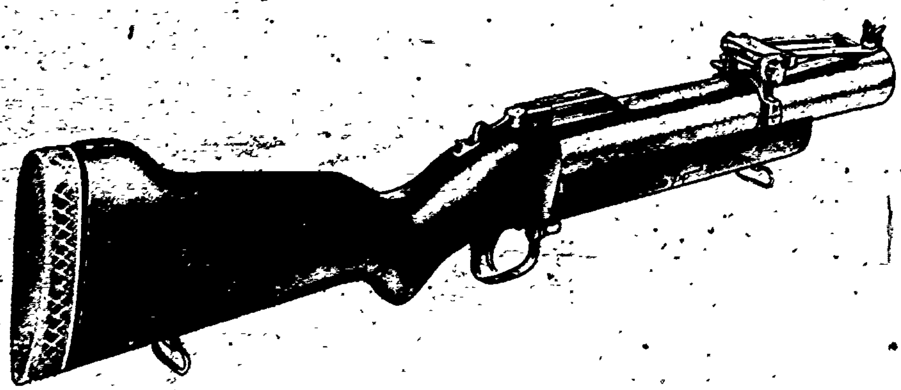
29.383

Figure 4-94.—Field stripping the M60 machinegun—continued.



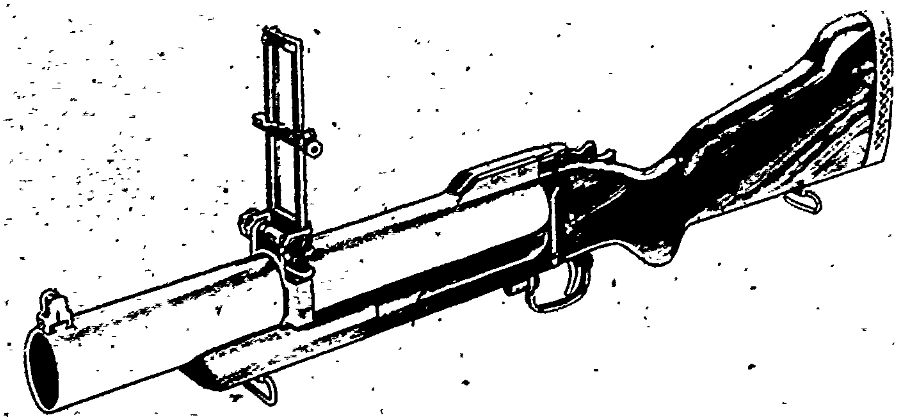
29.384

Figure 4-95.—Field stripping the M60 machinegun—continued.



29.361

Figure 4-96.—Grenade launcher M79-right rear view.



29.362

Figure 4-97.—Grenade launcher M79-left front view.

2. Unless the weapon is to be used immediately, never carry it with a round in the chamber.

3. Unless you are about to fire it, the safety of every small arms weapon must always be ON.

4. Consider a gun loaded until you yourself have opened the chamber and verified that it is empty. It isn't enough to wail, afterward, "I didn't know it was loaded." The "empty" weapon is the dangerous one.

5. Before firing any weapon, be sure that there are no obstructions in the bore.

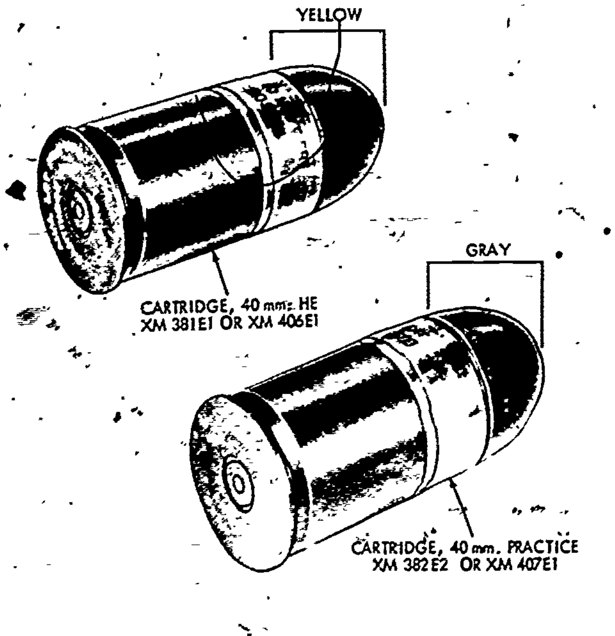
6. Before firing any weapon, be sure the ammunition you are using is the right ammunition. For example, the caliber .30 carbine cannot use standard rifle ammunition. Nor should you try to use Very signals with shotguns, even though they look much like shotgun shells.

7. Before firing, be sure there is no grease or oil on the ammunition or in the bore or chamber. Although lead bullets may be lightly waxed or greased, there must NEVER be any lubricant on the cartridge case. (This does not apply to aviation ammunition.) Lubricant on the

case or chamber is particularly bad because, upon firing, the case slips backward, causing a dangerously heavy thrust against the bolt.

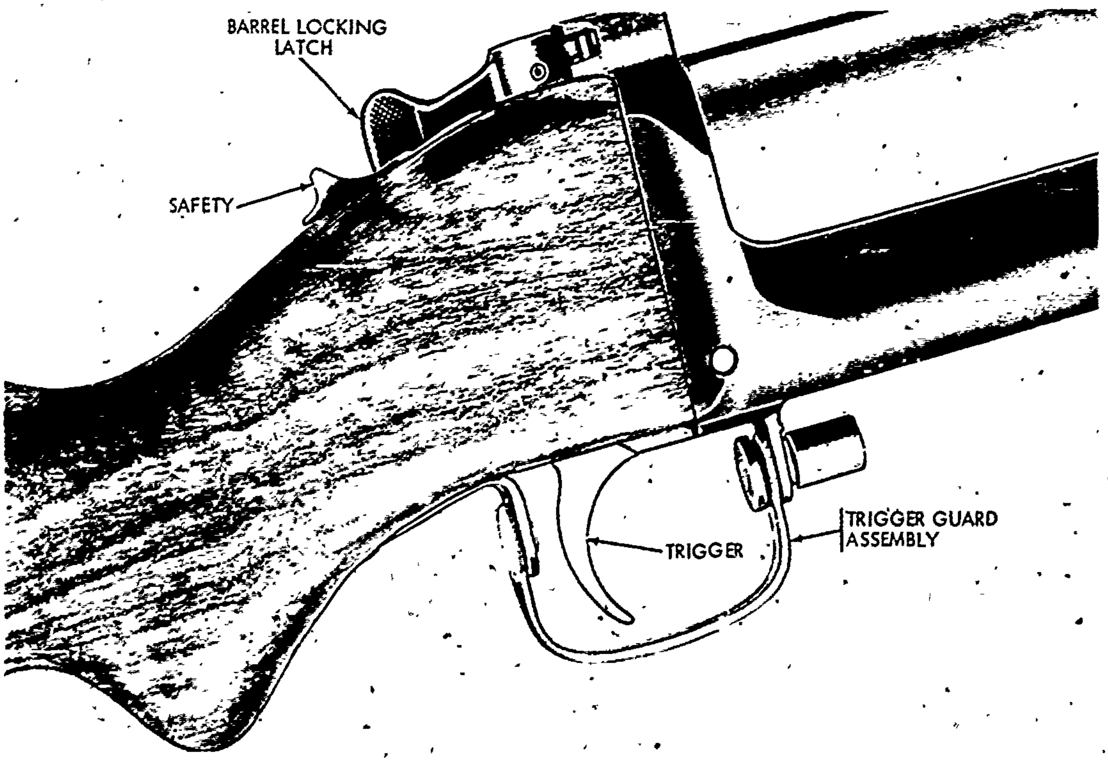
8. Keep ammunition dry and cool. Keep it out of the direct rays of the sun. Keep ammunition clean, but do NOT polish it or use abrasives on it. Do not attempt to use dented cartridges, cartridges with loose bullets, or cartridges eaten away by corrosion. Be particularly careful with tracer ammunition, which can ignite spontaneously if damp.

9. Misfires and hangfires can occur with small arms ammunition as well as with other types. On some weapons like the automatic pistol, the line-throwing gun, and a few others, you can recock and attempt to fire again without opening the breech. If after a couple of tries this proves unsucessful, or if the weapon cannot be recocked without opening the bolt, wait at least 10 seconds, then open the bolt and eject the defective round. Defective small arms ammunition



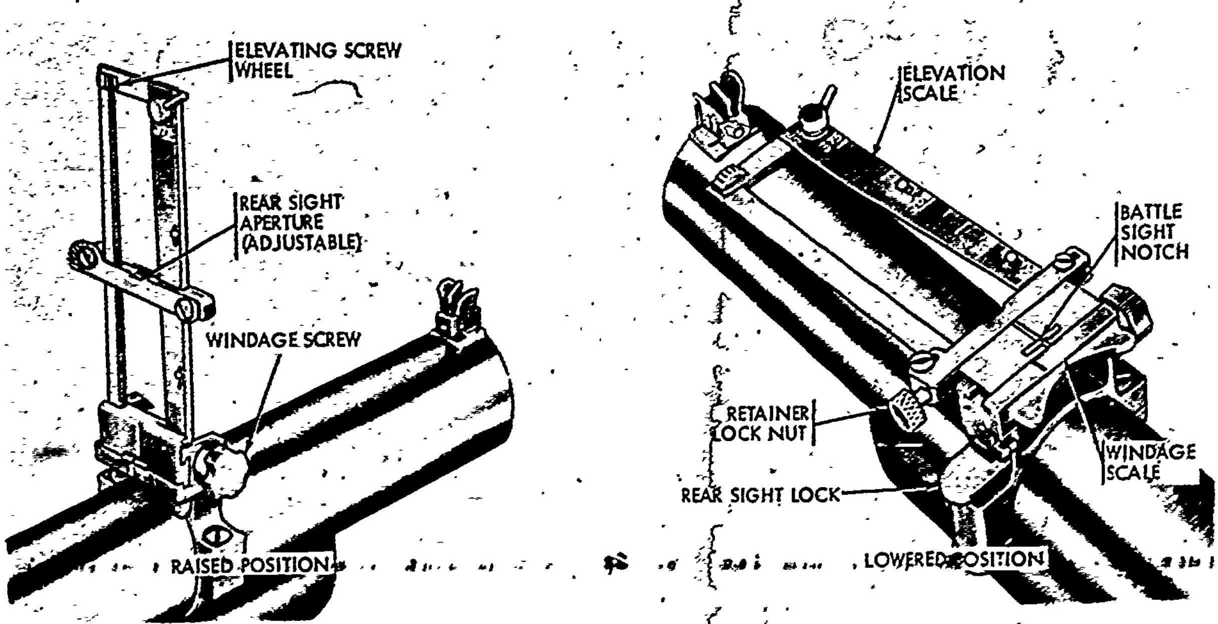
29.363

Figure 4-98.—Cartridges used with grenade launcher M79.



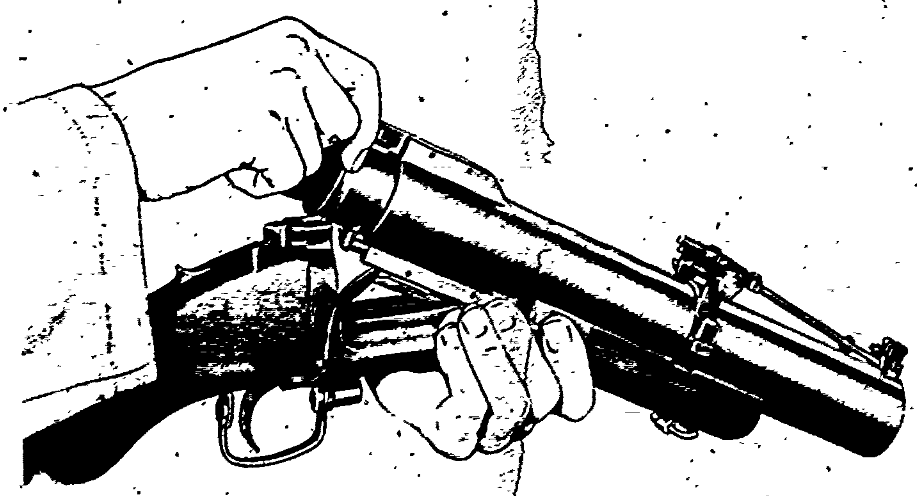
29.364

Figure 4-99.—Grenade launcher controls.



29.365

Figure 4-100.—Rear sight assembly.

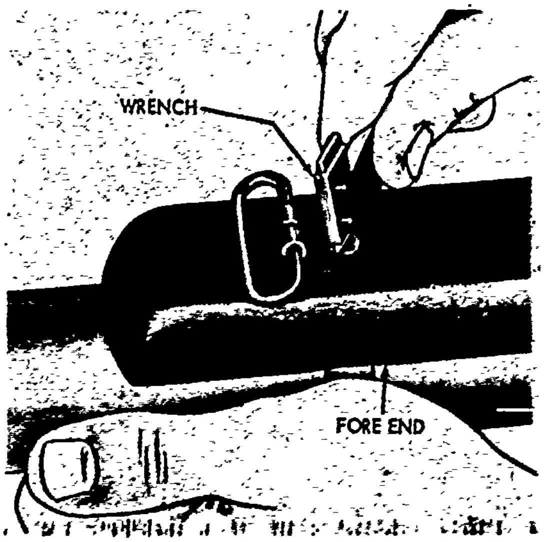


29.366

Figure 4-101.—Loading the grenade launcher M79.

29.367
Figure 4-102.—Firing grenade launcher in standing position.

29.368
Figure 4-103.—Firing grenade launcher in prone position.



29.369
Figure 4-104.—Removing screw securing fore end assembly to barrel.

should be disposed of in accordance with current regulations. It is prohibited to force out a bullet by firing another bullet.

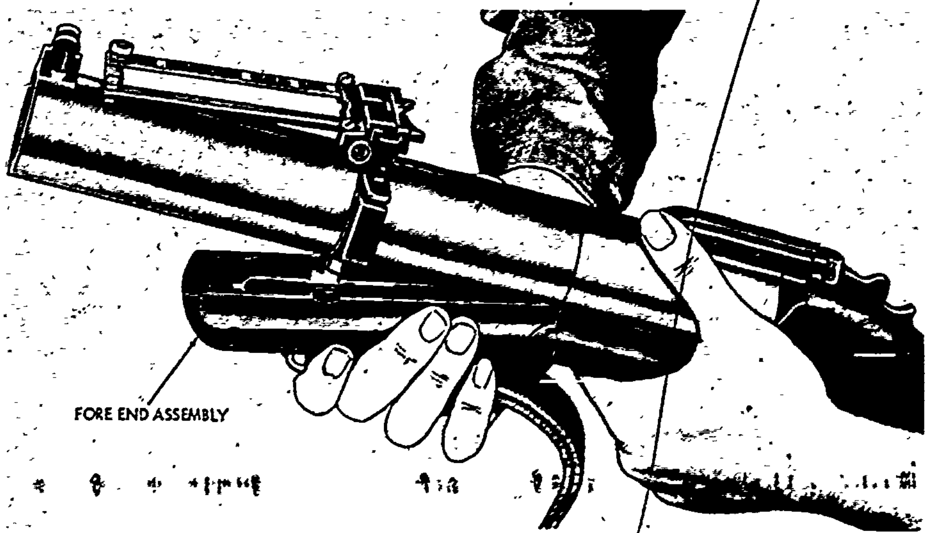
A misfire with blank cartridges may leave unburned powder deposited in the bore; always check the bore after any misfire and clean if necessary.

10. Guard against BLOWBACK. In this connection, blowback refers to leakage of high-pressure gases to the rear around the closed bolt. It can be caused either by excessive wear of the bolt or chamber, by obstructions that foul the bore, or by both. Blowback can be avoided by gaging and checking your weapons regularly and replacing worn parts as indicated, and by checking (see No. 5 above) to be sure that there are no obstructions in the bore.

STOW AND ISSUE SMALL ARMS

As a GMG you are responsible for the security, stowage, maintenance, and issue of all small arms.

Increasing reported instances of ammunition and weapon pilferage by dissident groups and

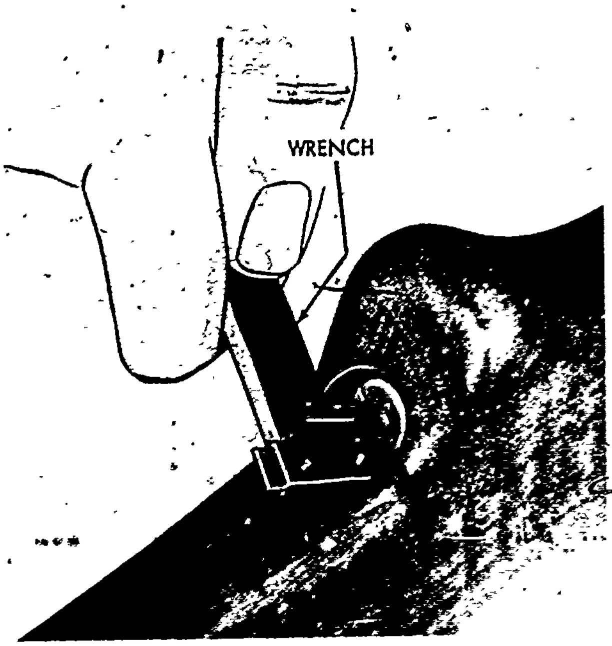


29.370

Figure 4-105.—Removing fore end assembly.

29.371

Figure 4-106.—Removing barrel group.



29.372

Figure 4-107.—Removing screw attaching receiver group to stock assembly.

individuals indicates the necessity for stricter control of storage, security, custodial responsibility, and inventory reconciliation procedures for easily pilfered items, which include small arms.

Small arms should always be stowed in an authorized and secure stowage to preclude pilferage. A strict accountability must be maintained at all times.

All small arms are considered equipage, and a signature of subcustody is required before they are issued from their normal place of stowage. It is important to get the signature of the man receiving the weapon; any type of signed custody record may be used as long as it bears the receiving individual's signature. The important thing is to keep the weapon locked up and, when it is issued, get a signature.

Maintenance of small arms cannot be stressed too strongly. The weapons must be field stripped, inspected, and cleaned after use. To prevent corrosion, a light coat of oil should be applied to exposed surfaces while the weapons are in their normal stowage. Prior to issue all oil must be removed.

CHAPTER 5
LANDING PARTY EQUIPMENT AND DEMOLITION MATERIALS

As a Gunner's Mate 3 you are required to know how to issue, assemble, and demonstrate the use of landing party equipment. This also includes maintaining the equipment in good repair. Currently the reference for assisting you in performing these tasks is the Landing Party Manual (LPM), OPNAV P34-03. However, this manual is presently under revision with completion expected in the near future.

The two manuals that will replace the current LPM are: the Landing Party Manual, NWIP 50-4 and the Landing Party Library (LPL). Some material formerly contained in the Landing Party Manual has been eliminated from the revised LPM and incorporated in the LPL. This system will assist in maintaining currency of that material and will provide more detailed information concerning a given subject than was possible when condensed for inclusion within earlier editions of the Landing Party Manual.

The purpose of the Landing Party Manual is to set forth the mission and organization of naval landing parties and emergency ground defense forces and to provide certain technical information and tactical policies and procedures not available in appropriate form in other source documents and publications.

The Landing Party Manual (revised) is intended for use as a guide in the training and operations of naval landing parties. It is designed to make readily available to all Navy personnel the basics necessary to the conduct of ground combat and the fundamentals of dealing with civil disturbances or riots. References to naval landing parties and afloat units are also intended to be utilized by naval emergency ground defense forces and shore stations.

The purpose of the Landing Party Library is to serve as a source for the training and operations of naval landing parties established by units afloat and emergency ground defense force units organized at naval shore establishments. It contains detailed and technical information concerning subject matter on the employment of naval forces ashore.

The conduct of ground force operations may require the use of naval landing party personnel, and a reasonable state of readiness for such actions should be maintained. The Landing Party Manual and Landing Party Library contain adequate doctrine and reference material for training personnel in the required skills of a landing party.

In scope, this chapter falls somewhere between the simple requirements of a Gunner's Mate 3 and selected coverage of the Landing Party Manual. A description of demolition materials and equipment used will be covered following the discussion on the Landing Party.

In this section we will discuss the following:

LANDING PARTY ASSIGNMENTS—what you might expect to be doing if you are assigned to a landing party.

THE EQUIPMENT—what it is, how to make it up, and how to wear it.

THE SHIP'S LANDING PARTY

To most sailors, the landing party might bring to mind one of two things. First, a peaceful, if dull, march down main street in a parade or, second, mortal hand-to-hand combat with enemy troops ashore. While both situations are true functions of the landing party, they represent the extremes. The landing party is organized, trained, and equipped to perform the following functions:

1. Limited ground force emergency operations generally involving:
   a. Weapons no larger than small arms.
   b. Equipment limited to that which can be reasonably carried on the person or

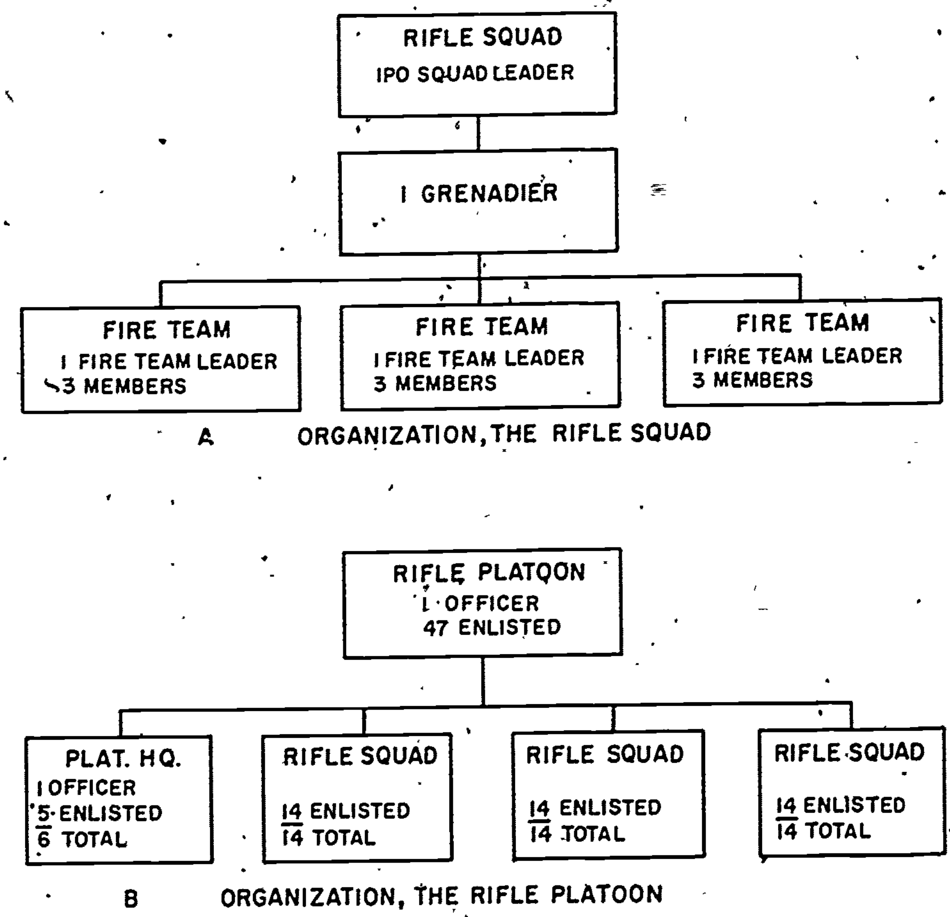
supplied from other equipment and stores normally available.
   c. A duration of one week or less.
2. Law and order and humanitarian functions during disturbances or national disasters.
3. Parades and ceremonies.

ORGANIZATION OF THE LANDING PARTY

The ship's landing party varies in size and composition according to the type of ship. It is mandatory that ships follow their designated organization closely so that the units of several ships or shore stations may be banded together to form a larger ground force with balanced subordinate units of known personnel and weapon strength. A destroyer, for example, is required to maintain a 14-man rifle squad; an amphibious type ship is required to maintain one rifle platoon composed of 1 officer and 47 enlisted men; and CVs and cruisers are required to maintain one rifle company composed of 6 officers and 204 enlisted men. In addition to the above requirements, flagships of carrier and cruiser divisions/groups are required to organize battalion headquarters companies for battalions formed by their divisions/groups. In addition to individual ship's landing parties, two platoon headquarters and one company headquarters will be organized by each squadron of DD, DDG, DLG, DLGN, DE, DEG, and DER types.

Figure 5-1A shows an organizational chart of a rifle squad. The squad is made up of a squad leader, a grenadier equipped with the M79 grenade launcher, and three fire teams consisting of a leader and 3 men each. Squads organized for independent duty can be augmented if necessary. A rifle squad consists of a total of 14 men.

Figure 5-1B shows the organization of a rifle platoon which is the result of combining the



84.390

Figure 5-1.—Organization, the rifle platoon.

landing parties of three destroyers. Notice that with the exception of the six people at the platoon headquarters, the major unit of the rifle platoon is the rifle squad. The normal strength of a rifle platoon is 1 officer and 47 enlisted men. In addition to individual weapons, a platoon may be equipped with anti-tank weapons, carried by personnel so designated by the platoon leader. A platoon organized for independent missions or one which comprises the entire landing party should be augmented by appropriate additional personnel necessary to accomplish the assigned mission.

The machine gun platoon is composed of 1 officer and 55 enlisted men and is divided into 3 machine gun sections. Each section consists of a headquarters unit and two squads. The section leader is either a petty officer second or third class which is a position, you as a Gunner's Mate, may well fill. In addition to individual weapons, each squad operates and maintains one 7.62 machine gun M60.

At the rifle company level, which consists of three rifle platoons and one machine gun platoon, Gunner's Mates are also employed as small arms repairmen. This is another incentive to learn as much as possible about the operation, repair, and maintenance of small arms.

LANDING PARTY EQUIPMENT

The type and amount of equipment carried ashore by the men of the landing party depends on the nature of the operation. Since it is intended that the naval landing party will not be employed beyond the scope of "limited ground force operations" during an emergency, the equipment and weapons prescribed are limited to light infantry weapons and equipment which can be carried on the person. The equipment we are primarily concerned with is equipment taken ashore and used in emergency field operations.

Naval landing parties engaged in combat or civil disturbances (riot or crowd control) operations will normally be equipped in accordance with Table 5-1. Actual combat existence and subsistence loads will be prescribed by the commander in accordance with on scene conditions and requirements. Table 5-2 is provided to indicate minimum individual equipment necessary for civil disturbance (riot or crowd control) operations.

Where deemed necessary by the appropriate commander, individuals may be issued special articles of equipment to conform to weather and type of operation.

UNIFORMS

Uniforms and other articles of clothing worn by members of the naval landing party will depend upon the individual's assigned mission and nature of the contemplated operation. The uniform to be worn is prescribed by the appropriate commander. Landing parties engaged in combat or civil disturbance operations normally will wear uniforms as shown in Table 5-3. For cold weather operations, additional articles of clothing should be issued.

WEARING OF EQUIPMENT

Combat equipment is worn or carried in a specified standard manner for convenience, uniform appearance, and ease of inspection. A smart appearance and military manner are closely associated with proper wearing of equipment. High equipment standards should always be maintained.

PROTECTIVE EQUIPMENT

Helmet and Helmet Liner

The helmet and liner are always worn in combat. When prescribed by the appropriate commander, the liner alone may be worn for law-enforcement operations, guard duty, or parades and ceremonies.

When properly worn, the helmet affords maximum protection to the forehead, temples, and back of the neck. The liner headband, helmet chinstrap, and liner chinstrap must be adjusted to the head size of wearer. The forward edge of the helmet should be on line and parallel to the deck, while the rear edge of the helmet should be low over the neck and parallel to the deck. The chinstrap of the helmet should be firmly fastened under the chin, and the liner chin strap should be tightly secured over the front edge of the helmet.

Armor Vest

The armor vest is designed to provide protection against low-velocity missiles, fragments from mines, grenades, mortar shells, and artillery fire. The vest does not protect against small-arms fire, although it tends to decrease its severity. The vest consists of a nylon filler which includes layers of tough nylon cloth stitched together to form the fragment-protection portion of the vest. A vinyl-plastic envelope covers the ballistic nylon filler and this, in turn, is enclosed

Table 5-1.—Infantry combat equipment of the naval landing party

	RIFLEMAN	ASST AUTO RIFLEMAN	AUTO RIFLEMAN	FIRE TEAM LEADER	GRENADIER	RIFLE SQUAD LEADER	RIFLE PLATOON GUIDE	MACHINEGUN SQUAD LEADER	GUNNER	ASSISTANT GUNNER	AMMUNITION CARRIER	MACHINEGUN SECTION LEADER	MESSENGER	SIGNALMAN	CHIEF INTELLIGENCE SECTION LEADER	ALL CHIEFS & OTHER COMM. PERS.	OFFICERS & OTHER SENIOR PO'S	ALL OTHERS	TOTAL RIFLE PLATOON	TOTAL MACHINEGUN PLATOON	TOTAL RIFLE COMPANY
BASIC INDIVIDUAL COMBAT EQUIPMENT																					
BLANKET/SLEEPING BAG	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
MESS KIT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
CANTEEN ASSEMBLY	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
HELMET ASSEMBLY, BATTLE, M1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
PACK, FIELD, COMPLETE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
FIRST AID KIT, INDIVIDUAL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
PONCHO, WET WEATHER W/LINER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
TAG, I D	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	96	112	420
TENT, SHELTER HALF, COMPLETE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
RUCKSACK	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
SUPPLEMENTARY INDIVIDUAL COMBAT EQUIPMENT																					
BAYONET KNIFE, M6 W/SCABBARD	1	1		1		1	1	1			1	1	1	1	1	1		1	35	42	154
KNIFE W/SHEATH			1		1				1	1							1		1	14	56
BELT, INDIVIDUAL, M1956	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
BOOK, FIELD MESSENGER, NMC 694 DM [1]						1	1	1				1	1	2	1	2	1		9	13	47
CASE, MAP																			1	1	11
COMPASS W/CASE				1		1	1	1				1					1		15	11	59
CUTTER, ASSEMBLY, WIRE						1								1					9		10
BINOCULARS 7X50											1			1			1		1	5	12
MASK, PROTECTIVE, M17A1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
MAGAZINES, M14	5	5	7	5		5	5	5			5	5	5	5	5	5		5	233	20	909
PISTOL, AUTO., 45 CAL. W/2 MAG'S & HOLSTER				1					1	1							1		10	14	29
U S RIFLE 7.62 MM, M14 W/A2 BIPOD	1	1		1		1	1	1			1	1	1	1	1	1		1	35	42	154
U.S. RIFLE 7.62 MM, M14 MODIFIED W/A2 BIPOD			1																9		29
ENTRENCHING TOOL SET [2]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	56	210
WATCH WRIST, LUMINOUS, WATERTIGHT														1	1	1			1	1	12
WHISTLE						1	1					1					1		6	11	32
GRENADE LAUNCHER M76	1																		3	3	9
POUCHES, AMMUNITION RIFLE	2	2	2	2	2	2	2	2			2	2	2	2	2	2		2	88	84	312
ORGANIC COMBAT EQUIPMENT																					
GRENADE LAUNCHER M79					1														3		9
MACHINEGUN, 7.62 MM, M60									1											6	9
SPARE BARREL, CASE, W/ASSESSORIES [3]										1											6
MOUNT, TRIPOD, MACHINEGUN M122 [4]								1													

1. STANDARD NAVY MESSAGE BLANKS MAY BE USED IN LIEU OF NMC 694 DM
2. SHOVEL, PICK MATTOCK, OR MACHETE
3. INCLUDES BORE CLEANING BRUSH, CHAMBER CLEANING BRUSH, RECEIVER CLEANING BRUSH, CARRYING CASE, RUPTURED CARTRIDGE EXTRACTOR, MAGAZINE ASSEMBLY, ASBESTOS MITTEN, CLEANING ROD (3 SECTION), COMBINATION TOOL
4. INCLUDES TRAVERSING AND ELEVATING MECHANISMS

84.391

Table 5-2.—Minimum civil disturbance equipment of the naval landing party

	RIFLEMAN	GRENADIER	OFFICERS, CPOS, POS, AND ALL OTHERS
U.S. RIFLE, 7.62 MM, M14 W/O AUTOMATIC CAPABILITY	1	1	
MAGAZINE, M14	4	—	
PISTOL, .45 CALIBER		1	1
MAGAZINE, .45 CALIBER		3	3
GRENADE LAUNCHER, M79		1	
HELMET W/LINER	1	1	1
BELT, INDIVIDUAL, M1956	1	1	1
POUCHES, MAGAZINE	4	1	1
FIRST AID KIT, INDIVIDUAL	1	1	1
CANTEEN ASSEMBLY	1	1	1
ARMORED VEST	1	1	1
MASK, PROTECTIVE, FIELD	1	1	1

84.392

in a lightweight nylon cloth cover. The vinyl-plastic envelope forms a water-proof barrier against damage from moisture, dirt, and other foreign matter. The lightweight, nylon cloth cover provides camouflage, wear resistance, and additional protection for the inner parts of the vest. The cover is equipped with pockets and grenade hangers as shown in figure 5-2.

The vest must be periodically examined for:

1. Tears, punctures, or damage to the outer nylon cover.
2. Bunching evidenced by lumps or distortion in the ballistic nylon filler. Bunching is the creasing and folding of the nylon filler within the outer case.
3. Noticeable increase in weight, indicating that the nylon filler has become wet.
4. Damaged or dirty hook-and-pile fastener.
5. Broken or missing elastic laces.

To clean the vest, use warm water and soap or detergents. Do not use cleaning solvent or gasoline. Do not fold the vest for storage.

Protective Mask

The M17 series chemical-biological field protective mask, when properly fitted and worn with the hood, gives protection against field concentrations of all known enemy chemical agents in vapor or aerosol form by filter elements that fit in the cheeks of the face piece. They filter the contaminated air but do not manufacture or produce oxygen.

The standard field protective mask is the M17A1. It has as an accessory, a resuscitation tube for giving mask to mouth artificial respiration by a masked individual to an individual casualty in a contaminated atmosphere. The mask has a voicemitter to facilitate communications, a device for drinking water from a canteen while masked (including a water canteen cap which is to be carried in the mask carrier), two eyelens outserts to protect the eyelenses, and a water proofing bag in which the mask can be enclosed to protect the filter elements from damage by water.

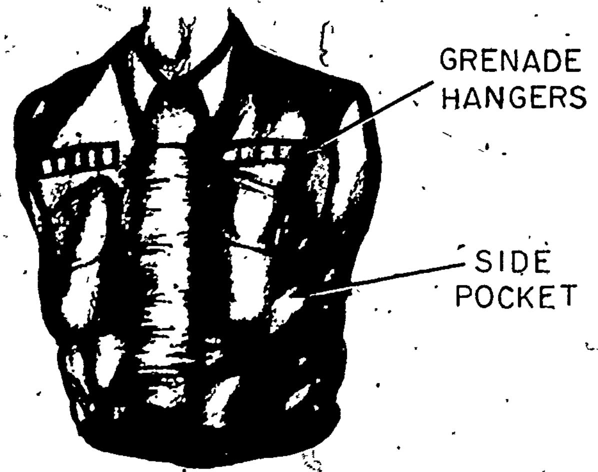
The following steps are used to don the mask:

Table 5-3.—Uniforms for combat and civil disturbance operations

	U.S. NAVY		U.S. MARINE CORPS	
	OFFICERS & CPOS	ENLISTED	OFFICERS	ENLISTED
WARM WEATHER OPERATIONS	WORKING, KHAKI	DUNGAREE	UTILITY	UTILITY
COLD WEATHER OPERATIONS	WORKING, BLUE OR WORKING, KHAKI	DUNGAREE	UTILITY WITH FIELD JACKET	UTILITY WITH FIELD JACKET

1. SELECTED ITEMS OF WINTER AND FOUL WEATHER CLOTHING SHOULD BE WORN AS PRESCRIBED BY THE LANDING PARTY COMMANDER IN ACCORDANCE WITH ON SCENE WEATHER CONDITIONS.

84.393

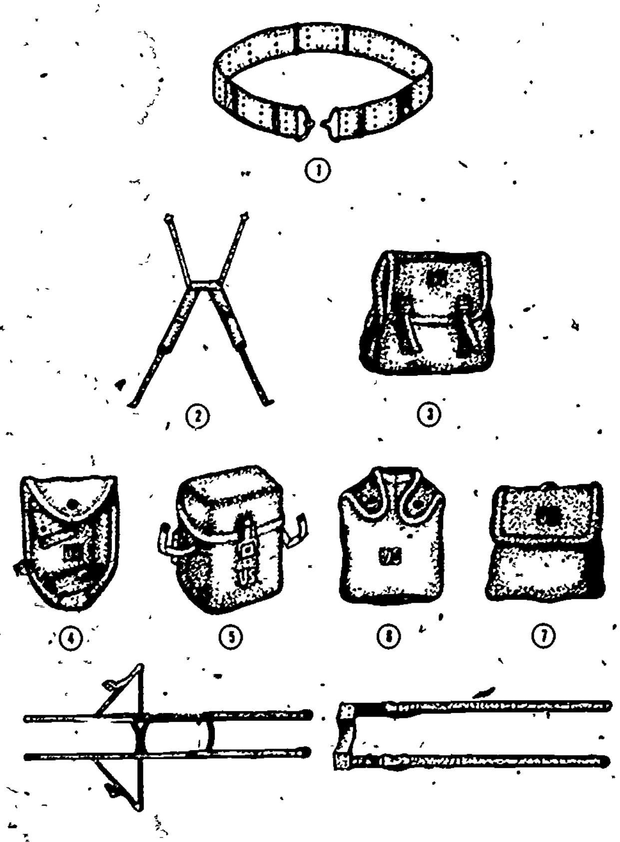


84.394
Figure 5-2.—Armor vest.

1. Remove headgear with right hand and open carrier with left hand.
2. Hold carrier open with left hand; grasp facepiece just below eyepieces and remove from case with right hand.
3. Grasp facepiece with both hands, sliding thumbs up inside facepiece under lower harness straps. Place other fingers straight and together outside facepiece above eyepiece. Lift chin slightly.
4. Seat chin pocket of facepiece firmly on chin. Bring head harness smoothly over head, ensuring that head harness straps are straight and head pad is centered.
5. Smooth edges of facepiece on face with upward and backward motion of hands, pressing out of bulges to secure airtight seal.
6. Close outlet valve by cupping heel of hand firmly over opening; blow hard to clear agent from facepiece.
7. Block air inlet valve assemblies shutting off air supply. Inhale. The facepiece will collapse if there are no leaks; resume breathing.
8. Replace headgear; close carrier flap.

LOAD CARRYING EQUIPMENT

Load carrying equipment for the landing party consists of a pistol belt, field pack suspenders, combat field pack, intrenching tool carrier, universal ammunition small arms pouch, canteen cover, sleeping bag carrier, pack adapter strap, and a first aid kit. The load carrying equipment is shown in figure 5-3.



1 BELT, PISTOL
2 SUSPENDERS, FIELD PACK COMBAT
3. FIELD PACK, COMBAT
4. CARRIER, INTRENCHING TOOL
5. POUCH, SMALL ARMS AMMUNITION, UNIVERSAL
6. COVER, CANTEEN
7 FIRST AID KIT, INDIVIDUAL
8 CARRIER, SLEEPING BAG
9. STRAP, PACK ADAPTER

84.395
Figure 5-3.—Long carrying equipment.

Suspenders

The cotton webbing suspenders with pistol belt are the two basic individual loading equipment items. All other components are suspended from or attached to these two items. The suspenders support the field pack and pistol belt, but may be worn without the field pack. In this case the suspenders are attached directly to the pistol belt an equal distance from center of the rear of the pistol belt. This will help to keep weight of the load evenly distributed on both shoulders.

Field Pack

The cotton duck field pack is 9 inches wide, 8 3/4 inches high, and 5 inches deep. It has an expandable flap secured by two straps and buckles. Two web straps on the bottom permit attachment of other items. A handle on the flap is used to hand carry the field pack. On the back are two attaching clips and eyelets so it can be attached to the suspenders and pistol belt.

The field pack is used to carry individual rations and equipment that are essential during field operations. It is designed to carry items in different ways to meet changing conditions.

When loading the pack, place hard items such as rations on the outside, with softer items like clothing on the inside towards the wearer's back. There are a series of eyelets at the edge of the pack flap that will accomodate the double hooks used on old style field equipment carriers for such items as machetes and wire cutters.

Intrenching Tool Carrier

The intrenching tool carrier is attached to the pistol belt by means of two attaching clips located on the back. An attachment for carrying the bayonet or bayonet knife scabbard is located in front of the carrier.

Ammunition Pouches

Each small arms ammunition pouch has plastic stiffeners in the back of the pouch so that clips of ammunition can be easily inserted and removed. Two attaching clips and supporting straps on each pouch are used to attach the pouch to the pistol belt and suspenders. Both sides of the ammunition pouch have attachments for carrying hand grenades. The pouches are designed to carry any of the basic load of ammunition. When extra ammunition is necessary, bandoleers may be loaded in the pouches by folding them accordian fashion with the bandoleer strap on top. This method permits easy insertion and removal of the bandoleers.

Canteen Cover

The canteen cover accomodates a canteen and canteen cup. The cover is attached to the pistol belt by means of two attaching clips on the back of the cover.

First Aid Kit

The first aid kit is attached to the pistol belt by means of an attaching clip on back of the kit. The case cover is secured by two snap fasteners.

WEARING LOAD CARRYING EQUIPMENT

Adjusting Pistol Belt

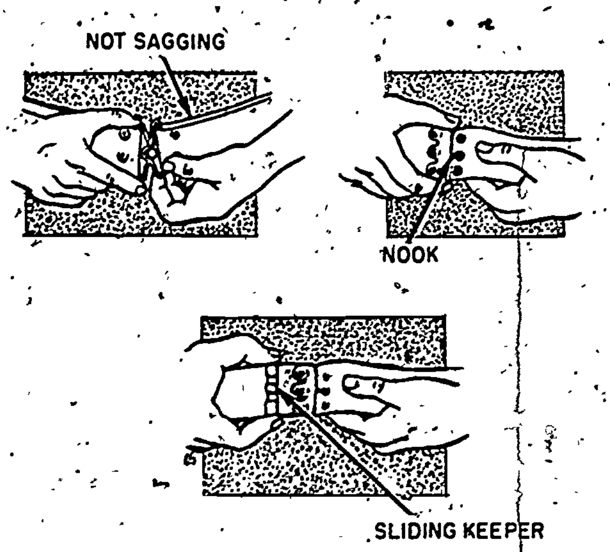
Unfasten the hook on each end of the belt from the center eyelet and adjust belt to the waist loose enough so as not to constrict the clothing and engage hooks in eyelet. Move a sliding keeper into position near to each hook to prevent hook from unfastening. The other sliding keeper should be moved into position close to the male and female belt fasteners. (See fig. 5-4).

Attaching Field Pack to Pistol Belt

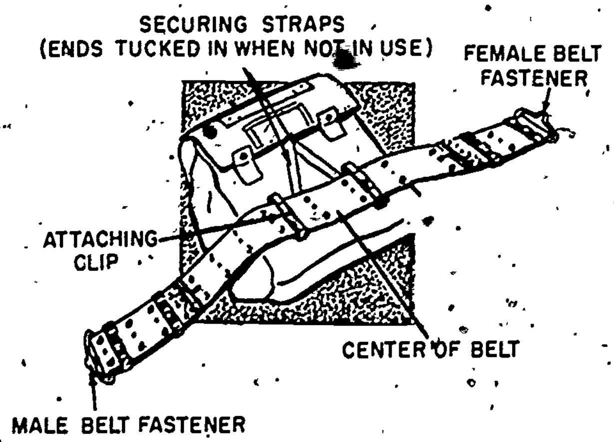
Lay the pistol belt out flat with the back facing up and the male fastener to the left as shown in figure 5-5. Locate center of the belt and insert it into the two open attaching clips of the pack. Close the two attaching clips, making sure the sliding bars engage the holes in the bottom of the clip.

Attaching Suspenders to the Field Pack and Pistol Belt

Lay the suspenders out flat above the pack (fig. 5-6) with the inside facing up and the back suspender straps to the bottom. Attach the back suspender straps to the pack by engaging the hooks of these two straps into the eyelets of the two webbed tabs of the pack with the open part of each hook facing to the back of the pack. To attach front suspender straps to the pistol belt, first fasten buckles of belt. Fold the suspenders back on the pack so they lay with the outside of the suspenders up. Engage the left front suspender strap hook into the eyelet on front of the belt nearest the female buckle and the right front suspender hook into the top eyelet on front of the belt, nearest the male buckle. The open part of the hooks are to the front of the belt and the loops are located to the side away from the belt fasteners. Adjustment of the front suspender straps is accomplished through buckles on the front suspender straps. The rear suspender straps are adjusted by their respective buckles to ensure that each shoulder pad is centered over the shoulders and the pistol belt hangs evenly front and rear.



84.396
Figure 5-4.—Adjusting the pistol belt.



84.397
Figure 5-5.—Attaching the field pack to pistol belt.

The following items are attached to the pistol belt:

Intrenching tool carrier

Canteen cover

Small arms ammunition pouches

First aid kit

Bayonet and scabbard

Wire cutters and carrier

Holster and pistol

Machete and sheath (when no intrenching tool is carried)

If either the field glasses or map case is carried, they may be slung from the shoulder.

There are other items of landing party equipment which are too detailed to cover in this manual. For the detailed information on this equipment and the landing party in general, refer to NWIP 50-4.

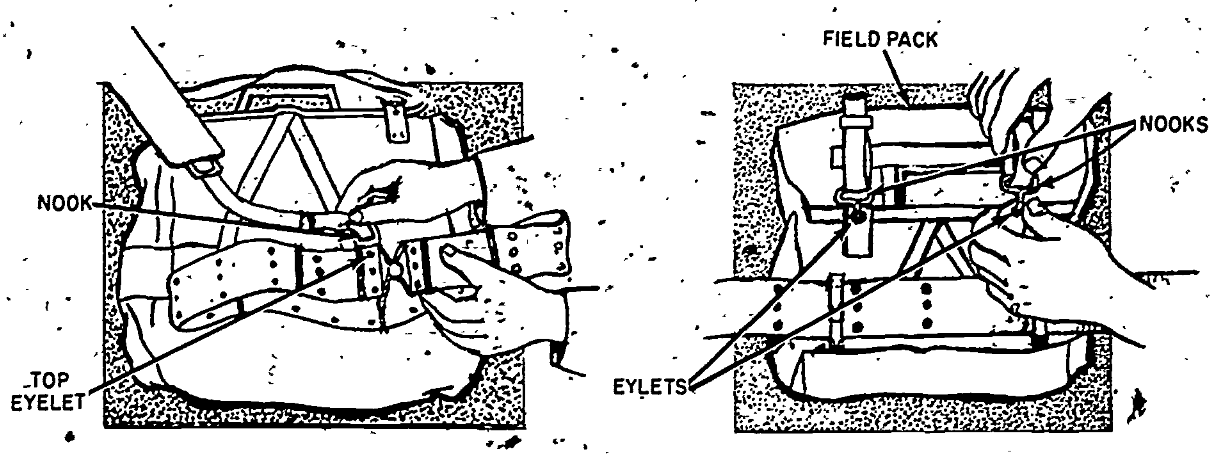
HAND GRENADES

A hand grenade is a small bomb with the user's arm providing the motive power to get it to the target. Hand grenades may be filled with explosives, explosives and chemicals, or (for practice purposes) may be empty or contain inert filler. Hand grenades come in many sizes, shapes, and types and are designed to fulfill a wide variety of purposes. They can be used for inflicting material and personnel casualties; for screening, signaling, and illuminating; for demolition and harassing; and for incendiary action.

TYPES AND CHARACTERISTICS

The general types of hand grenades issued are: (1) training, (2) practice, (3) fragmentation, (4) offensive, and (5) chemical. Each type is designed to do a special job. For a summary of the characteristics and capabilities of each hand grenade refer to Army Field Manual FM 23-30.

Certain characteristics common to all hand grenades are:



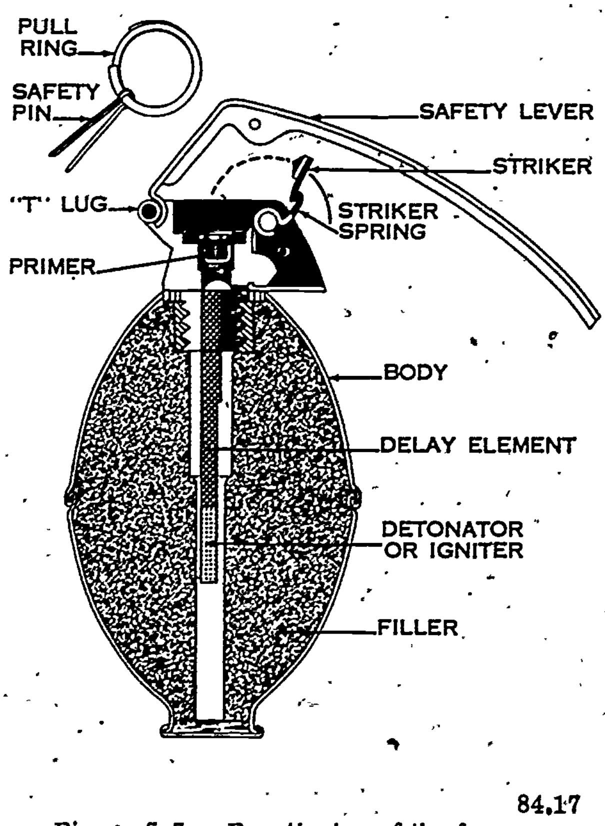
84.398

Figure 5-6.—Attaching suspenders to the pistol belt and field pack.

1. The range of a hand grenade is relatively short. The range depends on the ability of the individual and the shape of the grenade. A well trained sailor should be able to throw the fragmentation hand grenade an average of about 44 yards. He may average only about 27 yards with the heavier white phosphorous smoke grenade.

2. The effective casualty radius of a hand grenade is relatively small, when compared to that of other weapons. Effective casualty radius is defined as the radius of a circular area around the point of detonation within which at least 50 percent of the exposed personnel will become casualties. The effective casualty radius varies with the type of hand grenade used, so the casualties can and do occur at distances greater than this radius.

3. Delay type fuzes are used in all standard hand grenades. Detonation of the grenade is not on impact but after the delay element in the fuze has burned. The fuze assembly (fig. 5-7) consists of a fuze body safety lever, safety pin, striker spring, a primer, a delay element, and detonator or igniter. For further information about the operation of the fuze assembly, refer to FM 23-30. All casualty-producing grenades (fragmentation, offensive, and white phosphorous) have a 4- to 5-second delay. Because of this short delay, personnel must stay alert when arming and throwing hand grenades.

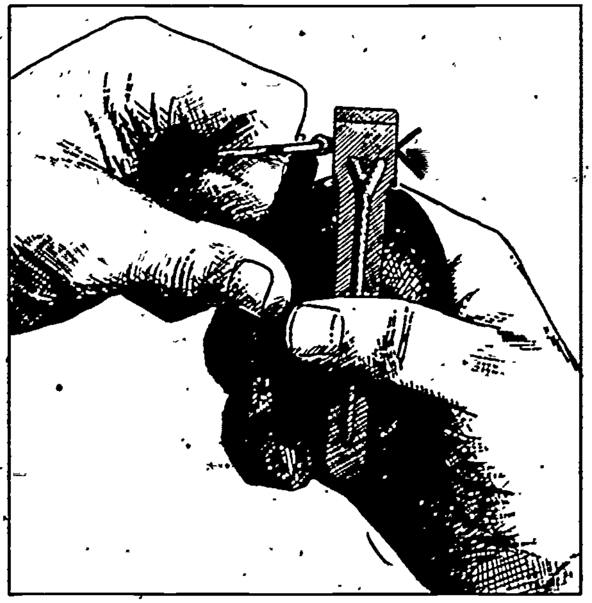


84.17

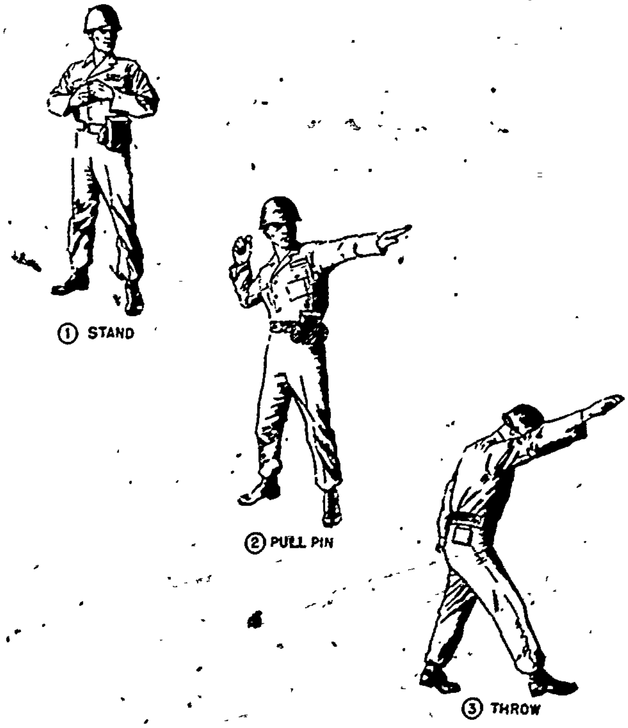
Figure 5-7.—Functioning of the fuze.

PROCEDURES FOR THROWING

For greater accuracy and range, the grenade should be thrown like a baseball, using the throwing motion most natural to the individual. It is important to grip the grenade properly. Figure 5-8 shows the proper position of the grenade prior to pulling the safety pin. First, cradle the grenade in the fingers of the throwing hand. Hold the safety lever down firmly under the thumb between the tip and first finger joint.



84.18
Figure 5-8.— Proper way to grip the hand grenade.



84.19
Figure 5-9.— To throw from the standing position.

In this way, the grenade fits snugly into the curved palm of your hand, giving you a firm, comfortable grip, but don't relax your thumb pressure on the safety lever until you throw the grenade.

The first steps in grenade throwing are to develop good throwing habits, and several throwing positions. Four throwing positions are recommended: (1) standing, (2) kneeling, (3) prone, and (4) crouch.

The procedures for throwing from the standing position are as follows:

1. Stand half-facing the target, with your weight balanced equally on both feet. Hold grenade chest high, using the correct grip (view 1 fig. 5-9).
2. Pull pin with a twisting, pulling motion. Cock your throwing arm to the rear (view 2).
3. Throw the grenade with a free and natural motion. As it leaves you hand, follow through by stepping forward with your rear foot (view 3). Observe the point for probable strike, then duck your head to avoid fragments or other effects.
4. Recover, then resume the original standing position.

Field Manual 23-30 explains the proper steps to be taken when using any of the other positions.

SAFETY

The following safety precautions must be observed when handling or using hand grenades.

1. Do not take any grenade apart unless ordered to do so by competent authority.

2. Do not tamper with grenades and do not recover or tamper with live grenades that fail to explode (duds). These duds are recovered and destroyed only by qualified personnel.

3. Do not pull the safety pin until you are ready to throw the grenade. If the safety pin will not pull out easily with a pulling-twisting motion, straighten its ends. In the majority of cases, this will not be necessary. Maintain a firm grip on the safety lever when removing the safety pin.

4. After you pull the safety pin, throw the grenade. Do not attempt to replace the pin to return it to a safe condition.

5. When throwing a fragmentation grenade without protective cover, drop immediately to a prone position, face down, with your helmet

toward the grenade. Keep your arms and legs flat against the ground. Other men in the area who are exposed must be warned to drop to a similar position. Steel helmets must be worn at all times when using grenades.

6. Although little danger is involved in using practice hand grenades, they require some degree of care in handling and throwing. You can throw the practice grenade a safe distance, but for the purpose of training and to preclude injury from an improperly loaded grenade, take cover. Wear the steel helmet, and keep all other personnel at a safe distance. Practice grenades that fail to function (duds) are not recovered for at least 10 minutes, and then only by trained personnel.

7. Grenades are issued in the "with fuze and without fuze" condition. They are not necessarily shipped in separate containers. The detonator of a fuze is very sensitive to heat, shock, or friction. Army Field Manual FM 23-30 explains the safety precautions and steps taken when fuzing hand grenades.

DEMOLITION

Before going into the subject of demolition we want to emphasize that the information contained in this section is NOT intended to qualify a man as an expert in demolition. Never attempt to tamper with demolition materials, leave this to the experts that have been specifically trained in demolition work.

The information contained in this chapter on demolition is meant only to familiarize GMGs with the equipment, materials, and safety precautions connected with demolition work. It is in no way intended to train GMGs to become demolition experts. Demolition work is a skill that is acquired only through intensive training and should NOT be attempted by untrained personnel.

A subject like this is not, of course, to be covered in a single section of one chapter. The use of explosives and associated blasting equipment for construction projects or large-scale demolition involves highly developed skills. These skills are developed through intensive training and a great deal of experience. Repeating what was written earlier, the following information on demolition is only to familiarize the GM with the explosives and equipment used. It is NOT intended as a self-teaching text to train GMs to become experts in demolition.

If you are assigned to the Seabees, your job as a GM will have a lot to do with handling, storing, and maintaining explosives and demolition materials. Demolition equipment is also issued to ships for use in eliminating hazards to navigation. The Gunner's Mates aboard are responsible for handling this material in so far as storage and maintenance is concerned.

The discussion in this section will give you some idea of the tools used, and the names and uses of some of the more important explosives and other materials involved in this work. We will not try to cover the specific practical application of demolition explosives. For a much more detailed discussion, which includes other demolition equipment and techniques, you should read OP 2212, Vol. 1, Demolition Materials.

DEMOLITION CHARGES

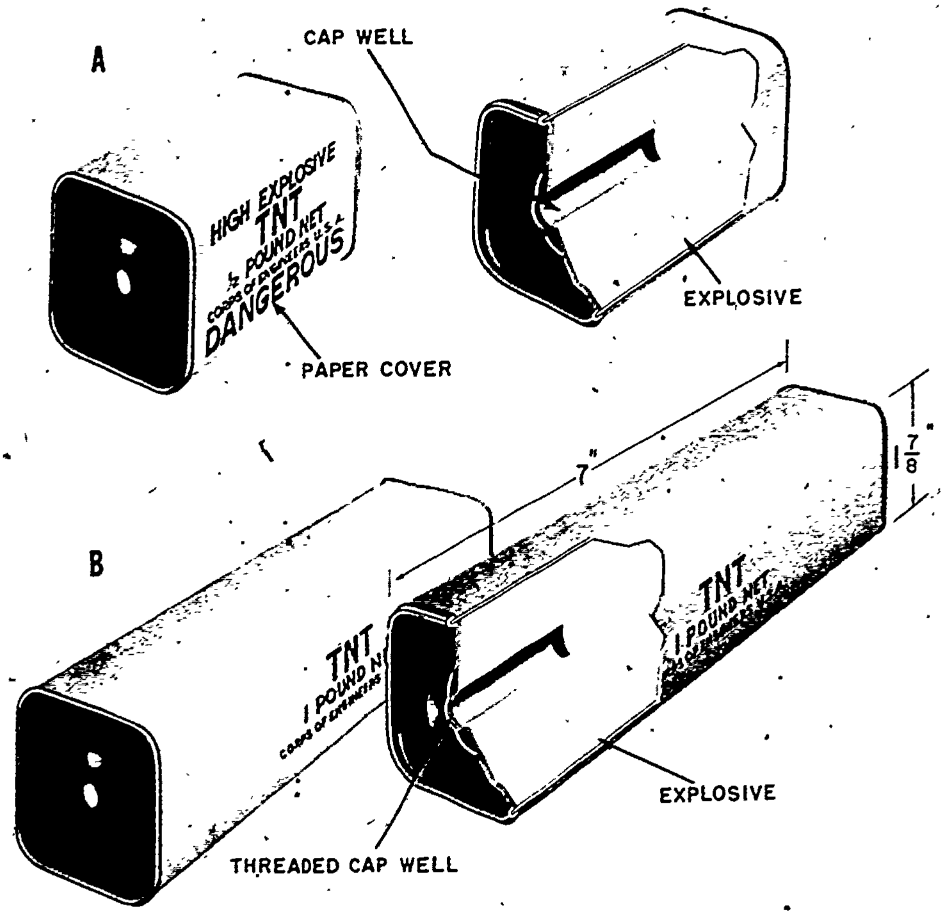
The demolition explosive usually issued to ships is most often TNT, in cast or pressed form, but it may be Tetrytol. The explosives come in half-pound and 1-pound blocks (fig. 5-10). TNT is also the main component of the 55-pound demolition charge.

The half-pound and 1-pound blocks are issued in cardboard boxes, and can be used either by themselves or as boosters to set off larger charges. Both sizes are made with cap wells (or activator wells) into which you can insert blasting caps (which we will presently explain).

The Mk 2 demolition charges (fig. 5-11) now issued to ships have rectangular rust-resisting steel cases a little over 9 inches square and a little over 14 inches high. Mods 2 and 3 are similar, except that Mod 2 has handling lugs. The 1-pound TNT block that is used as a booster to detonate the charge fits into a cavity in the main cast charge; the blasting cap that sets off the 1-pound block is screwed into the block's activator well. Figure 5-11 shows the charge as set up for blasting. The blasting cap is not inserted until just before the charge is set off.

BLASTING CAPS

Blasting caps are used for initiating high explosives. They are designed to be inserted in cap wells of demolition charges, and are also the detonating element in certain land mine firing devices. Special military blasting caps are designed to detonate the less sensitive explosives like TNT, military dynamite, and tetrytol. Blasting caps are extremely sensitive and may explode unless handled carefully. They must be protected



53.163

Figure 5-10.—TNT blocks—A. 1/2-pound block. B. 1-pound block.

from shock and extreme heat and not tampered with. Blasting caps must never be stored with other explosives. Two types, electric and nonelectric, are used in military operations.

Nonelectric Blasting Cap

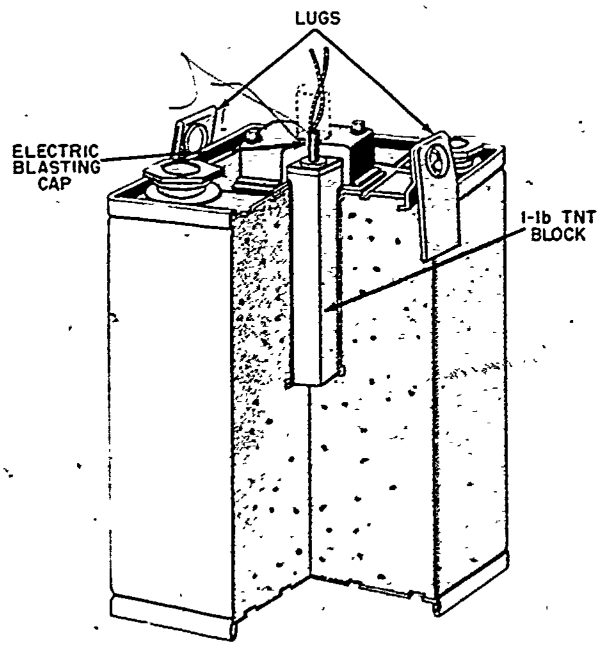
The Cap, Blasting Special, Nonelectric (fig. 5-12) is capable of detonating all standard types of demolition material that have been properly primed with the blasting cap for nonelectric firing.

The nonelectric blasting cap is contained in a clear-lacquered copper or aluminum tube. Three small explosive charges; the ignition charge, priming charge, and base charge are assembled in layers in the partially filled tube. A portion of the tube remains empty so the blasting cap can be fitted over and crimped to a time blasting fuse or the snout of a coupling base.

A flame from either a time blasting fuse, detonating cord, or special firing device will ignite the ignition (flash) charge. This ignites the priming charge which, in turn, detonates the base charge.

This blasting cap, along with time blasting fuse, is used for firing demolition charges nonelectrically. This method, while not the preferred one (electrical firing is safer), is used under many conditions because of the light weight of the material and speed of placement and use.

NOTE: Fuse. A fuse is a slow-burning powder-filled cord that carries flame to an explosive or combustible mass after burning



84.2
Figure 5-11.—Demolition charge Mk 2 Mod 2 (prepared for electrical firing).

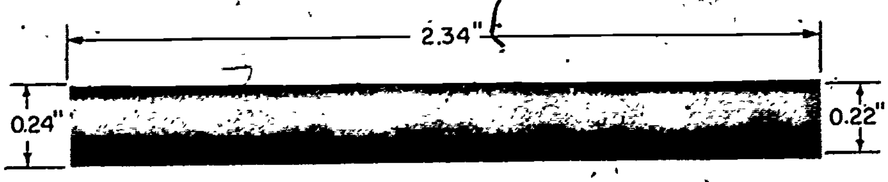
for a predetermined time. Fuze (Not to be confused with Fuse). The term fuze is a general one applying to any device that causes detonation, expulsion, or ignition upon the fulfillment of certain conditions, such as completion of a time delay, certain disturbances, impact, or inertia. The term is usually used in connection with bombs, pyrotechnics, or rocket heads. In demolition work, the term fuze is sometimes used interchangeable with the term firing device.

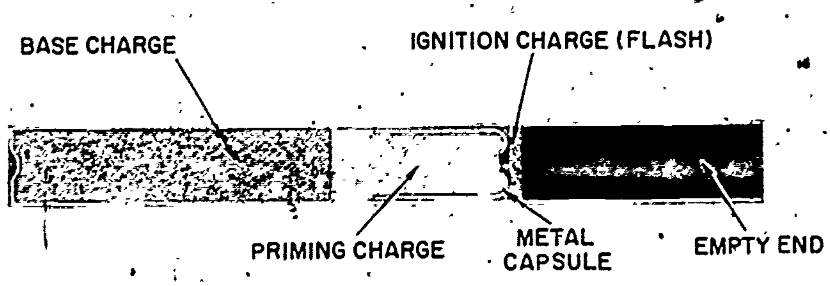
For all the details on the use of nonelectric blasting caps and their methods of ignition, it is recommended that you read FM 5-25, Explosives and Demolitions and OP 2212, Vol. 1, Demolition Materials. Figure 5-13 illustrates the method used in setting up a cap and fuse for nonelectric firing of a demolition charge.

The burning rate of time fuse will vary by the way it is handled and the conditions under which it is burned. So testing of the burning rate is essential before setting up a charge for demolition with a nonelectric blasting cap. The burning rate of fuses issued by the NAVORDSYSCOM varies between 30 and 45 seconds per foot.

Refer to figure 5-13 while we briefly go through the procedure of setting up a charge.

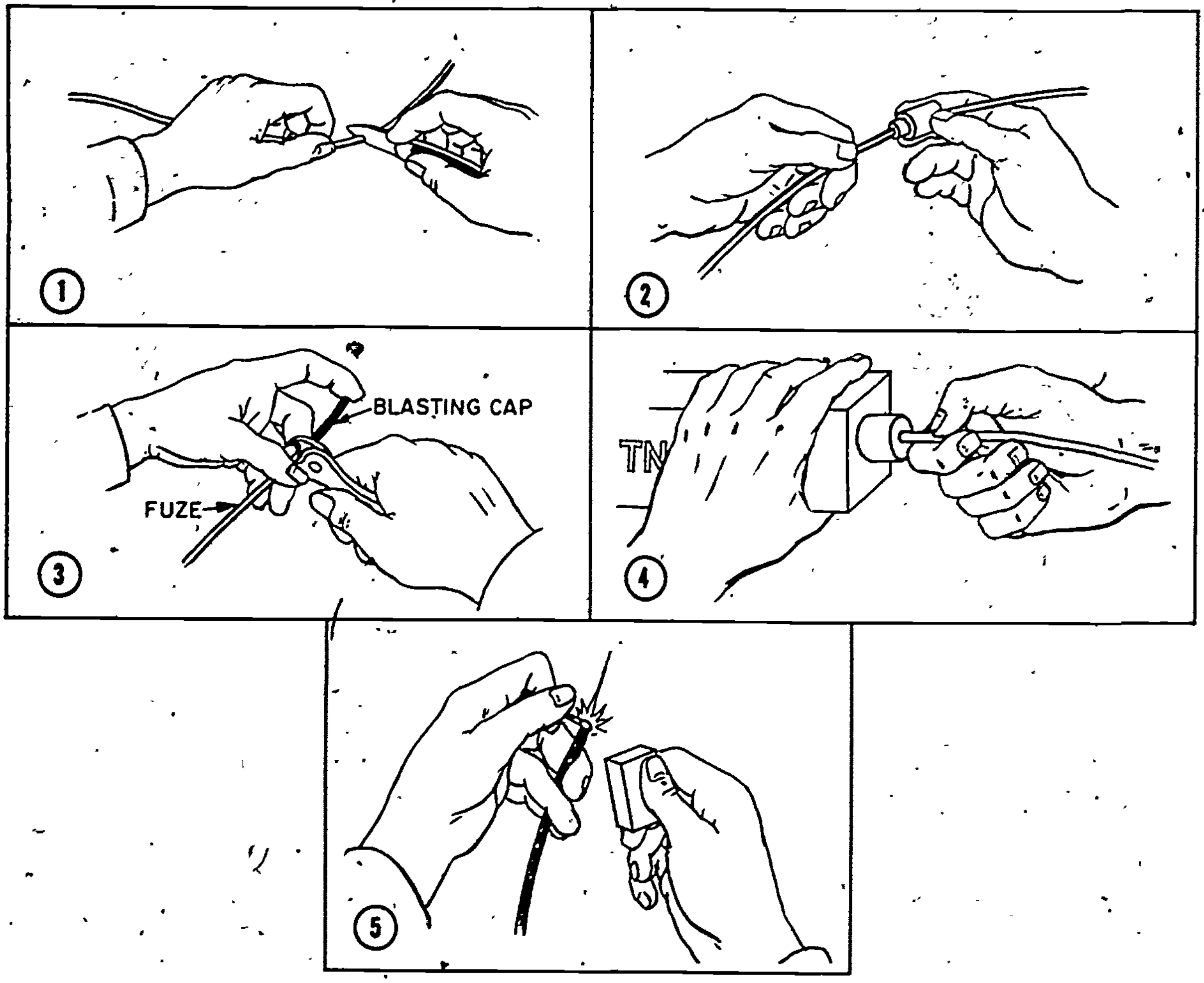
STEP 1. Cut off and discard a 6 to 12 inch portion of the exposed end of the blasting time fuse. A test must be made of the burning rate





53.157(83B)A

Figure 5-12.—Cap, blasting, special, nonelectric.



53.168

Figure 5-13.—Using cap and fuze for nonelectric firing of demolition charge (TNT block).

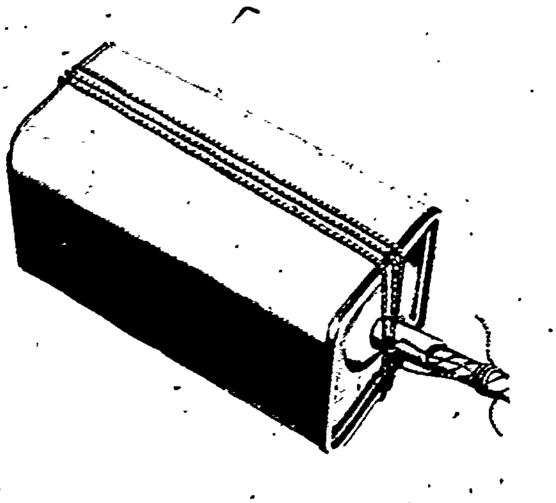
by burning a 6-foot sample length of time fuse. The 6-foot sample length should be tested from the same coil that will be utilized for the shot. The sample length should be initiated by an M60 Time Blasting Fuze igniter if available.

STEP 2. Cut off the desired length of time fuse and push it through the hole in the unthreaded end of the priming adapter.

STEP 3. Remove one nonelectric blasting cap from its box. Check inside the cap to ensure it is clear of obstructions. Check the end of the time fuse to ensure a square cut. Insert the time fuse into the cap (DO NOT TWIST OR TAP). Crimp the cap onto the time fuse 1/8 inch from the open end of cap. Use only the crimping tool to crimp caps. (DO NOT CRIMP NEAR FACE).

STEP 4. Insert the cap into the activator well of the demolition charge. Screw the adapter into the charge to hold the blasting cap in place. If screw adapters are not available, some means should be taken to prevent the cap from coming loose from the charge, such as wrapping a string tightly around the block a few times and tieing it securely over the well as shown in fig. 5-14.

STEP 5. The blasting time fuse may be lighted two ways. The first, which should always be used if available, is the M60 Time Blasting Fuze Igniter since it is the safest and surest



53.163(83B)
Figure 5-14.—Half-pound block of TNT primed nonelectrically.

method. If the M60 fuze igniter is used, it should be installed on the time fuse, prior to the installation of the blasting cap. The second way is by a wooden match. Slit the time fuse longitudinally and insert a match in the slit so that the head of the match protrudes slightly from the side of the time fuse. Hold the match and match box as shown in illustration No. 5 of figure 5-13 and draw the abrasive side of the match box against the match head. Do not attempt to light the match unless you are prepared to do it successfully the first time. After you have struck the match, leave the area and take cover—even though the attempt appears to be unsuccessful. Walk calmly but smartly to a safe area—NEVER RUN. If a long distance is necessary to reach the safe area, then additional length should be allowed on the blasting time fuse.

STEP 6. If a misfire is encountered, wait 30 minutes plus time for the blasting time fuse to burn.

Electric Blasting Caps

Figure 5-15 shows Cap, Blasting, Special, Electric Type, Nos. 1-10 Delay. The cap comes in 10 delay types, with each delay type differing in length as well as delay time. The delay time and consequently the length of a particular cap is dependent on the amount of delay charge contained in the delay element.

The figure shows that the construction of an electric blasting cap is simplicity in itself. An electric current heats a wire bridge setting off the heat-sensitive priming charge which, in turn, sets off the PETN base charge. This detonates the TNT block into which the cap has been inserted; if the block is the booster to a larger main charge, the train of explosions comes to an end with the detonation of the main charge.

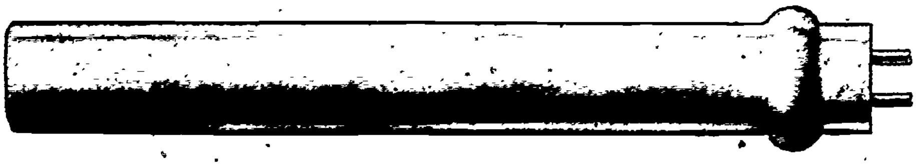
Another type of electric blasting cap is shown in figure 5-16. This is the Cap, Blasting, Electric, M6 and is used, as are the previously mentioned caps, to initiate high explosives. The cap consists of an aluminum alloy cup containing a base charge of RDX, intermediate charge of lead azide, and an ignition charge of lead styphnate and barium chromate. The lead wires are 12 feet long and extend through a rubber assembly into the ignition charge where they are connected to a wire bridge. The electrical characteristics of the M6 are so closely controlled that caps of this model, of different manufacturers, may be mixed in a firing circuit without causing misfires. A short-circuiting tab or shunt, as in other electric blasting caps, fastens the leads together to prevent accidental electric firing of the cap. Do NOT remove these until just before the cap is wired into the firing circuit.

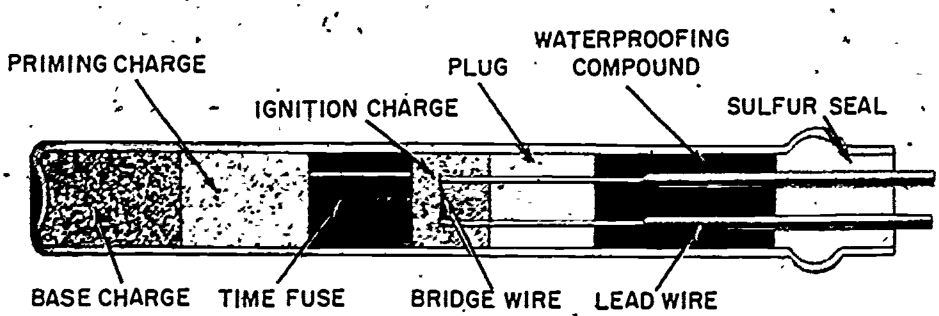
The electric blasting cap fits into the activator well of the demolition charge. But it doesn't fit tightly and can easily slip out. To hold the cap in the charge, use a primer adapter, a small plastic cylinder that screws into the threaded end of the TNT block and holds the cap in place. Figure 5-17A shows the adapter assembled in the block, with part of the adapter cut away to show how it holds the cap in place. Figure 5-17B illustrates the two steps in assembling the adapter and cap before they go into the charge. These steps are described in the next section of this chapter.

The other equipment used for electrical firing of demolition charges include a blasting machine for supplying current to the blasting cap (fig. 5-18), wire or cable of required length (the cable may be on a special reel like the one shown in figure 5-19) for connecting the machine to the charge, insulating tape for protecting the splices which connect the cable to the caps, and a blasting galvanometer for testing the circuit before you fire the charge.

BASIC PROCEDURES FOR SETTING UP AN ELECTRICAL CIRCUIT AND BLASTING

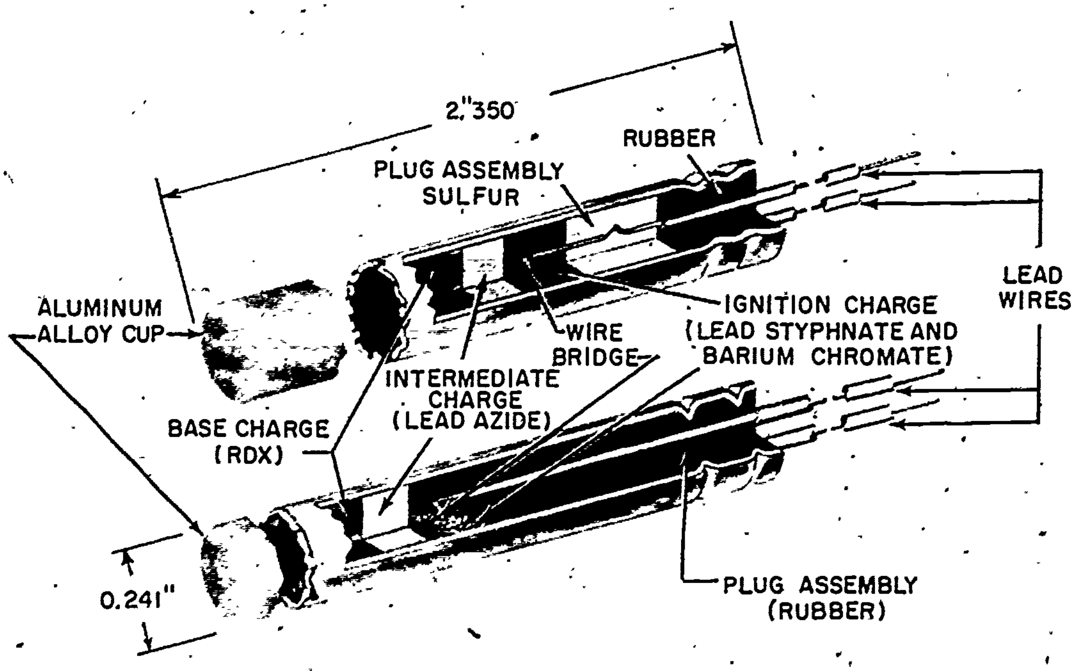
As a second class Gunner's Mate, you must be able to demonstrate your ability to work with





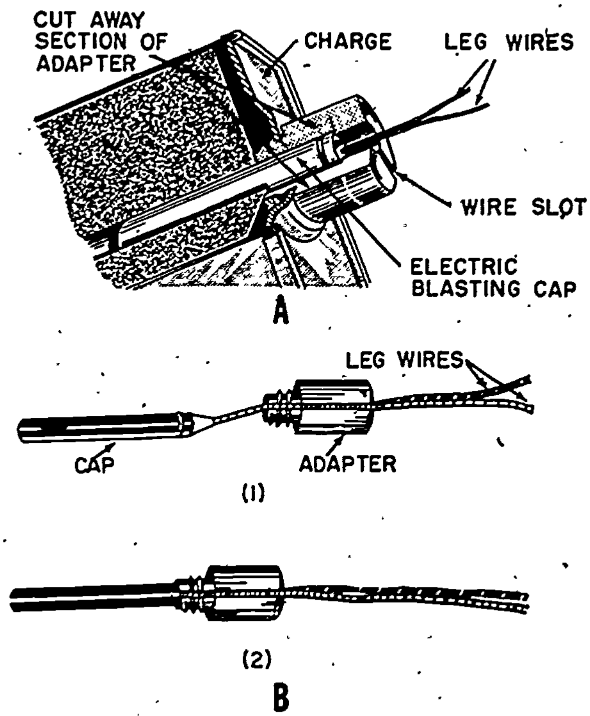
53.157(83B)B

Figure 5-15.—Cap, blasting, special, electric type, Nos. 1-10 delay.



53.157.2(53C)

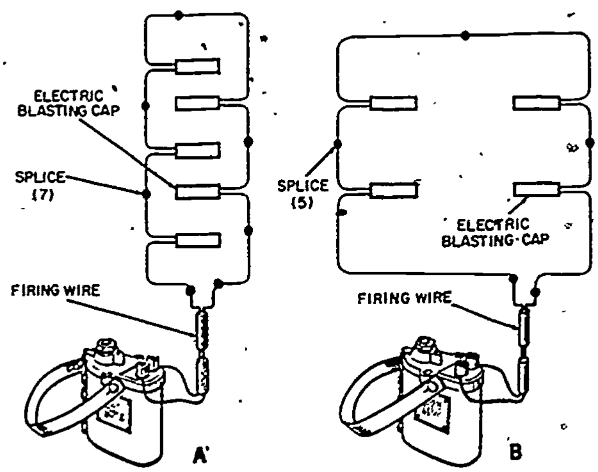
Figure 5-16.—Cap, blasting, electric M6.



53.158
Figure 5-17.—The priming adapter—A. Priming adapter and electric blasting cap assembled into charge. B. How to assemble the priming adapter and cap before assembly into charge.

the demolition equipment on your own ship. In general, this will most likely mean that you will have to show that you can work with the equipment we have discussed so far in this section. Of course, nothing you read here or elsewhere will make you a genuine expert with demolition. You need real training and experience with the gear for that. But, so that you can see how all the equipment we have described is used together, let's take up, step by step, the procedure for preparing and setting off a demolition set-up, using demolition charges Mk 2 Mods 2 or 3 and electric blasting caps.

1. Determine where the charges are to be placed. This, of course, depends on what is being demolished and the purpose of demolition. If you're sinking a floating hulk that's a menace to navigation, place the charges so that the hulk will go down promptly in water deep enough so that it will be out of the way. Make sure that all WT (water tight) doors are open. If you're



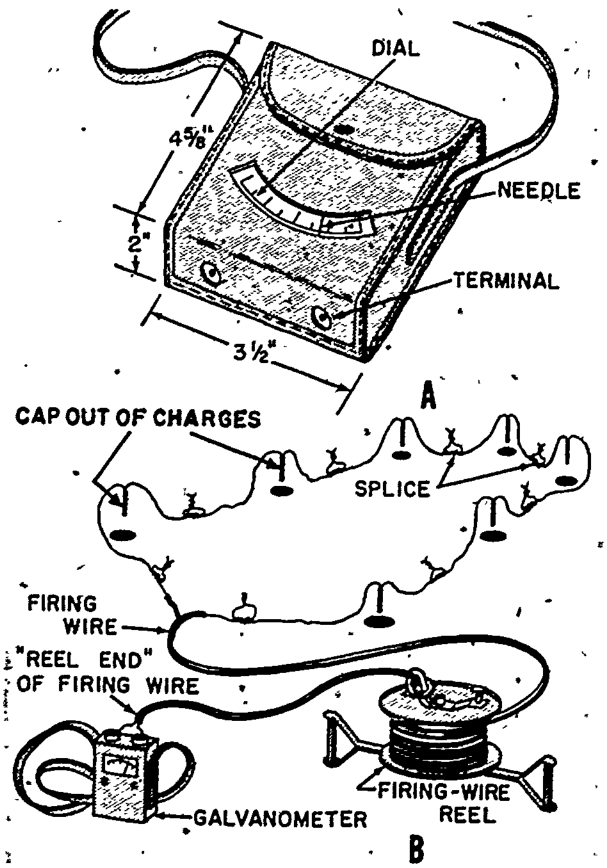
83.206
Figure 5-18.—A. Leapfrog series circuit. B. Common series circuit.

scuttling your own ship (this sad possibility is fortunately not frequent, but it might be necessary in the event of imminent capture by the enemy), you must, in addition, make it as difficult as possible for anybody ever to use the ship again. Or you may be wiring up small charges to be used in destroying secret or confidential equipment against the possibility of capture. You'll be guided by orders from competent authority, but you must know something about demolition techniques.

2. Usually you will set off several charges at once. To do this, you place the charges and make up a circuit which includes the blasting machine and all the charges in series. First you wire in all the caps, then connect them to the cable, and then test the circuit. Here are these steps in more detail:

a. Make sure your caps are all of the same manufacturer. Except for the M6 which was described earlier, caps of different make should NEVER be used together in one circuit. Be sure not to use more caps than your blasting machine is deisnged to handle; it's better to use fewer. When you take caps out of their box, don't try to pry them loose with a sharp instrument; use your fingers and slide them out carefully. Examine the caps before wiring them up; reject any that show signs of moisture or corrosion.

b. Grasp the wire above the cap and straighten the coil from the wire leads, being careful not to put tension between cap and wire leads. Place caps behind a suitable barrier or in



84.3

Figure 5-19.—A. Blasting galvanometer. B. Testing the firing circuit.

a heavy gauge bucket. Test each cap individually as far away from the bucket or barrier as the leads will allow with the galvanometer. After test of cap, shunt the cap by twisting the two wire legs together. Do this until you have tested the number of blasting caps you will use.

c. You make electrical tests for demolition set-ups with only one instrument—the blasting galvanometer. (See figure 5-19A.) You must NEVER use any other instrument. The blasting galvanometer is in a box, usually protected by a leather case, with a dial face on which you can see the galvanometer needle. It contains its own small battery as a source of current. At the base of the box are two terminals—flat metal discs. You test by touching the wires you are testing to the terminals. If current flows (and the currents indicated by the galvanometer are very tiny ones that will not set off a blasting cap), the needle deflects.

d. First you test both cable conductors BEFORE they are connected to anything. (Make sure their ends are not twisted together.) You should get NO steady indication on the galvanometer. (But it's O.K. for the needle to flick, then return to zero.) If you DO get a steady galvanometer needle deflection, there is a current leak or short circuit in the cable (caused by defective insulation or conductors touching each other). If the trouble cannot be rectified, use other cable that will test O.K.

e. Next, you wire the cable to the caps (but do NOT connect the blasting machine). Test the complete circuit by touching the cable terminals at the "reel end" (where the blasting machine will be connected) to the galvanometer. (See fig. 5-19B). This time you should get a definite steady needle deflection. If you don't, go over your circuit and repair it where it's broken. Test each splice and cap individually, if necessary. Or you may use the procedure described in the next section of this chapter for locating breaks in the circuit.

f. After testing the circuit, the next step is to set each blasting cap in its charge. Open the top of the charge shipping box. (The charge need not be removed from the shipping box to be used, however.) Break the paper seal protecting the activator well in the booster but don't use the blasting cap as a tool. Make sure there is no dirt in the well. Then slip the leg wires of the cap through the priming adapter's wire slot with the threaded end of the adapter pointing toward the cap (fig. 5-17).

If the leg wires don't slide readily through the slot, don't try to force them by pulling on the cap. Grasp the wires about 6 inches from the blasting cap and slide the adapter slot along the wires away from the cap. Tilt the adapter as you do this, to make the entry of the wires easier.

Now insert the cap gently all the way into the activator well; hold the adapter away from cap until it's all the way in. Then work the adapter down the wires until it reaches the well, and screw it in gently but firmly as far as it will go. Last, tie the wires so that the cable doesn't strain them at the cap. The Mk 2 Mods 2 and 3 charges have cable anchors under the bolts in the booster covers that can be used to secure the cable.

If you haven't tested the circuit, do it now. If time permits, it may be a good idea to do it again even if you tested it before assembling the caps into their charges.

3. The last step is to connect the blasting machine. Make sure everything else is in readiness, and that all personnel have cleared the danger area. Connect the cable to the blasting machine. Most blasting machines have removable handles, don't put the handle on until after the machine is connected, and just before you blast. To operate the machine, twist the handle smartly through its full range.

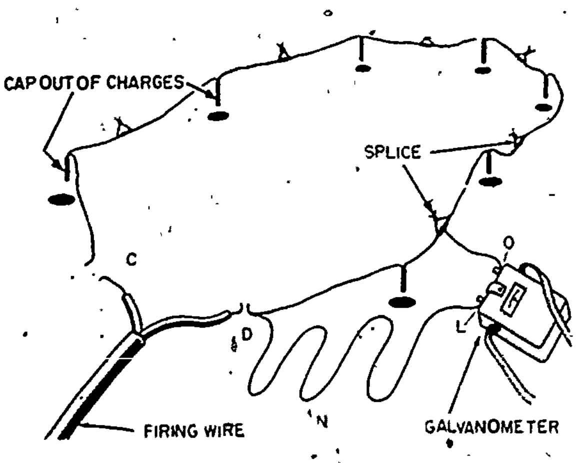
4. If the blast does not occur, remove the handle of the machine (and put it into your pocket to make sure nobody operates the machine inadvertently) and DISCONNECT the machine. Then, after 30 minutes and only then, is it safe to investigate the trouble further.

PROCEDURE FOR LOCATING BREAKS IN THE FIRING CIRCUIT

Here is a way (illustrated in fig. 5-20) in which a break in the firing circuit may be located if the circuit test from the reel end indicates an open circuit, or if you have a misfire.

1. First disconnect the blasting machine. Make sure the two wires at the reel end of the firing cable are separated and not touching any conductor.

2. Connect the two spliced wires at the far end of the firing cable (C and D in fig. 5-20) with the blasting galvanometer. (Don't break the splices; just touch them to the galvanometer's terminals.) If the instrument now shows a complete circuit, these connections (C and D) or the cable are faulty.



84.4

Figure 5-20. – Locating breaks in the firing circuit.

3. If the galvanometer still shows an open circuit, connect splice D to one terminal (L) of galvanometer, using a wire (N) long enough to reach all connections in the circuit. Move around the circuit with the galvanometer, touching the other terminal (O) to all splices in succession. At the first point where the instrument shows an open circuit, you know that there is a break between that point and the previous one.

If the break is accessible, splice the broken wire. If you can't handle it as a misfire; use additional priming, or set up another charge close by. After this repair, continue the test to locate additional breaks. When all are repaired, test the circuit again from the reel end.

SAFETY

Here is a brief summary of precautions to ensure both reliability and safety, which you should bear in mind when blasting with electric caps:

1. Use only Army Engineer Special blasting caps of the types described previously for military demolitions. Other caps are weaker and may cause misfires.

2. Use only one brand of cap in any one circuit.

3. Before using a blasting cap, inspect it for moisture. If you see any sign of dampness, use another cap. Never use a sharp instrument to pry a cap out of its box, and never take a cap out of its box unless you intend to use it.

4. All the firing in an electric blasting circuit must be the responsibility of one person only, and that man must know hiw job. He should keep the blasting machine, or its operating handle, on his person while the circuit is being wired to avoid accidental firing.

5. Before firing or testing, be sure the safety shunts are removed from all caps, but don't remove the shunts until you are actually wiring the caps into the circuit. If shunts are missing, keep the cap wires twisted together.

6. Never fail to use the blasting galvanometer to test your complete circuit before the blasting machine is connected. Don't depend on visual

inspection only. Use no other device to test the circuit. Dry-cell powered ohmmeters, for instance, may set off the blasting caps.

7. Never yank the leg wires of an electric cap, or subject them to any steady pull. This is important to remember when you're installing the priming-adapter. Secure the leg wires and firing cable with strong twine or other fastenings so that pulls on the cable will not be transmitted through the splice or to the cap.

8. Don't connect the cable to the blasting machine until you're ready to fire and the danger area is clear. Unless you are actually testing the circuit or you are actually making ready to blast, it's a good idea to keep the free ends of the cable twisted together.

9. Avoid setting up an electric blasting circuit when there is a thunderstorm brewing. In general, protect electric blasting caps, whether in circuit or not, from any stray electric currents.

10. When you use the blasting machine, twist the handle sharply to be sure you get enough output to fire. If the machine has a thong, wrap it about your wrist to prevent the machine from slipping when you twist. Immediately after the blast, disconnect the machine and twist the cable conductors together. If your circuit misfires, try once more. If it misfires again, disconnect the blasting machine, put the handle in your pocket, and twist the cable conductors together before you try to investigate the cause of misfire.

CHAPTER 6

BASIC MECHANISMS

The purpose of this chapter is to explain the fundamentals of basic machines so that you will have the background to better understand the ordnance equipment that you are now working with in the fleet. As new and more complex ordnance is introduced into the fleet, it is essential that today's Gunner's Mate have the knowledge of the technical fundamentals of the rate. The control mechanisms of the old as well as the new gun systems involve a combination of mechanical, hydraulic, electrical, and electronics devices with a high degree of complexity. A study of this chapter and the chapter that follows on electricity and electronics will supply you with most of the information you will need to help operate and maintain the ordnance equipment of the future as well as the present.

We will start this chapter by asking you three questions, and then provide the answers:

1. What is a machine?
2. What is a mechanism?
3. How will knowing the answers help you?

For the answers to the first two questions, let's turn to the dictionary. According to Webster, a machine is "Any device consisting of two or more resistant, relatively constrained parts, which may serve to transmit and modify force and motion so as to do some desired kind of work, popularly, a complex combination of such parts together with their framework, fastenings, etc." For the present, let us condense this mouthful by saying "A machine is a device which will do a job for you, or at least make the job easier."

As for the mechanism, the dictionary says that mechanisms are: "The parts of a machine...."

Now let's see how this information will help you.

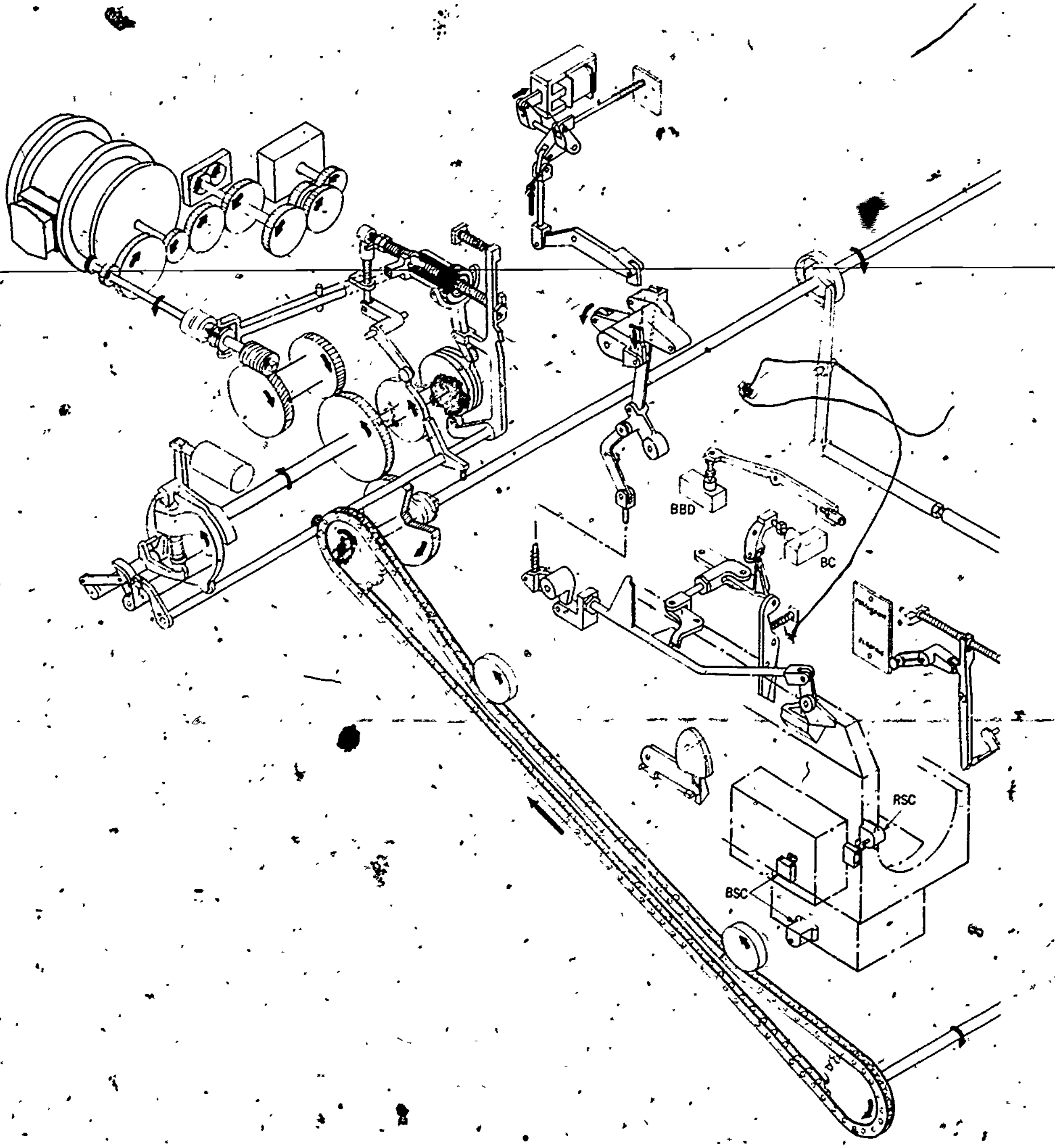
If you accept the definition of a machine, then a gun power drive, a hoist, and an automatic loader are machines. And, as a Gunner's Mate, a large part of your work will be concerned with just such devices. Experience has probably already shown you that gun power drives, rammers, etc., are sometimes complex in design and operation. At first glance, the publications issued to guide you in the maintenance and repair of such machines may appear baffling. This is true not only of electrical and electronic components, but mechanical ones as well. Look at figure 6-1 for an example. This is a mechanical schematic of a 3-inch loader. It shows all the parts (and their actions) which cause rounds of ammunition to be automatically drawn through the hopper and delivered into the gun chamber at a rate of 50 rounds a minute. In this text we are not going to explain the operation of the 3-inch loader. The illustration was chosen because it demonstrates the need for the information in this chapter.

Now for the definition of a mechanism. It was pointed out that a machine, no matter how complicated, is made up of smaller, simpler parts—mechanisms. See Fig. 6-1. Since your job requires you to maintain and repair machines, you must know how these machines work, and understand the theory behind their operation. It would be hard to understand the operation of a complex machine without first understanding the purposes and functions of its parts.

TYPES OF BASIC MECHANISMS

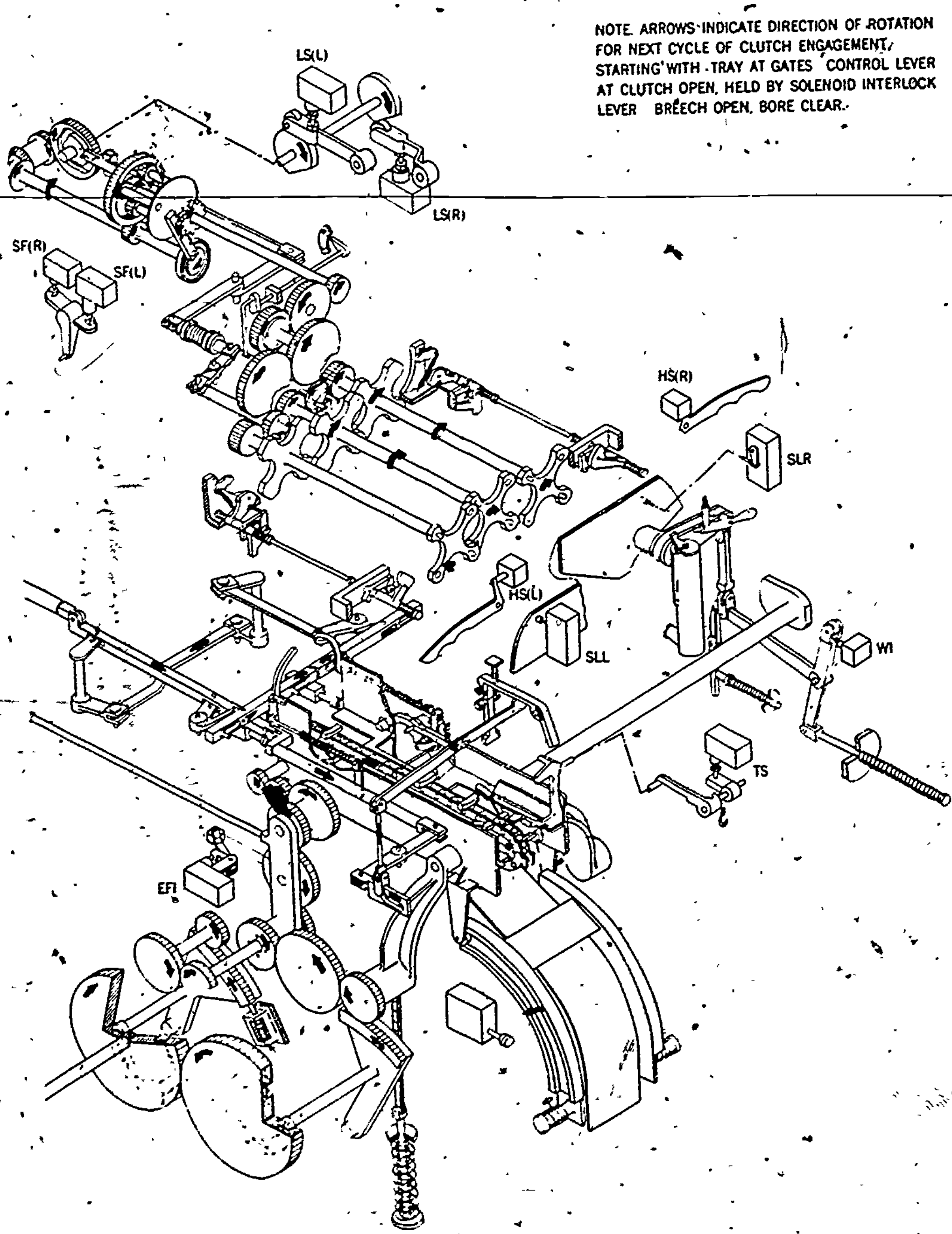
A modern gun of intermediate or larger caliber contains thousands of parts. Of these, a good percentage can be correctly labeled mechanisms. Fortunately for you, the Gunner's Mate, they can be grouped into a relatively small number of basic types. In this chapter we will study the following nine types of basic mechanisms, and show how they are used in ordnance:

Wheels and bearings
Gears
Cams
Levers and linkages



84.117

Figure 6-1.—A machine. 3"/50 RF loader schematic.



84.117

Figure 6-1. — A machine. 3"/50 RF loader schematic—Continued.

Chains and sprockets
Clutches
Springs
Buffers
Couplings

WHEELS AND BEARINGS

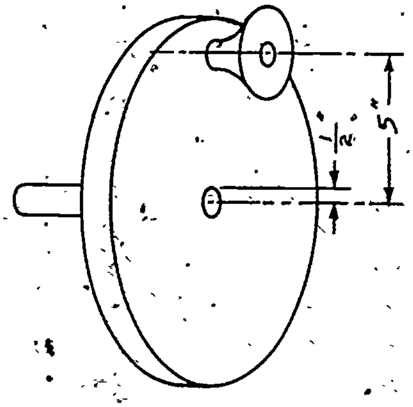
Wheels

The wheels we are talking about here are the type that are rigidly connected to axles. When either the wheel or axle turns, it turns the other.

When the wheel and axle turn as one, we have a simple machine. One common purpose of such a machine is to multiply the force exerted on it. A door knob, and the handle of an ice cream freezer, are only two examples of the varied uses of this device. One of the most common ordnance uses of the wheel and axle is shown in figure 6-2. Here you see a handwheel which could have come from nearly any gun that depends upon a pointer or trainer to move the mount around manually.

How does a set of handwheels help you move a gun? The question would answer itself if you ever removed the handwheels and tried to move the gun by rotating the small shaft (axle) with your fingers. There is a formula for determining the mechanical advantage that can be obtained from a wheel and axle arrangement. It is not necessary that you remember this formula; it is included only to emphasize our point.

Let us suppose that you apply 10 pounds of force on the handwheel. Assume that the handle is 5 inches from the center of the axle, and that the radius of the axle is one-half inch. We can figure the output from the formula.



84.118

Figure 6-2.—A wheel and axle used to multiply effort.

$$\frac{L}{\ell} = \frac{R}{E}$$

where

L = radius of the circle in which the handle turns
ℓ = radius of the axle
R = output
E = force applied to handle

$$\frac{5}{1/2} = \frac{R}{10}$$

$$R = \frac{5 \times 10}{1/2}$$

$$R = 5 \times 10 \times 2$$

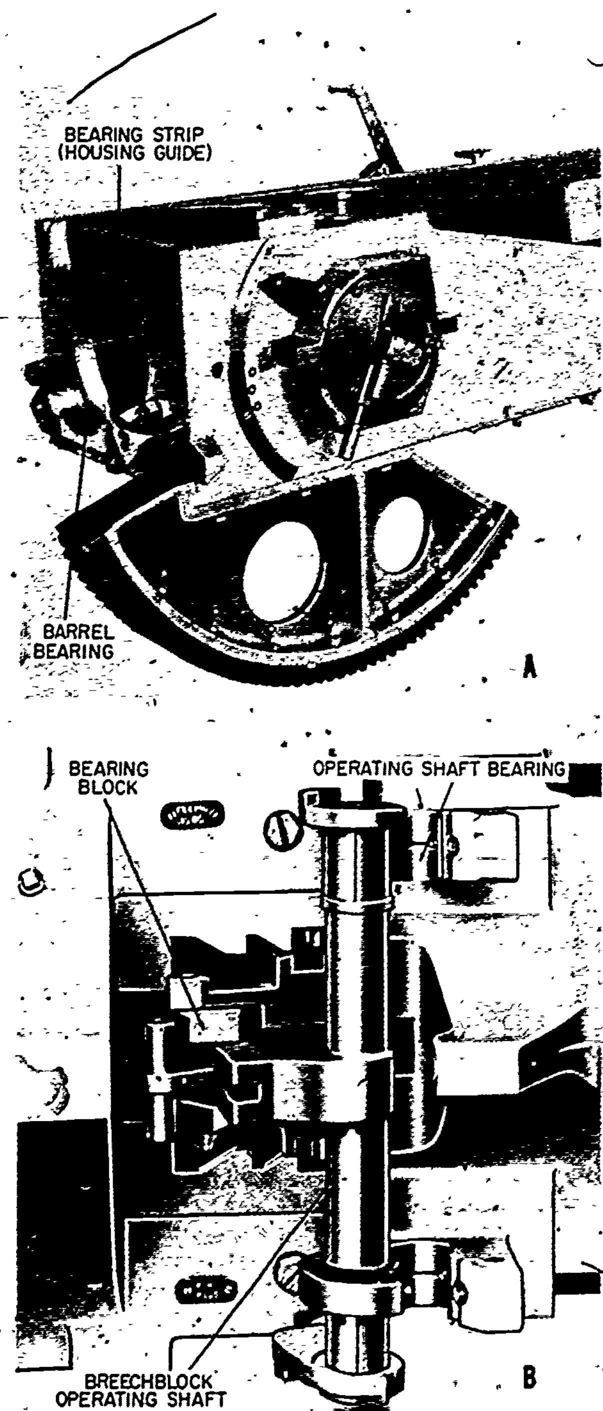
$$R = 100 \text{ pounds}$$

This means that a 10-pound force at the handwheel will apply a 100-pound force at the shaft.

Bearings

We must start our discussion of bearings with a brief word on friction. FRICTION is the resistance to relative motion between two bodies in contact. Sometimes this resistance is useful. For example, it is hard to walk on ice because there is very little friction between your shoes and the ice. In ordnance, however, friction is mostly unwanted. It takes effort to rotate trains of gears, move levers and shafts, etc. Friction in these mechanisms adds to the effort required. Lubrication is one answer. It coats the surfaces of moving parts in contact with one another—separates them by a fluid film. In some cases, though, this is not enough. Sometimes the speed of the moving parts, or the load on them, is so great that the oil film will be thrown out or ruptured. Here bearings (and lubrication) are the answer.

PLAIN (SLIDING) BEARINGS.—Most often the parts which rub together are made of steel. Sometimes the friction can be reduced sufficiently by simply inserting a strip of softer metal, such as bronze, between the two steel parts. This is the theory behind the plain, or sliding, type bearing. In figure 6-3 you can see three applications.



84.119
Figure 6-3. — Example of plain (sliding) bearings.

In figure 6-3A you see a gun slide weldment in which the gun and housing move in recoil and counterrecoil. The bearing strips (one is hidden) inside the slide are made of bronze, and support the heavy housing as it moves forward and aft during firing. The barrel bearing, also bronze, supports the barrel in these movements. In figure 6-3B you are looking up at a sliding wedge type breech mechanism. The breech operating shaft, in its rotating movement, raises and lowers the breechblock. You can see that the steel operating shaft is kept from coming into direct contact with the steel slide and bearing caps (not shown) by cylindrical bronze bearings. For ease in assembly and disassembly, the bearings are in two parts. Notice the oil grooves cut into the inside of the bearing. These grooves distribute the lubricant around the shaft from a zerk type fitting on the bearing caps.

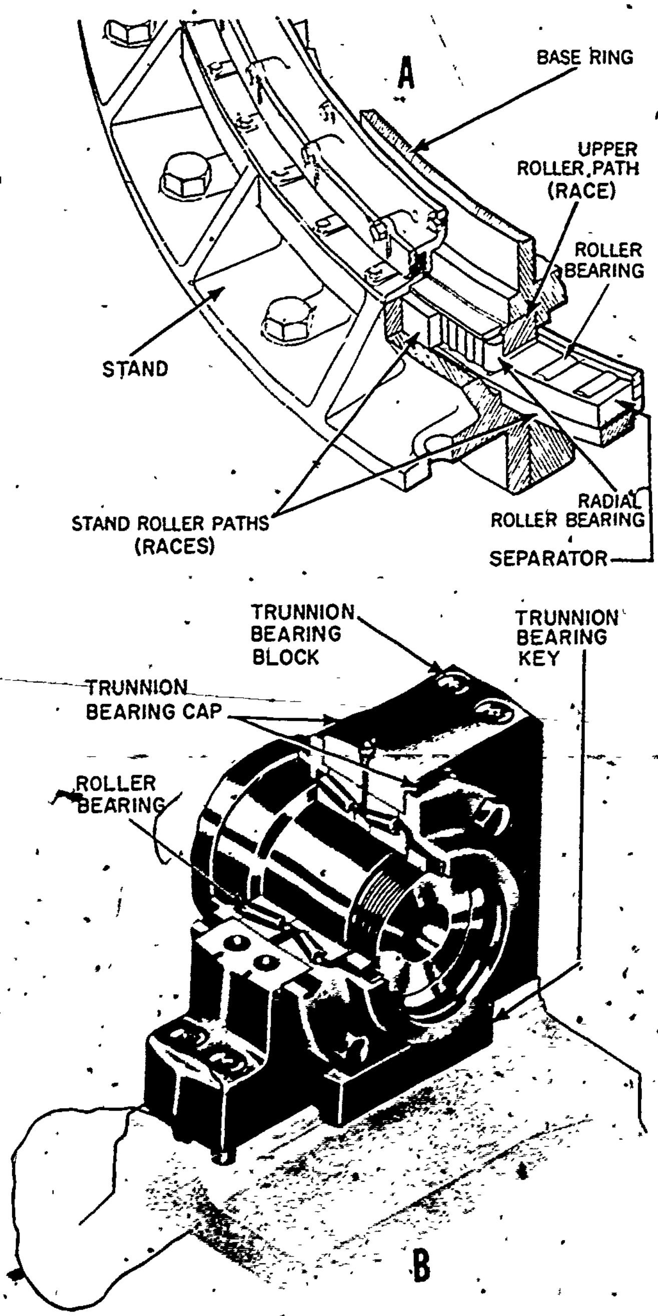
The bronze bearing blocks, up inside the breechblock, transmit the rotating movement of the operating shaft to a vertical movement to raise and lower the breech. These are oblong bearings, riding in slanted blockways in the block. They are lubricated by means of oil holes drilled throughout their length.

BEARINGS WITH ROLLER CONTACT. — The plain bearings we have just described will reduce friction. A much more efficient type, however, is that which inserts a rolling contact between the stationary and moving elements of the mechanism. The rolling elements are balls or rollers. The bearing assembly usually is made up of three parts — the rolling elements, a separator, and two races.

An ordnance application of roller bearings can be seen in figure 6-4A. Here they are used to reduce friction between the rotating gun mount (base ring) and the stationary stand. The horizontal rollers support the weight of the mount. The upper race (roller path) is part of the base ring. The lower race is part of the stand. The separator keeps the roller bearings from getting canted and running into one another. The upright (radial) bearings reduce friction between the base ring and stand when a sideways force is exerted on the mount.

In figure 6-4B you see tapered roller bearings used in trunnions. In this application they allow the trunnions to rotate freely, but restrict sideways and up-and-down movement as the gun bucks during firing.

BALL BEARINGS. — The roller bearing assemblies just described can be disassembled for replacement of parts, for cleaning, and for



84.120

Figure 6-4. Bearings with rolling contact.

examination, etc. Ball bearings, on the other hand, usually are assembled by the manufacturer and installled as a unit. Like roller bearings, the ball bearings reduce friction and, in some applications, prevent unwanted movement.

Sometimes maintenance publications refer to roller and ball bearings as being either thrust or radial bearings. The difference between the two depends upon the angle of intersection between the direction of the load and the plane of rotation of the bearing. Figure 6-5A shows a radial ball bearing assembly. The load here is pressing outward along the radius of the shaft. Now suppose a strong thrust is exerted on the right end of the shaft, tending to move it to the left. You can see that the radial bearing is not designed to support this axial thrust. Even putting a shoulder between the load and the inner race wouldn't do. It would just pop the bearings out of their races. The answer is to arrange the races differently, as in figure 6-5B. Here is a thrust bearing. With a shoulder under the lower race, and another between the load and the upper race, it will handle any axial load up to its design limit.

The horizontal bearings shown in figure 6-4A are another example of a roller thrust bearing assembly. The vertical roller bearings in the illustration are called radial bearings. Sometimes bearings are designed to support both thrust and radial loads, thus the term RADIAL THRUST bearings. For an example of such bearings see the tapered roller bearings in figure 6-4B.

GEARS

A gear is a toothed wheel that transmits motion. When it is engaged with another gear or tooth device, it can:

1. Change the direction of motion,
2. Change the type of motion (e.g., linear to circular),
3. Increase or decrease speed,
4. Increase or decrease force.

A detailed study of gear types and functions can be found in Basic Machines, NAVPERS 10624A. Our coverage of gears here is limited to those types which have ordnance applications. We will show four types of gears and how they actually work in a piece of ordnance equipment.

Spur Gears

A spur gear has teeth that are parallel to the axis of rotation of the gear, and to its axle or

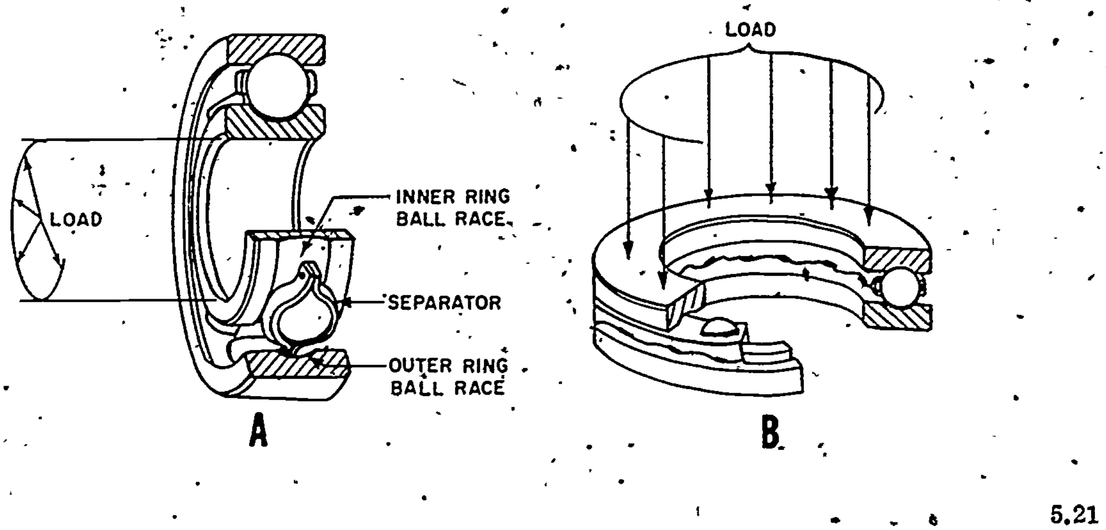


Figure 6-5.—Ball bearings—A. Radial type. B. Thrust type.

shaft. An external spur gear has teeth on an outer circumference. Because of their versatility (they can transmit motion, change direction of motion, etc.), spur gears are used in ordnance equipment more than any other type of gear.

Figure 6-6 shows a train of spur gears. It is a part of the hopper drive gearing used on the 3"/50 RF loaders. Its purpose is to turn the sprockets in such a direction, and at such a time, as to cause the loader to feed ammunition alternately, first from one side and then the other.

In figure 6-6, gear 1 is the only gear driven by an external force—an electric motor. It is driven in one direction only. Gears 3 and 6 are sliding gears which, while they never become completely disconnected from the extreme outboard gears (4 and 7), alternately mesh and unmesh with the center sprocket gear 5. In the illustration, gear 3 is meshed with gear 5, but gear 6 is not.

Here's what happens during a cycle, gear 1 rotates in a clockwise direction (see arrow) and drives gear 3 in the opposite (counterclockwise) direction. Gear 3 drives gears 4 and 5 which transmit their clockwise motion to their sprockets, pulling a round of ammunition from the right. After the sprockets move 90°, they are stopped by other devices in the loader control unit.

You have just seen how motion is transmitted by gearing, and how the direction of movement was changed (reversed) not once but twice. How about the ability of spur gears to increase or decrease the speed of a motion? This is done by gears 1 and 3. It is also done by gears 2 and 6 during a feeding cycle from the left. So let's make another cycle and see, in this case, how speed of motion is increased. Before we cycle from the left, let us slide gear 3 out of mesh with its driving gear and the center sprocket gear and, at the same time, move gear 6 into mesh with its driving gear 2 and the center sprocket gear 5.

When the new cycle starts, gear 1 rotates in the same direction as before, clockwise. Gear 2 is meshed with gear 1 and always moves in a counterclockwise direction. During this cycle, gear 2 imparts its motion to gear 6 and all subsequent gear movements are in the opposite direction from those occurring during the right-hand cycle. Thus gears 5 and 7 will turn in a counterclockwise direction 90° and then stop.

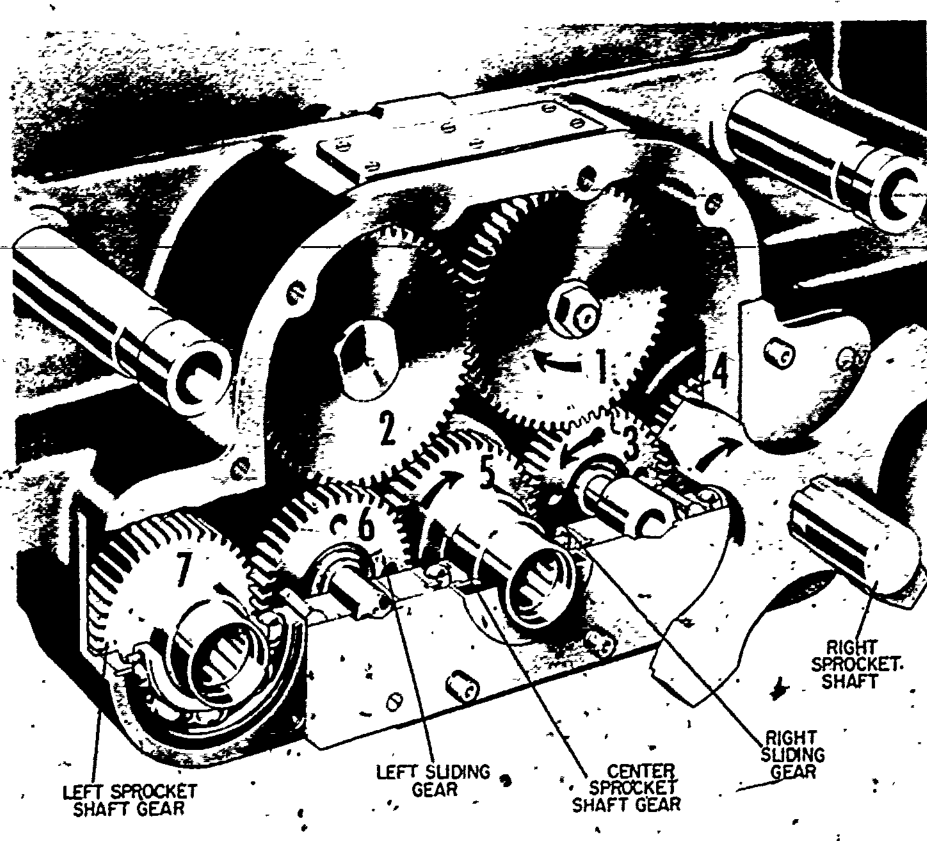
Sprocket movement is always 90°, one quarter turn. If you count the teeth in one quarter section of the sliding gear, you will find that there are 10. Since there is no slippage in gears, driving gear 2 had to move 10 teeth past its point of mesh with the sliding gear. From the illustration you can see that 10 teeth on the driving gear are equal to about a 60° segment. Since both gears moved through their segments during the same time period, the smaller gear rotated one-third faster than the larger gear driving it.

We have just demonstrated how a speed increase is obtained by driving a small gear with a larger gear. A speed decrease is obtained by doing just the opposite, using a small gear to drive a larger gear. Before leaving the subject of speed reduction and increase, we must tell you that any increase in speed is accomplished at the expense of force. You already understand this principle if you have ever driven an old automobile with a standard transmission. You know that to get such a car up an extremely steep hill you probably had to shift to low. This gearing arrangement reduced your speed but gave you greater force. Once at the top of the hill, you shifted to high which is a speed increasing arrangement of the transmission gearing. You could afford to sacrifice force, at that time, for speed.

Worm Gear

Worm gearing is used to obtain large speed reductions between nonintersecting shafts making an angle of 90° with each other. With a worm-and-wheel gearing arrangement, the velocity ratio is the ratio between the number of teeth on the gear (such as a spur gear) and the number of threads on the worm. Without going into formulas, we can say that a 30-tooth gear (wheel) that is meshed with a worm gear with only one thread will have a velocity of 1 to 30, i.e., the worm must make 30 revolutions in order to make the spur gear revolve once. A DOUBLE-THREADED worm will cause the spur gear to make one revolution after only 15 turns, etc.

Figure 6-7 illustrates a double-threaded worm and spur drive gear. You may recognize these gears as being part of the loader drive control mechanism of a 3"/50 RF gun. The worm can be driven by an electric drive motor or by a hand-crank. The spur gear has 24 teeth and the worm is double-threaded. (If you have trouble trying to find two threads on the worm, just think of the worm as having two positions by which a nut could be started onto its end.) With this gearing ratio the worm must turn



5.22.1

Figure 6-6.—Spur gears.

through 12 revolutions to rotate the spur gear one turn.

Worm gears are an excellent choice to drive indicating devices such as those in fuze setters and power drive indicator regulators. These dials must accurately transmit gear movements of fractions of degrees.

One more fact before moving on to the next type of gear. Movement of the spur gear cannot be backed up through the worm. This is called a non-reversing worm drive. This is why there is always a worm in gun elevation gearing. You can elevate a heavy gun manually to a certain degree and it will stay there. Without the worm, gravity would cause the heavy position of the gun (breech or muzzle) to settle. Its movements would back out through the gearing and handwheels.

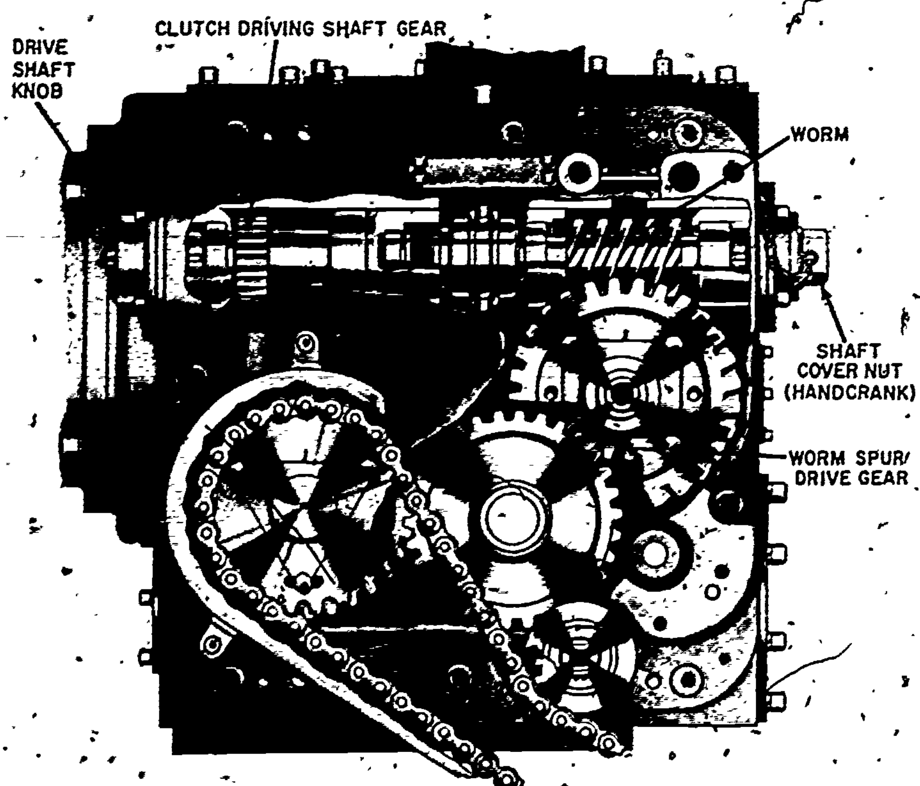
Bevel Gears

Bevel gears are used to connect two intersecting shafts. Figure 6-8 shows a set of bevel gears connecting a manual drive shaft to a train worm gear. Here the shafts are at right angles to one another, and the teeth are cut at a 45° angle. Bevel gears such as these are called MITER GEARS.

Any desired ratio of speed or force can be developed by bevel gears, just as with spur gears. By driving a large gear with a smaller one, you decrease speed but gain in force, and vice versa.

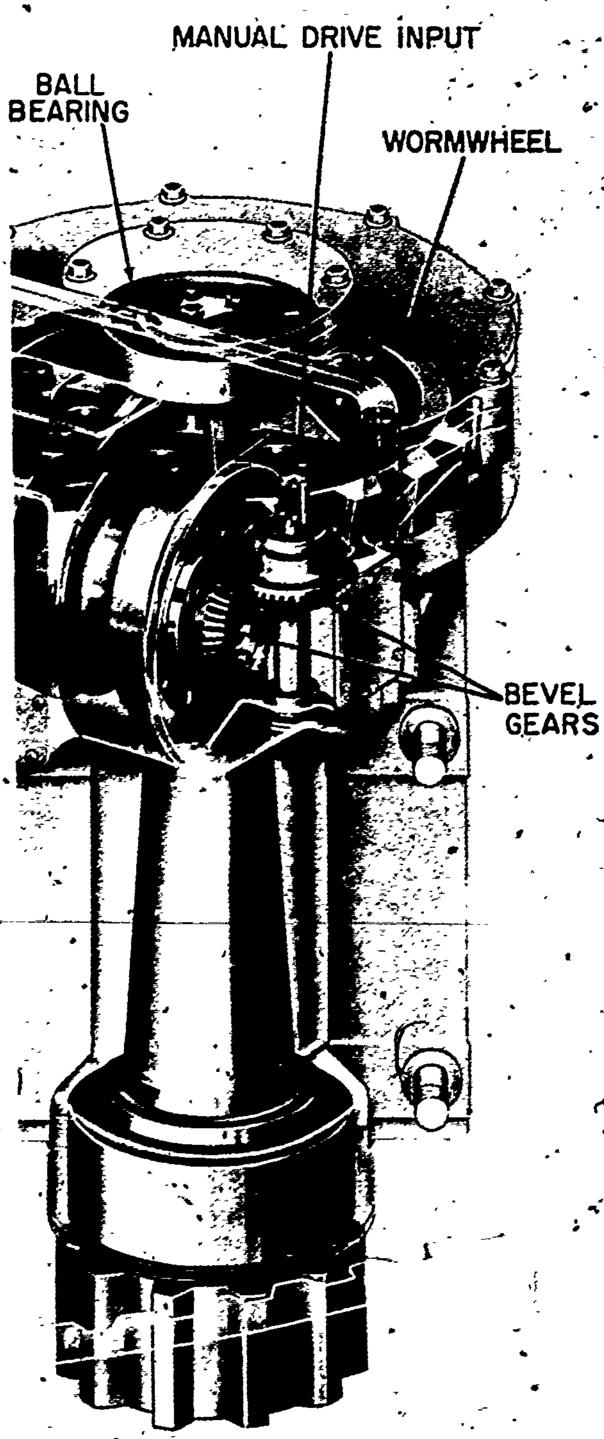
Rack and Pinion Gear

The gears we have looked at so far transmit rotation. Sometimes it is necessary to change circular motion to straight line motion. One way to do this is by the use of a cam, as you will see later. Another method uses a gear arrangement called a rack and pinion. (A pinion is a gear with a small number of teeth designed to mesh with a larger gear or rack). In figure 6-9A you can see that the pinion resembles a spur

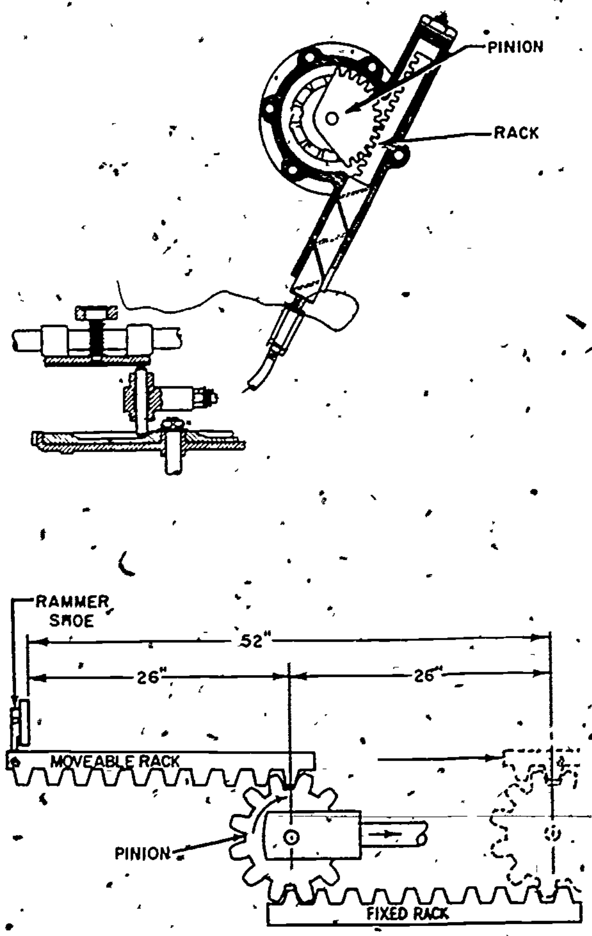


5.22.9

Figure 6-7.—Worm gear.



5.22.4
Figure 6-8. — Bevel gears.



5.22.13
Figure 6-9. — Rack and pinion — Converting rotary motion to linear motion.

gear. The rack has teeth similar to those of a spur gear but they are arranged in a straight line. In the example the rack and pinion are located in a trunnion, and are used to transmit gun elevation to the firing cutout mechanism. When the gun is elevated or depressed, the pinion is rotated. This causes the rack to walk up (or down), positioning a plunger over the face of the firing cutout cam. A rack and pinion can also be used to change straight line motion to circular motion. To do this, you simply connect to the pinion whatever you want rotated, and then pull or push the rack.

An unusual rack and pinion setup is used in some power rammers. A diagram of such an arrangement is shown in figure 6-9B. Here are two racks and one pinion. One rack is fixed to the stationary gun slide; the other carries the rammer shoe. The pinion is pulled back and forth by a piston in the hydraulic section of the rammer drive. With such a gearing design, linear motion of the hydraulic piston is changed to rotary motion of the pinion, then back to linear motion by the moving rack. Not only does it do all this, it doubles the linear input. Here's how:

You can see that the pinion is 26 inches from the face of the gun chamber. The rammer shoe is 52 inches from the chamber. When a cycle is started, the pinion is pulled to the right. As it walks along the fixed rack, the moving rack is pulled along also. At the end of 26 inches of pinion movement, the cycle ends. The rammer shoe has traveled 52 inches and has pushed the round of ammunition into the chamber. On the retract stroke the same actions occur in reverse. When the pinion is pushed back 10 teeth (26 inches), the upper rack will walk back 10 teeth also, but the combined movements position the rammer shoe 52 inches from the face of the chamber once again.

This multiplying gear arrangement makes it possible to get all of the rammer inside the gun shields of 5" gun mounts.

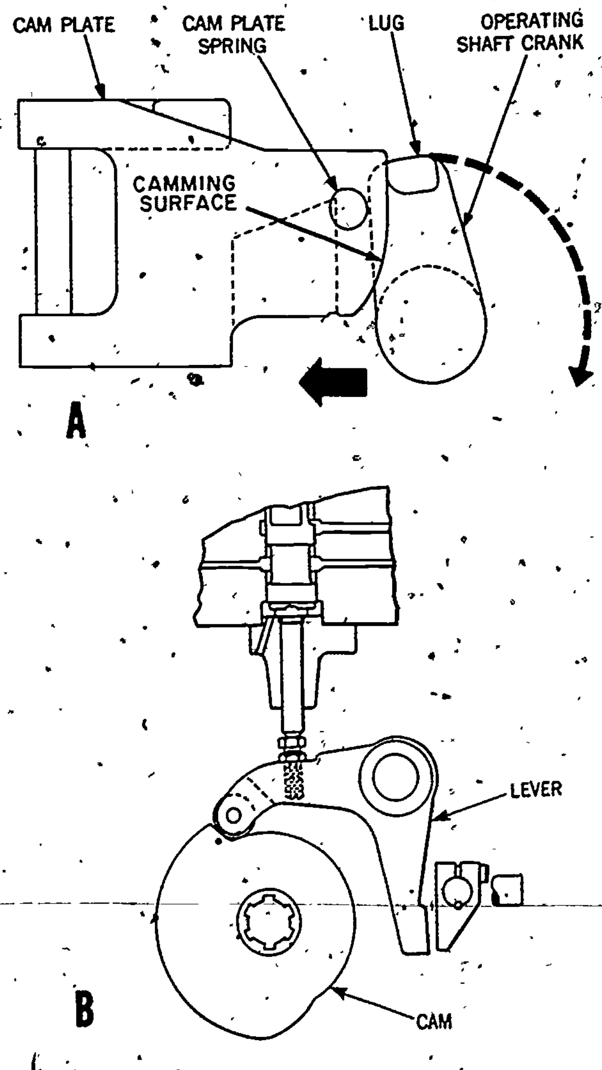
CAMS

A cam is an irregularly shaped device which is used to transmit motion through a follower. Some cams are stationary. When the follower is moved over the cam's specially shaped surface, it is moved up or down. In other applications the cam is built like a wheel with a lopsided edge. In this case, the follower is usually a shaft with a roller in contact with the cam. When the cam is rotated, the shaft moves back and forth following the cam's irregular contours.

Edge Cams

An edge cam is one which has the irregular surface machined around its outer edge. Figure 6-10A shows how an edge cam is used to lower the breechblock of a sliding wedge type breech mechanism.

The cam plate is secured to a nonrecoiling part of the mount. The operating shaft crank moves back and forth when the gun fires. In the illustration, the gun is returning to battery and a lug on the operating shaft crank has just come into contact with the cam. As the gun moves farther into battery, the lug is forced to ride down the slope of the cam. This causes the operating shaft to rotate clockwise, pulling the breechblock down.



84.125
Figure 6-10. — Edge cams — A. An edge cam rotating an operating shaft. B. An edge cam positioning a hydraulic valve.

Another application of the edge cam can be seen in figure 6-10B. Here rotary motion is changed

189

to straight line motion. As the cam is turned, the lever is forced to follow the specially designed contour around its edge. Through a plunger, the hydraulic valve is moved up or down during the cam's rotation. This causes hydraulic pressure in the valve block to be closed off or opened according to plan.

Face Cams

A face cam is one which has the irregular surfaces machined into its face (flat side). The follower is forced to move back and forth (or up and down) to maintain contact with the irregular surfaces.

Figure 6-11A shows a face cam used to interrupt gunfire when the gun is pointed at some part of the ship's structure. The cam has high and low areas cut into it. It is rotated by gearing when the mount is trained. The cam pin (follower) is positioned by a rack and pinion according to the gun's elevation. When it is unsafe to fire, the high part of the cam pushes the cam pin outward. Through linkage, this movement disconnects the foot treadle from the firing mechanism. In the case of electrical fire, the same linkage movement causes a switch to open, breaking the firing circuit to the firing mechanism.

In figure 6-11B you see another kind of face cam. Here the cam surface is an eccentric groove cut in the face of a cam gear. A roller, connected to one end of a follower shaft, rides in the groove. As the cam turns, the follower moves back and forth, imparting linear motion to whatever device it is attached to.

Barrel (Drum) Cams

Barrel cams are cylindrical in shape. Usually the camming surfaces are grooves spiralling around the inside or outside of the barrel. Figure 6-12 shows a barrel cam used in the 8" turret synchronizing control device. As the barrel is turned, the follower will move back and forth along the length of the barrel.

Another example of the barrel type cam is the differential cam used in 5"/38 indicator regulators.

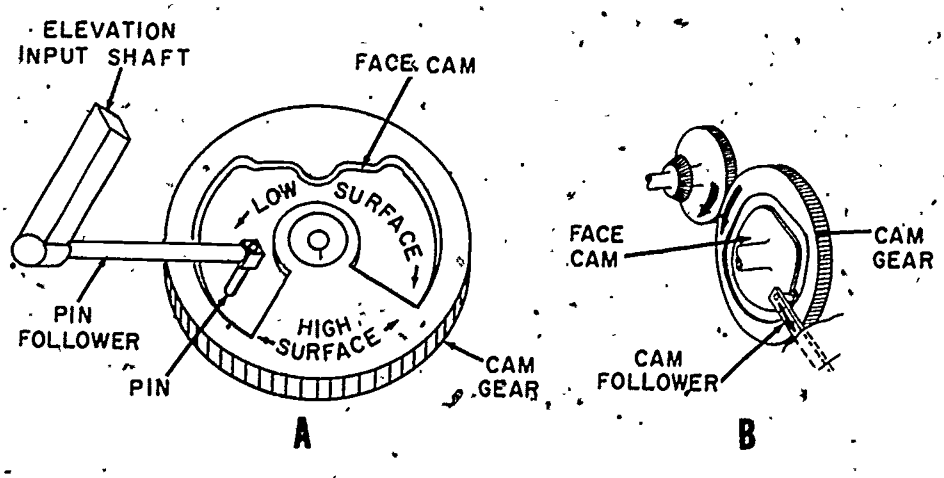
LEVERS AND LINKAGES

Levers are the simplest and perhaps the most familiar of all machines. There are three classes of levers—first, second, and third. They differ primarily in the relative points where effort is applied, where the resistance is overcome, and where the fulcrum is located. Of the three classes of levers, the first class is used most often in ordnance equipment. So our discussion here will be concerned only with that class.

In first class levers the effort and resistance are on opposite sides of the fulcrum, and the effort and resistance move in opposite directions.

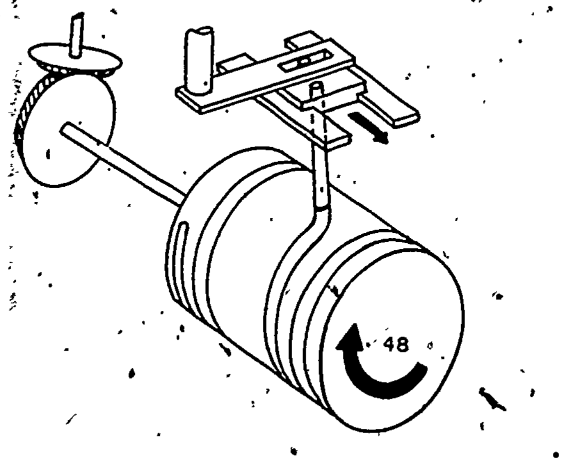
What is the purpose of levers? It depends upon their application. One thing they all do is transmit motion. Of more importance is their ability to magnify the effort exerted. Look at figure 6-13 while we show how a first class lever works.

Here you see part of the breech interlock mechanism of a 3"/50 RF gun. It is made up of



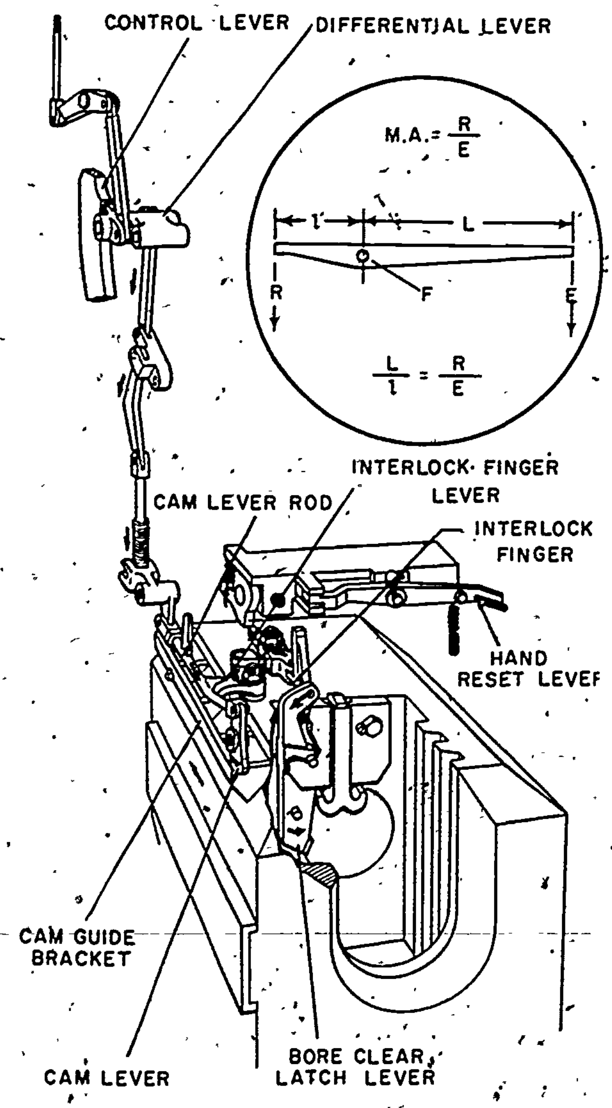
84.126.2

Figure 6-11.—Face cams.



84.127

Figure 6-12. — Barrel cam.



84.128

Figure 6-13. — A first class lever.

levers, cams, and linkages which prevent loading cycles from starting until certain conditions exist. A round must have been fired, the bore must be clear, and the gun completely back in battery. The actions and components of this mechanism are unimportant to this discussion. They are shown only to represent a resistance which must be overcome by some force before they will act. During actual firing this force comes from recoil, counterrecoil, and empty case extraction. For the first cycle to start, however, the linkage must be cleared by hand. This is the job of the hand reset lever. This is a first class lever, and it will multiply the force you exert on it to actuate the linkage and clear the mechanism. Here's how:

In the insert you see a lever. Like the hand reset lever, it has 3 basic parts — a force or effort (E), which you will apply at a distance (L) from the FULCRUM (F); and a resistance (R), which acts at a distance (l) from the fulcrum. If the resistance (R) at the end of the fulcrum is 60 pounds, how much force will you have to apply to overcome it?

Use the formula shown under the lever in figure 6-13; assume that L = 6 inches and l = 2 inches. Substitute these numbers into the formula.

$$\frac{6}{2} = \frac{60}{E}$$

$$E = \frac{60 \times 2}{6} = 20$$

You need apply a force of only 20 pounds to lift 60.

The formula above the lever (fig. 6-13) is used to compute mechanical advantage (MA). Mechanical advantage is the ratio of the resistance to the applied effort —

$$MA = \frac{R}{E}$$

Substituting the effort and resistance from the previous problem, you will find that

$$\frac{R}{E} = \frac{60}{20} = 3$$

Another method of finding mechanical advantage is by dividing the length of the effort arm L by the length of the resistance arm ℓ. In this case,

$$\frac{6}{2} = 3$$

Linkage mechanisms contain levers, cranks, and connecting links such as push rods, bars, and slides. Linkages are used in equipment which has to be opened or closed; for instance, valves in electric-hydraulic systems, gates, clutches, etc. Figure 6-14 shows the linkage mechanism used to open and unlatch the gates of a 3"/50 RF loader.

The front gates must be opened before the round of ammunition is started downward into line with the gun chamber. The rear gate must be unlatched also because the first movement of the loading tray is rearward, then downward. Movement of the linkage is started at the cam in the upper left-hand part of the illustration. As the cam turns, a first class lever is moved and sets the rest of the linkage in motion (follow the arrows). The first output of the cam-operated lever is in-line motion, straight backwards. Cranks transfer this motion to the front gates, moving them outboard. Follow on to the rear of the loader and you can see that a cam is moved forward. This pulls down the left end of a lever. As the right end of the lever is moved upward, it unlatches the rear gate.

The job of opening and unlatching the gates could be done with gears and shafts, but it should be obvious to you that the linkage will do it much more efficiently.

CHAINS AND SPROCKETS

You already understand the principle of the chain and sprocket mechanism if you know how a bicycle is powered. A chain is wrapped around two sprockets (some distance apart), and brought back and connected to itself by a connecting link. Since the chain engages matching teeth on the sprockets, when one sprocket is turned, the other must turn. Thus rotary motion is transmitted with no slippage.

Speed reduction or speed increase (with a corresponding increase of decrease in force) can be obtained with sprockets and chains in the same manner as with gearing. That is, when a small sprocket is used to drive a larger one, the result is a decrease in speed but an increase in force, and vice versa. The sprocket and chain mechanism is used in most ordnance applications to transmit motion. Motion thus transmitted can cover relatively large distances where the use of gearing would be prohibitive due to inefficiency and weight.

Many types of hoists, for example, use the chain and sprocket drive to move ammunition between different deck levels. In fact, it is not unusual to find dredger hoist chain drives which span three or four decks.

A smaller version of the chain and sprocket drive can be seen in figure 6-15. The chain here is used to catapult a 3"/50 round of ammunition from the tray into the gun chamber. The forward sprocket is driven by a gear train (not shown). The after sprocket is driven by the chain. As the chain moves forward, it carries the driving lug and shell carriage with it. This causes the round to move forward. The carriage is unlatched from the chain after a certain distance, and the driving lug provides the final catapulting action. After the round clears the tray, the tray starts its upward movement. Gearing, now, rotates the forward sprocket carriage aft to pick up the next round.

CLUTCHES

A clutch is a form of coupling used to connect shafts in equipment drives. There are two classes of clutches—the positive clutch and the friction clutch.

Positive Clutch

When a positive connection of one shaft with another is needed, a positive clutch is used. This clutch is the simplest of all shaft connectors. Because it does not slip, this clutch generates no heat. The use of the positive type clutch is limited by the speed of the shafts to be connected. If both shafts can be stopped, or made to move relatively slow, the positive clutch can cause the shafts to be engaged.

Figure 6-16 shows a clutch which is used to select one of two power sources to drive a mechanism. There are three sets of jaws. The jaw on the left has a fixed connection (by a coupling) to the primary source of power. The jaw on the right is part of the sprocket driven by an auxiliary power source. Between these two is a sliding jaw which slides left and right on a spline on the drive shaft. This center jaw

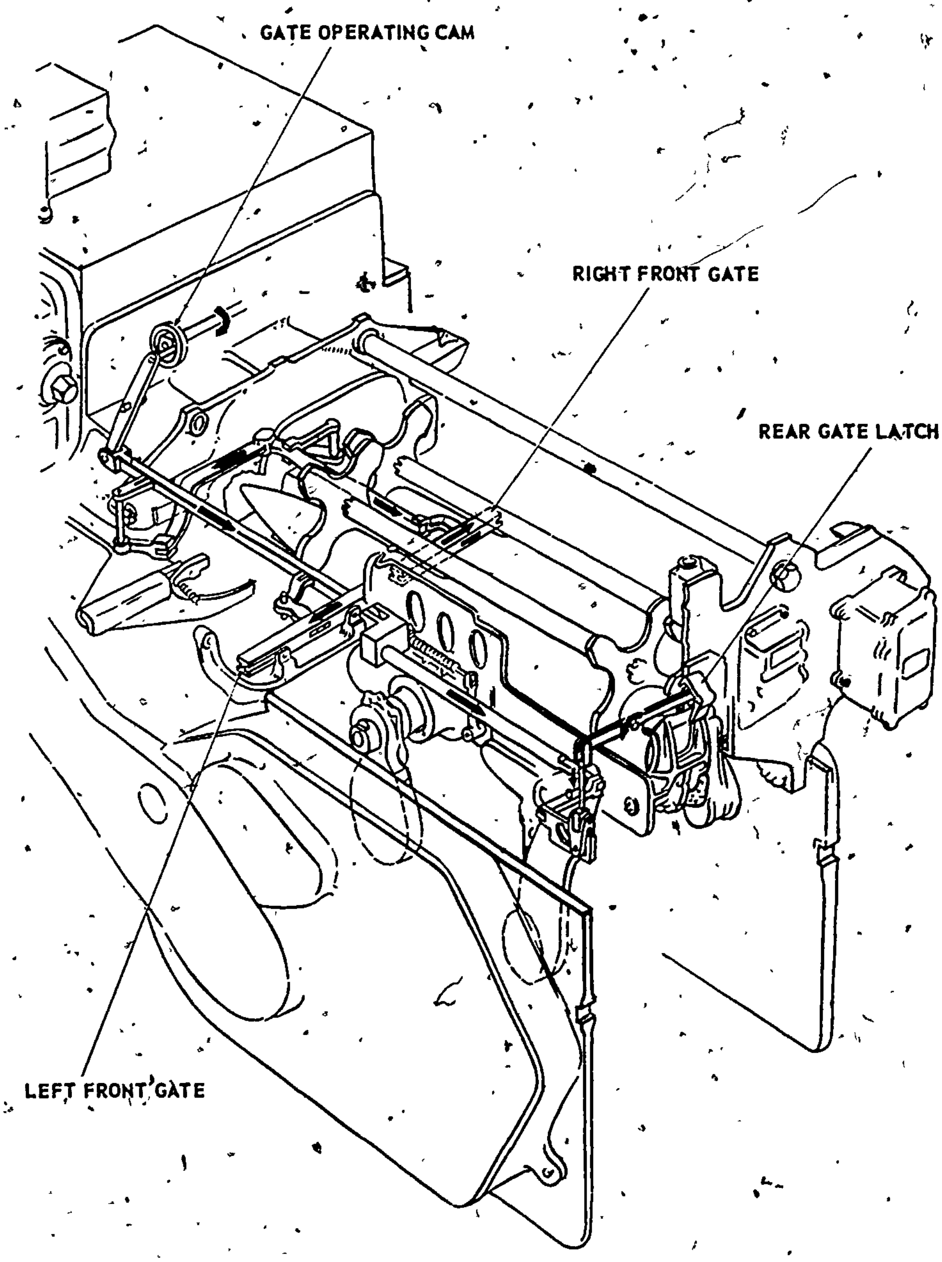
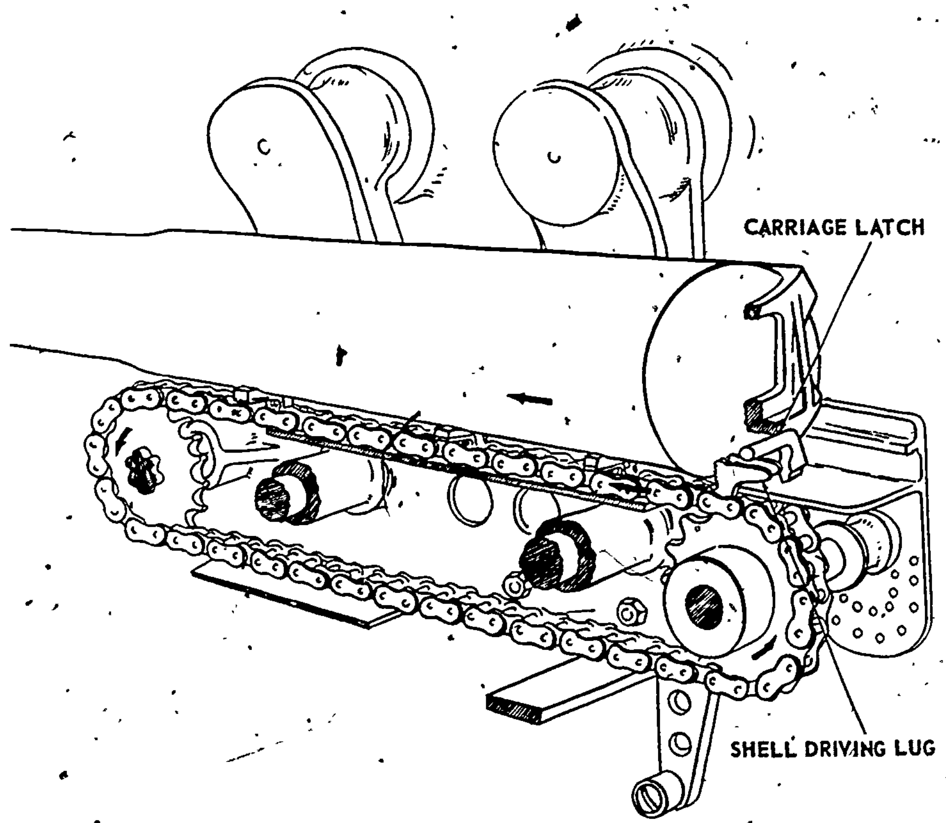


Figure 6-14. — Gate operating linkage. 84.129

has the only physical connection to the drive shaft. It is moved by the shifting lever. When shifted to the left, the sliding jaw engages the jaw secured to the primary power source and connects it to the driven mechanism through the drive shaft. When shifted to the right (as shown), it engages with the jaw driven by the chain and sprocket from the auxiliary source of power.

Square-jawed positive clutches are most often found in places such as handwheel gearing, where they are moved to select gear ratios or types of control inputs to the power drive.



84.130

Figure 6-15.—Chain and sprockets.

Friction Clutch

Sometimes it is necessary to connect a shaft which is rotating fairly fast with another which is not rotating. This can be done with a friction clutch. When an initially stationary shaft is to be driven by a moving shaft, the friction surfaces of the clutch (between the two shafts) will absorb the slippage until the driven shaft is brought up to speed. In this manner an electric drive motor can be kept running continuously, and power can be tapped from its drive shaft when desired. Engaging the friction type clutch causes the motion to be transmitted without serious shock to the shafts.

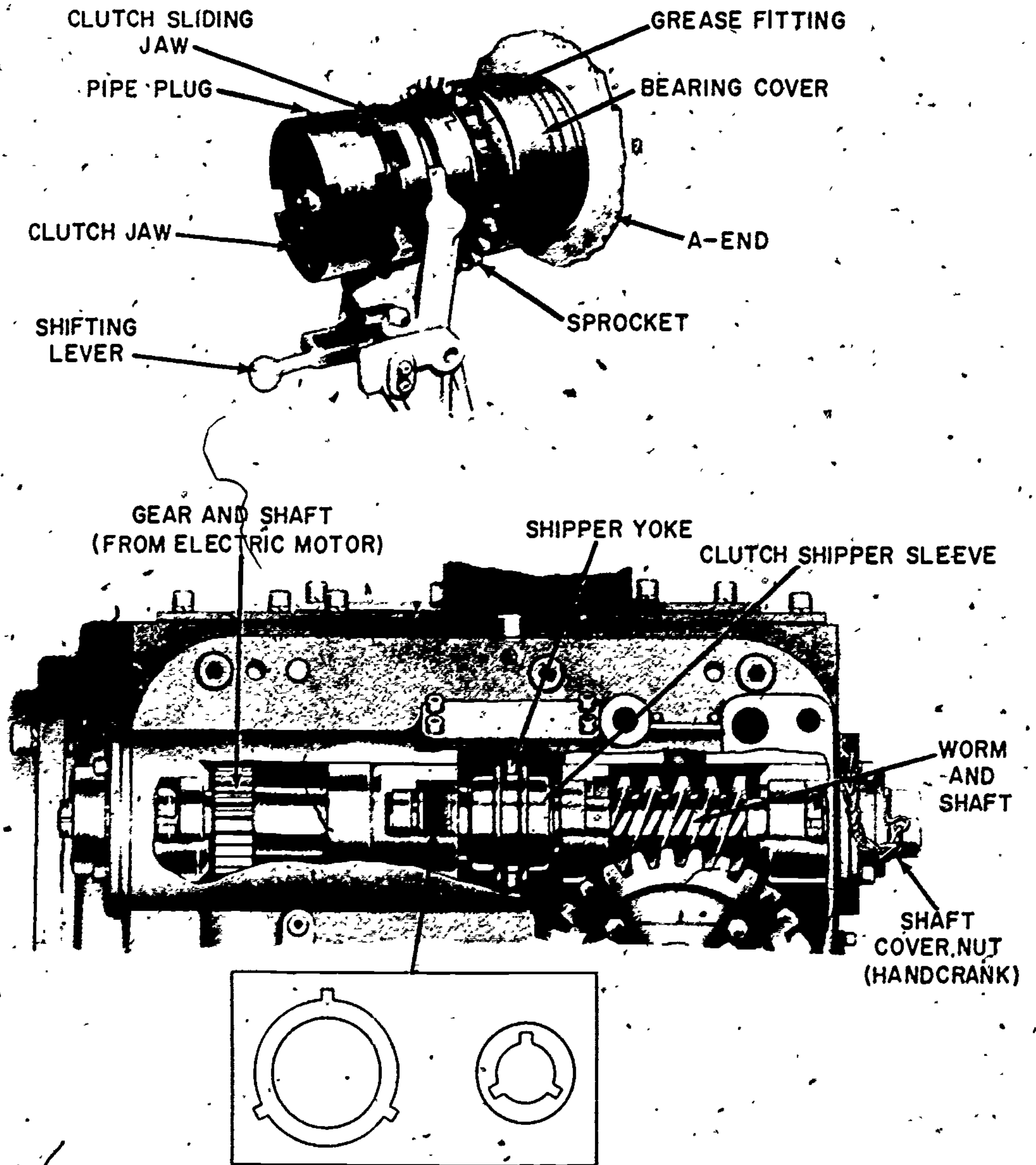
Figure 6-16 shows the clutch placed between an electric motor and the mechanical drive gearing of the 3"/50 RF automatic loader. The clutch is made up of several discs. The discs are of two types (shown in the insert) and are placed alternately on the shaft. The large disc has projections which fit into slots of a cup. The cup is part of the shaft from the electric motor. As the electric motor is running constantly, the attached discs are also rotating. The smaller discs, on the right in the insert, are keyed to the worm shaft.

When the clutch shipper sleeve is moved slightly to the right, no cycle is possible. The discs are not in immediate contact—the larger ones are rotating, the small ones are idle. When a cycle is started, the clutch shipper sleeve is slammed to the left, bringing the discs hard against each other. Through friction, the large discs transmit their rotation to the smaller discs, and the worm turns. Motion then goes through a train of gears to move the loader tray. When the cycle is completed, other mechanisms cause the clutch shipper sleeve to move right, disengaging the clutch.

SPRINGS

Springs are elastic bodies (metal in ordnance applications) which can be twisted, pulled, or

194



84.122:5.22.9

Figure 6-16. — Clutches — Positive-clutch (upper). Friction clutch (lower).

stretched by some force. When the force is released, they have the ability to return to their original shape. Because of this ability, springs are often used to store energy. Energy thus stored becomes a potential force in mechanical systems much as the dry cell batteries provide in electrical circuits.

According to their design and applications, springs can do a variety of jobs. So many, in fact, that it is not practicable to list them all here. What we will do is class the springs according to type, and show an example or two of how they are used in ordnance gear.

Compression springs store energy. They are designed so as always to press outward. Energy stored in such springs is often used to cause, or complete, functioning cycles.

Figure 6-17 shows a familiar helical compression type spring. Counterrecoil springs are used on guns 3-inches and smaller to absorb some of the force of gun recoil, and when the force is spent, they push the gun back into battery. The spring in the illustration is used on a 3"/50 RF and is under 3000 pounds initial pressure when installed. This force builds up much higher when the gun is in full recoil. The energy of the spring is used to force the gun back into battery.

Helical compression springs are also used:

1. To counterbalance heavy weights. Such springs are called equilibrator springs; they are found on 5"/38 loading machines and 3"/50 RF loaders.

2. To reduce shock or impact. Here the springs are used in buffers which will gradually check the motion of a moving weight.

3. To press on valves in valve blocks. They will keep them from being free-moving until acted upon by another force such as hydraulic pressures, cams, or linkage.

4. To permit some freedom of movement between components without disengaging them (sometimes called takeup springs) between two collars of aligned shafts. The springs are strong enough to allow one shaft to pull or push the other, working as one solid rod. If a malfunction (further along the linkage train) should occur, the other can complete its movement. The spring will take up, preventing damage to the mechanism.

An example of this spring action is found on the round feed shaft of the 3"/50 RF hopper drive gearing. In this usage any failure of the shift-gears (figure 6-1) to mesh properly will cause a takeup spring on the shaft to compress. The shifting mechanism is permitted to complete its cycle undamaged.

Tension springs (fig. 6-17) are just the opposite of compression springs. That is, they always tend to pull inward. In its usual form, the tension spring is wound helically like the compression type. This is the type of spring used to keep screen doors shut. In ordnance applications, it is used most often to keep a component such as a lever bearing against another component, a cam for instance. The lever maintains contact with the cam's irregular surface as the cam rotates.

Spiral springs (fig. 6-17) work like the main springs of clocks or watches. They store their energy by being wound (tightened) and transmit this energy by unwinding when released. An example of the spiral spring is the breech-closing spring of the 40-mm gun. The outer end of the spring is stationary. The inner end connects to the breechblock operating shaft. When the shaft is cammed downward, lowering the block, it turns the spring and tightens it. When the breechblock is released by the extractors, the spring unwinds, rotating the operating shaft, and moving the block upward to a closed position.

Torsion springs, (fig. 6-17) act in much the same manner as spiral springs. Usually such springs are used to return a component to its original position after being displaced. You find these springs on axis pins of some hoist doors, for example. The door is spring-loaded to a closed position. Pushing a round through the door forces it open, and then the door springs shut automatically behind the round.

Torsion springs are used in 40-mm loaders to keep tension on the loading and stop pawls. In this arrangement, the pawls can be pushed aside when ammunition is loaded through them, then spring outward again to prevent any backward movement of the ammunition.

BUFFERS

A buffer is used to cushion the collision of moving components. Some buffers are simply pieces of elastic material, such as rubber or plastic, placed between the moving parts at their point of impact. Also, compression springs can be used as buffers, as you just learned. Another type can be seen in figure 6-18.

Here is a hydraulic buffer using a piston that moves in a liquid-filled cylinder. When the buffer is not being acted upon, the piston is kept to the left by spring pressure. When the piston is acted upon by some mechanism, it is forced to the right, pushing fluid ahead of it out of the cylinder. During the first stage of buffing, the liquid can pass through throttling grooves to the rear of the piston. As the piston continues its movement, the throttling grooves cut off liquid flow and the fluid is forced up through a much narrower opening at the needle valve. This slows piston movement even further, and the mechanism moving the piston decelerates smoothly until it comes to rest.

The buffer shown in figure 6-18 is used to buff the loader drive control mechanism of a 3"/50 RF automatic loader. The same gun uses similar

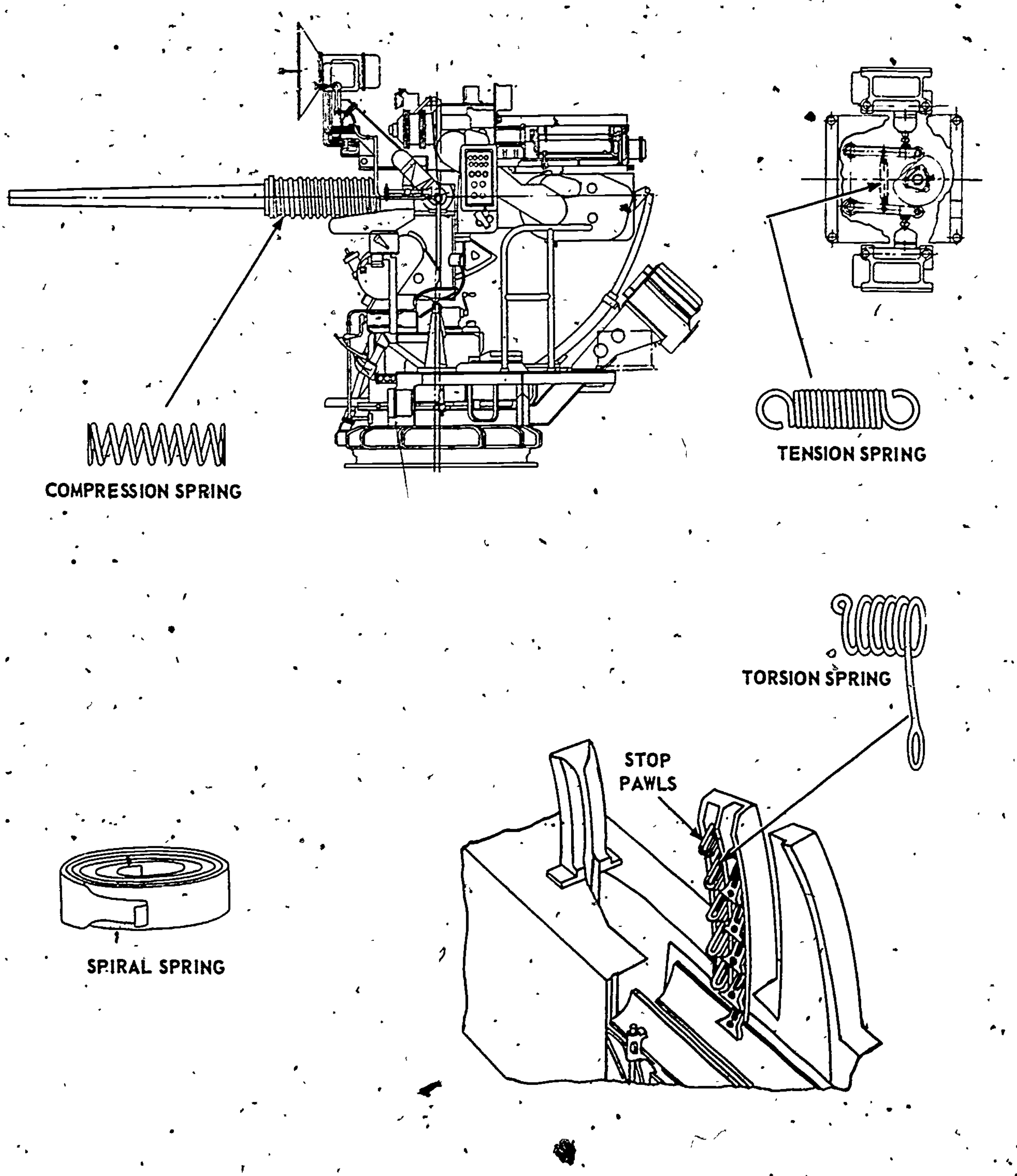
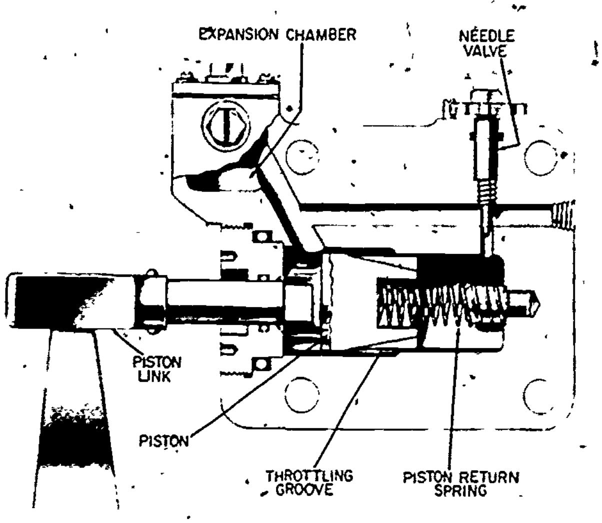


Figure 6-17.— Springs.



84.132

Figure 6-18.—Hydraulic buffer.

buffers to bring its loading tray to a smooth stop as it slams up and down approximately 50 times a minute. On a larger scale, hydraulic buffers are used to cushion the impact of gun mounts as they run into their train and elevation positive stops.

Another use of the hydraulic buffer is to absorb the kick of gunfire on guns 40-mm and larger. What about the large spring wrapped around the barrels of such guns as the 40-mm and 3"/50? It is true that these springs will absorb some of the gun's recoil energy, but their main purpose (in this case) is to force the gun back into battery after the hydraulic buffer (brake) stops the gun's rearward movement.

COUPLINGS

In a broad sense, the term "coupling" applies to any device that hold two parts together. For our purposes, these two parts will normally be shafts. In its most familiar application a coupling will permit one shaft to transmit motion to another although the shafts are misaligned. The misalignment may be intentional. That is, the shafts may have been designed to meet at an angle. In this case they transmit motion around a corner, so to speak. The misalignment may sometimes be unintentional or unavoidable because of wear, slippage, etc. Figure 6-19 shows four types of couplings which have wide ordnance applications.

The flexible coupling connects two shafts by means of a metal disc. This disc provides a small amount of flexibility, allowing slight axial misalignment between intersecting shafts. As you would imagine, there is a limit to the amount of force this coupling can transmit due to the relative weakness of the metal disc.

The adjustable flexible coupling joins two shafts by means of the metal disc and an adjustable element. By loosening the clamping bolt and turning the worm, the right-hand shaft can be turned. This type of coupling can be found on guns of nearly all calibers, especially in gun telescope and sightsetting gearing. These items must be finely adjusted and this type of coupling can do the job.

The fixed (Oldham) coupling is not as rigid as its name implies. While it is not designed to connect shafts which meet at an angle, it will transmit motion and allow for some misalignment between shafts which are parallel but fail to meet each other exactly. The drive shaft connects to the driven shaft through a coupling ring. The ring has a small amount of radial play, and this allows a small amount of misalignment of the shafts as they rotate.

There are variations of the Oldham type coupling, but they operate on the same principle. They are widely used on the output shafts of flange-mounted electric drive motors such as the rammer motor of the 5"/38 gun and loading machine.

The universal joint connects shafts which meet each other at an angle. The flexible shaft also does this. The major advantage of the universal joint is its strength. It is used in gearing and shafting which carry a heavier load. In the illustration you see it used with the manual drive gearing of a 5"/38 powder hoist.

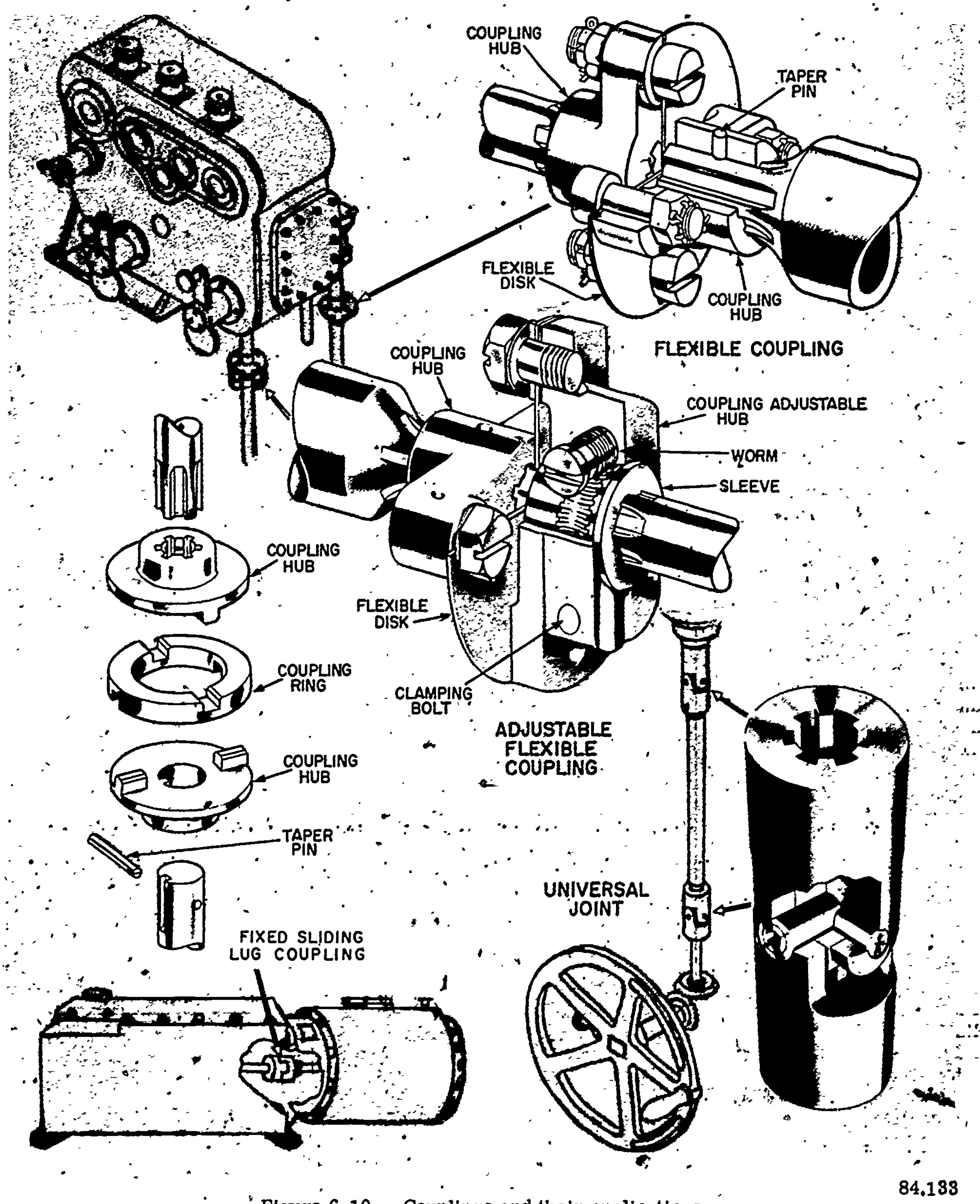
SUMMARY

In summary, let's review what you have learned in this section.

A machine is a device that helps you do work. As a Gunner's Mate, you will maintain and repair many different machines.

Machines are made up of smaller parts, many of which can be classed as mechanisms. We discussed nine types of basic mechanisms. There are more, but these nine represent those with the widest ordnance applications.

Some of the mechanisms, such as gears and levers, are designed to multiply the force of your effort. This gives you a mechanical advantage of more than one. When the mechanisms multiply



84.133

Figure 6-19. — Couplings and their applications.

either the motion or the speed of the applied force, you have a mechanical advantage of less than one.

We found that couplings are used to connect shafts which are misaligned, or may become misaligned. With an addition of an adjustable element (worm and gear), a coupling will permit a driven mechanism to be accurately positioned.

We saw how clutches permit shafts to be rapidly connected or disconnected.

Machines are not 100 percent efficient. One reason is friction. Friction is reduced by lubrication and bearings.

Knowledge of basic mechanisms will help you understand how a complex machine works. By breaking the machine down into parts, you can follow its actions through step by step.

Remember the schematic of the 3-inch loader (fig. 6-1), you were exposed to in the beginning of this chapter? If you return to it, you can see that a good many of the components in the schematic are basic mechanisms, which were covered (in one form or another) in this chapter. And while no effort was made to explain the loader's operation, you will find that most of its actions are clearer to you now.

CHAPTER 7

ELECTRICAL AND ELECTRONIC CIRCUIT ANALYSIS

There are many electrical and electronic circuits used in ordnance equipment. These circuits perform such jobs as automatic or local control, stabilization, amplification, and overload protection. It is beyond the scope of this book to examine each type of circuit individually, but fortunately there is a shortcut. All electrical circuits use some type of basic electrical or electronic devices; these devices, individually or working together, can delay, interrupt, isolate, or integrate electrical and electronic circuits, and prevent damage to equipment. The purpose of this chapter is to provide extensive information in the fields of electricity and electronics as they are related to ordnance equipment. Additional references should be made to Basic Electricity, NAVEDTRA 10086, and Basic Electronics, NAVEDTRA 10087. These publications are used by many ratings and present a more comprehensive view of the subject matter covered in this chapter.

We first explain some of the more common electrical devices used as part of a power drive circuit, we then construct a typical circuit and explain the procedures and equipment used to locate failures within the circuit.

The last section of this chapter is devoted to some of the electrical and electronic control devices, such as synchros and electron tubes, used in ordnance equipment. We also cover some of the safety precautions required for trouble-shooting electrical and electronic equipment.

ELECTRICAL CIRCUITS

A complete circuit is an unbroken path through which current flows from the negative terminal of the source through the load, back to the positive terminal, and through the source. All circuits have a source of voltage, plus some type of resistance (load) connected to the source. The resistance of the circuit load controls the current flowing through the circuit.

The voltage source is the generator, battery, or any other unit that supplies the electrical energy. The path is the wire or conductor that allows current flow from the source to the load, and from the load back to the source. The load is the equipment that is connected to the source and may vary from a simple light to more complicated equipment.

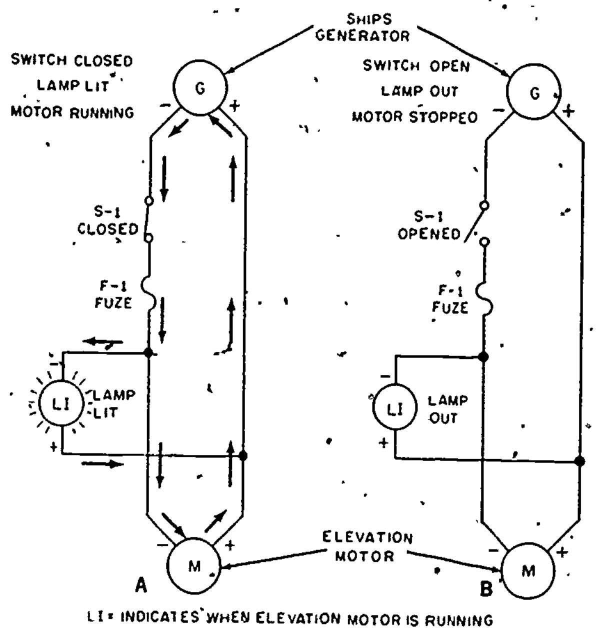
You learned from Basic Electricity that electricity is a combination of a force called voltage and the movement of electrons known as current. You also learned that voltage is a pressure that forces current to flow through a wire, and that current has the ability to heat a lamp filament white hot and thus produce light. Figure 7-1 shows a practical indicating circuit of the type used in power drives. The lamp, when lit, indicates that the electric motor is energized.

A.C./D.C. ELECTRICITY THEORY

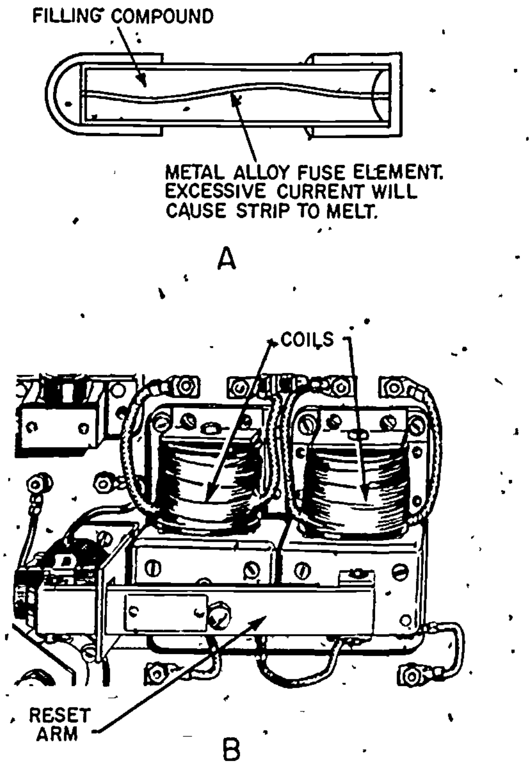
As explained in Basic Electricity the difference between a.c. and d.c. electricity is that current always flows in the same direction in a d.c. circuit and reverses its direction at regular intervals in an a.c. circuit.

The direction in which current flows in a circuit is indicated by plus (+) and (-) signs. You learned from Basic Electricity that there are two theories describing the direction of current flow, conventional and electron theory. In all circuits used in ordnance equipment the electron theory of current flow is used, this theory states that current leaves the negative (-) terminal, flows through the circuit, and returns to the positive (+) terminal of the voltage source (fig. 7-1A).

Current flow in a circuit does all the work involved in the operation of an electric or electronic device, whether it is a simple lamp or a complicated servo amplifier. In any application of current flow a continuous path must be provided between the two terminals of a voltage source.



84.332
Figure 7-1.—Practical indication circuit.



84.193
Figure 7-2.—Circuit protective devices—A. A fuse (cartridge type). B. Overload relays.

There are three general types of circuits. A series circuit is one in which there is only one path for current to flow. A parallel circuit is one in which there is more than one path for current flow and a series parallel circuit is a combination of series and parallel circuits (all are explained in Basic Electricity).

Elements In A Circuit

There are several devices designed to protect an electrical circuit: fuses, overload relays, relays, and switches. The most common, of course, is the fuse.

FUSES.—The simplest form of circuit protective device is the fuse. A fuse is a conducting element that will melt at a predetermined current value, thus opening the circuit and protecting the equipment against excessive current.

Early fuses were of the open type. These were unsafe because the fusible element upon blowing, threw out molten metal causing burns and fires. All fuses used by the Navy are of the enclosed type. The most common is the non-renewable cartridge fuse shown in figure 7-2A.

The fuse consists of the metal alloy fusible element, a fiber body filled with a nonflammable material, and ferrules closing the ends of the tube. When an abnormal amount of current (overload) flows through the fuse element, the element burns up. As the metal strip vaporizes, the filling compound acts to quench the arc.

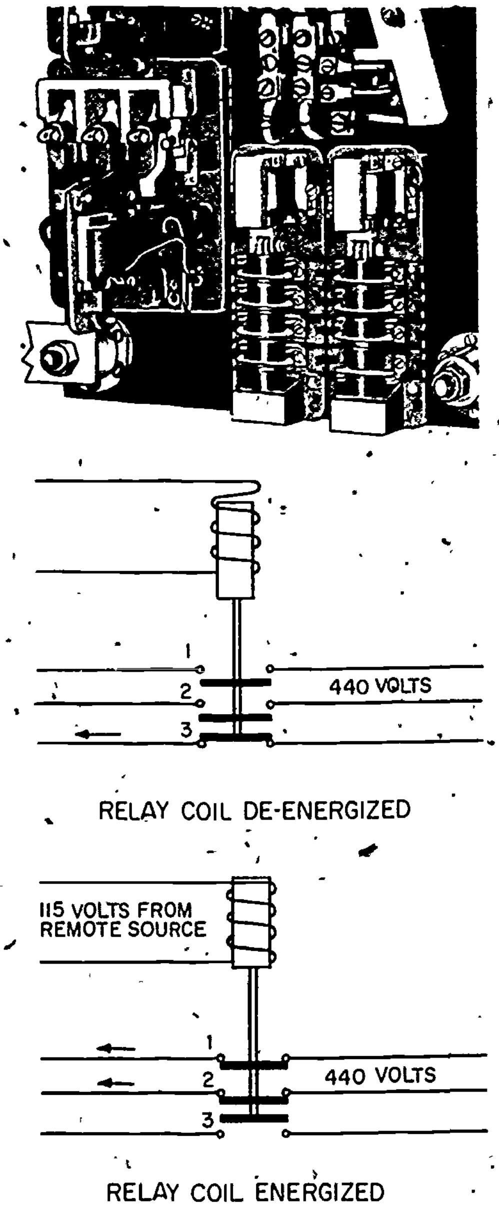
The most common cause of fuse failure is an overloaded circuit. There are, however, other causes. Failure to set the fuse into its contacts properly when installing, and even the conditions of the surrounding air, can cause a fuse to blow. Fuses are rated according to the amount of current that can safely be carried by the metal alloy fuse element; this current is usually measured in amperes.

OVERLOAD RELAYS.—Overload relays, like fuses, act to protect circuits and equipment but in a different way. They are designed to open a circuit under short-circuited or overloaded conditions without injury to themselves. In opening the circuit, these protective devices act as relays. Overload relays used in gun power control circuits, generally speaking, fall into one of two broad classes. They are either of the thermal overload type or the magnetic (dash pot) type.

The inductive thermal overload relay and reset assembly (fig. 7-2B) is made up of a primary current coil, a heater element as a secondary coil, a set of contacts operated by the heater, and a reset relay. When the circuit is energized, current passes through the primary coil. By inductive action, this current is induced into the heater element. If an overload occurs, excessive current in the heater element will cause it to deflect. This rotates the lower end of the assembly, releasing a latch which normally holds the contacts closed. Opening the contacts opens the circuit. The overload relay can be reset by a push-button which will energize a reset relay coil. When this coil is energized, it actuates a reset push rod and pulls the contacts closed.

In extreme emergencies the contacts of the overload relay can be kept closed by action of the reset circuit although an overload exists. Operating power drives by this method (holding the RESET EMER RUN button down on the mount) bypasses the protective functions of the overload relays and may result in damage to the equipment. For this reason, the cause of the overload should be investigated and corrected before attempting to resume normal power operation.

The magnetic overload relay serves the same purpose of protecting the equipment from damage in the event of an electrical overload. This type of relay consists of a coil, an iron plunger, and contacts operated by the plunger. When installed, the operating coil is connected in series with the protected circuit. Normal current through the coil will not cause the relay to operate. If an overload occurs, the increased current will cause the flux of the relay coil to become large enough to lift the plunger up into the center of the coil. This causes the contacts to open, and disconnects the equipment from the circuit.



84.194

Figure 7-3. —Control relays.

Relays

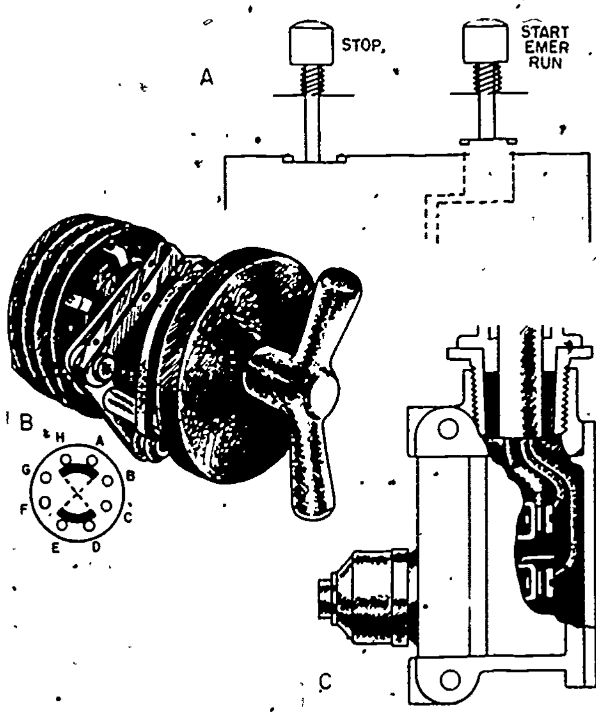
According to their application, relays can isolate, integrate, interrupt, or delay current flow in a circuit. Because of their wide and varied use, it is impossible to firmly type them. They can rightfully be called switches, protective devices, line contactors, etc., depending upon their function.

The type studied here is the power control relay (fig. 7-3). These are simple devices consisting of a coil, a plunger, and contacts which make or break the circuit, depending on the action of the plunger. From the illustration you can see that a relatively small current through the coil will control the passage of a much larger current through the contacts. In the deenergized position, current flow is stopped at contacts 1 and 2. Contact 3, however, is closed, and current is allowed to pass through the bottom circuit. When the coil is energized, the plunger is lifted, contacts 1 and 2 close, completing their circuits, and contact 3 opens.

The time delay relay acts in much the same way except there is a delay between energizing the coil and lifting the plunger. It is particularly useful in circuits where two large drive motors are energized by a single start button. The idea is to prevent both motors from starting at the same time and resulting in large surges of current flowing in the circuits. By placing one motor in the start circuit with a conventional control relay and the other motor with a time delay relay, initial starting currents are staggered.

The time delay relay used most often in gun power drives is the bellows, slow make, fast break type. Energizing the coil of the relay causes the plunger to be attracted upward. The plunger is attached to a metal bellows and its upward movement is slowed. As the bellows is compressed, the trapped air must escape past a needle valve. By adjusting the needle valve, the contacts of the relay can be made to open (or close) after a selected interval of time. De-energizing the coil of the relay allows a spring to return the plunger rapidly to its deenergized position.

Another type delay relay is the fast make, slow brake. When energizing the coil, the plunger activates the contacts rapidly. When deenergizing the coil, the plunger returns to the deenergized position slowly by porting air through a needle valve.



12.70(84)

Figure 7-4.—Switches—A. Pushbutton type. B. Multiple rotary switch. C. Microswitch.

Switches

A switch is used to complete, interrupt, or change connections in a circuit under load conditions.

The pushbutton switch is often used to start and stop electric drive motors. The button and its contact is spring loaded to either a normally open or closed position according to its use in the circuit. A simple pushbutton diagram is shown in figure 7-4A. Pushing the START button will complete the circuit. Pressing the normally close STOP button opens the circuit. The dotted line indicates a third circuit which is sometimes present in power drive pushbutton stations. In this case the START button, in addition to starting the power drive, is also used to energize the overload relay reset coils. Such a pushbutton station is labeled START-EMER-RUN.

A type "J" multiple rotary switch is shown in figure 7-4B. This switch contains a number of rotors (the movable contacts) and a number of pancake sections (stationary contacts). The number of sections required in the switch is determined by the individual application. A shaft with an operating handle extends through the center of the rotors. In the particular "J" type multiple rotary switch action shown (2JR), there are eight stationary contacts (A through H) and a rotor having two movable contacts 180° apart. Each movable contact bridges two adjacent stationary contacts. As shown, the rotor contacts segments A-H and E-D. By moving the rotor clockwise one position, segments A-B and F-E are connected.

The most common type of interlock switch is the sensitive switch. There are various kinds of sensitive switches with different means of actuation. These are small, short-travelling, snap-action switches shown in figure 7-4C. They are manufactured as normally open, normally closed, and double throw. The latter has no OFF position. The Microswitch is frequently used in referring to this type of switch. The term MICRO is a trade name for the switches made by the Micro Switch Division of Minneapolis Honeywell Regulator Company. Many other companies also manfacture sensitive switches so MICRO is not the true name of all sensitive switches. The principal advantage of this switch is its ability to be opened or closed by very small movements of its push-button. Because of this ability, it is used extensively as a safety interlock. These switches, for example, are used throughout the 3"/50 RF/loading circuit. They are actuated by their individual linkages to assure that the breechblock is fully down, the bore is clear, etc., before a loading cycle can be initiated.

By changing the wiring connections, these switches can be made to be normally open or normally closed. So you should be careful when placing a new sensitive switch in a circuit or rewiring an old one.

[illegible] BUILD A CIRCUIT

In this section we build a complete circuit, using most of the basic elements just discussed. In this way, you can see how a circuit which looks fairly complicated at first glance, actually is made up of individual, one-function, circuits. These smaller circuits are made up of just one or two simple devices (and their associated wiring) and do just one job. When properly connected to other one-function circuits, they can act automatically to start or stop current flow in a circuit, combine or divide these circuits, and act as safety devices to protect equipment and personnel.

The circuit we design here is a power control circuit. Its job is to connect and regulate a ship's 440-volt supply to a gun power drive. In figure 7-5A, you can see that 440 volts is connected directly to the train and elevation motors. This is good as far as it goes, but unless we have some way to interrupt this circuit, our motors will run continuously as long as the ship's generators are lit off. This means 24 hours a day.

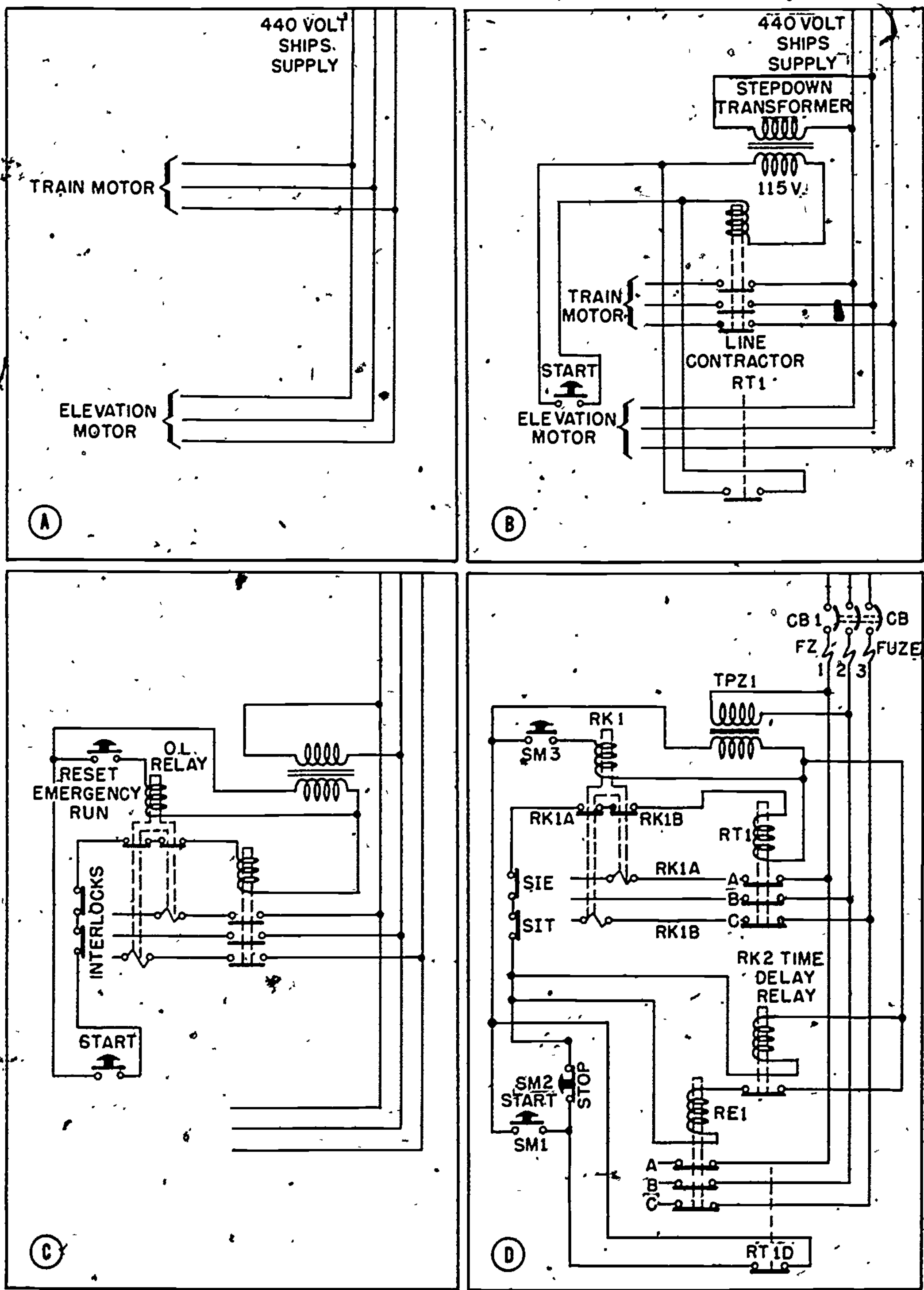
Look now at figure 7-5B. You can see that a line contactor has been placed in the line between the supply and the train motor. Its contacts are in the open position. Right above the relay coil of the line contactor you can see a stepdown transformer which has tapped voltage from the high voltage supply and has reduced it to 115 volts on its secondary windings. If you trace the output of this transformer, you see that it goes down through a simple START button (spring loaded to the open position), back up through the relay coil of the line contactor RT1 and then connects to the transformer completing the circuit. Now, when you press the start button, current flows through the start circuit energizing relay RT1. The relay's magnetic flux pulls the plunger up, and the four contacts close, applying 440 volts to the motor. The voltage is lost, however, if the start button is released, because releasing the button breaks the start circuit to the coil of relay RT1 and its contacts drop out, opening the 440-volt circuits. Since it would be a waste of manpower to assign a member of the gun crew to hold this button down all the time, let's add another circuit to do the job for us.

Notice the circuit that taps off the 115-volt start circuit. It goes [illegible] and through the lower (fourth) contact [illegible] We will call this the RUN (holding) circuit because it will permit current to flow through coil RT1 when the START button is released. How? Let's go back a minute. When you pressed the START button, current flowed not only through the circuit to relay coil RT1, but also down through the RUN circuit to its lowest contact. Of course, at this particular instant it could go no further. When the line contactor RT1 lifted, however, it also closed its lowest contact. This completes the circuit. More important, it provides an alternate path for current to energize relay coil RT1. Now even though the START button is lifted, current through the run circuit will keep RT1 energized and its contacts closed.

The next additions to our circuit are protective devices. Figure 7-5C shows an overload relay and its associated reset-emergency-run circuit, and interlocks, which in this case are two sensitive switches. The overload relay is the inductive thermal type. When an overload occurs, the relay trips and opens the 440-volt circuit to the amplidynes. They can be picked up again (reset) by pushing the RESET EMER RUN button. This button, when pushed, completes a circuit to the coil of the relay, pulling its contacts closed. In emergency, this procedure can be used although an overload exists. Because it bypasses the safety feature of the relay, however, this should only be done in emergency, and then, only sparingly.

Now for the sensitive switch interlocks. These switches are in the start circuit and will prevent current flow in this circuit unless they are closed. A practical application of these switches would be to connect them by linkage to train and elevation centering pins. By arranging the linkage and the internal circuitry of the switch a certain way, the switches act to open the start circuit when the centering pins are in. This prevents starting the power drive and attempting to train or elevate the gun while it is locked into its stowed position by the centering pins.

So far we have ignored the circuit to the elevation motor because, with one exception, the elevation circuit has the same components, and



84.195

Figure 7-5. — Power control circuits for amplidyne type power drive.

works the same way as the train circuit. Both circuits are supplied from the same 440-volt supply; the start and run circuits and interlocks are common to both train and elevation; and the overload relays are identical in construction and purpose. The only real difference between the train and elevation circuits is that the latter has a time delay relay RK2 in it.

In figure 7-5D, you can see line contactor RE1, which acts to complete the 440-volt ship's supply to the elevation motor in the same manner as RT1 did for train. You can see, however, that for the relay to be energized, the contact of the time delay relay must be closed.

The circuit works like this:

When the START button is pressed, the coil of RI1 and the coil of the time delay relay are both energized. (We will consider that the run circuit completes the alternate path for both relays and that the START button can be released). Current passes to the train motor, which builds up to operating speed. The time delay relay is the bellows type, set at 8 seconds. Eight seconds after the start button is pushed, the time delay relay has pulled its plunger up into the coil. Its contact closes, completing the circuit through coil RE1. When RE1 lifts, its contacts close, sending 440 volts to the elevation motor. The purpose of the time delay relay is to stagger the large starting currents through the circuit and prevent an overload. It allows the train motor time to wind up before the elevation motor starts.

The remaining elements in the circuit are the circuit breaker, fuses and the STOP button. In normal operation the circuit breaker is closed, supplying our circuit with 440 volts. It can be opened by hand, securing the power, while repairs are being made.

The fuses are in all three phase circuits. Their purpose and action have already been shown. The STOP button is spring loaded to the closed position. In most cases this button will affect both the start and run circuits. When you press the button, both circuits are opened and the relays drop out.

Causes Of Circuit Failures

The failure of a circuit to function properly usually is caused by a break in the circuit (open), a grounded circuit (this permits an undesired path of current return to the source), or a short circuit (a circuit that permits current to bypass a part of the circuit).

Any of these faults affects the current and voltage values and causes the circuit to function improperly.

Open circuits may result from dirty or loose connections, improperly installed wire, mechanical damage, faulty installation or repair, and vibration. If connections are clean and tight, no resistance is added to the circuit.

Short circuits are low-resistance paths or shortcuts that cause the current to bypass the load. The current from the source passes through the "short" instead of the load, causing the load to function improperly. Most shorts are accidental. They occur when vibration wears away the insulation, when salt water gets into connection boxes, when heat melts away insulation, and when carelessness brings two conductors together.

A grounded circuit is one in which one side of the path is connected to ground either intentionally or accidentally. An intentionally grounded circuit uses a ground which is the ship's hull, equipment chassis, etc., as one side of the line or one conductor. If the "hot side" conductor of a grounded source touches ground accidentally, a short circuit results. Power circuits in the Navy are not grounded and must be insulated from ground at all times. One side of this circuit may be grounded accidentally, and no harm will result, but if both sides are grounded, a short circuit is the result. An ungrounded circuit has a safety feature. If anyone accidentally touches one side of an ungrounded circuit, there will be no path for current flow through his body to the other side of the source. This is one reason why power circuits in the Navy are insulated from ground.

Types of Circuit Checks

There are three basic circuit checks used to locate shorts, grounds, and open circuits within electric and electronic equipment.

1. Voltage (volt) checks
2. Current (amperes) checks
3. Resistance (ohms) checks

Voltage checks reveal the amount of potential force present to move electrons in a circuit.

Current checks show the actual amount of electron flow through the circuit.

Resistance checks tell the resistance characteristics of the circuit, that is, how much opposition the circuit offers to the flow of electrons.

With the proper use of test equipment, failures in electric and electronic circuits can be detected and isolated to specific components by using one of these three checks.

Since volts, amperes and ohms are units of electrical measure, (Ohms Law explained in Basic Electricity), some measuring device must be used to measure them. One device used for this purpose is the multimeter.

CIRCUIT TESTING

A multimeter is a testing device which measures either a.c. or d.c. voltage, current (amps) or resistance (ohms). A multimeter converts electrical energy into mechanical motion. The mechanical motion positions a pointer (called a needle) on a scale located on the face of the meter. The scale indicates the number of the units being measured.

Figure 7-6 shows the front view (face) of a multimeter, which contains all the controls necessary for operating the meter. There are three major controls which function as follows.

A 10-position rotary switch, located in the lower left hand corner of the meter, is used both as a function switch and a resistance range selector, ((1) in fig. 7-6). Five of these positions set up ohmmeter (resistance) checks. In any of these positions the switch also acts as a range selector.

The eight-position switch (2) in the lower right hand corner selects ranges of current and voltage.

The zero-ohms control knob (3) is used to adjust meter circuit sensitivity to compensate for battery aging in the multimeter's circuits. It also is used to set the pointer (needle) at full scale deflection to the right, to indicate zero ohms when the function switch is set at any resistance range position, and test leads are shorted together, (4), (5), and (6) in fig. 7-6.

Six meter jacks are arranged in two rows of three on the face of a multimeter. Following is a list of the jacks and their functions.

The common jack (7) upper left hand corner accomodates the negative (black) test lead. This jack and its associated test leads are used in all circuit tests.

The +v ohms jack (8), center jack upper left, accomodates the positive (red) test lead for measuring voltage and current values of 500 volts and 1 ampere or less, as selected by the voltage and current range selector switch. This positive jack also is used for measuring circuit continuity or for measuring resistance of a circuit or circuit component.

The +10 ampere jack (9) accommodates the positive test lead for measuring current between 1 and 10 amperes.

The 1000 VAC jack (10), upper right hand corner, accommodates the positive test lead for measuring a-c voltages between 500 and 1000 volts.

The 1000 VDC jack (11) accommodates the positive test lead for measuring d-c voltages between 500 to 1000 volts.

The +5000 VDC multiplier jack (12) accommodates a special test lead with a built in resistance and is used with the common jack to measure d-c voltages between 1000 to 5000 volts.

The scale located at the top of the meter is used to read the value of the quantity under test. On this meter four separate scales are provided, one for resistance (ohms), one for d.c. voltage and current, and two for a.c. voltage. This type of meter cannot measure a.c. current. Once the meter is connected to the circuit under test the value of the tested quantity is read on the appropriate scale. Switches (1) and (2) determine which scale is read. For example, if the meter is set up for resistance tests, the ohms scale is read and then multiplied by the value shown on the setting of switch (1). If the scale reads 22 and switch (1) is in the RX100 position, the actual value of resistance in the circuit under test is 22 x 100 = 22[illegible] ohms.

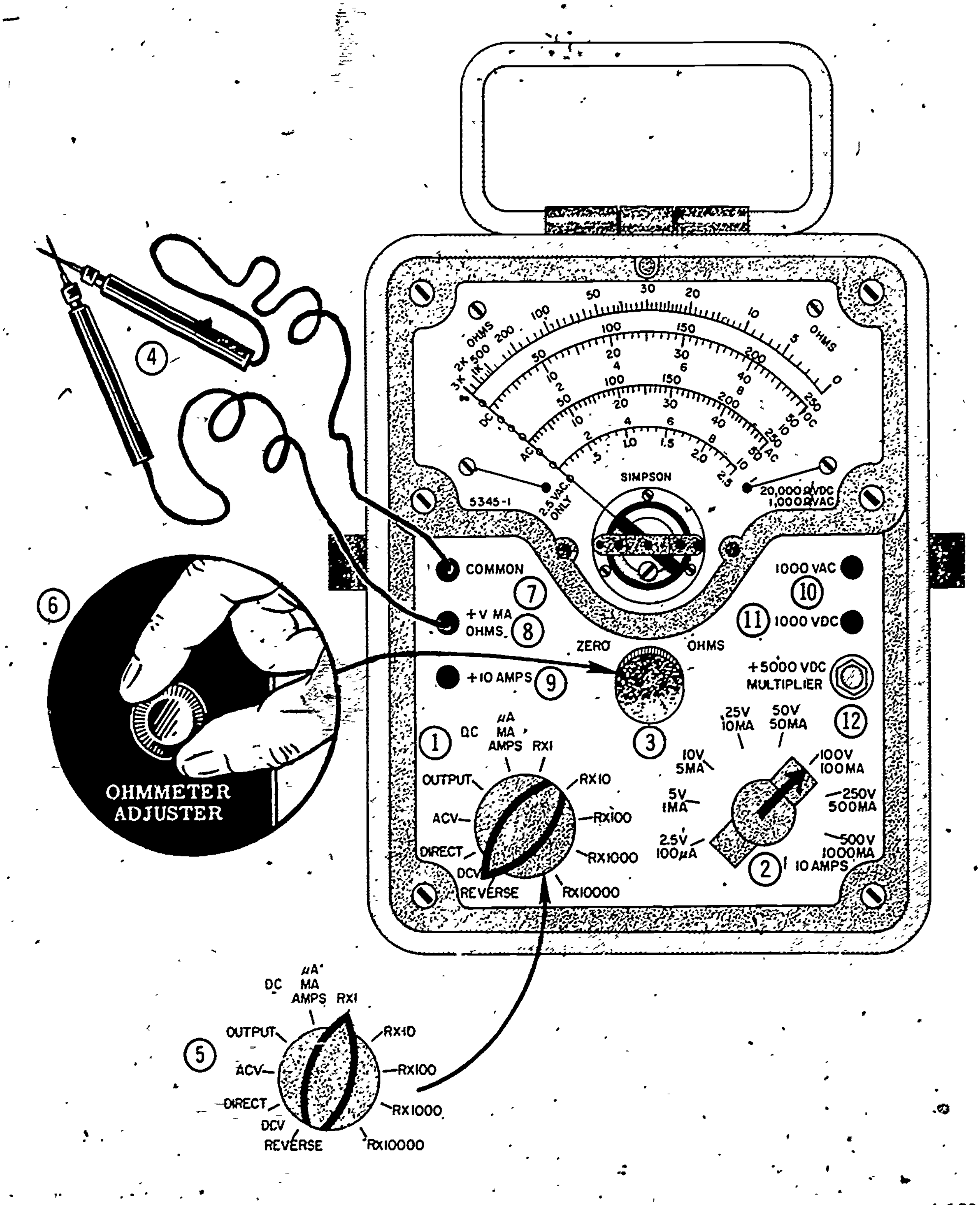
Switch (2) is used when voltage and current checks are to be made. If current is to be measured switch, 1 is placed in the AMPS, MA, μA position (11 o'clock position). The range of current to be measured is selected by switch (2).

Assuming switch (2) is in the 10 MA, position and switch (1) is in the DC AMPS, MA, μ A position, d.c. current is read on the d-c scale with full scale deflection (the pointer is all the way to the right) being equal to 10MA.

Before taking up the use of the meter, we will explain in detail the meaning of graduations on the dial.

The first time you look at the face of the meter, you may think the meter is complicated and difficult to read. As a matter of fact, it is no more difficult to read a meter than it is to tell time on a clock. Of course, a meter may be something new to you, and it will take some practice to learn how to read it quickly. However, it will not be long before you will be able to read the meter scales at a glance.

Beginning with the bottom scale (2.5VAC only) (fig. 7-6), you can see the scale is marked 0, .5, 1.0, 1.5, 2.0, and 2.5. Each graduation between these numbers is equivalent to .1 volt. Only a.c.



4.133

Figure 7-6. — AN/PSM-4A multimeter (front view).

voltage under 2.5 volts can be measured on this scale. To measure voltage on this scale, the voltage check switch(1) is set on ACV and the range select switch(2) is set on 2.5v/100μa. If, for example, after placing the test leads on the points to be tested, the needle on the dial pointed to the third graduation to the right of 1.0, your reading would be 1.3 volts.

The AC scale, located just above the 2.5v scale, has three scales from which voltage can be read in the range from 0 volts to 500 volts. The bottom set of readings are marked 0, 2, 4, 6, 8, and 10. On this scale, measurements can be read from 0 to 10 volts and 0 to 100 volts. The voltage check switch(1) is set on ACV and the range select switch(2) is set on 10v/5MA to read direct on the 0 to 10 volt scale. Each increment between the numbers on the 0 to 10 volt scale is equivalent to .2 volt. If, for example, the needle on the dial pointed to the seventh graduation to the right of 4, the actual reading would be 5.4 volts.

To measure voltage of less than 100 volts, you read the same scale as the 0 to 10 volt, however, you add a zero to each reading. For example, 2 becomes 20, 4 becomes 40, etc. In this case, the increments on the scale between numbers are equal to 2 volts. Switch(1) is set on ACV and switch (2) is set on 100v/100MA. If the dial needle pointed at three graduations to the right of 4, the reading would be 46 volts.

The next set of numbers above the 1 to 10v scale is marked from 0 to 50. On this scale, measurements of less than 500 volts can be read. To read voltages of less than 5 volts, a zero is dropped from each mark. Example, 10 becomes 1, 20 becomes 2, etc. and the scale is read direct with each increment between numbers being equivalent to .1 volt. Switch(1) is set ACV and switch (2) is set on 5v/1MA for this reading. If the dial needle pointed to eight graduations to the right of 20, the reading would be 2.8 volts. Remember, we drop the zero on this scale.

To read voltages of less than 50, we set switch (1) on ACV and switch (2) on 50v/50MA and read the 0 to 50 scale. We read the scale direct in that each increment between numbers is equal to 1 volt.

Readings of less than 500 volts can be read from the 0 to 50 volt scale. In this case, however, we add a zero to each reading. The graduations between numbers is equal to 10 volts when read on this scale. Switch(1) is set on ACV and switch 2 is set on 500v/1000MA, 10 AMPS. If, for example, the dial needle pointed at five graduations to the right of 20, the reading would indicate 250 volts. Remember, we add a zero to each reading.

The scale just above the line on the AC scale is used to take readings of 0 to 25 volts and 0 to 250 volts. To take readings of 0 to 25 volts, switch(1) is set in the ACV position, switch(2) is set on 25v/10MA. Each graduation between the numbers equals .5 volt. Here again, we must drop a zero to obtain the correct reading. Thus, if the needle on the dial pointed to five graduations to the right of the number 100 we would have a reading of 12.5 volts.

To take readings in the 0 to 250 volt range, the scale is read direct with each graduation between the numbers being equal to 5 volts. Switch (1) is set on ACV and switch (2) is set on 250v/500MA.

The numbers and graduations on the DC scale are identical to those on the AC scale so will not be discussed. The difference in taking readings is the positioning of switches (1) and (2).

Explanation of the ohms scale was covered earlier and will not be repeated.

For voltage checks switch (1) is placed in one of three positions; ACV (a-c volts), DCV DIRECT, or DCV REVERSE. The direct-reverse feature allows either positive or negative d-c voltage to be read without reversing the leads. If switch (1) is in the ACV position and switch (2) in the 100v/100MA position, the meter is set to read a-c voltage of less than 100 volts.

There are many types of multimeters found aboard ship and the one you use may not have the same features as the AN/PSM-4A. However, the general operation will be the same. If possible, always consult the operating instructions before using an unfamiliar meter. If you cannot obtain the operating instructions, read the face of the meter carefully and you should be able to determine how each control is to be used.

Using A Multimeter

Knowing how to use a meter is of little help if you cannot determine how a circuit should work under normal conditions. The fact that any electric motor should start when you push a start button is not enough. You must be able to tell what each individual component within an electric circuit should be doing and determine whether it is doing it correctly.

Most of the electrical schematics found in OPs identify by letters and numbers the components of each electrical circuit. These letters and numbers differ with each gun system. To check the electrical circuits of a weapon system, a thorough knowledge of electrical cable designations and component and equipment functions is required. In figure 7-7A we have a typical start circuit for an electric motor. This circuit is almost the same circuit as that shown in figure 7-5. The major differences between these two circuits are the way they are illustrated and the addition of indicating lights which help isolate component failures and pinpoint circuit malfunctions.

In most new OPs the type of electrical schematic shown in figure 7-7A is used and is called a straight line schematic. This schematic, in addition to showing an electrical circuit, usually contains a legend list which identifies each circuit component and explains their purposes (fig. 7-7B).

To show how indicating lights help us trouble shoot circuit failures, we'll explain three different types of malfunctions that could happen to a motor start circuit:

1. Blown fuse
2. Open or shorted transformer
3. Open control circuit

Where indicating lights point out circuit failures, some other type of test equipment must be employed to locate specific components causing failures. A multimeter is used for this purpose.

The first step taken before operating any electrical equipment is to ensure that all circuits to the electrical components are activated. First we positin CB-1 to the ON position (fig. 7-7A). This connects the 440 VAC ship supply to our electric motors and also supplies 115 VAC control voltage for the relay circuits.

CHECKING FOR A BLOWN FUSE.—With CB-1 positioned at ON, the following indicating lights should light: L-3, L-4, L-5, and L-6. Figure 7-7A shows how these lights will light and figure 7-7B tells why the lights should light.

We now have activated the circuits for the train and elevation motors. To start the motors, we must push start switch SM-1, this action should start both motors, but when SM-1 is depressed nothing happens, so we have a problem. With this type circuit the first thing to look for would be the status of the indicating lights. For some reason lights L-5 and L-6 are out. Why? What are these lights telling us? Let's start with L-5.

We found from figure 7-7B that L-5 gives us an indication that phase A of the 440 VAC power supply is available to our power supply circuit. Because L-5 is out we have no phase A for our motors and no power supply for our step down transformer TPZ-1.

Let's look at figure 7-7A and trace phase A of the 440 VAC power supply. We can see that each line of the 440 VAC power supply is labeled either A, B, or C. By following the line marked A from our 440 VAC supply we come to our first component, which is CB-1. From our knowledge of circuit breakers we know that when we position them to ON all contacts of the CB make contact and, since lights L-3 and L-4 are lit, we can assume that CB-1 is functioning properly. The next component in the phase A line is FZ-1. Reference to figure 7-7B shows us that FZ-1 is a fuse.

We can now assume that if we change fuse FZ-1 and if our circuit breaker is functioning properly, our circuit will be back to normal. But where is FZ-1 located? There are all kinds of panels and boxes within a system. How do we find the physical location of electrical components and how do we find what type and rating of fuse to use?

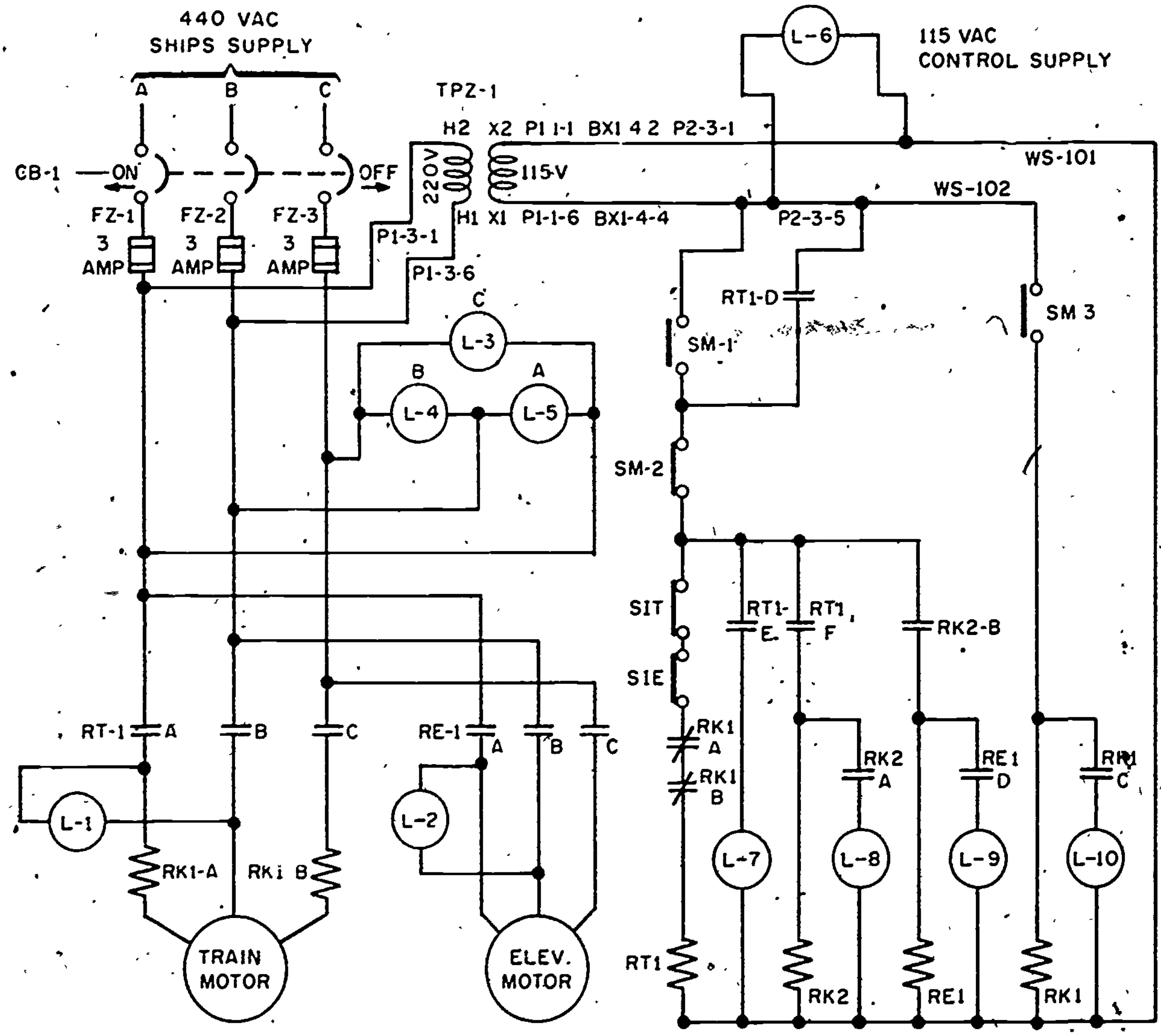
Again, let's check figure 7-7B and find FZ-1. You can see beside FZ-1 (P1) in parenthesis. This tells you that fuse FZ-1 is located in Panel P1, (P = panel and 1 = panel no. 1).

The fuse rating (3 AMP) is found in figure 7-7A beside FZ-1. After locating fuse FZ-1 in panel P1 and noting its size and shape, you have all the information you need to replace the fuse.

The main reason that we did not check the contacts of CB-1 is that it is always safer to check and replace fuses within a system than to work with a high voltage like 440 VAC. If after replacing fuse FZ-1, indicating lights L-5 and L-6 are still out, then a voltage check must be made of contactor CB-1. For our explanation when we replaced fuse FZ-1, indicating light L-5 lit but L-6 is still out, so we still have a problem.

TRANSFORMER MALFUNCTION.—The only indication necessary for the proper activation of our motor controller circuit is indicating light L-6. This gives us an indication that we have 115 VAC control supply available to operate the components of the control circuit. By looking at figure 7-7A we see that the only components between light L-6 and the two phase output from the 440 VAC power supply are fuses FZ-1 and FZ-2 and transformer TPZ-1.

By checking lights L-4 and L-5, which are lit, we know that CB-1 and fuses FZ-1 and FZ-2 are functioning properly. Since this leaves TPZ-1,



84.33.1

Figure 7-7A.— Motor start circuit.

we must now assume that our problem lies with the transformer.

From your study of transformers (Basic Electricity), you should remember that a transformer is a device with no moving parts that transfers energy from one a-c circuit to another by electromagnetic induction. The energy always is transferred without a change in frequency, but usually there are changes in voltage and current. A stepup transformer receives electrical energy at one voltage and delivers it at a higher voltage. Conversely, a step-down transformer receives energy at one voltage and delivers it at a lower voltage.

A simple transformer consists of two coils very close together, electrically insulated from each other. The coil to which the a-c voltage is applied is called the "primary." It generates a magnetic field which cuts through the turns of the other coil, called the "secondary," and generates a voltage in it. The coils are not

	FUZE (FZ)
	CIRCUIT BREAKER (CB)
	INDICATING LIGHT (L)
	OVERLOAD RELAY (RK) RELAY COIL (R)
CB-1	SHIPS SUPPLY CIRCUIT BREAKER (P1)
FZ-1	PHASE(A) LINE FUZE 440 VAC (P1)
FZ-2	PHASE(B) LINE FUZE 440 VAC (P1)
FZ-3	PHASE(C) LINE FUZE 440 VAC (P1)
L-1	TRAIN MOTOR ENERGIZED
L-2	ELEV. MOTOR ENERGIZED
L-3	440 VAC PHASE(C) AVAILABLE (P1)
L-4	440 VAC PHASE(B) AVAILABLE (P1)
L-5	440 VAC PHASE(A) AVAILABLE (P1)
L-6	115 VAC CONTROL SUPPLY AVAILABLE
L-7	TRAIN MOTOR CONTACTOR ENERGIZED
L-8	TIME DELAY RELAY ENERGIZED

	RELAY CONTACTS NORMALLY OPEN (N.O.)
	RELAY CONTACTS NORMALLY CLOSED (N.C.)
	MANUAL OPERATED SWITCH (SM) INTERLOCK SWITCH (SI)
	TRANSFORMER (TPZ)
L-9	ELEV. MOTOR CONTACTOR ENERGIZED
L-10	EM/RUN RELAY ENERGIZED
RT 1	TRAIN MOTOR CONTROL RELAY (P2)
RE 1	ELEV. MOTOR CONTACTOR RELAY (P2)
RK 1	EM/RUN RESET RELAY (P2)
RK 2	TIME DELAY RELAY .8 SEC DELAY ON-ENERG. (P2)
SM 1	MOTOR START SWITCH (N.O.)
SM 2	MOTOR STOP SWITCH (N.C.)
SM 3	EM/RUN START SWITCH (P2)
SIT	TRAIN SECURING PIN INTERLOCK SWITCH
SIE	ELEV. LOCKING PIN INTERLOCK SWITCH
TPZ-1	CONTROL SUPPLY TRANSFORMER (P1)

84.333.2

Figure 7-7B. — Motor start circuit legend.

213

physically connected to each other; they are however, magnetically coupled to each other. Thus, a transformer transfers electrical power from one coil to another by means of an alternating magnetic field.

Figure 7-7A shows that we have a 220 VAC input to the primary of transformer TPZ-1 and a 115 VAC output from the secondary, this makes TPZ-1 a step-down transformer.

For safety reasons it is always best to work with lower voltages wherever possible. Because the secondary of transformer TPZ-1 produces half the voltage of the primary, we'll work with voltages from the secondary and not the high voltage at the primary. The closest points in which to take low voltage meter readings from the secondary of TPZ-1 are points P1-1-1 and P1-1-6 (fig. 7-7A).

The designations P1-1-1 and P1-1-6 (fig.7-8A, 115 VAC control supply) simply mean panel No.1, terminal board No. 1, and terminals No. 1 and No. 6, respectively. Another type of designation, BX1-4-3, also shown in figure 7-8A and used later in this chapter, means general component box No. 1, terminal board No. 4, terminal No. 2.

These wire connections can be used as test points to determine the area of the motor start circuit that has failed. Also shown in figure 7-8A are wire designations WS-101 and WS-102. They represent just two wires of the 115 VAC control supply circuit. The purpose of any wire designation is to identify each wire of a unit or group of an entire system. In wire designation WS-101, WS means wire single conductor, and 101 means wire number one of the power distribution group. Each gun system OP contains a list of all cable and wire designations which identifies by groups each wire and cable assigned within a group. For example, any wire number from 100 through 199 could be assigned to a gun system power distribution group, whereas wires numbered 1000 through 1999 could be assigned to a gun's loading system.

Wire designation aids in installation, maintenance, and trouble shooting. Each wire is identified regardless of its physical location. That is, the wire carries the same designation throughout the system. This makes for easy identification as shown in figure 7-8B.

On many new gun systems wire designation also identifies the terminal points each wire is connected to. For example a wire could be identified by WS-102, (BX1-4-4/P2-3-5). Looking at figure 7-8B, you see that wire WS-102 runs from connection box 1 (BX1) terminal board 4 (TB-4) terminal 4, to panel 2 (P2) terminal board 3 (TB-3) terminal 5. This type of identification also helps when performing authorized changes to the equipment. By matching the wire designation to the terminal points the wire is connected to, you can ensure that the wires are connected to the proper terminals.

Also shown in figure 7-8A are transformer terminal markings H1, H2, X1, and X2 for TPZ-1. Generally, the high voltage leads are marked H and the low voltage leads marked X. These markings are used when connecting a transformer into a circuit.

Checking Transformer Voltage Output

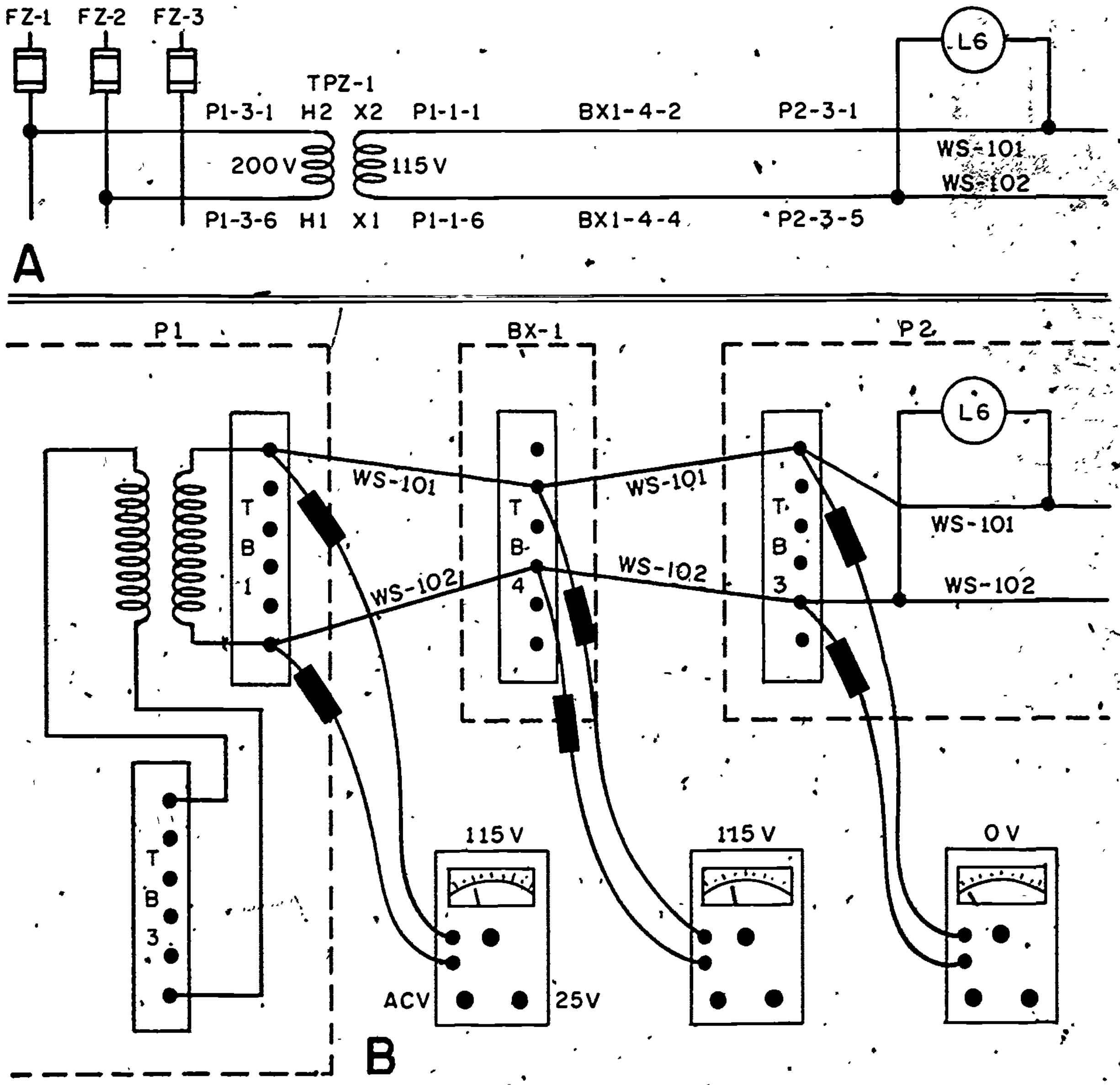
The simplest way to check the output of TPZ-1 is to take a voltage reading at terminal points P1-1-1 and P1-1-6 (fig. 7-8A). Set up a multimeter for a-c voltage readings. Position the eight position switch (2) in figure 7-6 at 500 V and switch (1) at ACV. The purpose of setting switch (2) at 500 V is a safety precaution taken which will prevent damage to the meter if a high voltage is present across terminals P1-1-1 and P1-1-6 due to component failure. Since there is 220 VAC present at the primary of TPZ-1, then there is also a possibility of having 220 on the secondary of the transformer.

Caution: When taking any voltage readings, always set the range switch (2) at the highest range as a protection to the meter.

When taking voltage readings, be sure not to touch the metal parts of the test leads when the leads are touching the terminal test points. The test leads can be applied to either test point because polarity of the leads does not matter when taking a-c voltage readings.

Apply the test leads across the secondary source of TPZ-1. If any voltage is present at terminal points P1-1-1 and P1-1-6, the meter pointer (needle) will deflect to the right. For the purpose of explanation, there is no voltage present at these terminal points.

CHECKING FOR AN OPEN TRANSFORMER.—To check out the transformer, first position CB-1 to the off position (fig. 7-7A). Attach a warning tag to the open switch stating that the circuit was opened for repairs and shall not be closed except by direct orders from the person who opened the switch. At P1 panel remove fuses FZ-1, and FZ-2. These are safety precautions which should be observed before disconnecting any wires. It is also a good idea to test a supposedly deenergized circuit with a voltage tester before commencing work on a circuit even though you

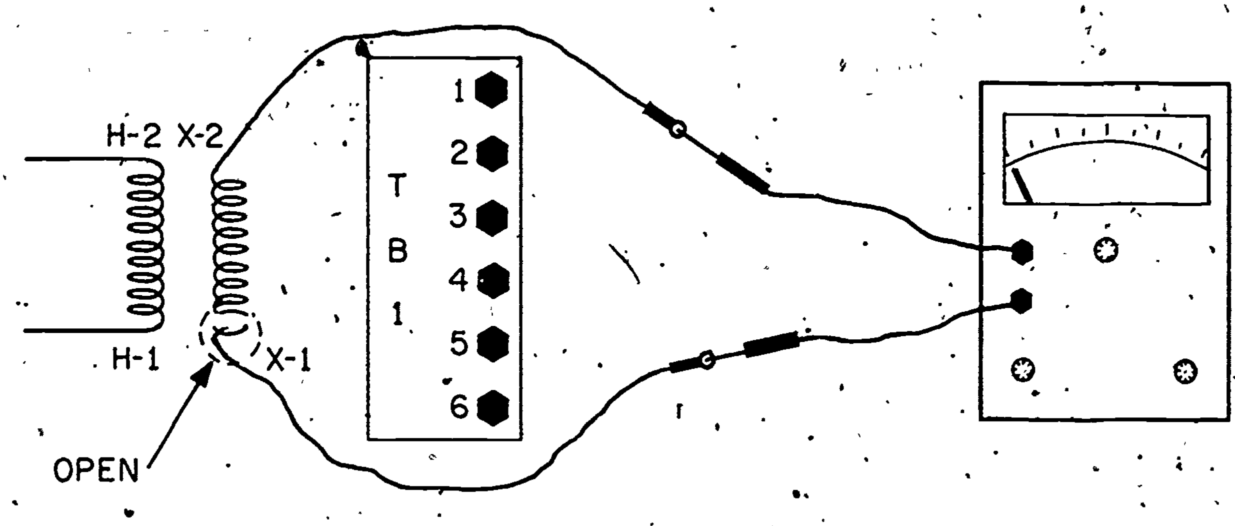


84.334

Figure 7-8. — Circuit abbreviations.

removed the fuses from the circuit, these tests are taken at P1-3-1 and P1-3-6. After ensuring that the circuit is deenergized, disconnect wires X-1 and X-2 on transformer TPZ-1 from terminals P1-1-1 and P1-1-6 (fig. 7-9).

Caution: Never use a multimeter as an ohmmeter on an energized circuit. Set up the multimeter to take resistance (ohms) readings, steps 4, 5, and 6 in figure 7-6. Apply the test leads to the disconnected leads of TPZ-1 as shown in figure 7-9. If the transformer secondary leads are open, the meter reading would indicate maximum resistance and the pointer would remain at the left side of the meter (fig. 7-9). This indicates that there is no complete circuit through the secondary of TPZ-1, or an open circuit.



84.335

Figure 7-9.—Checking transformer output.

REPLACING TRANSFORMER TPZ-1.—Before a new transformer can be connected into a circuit, it is necessary to know which transformer leads are primary and which are secondary. Most transformers have their terminal leads marked by either numbers, letters, or color coded wires.

If transformer leads are not marked, the primary and secondary leads must be determined. Usually high and low voltage leads are brought out on opposite sides of a transformer casing as shown in figure 7-10. The process of checking out which leads are primary and which are secondary is called phasing out the windings and is explained in Basic Electricity.

The first step to take when connecting TPZ-1 into the circuit would be to connect the high voltage lead H1 to terminal P1-3-6 and H2 lead to terminal P1-3-1 as shown in figure 7-8A. After the connections have been made, activate the power distribution circuit by replacing fuses FZ-1 and FZ-2 and then positioning CB-1 to ON.

Set up a multimeter to take a-c voltage readings, remembering to set the range switch at its highest range setting. Apply the test leads to the secondary leads of X1 and X2 of TPZ-1. The meter reads 115 VAC, this gives us an indication that the transformer is functioning properly. We can now connect the secondary leads of TPZ-1 into the circuit.

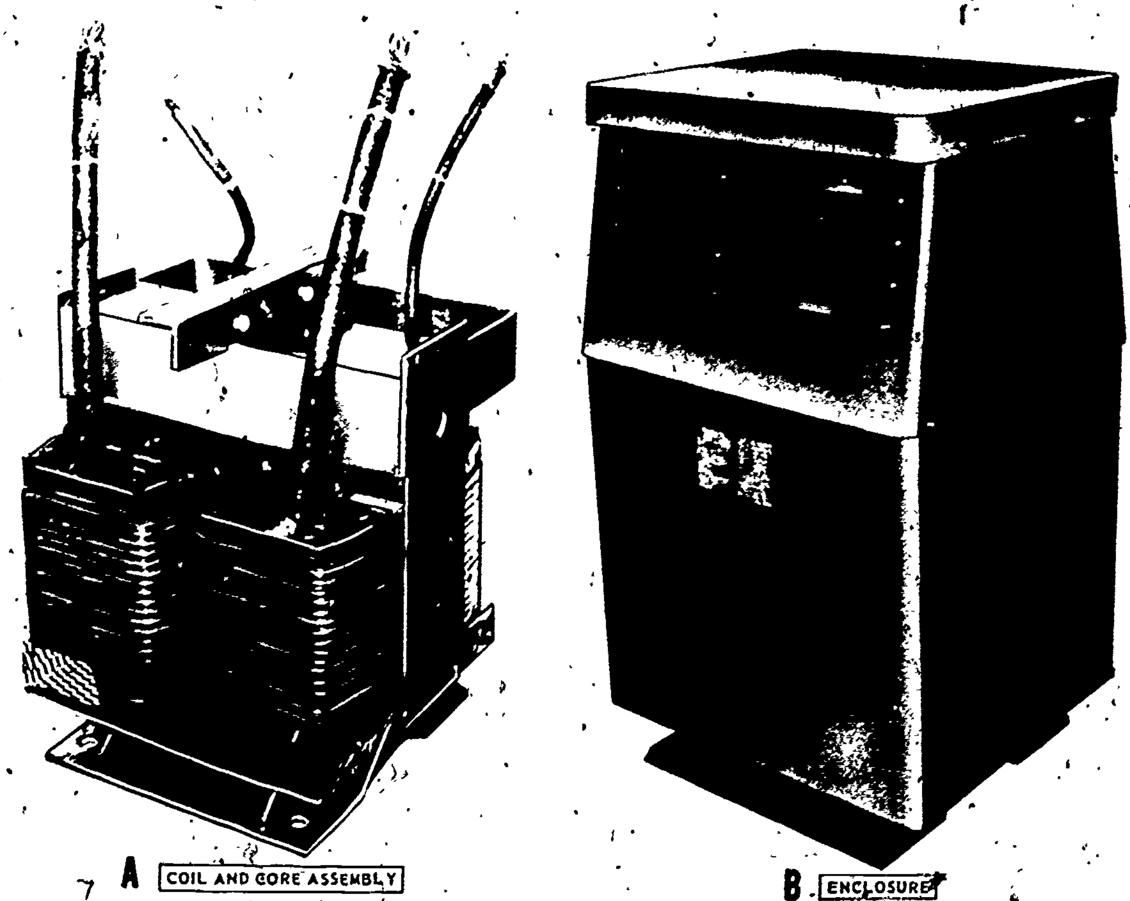
First we deenergize the circuit and tag the open switch of CB-1. We then ensure that the circuit is deenergized by taking voltage readings at the secondary of TPZ-1, the multimeter should read zero. Since the circuit is safe to work on, we can now connect the secondary leads X1 and X2 to terminals P1-1-1 and P1-1-6, (fig. 7-8A).

Make sure that all terminal connections are tight and then energize the circuit by positioning CB-1 to ON; if all goes well, indicating light L-6 should light. If for some reason L-6 is still out, the next step would be to check the light bulb for L-6 to see if it is burned out. The easiest way to do this would be to replace it with a new one. After replacing the bulb and with L-6 still out, we can make one more fast check and that would be to try and start our motors by pressing start switch SM-1. If this does not help, our next step would be to analyze the circuit by tracing out its components.

Circuit Testing

To trace the circuit shown in figure 7-7A, we must first go over the troubleshooting steps we have taken up to this point.

First we found that by replacing blown fuse FZ-1, we received all normal indications for our 440 VAC supply circuit to the electric motors. Second, when we replaced transformer TPZ-1, we had 115 VAC at the secondary of TPZ-1 but we still did not have an indication of 115 VAC supply available at light L-6. Both the fuse and transformer were causes of part of our circuit failure but replacing the light bulb at



147.125

Figure 7-10. — Single-phase transformer for shipboard use.

L-6 did nothing to add to the solution of our problem.

Look at figure 7-8A, we see that the only components between TPZ-1 and light L-6 are two wires (WS-101 and WS-102) and the terminal boards to which they are connected.

We know that we must have 115 VAC at start switch SM1 in order to energize train motor contactor relay RT-1. The contacts of RT-1 complete the run circuit to the train motor and also complete the circuit to our elevation motor contactor relay RE-1 (fig. 7-7A).

Because we have no indication at L-6 that we have 115 VAC available for our relays, we must assume that our problem lies somewhere between transformer TPZ-1 and light L-6.

POINT TO POINT MEASUREMENTS. Look at figure 7-8B, this illustration shows us how point to point voltage measurements can be made using a multimeter. First we ensure that our circuit is energized. We can then start checking our circuit by first locating the nearest connective point from which our 115 VAC control supply enters our relay circuits.

We know that the 115 VAC supply starts at the secondary of TPZ-1. Look at part A of figure 7-8. Start at the secondary (X) side of TPZ-1 and locate the first points shown on wires WS-101 and WS-102. We find that they are P1-1-1 and P1-1-6, these are the points at which we will start our point to point voltage tests.

First we locate panel P1 and the terminal board and terminal points indicated on figure 7-8B. We again set up our multimeter to take voltage readings. We then apply the test leads across terminals 1 to 6 of TB-1 (fig. 7-8B).

Our meter indicates 115 VAC at these points. This is a normal indication; therefore, our circuit is complete to this point.

WARNING: Under no circumstances should any person reach within or enter any enclosure for the purpose of servicing, adjusting, or troubleshooting electric or electronic equipment without the immediate presence or assistance of another person capable of rendering aid. Such person must be familiar with the methods of artificial respiration.

Next look at figure 7-8A and locate the next two test points between TPZ-1 and L-6. These are BX1-4-2 and BX1-4-4. We locate connection box BX1 and find terminal board TB-4 and terminals 2 and 4 (part B of figure 7-8). We apply our test leads across terminals 2 and 4 and again our meter reads 115 VAC; our circuit is good up to these last two points.

Our next step is to locate the next test point, P2-3-1 and P2-3-5 (part B of figure 7-8). We apply our test leads across terminals 1 and 5, and this time our meter reads zero volts. Since we must have a complete circuit for current to flow, the zero voltage reading indicates to us that we have an open circuit or a loose connection between BX1 and panel P-2.

LOOSE CONNECTIONS.—Troubles resulting from loose or open connections caused by shock or wear become noticeable through faulty operation or complete failure of the equipment concerned. Evidence of a loose connection could be a burned area around a terminal connection caused by arcing. Many circuit casualties caused by loose terminal connections occur after Ordalts, Shipalts, or field changes are performed on electrical equipment. It always is a good idea to check all terminal connections after a yard period or every time ordnance equipment has been worked on by either the ship's force or yard personnel. By checking the connections at TB-3 in P2 panel, we find that our problem lies at TB-3-1. The terminal screw for the terminal lug at terminal 1 is missing and wire WS-101 was off the terminal connection causing an open circuit. After replacing wire WS-101 and ensuring that the terminal screw is secured properly, we find that indicating light L-6 is now lit.

To make certain that the circuit is working properly, all we have to do is depress start button SM-1, this action starts both the train and elevation motors (fig. 7-7) and our circuit is back to normal.

WARNING: Exercise extreme care when working on electrical circuits. Always remove power sources and remove fuses before replacing wires or circuit components.

CURRENT MEASUREMENTS

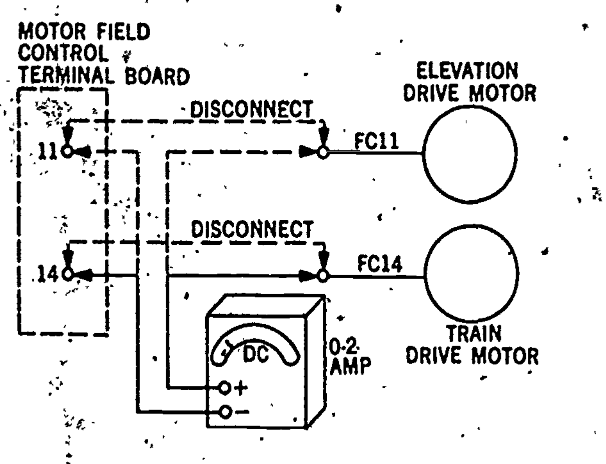
Unless an ammeter is already an integral part of a circuit, current measurements are rarely taken when troubleshooting ordnance equipment. If current measurements are taken the meter is placed in series with the circuit under test. One example of taking current readings would be to check the output of a drive motor field control windings. For a 3"/50 gun system, this is done by the following steps. (Refer to figure 7-11).

1. With the circuit breaker open, disconnect the lead at terminal FC14 (FC11) of the motor field control. Set up a multimeter to take direct-current (d.c.) ammeter readings (2.0 amp scale). Connect the negative terminal of the meter to terminal 11 (14) of the field control and the positive terminal of the meter to the disconnected lead FC11 (FC14).

2. Close the circuit breaker, place the control selector switch in local-surface position, and press the start button.

3. When the equipment is energized, check the reading of the ammeter. It should read about 1.4 amperes. If the meter reads higher or lower, an adjustment of the excitation voltage of the motor field control windings would be necessary.

This kind of test usually is performed during a regular maintenance action.



84.336

Figure 7-11.—Checking motor field control.

Ground Detection Indicator

Another type of current measuring device you should be familiar with is the ground detection indicator. A ground detection indicator is a continuous monitoring system designed to detect a first ground. Because the power distribution and control circuits are powered by ungrounded currents, the first ground will not always cause a malfunction. However, if the first ground is not discovered, and a second develops, the result could be an illogical and destructive sequence of gun mount operation. The reason for this action is that the two grounds act as an electrical conductor between the grounded components. A ground detection indicator will produce audio and visual indications if a gun system develops a short or ground.

For example, if a ground were to occur in the 5"/54 automatic loading system, and it was not corrected, perhaps nothing would happen. Operations might be normal. If a second ground develops, however, and some safety interlocks are energized due to the grounded circuit, the equipment could be damaged and personnel might be injured.

The elimination of grounds and potential grounds is preventive maintenance and the responsibility of gun crews.

When the ground detector indicator indicates that some part of the gun system is grounded, the Gunner's Mate must determine the location and cause of the ground. To do this, he uses his multimeter. Ground detection indicators are being installed on all new gun and missile systems.

TRANSISTORS

A transistor is a solid state device constructed of semiconductor materials. Transistors are capable of performing many of the functions of different types of electronic and electrical components such as electron tubes, interlock relays, switches, control relays, and current amplifiers.

In many cases, transistors are more desirable than tubes for ordnance equipment because they are smaller, require no warmup power, and operate at low voltages with comparatively high efficiency.

Semiconductors are the basic components of a transistor. How these materials behave and the electrical conduction properties which give the transistor its basic characteristics are explained in Basic Electronics, NAVEDTRA 10087.

In some ways, an electron tube and transistor are similar (electron tubes are explained in Basic Electronics). Both have three elements as illustrated in figure 7-12, and the functions of these elements can be compared.

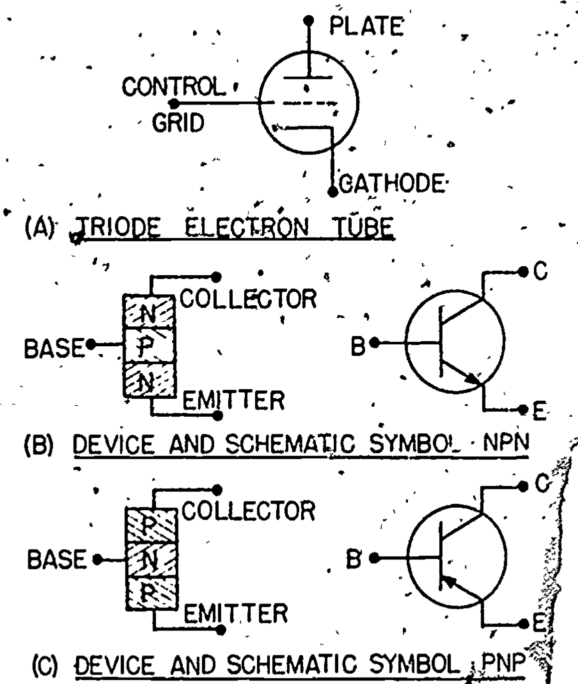
In the electron tube the three elements are:

1. The cathode which gives off, or emits, electrons.
2. The grid which controls the flow of electrons.
3. The plate which attracts, or collects, electrons.

In the transistor the three elements are:

1. The emitter which gives off, or emits, current carriers (electrons or holes).
2. The base which controls flow of current carriers.
3. The collector which collects current carriers.

Transistors are classed as PNP or NPN, according to the arrangement of impurities in the crystal. The collector of the PNP transistor



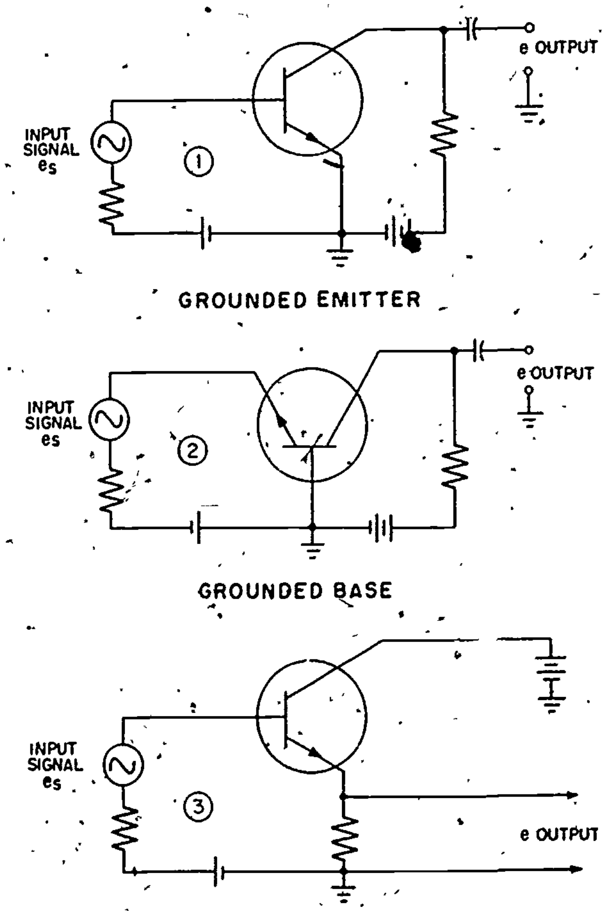
1.280(84A)
Figure 7-12. — Element comparison of tubes and transistors.

collects holes, whereas the collector of the NPN transistor collects electrons. The schematic symbols for both types are similar but not identical, as illustrated in figure 7-12. A heavy straight line represents the base, and the two lines slanted toward the base represent emitter and collector terminals. An arrow-head in the emitter line always points toward the N-type material and against the direction of electron flow (+ to -). Thus, if the arrow points toward the base line, the base in of N-type material. Since the base is always of the opposite type of material from emitter and collector, the transistor is of the PNP type. Similarly, if the arrow points away from the base line (toward the emitter), the transistor is of the NPN type. In other words, the arrow points toward the base in PNP transistors and away from the base in NPN transistors, (fig. 7-12).

Transistors are generally connected in one of three basic circuits (fig. 7-13). These circuits are the (1) grounded-emitter, (2) grounded-base, and (3) grounded-collector. The circuits are shown here merely to point out the three most common transistor circuit arrangements.

Notice that all three of these circuits have a common feature. The signal is always applied between the base and the emitter. By controlling this junction with forward or reverse bias, we regulate current flow in the output circuit.

Transistors and semiconductor devices are explained in detail in Basic Electronics.



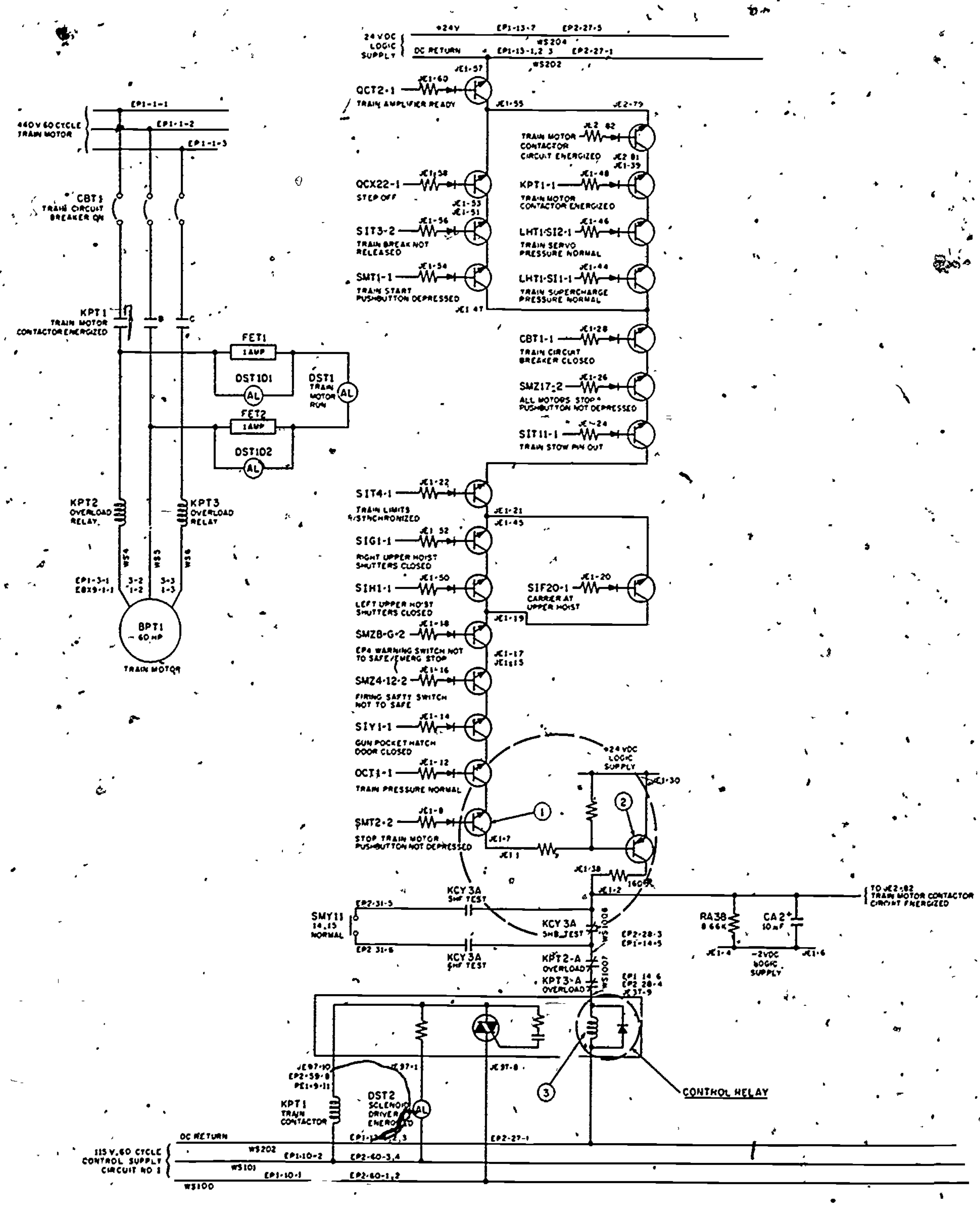
72.36

Figure 7-13. — Basic circuits.

Solid State Circuits

Figure 7-14 illustrates part of a solid state switching circuit used in the 5"/54 MK 9 gun system. Two types of transistors are used. The NPN transistors serve as switching elements; the one PNP transistor functions as the output transistor for that circuit. Since a transistor, like a simple switch, is characterized by a low resistance to current flow when it is closed and a high resistance when it is opened, they can be used as switches in a solid state electrical circuit. Transistors used as switches are operated in one of two conditions: The transistor is cut off (nonconducting) to open a circuit or the transistor is saturated (conducting heavily) to close a circuit. Under these conditions, it acts as a simple on-off toggle switch. The transistors illustrated in figure 7-14 are saturated or cut off by properly biasing them for the desired condition of operation.

In the following discussion of the functions of a solid state circuit only two transistors will be used. It must be remembered that, for that circuit to function properly, all of the transistor switches in the circuit must conduct at the same time to provide a single path for current flow. The two large circles shown in figure 7-14 show two transistors and one relay. These elements have been put into a simple circuit that will help you follow current flow during our discussion. Part A of figure 7-15 shows the electrical and electronic elements that are circled in figure 7-14, with the exception of switch SM-1. The switch has been added to illustrate how this circuit works. For the purpose of explanation SM-1 is designated as the train start pushbutton. The purpose of the circuits in figure 7-14 and figure 7-15 is to energize a



84.337

Figure 7-14.—Train start circuit.

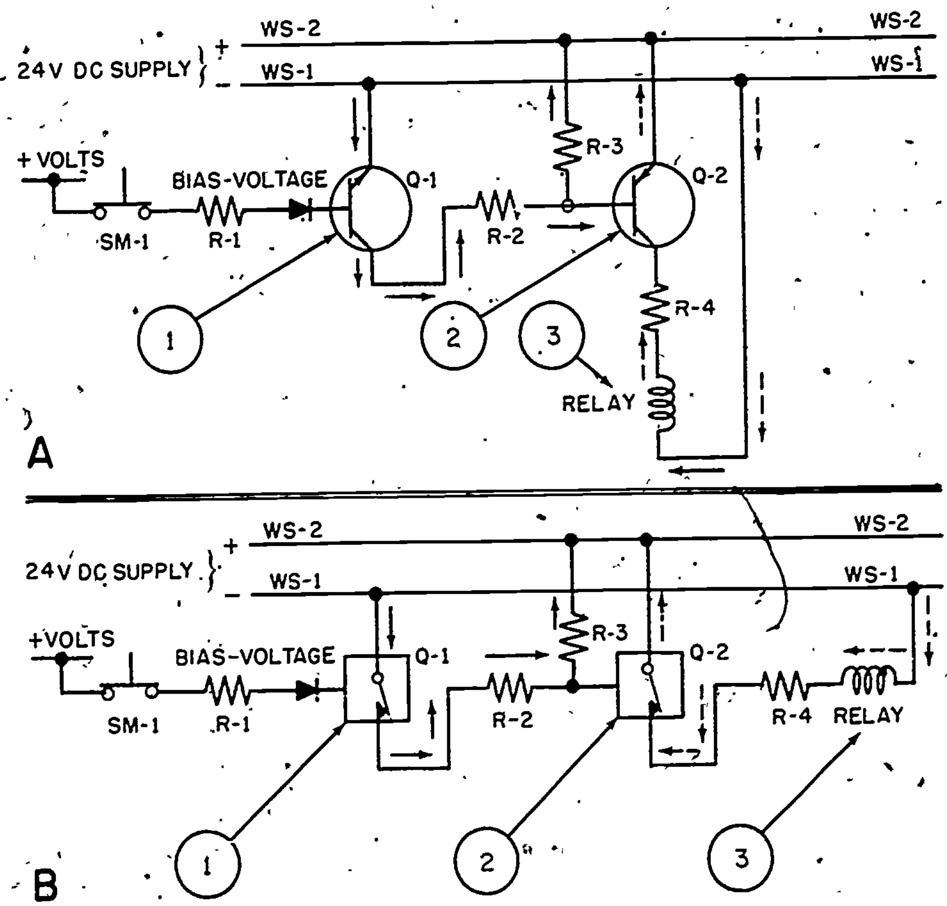


Figure 7-15.—Basic solid state circuit.

contactor for the train motor. This is the electric drive motor for the CAB hydraulic system used in the training mechanism of the 5"/54 MK 9 gun system.

The control relay shown in figure 7-15 is part of the circuit to the train motor and, when energized, will complete the circuit that energizes KPT1 (figure 7-14) which is the train contactor to the train motor BPT1. The purpose of part B of figure 7-15 is to show how a transistor resembles a switch. When these switches are closed, current will flow and the relay in that circuit will energize. By using both parts of figure 7-15 you should be able to understand more easily how current in this type circuit flows from the negative side to the positive side of the 24v d.c. input. Current flow is designated by the direction of the arrows.

When the train start pushbutton (SM-1) is depressed, a positive bias voltage will be present at the base of transistor Q1. This voltage forward biases the transistor in the base circuit causing bias current to flow in the base circuit, and placing a positive voltage on the base of Q1. This bias voltage fires (closes the switch) transistor Q1. Current from the 24v d-c supply will flow (solid arrow) from the negative side (wire WS-1) through Q1 to the voltage divider resistors (R-2 and R-3) and back to the positive side of the 24v d-c supply (wire WS-2). The resistors are used to provide the proper bias voltage to fire transistor Q2. When current flows through the voltage divider resistors R-2 and R-3, a negative voltage is developed between the base of Q2 and its emitter. This forward bias causes Q2 to conduct.

Transistor Q2 in this circuit is the output transistor and is used to perform the work; that is, to energize the relay in the circuit. When Q2 is properly biased, current in the second part of the circuit flows (dotted line) from the negative side of the 24v d.c. supply (wire WS-1) through the relay and resistor R-4 and through Q2 to the positive side of the 24v d.c. supply (wire WS-2). There are two basic circuits that make up this type of solid state system. Transistor Q1 acts as an interlock for the output transistor Q2. This part of the circuit prevents starting the train motor until all the safety interlocks have been met. The circuit from transistor Q2 serves as the relay supply that energizes the control relay to the train contactor KPT1.

Notice in figure 7-14 there are several other transistors in series with the transistors used as Q1 in figure 7-15. For current to flow through Q1 to develop a forward bias for Q2, all the transistors in series with Q1 must be forward biased.

Servicing Notes

Semiconductors, like electron tubes, are available in a large variety of types, each with its own unique characteristics. The characteristics of each of these devices usually are presented in specification sheets, or they may be included in tube or transistor manuals. The specifications include (1) a general description of the device, (2) the kind of semiconductor materials used, (3) some common applications of the device, (4) absolute maximum ratings, (5) collector power dissipation, (6) Alpha or Beta of the device, which are sometimes called the current transfer ratio, (7) the leakage current from collector to base when no emitter current flows (called collector current cutoff), and (8) additional information for engineering design purposes. The technician should know the semiconductor specifications before attempting a test to determine the quality of the device.

A standardized system of numbers and letters is used for designating diodes and transistors.

1. The first number indicates the number of junctions. Thus, 1 designates a diode (1 junction), 2 designates a transistor triode (which may be considered as made up of two diodes, the emitter-base and base-collector diodes), 3 designates a semiconductor tetrode (a four-element transistor with 3 junctions).

2. The letter N following the first number indicates a semiconductor.

3. The 2- or 3-digit number following the letter N has no particular significance, except that it indicates the order of registration. When this number is followed by a letter, it indicates a later, improved version.

Thus, a semiconductor designated as type 2N345A signifies that it is a 2-junction (3-element) transistor of semiconductor material, and that it is an improved version of type 345.

The arrangement and coding of transistor leads are shown in figure 7-16, A through E.

Figure 7-16A shows a transistor in an oval case. The collector lead is identified by a wide space between it and the base lead which, in turn, is followed by the emitter lead.

The transistor at B is contained in a round case with the three leads in line and equally spaced. The collector lead is marked on the case by means of a color dot, usually red. The other two leads are the base and emitter (2 and 3, respectively).

In figure 7-16C, the collector lead is marked by a red line on the case. The base and emitter leads follow clockwise around the device in that order.

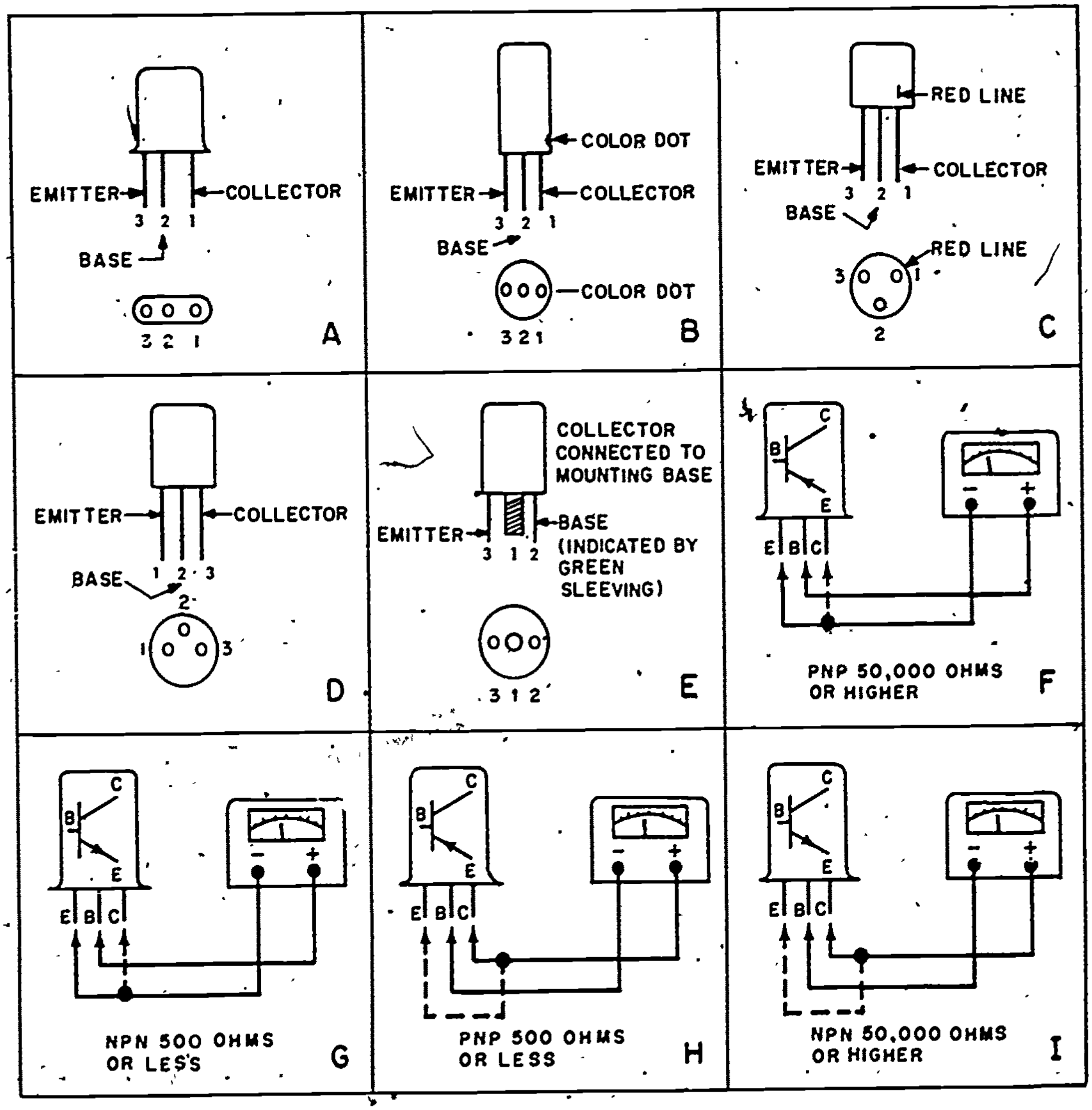
The leads on the transistor shown at D are located at three points of a quadrant. When viewed from the bottom in a clockwise direction, the first lead following the blank space is the emitter (1), followed by the base (2) and the collector (3).

Figure 7-16E shows a conventional power transistor. Here, the collector is connected to the mounting base, the mounting bolt forming the conductor for the collector. The base lead is identified by its green sleeving. Connecting one of the transistor elements (the collector in this case) to the mounting base provides additional cooling.

Although generally more rugged than the electron tube, the transistor is affected by electrical shock, heat, humidity, and excessive radiation.

Transistors may be damaged beyond repair by applying the incorrect polarity to the collector circuit or excessive voltage to the input circuit. Careless soldering techniques that overheat the transistor can also severely damage the device.

One of the most frequent causes of damage to a transistor is the electrostatic discharge from the human body when the device is handled. Such damage may be avoided by discharging the body to the chassis containing the transistor before the repair procedure begins.



1.288(84A)

Figure 7-16.—Transistor lead identification and transistor testing.

Small-sized tools should be used when servicing transistors and their associated circuit components. Small cutting pliers and needle-nose pliers are more useful than the conventional sizes. Narrow-blade screwdrivers are more useful than the larger types. A sharp-pointed thin metal probe is helpful in cleaning solder from small openings or areas. Soldering is performed more satisfactorily with a small low-voltage soldering iron or pencil (35 to 40 watts) having a narrow point or wedge.

The following precautions should be taken when it becomes necessary to replace a transistor which is soldered in the circuit. Before removing the old transistor, note the orientation of the collector, base, and emitter leads. Cut the leads of the new transistor to the proper length, using sharp cutters to prevent undue stress on the leads entering the transistor. Then, with the transistor properly positioned, solder the leads to the connections, using the proper solder and soldering iron and a heat sink.

TROUBLESHOOTING TRANSISTOR CIRCUITS

To find a bad transistor in a circuit, use the same methods for locating any other defective component. The first step in checking for trouble in transistor circuits is a thorough inspection of the equipment. Loose connections, broken leads, corroded terminal connections and other common type circuit problems should be corrected before checking for a bad transistor. Because the transistor is one of the most reliable components of a circuit, it should be the last to be suspected for causing circuit failures. If a transistor is suspected of causing trouble, however, the easy way to correct the problem is to replace the transistor.

If the new transistor restores the circuit to proper operation, the transistor that was replaced is the cause of the trouble.

CAUTION: Never remove or replace a transistor while the power source is connected to the circuit. Failure to observe this caution may result in damage to the transistor from a surge (rise) in current within the circuit.

Because some types of transistors are plug-in types, the above caution should always be observed. It is easy to forget to secure power sources when working with plug-in type transistors.

If the new transistor is damaged when placed into a circuit, the circuit must be checked for defects that caused the damage. However, if the transistor itself is suspected, it can be removed from the equipment for testing. In equipment employing sockets for the transistor, it is only necessary to remove the transistor from the socket (plug-in type). If the transistor is soldered, extreme care must be taken to prevent damage to the transistor from heat of the soldering iron when unsoldering the transistor.

Resistance Tests

A check can be made of a transistor by means of a multimeter. There are two general reasons for testing a transistor. First, you want to know whether a known transistor is good, or second, you may have an unmarked transistor and want to know its type (NPN or PNP). Connections for these tests are shown in figure 7-16F through I.

Connect the positive ohmmeter lead to the base of a transistor (F in figure 7-16). If a high resistance reading (50,000 ohms or higher) is obtained between the base and emitter and the base and collector, the transistor is a PNP type. If a low reading (500 ohms or less) is obtained, the transistor is an NPN type, (G in fig. 7-16). If the negative ohmmeter lead is connected to the base of the transistor as shown in H and I of figure 7-16, the result would be reversed. If the correct resistance readings are not obtained from the ohmmeter test, the transistor should be replaced.

Short Circuit Tests

To make a test to determine whether shorts or decreased resistance between elements have occurred, the resistance ratios from emitter to base and collector to base should be 500 to 1 or more. The direction of the ratio depends on whether the transistor is an NPN or PNP type. The resistance from collector to emitter should be nearly the same when measured in either direction. When making this test, ohmmeter readings should be taken in both directions (reverse the test leads).

Test Equipment Specifications

A multimeter which passes a current of more than 1 milliampere through a transistor cannot be used safely when testing transistors. Many transistors are designed to operate in low-voltage circuits. Multimeter AN/PSM-4 uses a battery power supply of 1.5v d.c. and 22.5v d.c. When using this meter, make sure that the voltage used never exceeds the voltage ratings of the transistor under test. If there is any doubt at all, use another meter to measure the voltage across the ohmmeter leads on each resistance range. This measurement must be made with a voltmeter having a high resistance such as a VTVM. For further information on transistor troubleshooting, refer to Basic Electronics.

LOGIC DIAGRAMS

In this section of the chapter we will discuss logic diagrams. We will not attempt to cover all phases of the subject but will introduce you to the symbols used in logic diagrams and give a brief explanation of how the symbols are used. Logic diagrams use functional symbols instead of words to represent circuit functions or sequential events in circuit operation.

You might wonder, as a GM, why you should know how to read logic diagrams. The answer to this is quite simple. As a GM 3 you are required to know the function of electrical and electronic circuit components. As a GM 2 you are required to know symbols commonly used in electronic diagrams. So it behooves every GM to understand the meaning of symbols used in schematic diagrams and drawings.

In this age of advanced electronic devices, more and more manufacturers are using logic diagrams to show circuit operation. This means that increasing numbers of publications are resorting to the use of logic diagrams. So careful study of the information presented here will give you a head start.

The skill in using logic diagrams depends, to a degree, on our ability to classify components as two-state devices. Examples of this are: a light is either on or off, a pushbutton switch is depressed or not depressed, a relay is energized or not energized.

Classification of some devices as two-state may be rather difficult. Consider as an example a three-position selector switch. When referring to one position of the switch, we can say it is either in that position or not in that position. If the switch is not in the position indicated, we can not determine with assurance what position the switch is in, however, we are able to describe the switch position as a two-state device.

There are many pairs of conditions that might be used to describe two-state operations. Some of these are:

High......................Low
Energized..............Not energized
Actuated................Not actuated
Closed....................Open
Running..................Stopped
On.........................Off

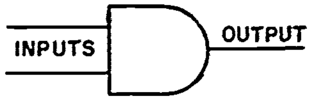
LOGIC SYMBOLS

We will now cover some of the symbols used in logic diagrams.

The first logic symbol shown in figure 7-17 is AND, which is described as "any device with two or more inputs and a single output, the output of which is ON only when all inputs are ON and is OFF when any one of the inputs is OFF".

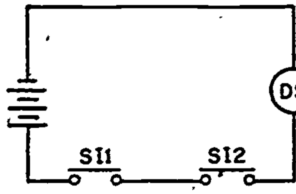
The electrical circuit shown in figure 7-18 represents an AND circuit. If it is assumed that the switches are inputs (the inputs are ON when the switches are closed and OFF when the switches are open) and that the output is the light, the output is ON when the light is glowing and OFF when the light is out.

The light circuit qualifies as an AND circuit because switch SI1 and switch SI2 must be closed (ON) before the light will glow (ON) and because, if one switch opens (OFF), the light will go out (OFF). You can see from figure 7-18 that this is a basic series circuit.



84.399

Figure 7-17. — Logic Symbol AND.



84.400

Figure 7-18. — AND circuit.

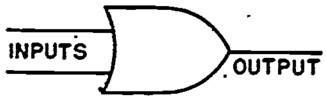
The second logic symbol shown in figure 7-19 is OR, which is described as "any device with two or more inputs and a single output, the output of which is ON when at least one input is ON and is OFF only when no inputs are ON."

The electric circuit shown in figure 7-20 represents an OR circuit. This circuit qualifies as an OR circuit because the light will glow (ON) if either switch SI1 or switch SI2 is closed (ON), and the light is out (OFF) only if both switches are open (OFF). Figure 7-20 is a basic parallel circuit.

Figure 7-21 shows a typical logic circuit which uses inverted and buffered switch outputs to trigger a solenoid driver. The solenoid driver, in turn, controls a solenoid which initiates a gun loading cycle. The circuit uses negative logic; that is, a low (ground) potential is the activating condition for the individual logic functions.

The circuit consists of AND gates, OR gates and interconnecting wiring. The circled numbers in figure 7-21 identify the gates. These identifying numbers normally are not shown on logic circuits but are shown here to assist in identifying the gates. The numbers within the gates identify the printed circuit board in EP2 panel on which the circuit is located. The numbers on the input and output lines of the gates identify the terminal pin that connects to that point.

Inputs to the logic gates are identified by both alphanumeric nomenclature and a brief description of what the input means. The input SIH 3-1 "HOIST DOWN" to gate 1 comes from point 1 of the inverter buffer associated with SIH 3. When the hoist is down, the switch is



84.401

Figure 7-19.—Logic Symbol OR.

activated and the high switch output through the inverter buffer produces a low logic input at point 1. (The inverted and buffered signals are applied to logic circuitry which produces the desired output only when all required conditions are present).

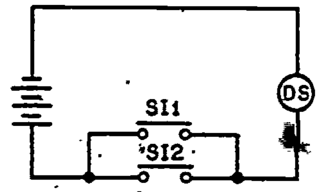
The description accompanying logic inputs to gates which end in a 2 or 1 denotes the condition of the equipment that is providing the logic input. For example, SIC 2-2 is NO POWDER CASE IN CRADLE (logic symbol 1 fig. 7-21). The description ending in 1 indicates the opposite POWDER CASE IN CRADLE.

Figure 7-21 can be classed as a typical gun loading logic circuit. It must be remembered, however, that no two circuits are identical in arrangement. The arrangement and inputs required for various circuits are determined by the output function of the component involved.

You will notice in figure 7-21, that all gates on the left are AND gates. Using gate (1) as an example, when inputs 67 and 68 and 80 and 81 are low, the output at 82 is low (activating). When any of the inputs is high, output 82 will be high (deactivating). The following table is a truth table of input and output conditions of gate (1).

Table 7-1.—TRUTH TABLE of 4-AND GATE CONDITIONS

Inputs				Output
67	68	80	81	82
HIGH	HIGH	HIGH	HIGH	HIGH
LOW	HIGH	HIGH	HIGH	HIGH
LOW	LOW	HIGH	HIGH	HIGH
LOW	LOW	LOW	HIGH	HIGH
LOW	LOW	LOW	LOW	LOW



84.402

Figure 7-20.—OR circuit.

It can be seen from figure 7-21 that the output of three AND gates ((2), (3), and (4)) is fed to two OR gates. Referring to gate (6) as an example, when 53 or 37 or 48 is low, output 36 is low. If one or more of the inputs to gate (6) is low, the output 36 will be low. The output from gate (6) must be low to activate the next logic gate, the circuit is complete when at least one input is low. Having inputs 37 and 48 wired together in this case does not affect operation of this OR gate. The following table is a truth table of 3-OR gate conditions.

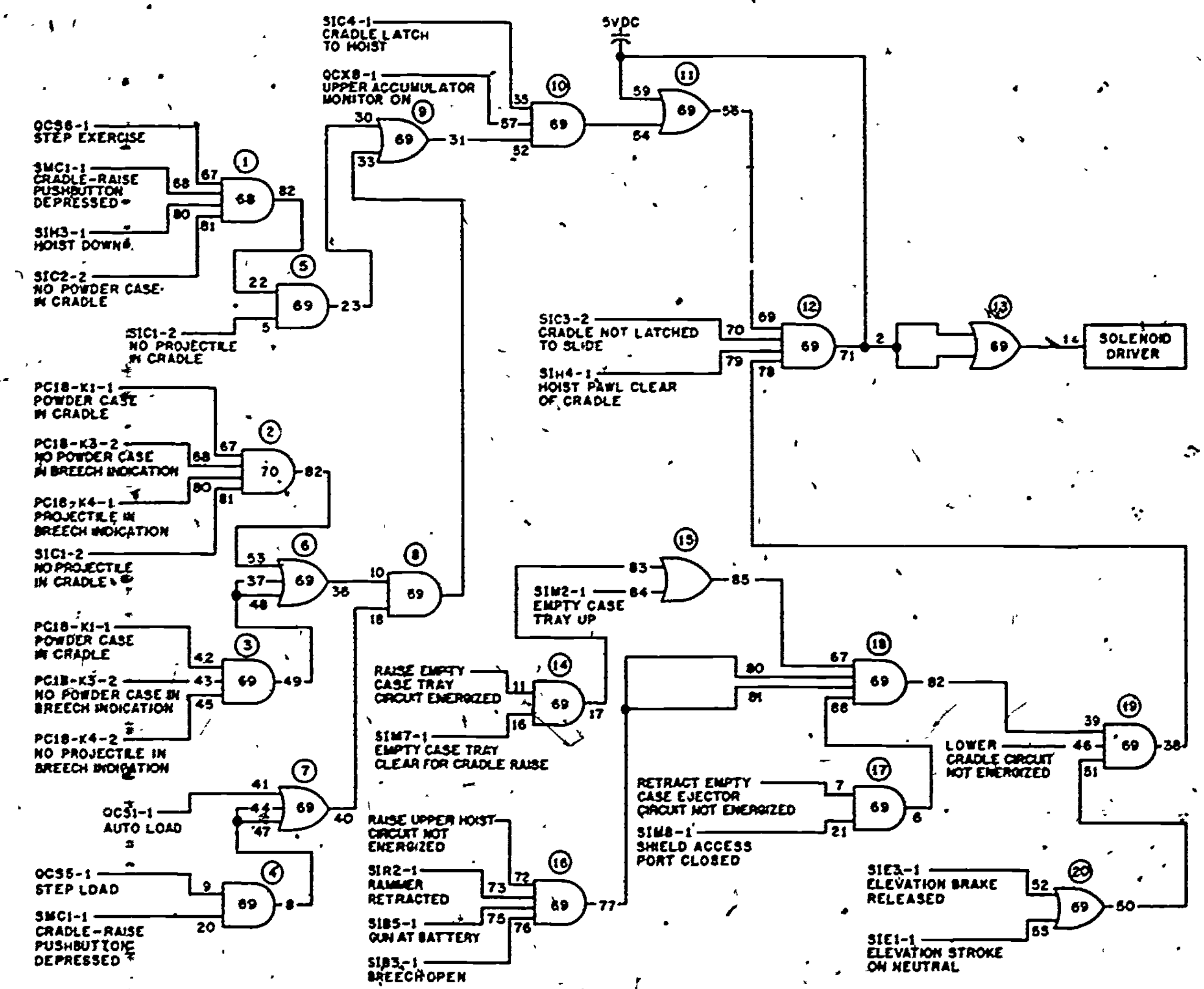
Table 7-2.—TRUTH TABLE of 3-OR GATE CONDITIONS

Inputs			Output
53	37	48	36
HIGH	HIGH	HIGH	HIGH
LOW	HIGH	HIGH	LOW
HIGH	LOW	HIGH	LOW
HIGH	HIGH	LOW	LOW
LOW	LOW	LOW	LOW

Comparing tables 7-1 and 7-2 you can see in an AND gate that, if any one input is HIGH, the output will be HIGH. By contrast, if any input to any OR gate is LOW, the output will be LOW.

LOGIC CIRCUIT OPERATION

There are two groups of gates in a gun loading logic system: mode selection gates and common gates. Mode selection gates are active when all conditions required for operation in



84.403

Figure 7-21.—Typical logic circuit.

a specific mode are present (example, step-load). Common gates are activated by inputs which are required to initiate a cycle in any mode of operation.

Thus mode selection gates (1) and (5) must be active to initiate a cycle in step-exercise; gates (3), (6), (7), and (8) in auto-load; and gates (4), (7), and (8) is step-load. A unique feature of the circuit in figure 7-21 is gate (2). The inputs to gate (2), which can be used with either step-load or auto-load, allow raising a powder case to the breech even though the breech contains a projectile. These conditions, which would exist only in the event of a misfire, allow clearing the gun with another powder case after the misfired case has been ejected.

In addition to the appropriate mode selection gates, all common gates (gates (10) through (20)) must be active to initiate a cycle. However, when a circuit contains an OR gate, only one input to the OR gate need be active. For example, in gate (15), either the empty case tray must be up or the empty case tray must be raising and clear.

When all conditions for an AND gate are active (low), the gate changes its output from high to low. Tracing the auto-load circuit, gate (3) is active when the cradle contains a powder case and the breech contains neither a powder case nor a projectile. The low output from gate (3) is applied to the gate (6) input. Since gate (6) is an OR gate, it requires only a single input to activate it and apply a low to gate (8). Gate (8) requires an additional input from gate (7) which is active when the gun mount is in autoload mode (or in step-exercise mode with the CRADLE—RAISE pushbutton depressed). When gate (8) output becomes low, gate (9) is activated. The remaining input conditions to gates (10) through (20) are required regardless of the mode of operation.

Gate (12), the final logic gate in this circuit, summarizes all logic inputs. This single output is inverted (changed from low to high) in gate (13) to trigger the solenoid driver. (The only purpose of gate (13) is to change the output of gate (12) from a low to a high, it has no other function). In addition to triggering the solenoid driver, the gate (12) output performs two other functions:

1. It feeds back to gate (11) to form a holding circuit. This low input to gate (11) is sufficient to hold the circuit, regardless of what happens to the inputs of gate (1) through (10), until an input to gate (12) and (14) through (20) deactivates the circuit at the end of a cycle. (When one of the inputs to gates (14) through (20) becomes high, the gate (12) output becomes high deactivating the circuit).
2. It applies a low signal to TIME CYCLE SELECTOR SWITCH in the back of EP2 panel. When correctly positioned, this switch and an associated timer automatically measure the elapsed time of logic circuit output. (This corresponds to the length of time required to complete a component cycle.)

SYNCHRO CIRCUITS

A synchro resembles an electric motor and like an electric motor is a basic electrical mechanism. Chapter 13 of this rate training manual explains servo-systems related to gun fire control systems. For you to fully understand these systems, you must have the background information about synchros.

United States Navy Synchros, Description and Operation Handbook, MIL-HDBK-225 (AS), and Synchro, Servo and Gyro Fundamentals, NAVEDTRA 10105, explain the types, principles, and functions of all synchros. You are urged to read those publications before taking up synchros in this section.

Synchro is the name given to a wide variety of position-sensing devices used to convert mechanical signals to electrical signals or to convert electrical signals to mechanical signals. The name synchro comes from the word synchronize, which means "to happen or take place at the same time." All synchros are self-synchronous; hence, the name is most descriptive of their basic action.

PURPOSE OF SYNCHROS

The purpose of synchros is the precise and rapid transmission of data among equipments and stations. The change in course, speed, and range of targets and the changes in a ship's position related to a target's position must be acted upon in a minimum of time. Speed and accuracy of data transmission are most important. Without the position-sensing device known as the synchro, the offensive and defensive capability of the Fleet would be greatly limited. Navy ships rely on synchros for rapid data transmission within weapon systems in such equipments as computers, fuze setters, sight setters, guns, turrets, rocket/missile launchers, and radar power drives. In many cases, the data is presented as visual information and acted upon by operating personnel, such as a sight setter in gun mount.

ADVANTAGES OF SYNCHROS

The flexibility of synchros over mechanical mechanisms such as gearing and shafting gives them marked advantages, for example:

1. The controlling unit can be a long distance from the controlled unit.
2. Any obstacle in the path can easily be bypassed by leading connecting wires around it.
3. The synchro system uses very little electrical power and eliminates the necessity of mechanical linkages between widely separated units.

Besides the advantages of using synchros over mechanical mechanisms, there are other advantages. They:

1. Provide continuous, accurate and visual reproduction of important or need-to-know information between widely separated stations.

2. Have good reliability, requiring minimum maintenance.
3. Are small in size, providing a significant saving in space and weight.
4. Have a wide adaptability without sacrificing precision.

Synchro systems are important in the field of ordnance in the control of naval weapons because of their accuracy and speed. Experience with naval weapons control and operation of ordnance readily prove the importance of the synchro mechanism. A point to remember is that naval weapons controlled from remote stations must use synchro systems for their control. A well-placed shot can save many lives, and the accuracy of a weapon depends upon the correct operation of the synchro system.

Classification of Synchros

Synchros work in teams. Two or more synchros interconnected electrically form a synchro circuit. Basically, synchros can be divided into three classifications:

1. Transmitters
2. Receivers
3. Differentials

The synchro transmitter is located at the controlling station and its output is an electrical order signal. These synchros were originally called "synchro generators," but are now functionally classified into the following two types:

1. Torque transmitter (TX)
2. Control transmitter (CX)

Torque and control transmitters are mechanically identical. However, the types of systems in which they are used differ. Torque transmitters are used in systems that require a mechanical output (dials, etc.), while control transmitters are used in systems that require an electrical output.

The synchro receiver is located at the station being controlled and its output can be either electrical or mechanical, depending on the type of synchro used. These synchros are functionally classified into the following types:

1. Torque receiver (TR)
2. Control transformer (CT)

Torque receivers are used where the rotors must perform a mechanical function, such as positioning a dial or valve. The main difference between torque receivers and torque transmitters is in their rotors. Rotors of torque receivers have a damper while rotors of torque transmitters do not. Torque receivers were originally known as "synchro motors."

Control transformers are used where an electrical signal output is required. It is safe to say that all power drives controlled by amplifiers also have control transformers.

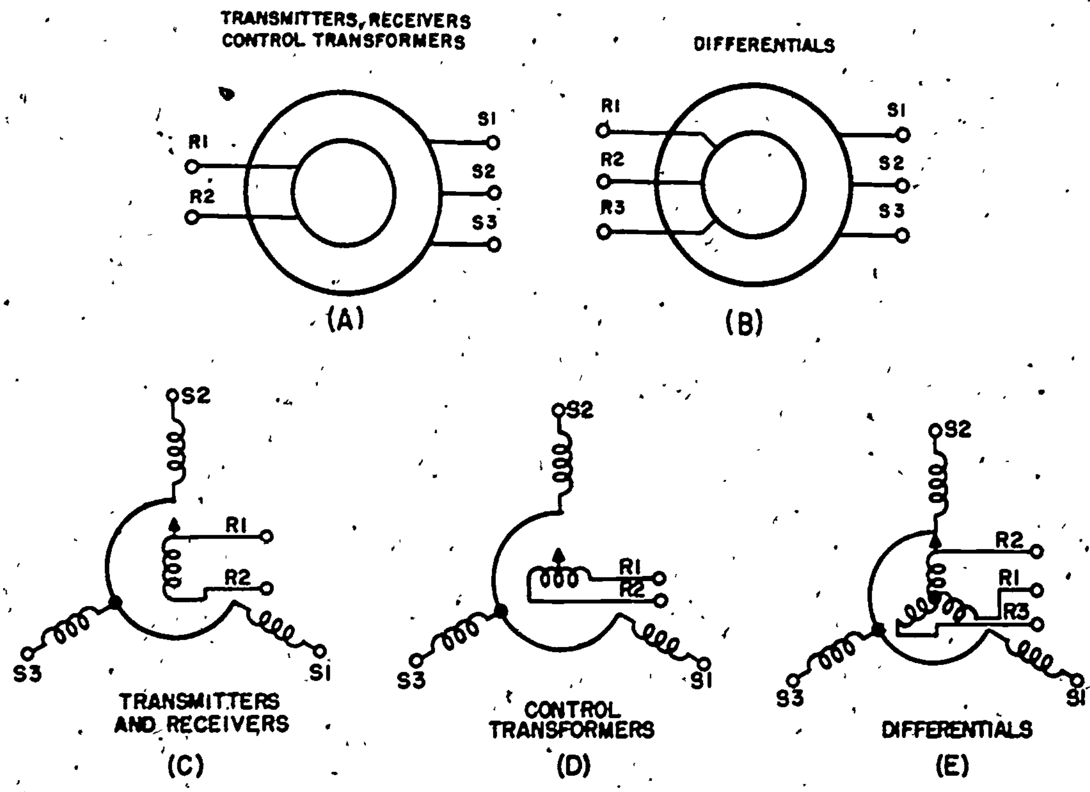
The synchro differential is used to add or subtract two signals and to transmit the result either to another synchro or as a mechanical output. In either case, the differential can always be identified by its rotor (R) leads. All other synchros have only two rotor leads while the differential has three. Functionally, differentials are classified as follows:

1. Torque differential transmitter (TDX)
2. Control differential transmitter (CDX)
3. Torque differential receiver (TDR)

MECHANICAL DAMPER. — A mechanical device known as an inertia damper is used to prevent oscillation or spinning when the synchro receiver's rotor turns in response to a sudden change of a received signal. The most common type of inertia damper consists of a heavy brass flywheel which is free to rotate around a bushing attached to the rotor shaft. A tension spring on the bushing rubs against the flywheel so that they turn together during normal operation. If the rotor shaft tends to change its speed or direction of rotation suddenly, the inertia of the damper opposes the changing conditions, and the resulting friction between the spring and the flywheel damps the tendency to oscillate. Because of the inertia damper, receiver and transmitter synchros are not completely interchangeable; a receiver may be used as a transmitter, but a transmitter is not suitable for use as a receiver.

Synchro Symbols

A synchro consists of a rotor (R) and a stator (S). The letters R and S are used to identify rotor and stator connections both on the synchro and in wiring diagrams and schematics. Synchros are represented by the symbols shown in figure 7-22. The symbols shown in parts (A) and (B) are used when it is necessary to show only the external connections to a synchro, while those shown in parts (C), (D), and (E) are used when it is important to see the positional relationship between rotor and stator. The small arrows on



1.119:120(72)

Figure 7-22.—Schematic symbols for synchros.

the rotors in parts (C), (D), and (E) indicate angular displacement of the rotor; in this illustration the displacement is zero.

Synchro Terms

Some standard synchro terms that you will use are defined as follows:

1. Rotor position: Amount of rotor offset from zero position, measured in degrees, minutes, or seconds.
2. Electrical zero: Standard position used as the electrical reference point from which all angular displacements are measured (not necessarily the zero position of the dial).
3. Angular position: Counterclockwise (viewed from the shaft extension end) angular rotor displacement from electrical zero position.
4. Direction of rotation: Clockwise or counterclockwise rotor rotation, determined when facing the shaft extension end of the synchro.
5. Increasing reading: Reading transmitted to a synchro when numerical value of the information transmitted increases.

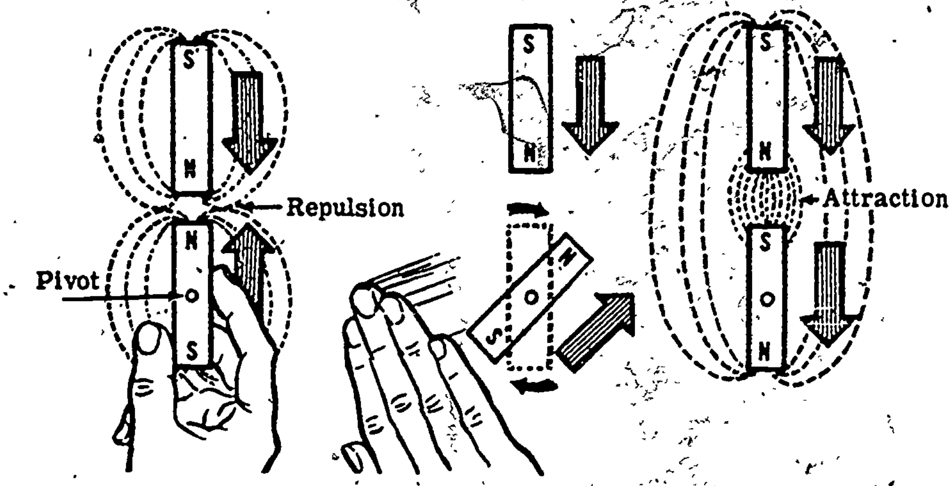
BASIC PRINCIPLES OF SYNCHROS

Synchros are electromagnetic devices; therefore, a review of magnetism will be necessary to understand synchro principles.

A bar magnet illustrates magnetic field and pole relationship of the synchro. The lines of force flow from south pole to north pole inside the magnet, as shown in figure 7-23.

Two bar magnets, shown in figure 7-23, illustrate the actions of like and unlike poles in bar magnets.

Three bar magnets, spaced 120° apart, and a removable bar magnet free to pivot within the ring of mounted magnets show basic synchro principles. (See figure 7-24). If the ring of three magnets is fixed, the single pivoted magnet moves so that its south pole is in line with the north



147.121(84A)

Figure 7-23.—Repulsion and attraction.

pole of magnet # 1. Since its north pole is attracted, equally by the south poles of magnets 2 and 3, it will remain between the two. The pivoted magnet, therefore, aligns itself with magnet # 1. The three magnetic fields combine to form one resultant magnetic field. If the three magnets are now rotated 120° and held in that position, the resultant magnetic field is also rotated through 120°. The pivoted bar magnet will turn in the same direction so that it remains aligned with the resultant magnetic field of the three magnets. This illustrates the action of a synchro receiver.

Three d.c. electromagnets could be used in place of the three permanent magnets mounted on the ring, and the effect on the magnet pivoted in the center would be the same. By feeding the proper amount of current in, the proper bar magnet can be made to rotate in either direction. The permanent magnet pivoted in the center could also be replaced by an electromagnet.

Because synchros operate on a.c. voltages, the magnet (R1 / R2) pivoted in the center is energized by an a.c. source; the fixed magnets (S1, S2, S3) are also energized by the a.c. source through another set of coils. The arrangement is shown in figure 7-25.

The pivoted electromagnet will react in the same manner as the bar magnet did when d.c. voltage was applied. The pivoted electromagnet will assume a position that depends upon the magnetic field established by the stator coils.

If 115 volts a.c. is applied to the rotor, at a given instant the flux takes the directions shown by the arrows in figure 7-26. Both flux loops cut the S2 winding, but only one cuts the S1 and S3 windings. If a voltmeter could be placed directly across the S2 winding, it would indicate 52 volts; across the S1 and S3 windings it would indicate 26 volts.

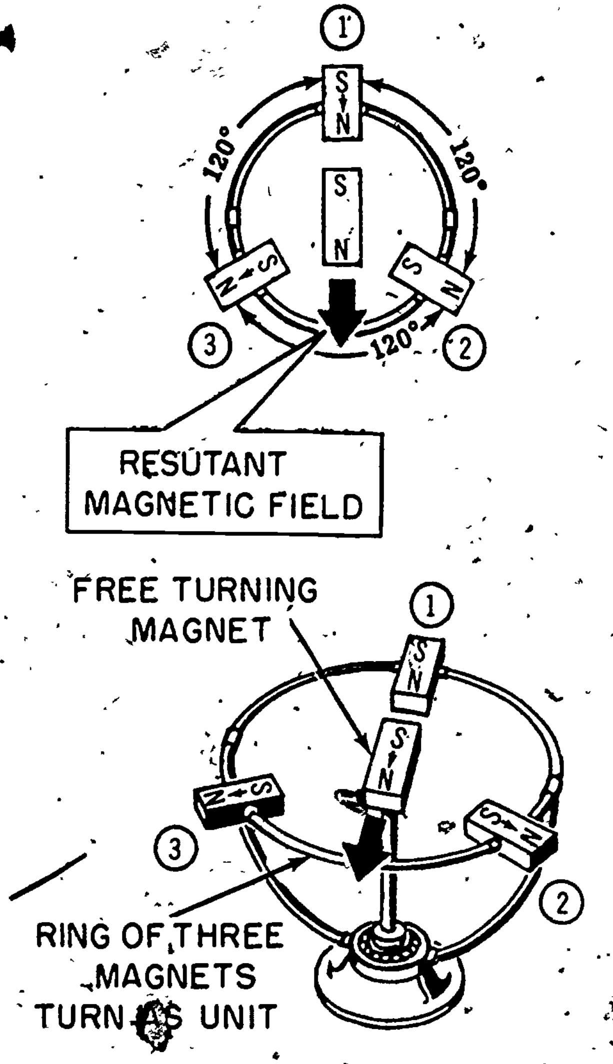
The coils of the stator are Y-connected (shown upside down in these illustrations). The stem of the Y is one coil and the branches of the Y are two other coils. They have a common connection, but no lead is brought out from this point.

SYNCHRO SYSTEM

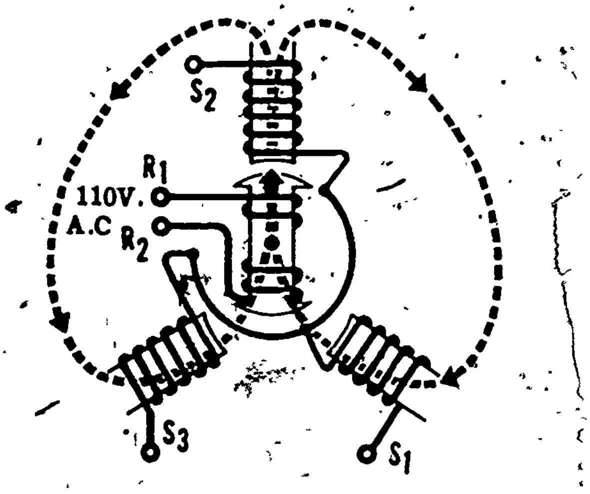
Torque synchro transmitters and receivers are used often in ordnance equipment to transmit information electrically from one point to another. The synchro transmitter sends out the signal and the synchro receiver receives it.

These synchros are connected in such a way that any amount of rotation of the transmitter rotor causes the rotor of the receiver to turn the same amount. The receiver either indicates the value of the signal by turning a dial, as shown in figure 7-27, or positions a light mechanical load, such as the valves shown in figure 7-28.

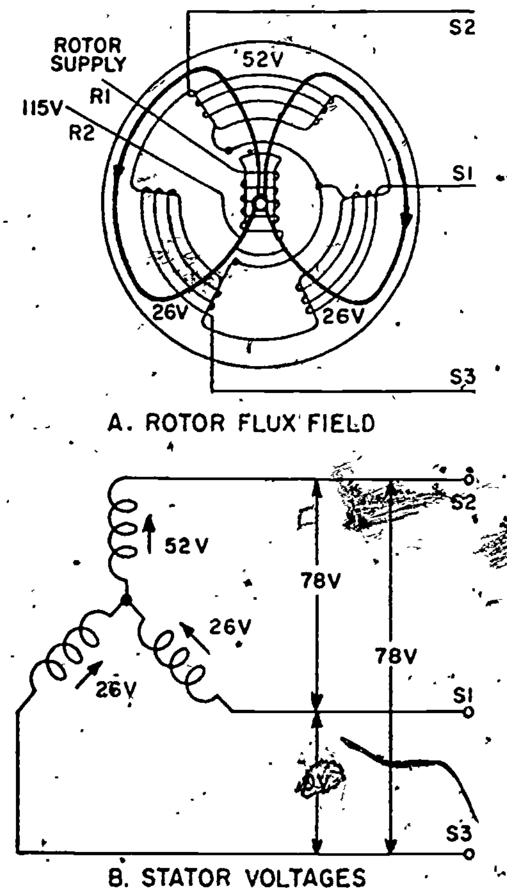
If it is desired that a director control a gun by use of a torque synchro system, the transmitter rotor will be geared to the director so that, when the director is moved, the rotor of the transmitter is also moved. An electrical signal, representing the amount of rotation of the transmitter rotor, is transmitted over wires to a synchro receiver located at the gun. This signal



84.339
Figure 7-24. — Pivoted bar magnet.



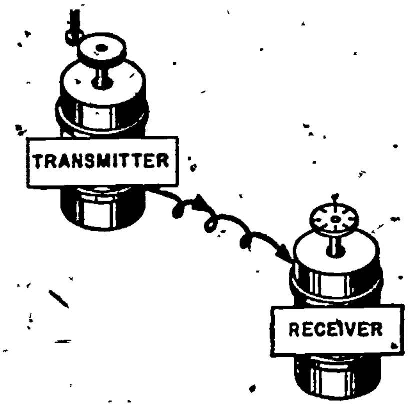
12.163.2
Figure 7-25.—Synchro primary magnetic field.



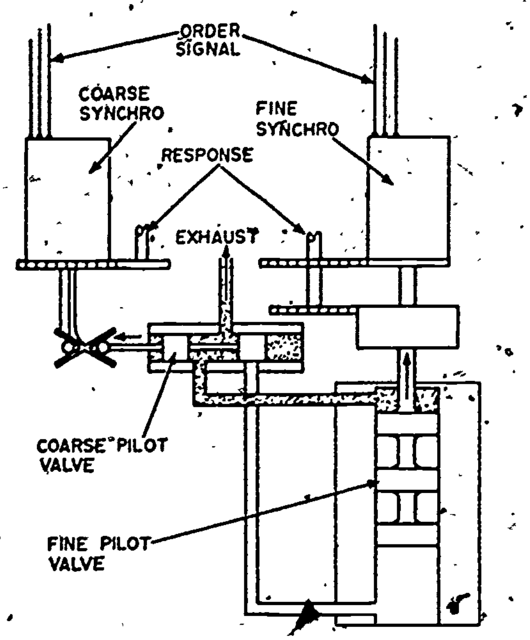
84.340
Figure 7-26. — Effective stator voltages.

causes the rotor of the synchro receiver to turn, or attempt to turn, the same amount that the transmitter rotor has turned. If the synchro receiver is connected to a power drive through a servo-system, as shown in figure 7-29, it will control the drive and thereby cause the gun to turn the same amount as the director.

In synchro transmission, any movement of the rotor in the torque synchro transmitter produces a corresponding movement of the rotor in the torque synchro receiver. The position of the rotor of a synchro receiver always conforms to the position of the rotor in a synchro transmitter.



12.156
Figure 7-27.—Simple torque synchro system.

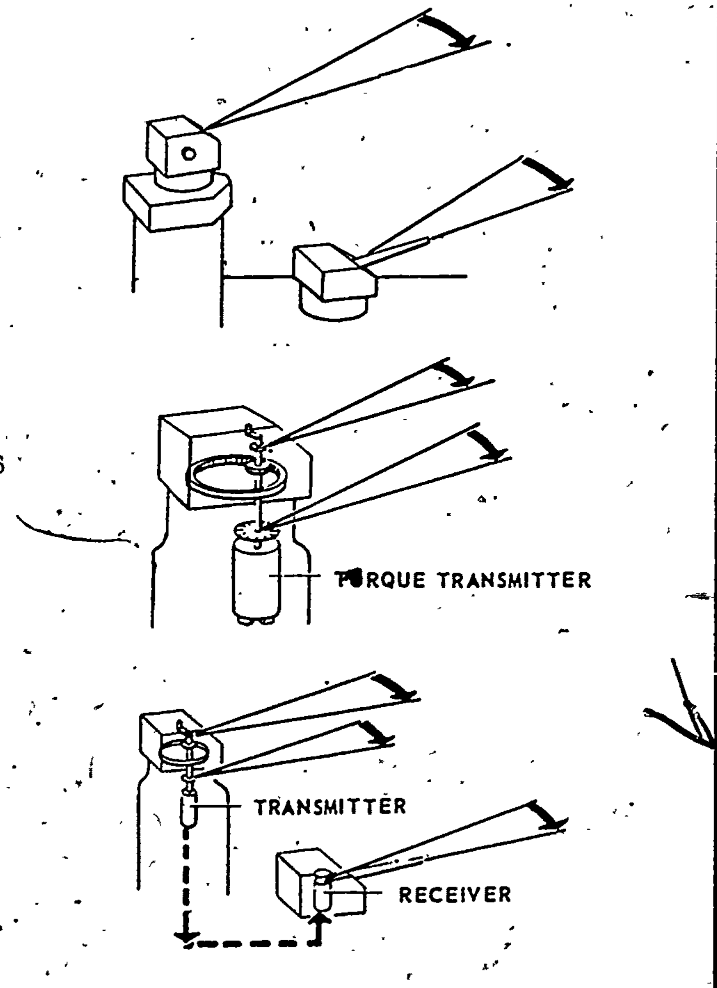


84.341
Figure 7-28.— Torque receivers in a 5"/38 power drive.

If reversing the direction of rotation of a receiver becomes necessary, it is done by interchanging stator leads S1 and S3, S2 represents electrical zero. Changing the S2 lead would introduce an error of 120°.

ELECTRICAL ZERO

If synchros are to work together properly in a system, it is essential that they be correctly



84.342
Figure 7-29.— Basic synchro system.

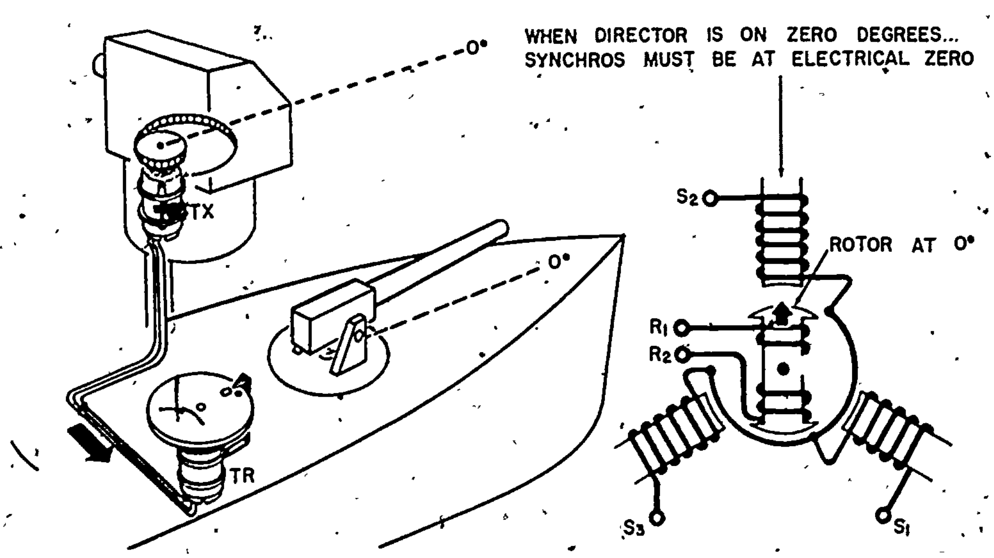
connected and aligned in respect to each other and to the other devices, such as directors and guns, with which they are used. Needless to say, the best of ordnance equipment would be ineffective if the synchros in the data transmission circuits were misaligned electrically or mechanically. Since synchros are the heart of the transmission systems, it only stands to reason that they must be properly connected and aligned before any satisfactory shooting can be expected.

Electrical zero is the reference point for alignment of all synchro units. The mechanical reference point for the units connected to the synchros depends upon the particular application of the synchro system. As a GM, on board ship, your primary concern with mechanical reference point will be the centerline of the ship for gun train and the standard reference plane for gun elevation. Remember, that whatever the system, the electrical and mechanical reference points must be aligned with each other.

A typical example of proper alignment is a TX-TR synchro team coupled to a gun director, so adjusted that the gun position can be read on the TR dial. The gun director is at zero when the gun points directly toward the ship's bow (fig 7-30). A TX is coupled mechanically to the director, and a TR is connected electrically to the TX. If this system were set up without paying any attention to the position of the TX rotor, it would indicate the gun position accurately if the TR dial was set on zero when the gun director read zero. If the same synchros remained in the same system, it would not be necessary to position them more accurately. Sometimes TRs and TXs become defective and must be replaced. If another TX were put into this system without checking the TR dial, its rotor probably would be positioned differently from that of the original TX. The TR would follow the new TX, and the TR dial would read incorrectly. To oversome this difficulty, a zero degree point is needed which is standard for all synchros. In the preceding example of the gun director, the system first should have been aligned so that all synchro rotors were at electrical zero, and all dials read zero when the gun director was on zero degrees. Then, any synchro could be replaced, without introducing error into the system, by installing the new synchro with its rotor on electrical zero when the gun director was on zero degrees. The electrical zero provides a standard way of aligning synchro units when they are connected together in a synchro system.

There are two ways in which this alignment can be accomplished. The most difficult way is to have two men, one at the transmitter and one at the receiver or control transformer, adjust the synchros while talking over sound powered telephones or some other communication device. The better way is to align all the synchros to electrical zero. Units may be zeroed individually, and only one man is required to do the work. Another advantage of using electrical zero is that trouble in the system always shows up in the same way. For example, in a properly zeroed TX-TR system, a short circuit from S2 to S3 causes all receiver dials to stop at 60 or 240 degrees.

In summary, zeroing a synchro means adjusting it mechanically so that it will work properly in a system in which all other synchros are zeroed. This mechanical adjustment is accomplished normally by physically turning the synchro rotor or stator. Navy Handbook MIL-HDBK-225 (AS) describes standard mounting hardware and gives simple methods for physically adjusting synchros to electrical zero.



12.163(84A)

Figure 7-30.—System zero.

ELECTRICAL ZERO CONDITIONS

For any given rotor position there is a definite set of stator voltages. One such rotor-position-stator-voltage condition can be established as an arbitrary reference point for all synchros which are electrically identical. Specific definitions for electrical zero are given here.

Transmitters And Receivers

A synchro transmitter, CX or TX, is zeroed if electrical zero voltages exist when the unit whose position the CX or TX transmits is set to its mechanical reference point. A synchro receiver, TR, is zeroed if, when electrical zero voltages exist, the device actuated by the receiver assumes its mechanical reference position. In a receiver or other unit having a rotatable stator, the zero position is the same, with the added provision that the unit to which the stator is geared is set to its reference position. In the electrical zero position, the axes of the rotor coil and the S2 coil are at zero displacement, and the voltage measured between terminals S1 and S3 will be minimum. The voltages from S2 to S1 and from S2 to S3 are in phase with excitation voltage across R1 to R2. The actual terminal voltages should be as follows:

115-volt Synchros	26-volt Synchros
R1 to R2 115 volts	R1 to R2 26 volts
S2 to S1 78 volts	S2 to S1 10.2 volts
S2 to S3 78 volts	S2 to S3 10.2 volts
S1 to S3 zero volts	S1 to S3 zero volts

Differential

A differential is zeroed if the unit can be inserted into a system without introducing a change in the system. In the electrical zero position the axes of coils R2 and S2 are at zero displacement. Terminal voltages are as follows:

115-Volt Synchros	26-Volt Synchros
R1 to R3 zero volts	R1 to R3 zero volts
S1 to S3 zero volts	S1 to S3 zero volts
R3 to R2 78 volts	R3 to R2 10.2 volts
S3 to S2 78 volts	S3 to S2 10.2 volts
R2 to R1 78 volts	R2 to R1 10.2 volts
S2 to S1 78 volts	S2 to S1 10.2 volts

Control Transformers

A synchro control transformer is zeroed if its rotor voltage is minimum when electrical zero voltages are applied to its stator. Turning the CT's shaft slightly counterclockwise will produce a voltage between R1 and R2 which is in phase with the voltage between R1 and R2 of the CX or TX supplying excitation to the CT stator. Electrical zero voltages, for stator only, are the same as for transmitters and receivers.

ZEROING PROCEDURES

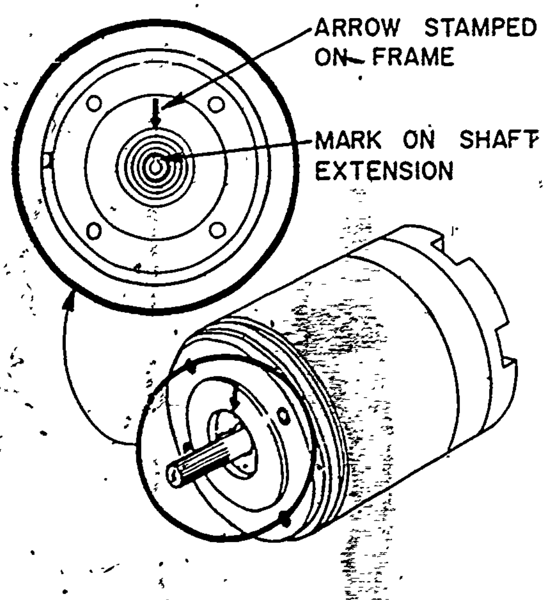
The procedure used for zeroing depends upon the facilities and tools available and how the synchros are connected in the system. The procedures described in the following paragraphs show how synchros may be zeroed by use of only a voltmeter and neon lamps; two lamps and a headset, synchro testers, or other synchros in the system. When zeroing differentials and control transformers, it is helpful to have a source of 78 volts (10.2 volts for 26-volt units).

Regardless of the method used, there are two major steps in each zeroing procedure: first, the coarse (or approximate) setting, and second, the fine setting. Many units are marked in such a manner that the coarse setting may be approximated physically. On standard units, an arrow is stamped on the frame and a line is marked on the shaft extension, figure 7-31.

Zeroing A Transmitter (CX or TX) Using A Voltmeter

The most accurate results can be obtained by using electronic or precision voltmeter having 0-to 250-volt ranges. On the 0- to 5-volt range the meter should be able to measure voltages as low as 0.1 volt. To zero a transmitter, proceed as follows:

1. Set the unit, whose position the CX or TX transmits, accurately in its zero reference position.
2. Remove all other connections from the transmitter's stator leads; set the voltmeter to its 0- to 250-volt scale; and connect as shown in figure 7-32A.
3. Turn the rotor or stator until the meter reads about 37 volts (15 volts for 26-volt units). This is the approximate zero setting.
4. Connect meter as shown in figure 7-32B, using 0- to 5- volt scale.
5. Adjust rotor or stator for null, minimum reading.



84.343

Figure 7-31.—Coarse electrical zero markings.

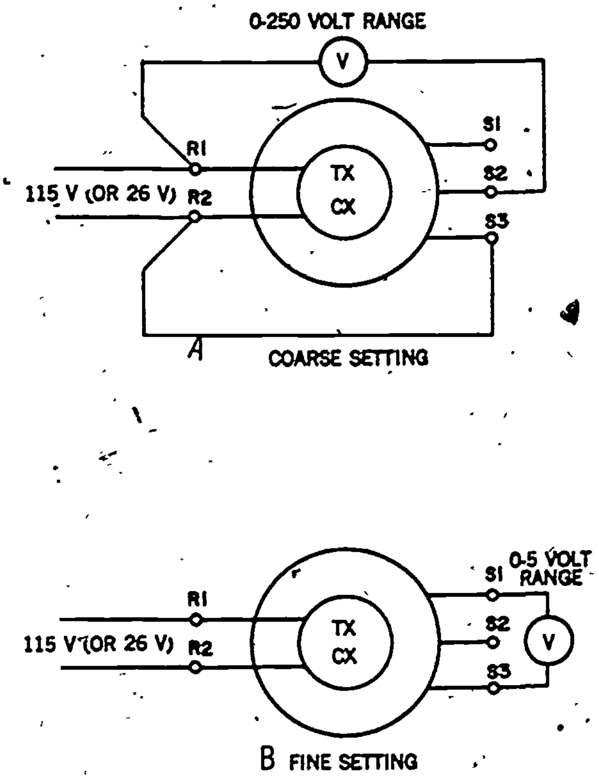
Zeroing a Torque Transmitter Using A Receiver Or Synchro Tester

This method is less certain than those previously described because it is based on the assumption that the other synchro used is accurate, which may or may not be true. Synchro Tester MK 2 all mods, described in Navy Handbook MIL-HDBK-225 (AS), is not sufficiently accurate to be relied on without question, and is for use on 115 volts, 60 Hz only. A receiver should also be checked to be sure it is at electrical zero when its dial reads zero or the reference value.

1. Connect the receiver or synchro tester to the transmitter as shown in figure 7-33.

2. Set the unit whose position the TX transmits accurately in its zero or reference position. Turn the transmitter until the receiver or synchro tester dial reads 0 degree. The transmitter is now at approximate zero setting.

3. Momentarily short S1 to S3. If the receiver or synchro tester dial moves when S1 is shorted to S3, the transmitter is not zeroed; shift it slightly and try again. When the TX is accurately zeroed, clamp it and reconnect for normal use. If the receiver dial does not read zero or the reference value, it is necessary to zero the receiver.



53.26

Figure 7-32.—Zeroing a TX or CX using a voltmeter.

Zeroing A Torque Receiver (TR) With A Free Rotor

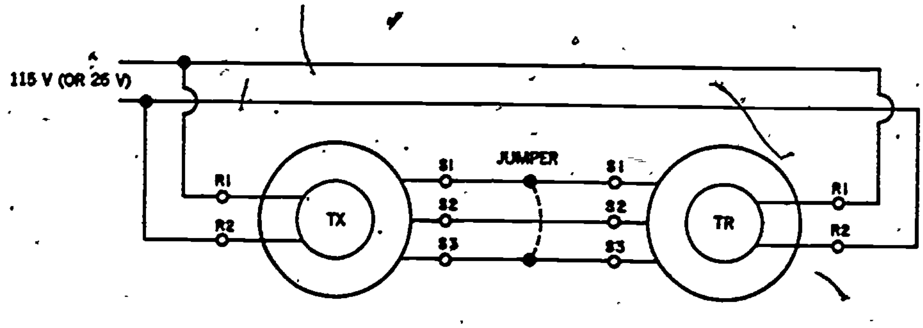
To zero a torque receiver with a free rotor, proceed as follows:

1. Disconnect stator leads and note normal connections for use when reconnecting.

2. Set voltmeter on 0- to 250-volt scale and connect as shown in figure 7-34A.

3. Temporarily connect jumper between S1 and S3 as shown by dotted line in figure 7-34A. Rotor will turn to 0° or 180 degrees. If meter reads about 40 volts (15 volts for 26-volt synchros), rotor is at 0°; proceed with step 4. If meter reads about 190 volts (38 volts for 26-volt units), rotor is at 180°; with jumper disconnected between S1 and S3, turn rotor to approximate zero setting. Reconnect jumper; now synchro should go to 0°; if meter reads 40 volts (15 volts for 26-volt synchros), proceed with step 4.

4. Connect meter as shown in figure 7-34B, using 0- to 5-volt range.



53.28

Figure 7-33.— Zeroing a TX by using a TR.

5. Adjust rotor or stator for minimum voltmeter reading.
6. Adjust mechanical response (dial, etc.) while the meter reading indicates zero or minimum voltage.

If a voltmeter is not available, two 115-volt neon lamps connected in series may be substituted for determining coarse setting. The neon lamps glow when the synchro is in the 180-degree position. Two 115-volt filament lamps of 6-watt rating or less (two small 24-volt lamps for 26-volt system) may also be used; lamps' minimum brightness occurs with the rotor at 0°, and maximum brightness occurs with rotor at 180 degrees.

Zeroing A Synchro Receiver
By Electrical Lock

If lead connections can be easily removed, remove all stator connections and reconnect as shown in figure 7-35. The shaft will definitely turn to 0 degree. Set the dial at its zero or reference position while the receiver is connected this way. If a source of 78 volts (10.2 volts for 26-volt units) is not available, 115 volts (15 volts for 26-volt units) may be connected to R1 and R2 providing it is not left connected in this manner for more than 1 or 2 minutes. Operation on higher than rated voltage causes the synchro to overheat.

Zeroing A Differential Transmitter
Using A Voltmeter

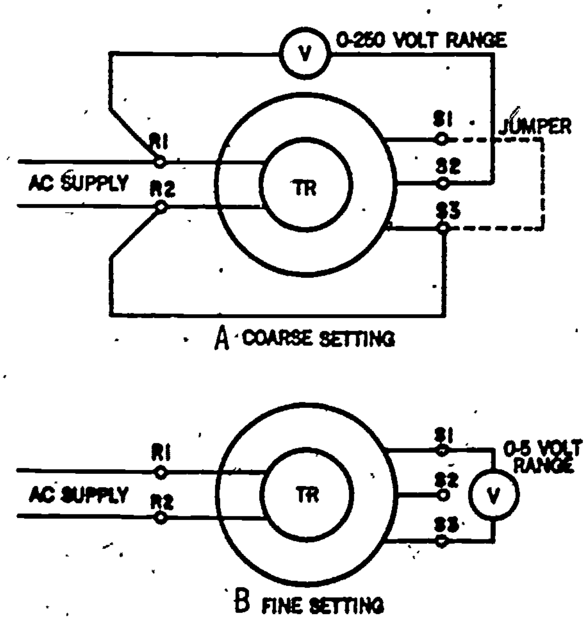
A differential transmitter may be most accurately zeroed by using an a-c voltmeter having 0- to 250 volt and 0- to 5-volt ranges. The procedure is as follows:

1. Set the unit, whose position the CDX or TDX transmits, accurately in its zero or reference position.

2. Remove all other connections from the differential leads, set the voltmeter on its 0- to 250-volt scale, and connect as shown in figure 7-36A.

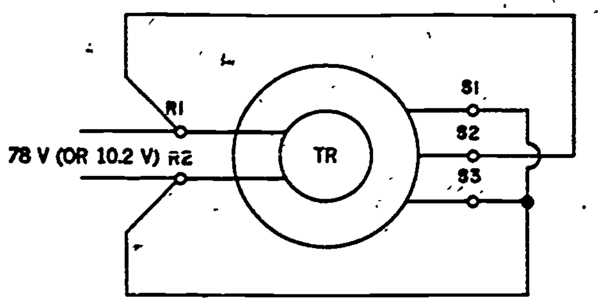
3. Unclamp the differential and turn it until the meter reads minimum. The differential is now on approximate electrical zero. Reconnect as shown in figure 7-36B.

4. Set the voltmeter on the 0- to 5-volt scale, and turn the differential transmitter until a null reading is obtained. Clamp the differential in this position, and reconnect all leads for normal operation.

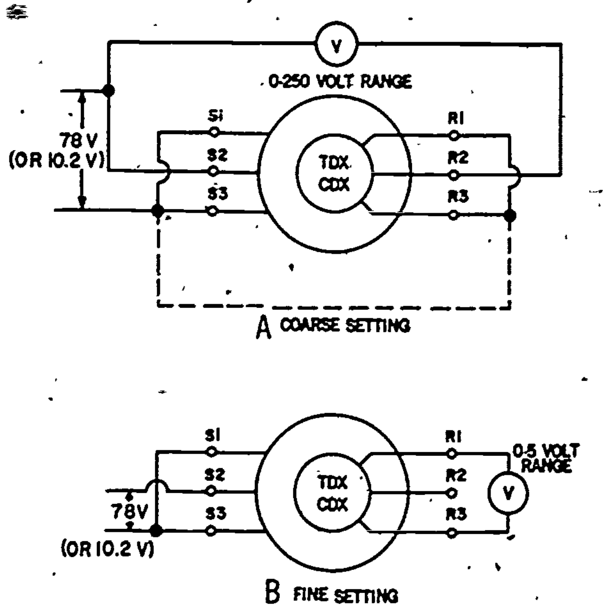


53.29

Figure 7-34.— Zeroing a TR with a free rotor.



53.30
Figure 7-35.— Zeroing torque receiver by electrical lock.



1.121(53)A
Figure 7-36.— Zeroing a differential transmitter using a voltmeter.

Zeroing A Torque Differential Transmitter Using A Receiver And A Torque Transmitter

The transmitter and receiver used may be part of the system in which the differential is used or separate units, such as Synchro Tester MK 2 all mods.

1. Check to see if the differential needs to be zeroed. First make sure the transmitter and receiver are correctly zeroed and the transmitter is held on 0° during adjustment. Connect as shown in figure 7-37. If the receiver shaft moves when jumper A is connected from S1 to S3, the transmitter is not 0°; recheck.

2. Set the unit, whose position the TDX transmits accurately in its zero or reference position. Unclamp the differential and turn it until the receiver dial reads 0 degrees. The differential is now approximately on electrical zero.

3. Connect jumper B (fig. 7-37) momentarily between receiver terminals S1 and S3, and differential terminals R1 and R3. If the receiver shaft, moves when jumper B is connected, the differential is not on 0°; rotate the differential slightly and try again. When the differential is zeroed, clamp it in position and remove jumpers.

Zeroing A Torque Differential Receiver Whose Rotor Is Free To Turn

When a TDR's rotor is not free to turn, it is necessary to use one of the methods described previously for a torque or control differential transmitter, but when the rotor is free to turn, they may be connected as shown in figure 7-38. Procedure is as follows:

1. Disconnect all other leads from differential. Tag all leads so normal connections can be easily made after zeroing.

2. Connect as shown in figure 7-38A. The rotor will turn to either 0° or 180° when a jumper, shown by the dotted line, is connected. If the meter reads about 28 volts (6 volts for 26-volt synchros), the differential is on approximate electrical zero; proceed with step 3. If meter reads about 156 volts (20 volts for 26-volt units), synchro is on 180°; disconnect the jumper, turn rotor to 180°, and reconnect jumper for approximate zero setting.

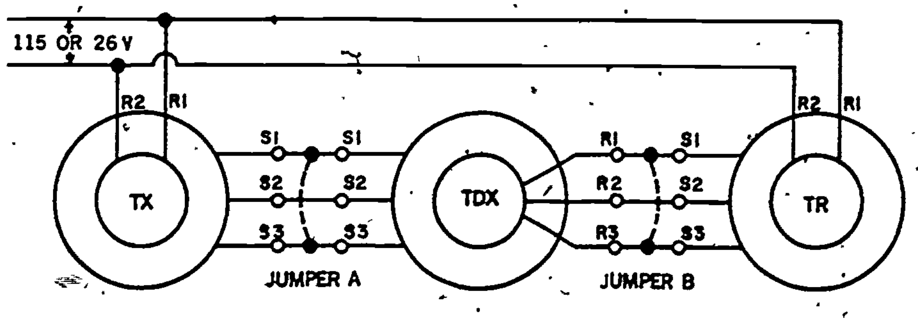
3. Change the connections to agree with those shown in figure 7-38B.

4. Rotate the synchro until the meter reading is minimum.

If a voltmeter is not available, two 115-volt neon lamps connected in series may be substituted, for 115-volt units only, in this procedure. The lamps do not light when the synchro assumes the electrical zero position, but do light when the synchro is on 180 degrees.

Zeroing A Differential Receiver Using Two Zeroed Transmitters

When a differential receiver is installed and cannot be easily disconnected, the following procedure may be used:



53.33

Figure 7-37.— Zeroing a TDX using a TX and TR.

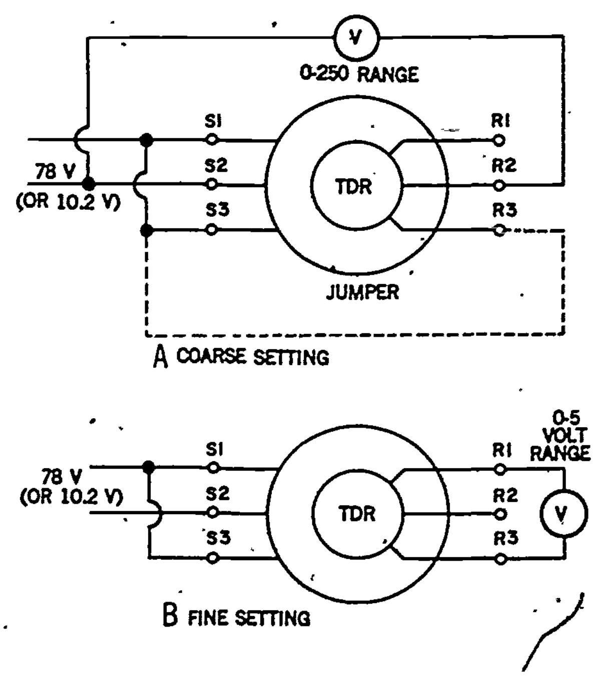
1. Be sure that both transmitters are zeroed and set in their zero or reference positions.
2. Connect temporary jumpers as shown in figure 7-39.
3. With the jumpers connected, unclamp the differential and adjust so that the dial on TDR reads zero or reference value. After zeroing, clamp the differential and remove jumpers.

If the differential receiver moves when the jumpers are connected, the transmitter on that side is not set to 0° and should be rechecked.

Zeroing A Control Transformer Using An A.C. Voltmeter

Using a voltmeter with 0- to 250- and 0- to 5-volt scale, control transformers may be zeroed as follows:

1. Remove connections from control transformer and reconnect as shown in figure 7-40A.
2. Turn the rotor or stator to obtain minimum voltage reading.
3. Reconnect meter as shown in figure 7-40B, and adjust rotor or stator for minimum reading.
4. Clamp the control transformer in position and reconnect all leads for normal use.



1.121(53)B

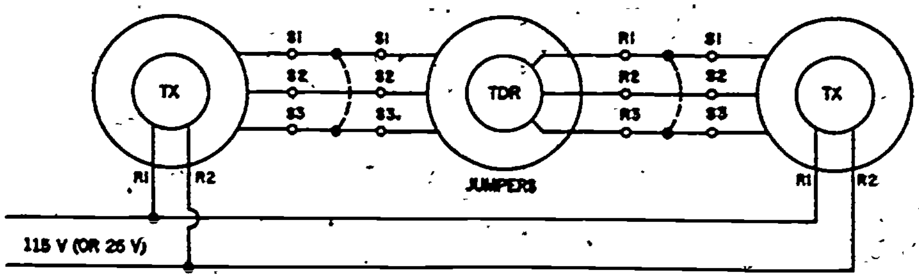
Figure 7-38.— Zeroing TDR with free rotor.

The described zeroing methods apply to all standard synchros and prestandard Navy synchros.

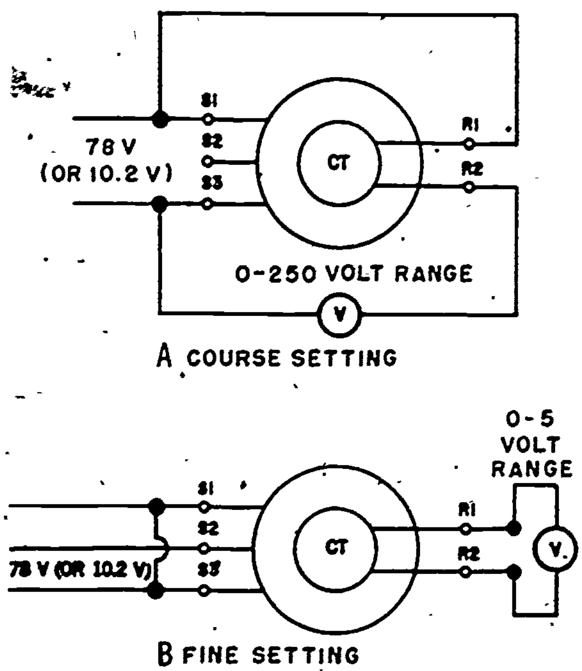
Before testing a new installation and before hunting trouble in an existing system, first be certain all units are zeroed. Also, be sure the device's mechanical position corresponding to electrical zero position is known before trying to zero the synchros. The mechanical reference position corresponding to electrical zero varies; therefore, it is suggested that the instruction books and other pertinent information be carefully read before attempting to zero a particular synchro system.

Troubles in synchro systems which have been in operation for some time are usually of two types.

1. The interconnecting synchro wiring often passes through switches. At these points, open circuits, shorts, and grounds may occur. GMs are expected to trace down these troubles with a



53.35
Figure 7-39.—Zeroing a TDR using two zeroed TXs.



53.36
Figure 7-40.—Zeroing a CT using a voltmeter.

meter. An open circuit can be found by checking for continuity between two points. Similarly, a ground can be found by checking resistance between the suspected point and ground. A reading of zero ohms means that the point in question is grounded.

2. The synchros themselves may become defective due to open and short circuits in the windings, bad bearings, worn slip rings, or dirty brushes. The recommended remedy for this type of trouble is to replace the synchro and return the old one to the supply department if they require it for turn-in.

Troubles in new and modified synchro systems are most often caused by improper wiring or misalignment, due to synchros not being zeroed. GMs are responsible for finding and correcting these troubles. Improper wiring can be checked with an ohmmeter by making a point-to-point continuity and resistance check. Misalignment of a synchro system can be corrected by realigning the entire system.

Aside from zeroing and troubleshooting the interconnecting wiring, the two important points to remember about synchro maintenance are:

1. If the synchro works, do not tamper with it.
2. If the synchro is defective, return it to the supply department if they require it for turn-in, and replace it with another one.

When trouble occurs in an installation containing many synchro systems, it may be very difficult to isolate this trouble to one particular system. Since it is vital that the maintenance man locate the point of trouble and fix it in as short a time as possible, indicators to aid him in locating the trouble quickly are included in the equipment. These indicators are usually signal lights mounted in a central control board and connected to the various synchro systems. When trouble occurs in a synchro system, the corresponding indicator light flashes. The maintenance man can then identify the defective system by reading the name or number adjacent to the light.

Maintenance And Troubleshooting Synchro Systems

One of the duties aboard ship will be to keep the synchro systems that are used in ordnance equipment in good working order. This means that GMs must be familiar with the do's and don'ts of synchro maintenance and repair.

The following is a list of actions that should not be taken.

1. Do not attempt to zero a synchro system that is already accurately zeroed because of a desire for practice. Quite often this results in misalignments.

2. Do not attempt to take a synchro apart, even if it is defective. A synchro is a piece of precision equipment which requires special equipment and techniques for disassembly. If the synchro is faulty, return it to the supply department if they require it for turn-in, and draw a replacement.

3. Never attempt to lubricate a synchro. A synchro, unlike an electric motor, does not require periodic lubrication.

Signal lights indicate either overload conditions or blown fuses. An overload indicator is actuated by excess current flowing in the stator windings. In one form of indicator, a neon lamp is connected to the stator leads by means of two transformers, (fig. 7-41). The primary, consisting of a few turns of heavy wire, is in series with two of the stator leads; and the secondary, consisting of many turns of fine wire, is in series with the lamp. The turn ratio is such that when excess current flows through the stator windings, the neon lamp lights. For example, when the difference in rotor positions exceeds approximately 18°, the lamp lights, indicating that the load on the receiver shaft is excessive.

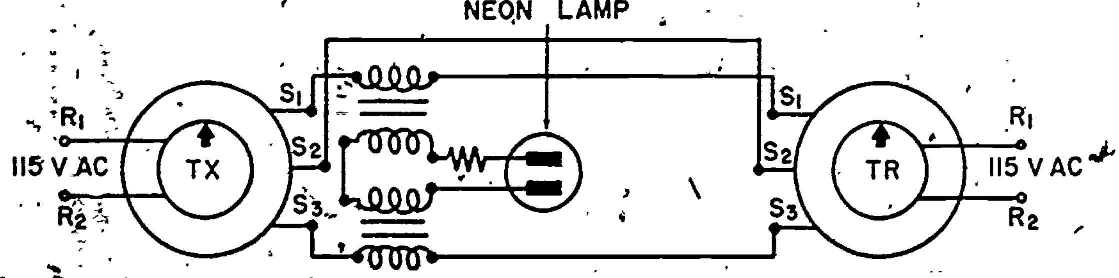
Fuse indicators are panel lights that glow when a fuse in the rotor circuit blows. If excessive current flows in the rotor windings due to a short circuit or excessive mechanical overload, one of the fuses will blow and the neon lamp across that fuse will light, (fig. 7-42). Another type of blown fuse indicator uses a small transformer with two identical primaries and a secondary. With both fuses closed, equal currents flow through the primaries which induce mutually cancelling voltage in the secondary. If a fuse blows, the induced voltage from one primary is present in the secondary and the lamp lights.

Synchro maintenance and troubleshooting is a very complex undertaking in modern ordnance equipment, and skilled personnel with ordnance rates work jointly to maintain the synchro systems in a high degree of readiness. Navy Handbook MIL-HDBK-225 (AS) is devoted to synchro troubles and should be used during analysis of synchro system casualties. The tables contained in this publication are useful tools for learning the many problems that may exist in synchro systems.

If the casualty exists in the transmitter, all receivers will be affected. If the casualty exists in a receiver, only that receiver will be affected, except in the case of shorted stator leads, when all synchros will be affected.

A list of synchro casualties and effects on a typical synchro system follows:

1. S1 and S3 shorted — Rotor locks on 0° or 180°.
2. S1 and S2 shorted — Rotor locks on 120° or 300°.
3. S2 and S3 shorted — Rotor locks on 240° or 060°.
4. S1, S2, and S3 shorted — Rotor spins.
5. R1 or R2 shorted — Rotor aligns as 090° or 270° from the signal, fuse blows.
6. R1 or R2 open — Rotor aligns at 0° or 180°, proper rotation, poor torque.



84.344

Figure 7-41.—Overload stator current indicator.

7. S1 open—Rotor oscillates over S1 or 180° from S1.
8. S2 open—Rotor oscillates over S2 or 180° from S2.
9. S3 open—Rotor oscillates over S3 or 180° from S3.
10. R1 and R2 reversed—Rotor aligns 180° from signal; proper rotation, good torque.
11. S1 and S2 reversed—Rotor aligns at 120° from signal, reversed rotation, good torque.
12. S2 and S3 reversed—Rotor aligns at 240° from signal, reversed rotation, good torque.
13. S1 and S3 reversed—Rotor aligns at 0°, reversed rotation, good torque.

Synchro units require careful handling at all times. Never force a synchro into place, never drill holes into its frame, never use pliers on the threaded shaft, and never use force to mount a gear or dial on the shaft.

ELECTRON TUBE CIRCUITS

Electron tubes are of many types and designations and perform many functions. They are used in ordnance equipment to control power drive circuits, and fuse setting circuits. Basic Electronics explains in detail the principles and characteristics of the electron tube and should be studied before reading this section, we merely present a quick review of electron tubes.

CHARACTERISTICS OF ELECTRON TUBES

The parts of an electron tube which directly control current flow are called "elements". The heated element which gives up electrons is called the "cathode". The "plate" of the tube when it has a positive potential attracts electrons. The "grid", mounted between the cathode and the plate, is the third element. The voltage applied to the grid controls the flow of electrons through the tube.

The cathode is heated by a filament or resistance wire called a "heater", It is not considered to be an element since it does not directly control the amount of current flow from cathode to plate.

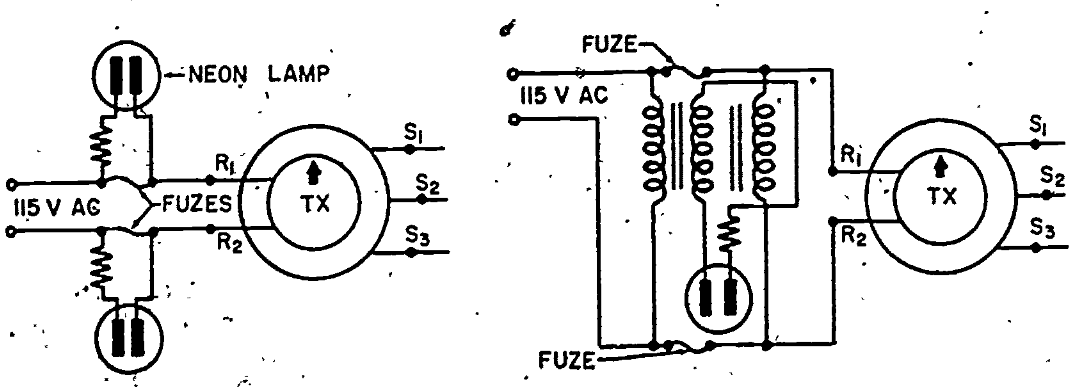
Four of the most common electron tubes are shown in figure 7-43. The names of the four basic types are taken from the names of Greek numbers and give the number of elements in each tube. For example, the word "penta" means five, and a pentode has five elements: a cathode, a plate, and three grids.

The pentode is used here to describe one method of troubleshooting tube circuits.

As a general rule, electron tubes do not have as long a life expectancy as resistors, capacitors, and other electronic circuit components.

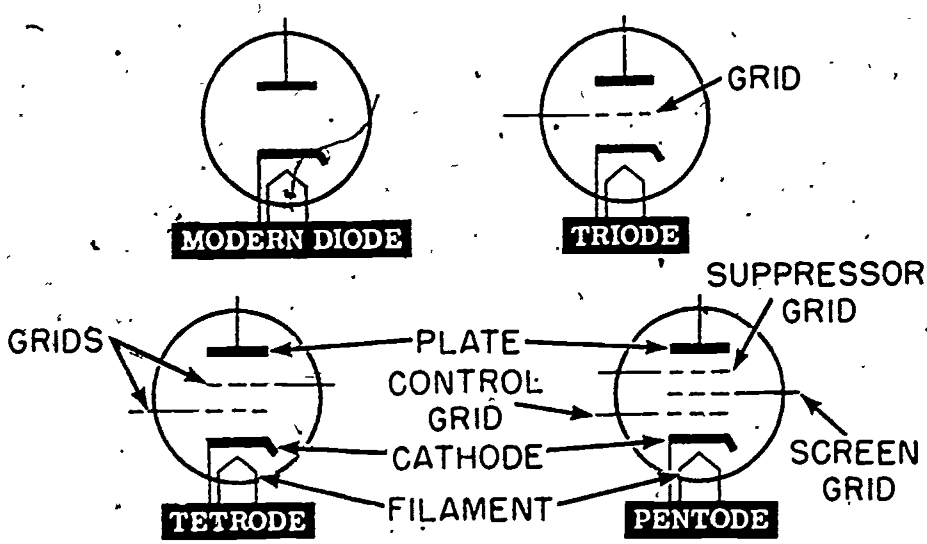
To provide for easy removal and replacement, the base of the tube is constructed in the form of a plug that can be inserted into a socket. The socket is mounted on the chassis that supports the electronic circuit. The electrical connection between the tube elements and the circuit is completed through the tube base terminals, which are called "pins". A typical rectifier tube showing the tube base and pin arrangement is illustrated in figure 7-44. Minature tubes differ in that the pins are mounted in and protrude through the glass envelope.

Each type of tube base has some kind of guide, key, pin arrangement, or (in case of the miniature tube) a missing pin to prevent the tube



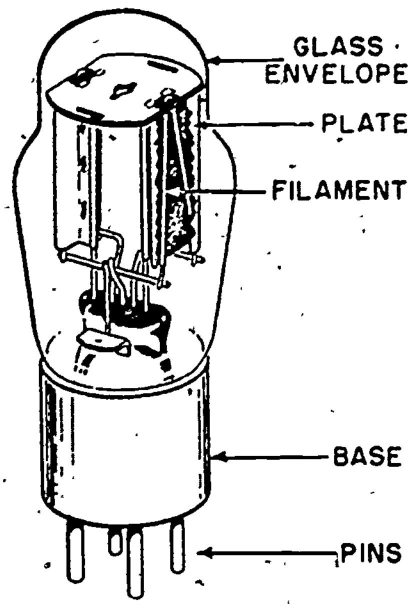
84.345

Figure 7-42.—Overload rotor current indicators.



20.16(84A)

Figure 7-43. — Basic types of vacuum tube.



4.140(84A)

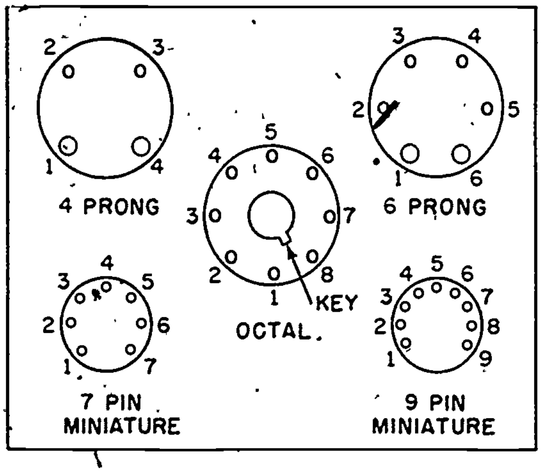
Figure 7-44. Assembled diode vacuum tube.

from being improperly plugged into the socket. Bottom views of typical tube bases are shown in figure 7-45. Of the five types illustrated, the octal, the 7-pin miniature, and the 9-pin miniature are by far the most common.

For ease in circuit tracing, electron tube pins are all assigned numbers. The pins are numbered in a clockwise direction when viewed from the bottom of either the tube base or socket. On tubes with a key or guide, such as the octal, pin # 1 is always the first pin in a clockwise direction from the key or keyway. Miniature tubes (both 7-pin and 9-pin) have a missing pin (wide space) that is used as the reference point. Pin # 1 on these tubes is the first pin in a clockwise direction from the wide space between pins. The 4-pin and 6-pin tubes are read clockwise with second large pin identified as pin # 1 (the large pins are always used for filaments).

TESTING ELECTRON TUBES

Electron tubes cause more than 50 percent of all electronic equipment failures. The condition of a tube can be determined by substituting a tube known to be good for the questionable one or by testing the tube with a tube tester. Tube tester TV-3B/U, shown in figure 7-46, is a portable tester designed to test and measure the mutual conductance of electron tubes of the receiving type, and many of the smaller transmitting types.

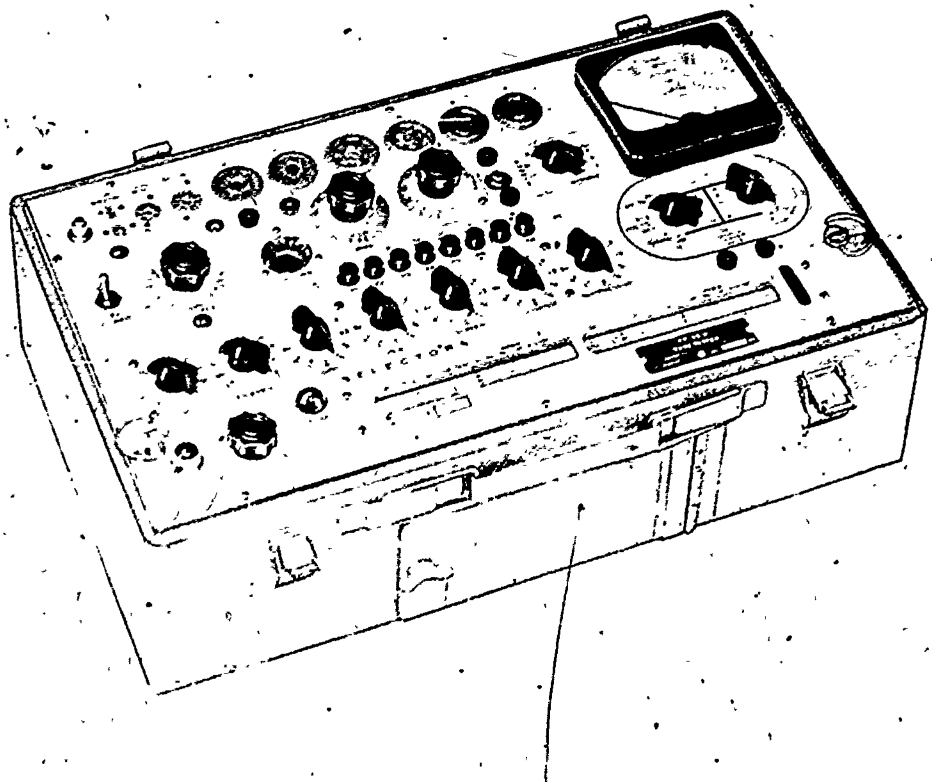


4.141(84A)
Figure 7-45.— Base types and numbering systems.

A multimeter section is incorporated in the test set which permits measurement of a.c. and d.c. volts, d.c. milliamperes, and resistance and capacitance in a number of ranges. Rectifier and diode tubes can also be checked for emission. Two other tube tests conducted with this meter are the short test, (for shorts between tube elements) and the gas test. For short tests, a neon lamp glows if there is a short between tube elements. Basic Electronics explains the operation of TV-3B/U.

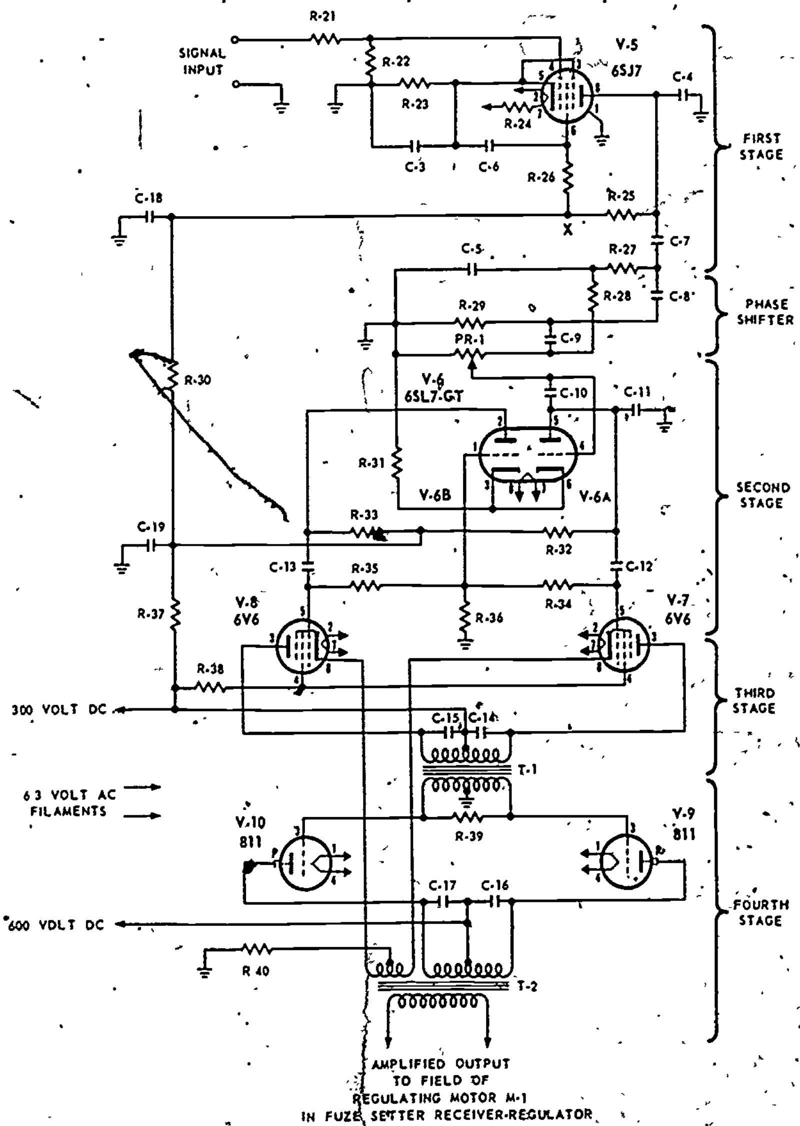
Keep in mind that a tube-testing device only compares the characteristic of a given tube with values established as standards for a particular type of tube. Substituting a good tube in the equipment, and observing the performance of the equipment, provides the most reliable evidence concerning the condition of the tube in question.

If a circuit is not restored to normal when a tube is replaced, the control circuit for that tube must be tested for faulty components. This can be done by taking voltage or continuity tests to pinpoint the casualty. We explain just one method; taking voltage readings.



20.346

Figure 7-46.— Tube tester TV-3B/U.



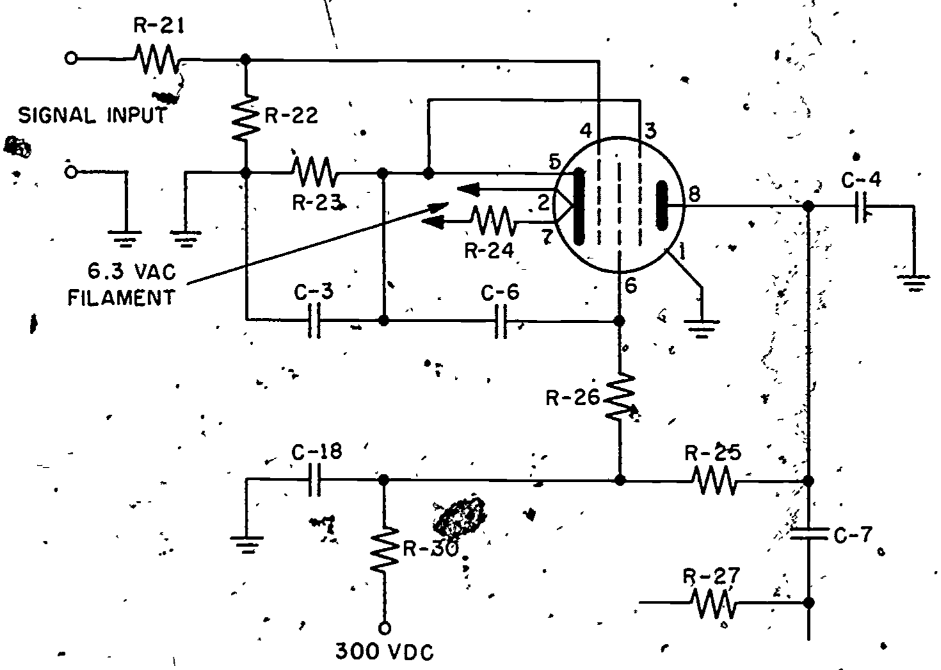
84.346

Figure 7-47.—Schematic diagram of an electron tube circuit.

TROUBLESHOOTING TUBE CIRCUITS USING VOLTAGE TESTS

Voltage tests are taken to measure d.c. electrode voltages. These measured voltages are compared to standard electrode voltages listed in OPs and ODs. Any significant difference between the measured voltage indicates a casualty. The OPs and ODs give test points, meter specifications, standard voltage readings, and the probable causes for non-standard voltage readings. The voltage test charts are good, and they are accurate. Considerable time is required, however, to make all the voltage tests in a given circuit. You can locate a casualty much faster by localizing the trouble to one stage, and then using voltage tests to pinpoint a casualty.

There are two things to remember whenever you make voltage tests. First, accept a reasonable difference between the measured voltage and



84.347

Figure 7-48.—Pinpointing by voltage tests.

the standard voltage. This reasonable difference allows for any meter error or any error due to the tolerance of the parts being tested. Second, follow the meter specifications in the test chart.

As an example, suppose that we use a volt-ohm-milliammeter (VOM) (fig. 7-6) to test the pentode V-5 shown in figure 7-47. We take voltage tests for possible casualties.

Notice the pin numbers at each electrode in the 6SJ7 (V-5) tube shown in figure 7-47. These pin numbers tell you where to connect the meter test leads listed on the voltage test charts. Each electrode is listed by a pin number.

First measure the voltage from the plate of tube V-5. Connect the common lead of the VOM to the chassis of the equipment under test; touch the other lead to pin 8. If the voltage output is too high, move the test prod to point 5 and read the voltage from R-23. If the R-23 voltage also is too high, resistor R-23 is responsible for the high reading at pin 8. Probably R-23 has increased in value due to aging. You have pinpointed the casualty; replace R-23. Figure 7-48 shows just the first stage of the amplifier circuit shown in figure 7-47.

On the other hand, if the R-23 voltage measures too low, the tube is responsible. Probably the cathode emission has decreased due to aging; replace tube V-5.

There are other casualties that could be responsible for a high reading at pin 8. An open R-26 or a leaky C-6 would decrease the screen grid voltage. The decreased screen voltage would decrease the current (I) causing the voltage reading at point 8 to be high. A loss of resistance in R-25 could also cause a high voltage reading at pin 8.

To test for a leaky capacitor C-6, measure the screen grid voltage at test point 6 with tube V-5 removed. If C-6 is OK, the VOM will read less than a standard voltage.

To test for an open R-26, measure the screen grid voltage at point 6 with tube V-5 in place. If R-26 is OK, the voltage at test point 6 will be standard, but if R-26 is open, the VOM will read zero.

Now, assume that the voltage reading at test point 8 is too low. You measure the I/R drop across R-23 at test point 5. If the voltage at R-23 is too high, you know that too much current (I) is flowing through the d.c. plate circuit. Too much current could be caused by a loss of bias. Since you have checked R-23 already, the loss of bias must be in the grid circuit. With a signal input to tube V-5, measure the d.c. voltage between points 4 and 5. It should be equal to the R-23 voltage between point 5 and ground. If the grid circuit is open, the bias between points 4 and 5 reads zero—probably due to an open in the signal input circuit.

An increase in the resistance of R-25 and R-30 can also cause a low reading at point 8. If any one of the three capacitors C-4, C-7, or C-18 is leaky or shorted, the voltage at point 8 will decrease.

Here's a quick test for all three capacitors. Remove tube V-5 and take a reading between point 8 and ground. If the reading is less than 300 VDC, one of the capacitors is a casualty.

Pinpointing by voltage tests can save time, but you must be able to reason out casualties. Always refer to troubleshooting charts and standard voltage charts listed in OPs and ODs related to your equipment.

This chapter does not cover all types of electric and electronic components used with ordnance equipment. Chapter 8 of this rate training manual explains the types of power drives used in gun mounts, turret, rocket and missile launchers. These power drives use both a.c. and d.c. motors as well as amplidyne generators. Before beginning chapter 8 the reader should study two basic training courses related to the subject matter covered in chapter 8. Basic Electricity and Basic Electronics provide a broad background which should enable the Gunner's Mate to understand the electrical and electronic components used with power drive equipment.

SAFETY

Some common safety features of electrical or electronics equipment are interlock switches, bleeder resistors, current-limiting resistors, insulating controls, and powerline safety devices (such as fuses). Keep in mind that these features cannot always be relied upon to function. Don't develop a false sense of security just because an equipment has safety features. The following list of safety precautions will help prevent electric shock or burns when working on or near electrical or electronic equipment.

1. Do not block high voltage protective cutout on doors or covers to keep the circuit energized with the cover off. It is intended that work be performed on such electrical equipment while the circuit is deenergized.

2. Always ground the provided ground lead located at the plug of portable tools such as electric drills to protect yourself from shock in case a ground occurs within the tool.

3. Always be sure that all condensors (capacitors) are fully discharged before commencing work on a deenergized high voltage circuit. Use an insulated shorting bar for this purpose.

4. Tag the switch OPEN (open the switch and place a tag on it stating "This circuit was ordered open for repairs and shall not be closed except by direct order of __________.") at the switchboard supplying power to the circuit on which you wish to work. When possible, remove the fuses protecting the circuit and place them in your tool box for safekeeping until the job is complete.

5. Always remove fuses with fuse pullers, and never remove fuses until after opening the switch connecting the circuit to the source of supply. Never replace a fuse with one LARGER than the circuit is designed to take.

6. Observe utmost caution when inspecting behind an open-back switchboard in an energized state.

7. Never use an incandescent test lamp unless its voltage rating is greater than the highest voltage which may be tested.

8. Always test a supposedly deenergized circuit with a voltage tester before commencing work on the circuit.

9. Never work on an electric circuit or network without first thoroughly acquainting yourself with its arrangement and with its points of power feed.

Electric shock may cause instant death or may cause unconsciousness, cessation of breathing, and burns. If a 60-Hz alternating current is passed through a person from hand to hand or head to foot, the effects when current is gradually increased from zero are as follows:

1. At about 1 milliampere (0.001 ampere) the shock can be felt.

2. At about 10 milliamperes (0.010 ampere) the shock is severe enough to paralyze muscles so that a person is unable to release the conductor.

3. At about 100 milliamperes (0.100 ampere) the shock is fatal if it lasts for one second or more.

It is important to remember that current is the shock factor rather than the amount of voltage.

You should clearly understand that the resistance of the human body is not great enough to prevent fatal shock from a voltage of as low as

115v. In many cases, voltages less than 115v are fatal. When the skin is dry, it has a high resistance. The resistance may be high enough to protect a person from fatal shock even if one hand touches a high voltage while another part of the body touches the chassis or another ground.

Contact resistance decreases when the skin is moist and body resistance may drop to as low as 300 ohms. With this low resistance, it can be seen that a very low voltage could supply enough current to cause death.

Under no circumstance should any person reach into any equipment or perform any work in lethal voltage areas without the presence of at least on person capable of giving aid in the event of an accident.

A worthwhile publication on electrical safety in NAVSHIPS 250-660-78, "How to keep ELECTRICITY from killing you". The pamphlet graphically points out the dangers of electric shock and how to avoid it. It further points out the pitfalls when working with electricity, and how to avoid them.

CHAPTER 8
ELECTRO-HYDRAULIC POWER DRIVE FUNDAMENTALS

ORDNANCE HYDRAULICS

Maintaining the hydraulic systems in peak operating condition is a major part of your work as a GMG. The more you understand how hydraulic systems work, the better able you will be to keep them working. It is not the intent of this chapter to cover all phases of hydraulics, but to present information on the application of hydraulics to ordnance equipment. We will, however, explain the hydraulic theory of operation of many pumps, valves, and other hydraulic mechanisms used with naval guns. For the fundamental concept in the field of hydraulics, it is recommended that you read chapters 2, 4, 8, and 13 of Fluid Power, NAVPERS 16193-B.

In the Navy, hydraulic equipment and applications of hydraulic principles surround you everywhere. As a Gunner's Mate these are of primary importance to you. In most gun mounts hydraulic equipment is used in power rammers, training and elevating gear, ammunition hoists, and many other types of ammunition handling equipment. Although these applications differ widely in purpose, they all depend on the same hydraulic principles. You'll find too that, although some of these mechanisms may be fairly complex, when taken as a whole, even a complex one is in reality a system composed of a number of relatively simple mechanical components. Once you grasp their basic principles and see how these simple components work together, you will be able to understand the workings of an entire system. In this section of the chapter we explain some hydraulic as well as electrical functions of power drives. If you understand this section on hydraulics, you will be better equipped to understand how power drives work and also will be able to maintain and repair hydraulic equipment.

PHYSICAL PROPERTIES OF LIQUIDS

The term "hydraulics" stems from the Greek word for water. In earlier times, hydraulics was a study of the behavior of water in motion. Today, however, the meaning of hydraulics has been broadened to cover the physical properties of all fluids and especially the oils which are used so extensively in our hydraulic systems.

Hydraulic principles have been employed for many years to serve mankind, mainly as a means of power to operate machinery. During more modern times, hydraulic applications have been broadened and, during the course of each day, may be seen performing functions such as raising barber chairs, providing power for car brakes, door stops, and for the more complex ordnance systems.

Blaise Pascal, a French scientist, laid the foundation for modern hydraulics. During his experiments with fluids, he discovered that pressure, when applied to a liquid in a container, is transmitted equally in all directions of the containing surfaces.

This law is used constantly in our hydraulic applications and must be thoroughly understood by each of us who are concerned with hydraulic principles.

The properties of liquids are very important in hydraulic applications. They must be thoroughly understood to know the behavior of liquids.

Shapelessness

Shapelessness is a valuable property of a liquid when it is used in a hydraulic system. This property permits the liquid to be led through a pipe or tube and to be moved by a pressure pump, piston, or by gravity.

Incompressibility is another property which is very valuable in hydraulic application. This permits work to be accomplished either directly or remotely with less loss of motion than can be obtained from a purely mechanical system.

Density

The term "density" means weight per unit of volume. For our purposes, weight will normally be expressed in pounds per cubic foot or cubic inches. For example, fresh water weighs 62.4 pounds per cubic foot, but oil, being less dense, weighs 50 pounds per cubic foot. Using water as a standard, the specific gravity of a liquid is the number of times a volume of that liquid is as heavy as an equal volume of water. For example, if a certain type of oil has a specific gravity of 0.75, it is only three-fourths as heavy as an equal volume of water. Specific gravity of liquid is found by taking the weight of a certain volume of liquid and dividing it by the weight of an equal volume of water.

Liquid Head

At any level, the pressure due to a liquid's weight depends upon the vertical height of liquid from that level to the surface of the liquid. The vertical distance between two horizontal levels of a liquid is known as the head of the liquid. If the surface in a supply tank is, for example, 144 feet above a spigot connected to it, the water head is 144 feet. Such a water head produces a pressure of 62.4 pounds per square inch, because a water column of one inch cross-sectional area has a volume of one cubic foot if it is 144 feet high.

ADVANTAGES OF HYDRAULIC SYSTEMS

Hydraulic systems have numerous advantages. Of considerable importance is the fact that commonly used hydraulic systems are economical to operate. Hydraulics eliminate the need for complicated systems of gears, cams, and levers. Motion can be transmitted without the normal lost motion found in mechanical parts. The use of fluids such as oil reduces the wear on equipment, and it is not subject to breakage as are mechanical parts. Also, parts of the system can be located at different points with little loss of force. Small forces can control much larger forces, partially because of the ease in transmitting this force. Finally, the system, if properly used, provides uniform and flexible control, despite variations of the load.

Hydraulic systems also have disadvantages. When used as train and elevation power drives, these systems must be located on the rotating structure of the gun mount, whereas most of the amplidyne power drive equipment is located off the mount. Hydraulic systems also require hydraulic tubing to interconnect components of the system. The tubing and other hydraulic components tend to clutter up the equipment space, causing bottlenecks during upkeep and repair. Another disadvantage of hydraulic systems is fluid leakage, which is almost impossible to prevent and which creates upkeep problems.

Hydraulic systems also affect the scope of training necessary for equipment maintenance. For example, personnel who maintain amplidyne power drives need training in electricity, electronics, and mechanics. Personnel who maintain hydraulic systems not only require training in electricity, mechanics, and hydraulics, but also may require as much training in electronics as those who maintain amplidyne power drives.

FORCES IN HYDRAULIC SYSTEMS

A knowledge of basic hydraulic formulas is essential to understanding the principles of hydraulics. The basic formulas and laws pertaining to hydraulics are covered in Fluid Power, NAVEDTRA 16193-B, so will not be discussed here. It is recommended that you read the applicable chapters in Fluid Power to help you better understand the principles of hydraulics before proceeding with this chapter.

Vacuum

The term vacuum and atmospheric pressure are used quite frequently in hydraulics. Vacuum is a space entirely without matter. Since it is difficult to form a perfect vacuum, a partial vacuum is used in hydraulics to prime pumps. This is done by causing an unbalanced atmospheric pressure.

Atmospheric Pressure

Atmospheric pressure is the weight of the air where we live and is 14.7 psi at sea level. Theoretically, by using a combination of partial vacuum and atmospheric pressure, water can be lifted 34 feet at sea level, but the practical limit is approximately 28 feet. Since oil is lighter than water, the theoretical distance that it can be lifted is 37 feet, although in actual practice 28 feet is the usual limit.

LIQUIDS IN MOTION

A flowing liquid always has two energies present. pressure energy, which overcomes friction, and velocity energy, which completes work because of its own work and motion. For example, consider a dam that holds back a body of water. If a wheel is placed at an outlet and then connected to a generator shaft, the liquid will rush out, turn the wheel, and cause the generator to generate electricity.

Volume of flow is the quantity of liquid that will pass a certain point in a given time. While volume of flow can be stated in cubic feet per minute or gallons per minute, it is usually expressed as gpm (gallons per minute).

Velocity of flow is the rate of speed at which a liquid is moving past a particular point, usually stated in feet per second (fps). As an area or cross section of pipe decreases, the velocity of flow increases. When velocity increases, pressure decreases as illustrated in figure 8-1.

At entrance A, the pressure is 100 psi, but in the Venturi, V, the pressure drops to approximately 50 psi. After the liquid passes through point V, the diameter of the pipe gradually returns to its normal size, and the guage at B again reads 100 psi.

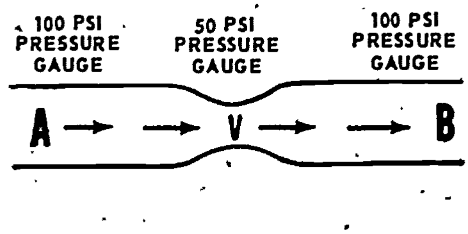
A turbulent flow usually results when the velocity of flow becomes too great or the passage becomes restricted. Turbulence is the effect of eddies and whirlpools. Care is taken to minimize turbulence in hydraulic systems by using moderate pipe bends and valves designed to offer as little resistance to flow as possible. To get a smooth or uniform flow in hydraulic systems, small streamlined pipes, low velocity of flow, and moderate bends are used.

Some of the factors that govern fluid flow are gravity, atmospheric pressure, applied force, inertia, and friction.

Gravity is the force exerted by the earth on all objects, tending to pull them to the center of the earth.

Inertia is a term for that property of matter by which it will remain at rest or in uniform motion in a straight line unless acted upon by some external force.

Atmospheric pressure, which acts on liquids either at rest or in motion, acts whenever any part of the hydraulic system is exposed to the open air. This pressure occurs because air has



4.7.4

Figure 8-1.—Pipe venturi.

weight, and since oil is a fluid, this pressure is exerted equally in all directions as the molecules move freely.

FRICTION

A force that opposes the motion of one body over another is friction. It is due to the irregularities in the contacting surfaces and to the deformation of the contact surfaces that is caused by pressure. Friction makes the work input to a hydraulic system slightly greater than the useful work accomplished by it. Hydraulic equipment is designed to keep friction at the lowest level by maintaining a desirable velocity of flow within the system, having clean, smooth pipes, laying pipes along the most direct route while avoiding sharp bends, and using valves and guages that interrupt the flow as little as possible. The system is so designed that variations from normal operation can be easily detected and remedied.

When liquid flow in a pipe is suddenly halted by a closing valve, the inertia of the liquid causes a sudden high pressure. The immediate effect is something like a hammer blow which results in clanking sounds. This high pressure can cause vibrations that are transmitted throughout the system at approximately one mile per second, alternately stretching and compressing the pipe.

The appropriate method to be used in the elimination of water hammer in a particular system is prescribed in pertinent publications. Methods and procedures found in these publications must be strictly followed.

PROPERTIES OF HYDRAULIC FLUID

In addition to the qualities of incompressibility and fluidity, the following properties are necessary to meet the particular requirements of modern hydraulic systems.

A high degree of chemical stability is necessary in a fluid that is subjected to prolonged periods of use at high temperatures. Fluids may break down if exposed to air, water, salt, or other impurities, especially if they are subjected to heat or kept in constant motion.

An ideal oil would be free from acid and be noncorrosive so that the metals used in the system would not be adversely affected.

If the oil is contaminated by impurities (acids, sludges, or gums), carbon deposits will form and will cause valves and pistons to stick.

Straight mineral oils do not remain completely noncorrosive under severe operating conditions.

Certain chemical additives or inhibitors are often dissolved in an oil to improve its chemical and physical behavior. These additives result in a fluid with improved characteristics for a limited time. Such oil however, often is subject to more rapid deterioration than would have been the case if the additive was not used. Additives are necessary in a fluid required to withstand the severe conditions encountered aboard ship.

Pour Point

Pour point of liquid is the temperature at which an oil will congeal or solidify and cease to pour. The pour point of a hydraulic fluid used should be at least 30° F. lower than the minimum temperature to be encountered when using the system. A low pour point is normally desired. As the pour point is neared by a hydraulic fluid, the viscosity of the fluid tends to increase, resulting in sluggish operation of the hydraulic system.

Flash Point

Flash point is the temperature of an oil at which the fumes or vapors that are given off will ignite or flash. Minimum flash point occurs when the vapors will flash, while the maximum flash point is reached when they burn steadily. Hydraulic fluids must withstand the high operating temperatures that are encountered during long periods of operation.

Viscosity and Viscometers

Viscosity of a liquid is the resistance to flow. This is an inherent characteristic due to its physical properties. Fluids which offer high resistance to flow are said to have a high viscosity, whereas those that flow more easily under the same temperature conditions have low viscosity. Viscosity increases with a decrease in temperature.

A desirable fluid for cold weather operations would be one with a low, flat viscosisty. An oil has a flat viscosity if a wide variation in temperature produces only a minimum change in resistance to flow.

A viscometer is used to determine the viscosity of a fluid. The viscosity index is a numerical indication of the degree of change in viscosity caused by a change temperature.

The lower the viscosity index, the greater the variations in viscosity with changes in temperature. These variations may range from above 100° F. to below 0° F. For example, oil with a viscosity index of 12 shows less change in viscosity with changes in temperature than does oil with a viscosity index of 10.

HYDRAULIC MECHANISMS

Hydraulic systems have a number of favorable characteristics. They are smooth and flexible in operation. They can efficiently transmit force in any direction or around corners without the need for gears, cams, or levers. They can provide a mechanical advantage in either linear or rotary movements.

A basic hydraulic system consists of a reservoir, a motor-driven pump, a valve group, a hydraulic cylinder (or motor), a series of lines, manifolds and associated components.

The reservoir is a container to hold the necessary supply of hydraulic fluid for operation of the system. When the system is in operation, hydraulic fluid leaves and returns through the reservoir outlet and inlet lines.

The pump is the heart of the hydraulic system. A pump draws hydraulic fluid from the reservoir, circulates it through the system and returns it to the reservoir.

A valve is a control that governs the quantity, pressure, or direction of fluid flow. A typical hydraulic system uses several types of valves.

A hydraulic cylinder converts hydraulic energy supplied by the pump into linear mechanical motion; a hydraulic motor converts hydraulic energy into rotary mechanical motion.

The various lines and manifolds connect the components of hydraulic system for distribution of the hydraulic fluid.

ORIFICES

An orifice is a constriction in a fluid passage limiting and regulating the flow rate. Because of their inherent damping effect, orifices also are used to minimize pulsations of shock waves in the hydraulic system.

The most common type of orifice is simply a small hole joining two fluid passages. Often an orifice is drilled through a threaded plug that is screwed into an opening between the fluid passages. Thus, by inserting plugs with different sized orifices, the flow can be changed.

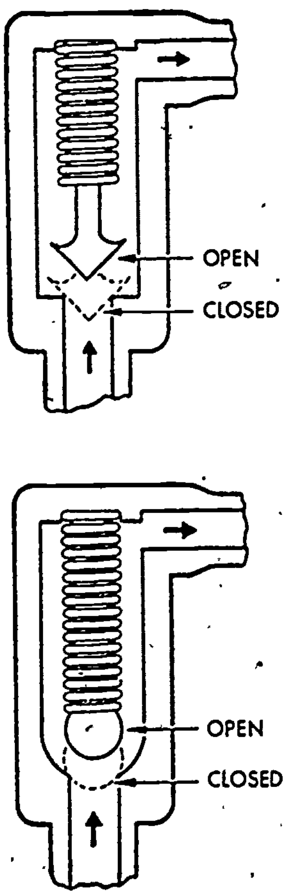
Another frequently used orifice is the spiral orifice. This type has a spiral groove around the circumference of a rod-like plug and the plug is snugly fitted into the bore of a fluid passage. Since the flow of hydraulic fluid must follow the spiral groove, the groove's dimension (including effective length and contour) determines the flow rate.

VALVES

Valves may be operated in a number of ways—manually, mechanically, electrically, pneumatically, or hydraulically. Some valves can be operated in more than one way.

Check Valves

Check valves (fig. 8-2), commonly used throughout a hydraulic system, allow fluid to flow in one direction only. Basically a check valve consists of a spring-loaded plunger and a valve seat. The spring is relatively weak and merely helps seat the plunger (close the valve) when flow ceases. The hydraulic fluid, moving in the direction of the arrow (fig. 8-2), lifts the plunger (opens the valve) permitting unrestricted passage of the fluid. The fluid cannot flow in the reverse direction because it would close the valve (check the flow). A check valve is sometimes called a directional valve.



33.54.1

Figure 8-2.—Check valve.

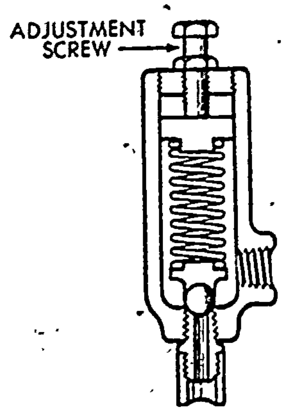
Relief Valves

Relief valves protect hydraulic systems against excessive pressure. If an abnormally high pressure develops, these valves open to bypass fluid before the pressure buildup can endanger the system. A simple relief valve (fig 8-3) consists of a spring-loaded plunger or ball and a valve seat. When the pressure within the system reaches a predetermined value, the spring compresses and the valve bypasses fluid usually back to the tank. The bypass pressure setting of the valve may be changed by varying the spring tension by means of the adjustment screw.

Compound Relief Valve

A compound relief valve commonly used in ordnance equipment is the Northern duplex (Dixie).

This valve limits maximum pressure buildup between the A-end and B-end. The valve may be installed in the transmission lines between the valve plates (fig. 8-27) or between the transmission ports in the valve plate (fig. 8-26).



33.54.2

Figure 8-3.—Relief valve.

The theory of operation of this valve is based on a differential in area. As shown in figure 8-4, this valve employs a pilot valve, main valve, and a double-ball check valve. The double-ball check valve allows this pilot valve to be used with alternating transmission lines. The area at the bottom of the main valve is one half the size of the area on the top of the main valve. Drilled passages within the main valve allow fluid to pass through the pilot valve to the top of the main valve. The movement of the pilot valve limits the pressure on top of the main valve and is adjusted for one-half of the desired pressure in the transmission line.

When the pressure in the system exceeds the desired pressure, the excess pressure is transmitted to the top of the main valve and below the pilot valve. This action causes the pilot valve to move up, compressing its spring and allowing the oil to move from above the main valve to the bottom of the pilot valve. Now the main valve can move up and dump the excess volume into the return line.

When pressure drops below the desired value, the pilot valve spring forces the pilot valve down moving the volume of oil back to the top of

84.20

Figure 8-4.—Northern duplex relief valve.

the main valve. The area differential on top of the main valve causes it to return to its seat.

Because the cover on top of the valve housing must be removed to turn the adjusting screw on the pilot valve, this valve is adjusted by the trial-and-error method. Remember that the pilot valve spring is adjusted to a value of one-half the required pressure in the transmission lines. Since the setting on this valve is determined by trial and error, it may be helpful to know that one complete turn of the adjusting screw in either direction will decrease or increase the pressure approximately 132 psi.

Figure 8-4 illustrates how the component parts of the relief valve are situated to provide a smooth relief action and to protect the hydraulic system from excessive pressure.

Directional Valves

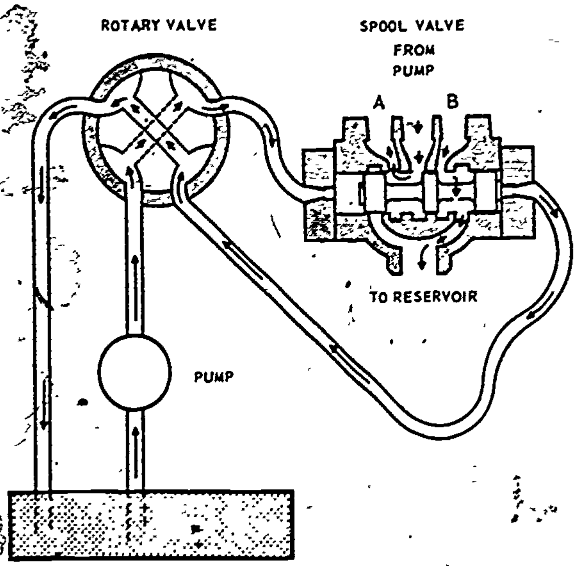
The valves previously described limit either the pressure or the flow of hydraulic fluid. A directional valve, as the name implies, directs the flow of fluid.

A directional valve may be operated hydraulically (by force differentials set upon opposite sides of its movable part) or by manual, electrical, or mechanical means. Sometimes two or more methods are used. The two most common types of directional valves are the rotary and the spool type. Rotary valves are frequently used to direct the flow of hydraulic fluid to other valves (fig. 8-5).

By rotating the core of a rotary valve, hydraulic fluid can be discharged through either of two parts. The rotary valve shown in figure 8-6 is an open center type with two cross passages. One is indicated by the dotted line in figure 8-5.

Spool-type valves have many uses in a hydraulic system. Figure 8-5 and 8-6 show a simple spool-type, four-way valve, but many valves of this type have more complex designs. Spool valves with additional lands and a spring, or even two spools in the same valve sleeve, are not uncommon. The spool valve shown in figure 8-5 is hydraulically operated. When hydraulic pressure is ported to one end of the spool, hydraulic fluid at the opposite end drains into the tank.

With hydraulic fluid ported to the left end of the spool, the resultant pressure differential causes the spool to shift to the right. With the spool shifted to the right, pressure fluid from the pump passes out through port A, while discharge fluid passes out through port B to tank. If the rotary valve is positioned to direct the hydraulic fluid against the right end of the spool,

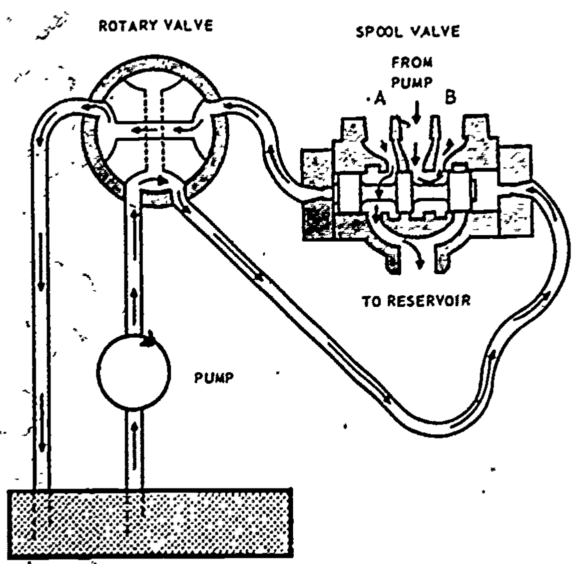


84.21
Figure 8-5.—Directional valves.

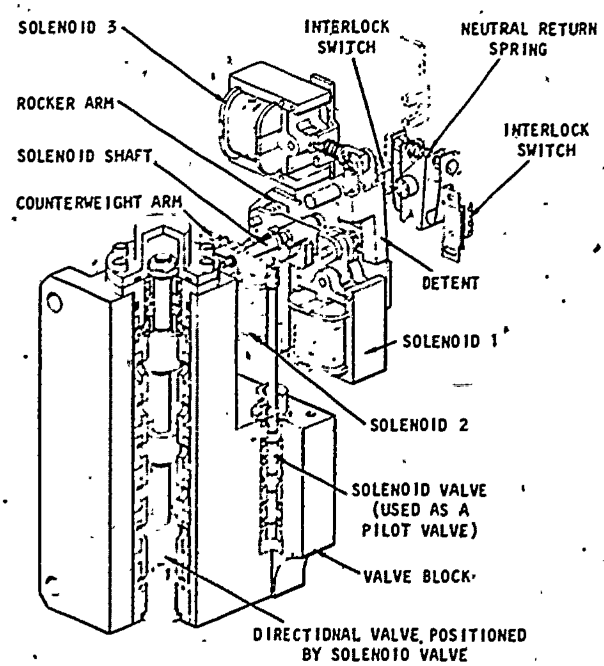
the spool shifts to the left (fig. 8-6). Now pressure fluid passes out through port B while port A acts as the return to the reservoir. By changing the flow direction in this manner, the movements of associated hydraulic components can be reversed.

Pilot Valves

Pilot valves govern the actions of other valves, but the term "pilot valve" does not designate a valve design or type. This term simply designates the specific use of a valve. For example, a compound relief valve incorporates a pilot valve to control opening and closing actions. Similarly, a rotary valve serves as a pilot valve to control the position of a spool-type directional valve. Valves that serve as pilot valves vary, not only in type and design but also in method of operation. Electrically operated pilot valves, called solenoid valves, are frequently used to position other valves. Solenoid operated valves are also used for other purposes, such as dump valves. The solenoid valve in figure 8-7 is relatively small, yet it has sufficient capacity to shift a larger, hydraulically



84.22
Figure 8-6.—Spool valve reversed.



84.23
Figure 8-7.—Solenoid valve assembly.

256

operated valve. The larger valve, in turn, supplies pressure fluid to associated working components. Two solenoids operate the solenoid valve plunger. The valve plunger is connected to a counterweight arm that is splined to the solenoid shaft. A rocker arm, linked to the core rods of both solenoids, is also splined to the solenoid shaft. When solenoid No. 1 is energized, the valve plunger shifts up; when solenoid No. 2 is energized, the valve plunger shifts down. As shown in figure 8-7, some solenoid valve assemblies have a third solenoid. In these applications, a detent holds the valve plunger in the shifted position, and the third solenoid is used to release the detent, thereupon, the valve plunger spring returns to the natural position.

HYDRAULIC PUMPS

A pump is a mechanism that uses an external source of power to apply force to a fluid. All pumps in open hydraulic systems take advantage of the fact that the earth's atmosphere, a gaseous fluid, exerts a static pressure whose existence becomes noticeable whenever a partial vacuum is created.

Anybody who drinks through a straw is making use of this phenomenon. By sucking on the straw, he creates a partial vacuum. Atmospheric pressure, acting on the liquid in the tumbler, forces enough of it up the straw to the partial vacuum.

In a common hand pump, figure 8-8, the lever-type pump handle is joined to a piston rod with a simple upward-opening check valve (numbered 1) in the piston. The downstroke of the piston applies pressure to the water in the pump, opening valve 1 and closing another check valve (numbered 2) at the base of the pump.

On the up stroke of the piston, pressure is reduced, and a partial vacuum is created in the area between the two valves. Valve 1 closes. Atmospheric pressure in the well forces water

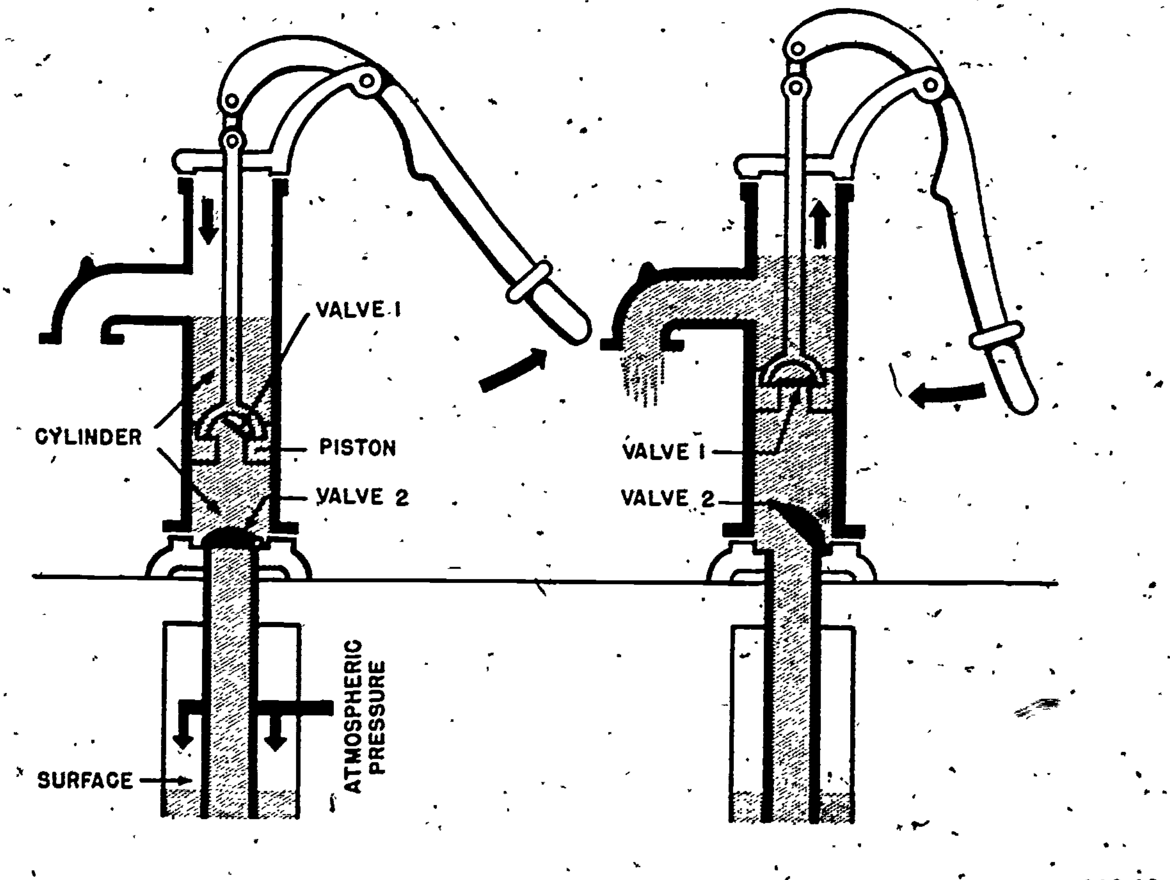


Figure 8-8.— How a simple hand pump operates.

up the pipe. The upward thrust of the water opens valve 2 but is not strong enough to open valve 1 as long as the piston continues to rise. The excess water thus drawn into the pump flows from the spout.

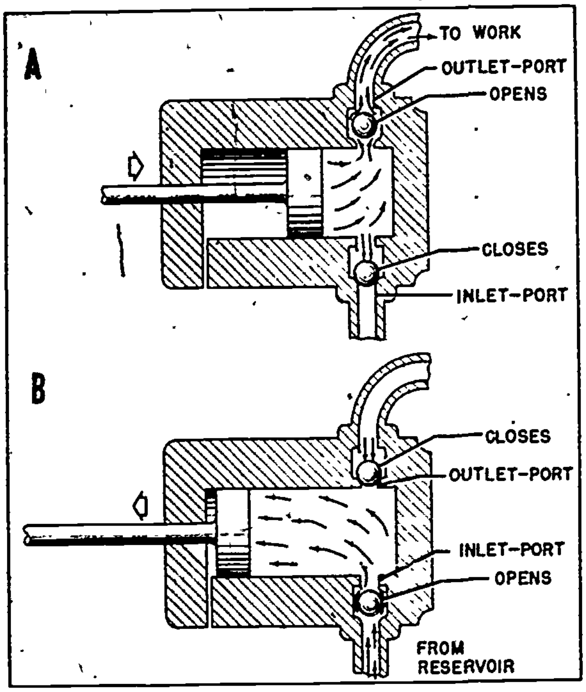
There is a great difference in structure, though not in fundamental operating principle, between the simple hand pump in figure 8-8 and the Waterbury constant-speed, axial-piston, variable-delivery pump that consitutes the A-end of a gun's electric-hydraulic train or elevation power drive. The summary below will prepare the way for the description of the A-end.

Types of Action

Pumps that are designed to perform work operations are installed as integral parts of closed hydraulic systems in which fluid from a reservoir is repeatedly circulated by pump action.

Pumps used in ordnance hydraulic equipment are divided into two main classes, the reciprocating and the rotary type.

RECIPROCATING PUMPS.—The reciprocating pump (so called because its parts must reciprocate, or move back and forth, to function) was the earliest type to be used in hydraulic systems. Most reciprocating pumps consist fundamentally of a piston that moves back and forth in a cylinder fitted with a check valve. The valves open and close ports to a source of liquid and to a work area. Figure 8-9 shows an elementary reciprocating pump. By pushing the piston to the right, the hydraulic pressure in the cylinder is increased. This action closes the inlet port and opens the outlet port permitting the fluid to flow to the work area. Figure 8-9A shows how this is done; when the piston is moved to the right, hydraulic pressure acts on both of the check valves, the check valve in the outlet port is pushed up, thus, allowing hydraulic fluid to pass around the check valve and into the work area. At the same time, the check valve in the inlet port is pushed down blocking the port from the reservoir. When the piston is moved to left (part B of fig. 8-9), the pressure in the cylinder drops and the outlet check valve closes the port to the cylinder. This action holds hydraulic fluid in the work area. The inlet check valve now opens, permitting the fluid in the reservoir to fill the cylinder. By positioning the valve back and forth, left to right, a pumping action is created. This type pump can be found in the Ford power drive on 5"/38 twin mounts and functions as a sump pump and oscillator.



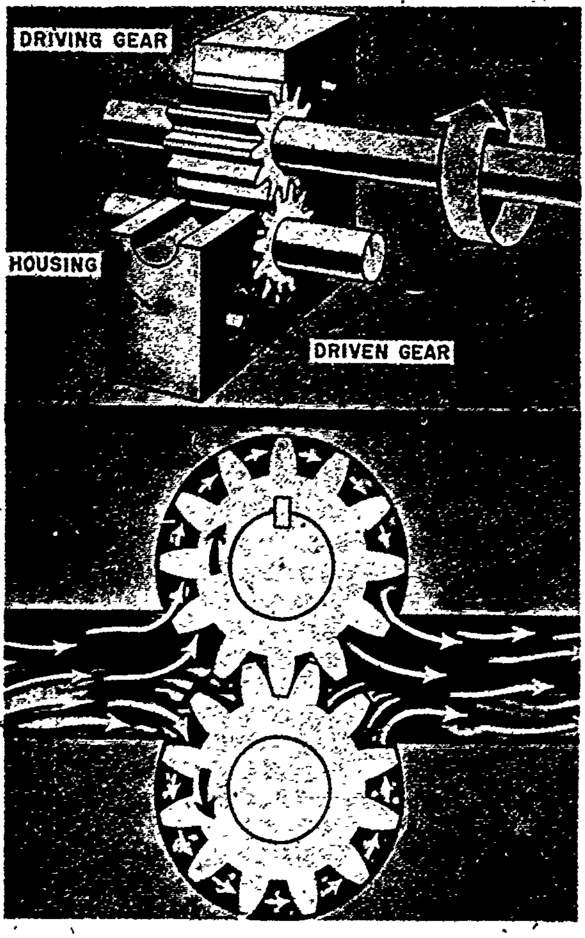
84.24

Figure 8-9.—Elementary reciprocating pump.

ROTARY PUMPS.—Rotary pumps have operating parts that revolve to exert force on fluids. Figure 8-10 shows a simple gear-type rotary pump. They are used for many purposes in ordnance hydraulic equipment. They are found in the rammer assembly in the 5"/38 gun mount and also are used as auxiliary pumps to supply servo and supercharge pressures in a hydraulic transmission.

The rotary pump did not come into general use until the electric motor became common. Electric motors are ideally adapted to drive rotary pumps since it is necessary only to couple two rotating shafts. All the pumps you encounter in ordnance hydraulic mechanisms are powered by electric motors. Rotary pumps come in all sorts of shapes and sizes, and with all sorts of designs. We will study only two types commonly used in ordnance hydraulic systems. First we explain the rotary gear pump and then we take up the rotary vane type pump.

A rotary gear pump essentially consists of a pair of meshing gears in a close-fitting housing fitted with intake and outlet openings for coupling to tube or pipe. The drive shaft of the power



84.25
Figure 8-10. — Elementary gear pump.

source is coupled to one of the gears which, in turn, drives the other (See part A of fig. 8-10). In operation, liquid passes from the inlet side, between the gear teeth and the housing, to the outlet side, as shown in part B of figure 8-10. Because of the close contact between the two gears, no liquid can leak back to the inlet side between the meshing teeth.

In considering the discharge of any pump, it's important to remember from Pascal's Law that liquids transmit pressure in all directions. Because of this, any pressure in the discharge line is exerted not only forward in the line but also back toward the gears. This back pressure causes:

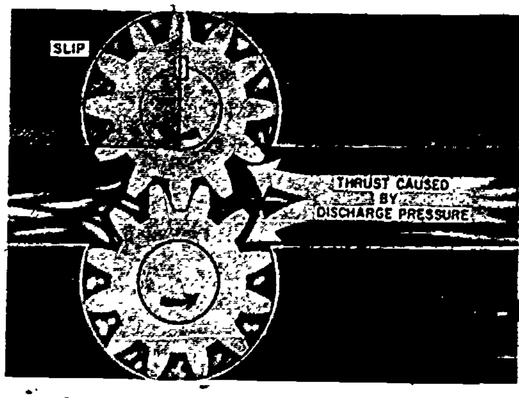
1. THRUST tending to distort and displace the gears. This back thrust, in turn, causes increased wear. (See fig. 8-11).

2. SLIP, or leakage within the pump itself, with consequent loss in efficiency. (See fig. 8-11.) It's because of slip that pump efficiency goes down somewhat with increased output pressures.

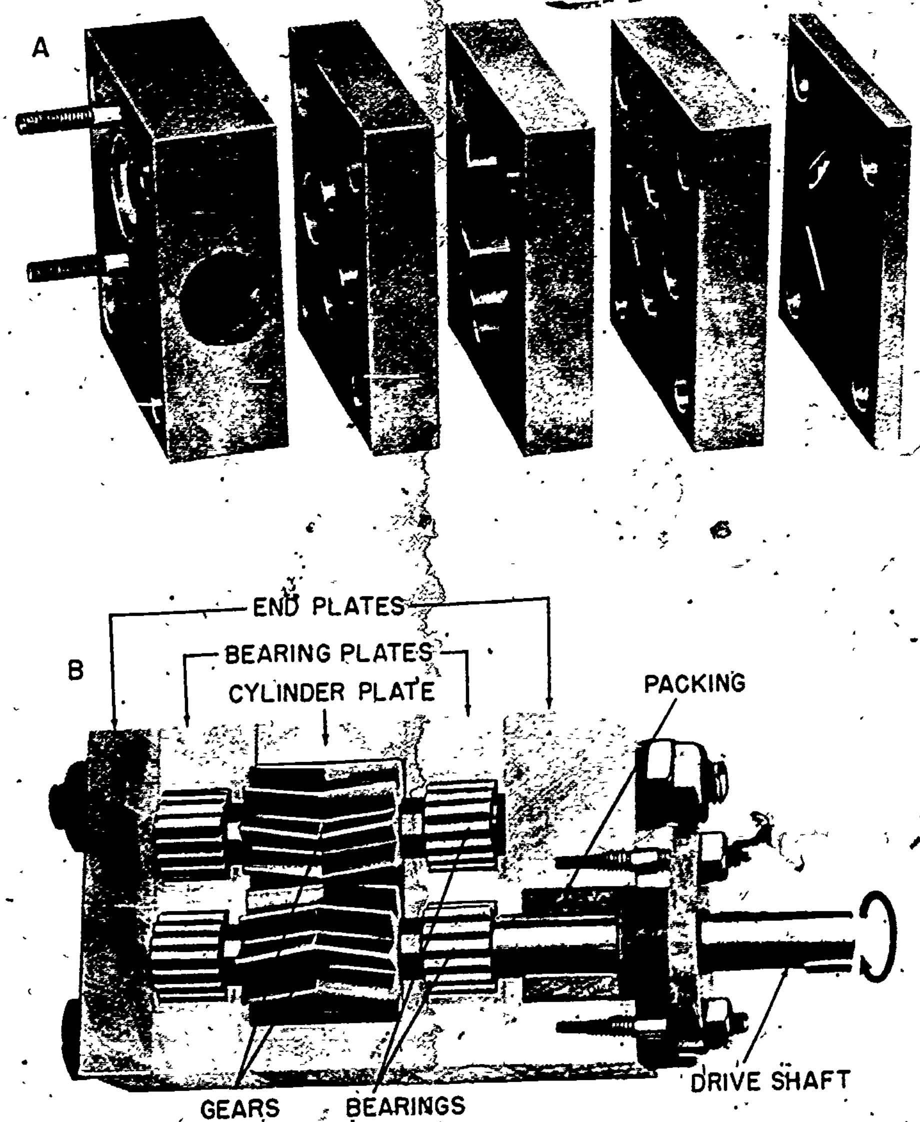
To overcome the effects of this back pressure, Northern nitralloy pumps are ruggedly constructed of hardened metals. In this way they can withstand the rigors of their normal loads and maintain the very close clearances required to minimize slip.

Basically, the Northern nitralloy series 4000 gear pump consists of a housing of five hardened alloy steel sections (shown in part A of fig. 8-12), accurately machined and ground, and bolted together by four long bolts running through all the sections. The center block, or CYLINDER PLATE, forms the housing for the gears. (See part B of fig. 8-12). On each side of the cylinder plate are mounted the BEARING PLATES which house the bearings on which the gear shafts rotate. Completing the normal assembly of this pump are two END PLATES. The one that receives the drive shaft contains the packing.

You'll generally find Northern pumps of this type in rammers (particularly in 5-inch mounts) and hoists. In these applications, the plain end plates illustrated in figure 8-12 are replaced by plates that incorporate mounting brackets or valve blocks necessary for the mechanism in which the pump is employed. Because of its sectional constructional feature, the pump is very



84.26
Figure 8-11. — Back thrust and slip.



147.113

Figure 8-12.—Construction of Northern nitralloy series 4000 gear pump.

versatile and relatively easy to assemble and disassemble.

Three types of gears may be used in the Northern nitralloy series 4000 pump: SPUR, HELICAL, and HERRINGBONE. Figure 8-13 shows these types. The spur type has one disadvantage: at high speeds and pressures some liquid is carried between the meshing teeth, forcing the gears apart. For this reason, spur-gear pumps are generally used only at low speeds and pressures. The helical (with slanting teeth) and herringbone (double helical with teeth meeting in herringbone pattern) types do not have this drawback because the teeth mesh gradually, forcing the trapped liquid out one side (in helical gears) or both sides (in herringbone).

A couple of hundred years ago, Sir Isaac Newton, the famous British mathematician, formulated three Laws of Motion to explain the behavior of matter. The second of these three laws states:

84.27
Figure 8-13.—Three types of gears may be used in the Northern nitralloy series 4000 pump.

"A body at rest tends to remain at rest, and a body in motion tends to continue in motion with the same velocity and in the same direction." Or in other words, once you set something in motion, it tries to keep going straight along at the same speed.

Now, suppose we try a little experiment. Take a shallow basin, and fill it about half full of water. With your hand; whirl the water around. You'll notice that the water banks up around the sides of the basin, leaving the center low, or even waterless. And, if you whirl the water hard enough, it will splash over the side.

According to the Newtonian Law that we've just stated, the water tends to move in a straight line when it's pushed. However, the sides of the basin hold it in, forcing it to follow a circular path. Because the water tends to go straight, it exerts force outward, so that if you push it hard enough it will mount the sides of the basin and spill over. This outward-tending force is what we call CENTRIFUGAL (Latin for CENTER-FLEEING) force. The greater the rate of rotation, the greater this force becomes.

In a centrifugal pump, you have instead of your hand, a set of paddles or blades (the IMPELLER) which whirl the water around. For reasons of design, which we won't go into here, the impeller blades are curved. Instead of the basin, you have a completely enclosed casing of special shape, the VOLUTE. The pump's outlet is at the outside edge of the casing. The inlet is through the center, or EYE.

When the pump operates, liquid enters the pump through the eye and is whirled around in the pump chamber by the rotation of the impeller. Centrifugal force drives the liquid directly outward from the center, setting up a greater pressure at the outer edge of the chamber than at the eye. At the same time the liquid is also pushed around and around in the pump by the turning of the blades, and is given more and more velocity as it moves farther out from the eye. As the liquid finally escapes into the discharge, it slows down and, in effect, its velocity is converted into liquid pressure or head.

The rotary pumps we have studied up to this point have all depended for their operation on the meshing of two gears or lobes. Even the internal-gear pumps work on this principle with the two gears one inside the other. The Vickers balanced-vane pump is different. It has only one rotating part, rather than two, and no gears at all.

You'll find rotary-vane pumps rather widely used in ordnance hydraulic systems, from 5-inch Vickers rammers and ammunition hoists to 16-inch projectile rings, elevating power drives, and powder hoists.

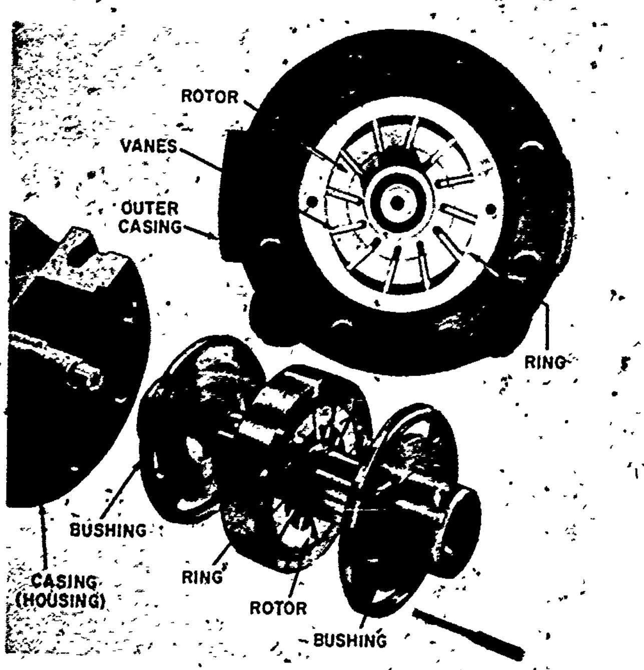
The basic construction of the Vickers balanced-vane pump is very simple indeed (fig. 8-14). Mounted on the drive shaft is the ROTOR, a cylindrical block of steel with 12 evenly spaced slots accurately machined in it. Snugly fitted into these slots are 12 vanes, which are blades of hardened steel. Though the vanes are not loose enough to rattle around, they are free to move in and out of the slots. The vanes have a beveled edge and a square-cut edge, and they are assembled in the rotor with the beveled edge trailing.

Surrounding the rotor is the hardened and ground RING, which is elliptical or oval in shape. The ring, in turn, is enclosed by the pump's outer case or HOUSING.

The sides of the pump are enclosed by two VALVE PLATE BUSHINGS, in whose sides are cut the intake and discharge ports.

Now as the rotor revolves at the pump's normal operating speed (1,200 rpm), what happens?

As you can guess, centrifugal force comes into the picture and the vanes in the rotor immediately try to fly out. Of course, the vanes can't actually

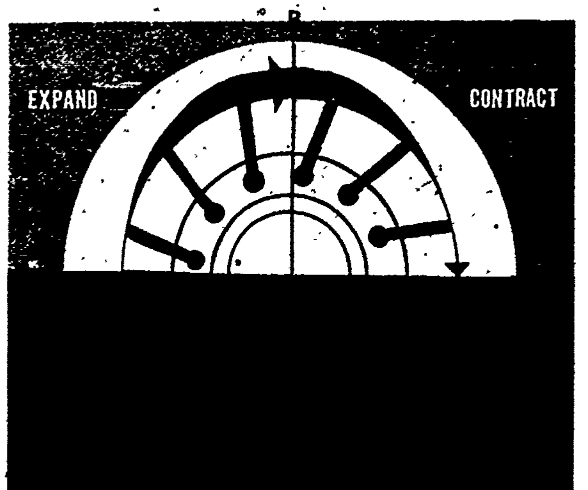


84.28
Figure 8-14.—Vicker's balanced-vane pump (cutaway and exploded views).

get far, because they're confined by the elliptical ring. But, under the thrust of centrifugal force, they push hard against the inside surface of the ring, and can form an oil-tight seal. As the rotor turns, the vanes remain in contact and follow the contour of the ring, sliding out of and into the rotor.

The ring's contour permits the vanes at the top and bottom to extend further than at the sides, where they are held all the way in. Thus, the vanes divide the space between rotor and ring into little spaces or chambers that change in size as the rotor turns. Figure 8-15 shows how the chambers expand as the rotor turns from A to B, then contract as they approach C, and so on around the ring.

In the vane pump, as in the gear pumps we've studied, the ordnance hydraulics designer must take into account not only the flow of fluid through the pump but also the pressure relationships. An analysis will show that when the pump, as we have so far described it, is in operation, there is a heavy thrust on the discharge side and a lesser, but still considerable, thrust on the inlet side. Since these thrusts are unbalanced, they can strain bearings and distort the pump



84.29
Figure 8-15.—How the chambers expand and contract in the balanced-gear vane pump.

housing. The thing to do with unbalanced pressure or thrusts is to balance them.

This balancing is done in the vane pump not by using balancing lines, but by putting the WHOLE pump to work, instead of only the upper half that you see in figure 8-16A.

Therefore, since the pump chambers expand and contract twice during each rotation, the pump has two intake and two discharge ports cut into the valve-plate bushings that cover each of its sides. The discharge and intake ports are paired, and the passages connecting the ports to their proper lines are arranged as in figure 8-16B.

In the actual pump these passages are not separate tubes, as the figure shows them, but are cut into the pump housing.

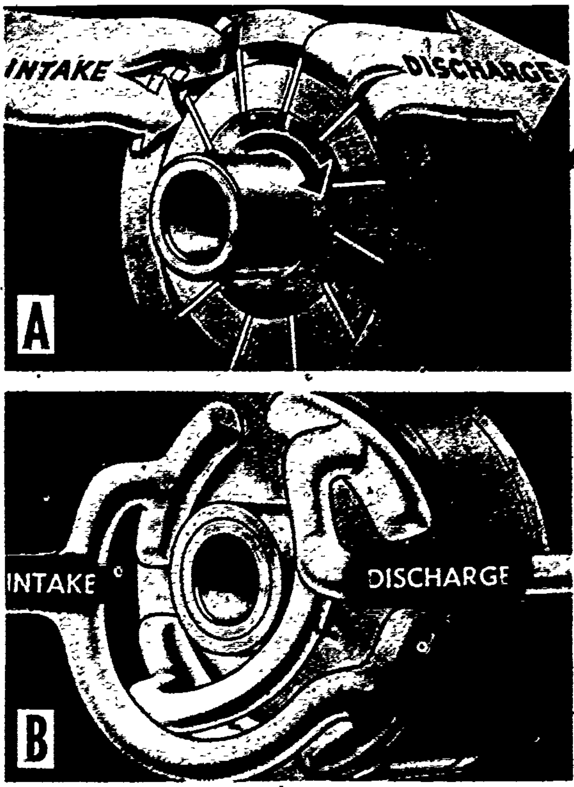
The discharge ports are equal in area and under equal fluid pressure. The intake ports are similarly equal in area and fluid pressure. It logically follows, then, that the discharge sections on opposite sides of the pump exert equal balanced thrusts, as do the intake sections (though the thrust at each intake is much smaller). We have, as a result, all the thrusts balancing out, regardless of pressures in the intake and discharge lines (fig. 8-17).

When you closely examine the valve-plate bushings, you will notice two grooves or passages leading from each discharge port to tiny holes that pierce the bushing (fig. 8-18A).

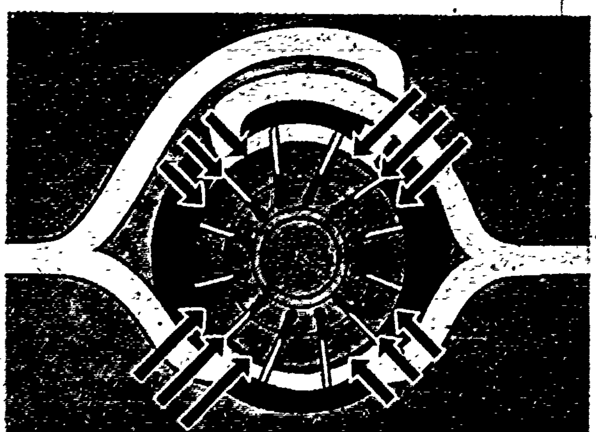
Tracing the flow of oil through these holes, you find that it goes to a shallow annular (ring-shaped) recess or depression around the rotor, thence to the pinhead-shaped openings at the bottom of each vane slot (fig. 8-18).

(In actuality, the valve-plate bushing closely fits against the ring; in the figure it has been separated from the ring to show the path of flow.)

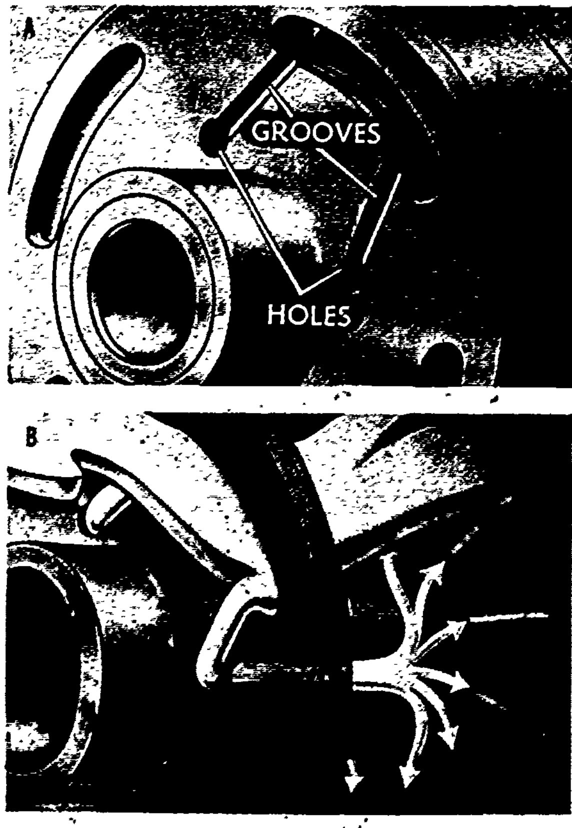
Since the vanes, though close fitting, must move in and out of their grooves twice during each revolution of the motor (and it rotates at approximately 1,200 rpm at normal speed), one purpose of this arrangement should be obvious. It's a forced self-lubrication system. It has another purpose too: The full output pressure of the pump is exerted at the base of every vane, helping centrifugal force to hold it outward against the ring. Pumps can be grouped according to whether they discharge liquid in volume separated by a period of no discharge (positive displacement),



84.30
Figure 8-16.—Balanced-vane pump: intake and discharge.



84.31
Figure 8-17.—Balancing of forces in Vickers balanced-vane pump.



84.32
Figure 8-18.—Balanced-vane pump. Forced self-lubrication system.

or, in a continuous flow (non-positive displacement). In addition, pumps can be classified according to whether or not the quantity of liquid discharged by the pump can be varied without changing the speed of rotation of the source of power (variable or constant delivery).

POSITIVE AND NON-POSITIVE DISPLACEMENT.—A positive displacement pump is one in which a definite volume of liquid is delivered for each cycle of pump operation, regardless of the resistance offered, provided the capacity of the power unit driving the pump is not exceeded. A non-positive displacement pump is one in which a volume of liquid delivered for each cycle is dependent upon the resistance offered to flow. This type of pump produces a force on the liquid that is constant for each particular speed of the pump. Resistance in the discharge line produces a force in the opposite direction. When these forces are equal, the liquid is in a state of equilibrium and does not flow.

If the outlet of a positive displacement pump is completely closed, either the unit driving the pump will be stalled or something will break. If the same thing is done to a non-positive displacement pump, the discharge pressure will rise to a maximum for that type of pump operating at that speed. Nothing more will happen except that the pump will churn the liquid and produce heat.

Positive displacement pumps deliver liquid in separate volumes, with no delivery in between, although a pump having many chambers may have an overlapping delivery which minimizes this effect. Non-positive displacement pumps deliver a practically continuous even flow for any given set of conditions of speed and resistance.

For every back and forth motion of the piston in the pump shown in figure 8-9, a complete cylinder of liquid will be delivered to the outlet while the piston is moving to the right on the discharge stroke. Nothing at all will be delivered while the piston is moving to the left, on its suction stroke. If the outlet were completely blocked, as by a shut-off valve, it would be impossible to move the piston to the right because of the virtual incompressibility of the liquid filling the chamber. If sufficient force were applied to the piston, the pressure in the chamber would rise until finally something would break.

Obviously this single chamber pump would give a badly pulsating delivery. In the rotary pump shown in figure 8-10, where each of the spaces between the teeth of the gears is a pump chamber, delivery will overlap so that a more nearly constant flow will be obtained. Another method of reducing the pulsation is to provide an air chamber near the pump outlet to damp the pulsations, but there is always some pulsatory effect with positive displacement pumps. Pulsations are objectionable because they cause jerky movements in driven mechanisms and set up vibrations in the whole system.

For the centrifugal pump, the liquid is not broken up into isolated volumes to be delivered one by one, but a pressure differential is created in the solid stream by the rotary and sweeping action of the impeller so that a smooth continuous flow results.

Reciprocating and rotary pumps of necessity are positive displacement pumps while jet, centrifugal, propeller, and mixed flow pumps of necessity are non-positive displacement pumps.

Types of Discharge

All pumps will deliver liquids at different volume rates if run at different speeds. It is not practical to vary the speed with ordinary positive displacement pumps although these pumps can be especially constructed to deliver different volumes of liquid while being run at the same speed. They can be constructed, that is, to give constant or variable delivery for each cycle so that volumes of delivery can be obtained without changing the operating speed of the pump.

This is managed with reciprocating pumps by altering the length of the work stroke of the piston. Thus in figure 8-9, each discharge stroke of the piston might displace 200 cubic inches of liquid, but the distance the piston travels might be shortened to give a stroke which would displace only 180 cubic inches. This would cut the volume of delivery 10 percent without altering the speed.

Gear type rotary pumps are not normally constructed to give variable delivery at constant speeds.

Centrifugal pumps deliver different volumes of liquid while running at a constant speed since the volume of discharge varies with the head against which the liquid must be discharged.

CAB HYDRAULIC TRANSMISSION

A hydraulic transmission is a combination of a hydraulic pump (A-end) and a hydraulic motor (B-end). The term CAB unit means Combination A and B ends. It is a variable-speed, bi-directional hydraulic transmission. In operation, a constant-speed electric motor drives the A-end, the A-end supplies hydraulic fluid to the B-end, and the B-end converts fluid flow into rotary movement.

The (A-end) unit is a variable-displacement, reversible-delivery pump. Speed and direction of the B-end's rotation depends upon the volume and direction of the hydraulic fluid supplied by the A-end unit. By regulating the output of the A-end, smooth and controlled acceleration of the B-end's output shaft is possible in either a clockwise or counterclockwise direction.

The following components are basic to all CAB hydraulic transmissions:

1. A constant-speed electric motor that drives the A-end pump and the auxiliary dual gear pump.
2. An A-end axial-piston pump with a variable tilt plate to supply hydraulic fluid to the B-end.
3. A B-end hydraulic motor that converts the flow of hydraulic fluid into rotary motion.
4. A valve plate to connect the A-end to the B-end.
5. A safety relief valve to regulate pressures between the A and B-ends, and to port replenishing fluid for that lost through slippage.
6. An auxiliary dual gear pump to supply "super-charge" and "servo" fluid pressures.

Beginning with the A-end unit, each of the above listed components will be discussed, with the exception of the electric motor.

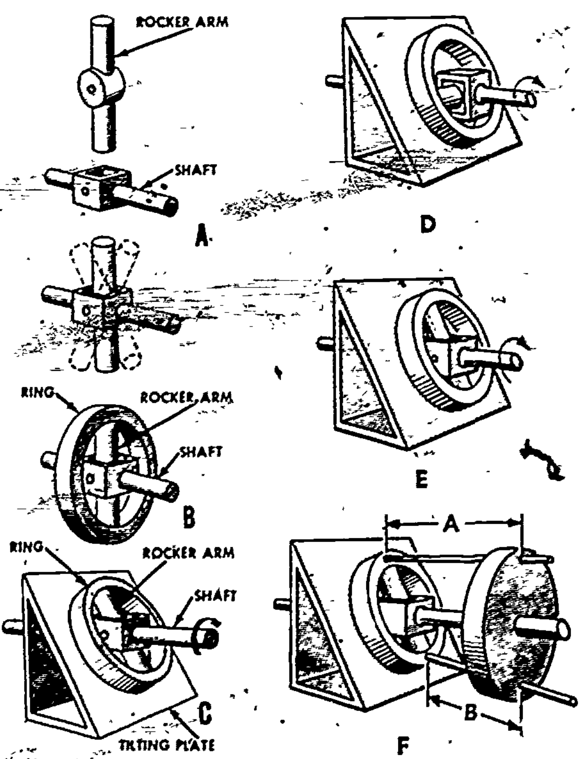
A-END COMPONENTS

The A-end is a reciprocating pump which has nine pistons, a cylinder barrel, a rotating socket plate, a valve plate, and a universal joint. The A-end axial piston pump has a variable delivery output, whereas a conventional axial piston pump has a constant-delivery output (the A-end pump has an adjustable tilt plate; the regular axial-delivery pump has a fixed tilt plate). In an A-end unit the connecting rods that operate the axial pistons are attached to a socket ring, and the socket ring (driven by an electric motor) turns within the non-rotating tilt plate. The tilt plate is positioned by two stroking pistons.

In axial piston pumps, a cylinder block with its pistons is rotated on a shaft in such a way that the pistons are driven back and forth in their cylinders in a direction parallel to the shaft. This is called axial motion. Liquid is forced into the cylinders by pressure difference while the pistons are moving outward, and is driven out of the cylinders by the pistons while they are moving inward. This pumping action is made possible by a universal joint. To explain how the joint works, we shall begin by constructing step by step the Williams universal joint and then explain the principles of the Bendix-Weiss universal.

Williams Universal Joint

Let us install a rocker arm on a horizontal shaft (part A fig. 8-19). The arm is joined to the shaft by a pin in such a way that it can be swung back and forth. Next we place a ring around the shaft and pin it to the rocker arm so that the ring can turn from left to right as shown in figure 8-19, Part B. We can now get two rotary motions in different planes at the same time, and in varying proportions as may be desired. The rocker arm can swing back and forth in one arc, and the ring can simultaneously move from left to right in another arc, in a plane at right angles to the plane in which the rocker arm moves.



84.33

Figure 8-19.—Basic universal joint.

Now let us add a tilting plate to our assembly (part C). For the time being let the tilting plate stand at a slant to the axis of the shaft. In this position the rocker arm is slanted back at the same angle as the tilting plate, so that it lies parallel to it. The ring is also parallel to the tilting plate and in contact with it. Its position in relation to the rocker arm is unchanged from that shown in part B.

Now let us keep the shaft horizontal and rotate it in a clockwise direction through a quarter of a turn, to the position shown in part D. The rocker arm is still in the same plane as the tilting plate, and is now perpendicular to the axis of the shaft. The ring has turned on the rocker arm pins so that it has changed its position in relation to the rocker arm, but it remains parallel to, and in contact with, the tilting plate.

Now let us rotate the shaft another quarter turn, as shown in part E. The parts are now in the position shown in part C, but with the ends of the rocker arm reversed. The ring still bears against the tilting plate.

If we continue to rotate the shaft, the rocker arm and the ring will turn about their pivots, with each changing its relation to the other, and with the ring always bearing against the plate. This will be even if we change, within limits, the angle of the plate..

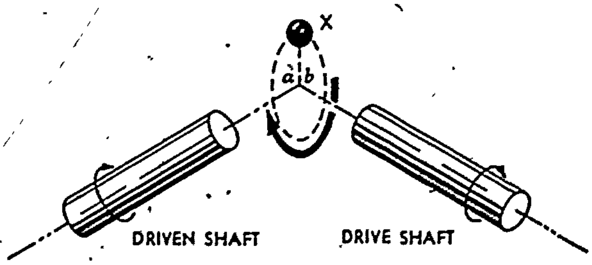
Now let us go a step farther and place a wheel upright on the shaft, as shown in part F of figure 8-19. The wheel is fixed to the shaft so that it rotates with the shaft. Let us also add two rods A and B, loosely connected to the tilting ring, and running through two holes standing opposite to each other in the fixed wheel. As the shaft is rotated, the fixed wheel runs perpendicular to the shaft at all times. The tilting ring rotates with the shaft and always remains tilted since it stays in contact with the tilting plate. We can see from the diagram that the distance along shaft A, from the tilting ring to the fixed wheel, is greater than the distance along shaft B. As we rotate the assembly, however, the distance along shaft A decreases as its point of attachment to the tilting ring comes closer to the fixed wheel, while the distance along shaft B increases. These changes continue until, after a half revolution, the initial position of the two rods are reversed. After another half revolution, the two rods will again be in their original positions.

From this we can see that the rods are moved in and out through the holes in the fixed wheel as the assembly rotates. This is the way the axial piston pump works. To get a pumping action, it is only necessary to place pistons at the ends of the rods, beyond the fixed wheel, and insert them in cylinders. The rods must be connected to the pistons and to the wheel by ball and socket joints. As the assembly rotates, each piston moves back and forth in its cylinder. Intake and discharge pipes can be arranged so that liquid enters the cylinders while the spaces between the piston heads and the bases of the cylinders are increasing, and leaves them during the other half of each revolution, when the piston heads are moving in the other direction.

Reference to part F of figure 8-19 will make it clear that the distance the pistons move back and forth in their cylinders depends on the tilt given to the tilting box. With no tilt at all, no pumping action would occur since the pistons would not move back and forth at all. The distances A and B in part F would be equal, and would remain equal as the assembly rotates. If the angle of tilt given to the tilting box were reversed, making distance A less than distance B, the pumping action would be reversed. What had been the discharge would now become the intake, and vice versa. By adding a mechanism to control the angle at which the tilting box stands, any variation in delivery can be obtained from a maximum in one direction through zero delivery to a maximum in the opposite direction although the drive shaft continues to rotate at a constant speed.

Bendix-Weiss Universal

The Bendix-Weiss universal joint is used with many of the axial piston pumps in today's ordnance equipment. This joint is based upon a geometrical principle which must be understood to grasp how the joint works. Figure 8-20 shows a drive shaft and a driven shaft standing at an angle to each other. Let us suppose that the drive shaft rotates the driven shaft through a pair of fingers set around a ball X. This ball carries the load of rotation in such a way that angle A



84.34

Figure 8-20.—Geometrical principle.

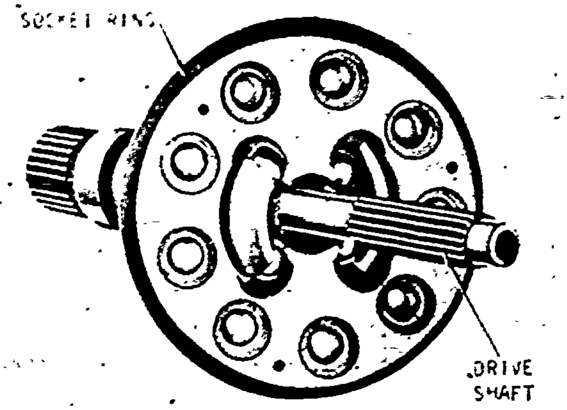
is equal to angle B. As the drive shaft rotates in the direction shown, X will move in the same direction in a circular path, always keeping angle A equal to angle B. After a complete revolution of the shaft, it will have returned to the original position. Since angle A has been kept equal to angle B, the driven shaft will rotate at exactly the speed of the drive shaft.

An arrangement which accomplishes this result is used in the Bendix-Weiss universal joint. The force of rotation is carried by a pair of balls which move back and forth in specially shaped runways or races as the drive shaft rotates. The races are given such a shape that the balls always remain in a single plane as they move back and forth in their races. Angle A will always equal angle B as the drive shaft rotates, just as in figure 8-20, and the units connected by the joint will therefore rotate at the same speed.

Four carbide balls, free to shift along four races (one in each quadrant, figures 8-21 and 8-22), carry the rotational forces. The faces for these ball races are machined into the jaw for the socket ring and the hub for the universal joint.

The four balls always shift together in a common plane (figure 8-23). Moreover, as the socket ring shifts in angle or direction, the balls automatically assume a new plane for accurate transmission of rotational movements. In operation, one pair of balls carries the clockwise torque; the other pair carries the counterclockwise torque.

Although the hub of the universal joint is keyed to the drive shaft, it is not rigidly attached. As shown in figure 8-24, four rectangular projections of the hub engage cutouts in the drive shaft for a positive transmission of torque, and the two pilot keys for each slot provide a snug fit, yet allow slight flexing movements.



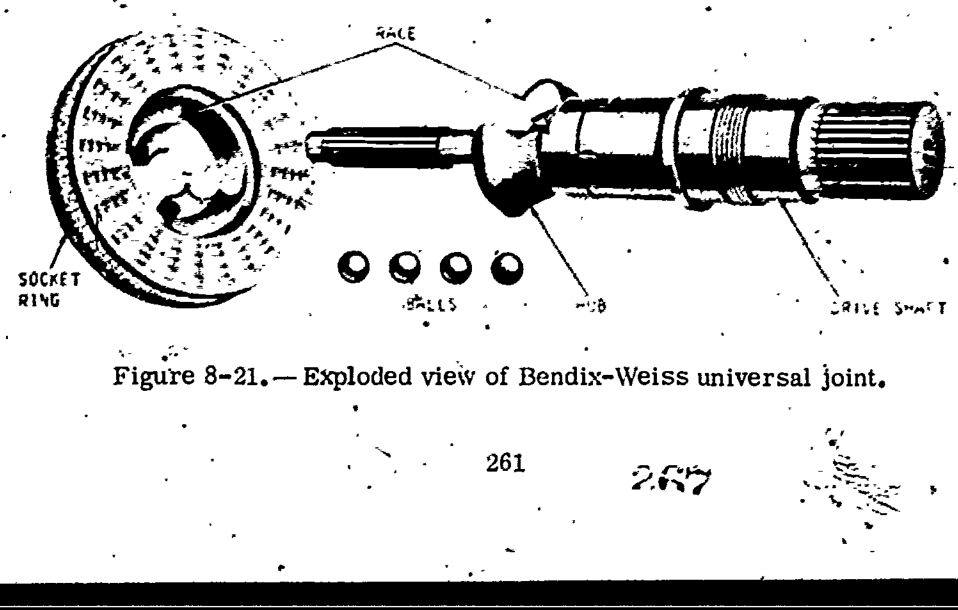
84.36

Figure 8-22.—Bendix-Weiss universal joint assembly.

Cylinder Barrel

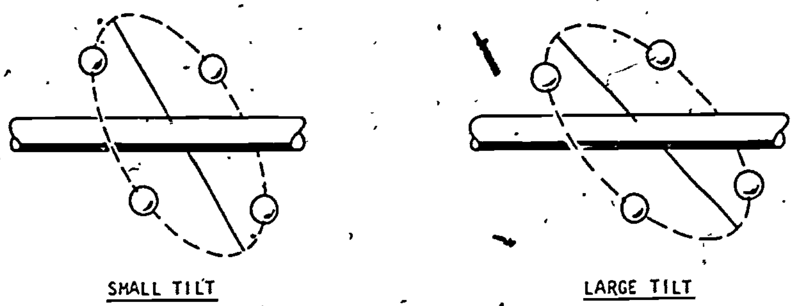
The cylinder barrel (fig. 8-25) is also driven by the A-end drive shaft, and accordingly rotates at the same velocity as the socket ring. The barrel has nine cylinder bores for the axial pistons of the A-end, and the head of each bore has a slot-shaped port. As the cylinder barrel rotates, fluid passes through these ports as they align with the two crescent-shaped ports in the stationary valve plate.

The cylinder barrel is loosely keyed to a drive sleeve to permit full contact between the mating faces of the barrel and the valve plate. Two keys 180 degrees apart around the circumference of the drive shaft, serve as lock guides for the cylinder barrel.



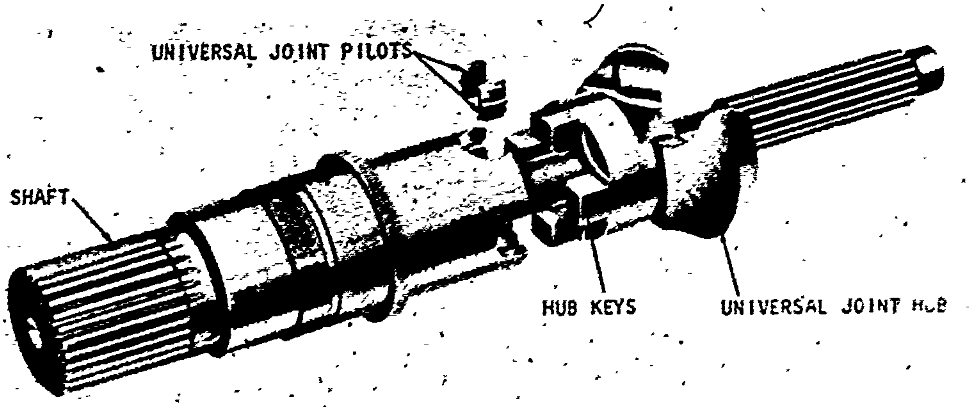
84.35

Figure 8-21.—Exploded view of Bendix-Weiss universal joint.



84.37

Figure 8-23.—Universal joint balls remain in common plane regardless of tilt plate angle.



84.38

Figure 8-24.—Exploded view of drive shaft and hub.

A compression spring, located between a spring retainer and the barrel, assures proper contact between the barrel and the valve plate when the unit is not in operation, or whenever the unit is started. During normal operation, unbalanced internal forces (as a result of the pumping action) hold the barrel in contact with the valve plate.

A bearing, mounted in the center of the valve plate face, supports and holds the drive shaft in proper alignment.

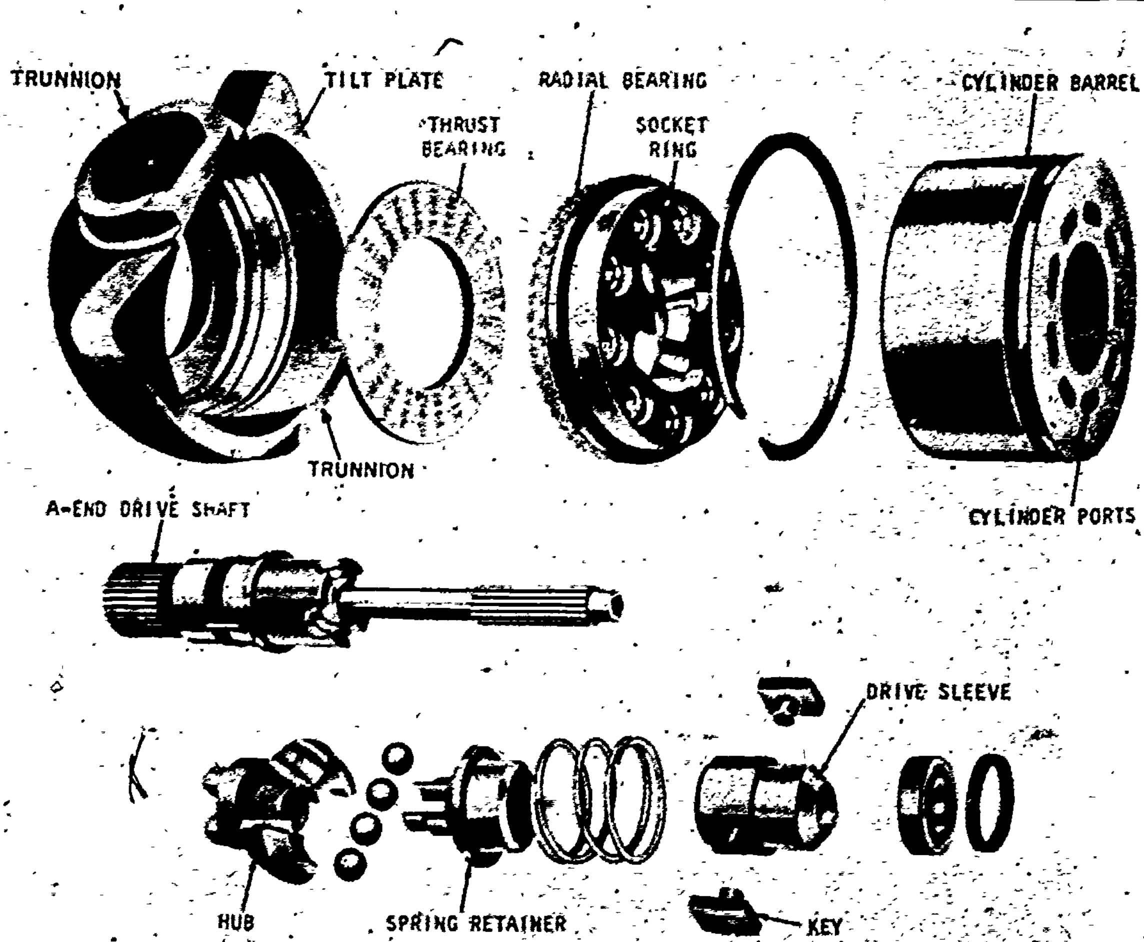
The non-rotating tilt plate, a bowl-shaped steel casting (figure 8-25), provides the means for changing the angle of the socket ring without interfering with its rotational movements. (The socket ring nests within the tilt plate, and both parts move in unison).

A thrust bearing and a radial bearing ring permit free rotation of the socket ring within the tilt plate. The thrust bearing is sandwiched between the socket ring and the tilt plate; the radial bearing ring encircles the circumference of the socket ring and rides against the inner wall of the tilt plate (fig. 8-25).

The face of the rotating socket ring has nine hemispherically shaped sockets to support and retain the ball-end connecting rods of the axial pistons.

The tilt plate turns on two trunnions that are integral parts of the bowl casting (fig. 8-25). These trunnions ride on bearings within the A-end housing.

Besides the trunnions, there are two other tilt plate projections: the A-end response shaft (fastened to the trunnion), and the two ears with hemispherical sockets to accomodate the stroking pistons. (As previously explained, the action of these stroking pistons establishes the position of the tilt plate.)



84.39

Figure 8-25.—Principal A-end components.

B-END

The A-end pump is used in connection with a hydraulic motor or a B-end. The A-end delivers liquid to the B-end which is used as a motor to perform some work operation by means of the liquid delivered to it by the pump. The only difference between the pump (A-end) and the motor (B-end) is that the tilting box of the motor is permanently set at an angle which amounts to 20° in most ordnance set-ups.

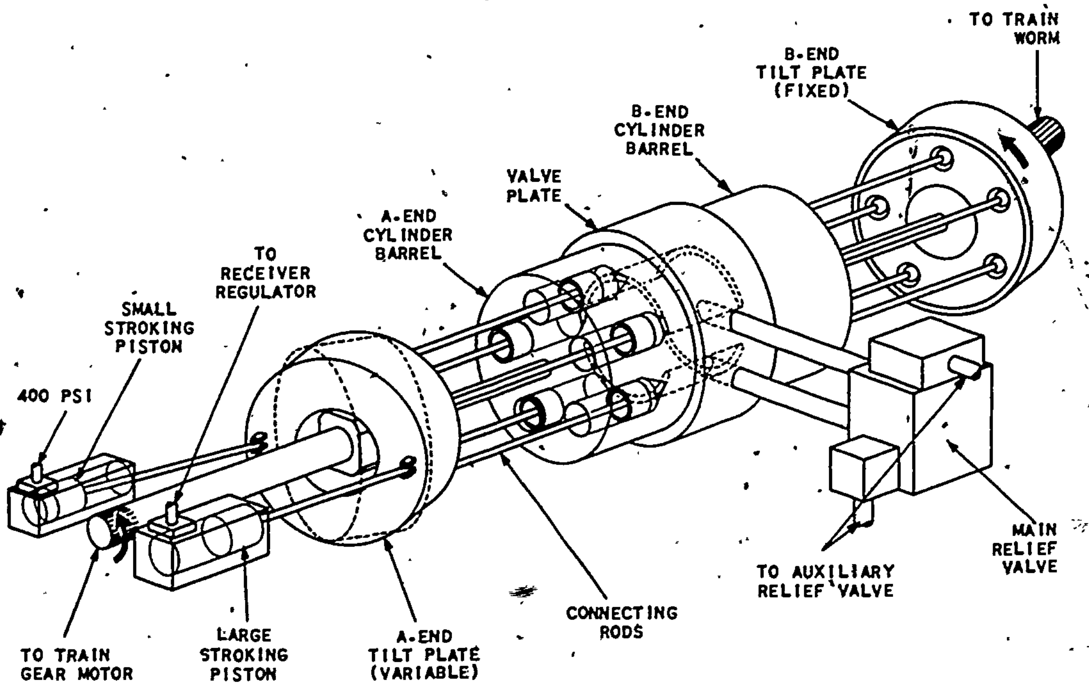
The hydraulic motor (B-end) can be directly connected hydraulically to the pump so that both the pump and the motor use the same valve plate and are located in the same housing (type C installation), (fig. 8-26), or the motor can be set up at a distance from the pump with the two mechanisms connected by piping (type K installation) (fig. 8-27). How the B-end is controlled by the A-end will be explained later in this chapter when we will discuss the operation of a hydraulic transmission.

In some turret hydraulic systems the special K type installation is used for the train power drives and employs one A-end and two B-ends which drive a single training gear. In larger turret systems, the two B-ends drive two pinions of the train drive assembly.

It makes no difference how the A-end unit is connected to the B-end motor; the theory of operations of a hydraulic transmission is identical.

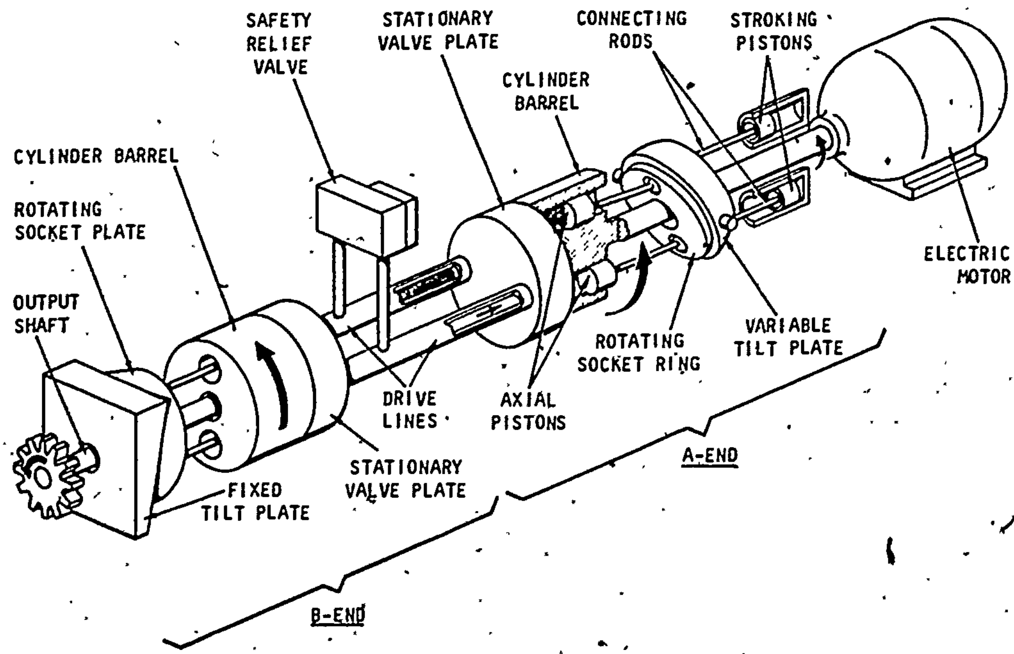
Valve Plate

The valve plate links the A-end pump to the B-end motor. Although the valve plates for



84.40

Figure 8-26.—Type "C" installation cab unit.



84.41

Figure 8-27.—Type "K" installation.

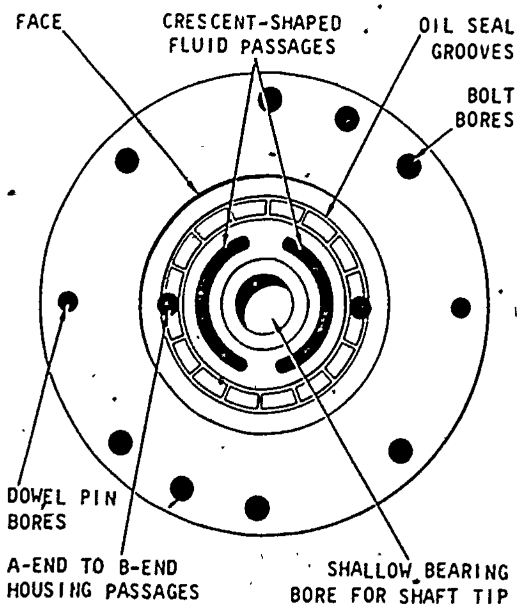
different CAB units may vary in external appearance, they are basically similar in functional characteristics.

A CAB valve plate has two accurately machined surfaces called the valve plate faces. During CAB operation, the A-end cylinder barrel rotates against one of the faces, and the B-end cylinder barrel rotates against the other. (Fig. 8-26).

Two crescent-shaped openings and two inter-housing passages (fig. 8-28) extend through the valve plate from face to face. The crescent-shaped openings port fluid between the A-end and B-ends, while the inter-housing passages allow the free exchange of circulating fluid between the A- and B-end components. (This exchange of fluid through the inter-housing passages does not directly influence operation of the A-end pump or the B-end motor, but it does dissipate heat generated within the CAB unit).

Safety Relief Valve

The safety relief valve limits maximum pressure buildups between the A-end and B-end, ports supercharge fluid to compensate for slippage, and serves as a bypass valve whenever the braking mechanism is set. A compound relief valve is



84.42
Figure 8-28.—Face of typical valve plate.

used as the safety valve for hydraulic transmissions and uses a pilot valve to control the main relief valve. Both the compound relief and the pilot valve were explained earlier in this chapter and will not be discussed here. Safety relief valves are cometimes called main relief valves when used with the type "C" installation and are connected to the valve plate (fig. 8-26). In the type "K" installation the safety relief valve is connected to the drive lines between the two valve plates (fig. 8-27).

AUXILIARY GEAR PUMPS

A small auxiliary gear pump, driven by the same electric motor that drives the A-end pump (fig. 8-29), supplies the necessary hydraulic pressure for the control mechanisms. This pump has two sets of gears. One set produces about 400 to 500 psi servo pressure; the other set delivers about 100 psi supercharge pressure. Servo pressure is used to operate the control components of the CAB unit. Supercharge pressure replenishes fluid losses from slippage and leakage and maintains the low pressure line at approximately 100 psi.

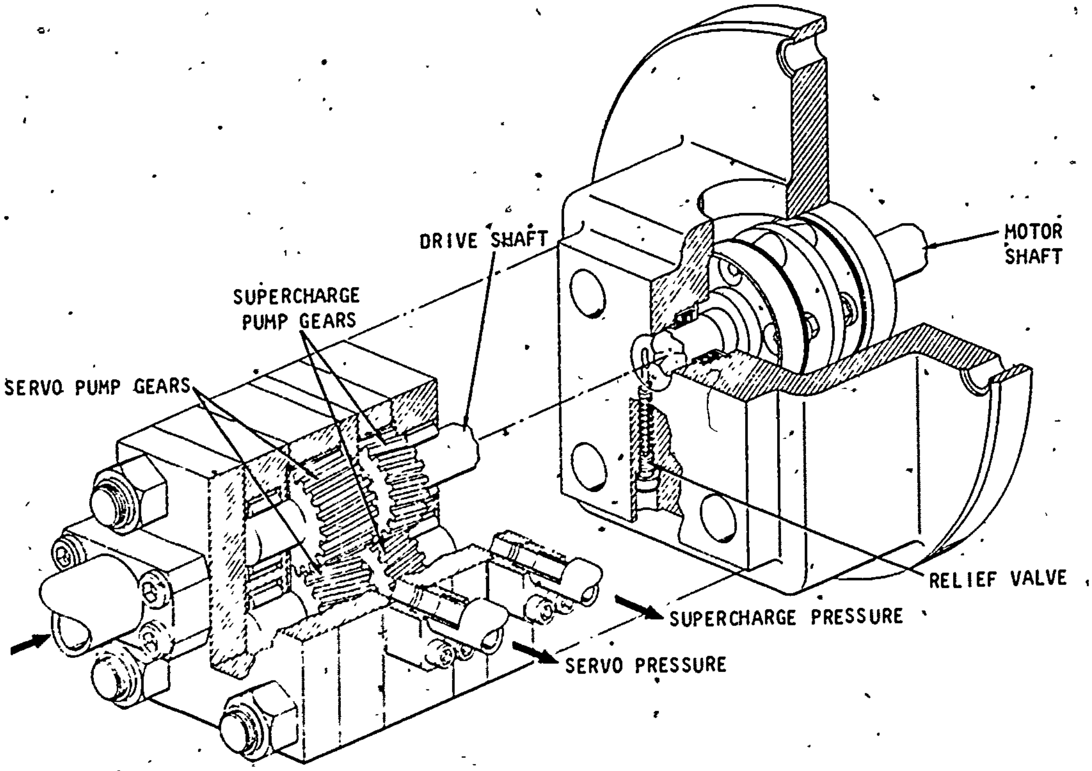
In our discussion so far we learned that a CAB hydraulic transmission converts a constant-speed mechanical input into a mechanical, variable-speed, bi-directional output, and that the mechanical input to the A-end is the rotating shaft of a constant-speed electric motor. This shaft drives the A-end. The A-end pumps hydraulic fluid to the B-end and the B-end transforms flow of the hydraulic fluid into rotary mechanical motions. The position of the A-end tilt plate controls the volume and direction of fluid pumped to the B-end which, in turn, controls the output of the B-end.

The servo control mechanism that positions the two stroking pistons of the A-end tilt plate are discussed later in this chapter.

In the following discussions on the operation of the A and B-ends the schematics used do not picture the actual CAB components. For illustrative purposes, only two axially operating pistons are shown for each of the A and B-ends, actual units have nine. Figure 8-26 schematically illustrates the relation of the A-end to other CAB components.

CAB OPERATIONS

With the tilt plate positioned at an angle, the rotating drive shaft of the electric motor forces the axial pistons of the A-end pump to



84.43

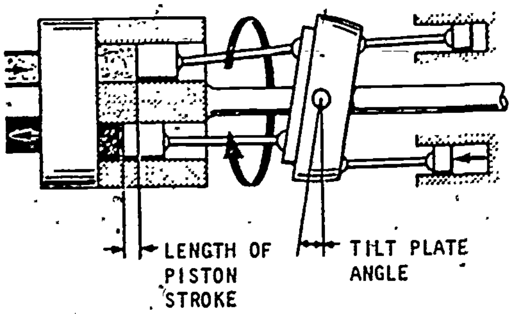
Figure 8-29.—Dual gear pump of typical cab unit.

move back and forth in their cylinders. The two stroking pistons, shown between the electric motor and the tilt plate, establish the angle (position) of the tilt plate, and the angle of the tilt plate determines:

1. The volume of fluid supplied to the B-end. (The volume of fluid varies directly with the length of axial piston stroke, and the length of piston stroke varies directly with the angle of the tilt plate).
2. The direction of fluid flow.

Figures 8-30, 8-31, and 8-32, show how the angle of the tilt plate affects A-end operation while the drive shaft of the electric motor maintains a constant speed and direction of rotation.

Comparing figure 8-30 with figure 8-31, note the greater angle of the tilt plate in figure 8-31 produces a correspondingly greater length of axial piston stroke to discharge a larger volume of fluid.

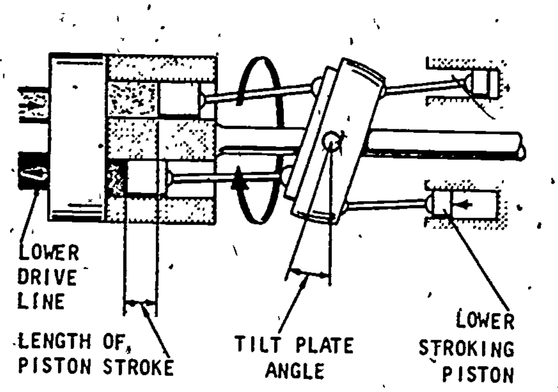


84.44

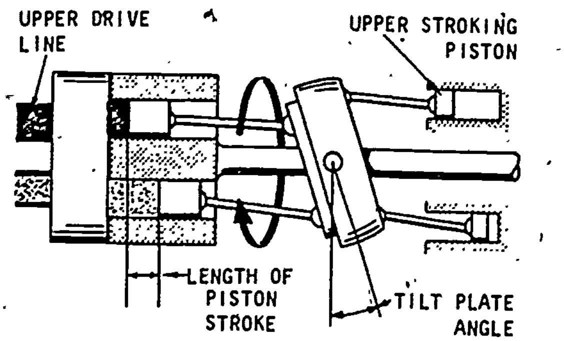
Figure 8-30.—Tilt plate positioned for short stroke.

Now, comparing figure 8-31 with figure 8-32, note how reversing the angle of the tilt plate changes the direction of fluid flow in the connecting lines.

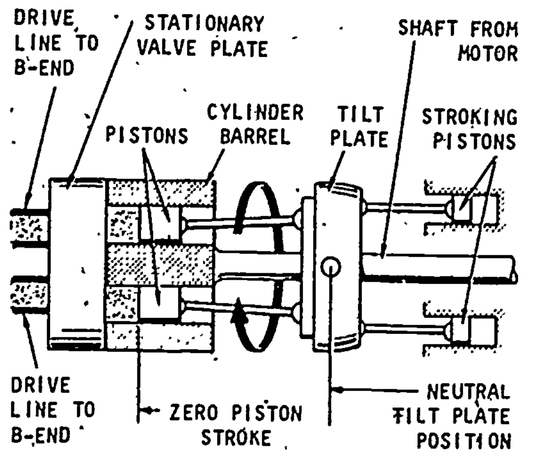
Figure 8-33 shows the tilt plate in the neutral position (perpendicular to the drive shaft). With



84.45
Figure 8-31.—Tilt plate positioned for long stroke.



84.46
Figure 8-32.—Tilt plate positioned at reverse angle.



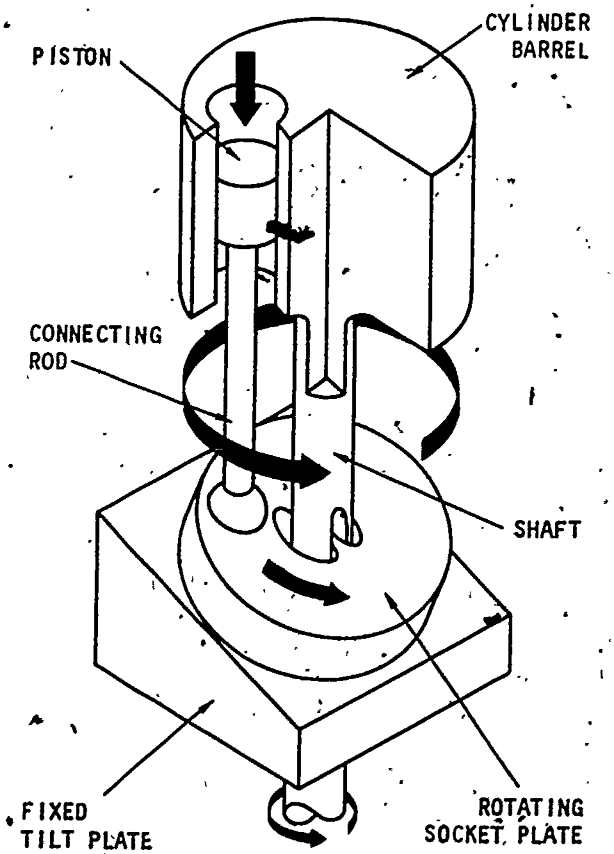
84.47
Figure 8-33.—Tilt plate at neutral position.

the tilt plate in this position, the pistons do not move back and forth in their cylinders when the drive shaft rotates the tilt plate socket ring and the cylinder barrel, and the A-end does not pump fluid to the B-end.

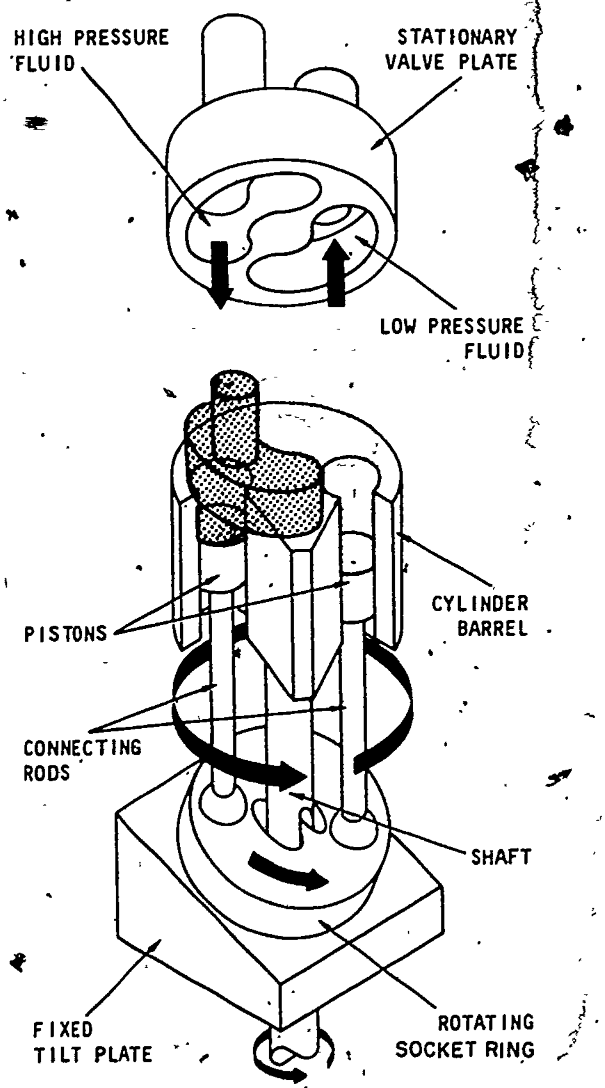
NOTE: The two stroking pistons move only when changing the speed or direction of B-end rotation.

The B-end hydraulic motor is similar to the A-end hydraulic pump, but has a fixed-position tilt plate and operates in a reverse manner to convert hydraulic pressure into rotary motion.

Figure 8-34, 8-35, and 8-36 illustrate B-end operation. When hydraulic pressure from the A-end is applied to the top of the piston as shown in figure 8-34 (for clarity, illustration shows a single piston—actual unit has nine), the resultant thrust of the ball-end connecting rod against the inclined socket ring causes it to rotate. Since a universal joint connects the

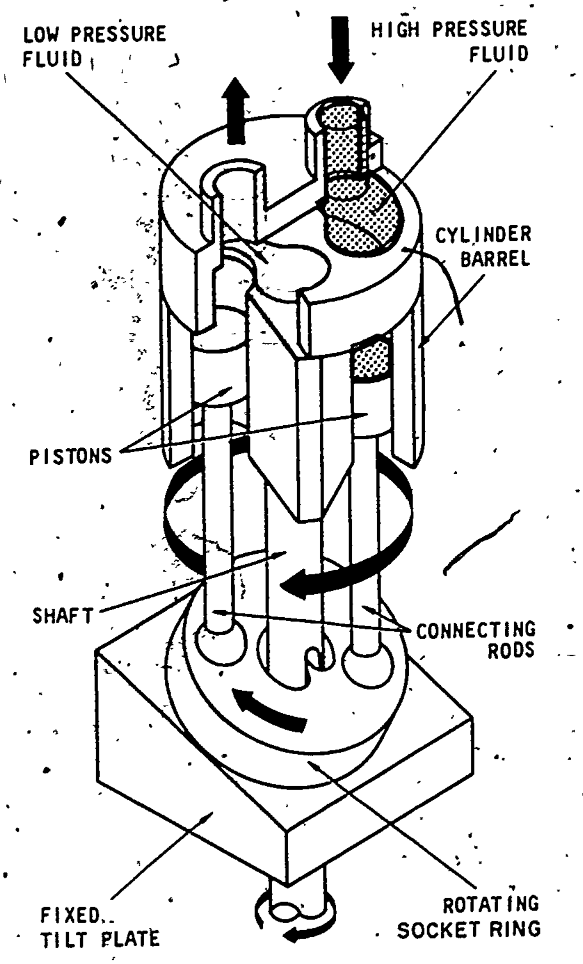


84.48
Figure 8-34.—Movement of B-end components.



84.49

Figure 8-35.—B-end operation.



84.50

Figure 8-36.—B-end operation (reverse direction).

socket ring to the B-end output shaft, both the output shaft and the cylinder barrel rotate with the socket ring.

To obtain continuous rotation, hydraulic fluid must be applied to the piston for the thrust stroke and drained on the return stroke. This action is carried out by rotating the cylinder barrel against a stationary valve plate having two crescent-shaped ports. One port supplies fluid to the piston on the thrust stroke; the other receives displaced fluid from the piston on the return stroke.

Figure 8-35 shows how a B-end operates by the flow of hydraulic fluid pumped from an A-end. As the piston passes under the high-pressure port (red-shaded area), it is forced downward, and this action causes the unit to rotate. When the cylinder barrel rotates, the cylinder bore moves past the land separating the two crescent-shaped ports, and empties into the low-pressure port (yellow-shaded area) as the piston moves on the upstroke. This discharge port for the B-end motor connects to the intake port for the A-end pump. Thus, hydraulic fluid circulates from the A-end to the B-end, and then returns from the B-end to the A-end.

By reversing the angle of the A-end tilt plate, the flow direction changes, and the B-end rotates in the opposite direction (fig. 8-36).

With the A-end tilt plate positioned for the maximum piston stroke, the A- and B-end pistons move equal distances, and theoretically, the A- and B-ends rotate at the same speed.

With the A-end tilt plate positioned to produce an A-end piston stroke that is only half that of the fixed-stroke B-end pistons, the fluid output of two A-end cylinders is needed to fill just one B-end cylinder. Accordingly, the B-end rotates at half the speed of the A-end. (As previously explained, when the A-end tilt is positioned perpendicular to the drive shaft, the A-end pistons cannot move axially, and the B-end shaft does not rotate).

So far in the chapter we have discussed the components that make up a hydraulic system. We also discussed the general operation of various hydraulic units, but did not delve too deeply into how these units are controlled. The remainder of this chapter will be devoted to power drive fundamentals which include requirements for the control of power drives.

POWER DRIVE FUNDAMENTALS

There are two principal problems in positioning a gun for firing. One is to get an accurate gun order signal; this is solved by the gun director-computer combination. The other problem is to transmit gun order signals promptly to the gun in such a manner that the position and movements of the gun will be synchronized with the signals from the director. The latter problem is complicated by the movements of the gun falling behind or over running gun order signals. This is due mainly to inertia of the gun, but also in part due to the lag in transmitting signals. Inertia tends to keep the gun in motion. Gun order signals are always changing, not only because of changes in the relative position of target and ship, but also because of the roll and pitch of the ship.

The problem of transforming gun order signals to mount movement is solved by the power drive of the gun. There are two types of power drives used in gun weapon systems. One type consists essentially of a receiver-regulator and a pump-motor combination. The receiver-regulator controls the pump-motor combination, and this in turn controls the movement of the gun. The pump-motor combination (A-B end) is known as an electric-hydraulic power drive.

The second type, the all-electric power drive, employs both a.c. and d.c. motors and an amplidyne generator. The output of the power amplifier (amplidyne generator) controls a d.c. drive motor which, in turn, controls mount movement. Since the amplidyne generator is capable of multiplying its input signal as much as 10,000 times, this type power drive is known as an amplidyne power drive.

The Navy uses power drives of various designs and complexities. Large electric-hydraulic power drives are used to control the movement of heavy turrets. Smaller power drives control dual-purpose mounts, and can be either electric-hydraulic or all electric. Regardless of the type power drive employed in a gun weapon system, it has several primary purposes and must function as servomechanisms (servo). The primary purposes of a power drive servosystem are to—

1. First, and most important, position or lay the turret or mount in response to train and elevation order signals.
2. Compare the order signal and the existing conditions: standing still, moving left or right, and obtaining a difference or error signal. This is done by the error detector.
3. Amplify a weak error signal to a point where work can be done with it. This is the job of the amplifier.
4. Provide a means to send a report back to the error detector to satisfy or null out the error signal. This is called response.

Since power drives use response (feedback), they are classified as servomechanisms. Servomechanisms (or servosystems) cause mechanical action to take place automatically in response to synchro signals.

SERVOMECHANISMS

Servomechanisms, called servos for short, are used extensively in ships' weapon systems. Synchros are used in servosystems to control the position and movement of computing, indicating, and transmitting devices. The power drives in turrets, gun mounts, directors, and rocket launchers use some type of servosystem.

Servos are part of a broad class of control systems that operate on the principle of feedback. The input signal to a servo is applied to an error detector, not directly to the amplifier. The input is an order signal which indicates the desired action of the servo. The other signal to the error detector is a feedback signal which represents the output of the servo. The feedback signal is the reaction of the servo to the error signal, which is the input to the amplifier. The error signal is the difference between the input signal and the feedback signal. If there is a difference (error) between the input and the output, corrective action automatically takes place to reduce the error toward zero.

The feedback signal forms a closed loop within the servo. In other words, there is a complete path through the servo to the load and back to the error detector. The output affects the input, and thus provides automatic followup control.

There is no standard definition of a servo. In this chapter, we will call a servo an electrical, electronic, mechanical, or hydraulic system which uses feedback. All servos have the following characteristics.

A servo is a control device whose basic job is to position a load. The load may be a turret, gun mount, computing device, or hydraulic valve. The load is attached in some manner to the output of the servo. Consider a gun mount. Its position is controlled in accordance with train and elevation orders which are inputs to the servo.

A servo is a power amplifier. The input to a servo is usually a very small signal. It is too weak to move the load by itself, so some sort of power amplification must take place within the servo. Again, take as an example a servo used to position a gun mount. The input to the servo is sometimes so small it can be measured with a milliammeter. To develop enough power to move the great weight of a gun mount, requires currents in the amperage range. Therefore most servos you will work with have one or more amplifying stages. The amplifier may be electrical, electronic, hydraulic, or two or more of these in combination.

SERVO CONTROL REQUIREMENTS

Servo control systems for a turret, gun mount, and rocket launcher all have the same basic requirement, and are made up of specific components which depend on each other to perform the functions of a servomechanism. There are many different names for servo control systems used in ordnance equipment. In most gun mounts, servo control systems are known as power control, stroke control, or electronic servo control systems. In turrets, servo control systems are called automatic servo system, power servo control system, and servo control system. No matter what a servo control system is called or what type of output it employs to control a servomechanism, the basic requirements are common. Because of this, we can divide a servomechanism into three groups, as in figure 8-37, and explain the functions of devices that make up each group.

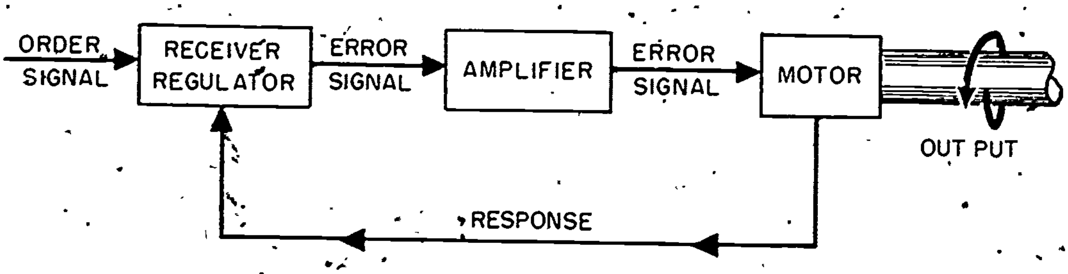
RECEIVER REGULATOR

The purpose of a receiver regulator is to control the positions of turrets, gun mounts, and rocket launchers in train and elevation by converting gun order signals into equivalent power drive control action. There are many different types and designs of receiver regulators, but all types can be divided into two sections: indicating section and control equipment section. All turrets and gun mounts have two or more receivers as part of their servo systems. They act independently of each other and differ only in their design. The train receiver regulator has a parallax input to compensate for horizontal parallax, which is the angle formed in the horizontal plane at the target by the intersection of the lines of sight from the two ordnance stations, the director and the mount. Parallax is explained in detail in chapter 12.

The elevation receiver regulator employs a roller path compensator which corrects the gun elevation order for any tilt in the gun roller path plane. Train position information is sent to the roller path compensator through the train response assembly which indicates the degree of mount train from the highest point of inclination. Roller path tilt and how it affects gun fire control also is explained in chapter 12.

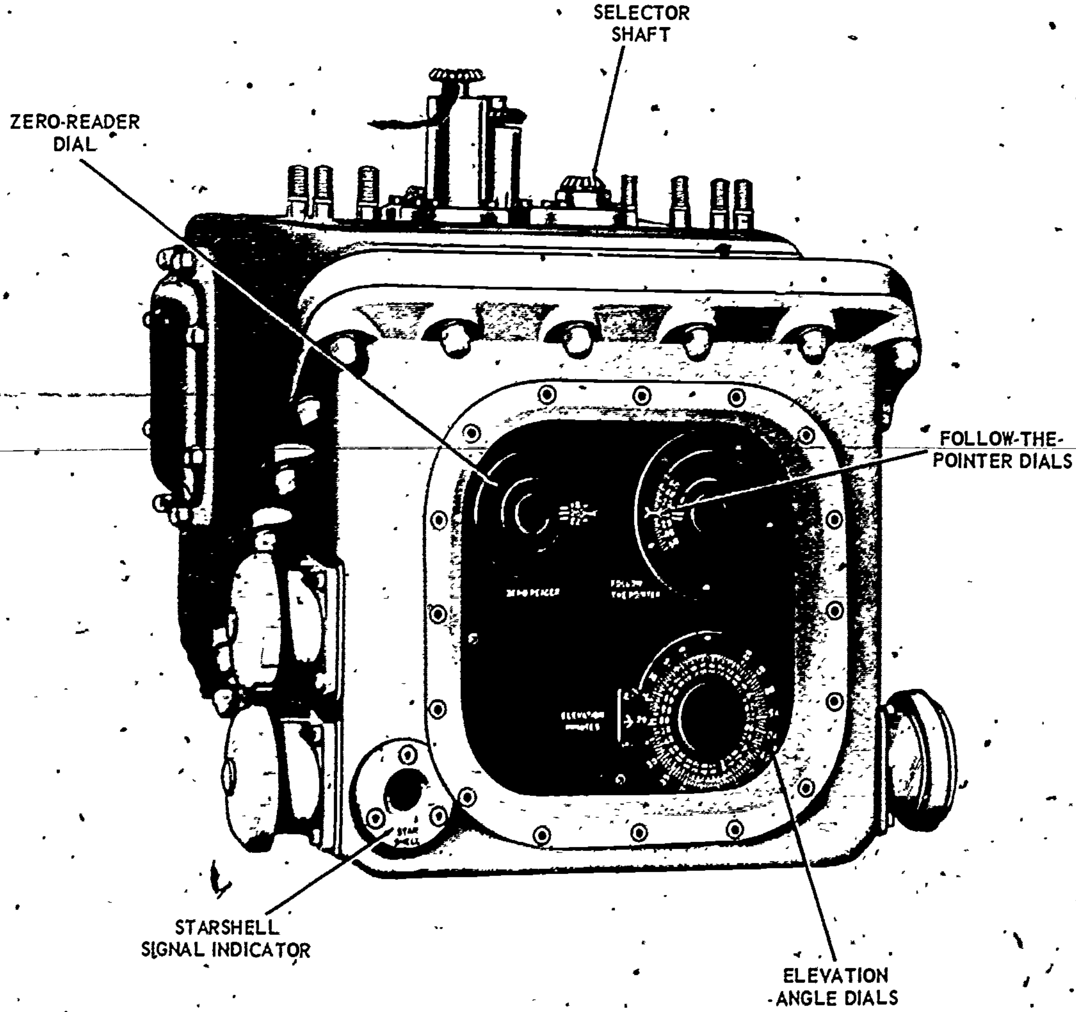
INDICATING SECTION

The indicating equipment of each receiver-regulator consists of the visual signaling devices used to show gun positions, gun order, and correction readings. Figure 8-38A and 8-38B show the locations of these devices on the face of the indicating equipment for elevation and train, respectively. The face of the indicating equipment on each instrument is illuminated by four double contact, 6- to 8-volt bulbs, set in two light wells.



84.182

Figure 8-37.—Power drive servosystem.



53.79

Figure 8-38A.—Elevation indicator-regulator dial.

277

Components

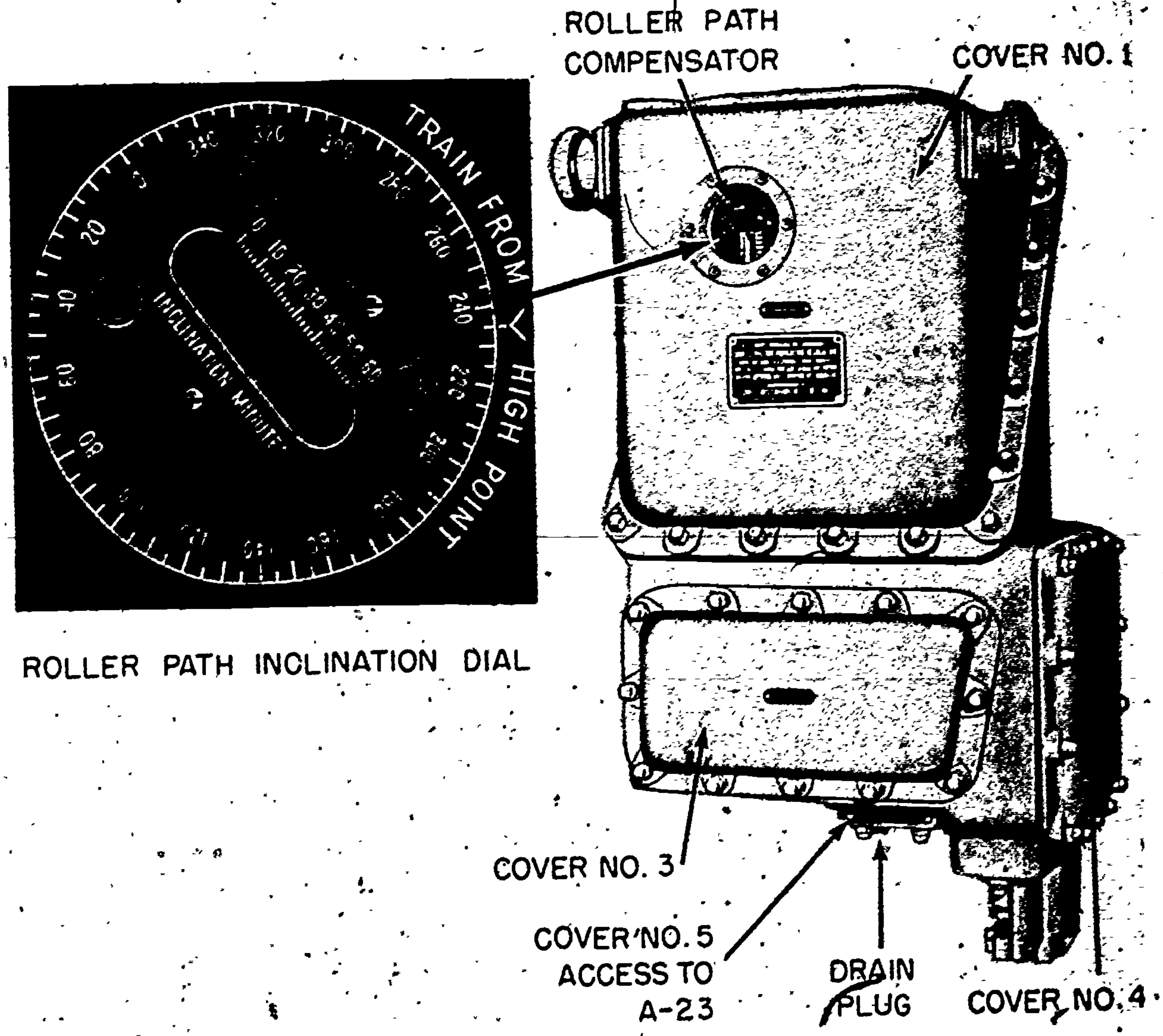
The components of the indicating equipment of the indicator-regulator are—

Gun position indicator.
Gun order indicator.
Parallax correction indicator (train only).
Roller path inclination indicator (elevation).
Star shell signal indicator.

Gun Position Indicators

Gun position is given in the respective instruments by two mechanically driven dials, marked ELEVATION MINUTES and TRAIN ANGLE. Both of these dials are calibrated to show angle of elevation or mount train against a fixed pointer at their left sides.

On the elevation indicator-regulator, there are two concentric gun-position dials, an outer



84.65

Figure 8-38B.—Roller path inclination dial.

278

(ring) dial and an inner (disc) dial, that show gun position in elevation relative to a horizontal reference plane. The outer (ring) dial is a coarse reader, marked from zero to 7100 minutes in the Mk 34 instrument, and to 9000 minutes in the Mk 42.

The ring dial is graduated in increments of 100 minutes and numbered every 500 minutes. To facilitate reading, the last zero is omitted from each number. The inner dial (fine reader) perimeter is marked from 00 to 100 six times. Graduations on the dial are marked in 5 minute intervals and numbered every 20 minutes from 00 through 80.

On the train indicator-regulator, the position dials indicate mount position in train without parallax correction. The train ring dial is a coarse reader, numbered every 10 degrees from zero to 360 degrees, the final zero being omitted from the markings. The inner dial is a fine reader, marked in 5-minute intervals from zero to 10 degrees, and numbered every 20 minutes.

The disc dials are positioned by corrected-response shaft inputs from their elevating or training gear drives. The ring dials receive this same input through a worm reduction.

Gun Order Indicators

The gun order indicators of each indicator-regulator consist of follow-the-pointer dials and zero-reader dials (figs. 8-38 and 8-39). The zero reader is a single disc dial which is read against a fixed index on the instrument panel (mask). The follow-the-pointer indicator has an inner disc dial and an outer ring dial.

Gun orders are received electrically from the gun director system and are indicated by rotation of the disc dials; the inner follow-the-pointer dial being driven by a fine indicating synchro motor, and the zero-reader dial by a coarse indicating synchro motor.

Corrected mechanical response, derived from actual gun and mount movements in elevation and train, turns the stator of the coarse indicating (zero-reader) synchro and the follow-the-pointer ring dial.

When corrected mechanical response is equal to gun order, the index on the zero-reader (coarse) dial is aligned with a fixed index, and the index on the follow-the-pointer ring dial is aligned with the zero graduation on the disc (fine) dial.

Elevation Gun-Order Indicators

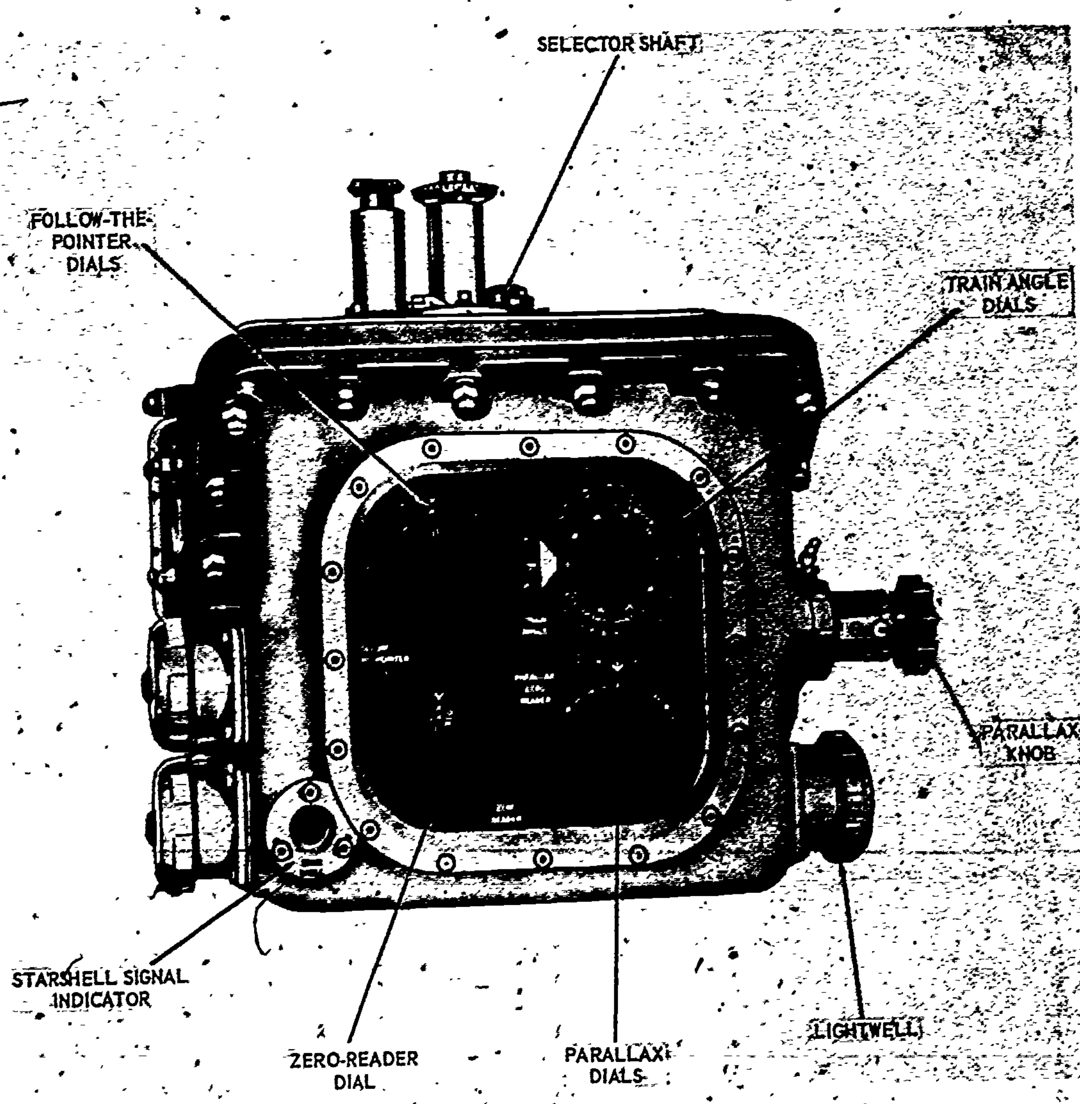
The gun-order dial (zero reader) graduations for elevation indicator-regulators are shown in figure 8-38. The zero reader coarse dial is marked in 100 minute increments from 1800 through 2200 and numbered 18, 20, and 22 respectively. The follow-the-pointer (fine) dial is graduated in 5-minute intervals and numbered from zero to 60 in 20 minute increments on each size of zero. The follow-the-pointer ring dial is marked only with an index arrow.

Train Gun-Order Indicators

The gun-order dial graduations for train indicator-regulators Mk 46 are shown in figure 8-39. In both the Mk 38 and Mk 46 instruments, the zero-reader (coarse) dial is graduated at five-degree intervals from 350 degrees through zero to 10 degrees, and is marked with the numerals 35, 0, and 1 at each 10-degree graduation. One revolution of the dial represents 360 degrees error (difference between order and mount position) in train. On Mk 42 instruments, the follow-the-pointer (fine) disc dial is graduated in 10-minute steps to 1 degree on each side of zero, being marked with the numerals 1°, 0, 1°. One revolution of this dial indicates a change in signal of 10 degrees. Between 1° right and 1° left, the dial is not numbered. The follow-the-pointer ring dial is marked only with an index arrow, each revolution of the dial being equivalent to a change in signal of 10 degrees. On Mk 38 instruments, the follow-the-pointer disc dial is graduated at five-minute intervals from 0 to 5 degrees on each side of zero, the 5-degree graduation being common for both right and left scales. The graduations are numbered every 20 minutes up to 2 degrees, and at 3, 4, and 5 degrees thereafter. As in the Mk 46 instrument, the ring dial has only an index arrow.

Roller Path Inclination Indicator

The roller path indicator shows bearing from the high point (fig. 8-38B). This dial is actuated by train response so that its circular scale indicates mount train. This scale is graduated in 5-degree steps and numbered from zero to 360 degrees. A pin in a slot at the center of the dial indicates inclination of the roller path. The linear scale is graduated in 2-minute steps, and numbered from zero to 60 minutes.



53.78

Figure 8-39.—Train indicator-regulator dial.

NOTE: All train indicator-regulator dials rotate in the same direction as the mounts are turning (when their rotation is caused by actual mount train). All elevation indicator-regulator dials move in an upward direction past the index arrows (when their rotation is caused by actual gun elevation).

Parallax Correctio: ·icator

In the train in ·ating system only, a parallax correction ·nal rotates the parallax synchro rotor and its zero-reader or disc dial (fig. 8-39). Mount parallax response rotates the parallax synchro stator and the parallax ring dial. When gun train position is corrected for parallax, the parallax zero-reader dial is aligned with the fixed index arrow. The value of the parallax correction is then given by the reading on the ring dial at the fixed index. The ring dial is graduated in 10-minute steps, from zero to 12 degrees on each side of zero, every degree being numbered. The zero point on the inner dial is also marked.

280

Search Spreads

The zero-reader parallax dial has graduations in most installations to facilitate the firing of illuminating projectile search spreads. When firing search spreads of illuminating projectiles, use is made of the parallax zero-reader dial and the parallax knob (fig. 8-39).

The outer graduations on the disc dial are used as a guide in offsetting the mount from the transmitted train order so as to produce a divergence of train angle between adjacent mounts. Starting from the zero graduation, there are six graduations in each direction, every second one being marked 1 degree, 2 degrees, and 3 degrees, respectively. The zero graduation is marked with an arrow and the numeral 0. Spacing of the graduations on the dials is different for each mount, however, because of the difference in parallax gearing in the train indicator-regulators.

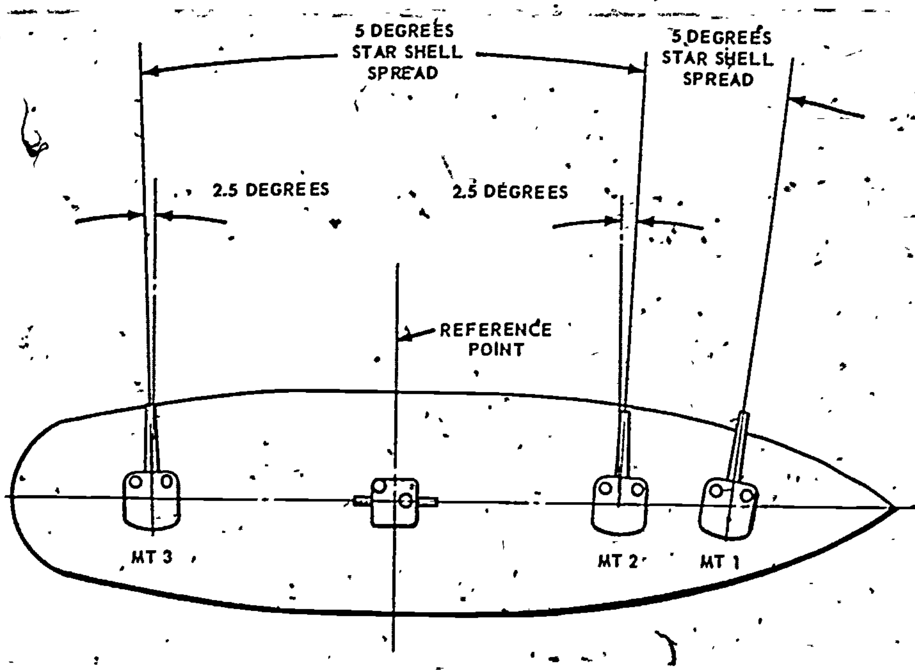
On dials for mounts located aft of a reference point, STBD is engraved to the left of the zero graduation, and PORT is engraved to the right of the zero. For mounts forward of the reference point, this arrangement is reversed. The engravings (STBD and PORT), and the corresponding graduations and numbers, are colored green and red, respectively. The arc of spread of mounts on a ship can be varied from 1.5 to 9 degrees by using the graduations to obtain divergence of train angle between adjacent mounts (fig. 8-40). To obtain a 2.5-degree divergence between adjacent mounts, the 2.5-degree marks on the dials are matched with the fixed indexes by means of the parallax knobs (fig. 8-39).

Star Shell Signal Indicators

The star shell signal indicator on each instrument consists of two double-contact, 6- to 8-volt lamps, housed in a lightwell and located under a red glass in the top corner of the indicator-regulator (figs. 8-38 and 8-39). (Elevation Indicator-Regulators Mk 34 and Train Indicator-Regulators Mk 38 have a blue glass on the star shell signal indicator). The lamps are lighted whenever the mount is ordered to fire illuminating projectiles, and hence does not follow the same director signals as the balance of the battery.

CORRECTIVE DEVICES

A parallax corrector is located in the aft section of each receiver regulator. This mechanical-electrical assembly contains other



84.51

Figure 8-40.—Mount positions for 5-degree star shell spread.

auxiliary components in addition to dials which show the amounts of the corrections added to the order as well as the position of the gun.

The function of the parallax corrector mechanism is to receive the unit parallax signal transmitted, select an appropriate portion of this signal as determined by the mount position, and to modify the B-end response to the gun order synchros by this correction.

The train regulator has two external mechanical inputs to the corrector: gun train response and star shell spread. The star shell spread is applied manually to the correction gear train through the hand crank and a spring-released clutch.

The elevation parallax corrector has two external mechanical inputs. One is gun elevation response and the other is gun train response. The train "B" end response input drives a roller path tilt corrector. The tilt corrector in turn adds a mechanical signal to the corrector.

Parallax Correction

Parallax correction components are provided in both the train and elevation receiver regulators. Without parallax correction, the gun would be pointed parallel to the line of sight of the director and, because of the horizontal distance between the director and the mount, the gun would not be pointed at the target. The amount of parallax correction needed depends upon many factors such as the distance to the target, the bearing of the target, and the horizontal distance between the director or reference point and the gun.

The use of parallax corrector mechanisms can be varied in many ways, and actual method of use is generally determined when the ship class characteristics are determined. Generally, correction for train parallax, correcting for horizontal distance between mount positions and reference director, is always made. However, several variations in the use of elevation parallax mechanisms are in service:

1. The elevation parallax corrector corrects for a vertical distance between the average height of all mounts and the reference point.

2. The elevation parallax corrector corrects for the elevation angle component resulting from the train parallax angle.

Regardless of the method used, the parallax mechanisms operate the same, only the magnitude of signal being changed.

Figures 8-41 and 8-42 illustrate the parallax correction problem.

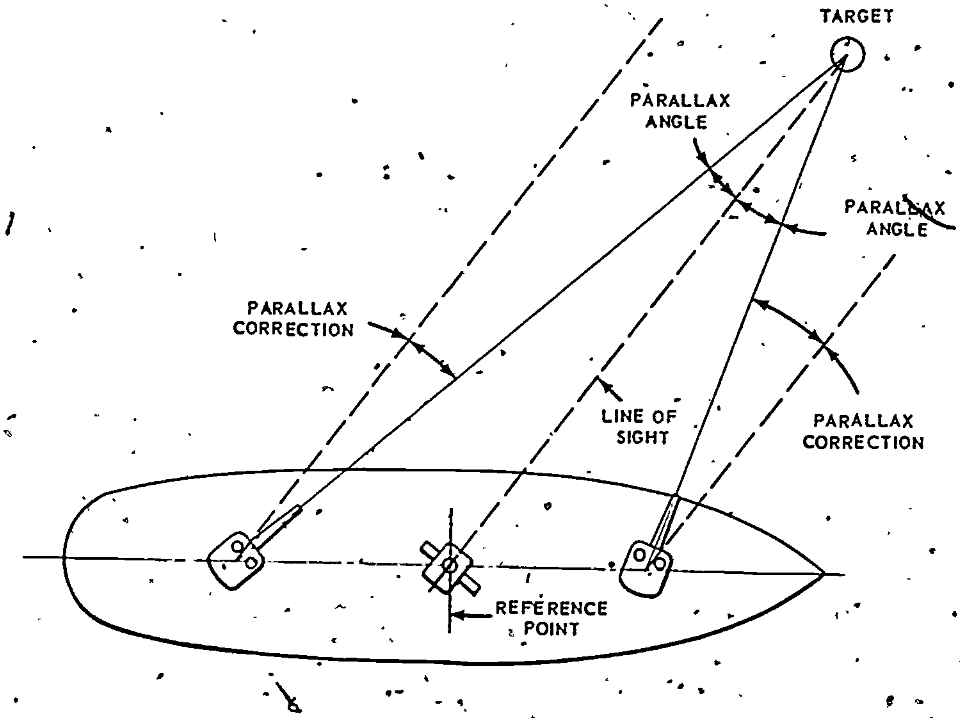
The electrical signals sent to the receiver regulators by the computer to correct for parallax are called unit parallax. Unit parallax is the parallax correction angle for a gun with a horizontal displacement of 300 feet fore or aft of the reference point. If a gun is mounted at any other distance from the reference point, the parallax correction angle will be a proportionate part of unit parallax based on the ratio of the distance of the gun from the reference point to the standard unit parallax distance of 300 feet. Guns aft of the reference point will have the correction signs reversed when compared with forward guns. Since unit parallax must be changed to give a signal which corresponds with the fore and aft position of the gun, a set of gears is mounted in the parallax corrector. These parallax change gears, as they are called, introduce the ratio that is required to convert unit parallax into the proper parallax correction. A diagram of the change gears is shown in figure 8-43.

Gears A, B, and C may be changed to agree with the position of the mount on which they are being used.

The method of adding parallax correction to the elevation orders is similar to the method used in adding parallax correction to the train orders. For this reason, the procedure used in adding the signal to the train order will be explained with the differences for elevation noted.

Unit parallax signals are received electrically at the parallax corrector on the stators of 1- and 36-speed synchro control transformers. A synchro changeover device in the parallax corrector amplifier changes the signal to the proper synchro in accordance with the magnitude of the input signal.

The rotors of these synchros are geared to the parallax motor. Any difference between the input signal and the rotor response position produces a signal voltage in the rotor winding. This signal is amplified by the parallax amplifier. A servomotor receives this amplified signal and drives the receiver synchro rotors into synchronism with the incoming signal. As the rotors near their point of synchronism, the changeover from the 1-speed receiver to the 36-speed receiver is accomplished by a synchro changeover circuit in



84.52

Figure 8-41.—Parallax correction to gun order.

the parallax amplifier. When the rotor is synchronized with the stator signal, the rotor output signal is zero, indicating that the required parallax correction has been added to the train order.

The parallax motor drives the unit parallax dial, the parallax limit stop mechanism, the parallax change gears, and other gears which drive the correction output shaft. The correction output shaft adds the parallax correction to the gear train of the train order response signal.

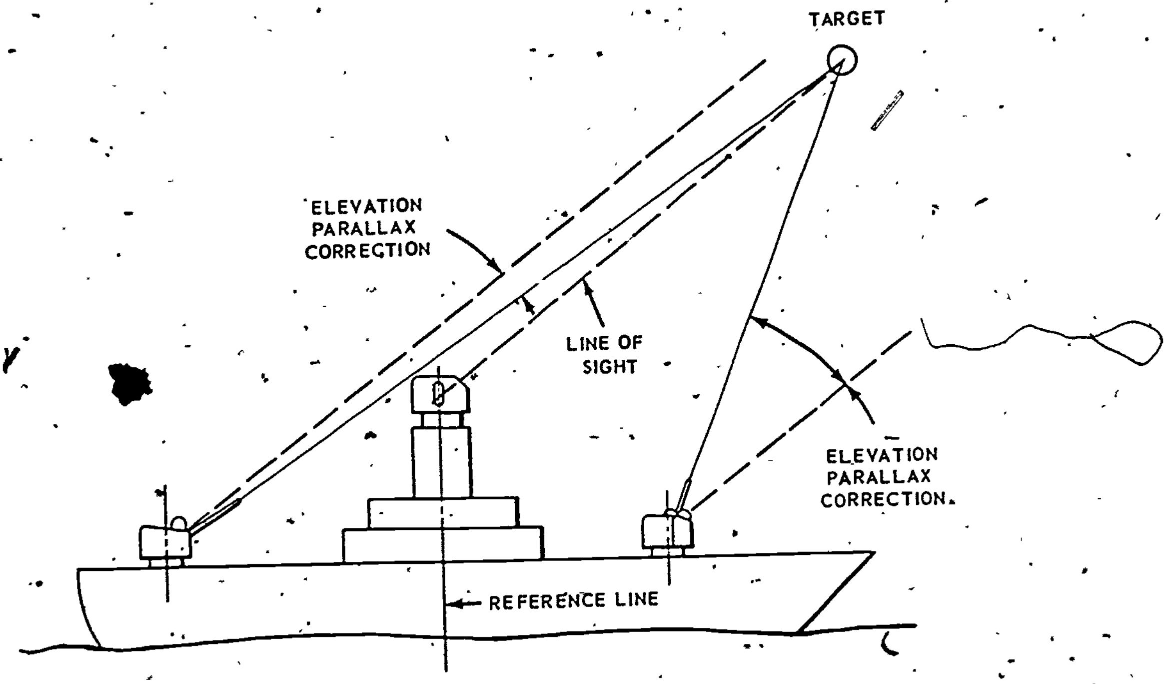
In the elevation parallax corrector, the correction signal is added to differential gearing and combined with the roller path tilt correction, and the algebraic sum of these inputs is used to correct the elevation order response.

Roller Path Compensator

Due to mount placement aboard ship, a gun may not be installed horizontal (parallel) with the gun director, and the resultant tilt affects the elevation angle of the gun. A roller path compensator (figs. 8-44 and 8-45) in the elevation receiver-regulator corrects for tilt errors by modifying the position input signal to the synchros. The correction is made by turning an adjusting screw on the compensator to align the horizontal planes of the gun director and the gun mount. This adjustment is made upon installation of the mount aboard ship and, once adjusted, should remain fixed.

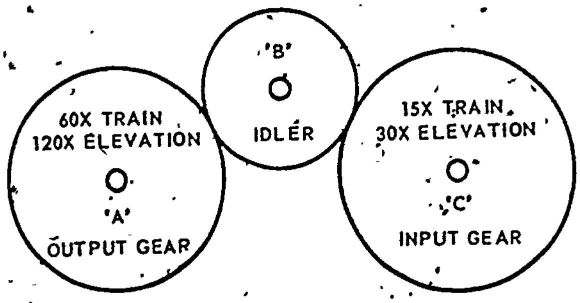
The train response assembly gearing applies train position information (fig. 8-45) to the roller path compensator. An eccentric translates rotary motion of the train position input to linear motion of a rack gear. This motion of the rack gear is transmitted to the elevation synchros to correct for the degree of roller path tilt.

Train response enters the elevation receiver-regulator through a flexible cable connected to the train response assembly. A worm drives a worm gear that is coupled to the train response input gear. The input gear drives a large gear (fig. 8-44). As the large gear turns, a gear support in the slot of the gear turns. The centering block, which is pinned to one end of the gear support, pushes the guide rails and moves the compensator carriage up and down. The rack gear, which is pinned to the compensator carriage, moves up and down with it.



84.53

Figure 8-42.—Correction to gun elevation for parallax.



84.54

Figure 8-43.—Parallax change gears.

Rack gear movement, transmitted to the synchros, mechanically repositions the synchro rotors. Since rack movement is proportional to roller path tilt, the elevation order signal is changed to compensate for the amount of tilt. As an example, assume that the roller path has a 1-degree upward tilt at the 10-degree train position. When the gun is ordered to train 10 degrees and elevate 50 degrees, the gun will actually elevate 49 degrees. The roller path compensator in this example orders the synchro to elevate 1 degree less than the ordered position to compensate for the tilt. An adjusting screw in the center of the large gear determines the amount of carriage and rack movement.

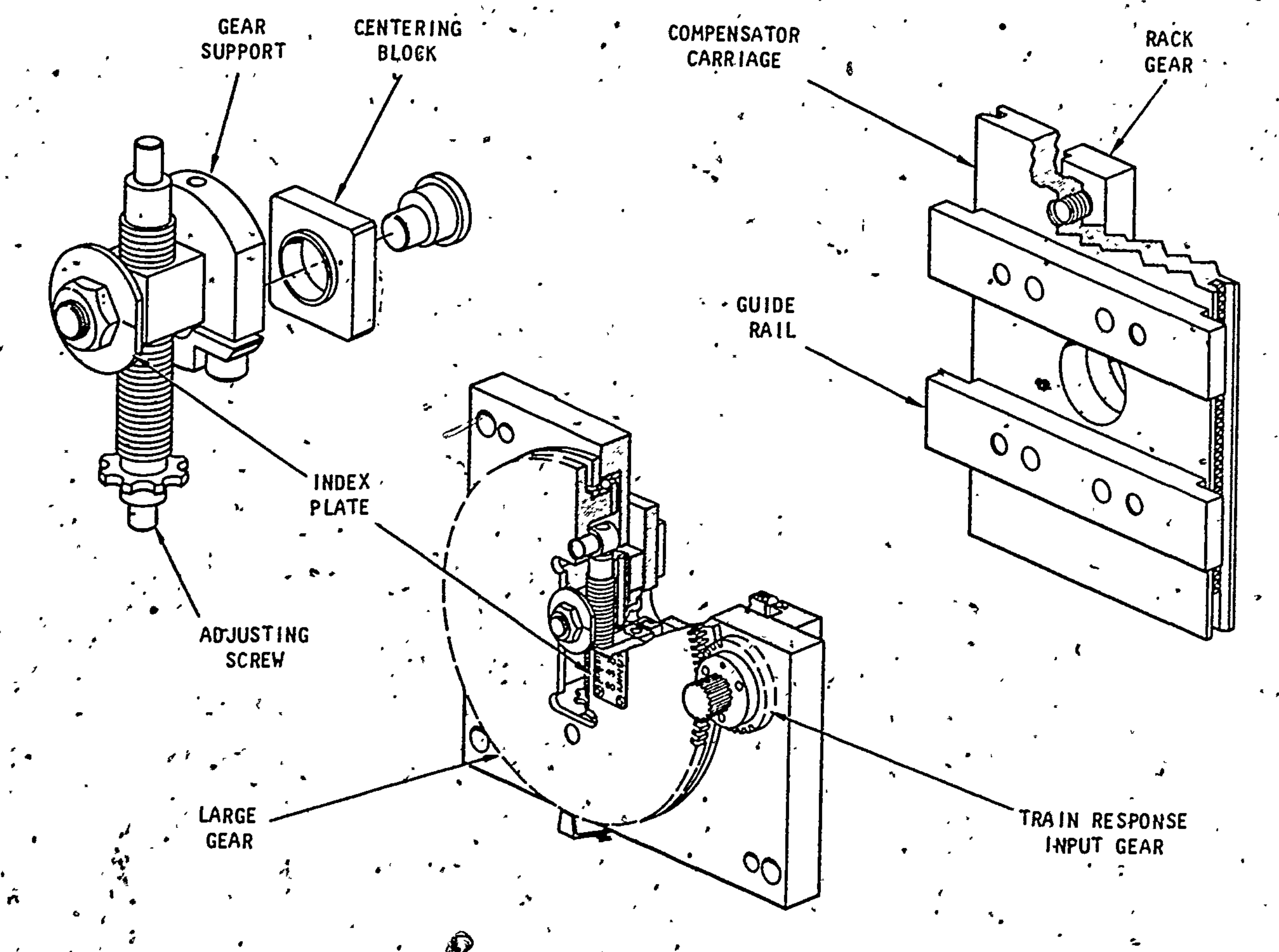
CONTROL SECTION

The control equipment of each receiver-regulator receives gun orders (electrically) in automatic control and (mechanically or electrically) in local control, and gun response (mechanically). In addition, the control equipment of the train unit receives parallax (electrically) while the elevation unit receives roller path tilt (mechanically). The equipment combines these inputs to produce a variable flow of liquid to or from the regulator valve block and the main piston and cylinder. As a result of these actions, the A-end tilting box is positioned to control movement of the guns in elevation and in train.

In the study of the theory of hydraulic operation in a receiver regulator, the following facts should be remembered:

1. The INCREASING order is the signal which causes right train and elevation.
2. The DECREASING order is the signal which causes left train and depression.

284



84.55

Figure 8-44.—Roller path compensator.

ERROR DETECTION

The purpose of the error detector is to compare a command (order) signal from the fire control system (FCS) with mount position and, if there is a difference, to send an error signal to a power drive servo control unit. In our discussion of error detection we explain two methods that are used in ordnance equipment.

An error signal originates when an FCS generates an order signal. The order signal is applied to the stators of a 1-speed (1X) and 36-speed (36X) synchro control transformers (CT), or to the stators of a 1X and 36X torque synchro receiver (TR); this signal represents the ordered position of the mount.

First we will explain the operation of a mechanical error detector which is a combination mechanical electrical arrangement consisting of a differential cam assembly (mechanical) directly connected to its order input device, a simple synchro receiver (electrical).

Mechanical Error Detector

The major components of the mechanical error detector are shown in figure 8-46. Response, mount position, is geared to the differential cam; when the mount turns, the differential cam rotates. The order signal is introduced to the differential cam by means of the torque synchro receiver.

For the present, we will consider the synchro stators as being fixed. The rotor, however, is free to turn. The only restriction is in the differential cam assembly. All of these devices are located in the receiver regulator at the mount.

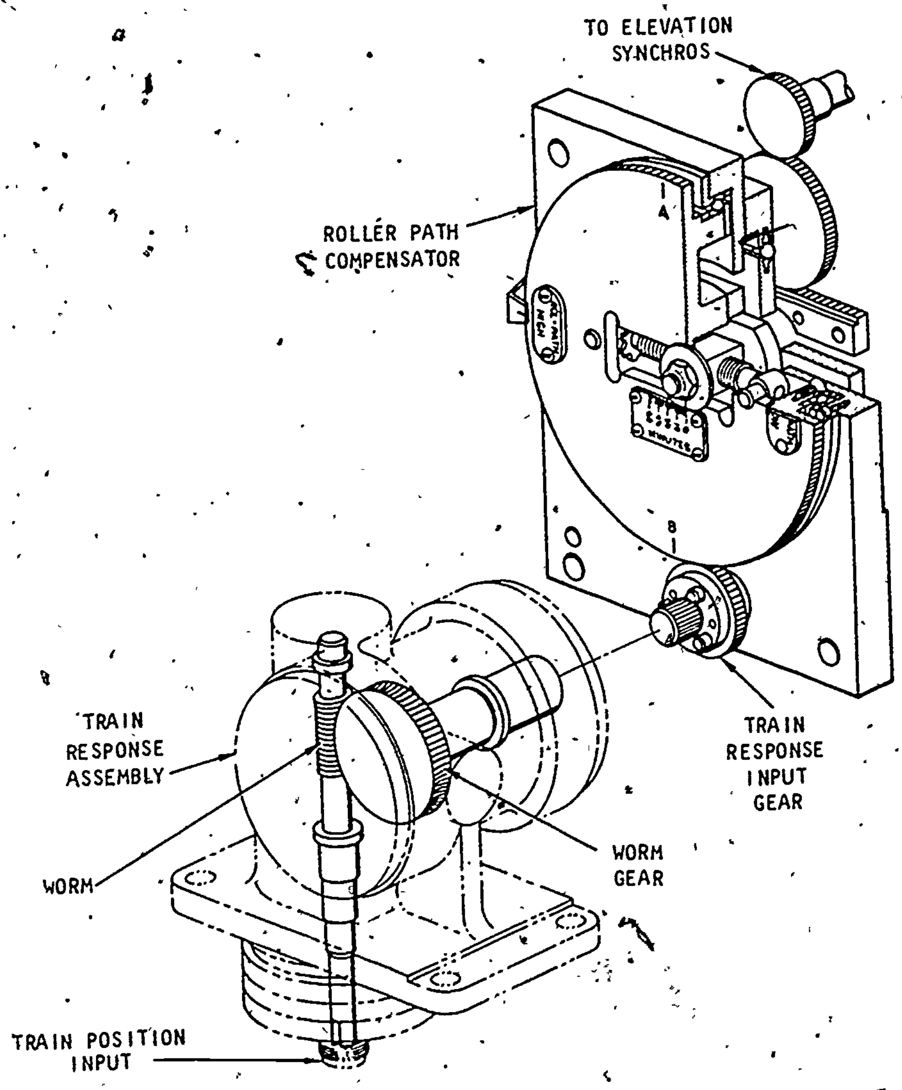
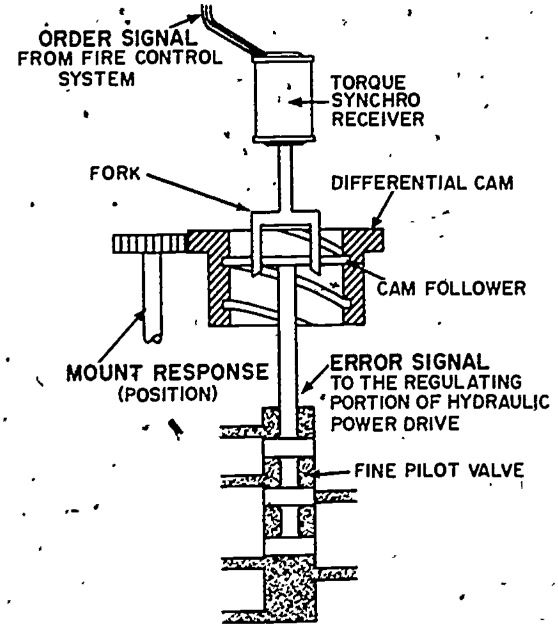


Figure 8-45.—Roller path compensator internal view.

You know from your study of torque synchro receivers that the rotor of our-error-detecting synchro acts as a slave to its mate in the fire control system. They act together to transmit position data. If the rotor of the FC transmitter were to be turned clockwise 45°, the receiver's rotor would turn clockwise 45°. Thus the output of our synchro receiver is mechanical rotation of its rotor—in the direction and in proportion to the amount of the order signal.

The differential cam assembly (fig. 8-47) compares gun order with gun position. It consists of a 2-pronged fork attached through the relief cam assembly to the rotor of the fine control synchro, a 3-fingered cam follower, and the differential cam. The differential cam is a hollow cylinder with three grooves curving up and around its inside surface. The fingers of the followers slide in these grooves, and the prongs of the fork extend down through slots in the follower. A shaft extends downward from the follower and is secured to the fine pilot valve.

When either the fork or the cam is rotated, the follower will move either up or down inside the cam, depending upon the direction of rotation. Thus reception of a signal by the fine control synchro will cause the rotation of the fork and



84.183

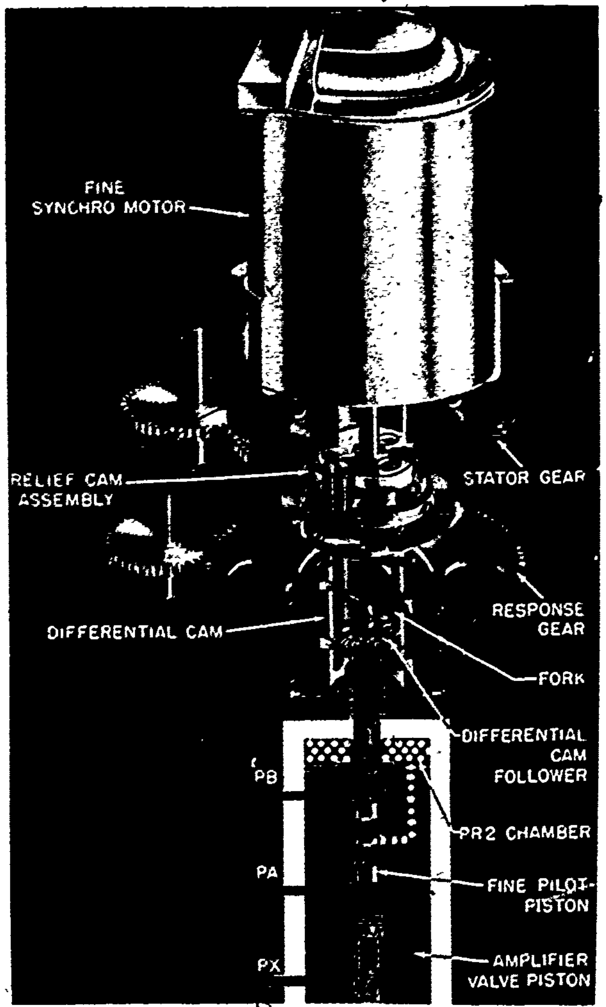
Figure 8-46.—A mechanical error detector.

follower. When the follower moves up or down, the attached fine pilot valve is also moved.

Mount movement (response) is geared to the differential cam in which the follower moves. As the mount moves to follow a signal, the response moves the differential cam, displacing the follower and the fine pilot valve in a direction opposite to that produced by the signal. This action returns the fine pilot valve to neutral when the gun order has been satisfied.

RELIEF CAM ASSEMBLIES.—The purpose of these assemblies is to permit the fine and coarse control synchros to follow the gun order signals when the pilot valves have reached their limits of travel.

The cams (31 and 32 in figure 8-48) are made so that their contact surfaces rise uniformly from a low point. The roller, attached to the driven mechanism, in normal operation is held in this low point by its spring. Any sudden change in the position of the cam—due to a reversal of gun order at high speed, for example—will momentarily cause the roller to leave the low point. The spring will return the roller to the low point of the cam fairly rapidly; but in the interim, the movement of the synchro will be prevented from reacting too violently on the hydraulic end of the control system.



53.52

Figure 8-47.—Differential cam assembly.

To sum up this section, we can say the order signal and response are compared at the differential cam assembly. Any difference between the two constitutes an error signal which causes movement of the fine pilot valve. We will show later how this movement is amplified and acted upon. Before that, however, let's return to the other type of error detector, the control transformer.

Electrical Error Detector

The control transformer (CT) is shown in figure 8-49. While it is a synchro, similar in

287

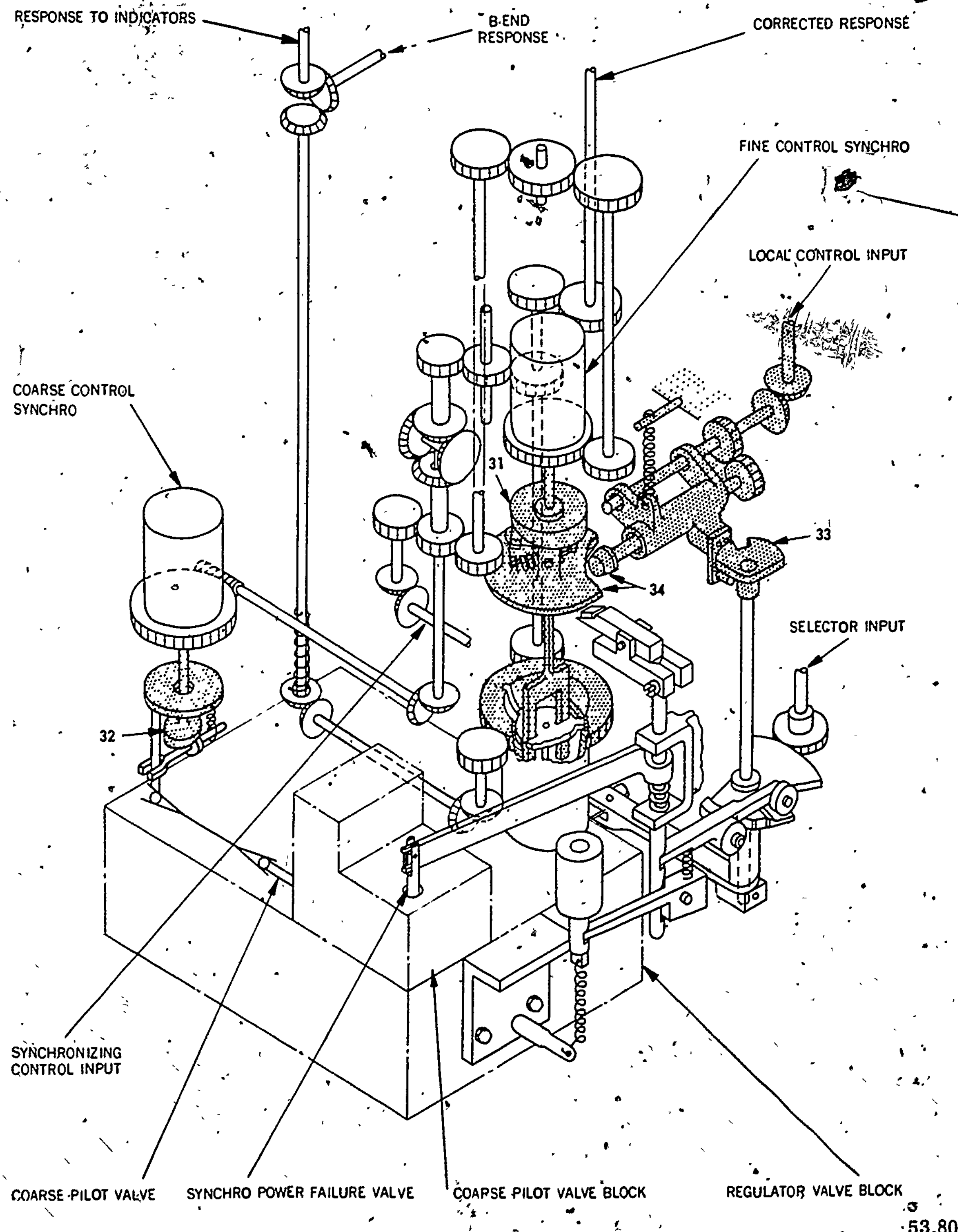
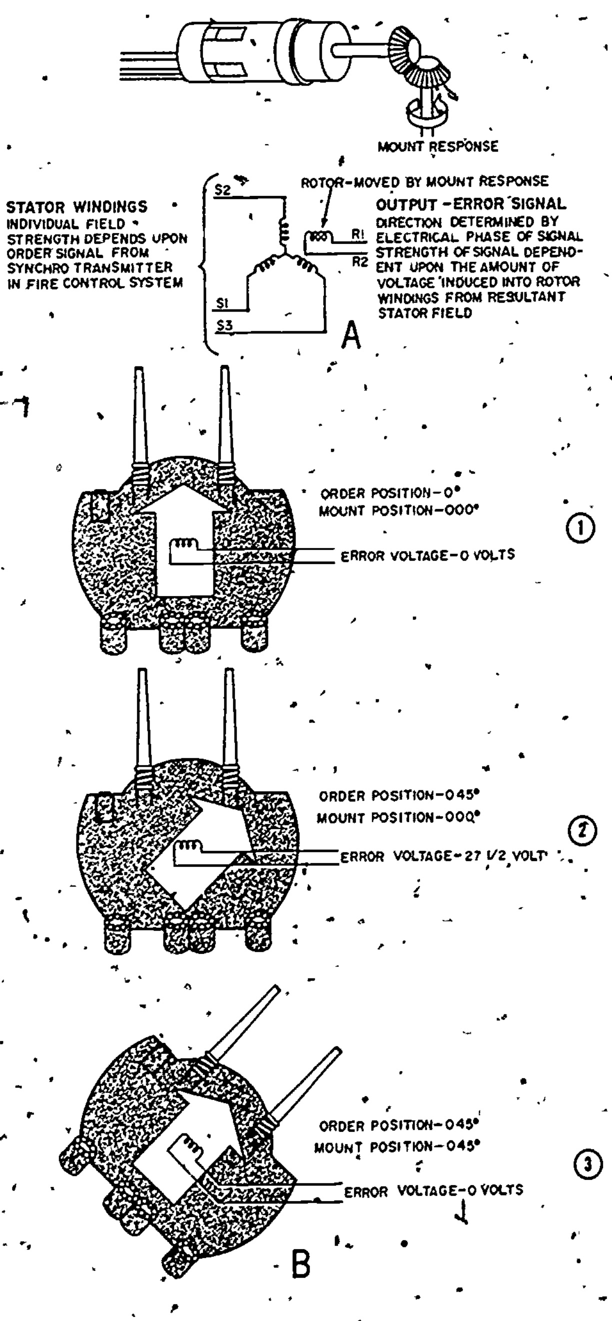


Figure 8-48.—Indicator regulator receiver assembly.



84.184

Figure 8-49.—The control transformer—A. The CT as an error detector. B. Actions of the CT as mount moves in response.

several ways to the one used with the differential cam assembly, there are some important differences. The first is that there is no direct supply of voltage to its rotor windings. Any flow of current in the rotor must be induced from the stator fields. Secondly, you can see from the illustration that mount response is connected to the CT's rotor. The rotor will move only when the mount moves. It also differs in its type of output, which is electrical rather than mechanical.

Before going further into our discussion of the CT as an error detector, look at figure 8-49B while we point out some additional information. The large arrow in each of the 3 illustrations represents the order signal. It is actually a resultant (combination) of the flux fields of the 3 stator windings. Considering the 3 stator windings as one, the field has a definite angular position. When the rotor of a corresponding transmitter (in the fire control system) is moved, the voltages in the CT stator field voltages rotate their resultant field, represented by the large arrow. The direction and amount of rotation is proportional to the error signal. This being a 1-speed CT, if the signal calls for the mount to move clockwise 45°, the resultant stator field moves clockwise 45°. One more bit of information—voltage is induced from the stator fields into the rotor by cutting lines of flux, that is, by transformer action. Any time the rotor is 90° from the large arrow, no lines of flux will be cut, and a certain voltage will be induced into the rotor.

Now look at figure 8-49B (1). Here mount position and order signal agree. The CT rotor is 90° from the large arrow. No error—no lines of flux cut—no induced voltage—no output to the power drive.

In figure 8-49B (2) an order is suddenly received for the mount to go to 045°. As the mount at this instant is still at 000°, the CT's rotor has not moved. The large arrow (resultant of the 3 stator fields) now induces an amount of voltage into the rotor proportional to the error. The output of the rotor is a voltage, the error signal. This signal is sent on to an electronic servo control unit servoamplifier.

The output of the servoamplifier controls the electrohydraulic servo valve which will position the mount into agreement with the order signal.

In figure 8-49B (3), the mount has been driven to 045°. Response, moving with the mount, has rotated the rotor back to its original position in relation to the large arrow (90°). At this point the order has been carried out. No error exists and there is no further output from the rotor.

THE AMPLIFIER

We have shown how error signals are produced. In both cases, however, the signals are relatively weak. The output of the simple synchro differential cam assembly can be measured in ounces. The electrical output of the control transformer at best will be only a fraction of the 115-volt supply of the transmitter.

We will now show one way in which each type of signal can be amplified. We will start with the explanation with the error produced by the differential cam assembly. We will show how the simple up and down motion of the fine pilot valve is converted to a hydraulic signal and then amplified.

HYDRAULIC AMPLIFICATION.—In figure 8-50 you see a stroke piston held in balance by two different fluid pressures. The balance is maintained by the 500 psi working on a piston face area TWICE that of the 1000 psi. The 1000 psi is held constant. The 500 psi is actually a variable; it can be reduced below that pressure or built up above it. Controlling this pressure is the job of the main control valve.

The main control valve is positioned in figure 8-50 so that the high pressure control HPC (1000 psi) port and PX (exhaust) (0 psi) are opened to the center chamber of the valve by small but equal amounts. The pressure formed in the chamber is one half HPC, or 500 psi.

If the valve is moved slightly to the left, PX will tend to close off and HPC will be opened slightly. Intermediate high pressure (IHP) in the center chamber will then rise toward 1000 psi. This causes the balance at the stroke piston to be upset, and it will move to the right with considerable force.

Moving the main control valve to the right causes the same actions, but in reverse. HPC will tend to close off while PX will open. Now IHP will drop and the 1000 psi at the stroke piston will cause the piston to move left.

One word of explanation before we bring the synchro receiver and the fine pilot valve back into the picture. The main control valve is moved not so much by changing pressures in its end chambers as by allowing fluid to flow into and out of the chambers. That is, by changing the fluid volume in the chambers.

Let us assume that a right train order signal is received by the synchro receiver. Movement of the rotor, and differential cam operation, will pull the pilot valve upward. The fluid in the upper chamber of the amplifier piston can now flow through the lower land chamber of the fine pilot to exhaust. This will cause the amplifier piston to move upward, and the fluid in the right-hand chamber of the main control valve can flow into the lower chamber of the amplifier valve.

The main control valve will now move to the right, IHP will drop below 500 psi, and the stroke piston will move left. As you will see later in this chapter, movement of the stroke piston will cause tilt to be put on the A-end tilting box, and the hydraulic pump will cause the mount to train right.

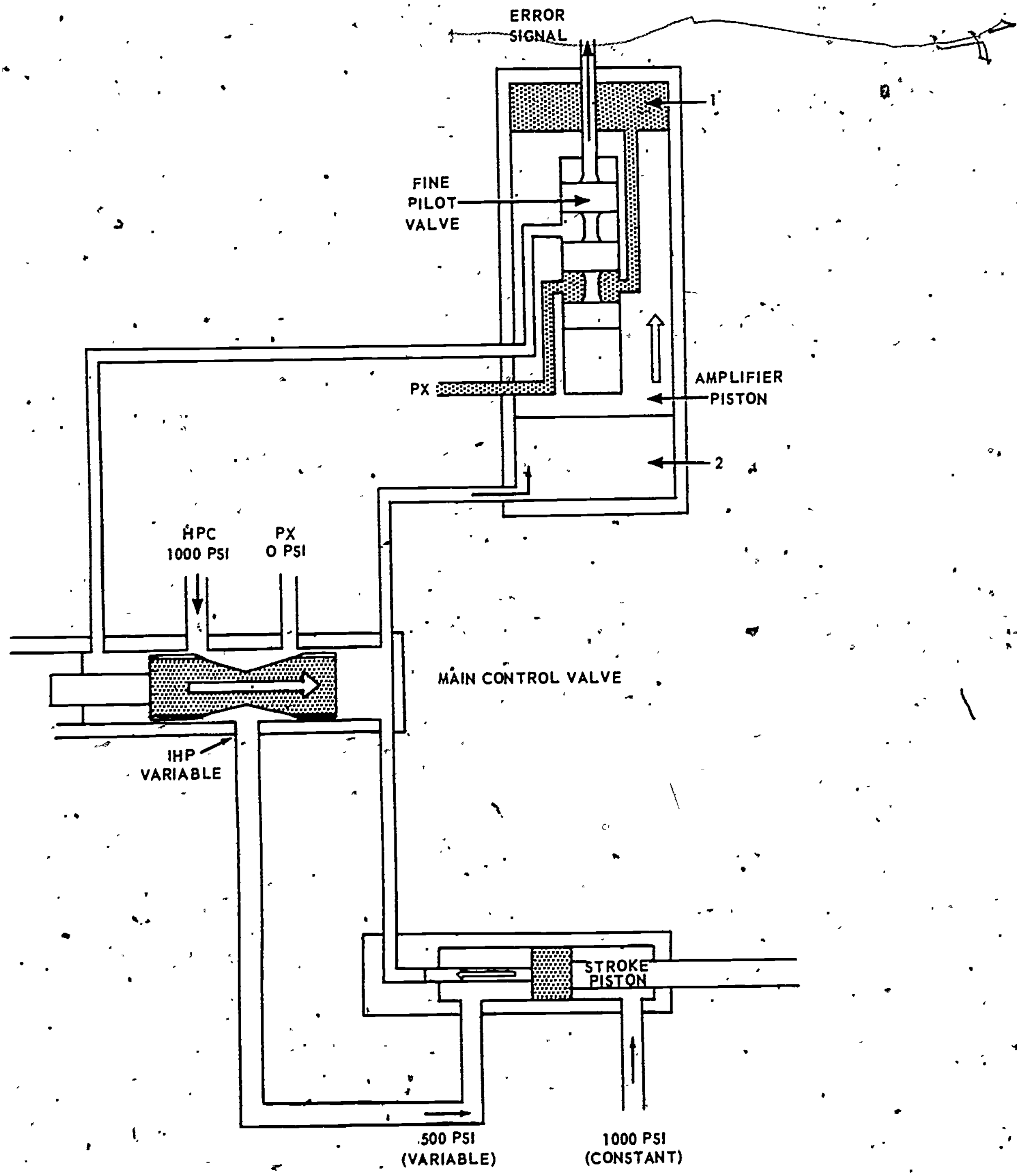
All of the actions mentioned above would occur if the signal had called for left train, but in the opposite directions. In the case of left train, the fine pilot valve would move downward. The upper chamber of the amplifier piston would be connected to high pressure and the piston would be forced downward. (These actions are not shown in the illustration). Liquid leaving the bottom of the amplifier piston causes the main control valve to shift left. IHP becomes greater than 500 psi, and the balance at the stroke piston is upset. The stroke piston moves right, shifting the tilt box in the A-end in a direction that will result in left train.

We have shown how a few ounces of synchro torque can set in motion, and control hydraulic pressures of hundreds of pounds.

ELECTROHYDRAULIC SERVO VALVE

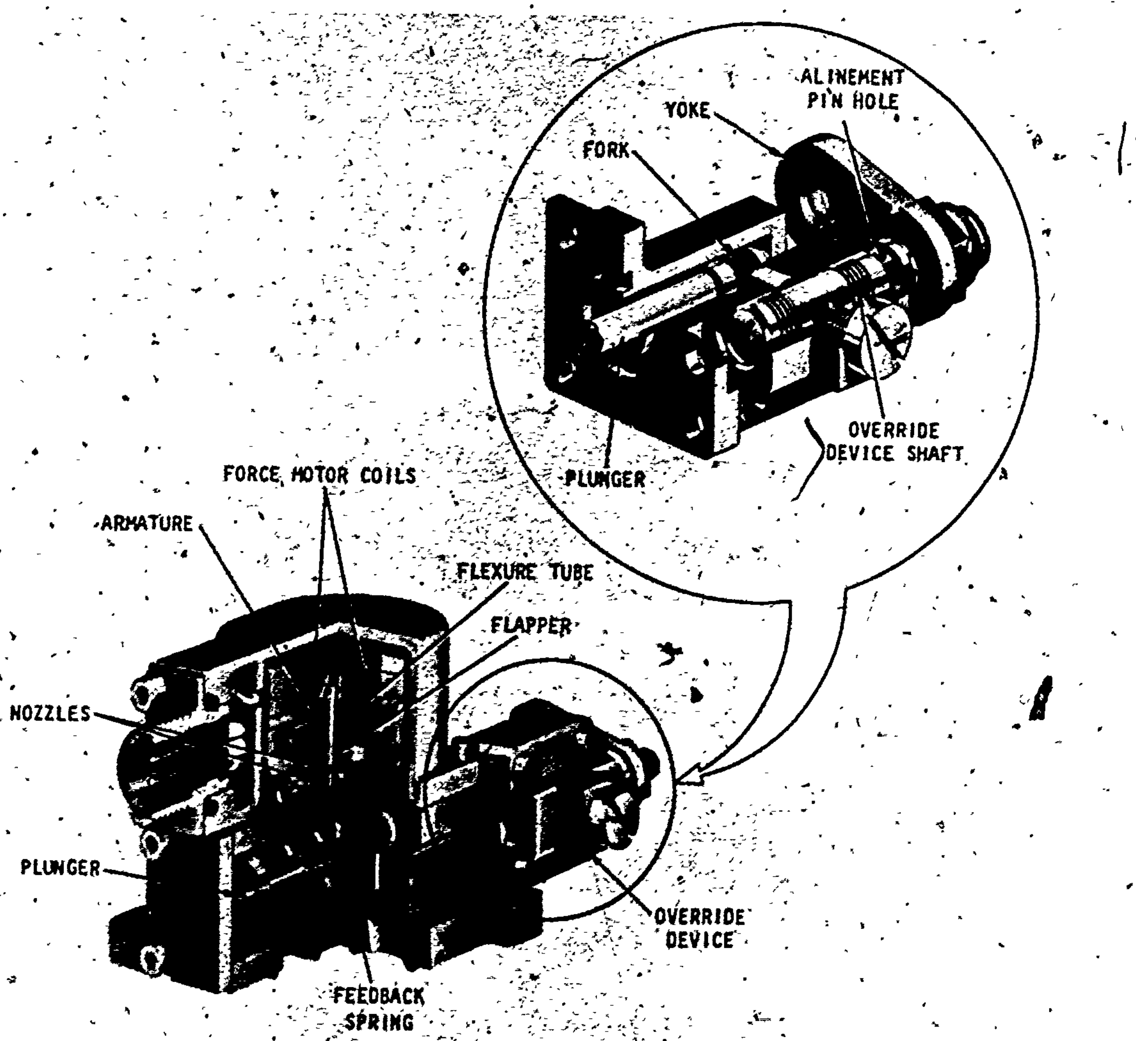
The electrohydraulic servo valve converts the electric output of the servoamplifier into a proportional hydraulic signal. Figure 8-51 illustrates the physical relationships of servo valve components which consist basically of a force motor and hydraulic amplifier. Output lines from the servo valve lead to stroking pistons in the CAB unit. The stroking pistons determine the position of the A-end tilt plate which controls the CAB units' output velocity.

The force motor of the servo valve converts the electrical input, supplied by the servoamplifier, to a flow rate. The electrical signal applied to the force motor coils generates a torque that causes the armature to move and bend on the flexure tube. The flapper attached to the armature moves with it, toward one nozzle and away from the other. Differential pressures caused by flapper movement between the nozzles move the plunger of the four-way valve. Plunger position regulates hydraulic fluid output to the stroking pistons.



84.185

Figure 8-50.—Amplifying the hydraulic error signal.



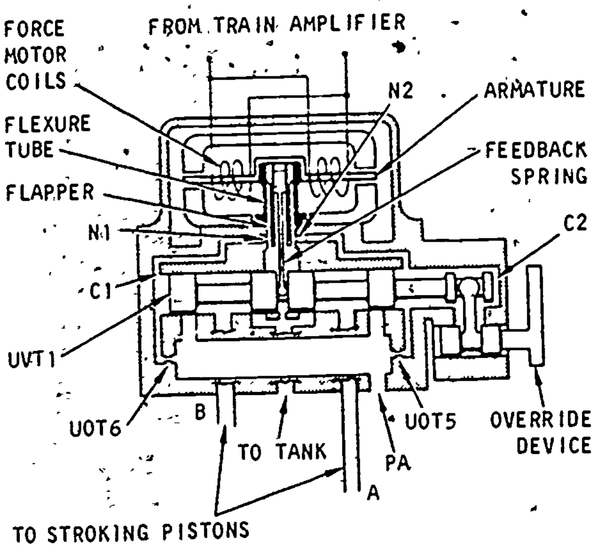
84.57

Figure 8-51.—Servo valve.

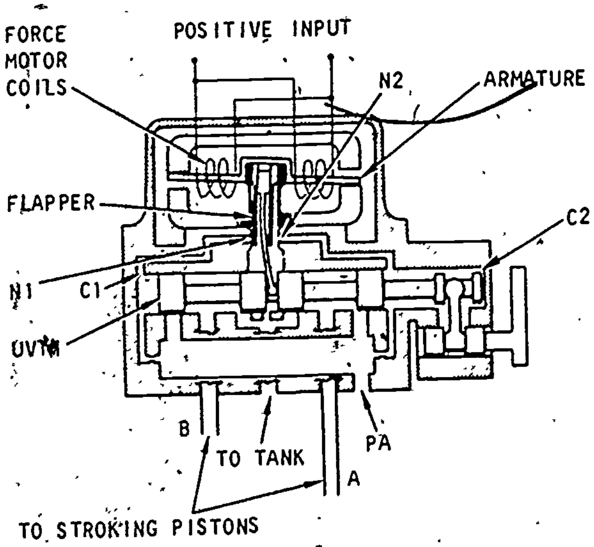
When the plunger moves from center, the feedback spring applies a torque to the armature. This torque, which is proportional to plunger displacement, opposes the torque developed by the force motor. As the order is complied with, and as response causes the signal to decrease, the flapper returns to neutral and the feedback spring returns the plunger to neutral.

With no signal applied to the force motor coils (fig. 8-52), the armature, flexure tube, flapper, and feedback spring are at neutral. PA control pressure is ported through the two fixed orifices, UOT5 and UOT6, to UVT1. The downstream sides of these orifices lead to pressure chambers C1 and C2 and to nozzles N1 and N2. The flapper regulates flow from the nozzles to the mixing chamber which ports to tank. With the flapper centered (neutral), flow through both nozzles is equal, UVT1 is at neutral, and output pressures to the stroking pistons are equal.

When a positive (increasing order) signal is applied to the force motor coils, the force motor shifts the armature and flapper to the right (fig. 8-53). This shift decreases flow through N1 and increases flow through N2, creating a pressure differential between C1 and C2. Because C1 pressure is greater, UVT1 shifts to the right, stroking piston B is ported to tank, and



84.58
Figure 8-52.—Servo valve (no input signal).



84.59
Figure 8-53.—Servo valve (positive input signal).

stroking piston A receives PA. Pressure at stroking piston A is now greater than the pressure at stroking piston B, causing the tilt plate to move.

When a negative (decreasing order) signal is applied to the force motor coils, the force motor shifts the armature and flapper to the left (fig. 8-54) and the action of UVT1 is reversed. Now, fluid flow decreases through N2, increasing the pressure in C2, and UVT1 shifts left, stroking piston A is ported to tank, and stroking piston B receives PA. Pressure at stroking piston B is now greater than at stroking piston A, causing the tilt plate to move in the opposite direction.

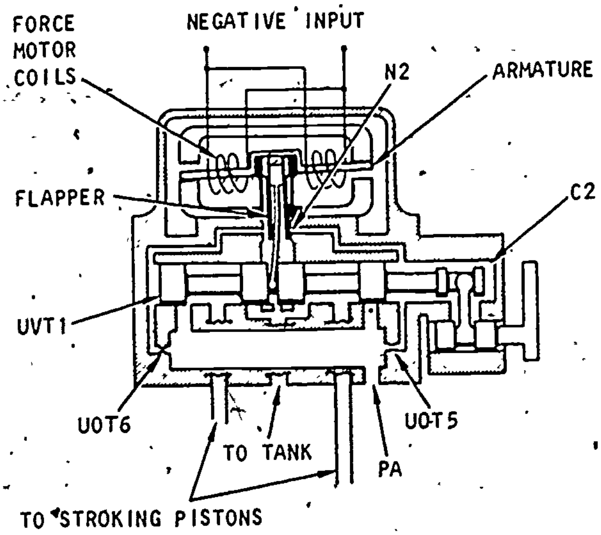
ELECTRIC SERVO CONTROL UNIT

The electronic servo control unit (servoamplifier) converts the small a.c. error signal from the synchro to a d.c. signal large enough, and of proper polarity, to activate a torque generator. The electronic servo control unit consists of a power supply and two amplifiers, one each for train and elevation control.

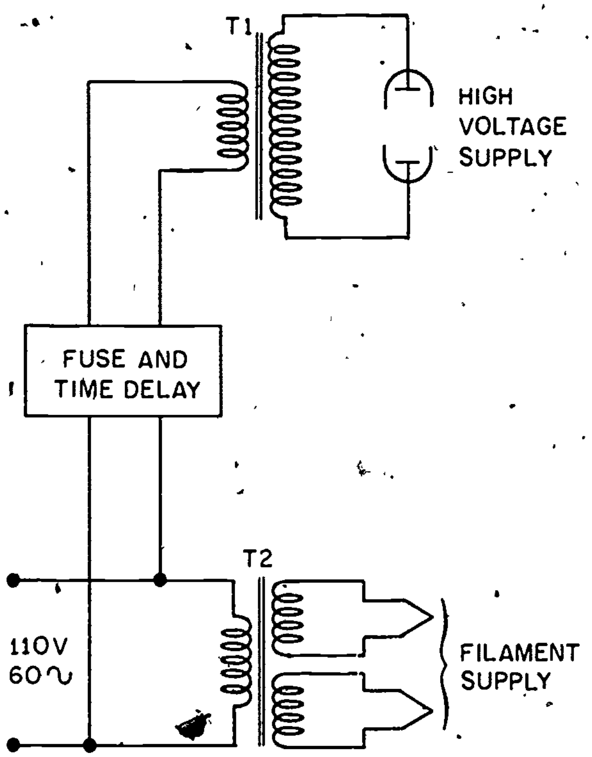
Power Supply

The power supply chassis contains tubes, transformers, inductors, relays, and a filter network to regulate and supply d.c. plate voltage for the servoamplifiers. The transformers in the power supply also furnish the 6.3 filament voltages for the tubes in the amplifier.

The 115-V., 60-hertz voltage from ship's supply enters the power supply chassis on the primary of transformer T2 (fig. 8-55), and travels through time delay relays and fuse circuits



84.60
Figure 8-54.—Servo valve (negative input signal).



84.61

Figure 8-55.—Power supply.

to the primary of transformer T1. These relays ensure that the cathodes of the vacuum tubes are heated before high voltage is applied to the rectifier tubes.

Most servoamplifiers have four sections; the synchro changeover unit, the a.c. amplifier, the demodulator, and the d.c. amplifier. Figure 8-56 shows how these sections function in a power drive servo-control system. The reader should refer to this illustration throughout the discussion on the functions of the four sections of a servoamplifier.

SYNCHRO CHANGEOVER UNIT

The synchro changeover unit passes either the 36X or 1X synchro signal to the a.c. amplifier unit. The 1X synchro signal is passed to the amplifier whenever the mount is more than 2°30' out of correspondence with its controlling director, the 36X signal is passed to the amplifier when the error is less than 2°30'. How a synchro changeover unit functions is explained further on.

A. C. Amplifier

The a.c. amplifier receives a 1X or 36X synchro error signal from the synchro changeover unit, amplifies the signal and converts it into a push-pull output for use in the demodulator. The a.c. amplifier contains two vacuum tubes, a transformer, and associated circuits. One vacuum tube functions as a voltage amplifier, while the other tube is a cathode follower power (current) amplifier. The transformer acts as a coupling device for the next stage (demodulator). The actions of vacuum tubes were explained in chapter 7.

Demodulator

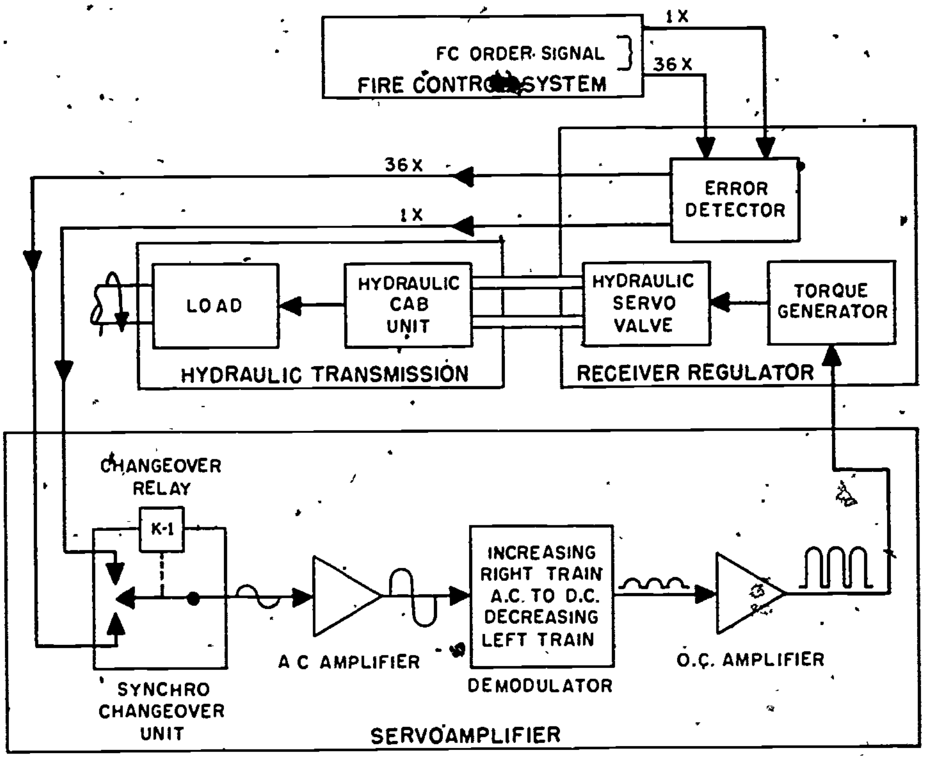
The demodulator converts the a.c. error signal into a pulsating d.c. error signal, the amplitude of which is varied in accordance with the strength of the a.c. signal. The demodulator also discriminates between an increasing error (right train or elevation) signal by having the output polarity change when the order signal changes. If the output across the demodulator load is polarized for an increasing order signal, the polarity across the load will reverse when a decreasing order signal is applied. Rectification (changing a.c. to d.c.) will be explained shortly.

D. C. Amplifier

The d.c. amplifier is the last stage of amplification before the signal reaches the torque generator. The torque generator controls either an electrohydraulic servo valve or a rotary type valve located in the receiver regulators. These valves control the hydraulic output to the A-end of the hydraulic transmission power drive. A filter network in the output circuits to the torque generator prevents sudden changes in current from reaching the torque generator field windings. The d.c. amplifier receives two additional inputs.

1. A dither signal from the 6.3V filament supply is induced, via a transformer, to the grid of a vacuum tube. This dither action maintains vibration of the hydraulic system to prevent valves in the system from sticking.

2. Another signal is received from the B-end tachometer, which is geared to the B-end of the hydraulic transmission. It generates a voltage proportional to the speed of rotation of the B-end. This B-end velocity feedback reduces the B-end error when the gun is following roll signals.



84.62

Figure 8-56.—Electronic servo control unit functions.

There are many more functions of a servo amplifier which cannot be discussed in this text due to the amount of material that has to be covered. System OPs explain in detail the operation of all elements of a servoamplifier. The purpose of this text is to explain the theory and application of a servoamplifier used in ordnance equipment. We have purposely by-passed some actions of servoamplifiers which are necessary for proper power drive operation.

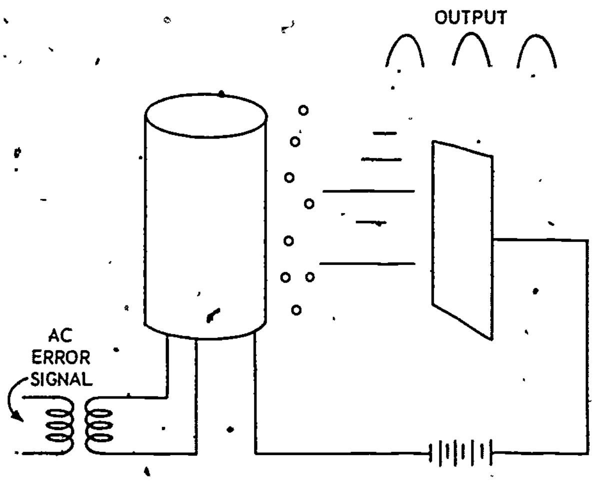
In the next section of this chapter we discuss some of the servoamplifier refinements necessary for power drive operation, such as the action of the synchro changeover unit and how the a.c. error signal is converted to a d.c. error signal (rectification).

RECTIFICATION

Rectification is the name given to the process of changing alternating current to direct current. Our electrical error signals left the control transformer as alternating current, but the electron tube amplifier (for gun power drives) operates on direct current. Therefore, the signal must be rectified. This is done in the first stage of the amplifier. The device used is a 2-element electron tube, a diode (fig. 8-57). The filament is used only to heat the cathode. It is not considered as an element of the tube.

When the cathode is heated, it gives off electrons which form a space charge around it. Like the electrons in it, the space charge is negative. If a positively charged plate is near the space charge, electrons will be attracted and current will flow. The number of electrons that flow to the plate depends on the relation of the plate voltage to the cathode voltage. In no case can the current flow from the plate to the cathode, because the plate is not heated and therefore will not emit electrons. The diode tube, then, acts to pass current in one direction only.

Our error signal from the control transformer is alternating current. A simple diode like the one just discussed will pass only on half of each cycle. Its output will be in only one direction (which is what we want), but it will be pulsating. This output of our diode is called half-wave



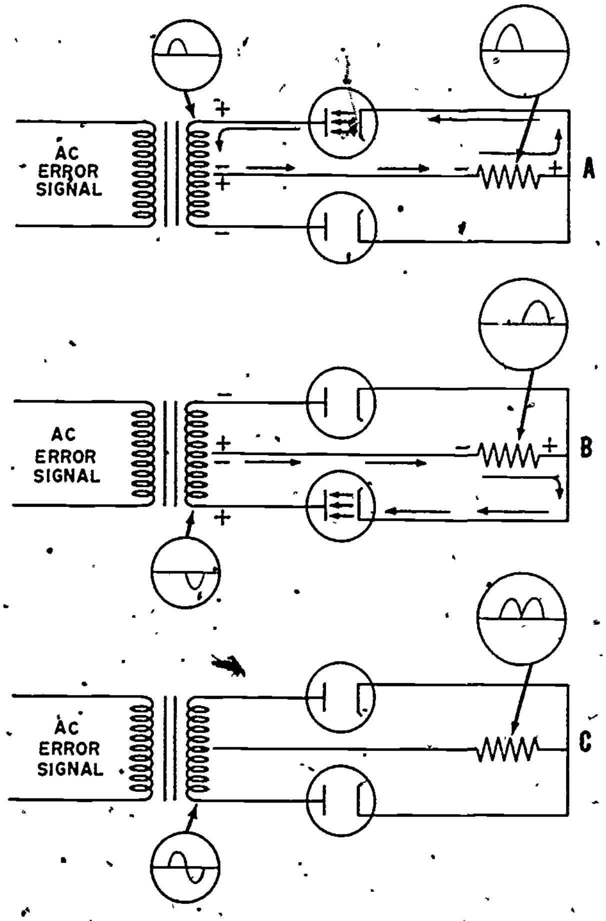
84.188
Figure 8-57.—Changing the a.c. error signal to d.c.—half-wave rectification.

rectification. It is not good enough for gun power drive amplifiers.

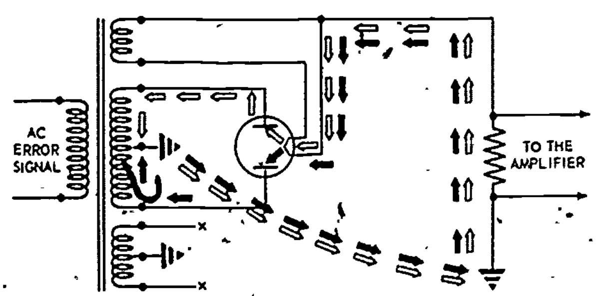
The answer, full-wave rectification, is fairly simple. In figure 8-58 you see that the transformer secondary is divided into two halves by a tap at the center of its winding. A diode rectifier tube is placed in series with each half of the secondary and the load. Effectively, you have two half-wave rectifiers working on the error signal voltage.

On the first half cycle (fig. 8-58A), the a-c voltage causes the upper diode plate to go positive; current flows, and a pulse of voltage is sent across the load. On this half cycle the lower diode plate is negative with respect to its cathode and will not conduct. On the second half cycle (fig. 8-58B), the upper diode plate becomes negative and will not conduct; the plate of the lower diode, however, is now positive so that current will flow through it and the load. Since both pulses of current through the load are in the same direction, a d.c. ripple voltage appears across the load as in figure 8-58C. In an actual circuit you will find an assortment of coils and capacitors which will then filter out the ripple, and result will be straight line direct current.

We have shown how full-wave rectification is accomplished by using two separate diode tubes. The more common way of diode rectification, however, is shown in figure 8-59. At first glance there may be little comparison with this circuit and the one just described. A closer look, however, will reveal that the only difference is that the



84.189
Figure 8-58.—Basic rectifier—two diode tubes.



84.190
Figure 8-59.—A more typical rectification circuit—a duodiode tube.

two diode tubes have been put into one envelope, or glass housing. The two plates share a common cathode. The center tap from the transformer secondary is grounded, as is one end of the load resistor. The flow of current between the two is indicated by arrows.

Like the basic full-wave rectifier, the duo-diode is connected to opposite ends of the transformer winding so that there is always a 180° phase difference between the two plates. During one-half of the a.c. input cycle, one plate will draw electrons from the cathode. During the other half cycle, the other plate draws the electrons. Since the load resistor is connected between the cathode and the transformer secondary windings, current flow through the load resistors is in the same direction for both half cycles.

DUAL SYNCHRO SYSTEMS

From an earlier section of this chapter you learned that synchro receivers play an important part in the power drive picture as error detectors. The control transformer type serves this purpose by itself. The other receiver, a torque synchro, works with the differential cam assembly. In each example of error detection (figs. 8-46 and 8-49,) only one synchro receiver is shown. One important fact was intentionally left out of the discussion. There are actually TWO receivers at the gun mount, and they have two mates (transmitters) in the fire control system. One transmitter and one receiver are called the coarse system. The other pair is the fine system. The difference between the two receivers is in the ratio of the gearing connecting them to mount responses. A commonly used coarse synchro ratio is 1 to 1. This means that for every one revolution the gun mount makes, it drives the synchro through one revolution. The ratio of response-to-fine synchro is much higher, in most cases 36 to 1. This means that for every 1 degree of mount movement the fine synchro will be rotated 36 degrees. Ten degrees of mount movement will cause the synchro to be moved 360°—one full turn.

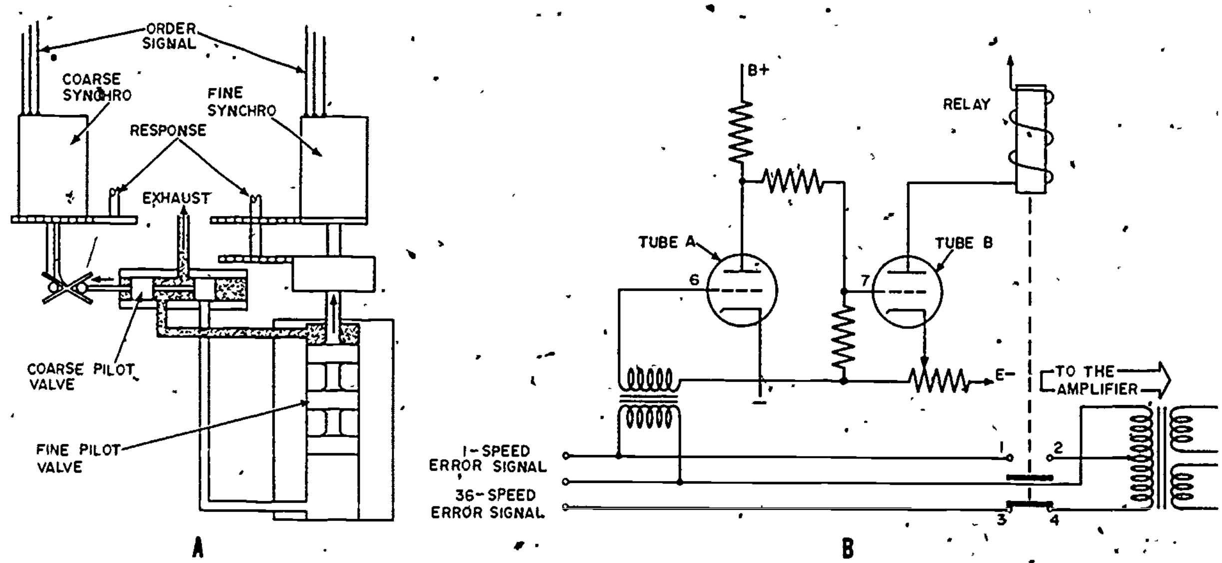
The use of the fine system provides the power drive with accuracy. The purpose of the coarse system is to prevent the fine system from attempting to cancel out the error signal at multiples of 10 degrees from the true synchronization point. And in the case of the control transformer, a false point of correspondence can be set up not only at 10° multiples but at 5° as well.

The control transformer, you recall, had no error voltage when its rotor was 90° from the resultant stator field (order). Electrically speaking then, the 36-speed CT has TWO angular positions (with respect to the stator signal) at which the rotor will have a zero voltage output. These positions are at right angles to the stator signal. A 90° OR 270° displacement of the rotor with respect to the stator signal will result in zero voltage at the rotor. Let us assume that an order signal tells the mount to train 5 degrees. Now the CT was initially set with its rotor winding at 90° to the stator signal. The 5° train signal would, in effect, be the same as rotating the 36-speed rotor through 180°; or to the 270° position of the CT and a zero voltage output. We have already seen how 10° of mount movement rotates the rotor through one revolution, therefore 5° of mount train should cause a 180° movement of the rotor. The 5° order, as far as the fine CT is concerned, is a zero error output. Theoretically, the mount would not move.

This won't do. A 5° train signal has been ordered and there seems to be no error voltage. We will see how this is compensated for by using the coarse CT and a synchro switching circuit. Actually we have been belaboring a point in the preceding discussion of the CT. Even without a coarse CT, the fine CT would probably cause the mount to drive to correspondence. This is because it is practically impossible to get an absolute zero voltage from a synchro.

Synchro Changeover

For the first example of how a power drive chooses between coarse and fine control, look at figure 8-60A. Here are our old friends the fine pilot valve and differential cam assembly plus two new faces, the coarse synchro and pilot valve. Although the illustration shows both synchros receiving the order signal, we will disregard the coarse system for the present. From our earlier discussion you know that, when there is a difference between mount position (response) and the order signal, the fine pilot valve will be moved. Let us assume that there is a 90° error, calling for right train, and that this causes the fine pilot valve to be pulled upward. As the mount trains right, response to the differential cam and the fine synchro stator starts to cancel out the error by moving the fine pilot valve back toward its neutral position. As the response gear ratio to the fine system is 36 to 1, it will take only 10° of mount movement to entirely cancel out the error signal (still disregarding coarse control).



84.191

Figure 8-60.— Two methods by which power drives choose between coarse and fine control.

This would cause the power drive output to cease and the mount to come to a standstill while still 80° from true synchronization. Now let's return to the coarse system.

When the order signal was received at the fine synchro, the coarse synchro received the same signal. As the fine pilot valve was pulled upward, the coarse pilot valve was pulled to the left. This causes the upper chamber of the fine pilot valve to be opened to exhaust through the coarse pilot valve. You can see, however, that any flow out from under the fine pilot valve is blocked. Through design, the coarse synchro will not move to the right to open the lower chamber of the fine pilot valve until the mount is within 3° of synchronization. At that time the fine synchro and pilot valve take over and drive the mount the remaining 3 degrees. There are relief cam assemblies (not shown) which permit the fine and coarse synchro rotors to follow order signals when the pilot valves reach their limit of travel.

Another method by which a power drive chooses either the fine or coarse error signal is shown in figure 8-60B. In this example, the error signals are coming from 1-speed and 36-speed control transformer error detectors. You will remember that the output of CTs is electrical voltage, proportional to the amount of error. Both signals share a common lead, and must pass through the contacts of a relay. At this particular instance, the fine signal is being sent to the amplifier through the common lead and the closed contact 3-4. If the coil of the relay is energized, however, the contacts will be lifted. This will open the fine error signal circuit at 3-4, and will complete the coarse signal circuit through 1-2. The problem, then, is to energize the relay coil when the 1-speed error signal reaches a predetermined level. This level will correspond to about 3° of mount displacement from the order signal.

The 1-speed error signal is applied to the primary of a transformer. The secondary of this transformer controls the voltage at grid 6. With no error signal the tube is conducting near saturation. This is due to circuit design. Now, when the 1-speed CT detects an error, it transmits a signal through the transformer to grid 6. The positive half cycle of the error signal on grid 6 will cause no appreciable increase in plate conduction since the tube is already conducting heavily. The negative half cycle, however, will cause conduction of the tube to decrease. This means that the average conduction of the tube through one full cycle of the error signal will be decreased.

When conduction of the tube decreases, its plate voltage increases. This voltage change (positive) is sent to grid 7 of tube B, a conventional amplifier. The positive voltage on its grid increases the current flow through the relay coil.

If the 1-speed error signal is large enough, the relay will lift. Closing contacts 1-2 connects the coarse error signal to the amplifier, at the same time disconnecting the fine error signal. The mount will follow the coarse error signal until the signal becomes so small that the relay is de-energized. This happens when the mount is very near synchronization. At this time the mount will continue to follow the error signal in fine control.

Preventing Overswings

Overswings are those small back and forth movements of a mount as it comes into correspondence with an order signal. They are especially noticeable when the mount is shifted into automatic control while still some distance from its ordered position. Usually there are only one or two overswings before settling down. Devices in the power drive keep these annoying movements to a minimum, but cannot entirely eliminate them. This is due to the large inertia of heavy mounts and an inherent lag in all power drive regulating equipment.

There are several methods of preventing large overswings. Because of their differences, no one method can be chosen to illustrate them all. In this section of GMG 3&2 we will present briefly the theory behind three separate methods.

Method No. 1 is used with the error-detecting devices shown in figure 8-60A. Using only these devices, the power drive would drive at full speed toward synchronization under control of the coarse pilot valve. No reduction in speed is possible until the fine system takes over, which would occur when the error has been reduced to about 1.5°. At this point the hydraulic valves in the receiver regulator would begin to function to slow the mount. No appreciable slowdown would occur, however, until the amplifier valve is nearly at its neutral position. This means the error is not in the vicinity of 30 minutes. It would be impossible to change the motion of the gun from that of maximum speed to that of the signal in the small amount of angle left. This situation will cause the gun to overrun the point of correspondence.

To minimize these overruns, a synchronizing control device is added to the system. The function of this device is to serve notice to the power drive that synchronization is about to be reached. It will give this notice at some appreciable time and distance before the actual synchronization occurs. Acting on this advance notice, the power drive will operate to slow the gun down as it approaches correspondence.

The synchronizing control device (SCD) is a small but complex hydraulic assembly consisting of a hydraulic motor, several valves, an intermittent drive, and shafting. The output of the SCD drives the stators of the coarse and fine synchros. Let us assume that the gun power drive is shifted to automatic, and that there is a large difference between gun position and gun order.

On a 90° error signal when the selector lever is placed in automatic, the mount will start driving toward the point of synchronization. Mount response and the synchro control time output are added together at the differential to cancel out the coarse error voltage at a ratio of 2-1. As the mount reaches the false point of synchronization (45°) the coarse pilot valve moves to its center position and the fine pilot valve moves to its center or neutral position. At this time, the mount will momentarily come to a stop. All valves, except in the (SCD), are at their neutral position and all electrical error signals are at zero. At this false point of synchronization, the (SCD) will reverse and it will drive back to its neutral position. The SCD output at this time going to differential D-2 side gear and mount response on the other side gear will cause the output of the differential to be zero. With no output of differential D-2, the coarse pilot valve will remain on neutral during the last 45° of mount travel. The output of the SCD will go to the stator of the fine synchro and with no electrical error present, the stator and rotor will be driven together as the mount travels the last 45°. The mount will drive into synchronization at an ever decreasing speed. This decreasing speed is being caused by the offset centering valve moving back to its original neutral position. When the offset centering valve gets to a point where P3 and P4 are open equally to PX, the SCD motor will detent and the motor will stop. The entire operation from the false point to true point of synchronization will be in fine control at an ever decreasing speed, thereby, eliminating overtravel.

The type of synchronizing control device just discussed is found in hydraulic power drives—chiefly those used with the 5"/38 twin mounts, and turrets. The SCDs used in turret power drives are driven by small electric motors rather than hydraulic ones, however.

Method No. 2 is used with hydraulic drives, but is applicable only to the power drives on the 5"/54 Mk. 42 guns. While this power drive uses control transformers as error detectors, there is a large difference between these and the CTs shown in figure 8-49.

A CT usually has only one response—B-end response to its rotor. With the CTs output controlling a power drive, mount movement drives the CT rotor in such a direction as to reduce the signal. When the mount arrives at its ordered position, response will have driven the rotor to its electrical zero position. There is no output, and the mount stops.

In figure 8-61A, however, you see a different setup. Here there are two responses to the CT. The stator is geared to B-end output (mount response) and the rotor is geared to the rotary piston. The purpose of having two responses is to cause the A-end tilt box to start removing tilt before the mount arrives at its ordered position. The following is a brief discussion of how this is accomplished.

As in a conventional CT, the error signal is produced by rotating a resultant of the three CT stator field voltages. The error voltages induced into the rotor windings are sent to an amplifier and on to a torque generator. Rotation of the generator moves a rotary valve. This switches hydraulic circuits to the rotary piston, causing it to turn in a direction equivalent to the desired movement of the mount (train or elevation). Rotary piston movement sets the hydraulic regulating devices in motion, causing tilt to be put on the A-end pump. This, you will recall, causes the mount to move.

Even while this is happening, however, the moment the rotary piston moves, it turns the rotor of the CT in such a direction as to cancel out a portion of the original error. Now, as the mount moves toward its ordered position, B-end response moves the CT stators, also in a direction to cancel out the error. When the stators overtake and pass the rotor, a phase shift occurs in the signal voltage. The result of the phase shift is an output from the rotor in an opposite direction from the first error signal. In other words, if the first signal called for right train and tilt is put on the A-end, the electrical phase shift will cause the error signal to call for, in effect, left train. Hydraulic actions reverse in the regulator, and tilt begins to be removed from the A-end. Theoretically the A-end tilt box should reach neutral when the mount arrives at its ordered position. As you can see, these actions will prevent any prolonged overswings of the mount. Figure 8-61B shows in four steps the action described above.

Method No. 3 is used to improve the synchronization of an electrically driven (amplidyne) mount to an order signal. This drive uses the conventional CT to develop the electrical error signal, and the electron tube amplifier to increase the signal. The method of reducing overswings for this drive, then, must be electrical. The problem is this:

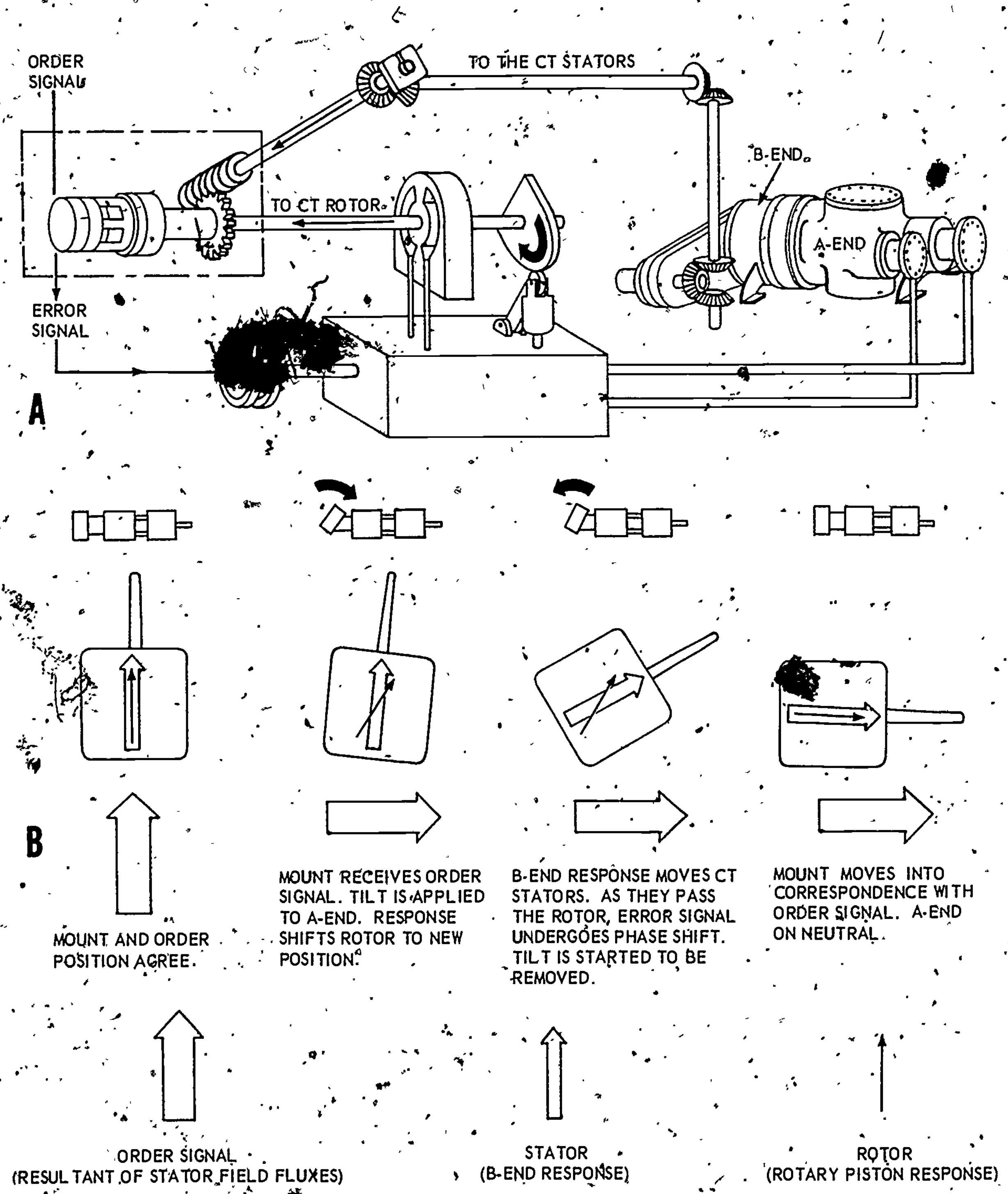
So that the power drive will accurately and speedily act on error signals, however small, it must be made very sensitive. This can be done by increasing the amplifier gain. This is technician's talk for adjustments to a stage in the amplifier whereby the signal strength is increased or the reaction of a stage to the signal is increased. A gain might be adjusted too tight (high) and become unstable. This will result in overswings.

To smooth out the power drive operation, the gain must be damped. In amplidyne drives this is most often accomplished by introducing voltages in opposition to the signal voltage. But damping, like gain, can be overdone. An overdamped power drive will take a long time to synchronize. On the other hand, an under-damped power drive will hunt around, about the point of synchronization, due to the small amount of restraint placed on the error signal. Somewhere between the two extremes a balance must be obtained, so that the power drive will be accurate and smooth, and have a short synchronization time.

The 3"/50 RF gun power drives are prevented from hunting by feeding several stabilizing voltages into the amplifier. These will modify the effect of the error signal. Two of these voltages, and their source, can be seen in figure 8-62.

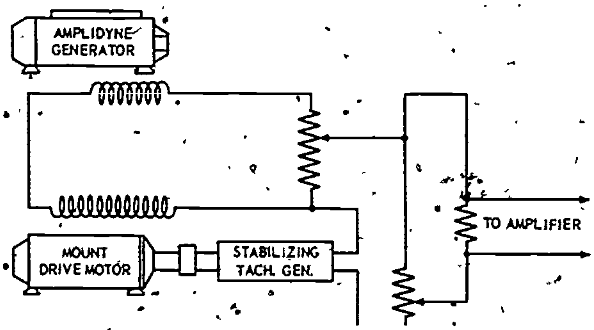
One of the voltages is the speed voltage originating at the stabilizing tachometer generator. The other voltage is taken from the field windings of both the amplidyne generator and the mount drive motor. As this voltage is proportional to the amount of current drawn by the drive motor, it is called the "current" voltage. A fraction of each of these voltages is taken from a potentiometer. The sum of these fractions is sent to the amplifier, where it acts in opposition to the signal voltage, to reduce overswings.

The current voltage, being proportional to the amount of current drawn by the drive motor, is strongest when the drive motor is reversing its direction of movement and drawing heavy current. The stabilizing tachometer generator is geared to the mount's drive motor. The electrical output of this generator is proportional to mount's speed. If the mount is swinging back and forth through its correspondence point, it will have its greatest speed as it passes correspondence. Speed voltage will be greatest at this time.



83.85

Figure 8-61.—A. Control transformer with two responses. B. The CT acting to remove tilt as mount moves into correspondence.



84.192

Figure 8-62.—Two synchronizing circuits of an amplidyne drive.

Now to return to the big picture. When a mount, moving to the left, overtravels its correspondence point, response immediately causes the error detector to reverse its signal; that is, it now calls for right train. The signal is opposed at the amplifier by the current voltage from the drive motor which is now attempting to reverse its motion and drawing heavy current. This will cause the speed of travel to be reduced as the mount backswings toward correspondence, modifying it. So, by action of both synchronizing voltages each overswing is shorter than the one before.

THE MOTOR

Motors are the power drive components which accept the amplified error signal and do the physical work of moving the mount into correspondence with the order signal. They are motors in function only and bear no physical resemblance to the usual concept of a motor found in an automobile. We can say that a motor is a drive that causes, sets up, or imparts motion—a source of mechanical power or energy.

There are two types of motor units used as part of a power drive servo-system. The first type to be discussed is the hydraulic A/B-end combination used on 5" guns and turrets. The second is a d-c drive motor used with the amplidyne generator-motor combination power drive used extensively on 3"/50 RF mounts. The fundamentals of both type motors were explained earlier in this chapter and in chapter 7.

ELECTRIC-HYDRAULIC POWER DRIVE

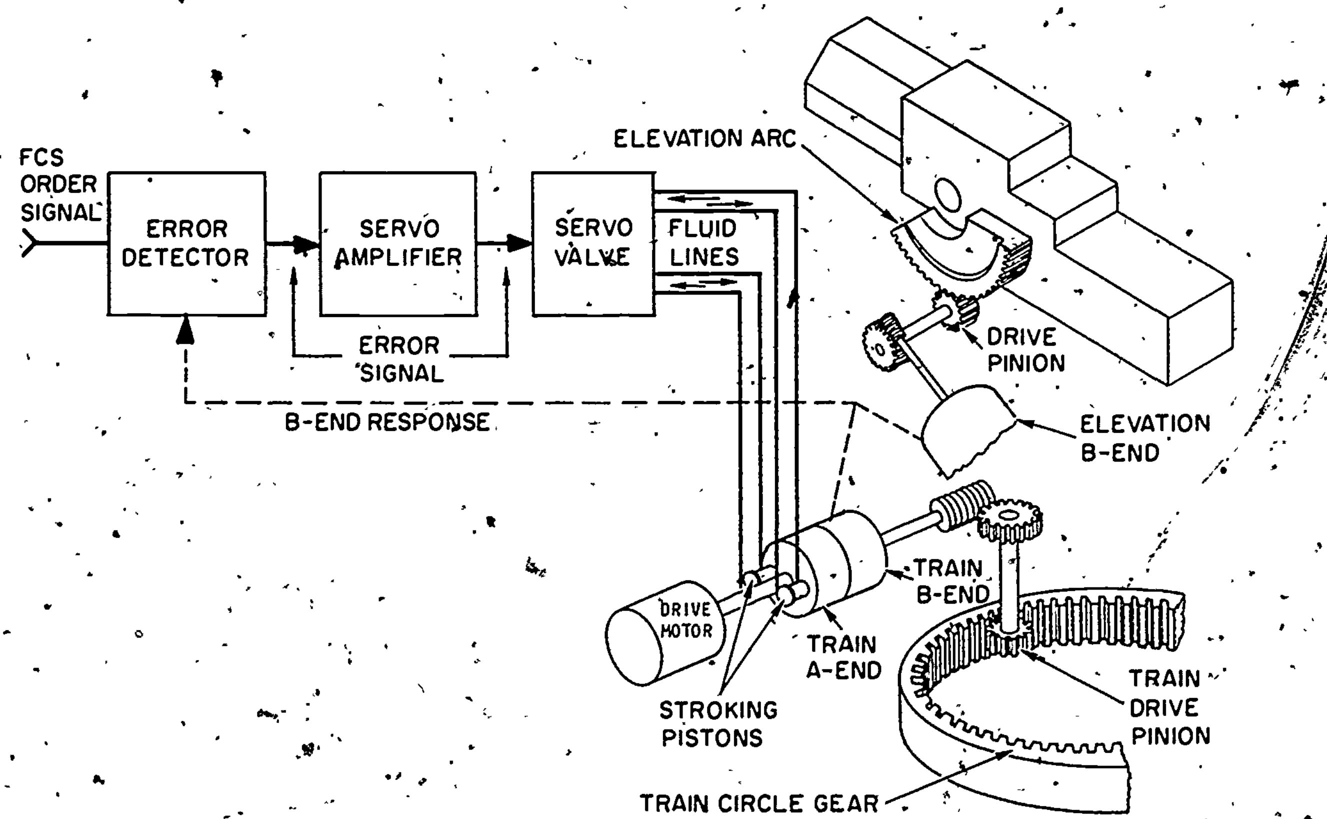
The previous topics of this chapter dealt with the functions of the separate units for control of a power drive servo. In this section, these functions are combined to give an overall view of a hydraulic control as it occurs.

An order signal originates at an FCS, and represents the position to which the fire control director will position the gun. The order signal is applied to synchros in the receiver-regulator.

A synchro receives the order signal, compares it with actual gun position, and generates an error signal (figs. 8-46 and 8-49). The error signal is amplified either hydraulically (fig. 8-50) or electrically (fig. 8-56), and applied to the hydraulic unit stroking pistons either directly from a hydraulic amplifier (fig. 8-50) or an electro-hydraulic servo valve (fig. 8-51). Stroking piston motion controls the hydraulic transmission which rotates a drive pinion that positions the mount in train and elevation (fig. 8-63). The stroke piston is the connection between the amplified error signal and the A-end tilt box. Figure 8-64 shows two types of stroke piston control. Part A illustrates just one stroke piston; this type of control is usually used with the hydraulic amplifier shown in figure 8-50.

Part B shows two stroke pistons (the face of piston A is twice the size of piston B). Both of these systems function on the principle of differential in working area. The type shown in part B works in conjunction with the servo valve shown in figure 8-52.

Earlier in this chapter we explained the function of the major elements of a hydraulic power drive (CAB unit). We will review these elements before explaining how the A-end tilt box (plate) is positioned by the stroke pistons. The A-end (pump) is driven by a constant-speed electric motor. The output is made variable by action of the tilting box. The stroke piston which moves the tilt box is connected to the hydraulic amplified error signal by transmission fluid lines (fig. 8-63). The B-end (motor) is driven by the fluid output of the A-end. The speed of the B-end is dependent upon the amount of tilt of the A-end; more tilt, more speed. The direction of rotation of the B-end is determined by whichever fluid line is high pressure and which is return. The output of the B-end is mechanical rotation, it is directly connected to the mount train or elevation gearing (fig. 8-63).



84.63

Figure 8-63.—Train or elevation hydraulic servosystem.

Stroke Piston Operation

In figure 8-64A the stroke piston is being acted upon by two hydraulic pressures. The 1000 psi side is held constant and works on a certain size piston face area. The left side of the stroke piston is acted upon by a force made variable by our error signal. This force works on twice the stroke piston face area as that of the constant 1000 psi. In this case, 500 psi would balance it, and the stroking piston would remain motionless. Raising the pressure on the left side of the stroke piston above 500 psi moves the piston to the right and puts tilt on the A-end which causes left train and depression. Reducing the pressure below 500 psi shifts the stroke piston to the left, reversing the direction of A-end tilt causing right train and elevation. The hydraulic amplifier (fig. 8-50) controls the action of a single-stroke piston.

In figure 8-64B you see practically the same actions. Here are two stroke pistons whose piston faces are of different sizes (the face of piston A is twice the size of piston B). The pistons are kept in balance by the same method shown in part A of figure 8-64, the main difference being the amount of pressure used to control the stroke pistons. When an increasing order signal is applied to the servo valve (fig. 8-53) a pressure differential is created which causes stroking piston A (fig. 8-64B) to move and will cause the mount to train right, or the gun will elevate. When a decreasing order signal is applied to the servo valve (fig. 8-54), the tilt box will move in the opposite direction and the mount will train

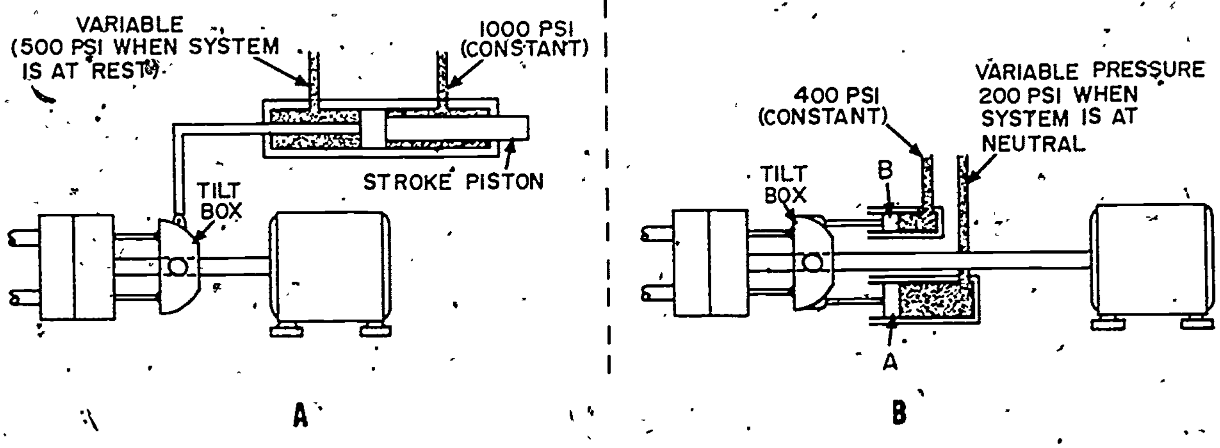


Figure 8-64.—Putting tilt on the A-end tilt box.

left or the gun will depress. In the next section we explain the devices which, in the all-electric type power drive, receive the order signal from an amplifier, amplify it still further, and use it to power the drive motor on a gun mount.

AMPLIDYNE GENERATOR POWER DRIVE

An amplidyne power drive (fig. 8-65) consists basically of four units:

1. Receiver-regulator;
2. Amplifier;
3. Amplidyne motor/generator; and
4. D-C drive motor.

As explained early in this chapter, a power drive acts as a servosystem which uses feedback (response). In the amplidyne power drive, this type of feedback system is sometimes called a followup system.

In the amplidyne followup system, each receiver-regulator acts as a clearing-house for information. Gun laying is completely automatic (requires no assistance from personnel on the mount).

The synchro control transformer located in the receiver-regulator receives the order signal which electrically indicates the required load position. The actual position is determined by means of the rotor of the synchro control transformer which is rotated by the response shaft. The shaft in turn is geared to the load.

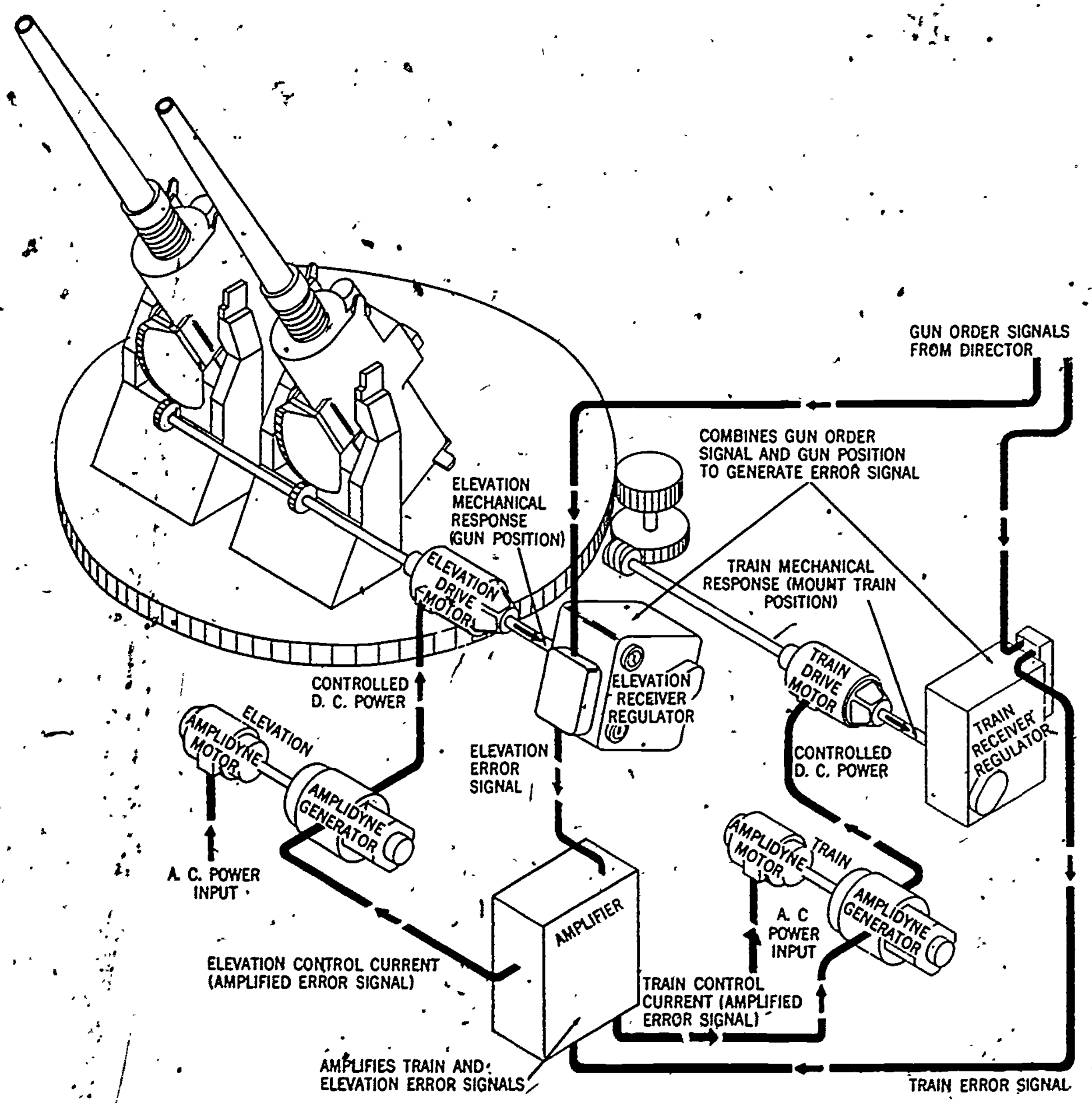
The actual load position is compared by the synchro unit (error detector) with the position order signal. The angular difference between the two positions constitutes the error signal. The error output of the error detector is transmitted to the amplifier (fig. 8-66). The error signal indicates the extent and direction of the error.

The amplifier amplifies the error signal and converts it from a.c. to d.c. to energize the field windings of the amplidyne generator.

The amplidyne motor/generator set is basically a large power amplifier. Its power output depends on the strength of its control field control. The strength of the control field current depends on the extent of the error signal received from the amplifier. Therefore more power is applied to the d.c. drive motor for a larger signal than for a smaller one.

The amplidyne generator, shown schematically in figure 8-67, is a power amplifier on a large scale. Any generator is capable of amplifying power, but not enough to move a load the size of a gun mount. The amplidyne generator is capable of multiplying the input to its control windings (our order signal from the electron tube amplifier) as much as 10,000 times. The output of the amplidyne generator is applied to the drive motor on the mount and turns it in the proper direction to reduce the original error.

From the illustration you can see that the control fields of the generator (F1-F2, F3-F4) are fed from two tubes (V213 and V214). These tubes are the third stage of the electron tube amplifier. In the second stage of the amplifier

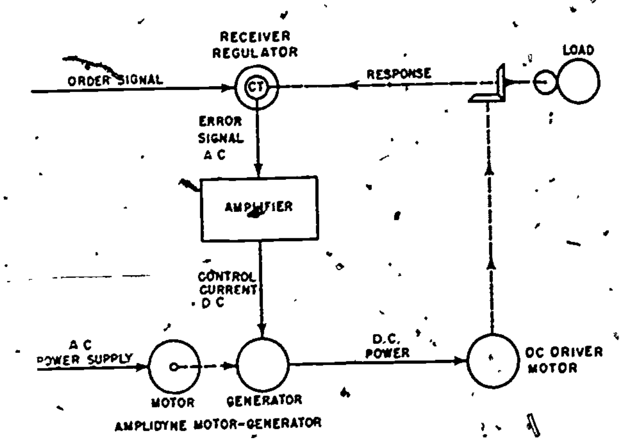


84.64

Figure 8-65.—Train or elevation amplidyne servosystem.

(not discussed), an elevation signal causes the control grid voltage of V213 to become more negative and that of V214 to become more positive. This will result in heavy current for the F1-F2 field and light current for F3-F4. A depression signal has the opposite effect.

In one field of the generator the windings go around the pole in one direction, and in the other field they go in the opposite direction. As long as the two currents are equal, their combined magnetizing effect is zero. If the F1-F2 field receives more current, a field polarity will be



110.25

Figure 8-66.—Amplidyne followup system.

set up and current will flow as indicated by the arrows. And naturally, if F3-F4 receives more current, the field polarity will be reversed, and likewise the direction of current flow.

The output of the generator is taken from the load brushes. It is proportional to the error signal on the control windings, but greatly amplified. From the generator, the output goes as orders to the d.c. drive motor on the mount.

The d.c. drive motors, located on the mount, train and elevate the gun by means of its gearing (fig. 8-65). The direct current to operate the drive motor is supplied by the amplidyne generator. The rotation direction of the motor depends on the polarity of the output of the amplidyne generator. The direction of this output, in turn, depends on the direction of the error signal. Consequently the motor moves the load in the proper direction to reduce the error.

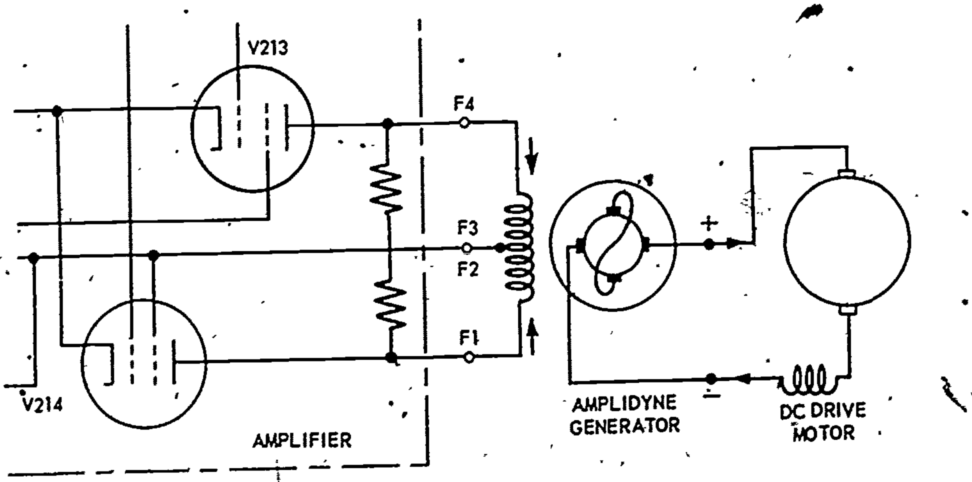
As long as there is an order signal present, there also is an error signal. Without an error signal, no power would be supplied to the drive motor to move the mount. Because of the immense amplification capability of the amplidyne (as much as 10,000 times the input), the necessary power to drive the motor can be provided even when the error is extremely small.

So far in this chapter we have discussed power drives that use response. Response is that part of a power drive servo that tells the error detector that the order signal has been carried out, or we can say that response is the movement effected by servo operation, or a signal based on it. This signal is fed back to the error-sensing device at the system input, also called "feedback". Feedback is that signal from the servo output fed back to input to regulate servo action.

Before going into a technical study of response, let us examine a situation that explains response (feedback) that might occur during your daily routine aboard ship.

The situation goes like this: The leading chief of a gun battery (GMGC Lightfoot) receives orders from the fire control officer for GMG 3 Lightning to report to director one for a training period. The chief locates Gunner's Mate Lightning and orders him to report to director one, he also instructs Lightning to notify him (the chief) by telephone as soon as he has carried out the order.

If you examine this exchange of orders, you may find this example is not so far out after all.



84.187

Figure 8-67.—Current control and amplification through the amplidyne generator.

The chief, in receiving an order for Lightning and locating him, acted as an error detector, the error being that Lightning was not at director one. The error was canceled by Lightning's arrival at the director. Response was the telephone call to the chief made by Lightning when he arrived at the director.

RESPONSE

Of course, the situation described above is not a technical example of response. A better description is found earlier in this chapter where response was shown to be one of two inputs to the error detector. Response told the error detector what the existing conditions of the mount were—whether the mount was standing still or whether it was moving, and if so, in what direction.

Generally speaking, the devices used to transmit response fall into two categories—mechanical and electrical. Response produced electrically is usually given the name feedback, and is most extensively used to cancel out speed error signals produced locally at the gun mount. Signals thus produced are not covered in this chapter, so we will not explore electric response.

Mechanical response is transmitted by a system of shafts and gearings. It may be taken directly from the B-end motor of a hydraulic power drive, or from the d.c. drive motor of the amplidyne system.

Return to figure 8-46 and you will see response connected to the differential cam assembly. Here, you remember, an order signal caused the fork to rotate, and move the fine pilot valve in a certain direction, let's say upward. As the mount moved in accordance with the ordered signal, response was fed back to the differential cam, rotating it. Through design, response rotates the cam in such a way as to turn the fork (and move the fine pilot valve) back toward its neutral position. When the mount arrives at its ordered position, the fine pilot valve will be returned to neutral. This cancels any further error signal into the hydraulic regulating components of the power drive, and the mount comes to a halt.

Another example of response is shown in figure 8-49A. Here it is geared to the rotor of the control transformer. In this case, when the mount arrives at its order position the CT rotor has been turned so that it is 90° from the order signal. The error has been satisfied, and there is no further output from the rotor windings. The control windings of the amplidyne generator balance once again, and the drive motor at the mount stops.

SAFETY

Today's naval ordnance and the science of gunnery have become so bulky and complicated that safety has become a major subject. Automatic functions of gun, rocket, and missile system power drives make repair and adjustments a hazard unless the Gunner's Mate's emphasis is placed on safety around machinery.

Most of the safety warnings and precautions that you come across in the course of your work are the result of accidents which caused death or injury due to carelessness. Safety around ordnance machinery is based on common sense which prevents accidents. Safety means to keep alert; know what you are doing at all times. When working around ordnance machinery, develop good safety habits.

When listing safety precautions, it is difficult to cover every possible situation that may arise and which, if improperly handled, may produce serious results. However, if a thorough understanding of the basic ideas behind safety precautions can be developed, unsafe conditions can be recognized and corrected and further action can be taken instinctively when the unexpected occurs.

Safety is the responsibility of everyone. Safety precautions, rules, and regulations should be made the subject of frequent instructions. In this way, safety will become an integral part of each individual's working habits.

The key to safety, when performing maintenance, testing or operating ordnance equipment, is the awareness of danger and the knowledge of how to avoid it.

Listed below are a few of the safety precautions concerned with the maintenance and operation of hydraulic equipment. Additional safety precautions may be found in the pertinent technical manuals and OPs for the equipment.

If clothing becomes drenched with hydraulic fluid, immediately change into dry clothing because hydraulic fluid is injurious to health when in prolonged contact with skin. It is also a fire hazard. Immediately wipe up all spilled fluid.

Shut down system before undertaking any repairs. Release fluid pressure before disconnecting any pressure line. Release gaseous nitrogen and hydraulic fluid pressure before disconnecting an accumulator.

If work must be performed in an area where the activation of the gun system will cause personal danger in a power-on condition, station a safety man at each central station, establish phone communication with the safety man, and use extreme caution.

When working in a power-off condition, do not start gun system until communications have been established between the safety observer and the mount supervisors.

Do not allow unqualified or unauthorized personnel to operate the control panels. Trainees or other persons undergoing instruction shall operate only under the strict personal supervision of a qualified and responsible operator.

Whenever any motion of a power drive unit is capable of inflicting injury to personnel or material, not continuously visible to the person controlling such motion, the officer or petty officer authorizing the unit to be moved by power shall ensure a safety watch. The safety watch shall be omitted in general quarters, but must be maintained in areas where such injury is possible, both inside and outside the unit being moved. There shall be telephone or other effective voice communication established and maintained between the station controlling the unit and the safety watch.

Safety practices in maintenance and repair of ordnance gear involve not only the gear itself, but the tools with which you perform the repair and maintenance work.

Never lay hand tools on top of running machinery where vibration can cause the tools to fall into exposed working areas.

Avoid performing maintenance operations around running machinery, hydraulic systems which are under full pressure, or energized electrical equipment unless it is absolutely necessary.

Safety precautions must be taken when performing maintenance, testing, and operating ordnance hydraulic or pneumatic equipment. High pressure liquid and air can cause major injuries to your face, hands, and other parts of the body by jets of air or liquids escaping from valves or pipe connections which are highly pressurized.

When working with high pressure systems, always bleed off air and hydraulic pressures before working on any ordnance equipment.

All hydraulic leaks should be reported immediately and corrected at the first opportunity. A small leak in a high-pressure system appears as a fine spray or mist which, in some fluids, could be ignited by a spark, thereby causing an explosion.

Hydraulic systems operate under hydraulic pressures ranging from approximately 100 psi to 2000 psi. If the above safety rules are not observed, these pressures could present hazards to personnel.

When working around rotating machinery, remember the following safety precautions:

1. Never wear loose clothing.
2. Never remove a guard or cover from running machinery.
3. Never operate mechanical or powered equipment unless you are thoroughly familiar with its control and functions.
4. Be sure all personnel are clear of moving parts before starting or operating power equipment.
5. Never try to clear jammed machinery without first cutting off all power to the equipment.

Remember, safety is a state of mind.

CHAPTER 9

GUN MOUNTS

This chapter is devoted primarily to those significant features of modern gun mounts that are responsible for making them the effective weapons they are today. Each feature will be discussed in a simplified form, with enough detail regarding its application to facilitate the readers understanding of operating principles when he encounters them in actual gun mounts aboard ship. This chapter explains how the major assemblies and subassemblies make up a gun mount.

A gun mount is defined as the supporting structure assembly and operating device for one or several guns. The mounts may be open or enclosed in a shield. Each mount is assembled as a unit by the manufacturer, then hoisted onboard ship and bolted in place.

Modern guns mounts have been effectively developed to meet the threat of all types of targets and comprise an entire system of gun supporting parts which enable them to rapidly load, position, and fire their projectiles with such speed and accuracy that they have become the backbone of the United States Navy's support forces in all wars since the early 1900's.

GUN MOUNT COMPONENTS

Depending upon size and function of gun mounts, their subassemblies will vary, but the basic components are common to all gun mounts 40mm and larger. We can break down their main assemblies into the following components.

1. Barrel,
2. Housing,
3. Slide,
4. Carriage,
5. Stand,
6. Breech assembly, and
7. Gas ejection system.

BARREL

The term "gun" actually designates only the gun tube, or barrel, but is commonly used to refer to the entire mount assembly of which the barrel is only a part. A gun is essentially a tube closed at one end, from which the projectile is fired and given its initial direction. A modern gun barrel is a thick-walled, metal tube which houses a propellant charge and projectile in its breech end. When the gun is loaded and then fired, it issues the projectile from its muzzle end.

The features of a gun barrel are shown in figure 9-1 for both case and bag guns.

At the rear or breech end of the gun barrel is a breech housing, which houses the breechblock or plug; this can be opened for loading and closed for firing by a breech mechanism. The purpose of the breechblock or plug is to seal off or block the after end of the gun chamber.

The chamber is the thickest part of a gun barrel. The gas pressure caused by the burning propellant is at its maximum within the chamber, therefore, this section has to withstand the initial high pressure of the propellant's exceedingly high burning rate. The purpose of the chamber is to house the propelling charge when the gun is ready to fire.

The bore is that part of a gun barrel which provides a path for the projectile to travel and is rifled to provide projectile spin for greater accuracy.

Rifling is that part of the bore's inner surface, made up of spiral grooves, that impart rotation to the projectile. It also seals off the forward end of the chamber at the origin of rifling and prevents the burning propellant gases from escaping out through the muzzle end. The origin of rifling is just forward of the chamber and is approximately the same location as the forcing cone.

The forcing cone, (fig. 9-2), is where the rotating band of the projectile is forced into the rifling when the projectile is loaded. Since rifling serves an important function, we will explain it in more detail.

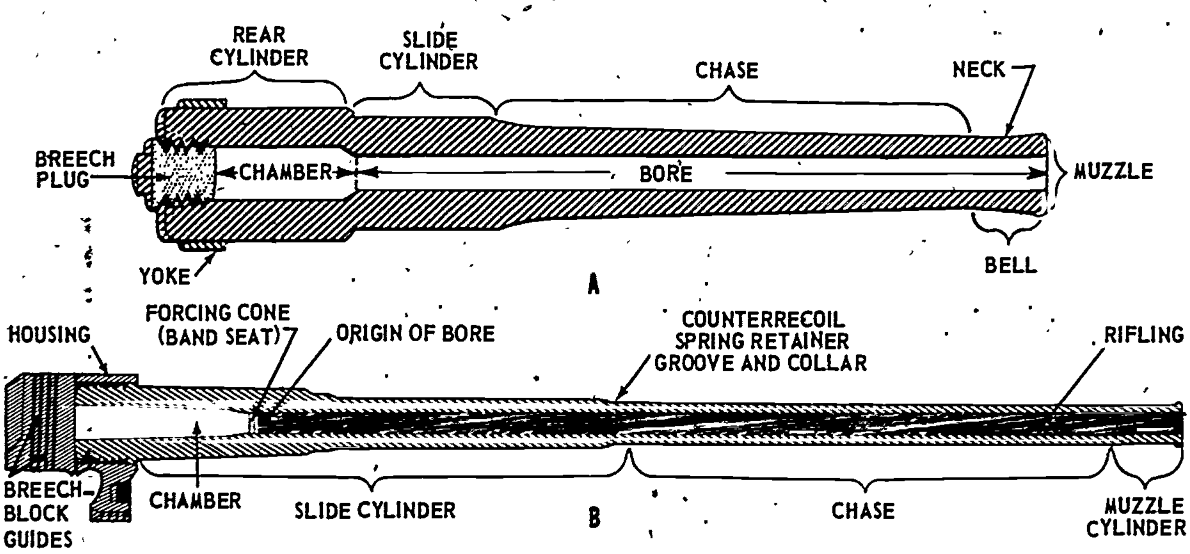


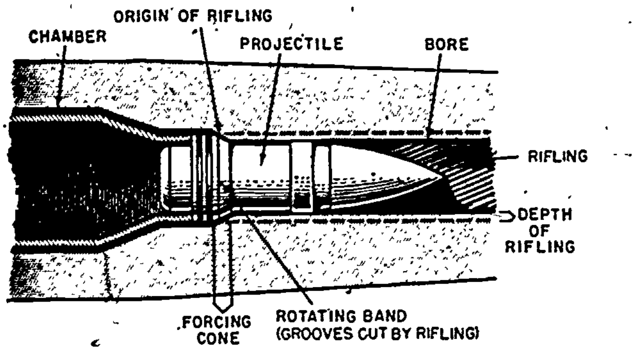
Figure 9-1.—Gun barrels: A. Cross section of modern NAVY bag gun. B. Cross section of 3"/50 (case ammunition, fixed).

Rifling

Early Navy guns were capable of hurling a projectile a considerable distance but their fire was so inaccurate at long ranges that the gun's capability for a target hit was reasonably certain only at point-blank ranges of 80 to 100 yards. Early experiments with ordnance showed that, ballistically, a round ball was the least efficient shape for use as a projectile. To improve range and accuracy, larger round shot were used with the understanding that wind and air resistance would be less in massive round shot than lighter ones, thus increasing both range and accuracy. Since the smooth-bore cannons were capable of firing only round shot, it was difficult to make a projectile more massive. This was due in part to the size of the cannon having to be increased as the round shot's size was increased. A massive cannon would have to be used to withstand the powder pressures if the size of shot were increased too much. This would make the cannon unwieldy and near impossible to handle. To increase the weight of shot, they were elongated rather than round. Experiments proved, however, that unless the projectile could be made to spin around its long axis, it would tumble erractically end-over-end and would be harder to control than the smaller spherical, round ball shot. This type of projectile has the ballistics of a brick.

Accuracy and longer ranges of modern guns have been improved by adding rifling, and by elongating gun projectiles. If you have ever watched a football game, you have seen how the shape of the football cuts down both wind and air resistance due to its pointed ends. The player who throws the football improves his accuracy by making the ball spin; that is what rifling does to a projectile.

Rifling is a set of spiral or helical grooves, machined into the bore of the gun, (figs. 9-3 and 9-4). In most types of larger guns, the rifling is cut into a liner; fig. 9-3 shows the rifling cut into the liner of an 8-inch turret of recent design. The purpose of using a liner is to prevent replacing the entire gun barrel when the rifling is worn down to a point that it affects the initial velocity of the projectile. Each round fired through the gun causes erosion (wear in the gun bore). The major result of wear of the rifling is the loss of pressure applied by the burning propellant as it forces the projectile through the bore. You learned earlier that the projectile's rotating band prevents the propellant gases from escaping out through the muzzle end of the barrel. Since each projectile is forced into the gun's rifling at the origin of rifling, this is the area of the barrel that receives the most wear. When the erosion becomes too great, the gun liner has to be replaced. The



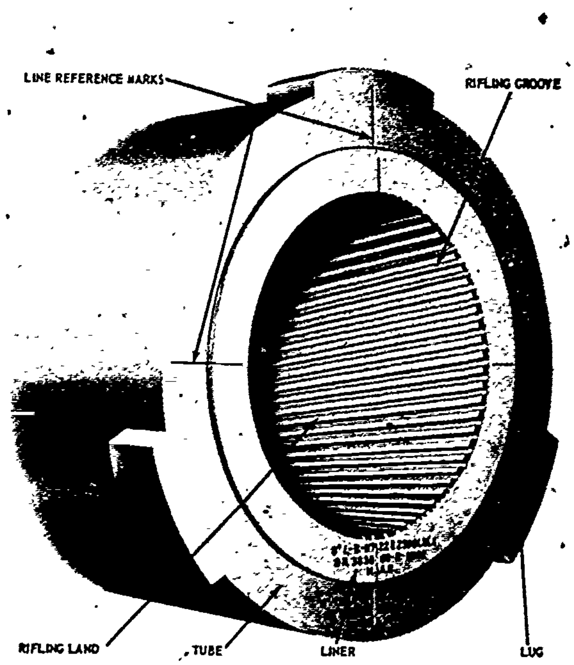
84.235(110A)
Figure 9-2.—Cross section of gun chamber.

fire control technicians can compensate for erosion by making initial velocity correction to their computers, but only up to a certain point, after which a new barrel or liner must be installed. New liners (fig. 9-3) are forced into the gun tube and keyed into place. The liner can be jacked out of the gun tube by means of jacking lugs, which serve to anchor a jack when replacing a liner (fig. 9-3). The type of rifling shown in figure 9-4 is machined into the gun bore and, when worn, the entire gun barrel must be replaced.

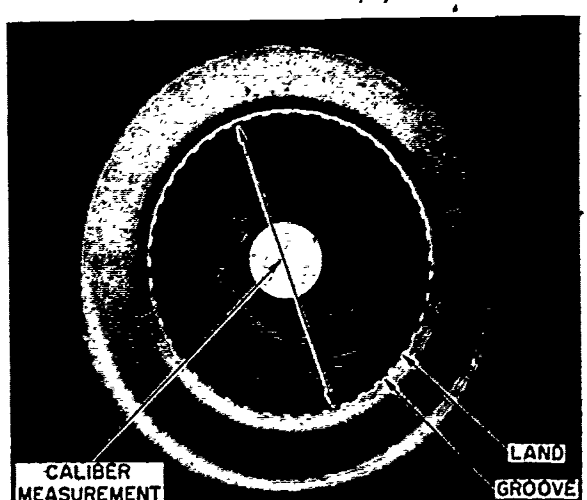
In figure 9-5 you can see how the spiral grooves engage the copper rotating band secured to the body of the projectile and twist it as it moves through the barrel. By the time the projectile has left the muzzle (fig. 9-6), it is spinning at a great speed. In some guns it rotates about 40,000 revolutions per minute.

In figure 9-4 the rifling is shown viewed from the muzzle end of a barrel. The raised portions of the rifling, between the grooves, are called lands (fig. 9-7). In nearly all naval guns the rifling has a uniform right-hand twist. The projectile is turned clockwise, as viewed from aft (fig. 9-6) as it travels through the gun bore. You can also see how the rotating band is deeply engraved by the rifling as the projectile leaves the gun barrel. The rifling of modern guns is chrome plated for longer service life.

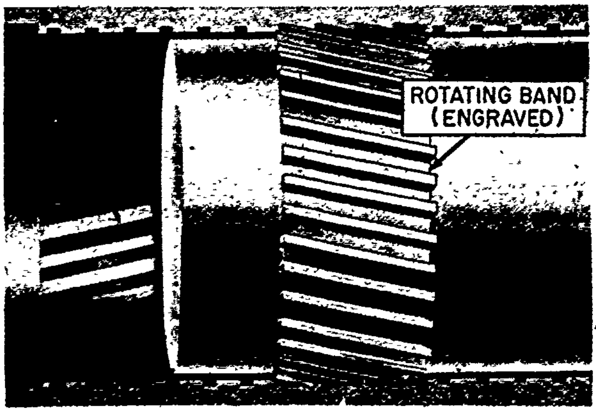
The bore diameter or caliber of a rifled gun is measured from the top of one land (the high surface between grooves) to that on the opposite side of the bore (figs. 9-4 and 9-7). The diameter of a gun's bore is also used to express the length of the gun's bore. For example, the term 16 inch 50 means that the diameter of the bore is



84.136
Figure 9-3.—Muzzle end of an 8-inch gun, showing liner with rifling, matching reference marks, and jack lugs.



84.143.1
Figure 9-4.—Rifled bore (viewed head-on).



84.143.2

Figure 9-5.—The rifling engraves the rotating band.

16 inches and the length of the gun's bore is 50 calibers long; the actual length of the gun barrel bore is (16 x 50) or 800 inches.

Exterior Sections

The other features of a gun barrel are classified as the exterior sections, as shown in figure 9-1. Starting at the muzzle end we have the bell, which is the thick part of the muzzle. It discourages any tendency for the metal to split. Many guns do not have this feature, but have lugs as shown in figure 9-3. The next section is the neck, which is the thinnest part of the gun barrel (fig. 9-1).

Next, we have the gun chase, which is the outer section between the slide cylinder and the muzzle bell. The slide cylinder is that part of the gun barrel which moves within the slide during recoil. The rear cylinder surrounds the chamber in some type guns. The yoke is the chief support of recoiling parts. A gun housing is equivalent to the yoke and houses the breech mechanism on case guns (fig. 9-1).

HOUSING

The housing moves in recoil and counterrecoil on the bearing surfaces in the slide. The barrel is locked into the housing (fig. 9-8) by a bayonet joint and a locking key. The housing has the breechblock guideways for sliding wedge type breechblocks to work in. The housing also contains half of the recoil system. In the 5"/38, two recoil cylinders are machined into the housing. These cylinders ride back and forth over stationary pistons, buffing the rearward movement of the gun when it fires. In the 3"/50 RF the housing is attached to the piston and moves it forward and aft in a stationary cylinder to buff recoil.

The housing (and barrel) are IN BATTERY when they are in their full forward position. In most cases a mark is painted on the housing to line up with a similar mark on the slide when the gun is in battery. This is a safety feature; it is checked by some member of the gun crew to prevent firing when the gun is not in its full forward position.

SLIDE

The slide doesn't slide, but is fitted with bearing surfaces which support and guide the sliding (recoiling) barrel and housing. The gun is elevated and depressed by elevation gearing (fig. 9-9B). This gearing is connected to the slide by a pinion which meshes with an elevating arc. The elevating arc is a segment of a large external spur gear, and is solidly bolted to the slide.

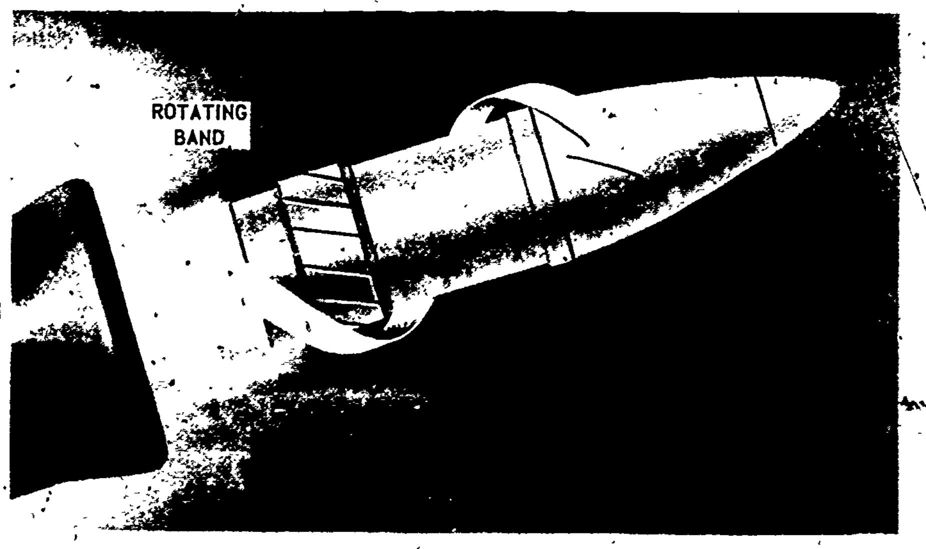
The slide comes in many shapes and sizes; but it can always be recognized because the trunnions are a part of it, and it carries the recoiling parts of the gun. Figure 9-9 shows some features of the slide.

CARRIAGE ASSEMBLY

The carriage generally consists of two main parts; the base ring, and the gun carriage itself. The base ring, a large rectangular weldment with a circular deep section ring at the bottom, rides on the horizontal roller bearings in the stand. Horizontal bearings (fig. 9-10) support the weight of the carriage, and will take up any thrust during firing. Vertical bearings are used to carry any radial load caused by the roll and pitch of the ship, and the horizontal thrust of firing.

Holding-down clips (fig. 9-11) are bolted to the base ring and hook under the training circle. There is enough clearance to permit the mount to train freely. But the clips will prevent the mount from bucking upward during firing, or while in heavy seas.

The carriage, which carries the gun proper, is bolted to the base ring. Basically the carriage consists of a pair of massive brackets (called cheeks) firmly braced together. The carriage



84.143.3

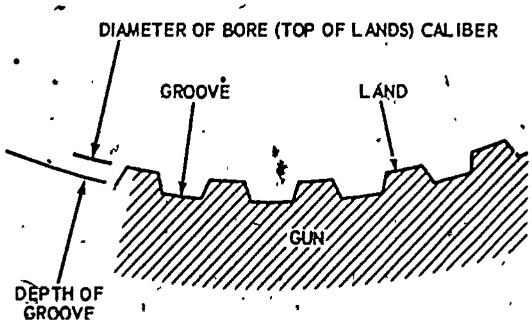
Figure 9-6.—Rotational velocity is imparted by rifling.

cheeks are machined and fitted to hold the trunnion bearings. The trunnions (machined onto the slide) work in these bearings, making it possible to elevate and depress the gun (fig. 9-12).

STAND

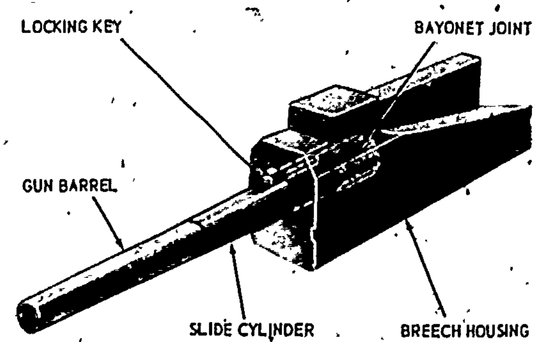
The stand (fig. 9-13) is that part of the gun mount which is firmly secured to the ship's deck. It carries the weight of the entire mount. Bolted to the stand is the training circle, a large internal spur gear. A large pinion gear in the train gearing meshes with the training circle. When this pinion is rotated (by either a power drive or handwheels), the pinion walks around the training circle, turning the mount.

To reduce friction between the trainable portion of the gun mount and the stand, several sets of bearings are used. As you remember from your study of bearings with rolling contact (chapter 6), these bearings require two roller paths (races). The gun mount stand contains the stationary races; the carriage provides the moving ones.



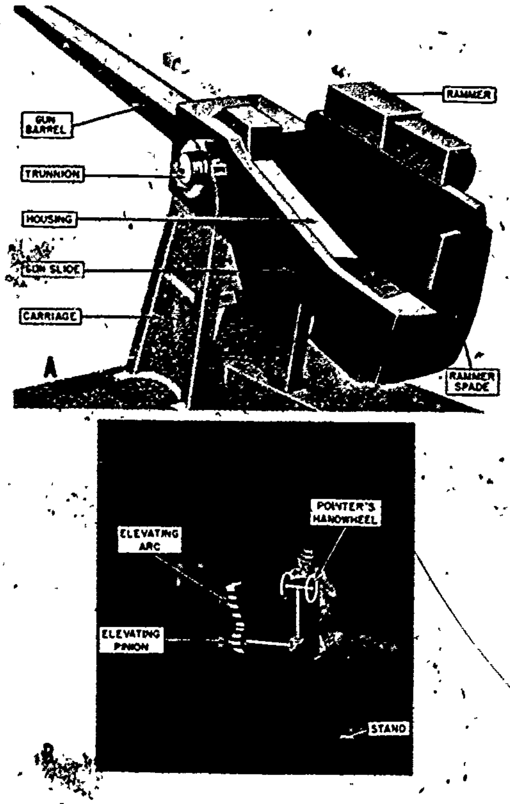
84.143.4

Figure 9-7.—Details of gun rifling.



84.140

Figure 9-8.—The barrel is fastened in the housing with a bayonet joint and locking key.

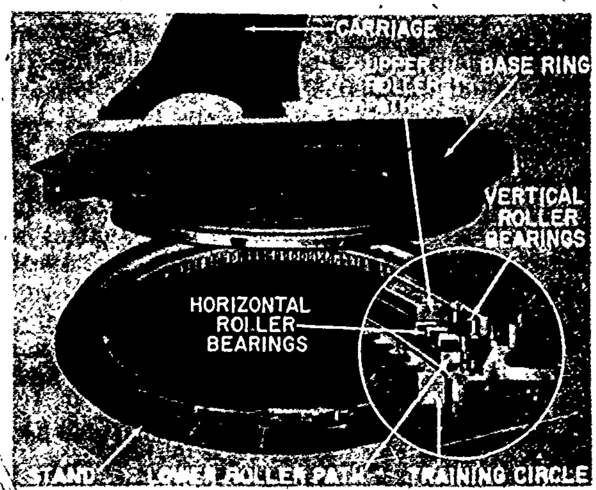


84.153
Figure 9-9. — The slide. A. Main features. B. Principle of elevating mechanism.

In figure 9-14 the main assemblies are illustrated to reveal what might be called the skeleton of a gun mount. They are stripped away from each other to show how the main assemblies of a gun mount fit together to form a complete major unit.

BREECH MECHANISMS

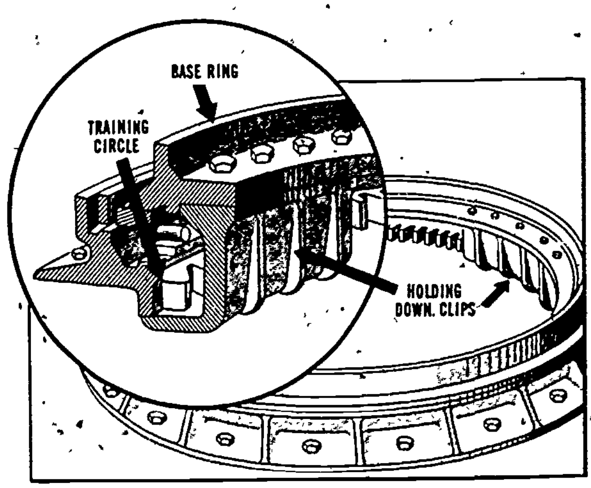
The breech mechanism used with gun mounts is classified as a vertical sliding wedge breech block. Guns whose propelling charges are contained in metal cases use this type of breech mechanism, which functions not only to seal off the after end of the gun chamber but also to extract the fired metal case from the gun chamber during the guns counterrecoil cycle. Sliding wedge breech blocks can be operated either mechanically or hydraulically and differ only in their design. They all serve the same purpose. The operation of breech mechanisms will be discussed in another chapter.



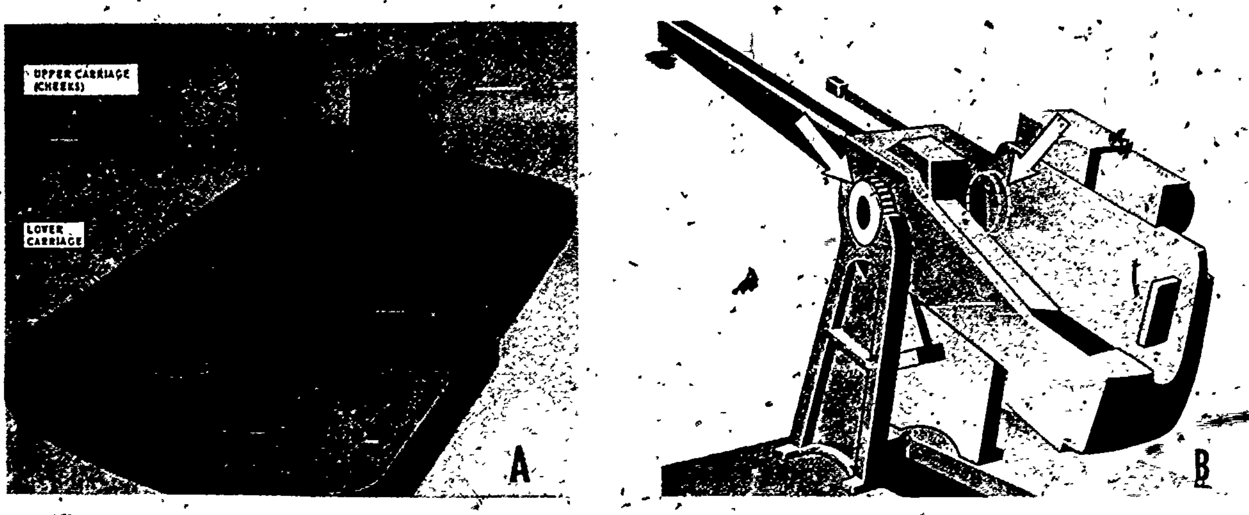
84.138
Figure 9-10. — Vertical (radial) and horizontal roller bearings carry the loads and thrust.

GAS EJECTION FUNCTIONS

The gas ejection system is used to expel residual gases from the gun bore after firing, thereby lessening the danger of a flareback. When a gun fires, not all of the propellant may be completely burned; there is often an inflammable



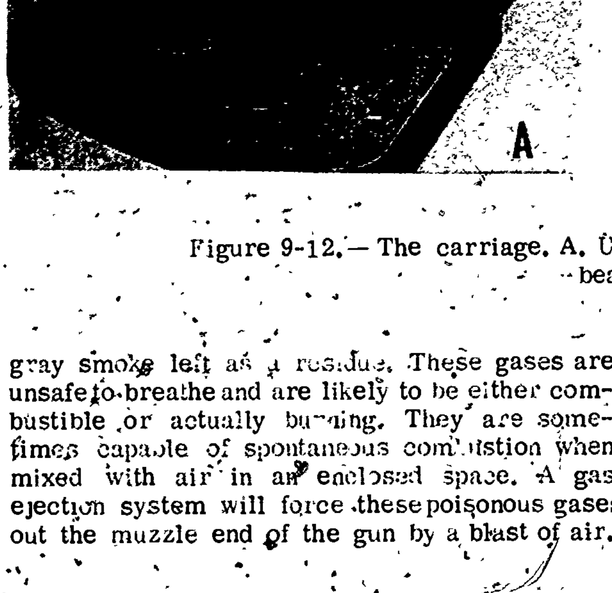
84.139
Figure 9-11. — Holding-down clips permit rotation but prevent separation.



110.48

Figure 9-12.—The carriage. A. Upper and lower carriage. B. Trunnion bearings.

gray smoke left as a residue. These gases are unsafe to breathe and are likely to be either combustible or actually burning. They are sometimes capable of spontaneous combustion when mixed with air in an enclosed space. A gas ejection system will force these poisonous gases out the muzzle end of the gun by a blast of air.



84.152

Figure 9-13.—Details of the stand.

All enclosed gun mounts and turrets have some type of gas ejection system.

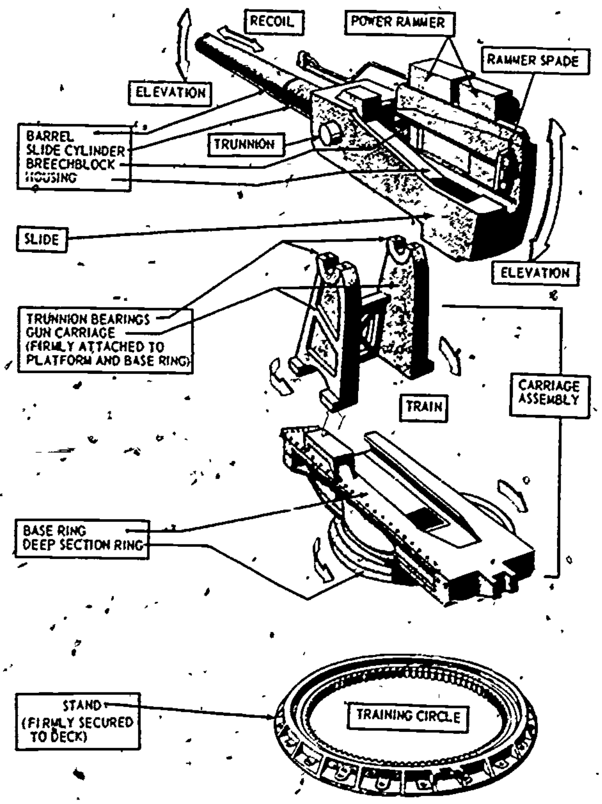
GAS EJECTION SYSTEM

Fundamentally the gas ejector is a system of piping that connects several ports or nozzles in and around the breech. Air for the system is supplied from the ship's compressed air supply. In the gas ejector illustrated in figure 9-15, the nozzles are located right behind the breechblock, so that the blast is directed up the gun bore.

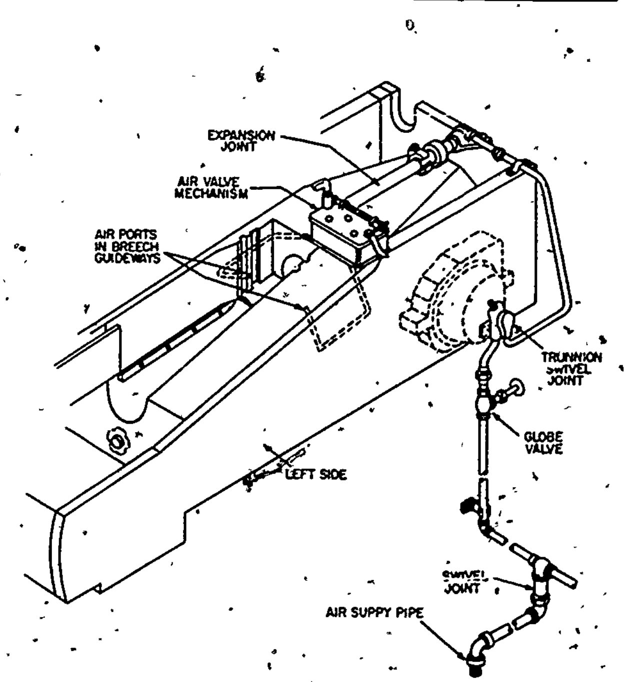
The air valves of all gas ejector systems open automatically during the firing cycle. The method for closing them varies according to the gun. The 5"/54 Mk 42 closes automatically between each round. The 5"/38 system shuts off as the projectileman rams a new charge into the breech. Gas ejection air is shut off by hand in turret guns.

Gas ejector systems operate at 55 to 200 psi, depending upon the particular installation. The air comes from the ship's air compressor (low or medium pressure). Sometimes a ship's high pressure system (over 1000 psi) is connected through reducers to gas ejection piping for emergency use.

Let's trace the gas ejector system a little further back. Air is fed to the air valve by an expansion joint, which consists of two pipes fitting one within the other and equipped with packing so that the air cannot leak out. The inner



84.137
Figure 9-14. – Main assemblies of 5"/38 dual-purpose gun.



84.146
Figure 9-15. — Gas ejection system (5"/38).

pipe can move with respect to the outer as the gun moves in recoil and counterrecoil. Thus air can go through the system even while counterrecoil is taking place.

Naturally, the gas ejection system must operate effectively at all angles of elevation and train. To make this possible, the air is led in through swivel joints, which permit one section of pipe to rotate with respect to the other without permitting air leakage. If the air line comes up from the ship's supply, through the center or base of the mount, a swivel joint there will permit movement in train. At the trunnion, about which the gun moves in elevation and depresses, is another swivel joint, which permits free passage of air in the line to the gun breech and allows free movement of the gun.

On older mounts and turrets you'll often find flexible hose connections for hooking up to a standby air line in an emergency.

One more thing about gas ejectors. They are intended to help prevent flarebacks but, especially in bag guns, they are not automatic insurance against either foul bores or flarebacks. After firing a shot, every bore is a foul bore. All the gas ejector can do is remove dangerous gases faster than they would dissipate of themselves.

CLASSIFICATION OF MOUNTS

There are many ways to classify gun mounts. Depending upon whether or not they have shields to protect the gun and crew from the weather and splinters, mounts are called either open or enclosed. Depending upon how many guns (barrels) a mount has, it can be single, twin, or quad, and so on. For the purpose of this text however, gun mounts will be classed as to: Battery, Caliber, and Function.

BY BATTERY

For some time Navy gun mounts were classed by batteries using the terms main, secondary, and antiaircraft. There is not firm law laid down for dividing gun mounts into these classes. That is, a gun such as a 5"/38 would likely be part of the antiaircraft battery on a cruiser, but on a destroyer it would be considered part of the ship's main battery. The classification of gun mounts according to this plan varies from one type ship to another, and is a matter of local option. Generally speaking, the main battery would be the ship's primary fighting weapons with consideration given to the punch that the weapons deliver, and their range. Secondary batteries would be the ship's second string of ordnance. Usually these guns are of shorter range than the main battery, but have a better rate of fire. The antiaircraft batteries will be made up solely of guns designed to be fired against aircraft.

A system which eliminates much of this overlapping of classification is now being used in several official publications. Gun mounts under this system divide guns into the following three classifications.

SURFACE BATTERY.—These weapons are designed to be used against surface or shore targets only.

DUAL PURPOSE BATTERY.—These weapons are designed to be used against both surface (or shore) and aircraft targets. Also, the fire control system with which they are normally associated is equipped to handle both surface and AA problems—for example, 5" guns.

MACHINEGUN BATTERY.—Guns belonging to this classification are primarily antiaircraft weapons. In emergency, of course, they could be used against any target, but their associated fire control equipment can compute accurately for AA targets only.

BY CALIBER.

Guns are often classified by the caliber of their bore. The names of the classes are major, intermediate, and minor.

Major caliber guns are those of 8-inch and larger.

Intermediate caliber guns are those under 8-inches and above 3-inches in caliber. At present this class includes all 5-inch guns and the 6-inch guns in turrets.

Minor caliber guns are those 3-inch and below (not including small arms).

BY FUNCTION

Guns are classed as to function (type of fire) as:

Single fire, where the breech mechanism is always opened and closed by hand.

Semiautomatic, which use the force of explosion to open the breech, eject the cartridge case, and cock the firing mechanism. Loading, however, requires a member of the gun crew to place a round in the breech or tray. The 5"/38 and 6"/47 case guns are examples of semiautomatic guns.

Automatic, which use the force of the explosion to perform all loading and reloading operations. 40-mm's are automatic guns.

Rapid fire (RF), which use power-operated equipment to automatically load rounds into the breech as long as the electrical loading circuits are closed. 3"/50, 5"/54 MK 45 and Mk 42, and 8"/55 case guns are examples of rapid fire guns.

FEATURES OF GUN MOUNTS

There are several distinctive features that are found in all modern gun mounts which will vary according to the gun mount's functions. These varying features apply to the types and characteristics of their sub-systems. We have discussed the gun mount's main assemblies. We will now show the difference between the gun mounts most likely to be found aboard combat ships in today's Navy. Though gun mounts differ in varying forms, they all have the following modern characteristics:

1. Electrical firing;
2. Ammunition feed systems, power rammers, power hoists;
3. Hydraulically controlled recoil and counterrecoil systems;
4. Training and elevating power drives;
5. Remote control; and
6. Sighting equipment.

The gun mounts to be discussed are the: 3"/50 RF, 5"/38 DP, and 5"/54 RF.

3"/50 RF GUN MOUNT

The 3"/50 rapid-fire guns are semiautomatic guns with automatic power-driven loaders, installed in open or enclosed twin or single mounts. They are primarily intended for air defense, but can be used against surface targets. They were planned during World War II when a need developed for a rapid-fire gun with a larger explosive projectile that could stop suicide planes or dive bombers. The 3"/50 mount was not completed in time to be used in combat in World War II, but it has since proved itself very effective and, since World War II, has virtually displaced its predecessors—40mm twin and quadruple mounts—on combat vessels. It is generally used with relative-rate fire control systems.

The 3"/50 rapid-fire mounts now operational in the fleet are the outwardly identical twin Mk 27 and Mods and Mk 33 and mods, and the single Mk 34. All use the same gun and similar loading mechanisms (except that in the twin mount the assemblies are of opposite hand). The two marks of twins are similar in nearly all details except the slide (fig. 9-16).

Two mods of the Mk 33 are enclosed twin mounts with aluminum shield. The other mods are twins with modifications for installation of a fire control radar antenna, or for substitution of aluminum platforms instead of steel. The Mk 34 mount is an open single, similar in controls and equipment to the twin, with a right-hand slide and loader assembly.

CONSTRUCTION

The barrel of the 3"/50 gun is a one-piece, rifled, chambered tube, with breech end locked to the housing by a bayonet type joint. The housing contains the vertical sliding-wedge breech mechanism. The slide supports the recoiling parts (gun barrel and housing) on bearings. Recoil and counterrecoil movement are controlled by a hydraulic recoil cylinder and a large counterrecoil spring surrounding the barrel.

The slide, gun, and housing are supported by the carriage. The slide trunnions rest in roller bearings at the top of the carriage. The elevating arc on the slide meshes with the elevating pinion of the mount elevation power drive system. The stand is a deck-flange, base-ring design which includes the training circle and the stationary roller path. In train, the mount is driven by a power motor which rotates the training pinion.

AUTOMATIC LOADER

In many features of design, the 3"/50 rapid-fire gun differs markedly from other gun mounts. The main distinguishing feature is the automatic loader.

The loader is an independent, electric power-driven machine mounted on the after part of the slide. It mechanically loads each gun at the rate of 45 rounds per minute as long as ammunition is served, as shown in figure 9-17, and the firing circuit is closed.

The major loader components that will be discussed are the —

1. Loader drive unit,
2. Hopper,
3. Transfer tray and shell carriage,
4. Control system,
5. Left side plate, and
6. Right side plate.

The loader drive unit consists of a 3-horsepower motor and various chain and gear drives. Most of the latter are located in the main housing, which is a large, square, boxlike structure mounted on top of the gun slide. The drive motor is flange-mounted to the forward face of this housing. The drive motor drives the gearing and chains which, in turn, cause all the mechanical parts of the loader to function at the proper time and in the proper sequence.

The hopper, into which the ammunition is manually fed by the two shellmen, is located directly abaft the main housing and is secured to the left and right side plates.

The heart of the hopper is the hopper feed mechanism which consists of right, center, and left shaft-and-sprocket units and right and left round-aligning attachments. The aligning attachments ensure that the ammunition is correctly loaded by the shellmen.

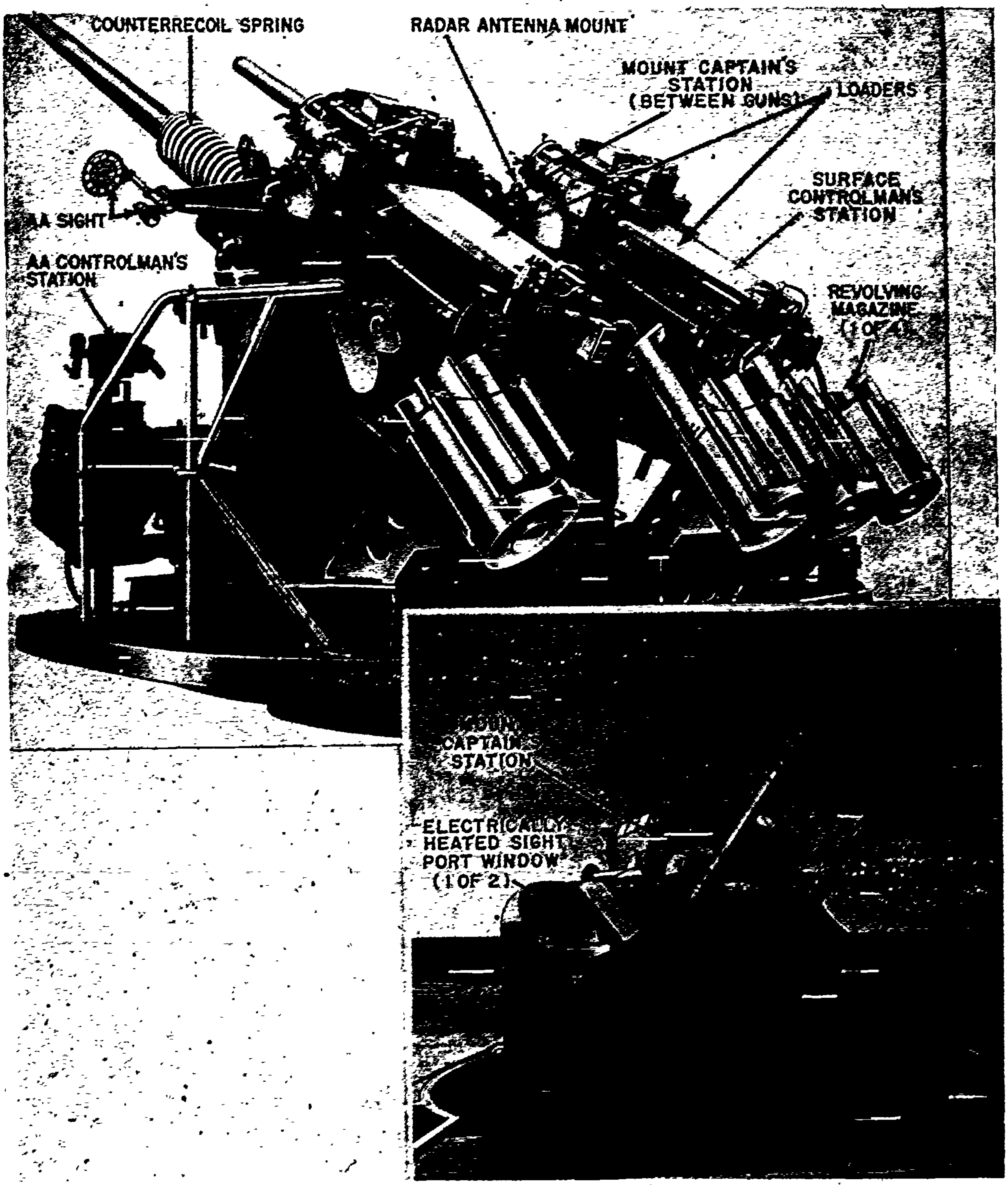
The right and left sprockets revolve intermittently in one direction to move ammunition to the center. The center sprocket revolves in alternate directions to accept rounds from right and left sprockets. (The sequence of sprocket rotation was explained in detail in chapter 6). After five rounds have been loaded, the first round will be indexed (loaded into the transfer tray for catapulting) by the center sprocket. (See figure 9-18).

The transfer tray and shell carriage unit is the loader component that moves each round of ammunition from its index position down into line with the gun bore, and catapults it into the breech chamber. (See figure 9-19). The tray is a rectangular box structure with 2 sprockets, 1 in each end of the tray, about which the endless ramming chain is looped.

The tray is supported and positioned by four arms pivoted in the right and left side plates. The two left tray arms, hence the whole tray assembly, are driven by the transfer-tray drive gears mounted in the left side plate. Drive for the rammer chain comes from concentric shafting through the left forward tray arm to the forward chain sprocket.

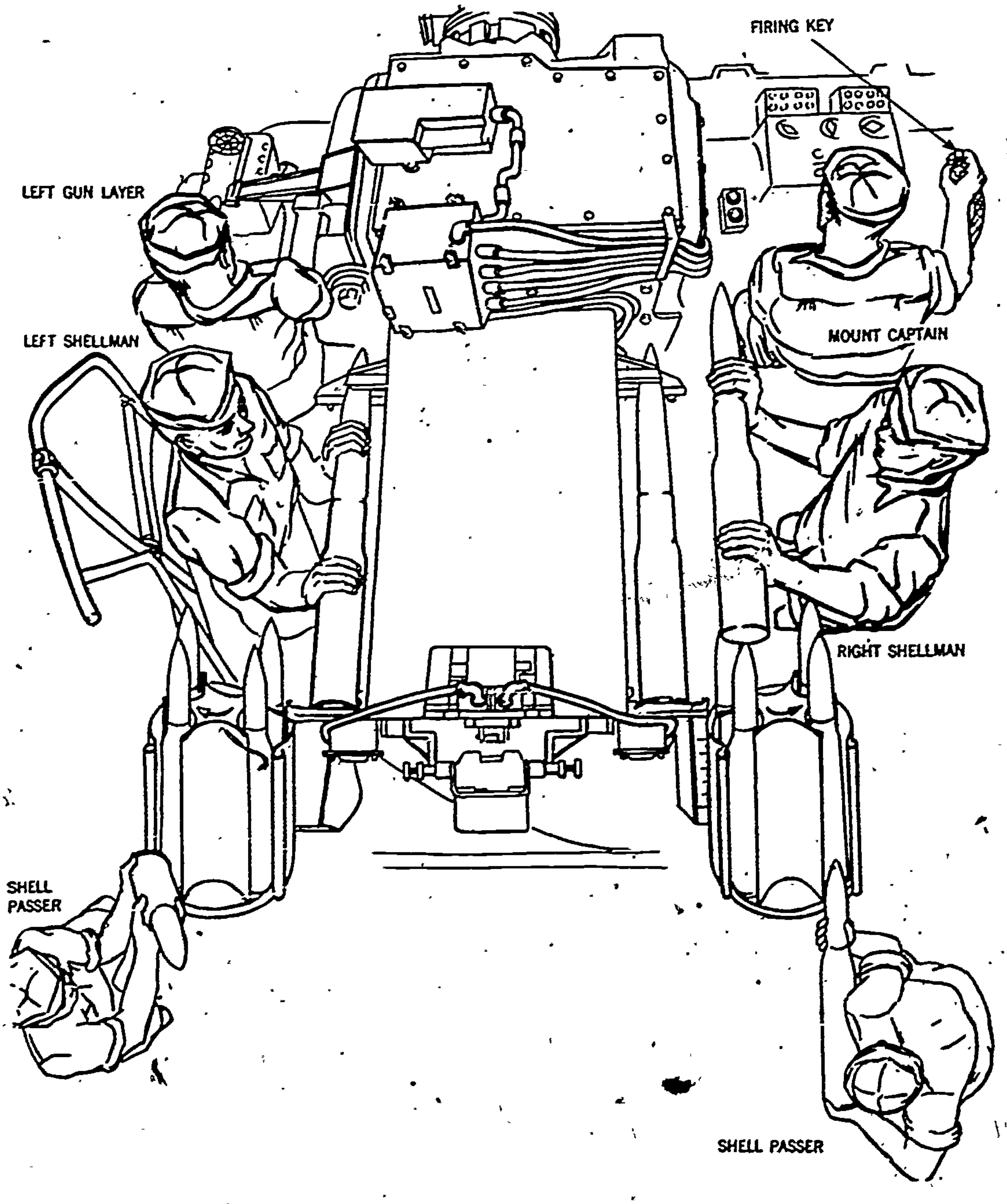
Secured to the rammer chain on the upper part of the tray is the shell carriage, a small L-shaped casting, to support, transport, and release the round on the tray during the ramming cycle. The cycle of operation of the transfer tray assembly begins when an indexed round from the hopper seats in the shell carriage. The four arms then begin to rotate about their pivots, translating the tray forward.

When the tray is almost in line with the breech opening, it begins to swing forward toward the breech. At this point the rammer chain begins



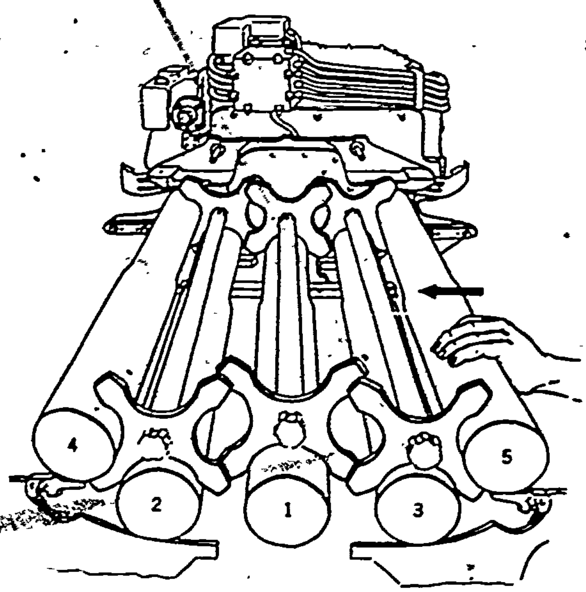
3.122

Figure 9-16.—3''/50 RF twin mount Mk 27 Mod 3. (Mk 33 is externally similar). Inset: 3''/50 twin mount Mk 33 Mod 4.



84.66

Figure 9-17.—3''/50 rapid-fire gun. Ammunition service to loader.



110.68.1
Figure 9-18. — 3"/50 rapid-fire gun. Sprockets drawing ammunition into the freed mechanism of the automatic loader.

moving the shell carriage and round rapidly forward.

When the tray is at its forwardmost point, the carriage is all the way forward, relative to the tray, and is releasing the round, which travels on into the breech as shown in figure 9-20. The tray then reverses its direction and moves aft and up to pick up another round. During this time the ramming chain moves aft to reposition the shell carriage on the tray.

The right and left side plates of the loader are similar steel forgings – roughly 4 feet long and 2 feet deep – secured to the right and left sides of the gun slide respectively. They support all the loader subassemblies except the drive gear. In addition, each includes many loader operating and control devices and elements of the breech mechanism.

The loader control system synchronizes and interlocks the components of the loader with the breech mechanism and with each other. It consists of electrical circuits, solenoids, selector switches, automatic switches, firing keys, electrical interlocks, and other items. The mount captain's control panel (described in the next section) is a combination control and indicator station for the loader control system.

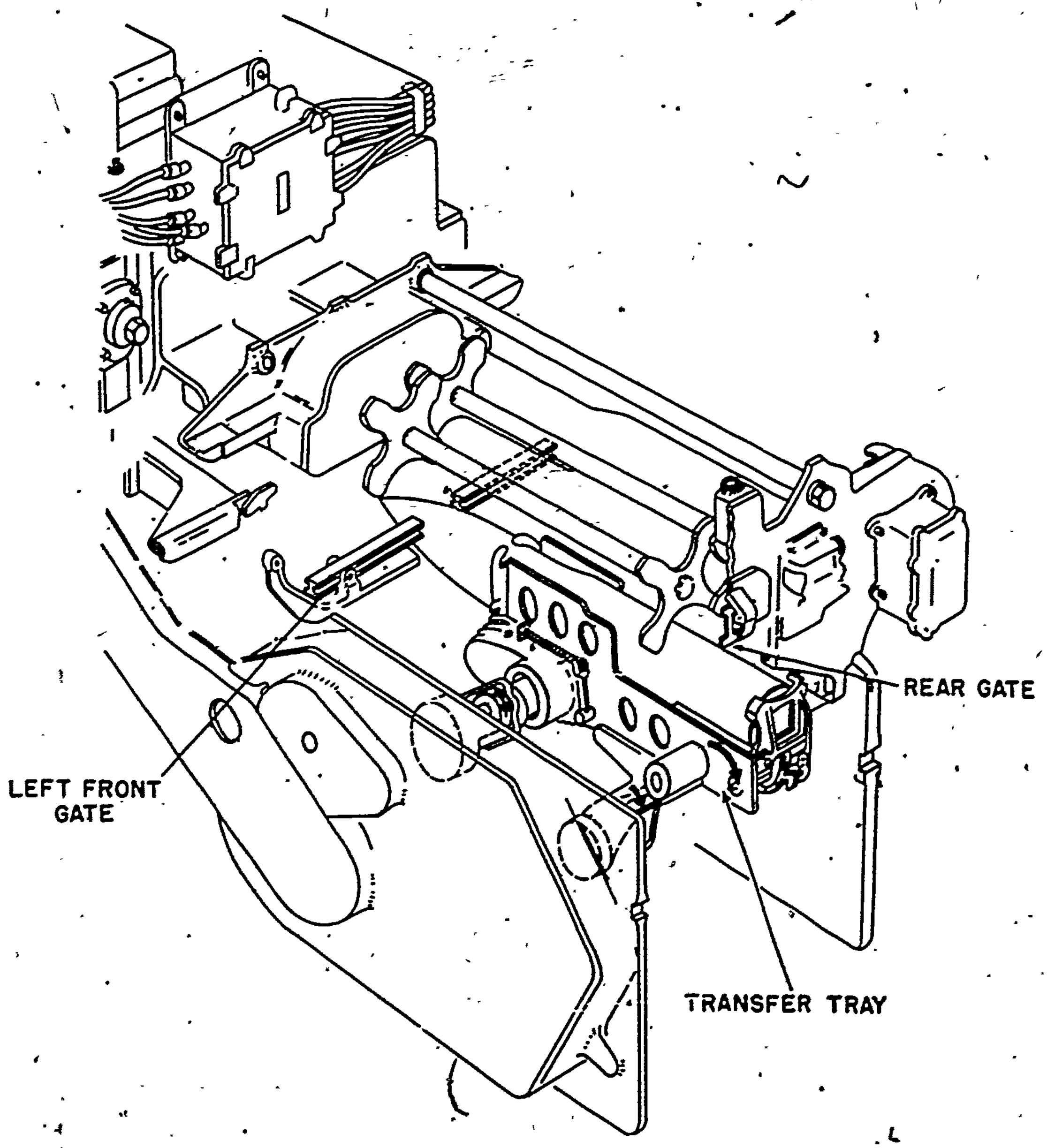
MOUNT CONTROL STATIONS

The mount's amplidyne electric power drives may be controlled in automatic from a director or in local at the mount. There is no manual control as such, only an auxiliary handcrank for securing or servicing the mount. These mounts feature a unique local control arrangement in that there are two types of local control, local AA and local surface. Each has a separate control station. Local surface is the right gun-laying station. When the gun-laying drive selection is local AA, the left gun layer controls the mount in both train and elevation, and fires the gun. The left gun layer's controls consist of a ring sight, a one-man gun-laying control unit with gun firing key in right hand grip, a fire cutout indicator, and a gun-laying emergency stop control. There is no sight-setting provision at this station.

The right gun layer is responsible for starting the elevation and train drive, selecting the control station, laying and firing the guns when the drive selection is local surface, and observing correspondence between gun position and gun order signals. The right gun layer's controls consist of a telescope and open sight, a one-man gun-laying control panel, and a train cable-twist indicator (fig. 9-21). The gun-laying control panel, for a twin mount, contains a control-station selector switch, gun-firing cutout lights, power-on lights, correspondence-indicator meters to indicate correspondence between gun and mount position and the order signal, and power start and stop buttons.

Used in conjunction with the local surface station, but requiring an additional operator, is the sightsetter station (fig. 9-22). It is located directly behind the right gun layer. The sightsetter operator receives sight-setting orders via telephone from the director or other fire control station and sets them into the sightsetter's unit by handwheel operation. This action offsets the right gun layer's sight the required amount. The sightsetter is used only with local surface gun laying.

The mount captain's station on a twin mount is located between the guns. It is to the left of the gun on a single mount. The mount captain is the supervising gunner and crew captain. His operations are directed via telephone by the control officer. He controls and directs the performance of both guns by his use of the mount captain's controls. In emergency he stops the

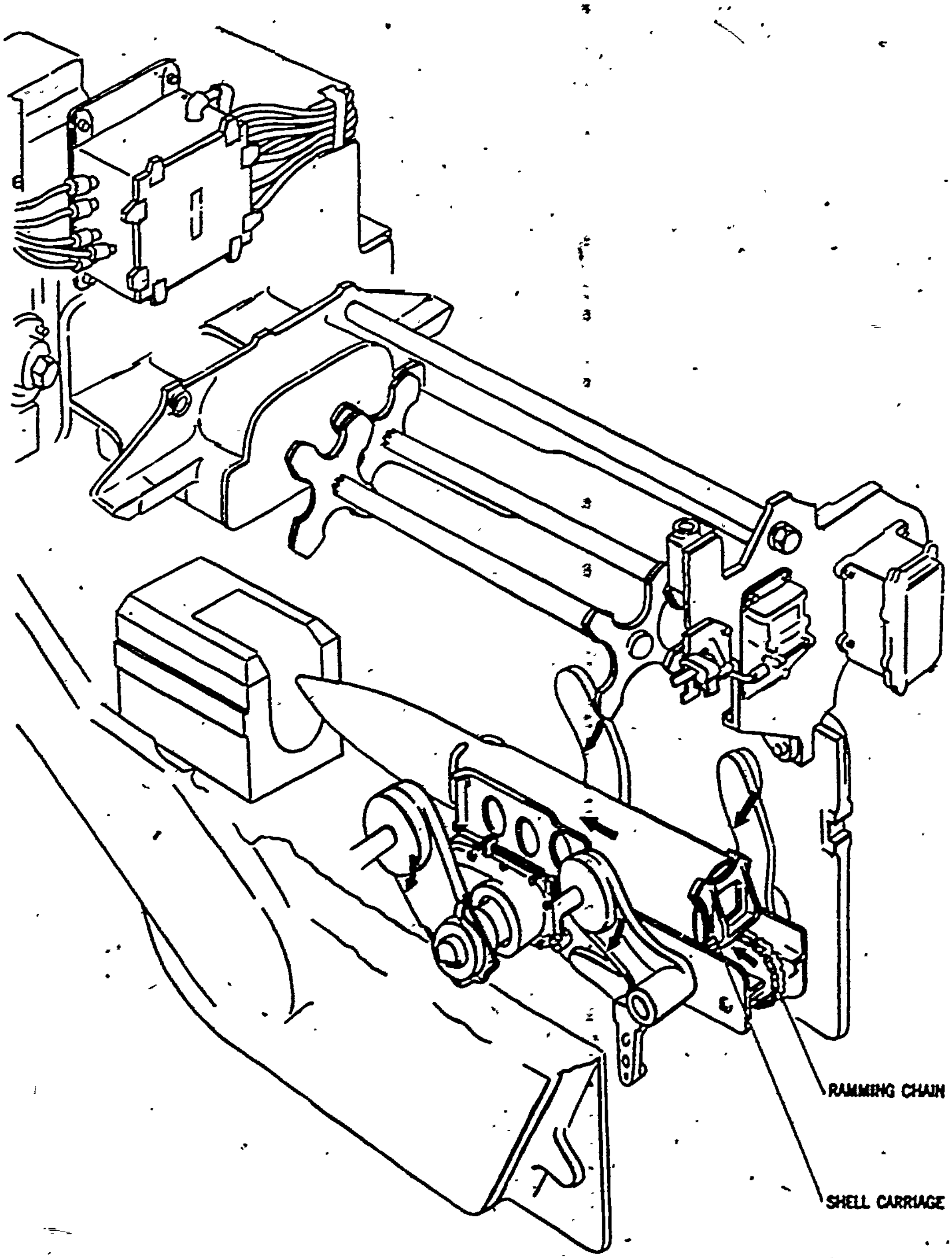


110.68.2A

Figure 9-19. — 3''/50 rapid-fire gun. Tray of automatic loader swinging down into alignment with open breech.

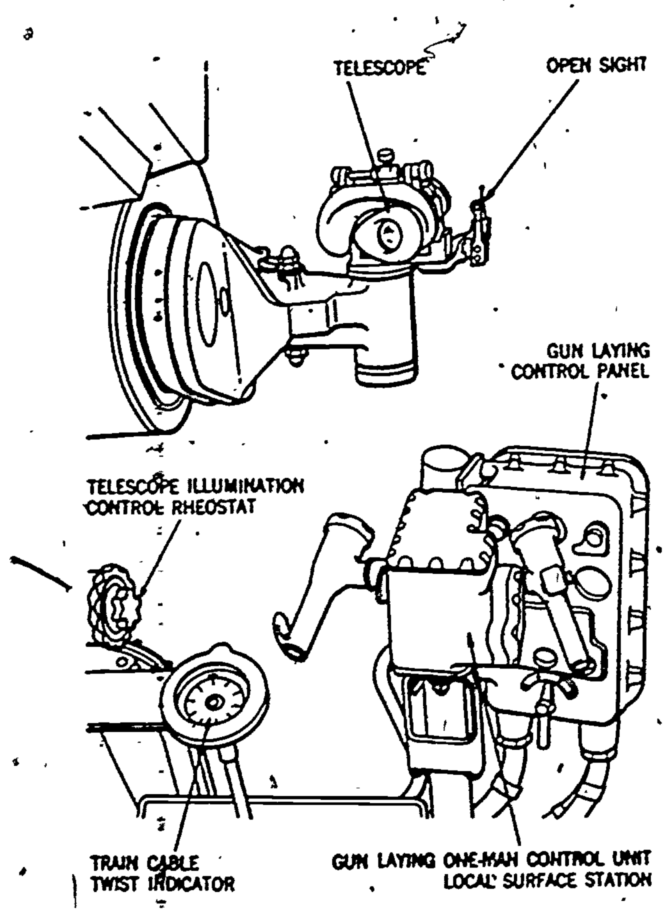
firing of either or both guns. His panel of switches allows him to select the control station, switch to single or automatic fire, and select the gun or guns to fire.

Other elements of his control panel are master pushbuttons for stopping either one or both of the loaders, power-drive emergency stop buttons, and various illuminating indicators to indicate the occurence and location of malfunctions. The gun captain's firing key must be closed before the loaders will function. The key has a latch to hold it in closed position when control of fire is to be at either left or right control station or at the director.



110.68.2A

Figure 9-20.—3"/50 rapid-fire gun. Shell carriagecatapultingcartridge into open breech.



110.69.2

Figure 9-21.—3"/50 rapid-fire gun mount. Surface controlman's station.

AMMUNITION

The 3"/50 gun fires fixed ammunition. A complete round is 34.74 inches long and weighs 24 pounds (the projectile, with fuze, weighs 13 pounds). Since neither the mound installation nor the associated fire control system includes provision for fuze setting, only VT-fuzed projectiles are used in AA fire. Base-fuzed and point-detonating fuzed projectiles for surface fire are also available.

PERSONNEL

The personnel arrangement of a 3"/50 rapid-fire twin mount is shown in figure 9-23. The normal crew is composed of 11 men, as follows: a mount captain, 2 control-station men, 4 shellmen, and 4 shell passers. (One control-station man controls the mount in local surface, the other in local AA). An additional crew member, a sightsetter, is required in local surface control. The shellmen transfer ammunition from the gun carriage racks to the right and left sides of the hopper of each gun. The shell passers keep the carriage racks, called magazines, supplied with ammunition from a ready-service locker or hand-passing scuttles leading up from the handling rooms. The handling rooms are supplied by dredger hoist from the ship's magazines. The number of passers may vary, depending upon the arrangement of ready-service lockers and passing scuttles.

5"/38 DP GUN MOUNT

The 5"/38 gun is one of the most widely used naval weapons in the fleet. It is not a new design, but its reliability and the essential soundness of its design have continued its usefulness into a day when it is far outranged by newer weapons. Many of its design features persist in the very newest gun designs in the fleet, but on the whole it can be considered the prototype of the "conventional U.S. naval gun." It is the weapon characteristically used with linear-rate fire control systems.

The 5"/38 gun appears in the following general types of mounts:

1. Enclosed twin mount with ammunition-handling room beneath the mount. This type of mount is a standard installation on many cruisers and destroyers, and some aircraft carriers (fig. 9-24).

2. Enclosed single mount with ammunition-handling room beneath the mount. This is the old standard destroyer type mount. It is now found on many minecraft and auxiliaries (repair ships, destroyer tenders, etc.).

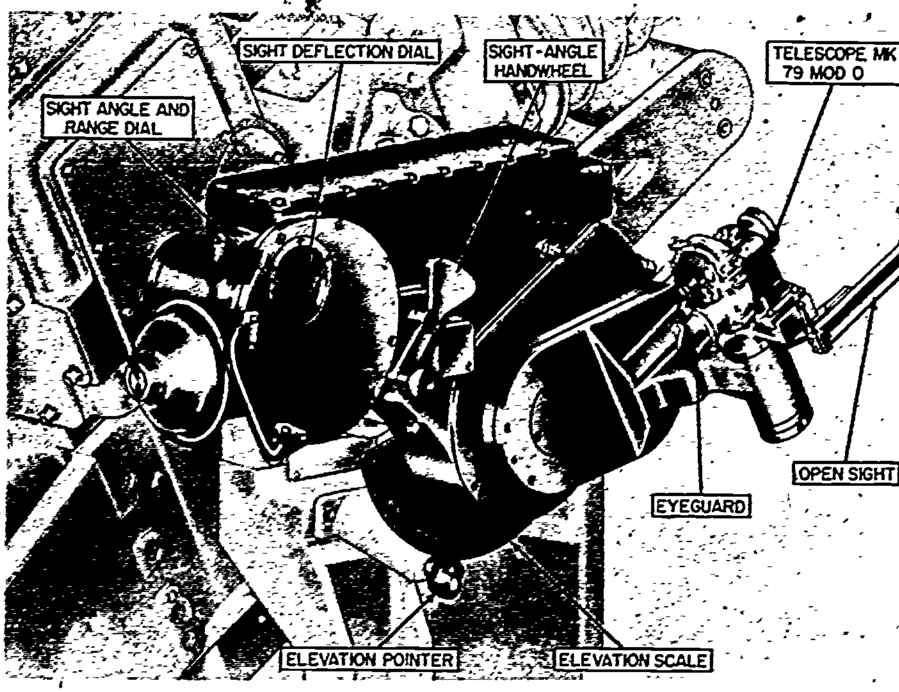
3. Open single mount with ammunition-handling room beneath the mount. This mount is used on auxiliary ships.

4. Open single mount without ammunition hoists or handling room. Because mounts of this type can be installed without extensive reconstruction, it is used on converted merchant vessels and some missile cruisers.

Another mount similar in design to the 5"/38 is the 5"/54 (MK 39), which is used on Midway class aircraft carriers. It has a longer barrel and an amplidyne all-electric power drive in contrast to the electric-hydraulic power drive used in all 5"/38 mounts. Do not confuse this mount with the automatic-loading 5"/54 (MK 42) which is covered later in this chapter.

GENERAL DESCRIPTION OF 5"/38 MOUNTS

The 5"/38 caliber gun is a semiautomatic, dual purpose, base-ring-mounted gun which uses



84.67

Figure 9-22.—3"/50 rapid-fire mount. Sight setter's controls and surface controlman's sight.

separated ammunition. Its principal features are—

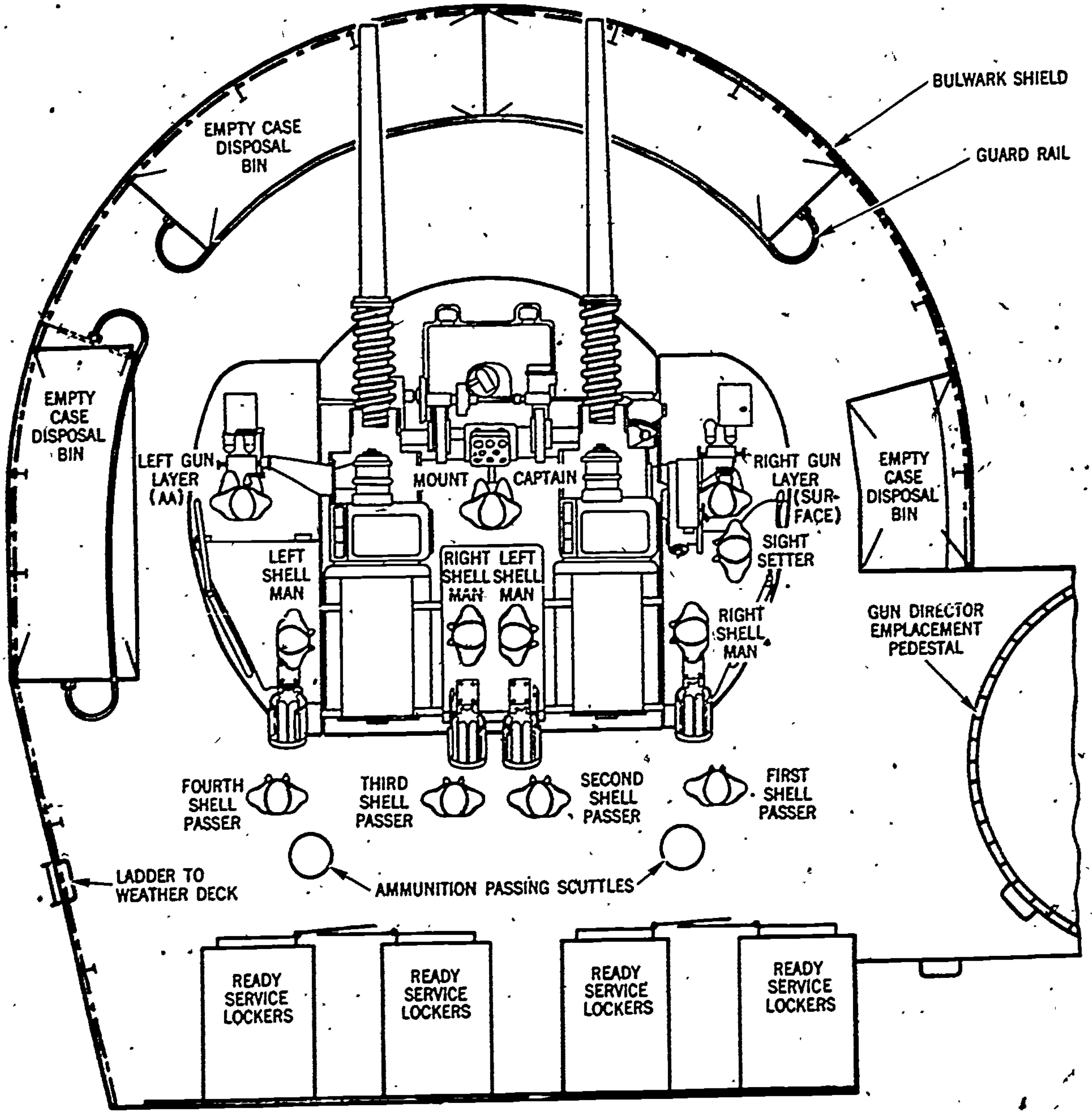
1. Vertical sliding-wedge breech mechanism.
2. Hydraulic recoil and hydropneumatic counterrecoil systems.
3. Power-operated rammer.
4. Power-operated elevating and training gear.
5. Moveable-prism telescopes.
6. Power-operated fuze-setting projectile hoist.
7. Power-operated powder hoist on all twin mounts and some singles.

The 5"/38 mount uses separated ammunition consisting of a 54-pound projectile (weight varies somewhat with type of projectile) and case assembly weighing about 28 pounds, which includes a 15-pound powder charge. Ballistic performance obtained with a 15-pound service charge (full charge) is as follows: initial velocity, 2,600 feet per second; maximum horizontal range, 18,000 yards; maximum vertical range, 37,300 feet. The gun is capable of sustained firing at a rate well in excess of any which can be attained by the loading crew. An experienced crew can load about 15 rounds per minute for long periods, and may attain a short-period rate of 22 rounds per minute.

The gun has a radially expanded, steel monobloc barrel. The rifling has a uniform twist of 1 turn in 30 calibers. The bore is chromium plated from the forward portion of the powder chamber to the muzzle. The barrel is connected to the housing by a bayonet type joint.

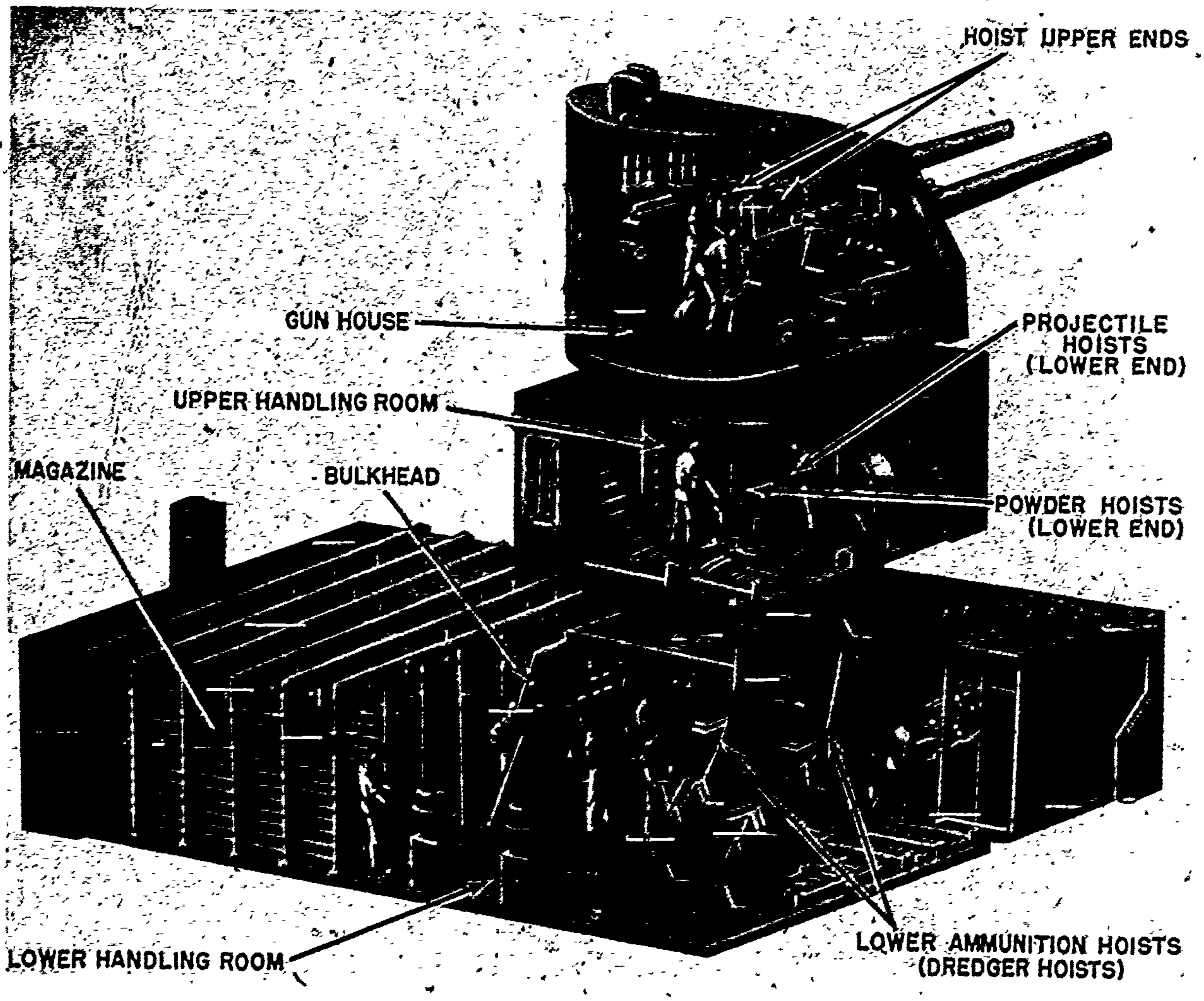
The housing (fig. 9-25) is a rectangular block-shaped forging, with forward portion machined to receive the barrel. In the center is a vertical well for the breechblock; and to its rear is a trough-like ammunition-loading tray. The housing contains twin interconnected recoil cylinders (groove type) and a single counterrecoil cylinder. The housing supports and locks the gun in the slide, and moves on the slide guides during recoil and counterrecoil.

The slide is a large box-shaped weldment, open at top and bottom, within which the housing moves in recoil and counterrecoil. The housing is supported and guided by two guide rails bolted to the inner side plates. The elevating arc and the



110.70

Figure 9-23.—3"/50 rapid-fire twin mount. Crew stations.



110.53.1

Figure 9-24.—5"/38 twin mount.

rammer are secured to the slide. Other mount structure details resemble those described earlier in this chapter.

Other Characteristics of 5"/38 Mounts

All enclosed mounts are housed in a shield of armor plate. The shield is a boxlike structure that provides weather, blast, and splinter protection for crew, (fig. 9-24).

Operating personnel enter or leave the mount through doors on both sides near the after end. Other doors and access cover plates provide for inspection and repair. A roof hatch may be located near the after end of the gun mount. Where necessary, this hatch has a blast hood.

Sight hoods on the side shield plates (twin mounts only) protect the three sight telescopes. A ventilation system supplies air to the mount and handling room.

Lights in the gun and handling room are energized by the ship's general illumination circuit, which also includes outlets for battle lanterns, window-wiper motors on each sight telescope, and the battle illumination system, which energizes small lamps at all instruments and controls.

Gun elevation, gun train, fuze setting, and sight setting synchro signals are supplied to the indicator-regulators in the mount by fire control circuits from the computer.

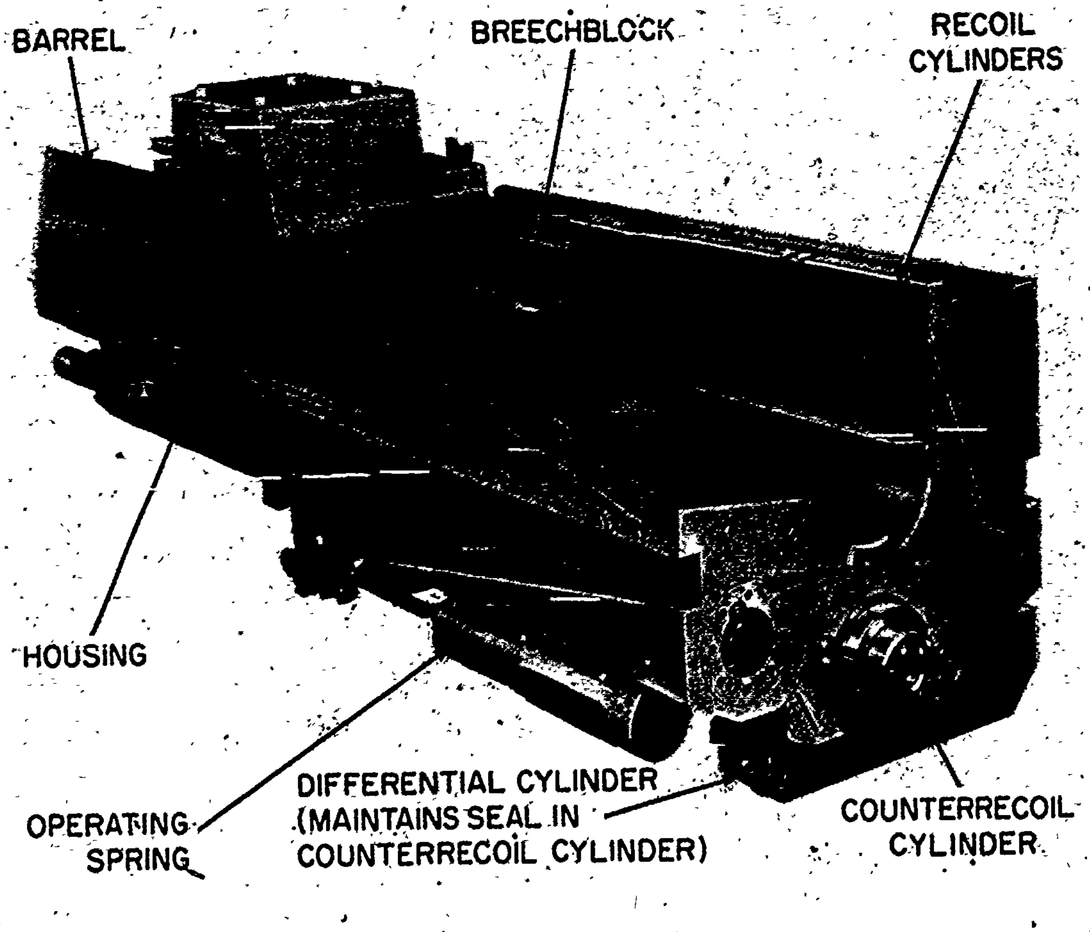
Communication facilities in 5"/38 mounts may include (1) a voice tube between gun room and upper handling room, (2) an automatic telephone in the ship's general communication system, (3) a sound-powered battle phone circuit between mount and fire control stations, (4) an auxiliary sound-powered phone circuit with call bell between mount and lower ammunition-handling room, and (5) a loudspeaker connected to the director and plotting room.

RECOIL AND COUNTERRECOIL

When a round is fired, the burning propellant develops a gas pressure in the gun chamber of sufficient size to hurl a major caliber projectile several miles. As the pressure in the chamber is exerted equally in all directions, there is the same tremendous force tending to move the gun barrel assembly to the rear.

If the gun mount were held rigidly, without recoil, it would be impractical to build a carriage strong enough to withstand these firing stresses without breaking or overturning. The problem could be solved, as it was with the Revolutionary War type cannon, by mounting the carriage on wheels and letting the entire mount be thrown across the deck at each discharge. This seriously affected rate of fire, of course, because each time it was necessary to haul the entire mount back into position and point it before firing again.

The problem, then, was to bring carriage stresses down to a reasonable value and to obtain carriage stability. A German inventor solved this problem in 1888, and by 1897, the French had put it to use in their artillery. The resultant



53.89.2

Figure 9-25. — 5-inch housing and gun (removed from slide).

increase in the "French 75's" rate of fire amounted to a revolution in ordnance and, by the end of World War I, all nations were forced to adopt the new recoil system.

Basically, the modern recoil system is a sort of cushion put between the gun and carriage, allowing the gun tube to be driven rearward, through a limited, controlled distance, while the carriage remains stationary. After absorbing the recoil over a convenient distance, a COUNTER-RECOIL system returns the gun to battery. The major components of both systems are:

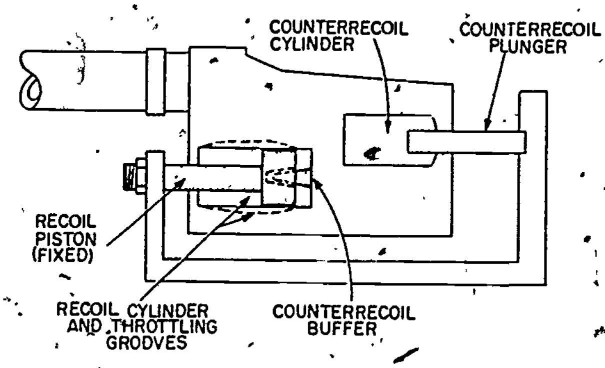
1. The recoil system or brake—stops recoil.
2. Counterrecoil mechanism—used primarily to return the gun to battery and hold it there until fired again. Also assists recoil system in stopping the gun in recoil.
3. Counterrecoil buffer—reduces shock on the gun mount assembly as the gun returns to battery at the end of counterrecoil.

The recoil brake is shown in a simplified schematic in figure 9-26. There are many variations of the recoil brake, but the stylized version in the illustration will do to explain the basic principles of all recoil systems, 40mm and larger. Here you see a hydraulic mechanism known sometimes as a dashpot. It has a piston and a cylinder. The cylinder contains liquid which can move from one side of the cylinder to the other, but its rate of movement is throttled by grooves in the walls of the cylinder. The depth of the grooves is variable, being deepest toward the center, and narrowing at the ends.

When the gun is fired, the force of recoil pushes the housing (and the recoil cylinder) to the rear, exerting pressure on the liquid in the forward end of the cylinder. The cylinder moves aft but is subject to the braking action of the hydraulic fluid as it is forced through the throttling grooves.

At the beginning of recoil the grooves are comparatively deep. There is little resistance to recoil. As the housing moves aft, the grooves become shallower, throttling down the fluid flow. The grooves taper down until they disappear at about the end of the designed length of recoil.

In effect, the recoil brake converts the sudden destructive force of recoil to a powerful but controllable thrust over a considerable distance. Counterrecoil systems are designed primarily to return the recoiling parts to their in-battery position after the force of recoil is spent.



84.147
Figure 9-26.—Conventional recoil and counterrecoil system (simplified).

There are two basic types. Guns smaller than 5-inch use springs. The spring is wrapped around the gun barrel, one end resting against the stationary slide. A collar on the recoiling barrel holds the other end of the spring.

The spring is installed under a high initial pressure, enough to hold the gun in battery at all angles of elevation. When the gun fires and recoils, the spring is compressed. When the recoil brake, assisted by the counterrecoil system, brings the rearward moving gun to a stop, the spring uses its stored up energy to push the gun back into battery.

The other type of counterrecoil system (used on guns 5-inch and larger) is the hydropneumatic type. The pneumatic (air) part of the mechanism is used to push the gun back into battery, and the hydro (liquid) part of the mechanism is used to keep the air from leaking out of the system. The entire mechanism works like this.

In figure 9-27 you see a schematic of the counterrecoil cylinder and differential cylinder assemblies. The piston is sticking part way into an air-charged cylinder of the housing. As the housing recoils, the air pressure in the cylinder is compressed and becomes greater than normal. This is because the amount of space in the cylinder is decreased, being taken up by more of the piston. When the recoil brake stops the rearward movement of the gun, the air in the counterrecoil system expands, pushing the gun back into battery.

To seal the air in the cylinder, packings are installed around the counterrecoil plunger. By themselves, however, the packings cannot effectively prevent leakage. A small differential cylinder (fig. 9-27) acts to tighten the packing even more.

The piston is free floating, being acted upon by air pressure tapped from the counterrecoil air cylinder and opposed by the thrust of the noncompressible oil. The oil side is connected to the center of the chevron packings of the counterrecoil air plunger.

Part of the area of the oil side of the differential piston head is occupied by the end of the piston rod and cannot receive the thrust of the trapped oil, whereas the entire area of the air side of this head receives the thrust of the trapped air. Therefore, at all times, the pressure in terms of pounds per square inch (psi) on the oil side will be greater than the corresponding pressure, in psi, on the air side.

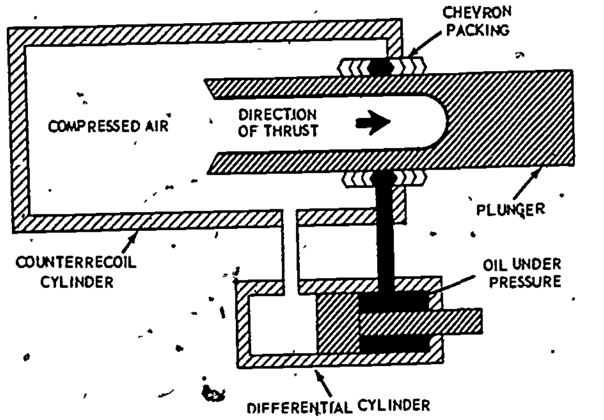
This means that whenever recoil action raises the air pressure, the unit pressure of the oil (and of course this includes oil at the packing gland) rises proportionally higher. This causes the packings to inflate and prevents leakage of the air. This also means that if there is any leakage, it will be in an oil leak, not an air leak.

As the gun is forced back into battery, liquid in the recoil cylinder is forced through the throttling grooves as the piston moves aft (relative to the cylinder). Even with this partial buffing effect, the counterrecoiling gun has considerable mass, and the shock at the end of counterrecoil is quite appreciable. The counterrecoil buffers, also shown in figure 9-26, are designed to reduce this shock.

The buffer is part of the recoiling housing. When the gun is in battery (as illustrated), the buffer is in a mating hole drilled into the recoil piston. When the gun recoils, the buffer is drawn rearward. In counterrecoil the buffer moves forward, entering the hole in the recoil piston. This partially traps fluid in the piston which can only escape through narrow passages. This action buffs the final few inches of counterrecoil.

Differential Piston

In figure 9-28 you see a differential piston rod as it actually looks extending through the packing gland nut. The piston is housed in the differential cylinder located underneath the breech housing. The position of the piston rod indicates the extent of the oil supply within the cylinder. When the piston rod is extended as shown in figure 9-28A, the supply of oil in the cylinder is low. In this case, oil should be added until the end of the piston rod is flush with the gland nut at the end of the cylinder, through which the rod passes (fig. 9-28B). This position



84.148

Figure 9-27.—Function of differential piston in hydropneumatic counterrecoil system.

of the piston rod indicates that the correct amount of oil is being maintained within the cylinder. If the recoil and counterrecoil systems are properly maintained, the gun will recoil and return to battery in less than 1 second. Since the speed in both recoil and counterrecoil is so important to a gun's high rate of fire (how fast the gun can be returned to battery so that the next round can be loaded), a thorough understanding of how these systems work is essential if you are to keep the guns punching, and punching fast, against the enemy.

RAMMER AND AMMUNITION HANDLING CYCLE

The rammer is a semiautomatic electric-hydraulic unit on the upper rear part of the slide. A 7-1/2-hp electric motor drives a pump whose output is controlled by valves to operate the rammer piston. The piston in the cylinder is mechanically linked to a rubber-faced rammer spade which moves forward along the loading tray, and to the rear in an elevated path along the slide. The cycle of operation is a follows:

1. Two crewmen (the projectileman and powderman) take the projectile and powder case out of their hoists and deposit them in the loading tray in the slide.

2. The rammerman depresses a control handle (fig. 9-29A). The rammer piston forces the rammer spade forward (arrow 1) to ram the round into the chamber.

3. When the breechblock closes and the gun fires and recoils (arrow 2 in fig. 9-29B), the rammer spade is automatically retracted (arrow 3) along an upper path in the slide. This lifts the spade so that it will not obstruct the extracted cartridge case's path (arrow 4, fig. 9-29C) to the rear. A crewman throws the fired case out of the mount in single mounts, and in twin mounts when gun elevation exceeds about 30 degrees. Except for these considerations case ejection is automatic.

4. The gun captain prepares for the next round by lowering the rammer spade to ram position.

Hoists

Figure 9-24 shows a conventional type ammunition transport installation for a twin 5"/38 mount. In this arrangement, powder cartridges are manually loaded into dredger hoists which lift them to the upper handling room; here they are manually removed from their tanks and transferred to a powder hoist which lifts them to the gun house. In the gun house a crewman manually transfers them from powder hoist to gun slide. Projectiles typically are handled similarly, except that they are not stowed in tanks.

The powder and projectile hoists between the handling room and the gun house function quite differently. The powder hoist (dredger hoists are similar in principle) consists fundamentally of an articulated endless chain with supports or flights secured to it at regular intervals (fig. 9-30A). Powder cases are loaded by pushing them into the hoist in the path of the flights; when the hoist starts, the chain is driven upward until the next vacant flight is in loading position. When the next unit is loaded, the hoist goes up one more flight, and so on. The hoist is driven by a rotary hydraulic motor whose functioning is controlled by valves.

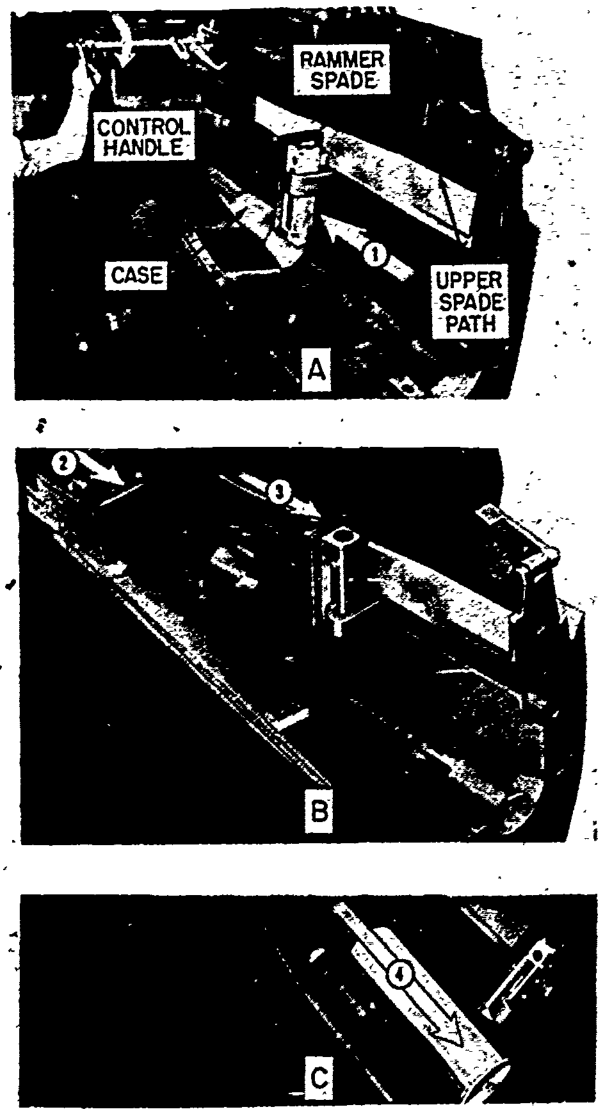
Endless-chain hoists generally can be operated in reverse to lower ammunition aboard. In either mode of operation, the hoist moves one flight at a time, intermittently in the same direction. Only one side of the chain is used.

The projectile hoist, in contrast, has an endless chain in which both sides of the chain are used (fig. 9-30B). There are 2 flights, arranged so that when one is at the top of the hoist on one side, the other is at the bottom of the hoist on the other. The chain runs first in one direction, then the other, and the flights always move from all the way at the top to all the way at the bottom (or vice versa), as in the oldtime well with 2 oaken buckets, one of which descended while the other went up. The projectile is loaded into one side, and automatically the hoist starts if the top is empty. As the loaded flight ascends, the empty comes down. The cycle reverses for the next projectile.

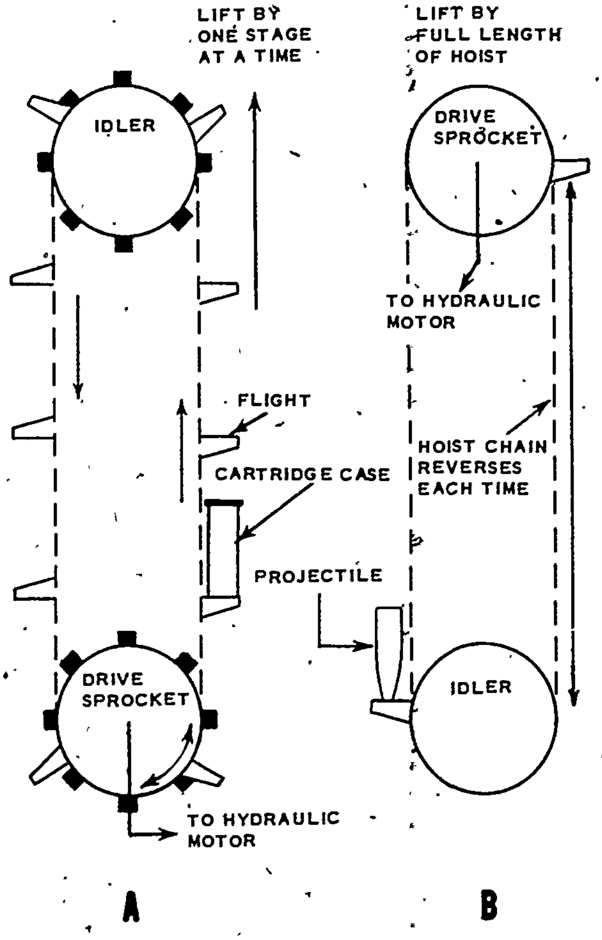
In addition to hoisting projectiles (it is never used for lowering them), the 5-inch projectile hoist also sets the projectile fuze (when a projectile with time fuze is loaded). As you can see in figure 9-31, the projectile hoist has three chains. The center one is the hoist chain. It is driven by a hydraulic motor through shafting that rotates a sprocket at the top of the hoist. Each of the other two chains is part of the fuze-setting linkage. They are positioned by the fuze setter indicator-regulator which is controlled by a servomechanism in the fire control computer. Each projectile flight has a small sprocket wheel which engages one of the fuze-setting chains. As the projectile flight is hoisted by the hoist chain,

84.68

Figure 9-28. — Differential piston rod.



110.62
Figure 9-29.—5"/38 mount. Loading and extraction operations.



84.150
Figure 9-30.—Principles of 5"/38 hoists. A. Powder hoist. B. Projectile hoist. (fuze setter not shown).

the small sprocket wheel "walks" up the fuze-setting chain. This rotates the inner socket and the spring loaded pawls inside the flight (fig. 9-32A). A mechanical time-fuzed projectile is manually loaded nose down in the projectile flight in such a way that the fixed lug of the projectile fuze (fig. 9-32B) is placed into the V slot located on the outer socket of the flight (fig. 9-32A). As the projectile is hoisted, the time ring lug on the fuze is rotated by the inner socket ring (fig. 9-32A). This adjusts the fuze to the desired time setting. So long as the projectile remains in the hoist, the time fuze setting is continuously adjusted by the fuze-setting chain and ring. The time lapse from the instant the projectile is removed from the hoist (after which its fuze adjustment ceases) until it is fired is called dead time, which is estimated and included in the fire control computation.

This discussion of ammunition hoists has concentrated on twin mounts, which are the most elaborately equipped. Some single 5-inch mounts are equipped with one powder hoist and one projectile hoist per mount. Other single 5"/38 mounts may have only a projectile hoist, plus (instead of a powder hoist) a deck scuttle through which powder cases are pushed by hand. Some auxiliaries are still equipped with open mounts with similar arrangements, or with no hoists at all, but this is not the normal condition aboard combat vessels in the active fleet.

Checking Fuze Settings

The mechanical time fuze shown on figure 9-32B has a fixed index (scribe mark) which is used for setting or checking the fuze setting. By matching this index with a number located on the time ring index, you can check the setting on the fuze with the reading on the fuze-setting indicator-regulator dials (fig. 9-33). They should correspond if the fuzes are being properly set. In figure 9-33 you can see that both readings are the same and read 20 seconds; in figure 9-32B the reading of the fuze is 40 seconds. Most mechanical time fuzes can be set from 0 to 45 seconds. The time ring lug on the fuze (fig. 9-32B) is also used to set the fuze manually if the fuzesetting mechanism is down; it is also used to set the fuze on safe by matching the letter S on the time ring index with the fixed index. A special fuze setting wrench is used for this purpose.

5"/54 GUN MOUNT MK 42 MODS 3, 4, 7, AND 8

With the coming of jet aircraft, it has been necessary to develop a reliable AA gun with increased tracking and firing rates. The 5"/54 Gun Mount Mk 42 has proven to be a reliable and efficient weapon against high speed aircraft.

The 5-inch mount Mk 42 (fig. 9-34) is a shielded dual-purpose, single-gun mount with an automatic firing rate of approximately 40 rounds per minute. The gun is trained and elevated (laid) by separate electrically controlled, hydraulically operated power drives. Ammunition is served by an automatic, dual-hoist gun loading system which is hydraulically operated and electrically controlled.

The gun mount consists of the following main components:

1. Gun assembly;
2. Slide assembly;
3. Gun loading system; and
4. Gun laying system.

The gun mount also contains the following auxiliary systems:

1. Sprinkling systems;
2. Electrical system; and
3. Heating, lighting, communication, and ventilation systems.

Basically, the gun and slide assemblies are standard, except that the breechblock and extractors are hydraulically operated. The 5"/54 gun is unique, in that roller bearings support the gun housing during recoil and counterrecoil.

RECOIL AND COUNTERRECOIL SYSTEMS

The gun recoil and counterrecoil systems are conventional, except that the location of the recoil pistons is changed, and the counterrecoil system differs in that two air chambers are used. The counterrecoil system also is so arranged that the differential and air chamber cylinder are mounted to the slide, and the piston rods bear against the after edge of the gun's main housing.

GUN LOADING SYSTEM

The gun loading system (fig. 9-35) extends upward through the ship, from the ammunition handling room (near the magazine) to the mount gun room. This loading system consists of a dual set of units which automatically serve rounds of separated ammunition to the gun from both sides of the slide.

The following is a brief description of how ammunition moves from the ammunition handling room up through the loading system, utilizing the following units of equipment:

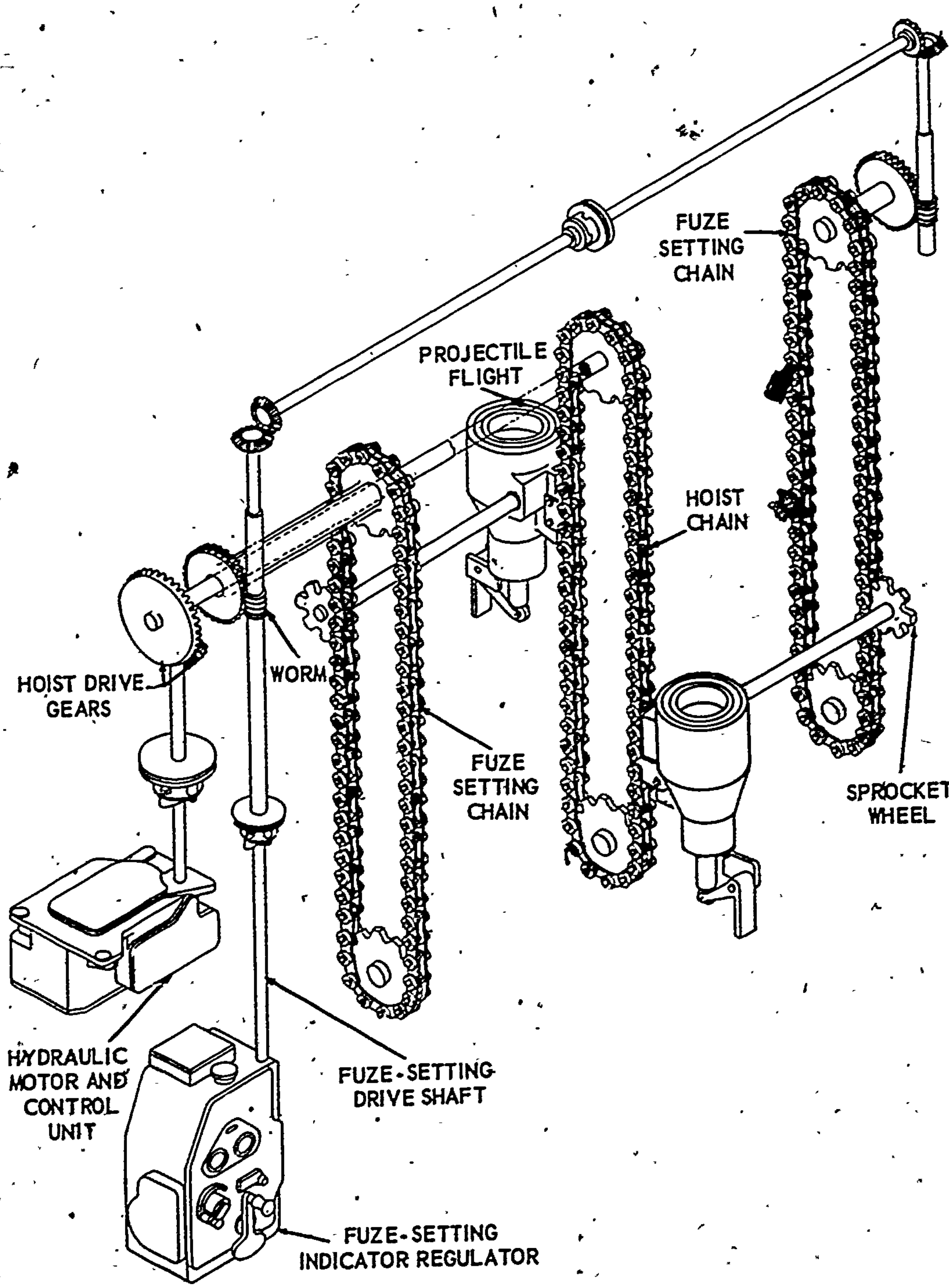
1. Loaders—Rounds of separated ammunition are manually loaded into the loaders (drums that automatically feed the lower hoist).

2. Lower Hoists—The rounds are automatically fed from the lower hoists, which raise each round to the carriers (on Mods 3 and 4) or to the transfer station (on Mods 7 and 8) which positions the round into the carrier.

3. Carriers—The rounds of ammunition are transferred from the stationary lower hoists to the rotatable upper hoists, located on the rotating structure of the gun mount, by the carriers.

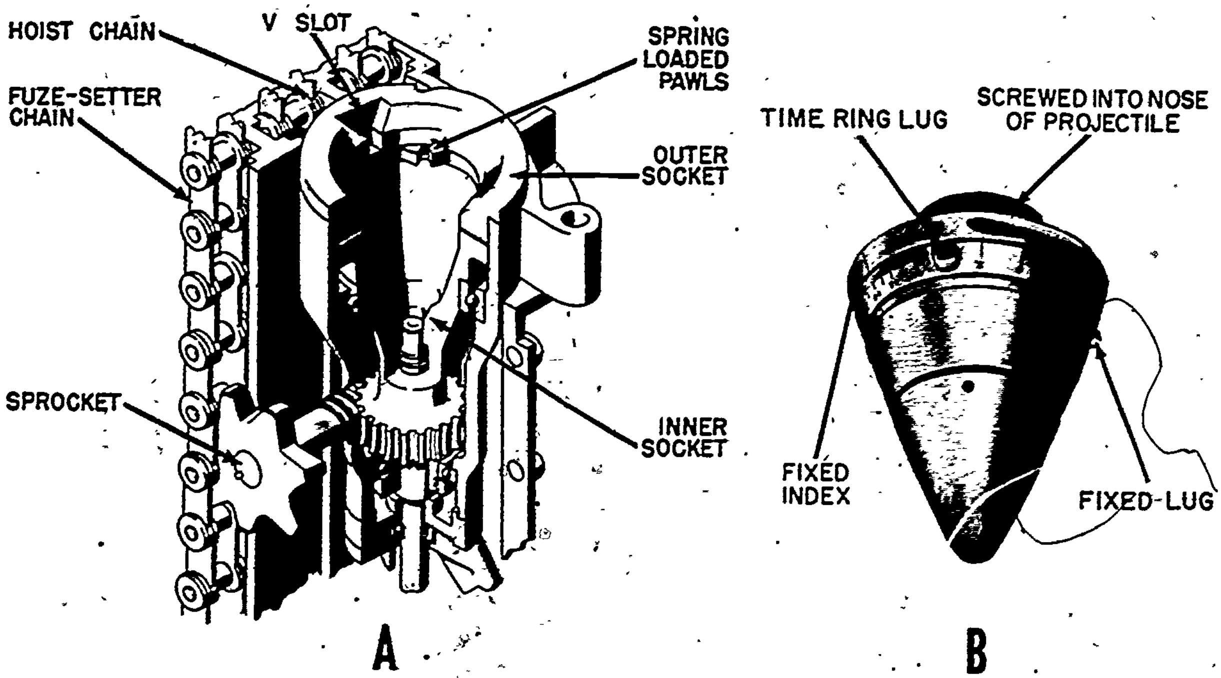
4. Upper hoists—The rounds are alternately raised from the carriers to the cradles by the upper hoists.

5. Cradles—The rounds are transferred from the upper hoists to the transfer trays, located



110.63

Figure 9-31. — 5-inch projectile hoist. (schematic).



84.151

Figure 9-32.—Fuze-setting mechanism, 5"/38 caliber gun. A. Projectile flight. B. Fuze.

on each side of the slide, by the cradles which alternately swing upward.

6. Transfer trays—The rounds are held in the transfer trays while the projectile fuzes are set (on mechanical time-fuzed projectiles only). The transfer trays then lower the rounds to the ramming position, in line with gun chamber.

7. Rammers—Rounds are rammed into the gun chamber by the rammer spade which extends through the transfer trays.

84.69

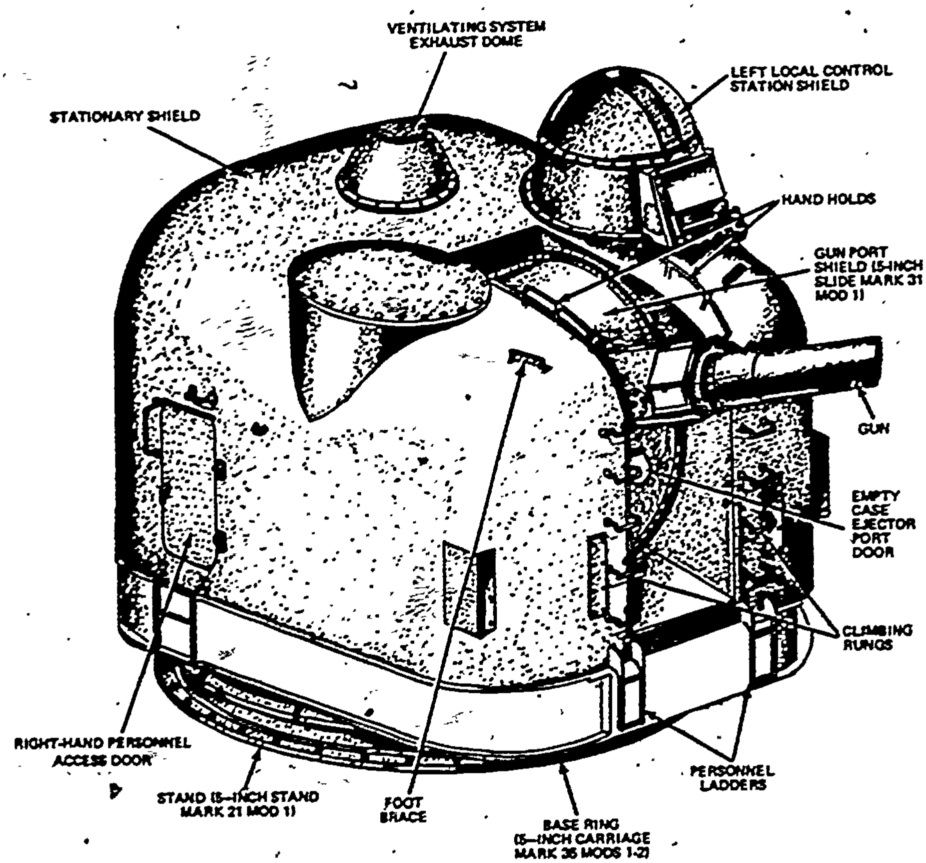
Figure 9-33.—Checking fuze settings.

After gun fires and breech is opened, the extractor catapults empty powder case rearward into the empty case tray. This tray then lowers the expended case into the empty case ejector which ejects case from mount.

To facilitate understanding, gun loading systems in this manual are divided into three groups:

1. Lower gun loading system.
2. Upper gun loading system.
3. Intermediate section (ammunition carrier).

The lower gun loading system includes the loader drums and lower hoists (fig. 9-35), three hydraulic power units, and the control equipment necessary for their operation. This portion of the gun mount assembly is also referred to as stationary, or nonrotating gun mount components (fig. 9-36).



84.404

Figure 9-34.—Right front view, 5-inch shield Mk 61 Mod 1.

The upper gun loading system consists of upper ammunition hoists, transfer trays, rammer, empty case tray, empty case ejector, and fuze setters (fig. 9-35). All upper gun loading system components are part of the rotating gun mount assembly and move with the mount when the gun trains (fig. 9-36).

The intermediate section (carrier) transfers rounds of ammunition from fixed lower hoists to the rotatable upper hoists. In so doing, the carrier acts as an independent transferring mechanism between the stationary gun mount assemblies (lower gun loading system) and the rotatable gun mount assemblies (upper gun loading system). Physically the carrier is part of the carriage and receives its hydraulic power from the upper gun loading system supply.

DESIGN DIFFERENCES

All mods of the mount have the same basic design. The only major difference in the mount installations is the design of the lower ammunition hoists and the ammunition carrier. In the Mods 3-4 mounts, the lower hoists and carrier are completely different from those installed in the Mods 7-8 mounts. The difference is clearly illustrated in figures 9-36 and 9-37.

Lower Hoists and Carrier in Mods 3-4 Mounts

In the Mods 3-4 mounts (fig. 9-36), the lower hoists are straight and terminate directly under the tubes of the ammunition carrier. These hoists are cycled by control units that are operated by hydraulic pressure from an accumulator system. The hoist cycles are initiated by solenoid actions in the control units.

In this hoist design, the rounds contained by the hoists move directly upward from the tops of the hoist tubes into the carrier tubes. When the carrier is loaded, it rotates to the upper hoists where the carrier ejectors transfer the rounds from the carrier tubes to the upper hoists tubes.

Lower Hoists and Carrier in Mods 7-8 Mounts

In the Mods 7-8 mounts (fig. 9-37), some of the lower hoists are curved and some are straight, but each hoist has two ammunition handling tubes, (one for hoisting, one for strikedown, the strikedown tubes are still in place but have been deactivated) and is operated by an electrically driven hydraulic power transmission which is stroked by a hydraulic servomechanism installed in a solenoid-operated control unit.

In this design, the hoist tubes are capped by transfer tubes which are located alongside the carrier tubes. The transfer tubes are units of the lower hoists and are operated by hydraulic pressure from an accumulator system.

When the hoists are cycled, the rounds in the hoist tubes are elevated into the transfer tubes. From there they are ejected laterally into the opposing carrier tubes. The transfer tube ejectors then retract so that they will be in position to receive another pair of rounds from the lower hoists, and the carrier tube ejectors close over the rounds in the carrier tubes. The carrier

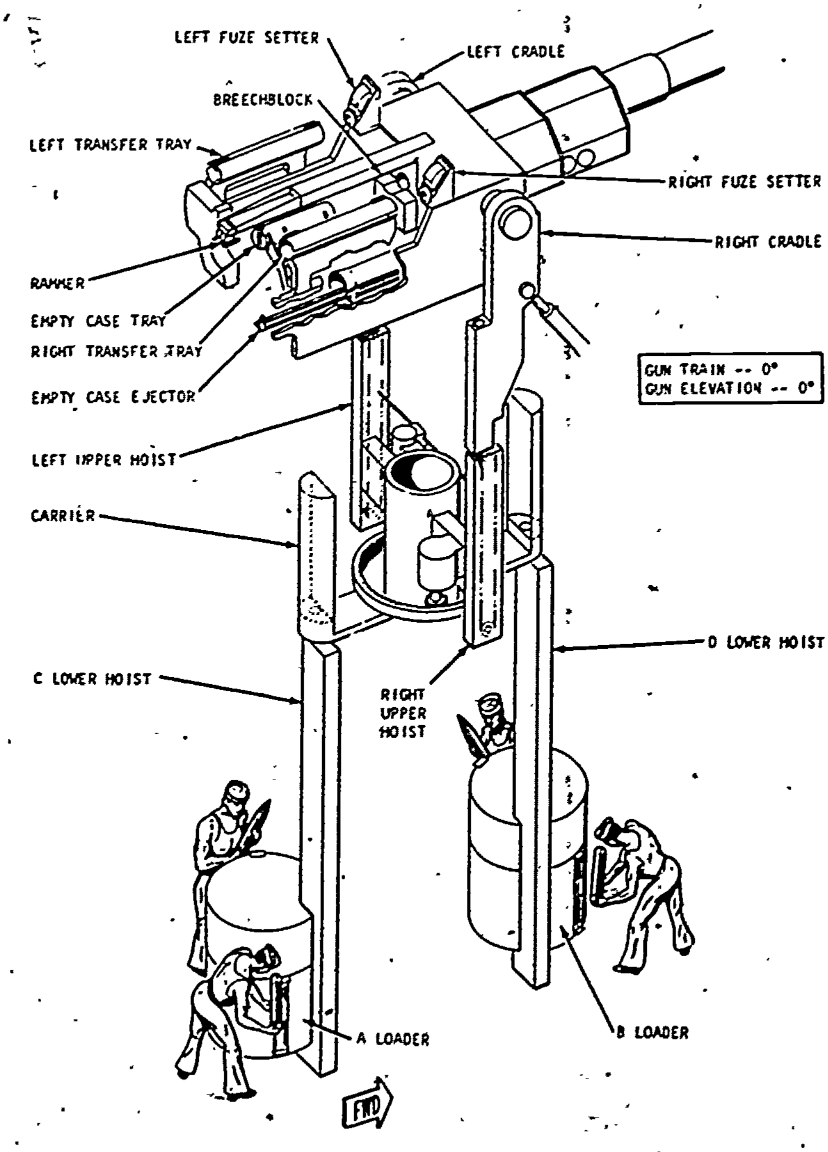


Figure 9-35.—Ammunition handlers load A and B loaders. 84.72

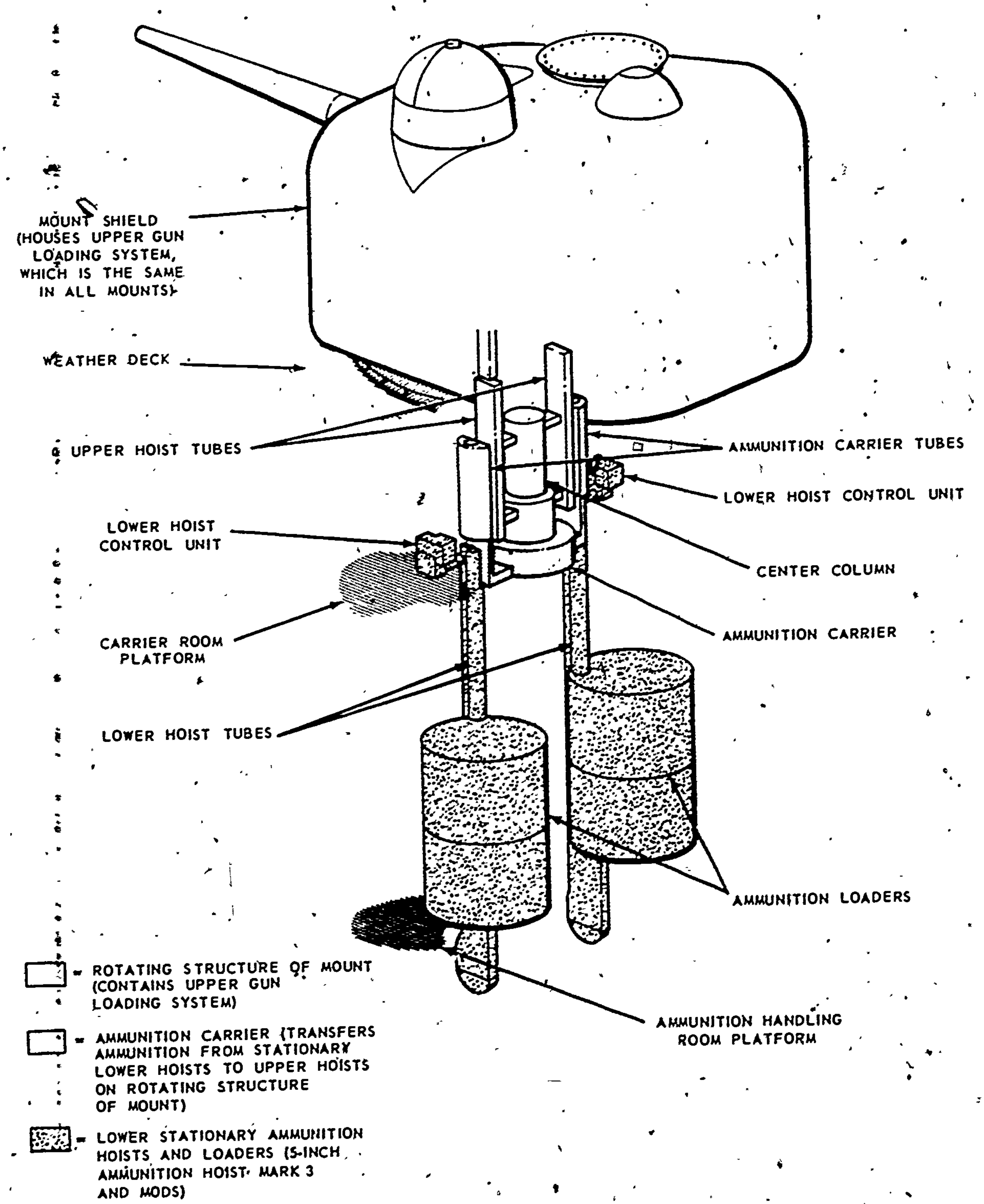


Figure 9-36.—Typical arrangement of lower hoists and carrier Mods 3-4 mounts.

then rotates to the upper hoists where the carrier ejectors transfer the rounds from the carrier tubes to the upper hoist tubes.

The curved lower hoists are installed in mounts where the handling rooms are not located directly below the carrier rooms. This condition exists in all of the mounts in the CVA-class vessels and in the mount in the DLG-class vessels.

The curve in the hoists of the forward DLG mount is very slight. In the CVA mounts, however, all of the hoists curve through two 90-degree angles and consist of vertical, curved, and horizontal tube sections.

Minor Differences in Mount Design

Because of the variation in the vertical distance between the handling room and carrier room in different mount installations, the height of the lower hoists differs from mount to mount.

All mods of the mount have maximum gun elevation angles of 85 degrees and, with the exception of the CVA mounts, have 720 degrees of training freedom (360 degrees in either direction from the stowed position of the mount).

Maximum angles of gun depression vary in different mounts from 7.5 degrees to 15 degrees, as determined by structural characteristics of the vessel.

GUN LAYING SYSTEM

The mount itself can be operated in either remote or local control. No provision is made for hand-powered operation. Manually operated hand cranks are connected to the training and elevating gears. This mode of operation is only used for maintenance, stowing purposes, and for use in connection with certain mount and gun alignment procedures involved in the installation of the train and elevation receiver-regulators.

The training and elevating gear assemblies are electrically controlled, hydraulically operated power drives that accurately position the mount and gun in response to electrical gun train and gun elevation orders. These orders can be applied to the train and elevation receiver-regulators from remote fire control stations or from the one-man control unit operated by the local control man in the mount.

The training gear assembly consists of a training gear, a power drive, and a receiver-regulator. The receiver-regulator converts the electrical gun train order signals into hydraulic control inputs to the power drive, which is an electrically driven, hydraulic power transmission. The output shaft of the power drive turns the training pinion, which drives the mount in train.

The elevating gear assembly consist of an elevating gear, a power drive, a receiver-regulator, and a firing cutout. The receiver-regulator converts the electrical gun elevation order signals into hydraulic control signals and applies them to the power drive, the drive turns the elevating pinion, and the pinion elevates or depresses the gun.

Both the training and the elevating gear assemblies are equipped with limit stop mechanisms. In the train receiver-regulator, the stop mechansim decelerates and stops the train drive as the mount approaches and reaches its limits of operation in either direction of train. The limit stop mechanism in the elevation receiver-regulator brakes the gun to a stop as it reaches its limits of travel in elevation or depression.

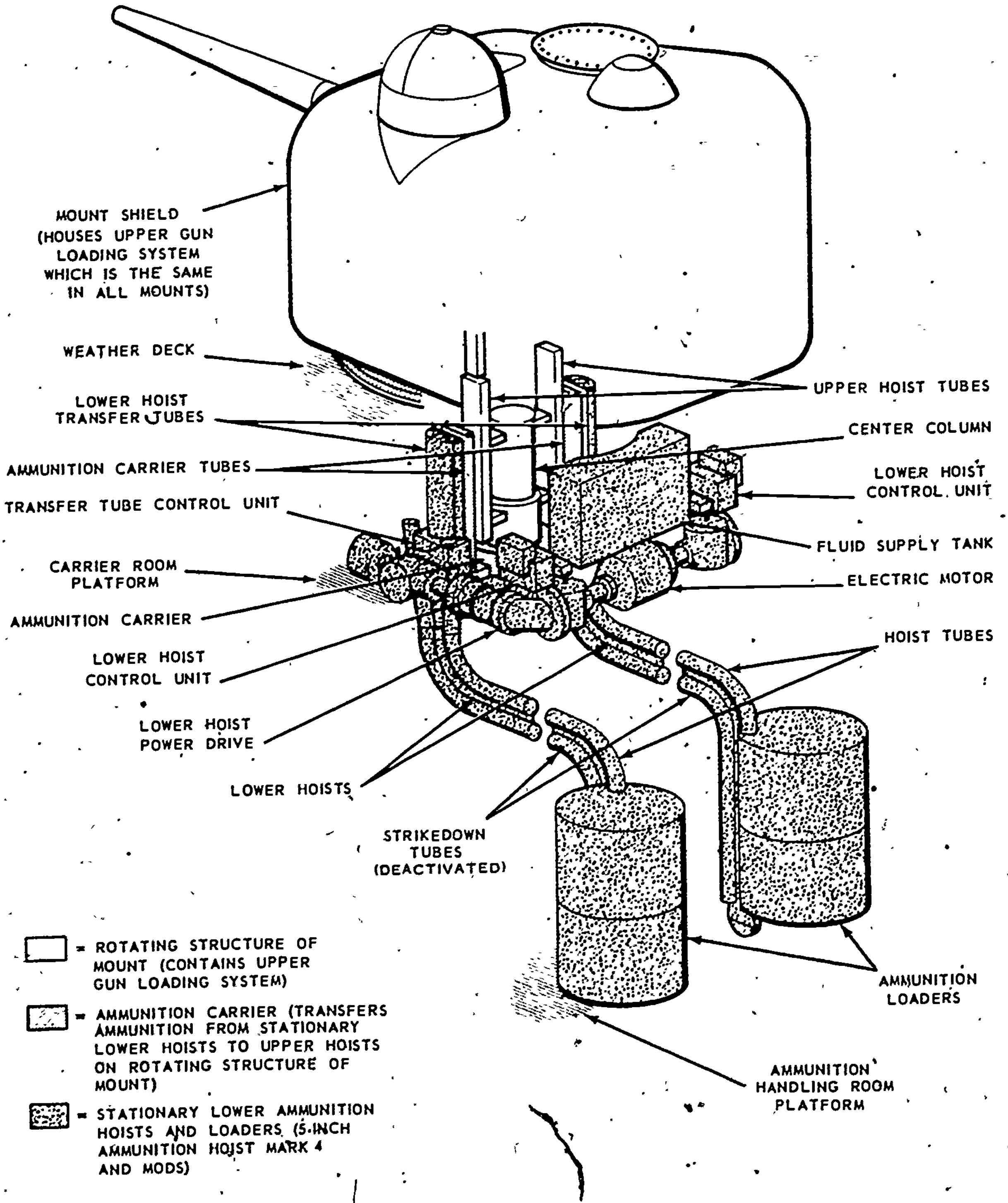
The firing cutout is connected by response gearing to the training and elevating pinion drive shafts, and operates switches in the firing circuit to prevent firing when the gun is pointed into a danger sector.

PERSONNEL

The gun loading system and gun laying systems are separately controlled, and either system can be independently operated. Responsibility for control of the gun loading system is primarily delegated to the gun captain and the loader control man, while control of the gun laying system is the responsibility of the mount captain and the local control man. Duties of the carrier control man are divided between the two systems. The duties of a gun crew for the 5"/54 are described below (less ammunition handlers). Figure 9-38 illustrates the positions of the gun room crew and the control panels under their control.

MOUNT CAPTAIN — The mount captain is the senior man in the mount and is stationed at control panel P3 in the left rear of the gunhouse. He is in charge of the entire mount crew and receives all mount operation orders from ship fire control station via the JP telephone circuit. The mount captain communicates with the local control man over the JP telephone circuit and transmits mount activation, operation, and deactivation orders to the gun captain and mount crew (except local control man) over the X17J telephone circuit.

The mount captain's duties and responsibilities extend to the operation of train and elevation securing pins, controlling the method of mount operation, controlling operation of the train and



84.74

Figure 9-37.—Typical arrangement of lower hoists and carrier in Mods 7-8 mounts.

elevation motors through switches on the P3 control panel, and operating the heating, ventilating, and lighting systems in the gunhouse through controls on the control panel P8.

In addition, the mount captain supervises indoctrination, training, and performance of the mount crew, and is responsible for the observance of all mount safety precautions. He also opens and closes the breechblock in misfire procedures, operates the breech sprinkling system, and he may operate the sightsetting transmitters in the P3 control panel in accordance with telephoned instructions.

LEFT LOCAL CONTROL MAN—The local control man is stationed at the left local control station as shown in figure 9-38. He operates the left one man control unit, left telescope, control panel P6, and auxiliary control panel P9. When ordered by the mount captain, he synchronizes the mount in train and elevation.

The left local control man also serves as a safety observer except when actively engaged in local control or local firing, operates the sightsetting transmitters in the P6 control panel when ordered to set sights by the mount captain and, on command, monitors the firing key during local firing.

GUN CAPTAIN—The gun captain is stationed at the control panel P4 in the right rear corner of the gunhouse (fig. 9-38). He is in charge of the gun loading crew, and is directly responsible to the mount captain.

The gun captain has, perhaps, more varied duties and responsibilities than anyone in the gun crew. He receives all gun loading orders from the mount captain, transmits gun loading system activation, operation, and deactivation orders to the gun loading crew, releases or secures the safety link, controls the method of gun loading system (whether the gun is loaded from both sides through dual hoist system, or from one side through single hoist arrangement, and whether or not fuzes are to be set) through switches on control panel P4, and directs the gun loading crew in required equipment checks before starting power operation of the gun loading system.

He controls operation of the loader, lower hoist, upper gun loading motors, and gun loading system in manual or power operation through switches on the control panel P4.

The gun captain checks the movement of ammunition through the gun loading system by means of indicating lights on control panel P4, checks gun loading units on the slide for proper operation and safe performance at all times, and stops operation of the gun loading system in the event of malfunction or casualty.

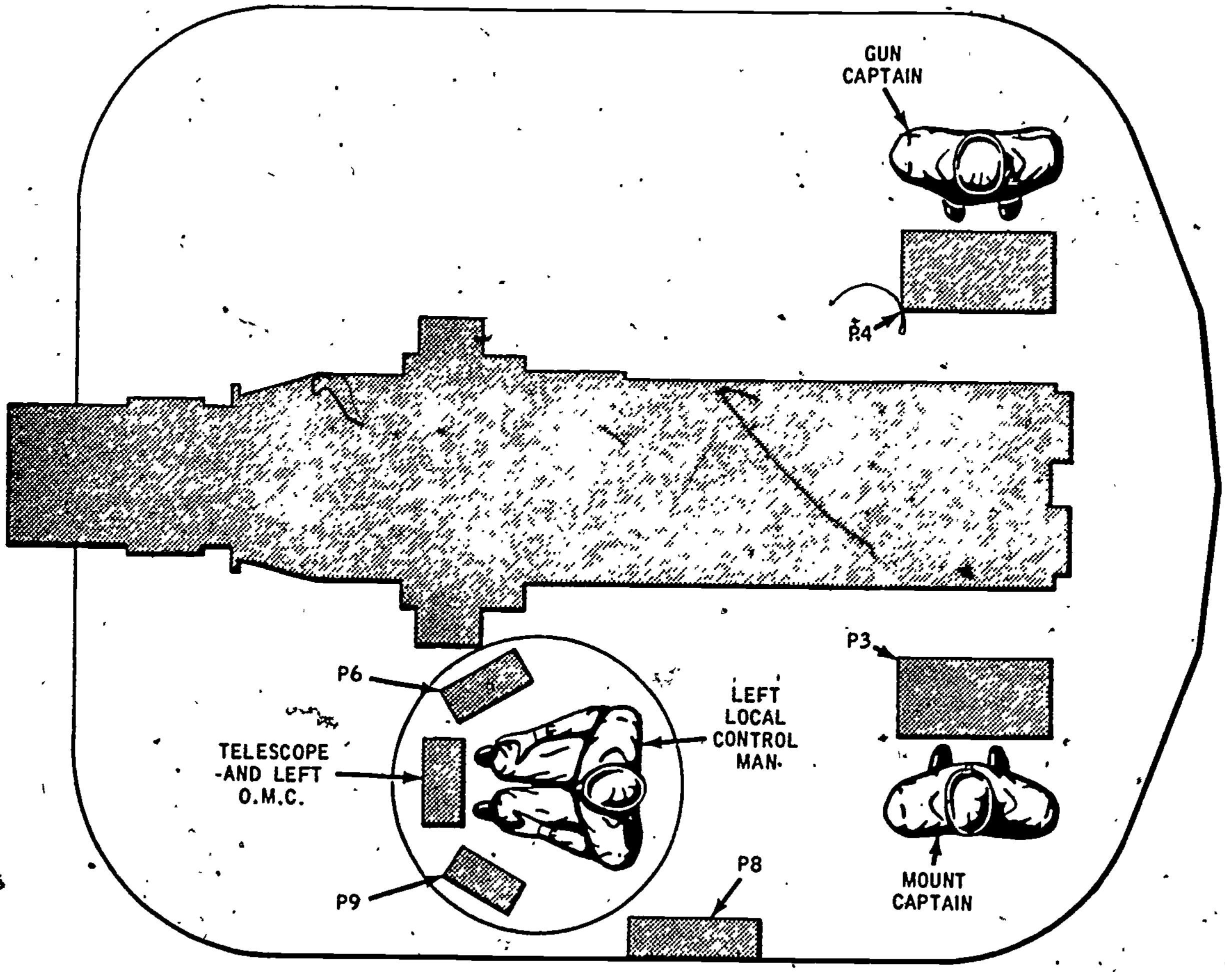
In addition, he organizes and supervises the procedures used to clear a gun in case of misfire, removes the misfired case from the breech and loads the clearing charge, operates the star shell spread knob on the train receiver-regulator, inserting spread values into gun train order on instructions received from the mount captain, and operates the sprinkling station A in the gunhouse (and station C in mounts Mods 3-4).

CARRIER ROOM CONTROL MAN—The carrier room control man is stationed in the carrier room between the control panels P1 and P2. He controls the mount power supply system from the P1 and P2 panels. Lights on the P1 panel indicate when power is available to the system, and when motors are running on the gun mount. The P2 panel houses amplifiers for the fuze setters, parallax systems, and train and elevation power drives. On the face of this panel are switches and light arrangements that function as a means of communication between gun captain and the carrier room control man. He also operates C- and D-lower ammunition hoists when in local operation, and shifts the carrier or upper hoist to one-side operation when directed by the gun captain.

LOADER CONTROL MAN—The loader control man is in charge of the handling room crew and ammunition handling room equipment. He controls the loader drums by means of switches on the P5 panel (located between the A and B loader drums) when the loaders are being operated in the manual power mode. This panel enables the loader control man, with permission from the gun captain, to operate the loader drums in manual power operation. Normally, manual power operation (manual switch-controlled power cycles) is used during loading, unloading, exercising, or testing of the loader drums. The loader room control man also corrects malfunctions and casualties when directed by the gun captain, supervises indoctrination, training, and performance of handling room crew, and operates sprinkling station D in the handling room.

One Side Operation

The gun captain can select for one-side automatic power operation of the loading system when a casualty occurs to some units of the loading system. The procedures necessary for one-side operation vary with which unit of the loading system is inoperative. Depending upon the nature of



84.75

Figure 9-38.—Gun room stations and control panels.

the casualty the gun captain can deactivate one side of the gun loading system or instruct the carrier room control man to mechanically deactivate the malfunctioning unit. One side operation (using one hoist) will reduce the gun rate of fire to 20 rounds per minute.

One advantage of the gun loading system employed with the 5"/54 gun mount is that once the loader drums are loaded, the ammunition handling crew need not be on station for automatic gun firing operation. This enables a ship's weapon system to function during a condition of readiness with a minimum amount of personnel. The ammunition handling crew which consists of four powder men and four projectile men can be utilized for other duties in the event of personnel casualties. The ammunition handling crew are needed only to replenish the 40 rounds of ammunition loaded into the loader drums after a firing mission, or they can be left at their station if more than 40 rounds are to be used.

5"/54 MK 42 MOD 9

This mount is designed for the main gun battery of DE 1052 class ships and is used as a tactical weapon against surface, shore, and air targets. The major changes between the 5"/54 Mod 9 and the mods 3, 4, 7, and 8 are in the train and elevation receiver-regulators, the fuze setters, and the electrical control system. The objective of this type mount design is to increase reliability and improve maintainability where possible and to incorporate features which would reduce the weight of the mount without degrading performance.

The design changes to the receiver-regulators greatly improve reliability and maintainability, and reduce equipment weight by eliminating the large and complex valve block required in the present design of the Mods 3, 4, 7, and 8. These design changes employ an electrohydraulic servo valve control system, which is easily interchangeable between train and elevation systems. These interchangeable features are accomplished by the use of solid state amplifiers, and evolve directly from the general concept in design of some type of missile launching systems.

FUZE SETTER CHANGES

The fuze setters are substantially lighter in weight than those used in the Mods 3, 4, 7, and 8 mounts. They contain fewer moving parts, employ solid state amplifiers, and operate with greater accuracy. The reductions in weight which result from the redesign of the fuze setter and its associated amplifiers are as follows: the new fuze setter unit weighs 36 pounds, where the old unit weighed 317 pounds; the weight of the fuze setting amplifiers has changed from 115 pounds to 17 pounds.

CONTROL SYSTEM CHANGES

The electrical control system of the gun mount has been completely redesigned. The mount captain's P-3 panel and the gun captain's P-4 panel have been eliminated. One control panel (EP-2), located in the carrier room, contains all controls previously embodied in the P-3 and P-4 panels (fig. 9-39). The number of on-mount personnel has also been reduced, due to two features of gun mount design being changed or eliminated within the gun house. The right hand local control station has been eliminated, and the mount captain station has been changed from the gun house to the carrier room.

PERSONNEL

The Gun Mount Control System Mk 114 Mod 0 is the mount electrical network which enables the gun crew to control and monitor the operation of the gun mount. It consists of one power panel, four control panels, and two separately mounted rotary switches. The panels are designated EP1 through EP5; the switches are safety switches and designated SMX14 and SMX17. The crew members that control mount operations consist of a mount captain, an assistant mount captain (OMC operator), a gun captain, and loader safety observer.

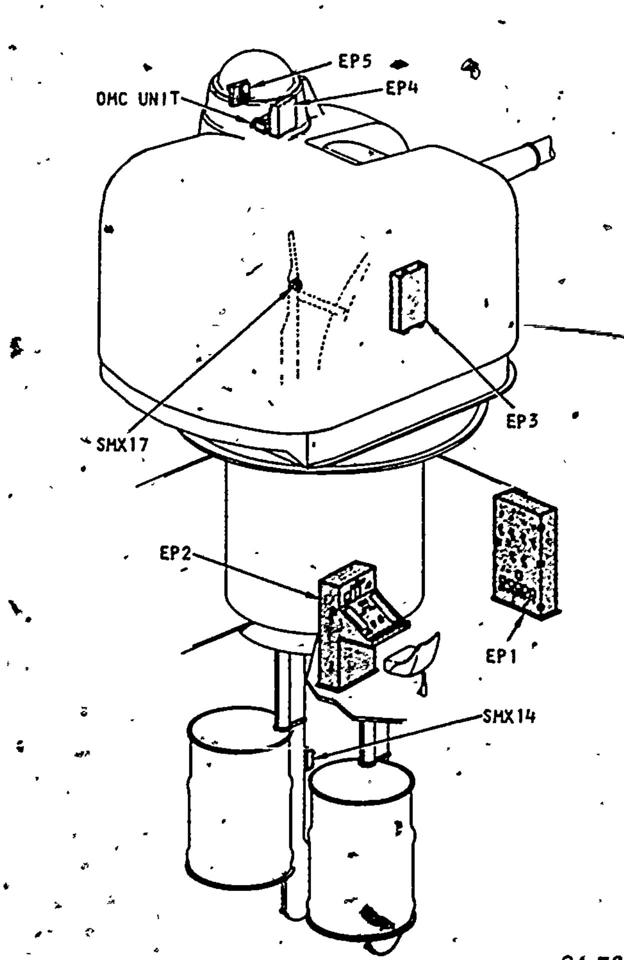
Mount Captain

The mount captain supervises the entire mount crew and is responsible to the ship's weapons officer. He is stationed at the EP2 panel located in the carrier room and controls the method of mount operation through selector switches on the EP2 panel. He also controls power distribution to the gun mount components by positioning switches on the EP1 panel. The EP1 panel located in the carrier room (fig. 9-39) is the main distribution point for electrical power to the gun mount. The panel contains power distribution lines, circuit breakers, contactors, overload relays, manual switches, and indicating lamps which control and monitor power distribution. The EP2 panel is the principal operational control point for gun mount operation. It contains selector switches, push-button switches, indicating lights, train and elevation control and sight setting dials, and a firing safety switch. The mount captain uses the EP2 panel to select the mode of operation desired to either fire, check out, or exercise gun mount components. There are three modes of operation which are used for gun mount activation:

AUTO-LOAD MODE—Is the sequential electrical, hydraulic, and mechanical operation of system components. When auto-load is selected, the mount moves rounds from the loaders to the gun without further manual switching.

STEP-LOAD MODE—Is the sequential operation of system components initiated by individual manual switching actions at the EP2 panel. This individual switching moves ammunition through the gun loading system and is used as an auxiliary mode of operation if auto-load circuitry is inoperative. Step-load is also used to check out individual gun loading components from the loader drums to the empty case ejector.

STEP-EXERCISE MODE—Is used to check the operation of individual components without rounds of ammunition within the system. The gun loading components operate much as they do in step-load and require manual selection to imitate each individual cycle. In this mode of operation the entire loading system can be checked without the use of ammunition, eliminating the job of carrying rounds of ammunition from gun mount components back down to the magazine.



84.76

Figure 9-39.—Gun mount control panels.

Assistant, Mount Captain

The assistant mount captain serves as safety observer and is stationed in the OMC station (fig. 9-39). He controls the mount in local tracking control, operates switches on the EP4 panel and can relieve the mount captain under prolonged standby conditions. The EP4 panel is located on the right side of the OMC station and contains indicating dials, lights, and manual switches operated by the assistant mount captain. This panel selects the sight setting source when in local control and contains elevation and train position indicating dials.

Gun Captain

The gun captain is stationed on the right side of the gun house. He observes the operation of equipment within the gun house and reports any malfunctions to the mount captain. He can stop the gun loading operations by safety switch SMX17 in the event of a casualty. He operates EP3 panel and supervises manual loading of illuminating projectiles and the unloading of the transfer tray after firing. The EP3 panel, located in the gun house, contains switches which control the heating, lighting, ventilating and anti-icing systems of the gun mount. The gun captain's safety switch SMX17, located on the cradle guide arc support (fig. 9-39), is a manual safety switch with four positions. Figure 9-40 shows the switch positions. The handle of SMX17 can be removed while in the Safe Emergency Stop position, preventing operation of the upper gun system.

Loader Safety Observer

The loader safety observer is stationed at safety switch SMX14, located in the ammunition handling room (fig. 9-39). He is in charge of the handling room crew and receives loading instructions from the mount captain through telephone circuits. The loader safety switch SMX14 is positioned to stop (fig. 9-40) by the loader safety observer in the event of unsafe or improper operation of the lower gun loading system.

LOAD TO FIRE SEQUENCE

Gun loading systems employed in the 5"/54 Mk 42 gun mounts differ in that the Mods 7 and 8 gun mounts use transfer tubes to eject rounds of ammunition from the lower hoists into the ammunition carriers (fig. 9-37). The Mods 3, 4, and 9 gun mounts have no transfer tubes but raise the rounds of ammunition from the lower hoists directly into the carriers. Since the subject of this section is the 5"/54 Mod 9, the gun loading system used with this mount (fig. 9-35) will be used to explain how ammunition is transferred from the lower handling room to the gun chamber.

Load To Fire Cycle

Each phase of gun loading consists of several actions that prepare, position, or move the ammunition to the next phase of operation. When a round passes through a phase of operation, that phase can perform its function on the next round while the preceding round is advancing to the following stage. How far each phase of operation can advance is determined by interlocks and the physical status of the next related phase of the gun loading operation.

From Loader to Carrier

The sequence begins with the filling of the loader drums. Ammunition handlers place projectiles and powder cases into cavities of each loader drum (fig. 9-35).

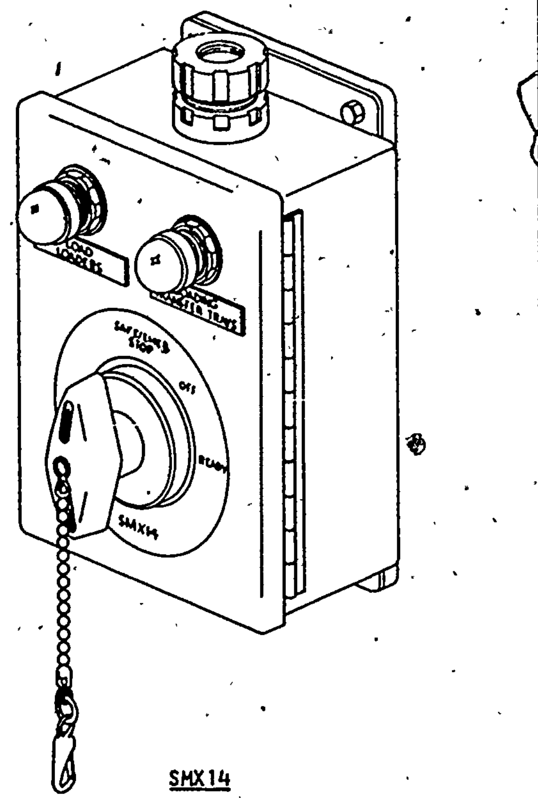
The loaders align the projectiles and powder cases of rounds 1 and 2 with the lift pawls of the lower ammunition hoist (fig. 9-41A). The lower hoist lift pawls raise rounds 1 and 2 out of the loader drums (fig. 9-41B). The first raise cycle of the lower hoist is completed when rounds 1 and 2 are at the first flight level in the lower hoist tubes. The loader drums index rounds 3 and 4 to the hoist position (fig. 9-41C). The lower hoists raise rounds 1 and 2 to the ammunition carrier tubes and rounds 3 and 4 out of the loader drums toward the first flight lever (fig. 9-41D).

From Carrier To Upper Hoist

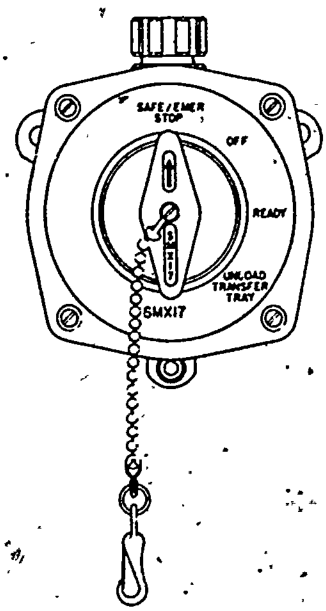
At the end of the second raise cycle, the lower hoists position rounds 1 and 2 in the carrier tubes, and rounds 3 and 4 advance to the first flight level in the lower hoist tubes. The loader drums index the next set of rounds over the lower hoist pawls (fig. 9-42A). The carrier begins moving rounds 1 and 2 from the lower hoists toward the upper hoist (fig. 9-42B), and the upper hoist prepares to receive rounds 1 and 2 from the carrier. Note the reversed positions of the upper hoist lift pawls: The left pawl is down and the right pawl is up. Upper hoist operation alternately raises rounds (fig. 9-42C). The carrier rotates alongside the upper hoists, and the carrier ejector mechanism ejects the rounds into the upper hoist tubes (fig. 9-42D).

From Upper Hoist To Cradle

When the upper hoist shutters close and the carrier mechanism retracts, the left upper hoist pawl begins raising round 1 into the left cradle as the right upper hoist pawl lowers to the start-of-hoist position below round 2. The carrier begins rotating to the lower hoist to pick up rounds 3 and 4 (fig. 9-43A). The left upper hoist raise movement ends when round 1 is positioned in the left cradle, the right upper hoist pawl is down and ready to raise round 2, the carrier is latched to the lower hoist, and rounds 3 and 4 are being hoisted into the carrier tubes (fig. 9-43B). When rounds 3 and 4 move into the carrier tubes, the right upper hoist pawl begins raising round 2 into the right cradle. The left upper hoist pawl lowers to the start-of-hoist position, and the



SMX14



SMX17

84.77

Figure 9-40.—Safety switches.

cradle swings up from the left upper hoist to the slide (alongside the left transfer tray (fig. 9-43C). The left cradle latches to the slide as the lower hoists position rounds 3 and 4 in the carrier tubes. Round 2 continues moving up into the right cradle (fig. 9-43D).

From Transfer Tray To Ram Position

The left cradle ejects round 1 into the left transfer tray, where it is held in position for fuze setting. Round 2 is being raised into the right cradle, as the carrier begins moving rounds 3 and 4 from the lower hoists to the upper hoists (fig. 9-44A). The left fuze setter extends to set the fuze of round 1. The left cradle swings down from the slide to the left upper hoist. The right cradle begins raising round 2 the slide. The carrier arrives at the upper hoists with rounds 3 and 4 (fig. 9-44B). The fuze is now set on round 1, and the left cradle latches itself to the left upper hoist. Round 2 in the right cradle continues raising to the slide. The left upper hoist pawl begins lowering to the start-of-hoist position. The carrier begins rotating to the lower hoist to index over the next set of rounds (fig. 9-44C). The left fuze setter retracts, and the left transfer tray starts lowering round 1 into the ramming position. The right cradle latches to the slide, and the left upper hoist pawl continues raising round 3 to the left cradle while the right hoist pawl continues lowering (fig. 9-44D).

From Ram Position To Gun Firing

When round 1 is in the ram position, the left transfer tray releases the round and the rammer spade rams the round into the gun chamber. At the same time round 3 continues up into the left cradle (fig. 9-45A). The breechblock raises to close the breech and raises the rammer spade to the latched position for the rammer retract stroke. The left (empty) transfer tray raises, and the empty case tray positions itself behind the breech. The fuze is set on round 2, and the left cradle raises round 3; the right cradle lowers to the upper hoist (fig. 9-45B). Round 1 fires and the recoil action initiates rammer spade retraction. The breechblock opens, and the empty case of round 1 is extracted into the empty case tray as recoil ends and counterrecoil begins.

The right fuze setter retracts from round 2, and the left cradle latches to the slide (fig. 9-45C). As the gun moves back into battery, the right transfer tray lowers round 2 into ramming position. The empty case tray lowers into alignment with the empty case ejector (fig. 9-45C).

Round 2 is rammed into the gun chamber and the case of round 1 is ejected into the ejector tube. The gun fires round 2, and the empty case of round 2 is extracted into the empty case tray and lowers the empty case to the case ejector. As the rounds are fired, each empty case in the ejector tube pushes the case ahead of it further into the tube where it is held by a spring loaded pawl. The empty cases are ejected out through the forward section of the gun mount by means of a tube located below the gun barrel.

Round Selection

In the Mod 9 gun system, a round select pushbutton located on the EP2 panel is used to select either one-type or two-type operation. The loader can be loaded with two types of ammunition. For example, the A loader drum can be loaded with AA common, and the B loader with VT fuzed projectiles. The selection of two-type operation ensures that only one side of the gun loading system is used. The other side remains loaded with another type ammunition held in readiness for a switch to that type ammunition. In two-type operation the mount fires approximately 24 rounds per minute.

5"/54 MK 42 MOD 10

The 5"/54 Mod 10 gun mount is not an all new mount but is actually a modified Mod 7 and 8 mount and is designed to be used as the main battery on DEs, DDs, DDGs, DLGs, and a DLG(N). Functionally the Mod 10 is similar to the Mod 9 in that both Mods utilize solid state gun mount control systems and electric-hydraulic power drives to control mount operation.

Structurally, however, there are some differences. The shield on Mod 9 mounts is constructed of laminated fiberglass while the shield on the Mod 10 is steel.

Lower hoists on the two Mods are different. The Mod 9 gun mount lower hoists transfer ammunition from the hoists directly into the carrier. The Mod 10 gun mount lower hoists raise rounds of ammunition from the loaders to a transfer station in the carrier room. The transfer station ejectors eject the rounds into the carrier.

In view of the similarity between the Mod 9 and Mod 10 gun mounts, and having previously discussed the Mod 9, no further discussion will be presented on the Mod 10.

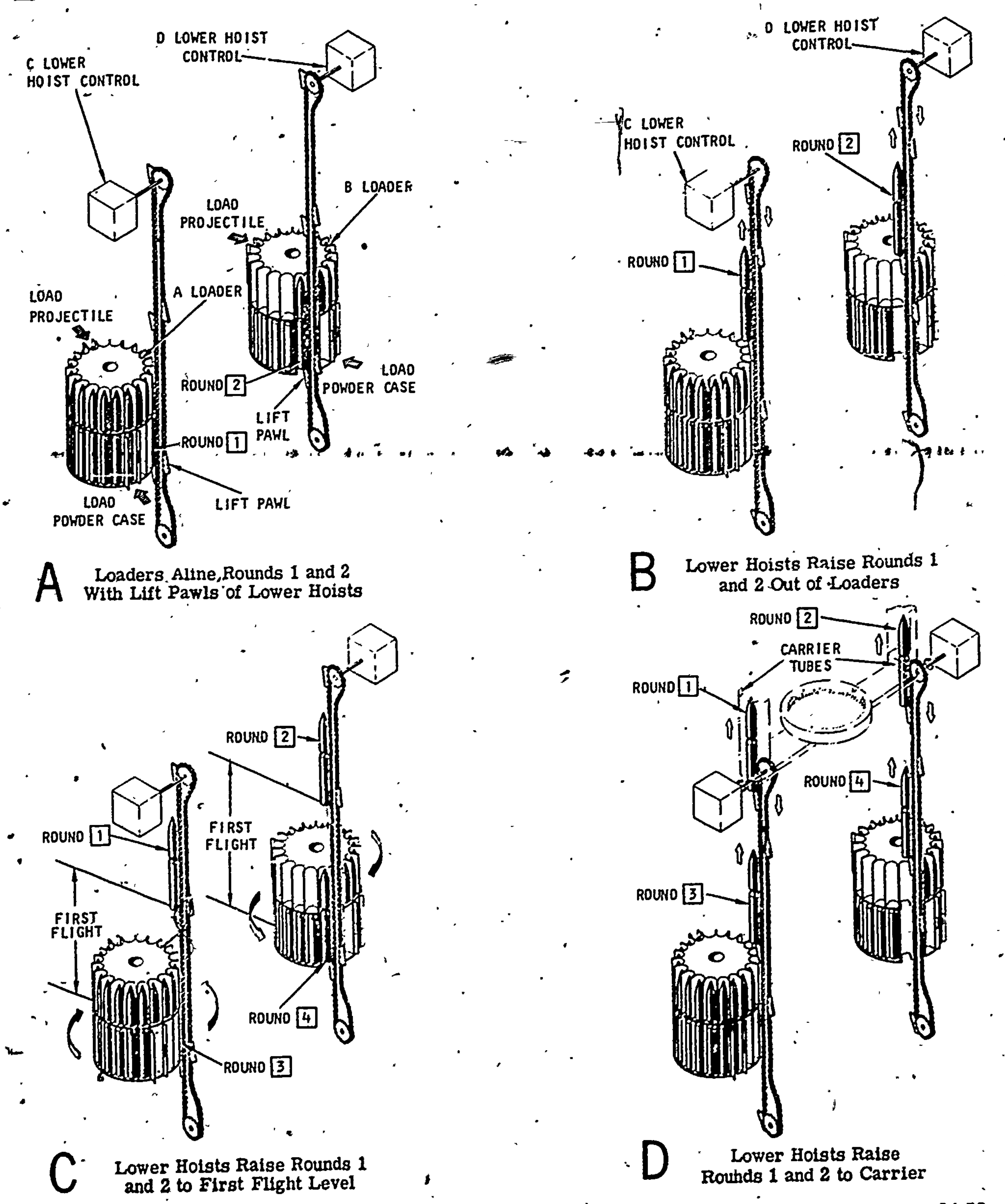
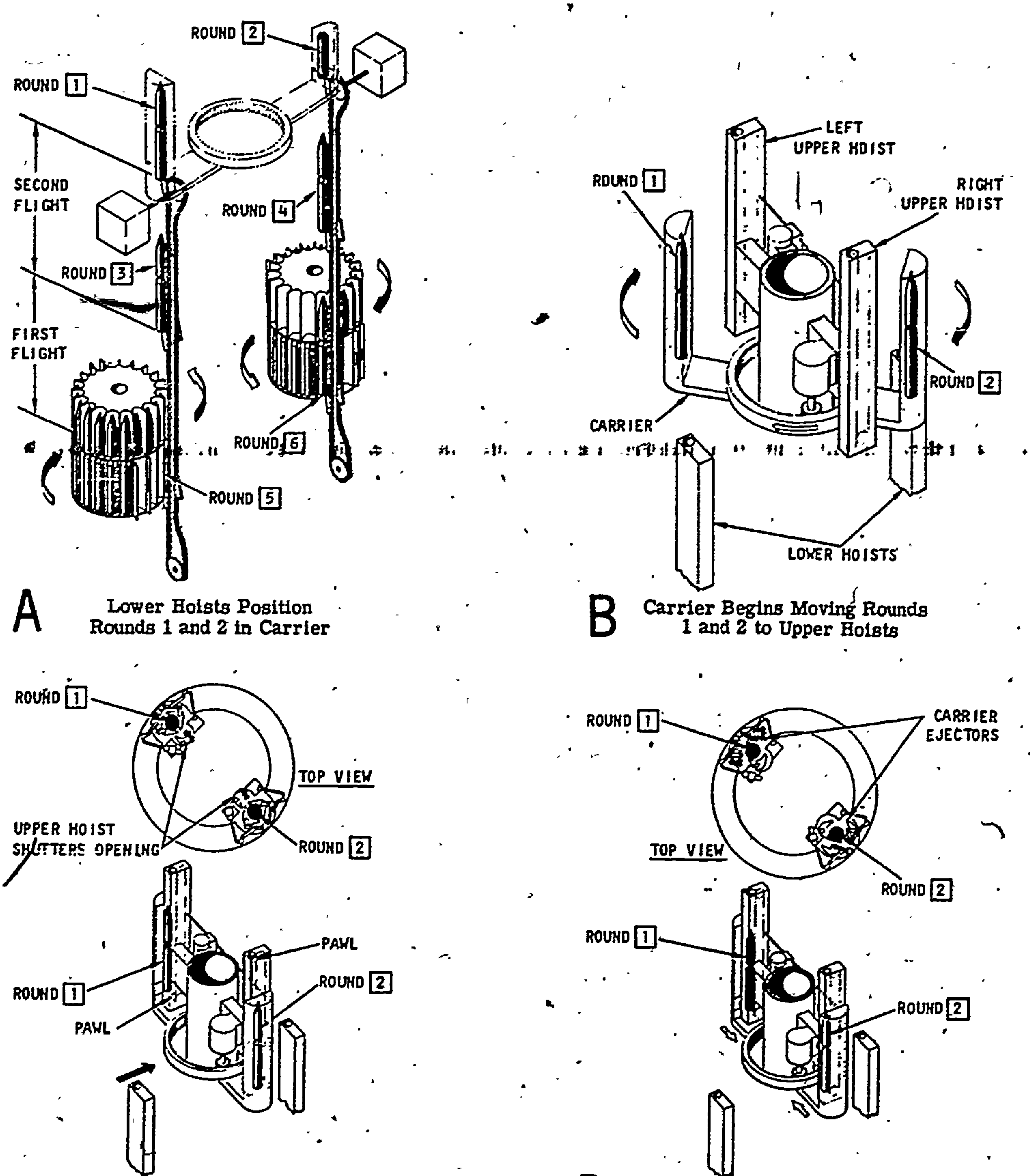


Figure 9-41.—From loader to carrier.



A Lower Hoists Position Rounds 1 and 2 in Carrier

B Carrier Begins Moving Rounds 1 and 2 to Upper Hoists

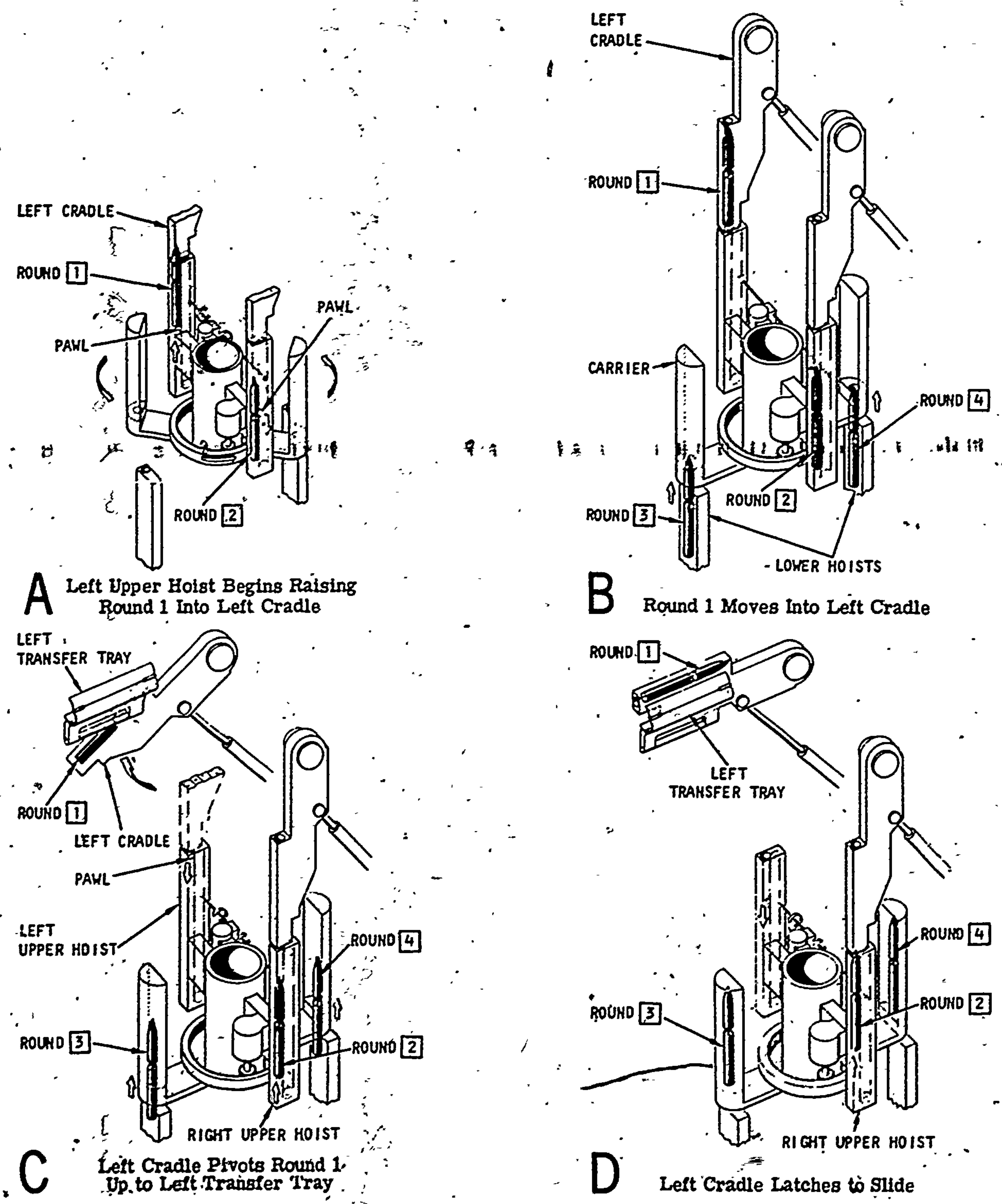
C Carrier Ejects Rounds 1 and 2 Into Upper Hoists

D Upper Hoists Prepare to Receive Rounds 1 and 2

84.79

Figure 9-42.—From carrier to upper hoist.

348



84.80

Figure 9-43.—From upper hoist to cradle.

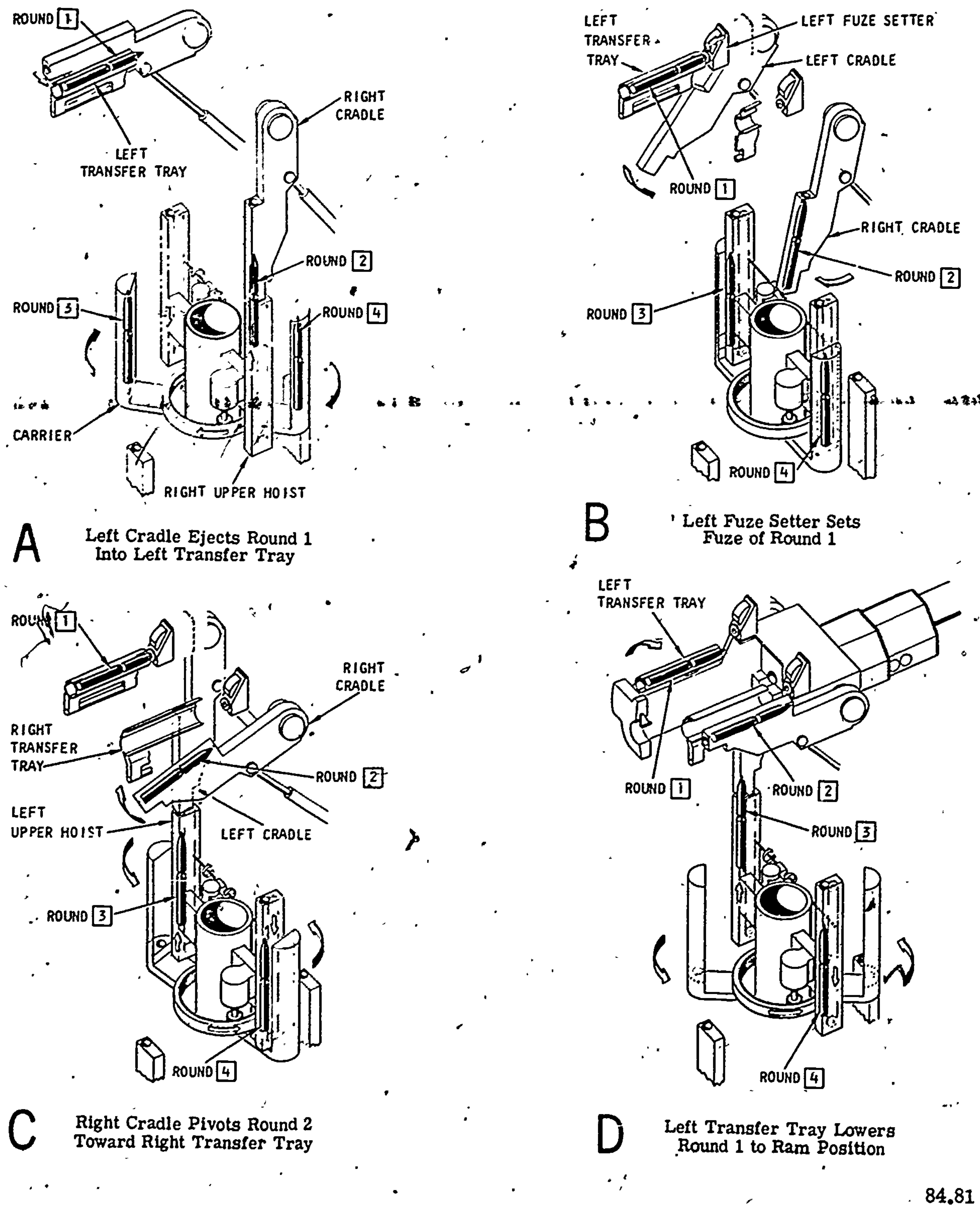
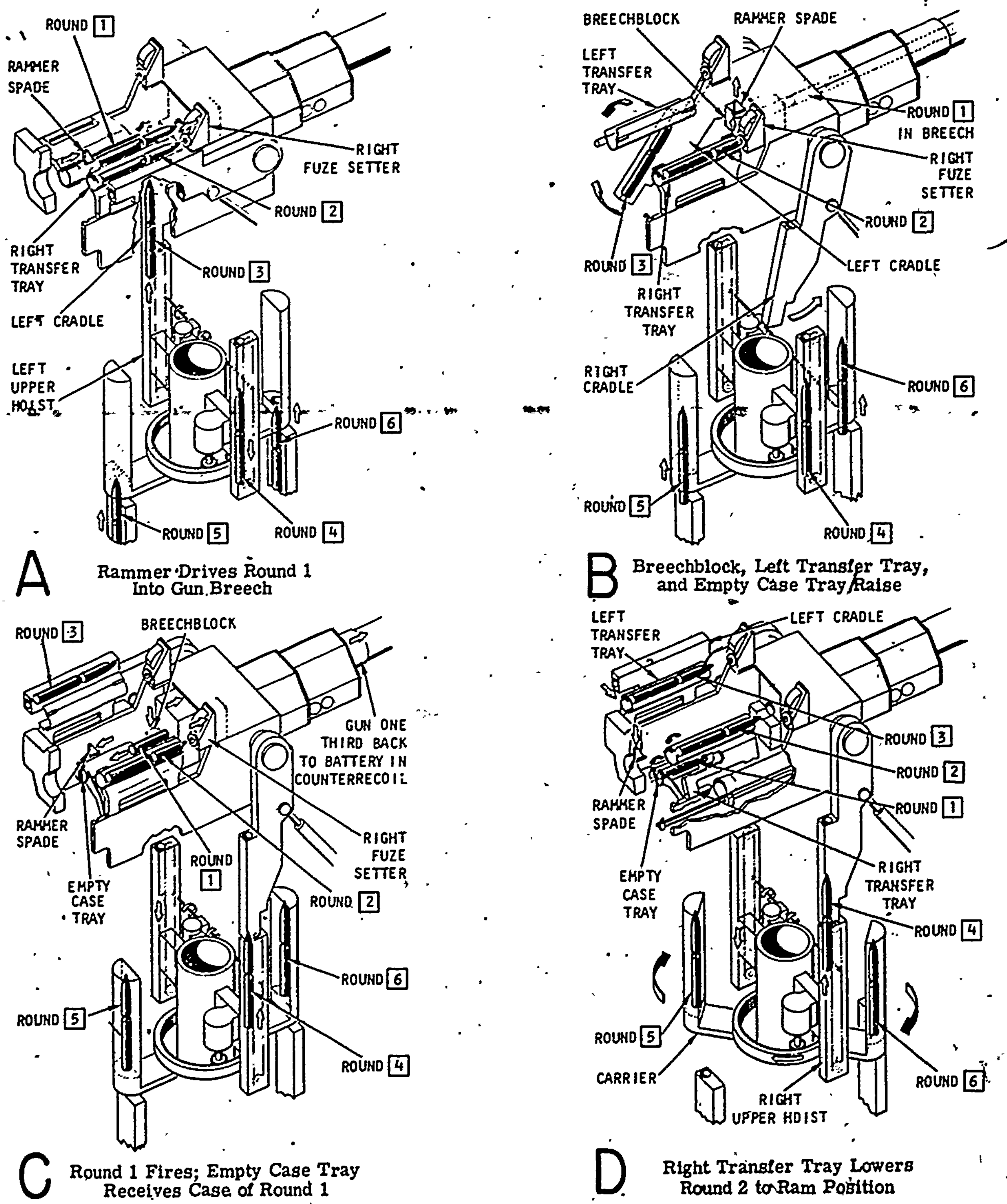


Figure 9-44.— From transfer tray to ram position.



A Rammer Drives Round 1 Into Gun Breech

B Breechblock, Left Transfer Tray, and Empty Case Tray Raise

C Round 1 Fires; Empty Case Tray Receives Case of Round 1

D Right Transfer Tray Lowers Round 2 to Ram Position

84.82

Figure 9-45.—From ram position to gun firing.

5"/54 MK 45 MOD 0

The Mk 45 gun mount (fig. 9-46) is a fully automated, single barrel weapon that stows, aims, and fires 5"/54 ammunition. A light weight gun mount, the Mk 45 provides surface escort vessels with a weapon for firing 70-pound projectiles at surface craft, low-altitude aircraft, and shore targets.

The mount offers outstanding reliability and maintainability, is served by a minimum of personnel, and is operated, monitered, and exercised remotely; personnel do not enter the gun house except for maintenance. Two safety keys located on the EP1 panel disable all gun loading circuits and one safety key located on the EP2 panel disables the gun laying circuits before the crew enters the gunhouse. One mount operator performs mount switching functions as directed for complete gun mount operation. The ammunition handlers load projectiles and powder cases into the lower hoist (on mounts with a lower hoist). In mounts that do not have a lower hoist, the ammunition is loaded into the upper loading station. The mount loader drum holds 20 rounds in ready service. The lower hoist replenishes the loader drum during sustained firing without interrupting the fire mission. For mounts without a lower hoist this is done via the upper loading station. The load and fire cycle can be interrupted if a special-purpose type of ammunition, such as star shell, is to be used, or if misfire—clearing is needed.

The mount design emphasizes crew safety. The crew need not enter the gunhouse to extract misfires. Misfires can be automatically and rapidly extracted, a clearing charge loaded, and the gun cleared and returned to service without personnel entering the gunhouse. A round can also be unloaded from the cradle automatically before the ram cycle is started. The EP2 operator initiates an Auto-Unload cycle which lowers the round to the upper hoist unload doors and the ammunition handlers manually remove the round from the upper hoist.

GUN MOUNT COMPONENTS

The mount has two structural component groups; (fig. 9-46) stationary and rotating. The stationary group of components include two operating panels EP1 and EP2 (the mount control system), lower hoist (if required), loader drum, fuze setter, upper hoist, and lower accumulator system.

The stationary group of the gunloading system components is in the loader room (fig. 9-46) and in the ammunition handling room (for mounts requiring a lower hoist) a compartment one or more decks below the loader room. The stationary components stow, select, and transfer ammunition (powder and projectile) to the rotating structure above deck. If the projectile of a selected round has a mechanical time fuze (MT), a fuze setter (mounted to the loader drum) sets the fuze before the round moves to the upper hoist. The panels, power distribution panel EP1 and control panel EP2, provide the means for one man to initiate and monitor operation of the gun mount.

The rotating group of components include the gun laying (train and elevation) systems, carriage, cradle, slide, gun barrel, upper accumulator system, and shield. These components rotate together on a stand secured to the weather deck. The stand forms a bearing, a roller path, for the rotating structure.

CONTROL SYSTEM

The gun mount control system consists of two control panels: EP1 power panel and EP2 control panel. The power panel (EP1) receives power from the ship's supply and distributes it within the mount and other panels.

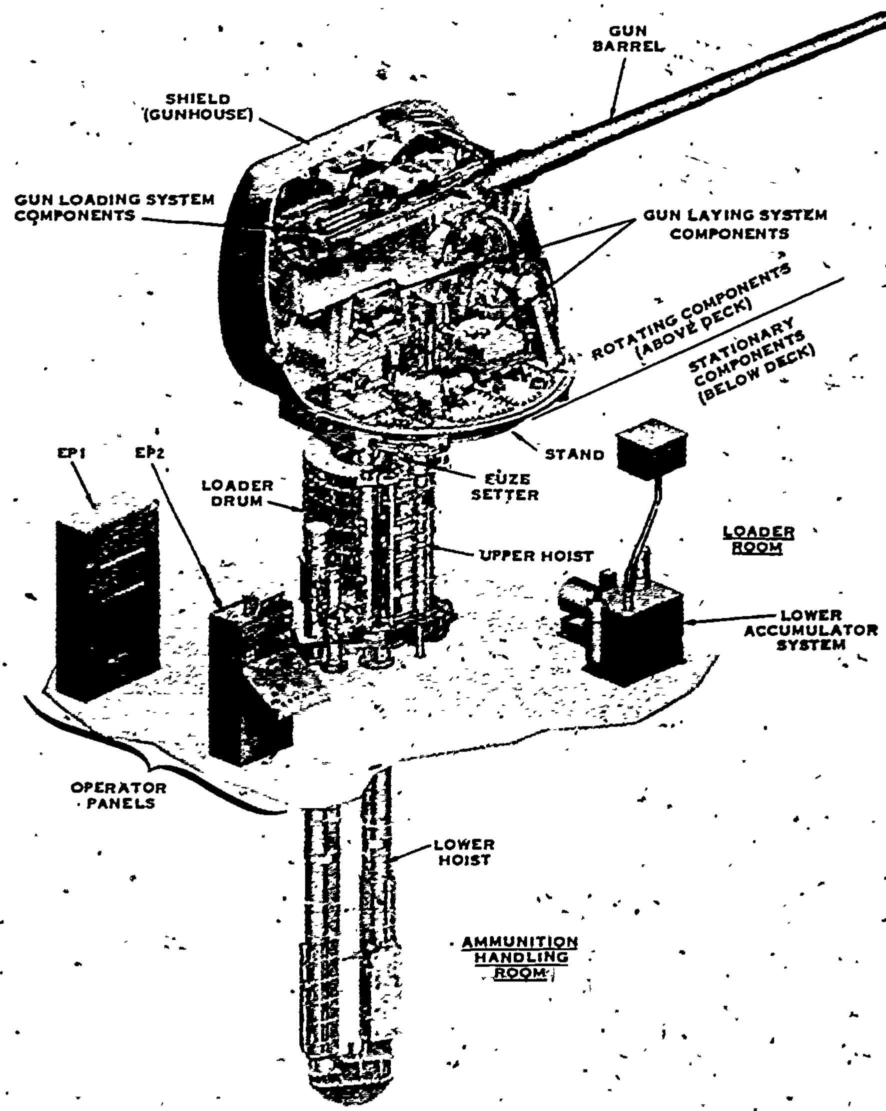
The control panel (EP2) permits selecting the various modes of mount operation. A test board, in the EP2 panel, is used for local control of the gun laying system and fuze setter.

The gun laying system positions the gun in both train and elevation, and consists of separate train and elevation power drive assemblies. These assemblies are electrically controlled and hydraulically operated in response to orders from either a remote fire control system, or the on mount local control system. A firing cutout system opens the firing circuit whenever the gun is positioned to a non-firing zone.

Unlike older gun mounts, the firing cutout cams are located in the train and elevation receiver-regulators.

The mount local control system permits total system exercise and test. One man can activate and exercise the mount and verify mount operation ability in less than 5 minutes.

A troubleshooting status board located within the EP2 panel is used in conjunction with indicating lights and dials, to pin point the cause of mount stoppage. Standardized parts are used extensively, and many of the amplifiers and logic circuit cards are physically and functionally interchangeable.



84.405

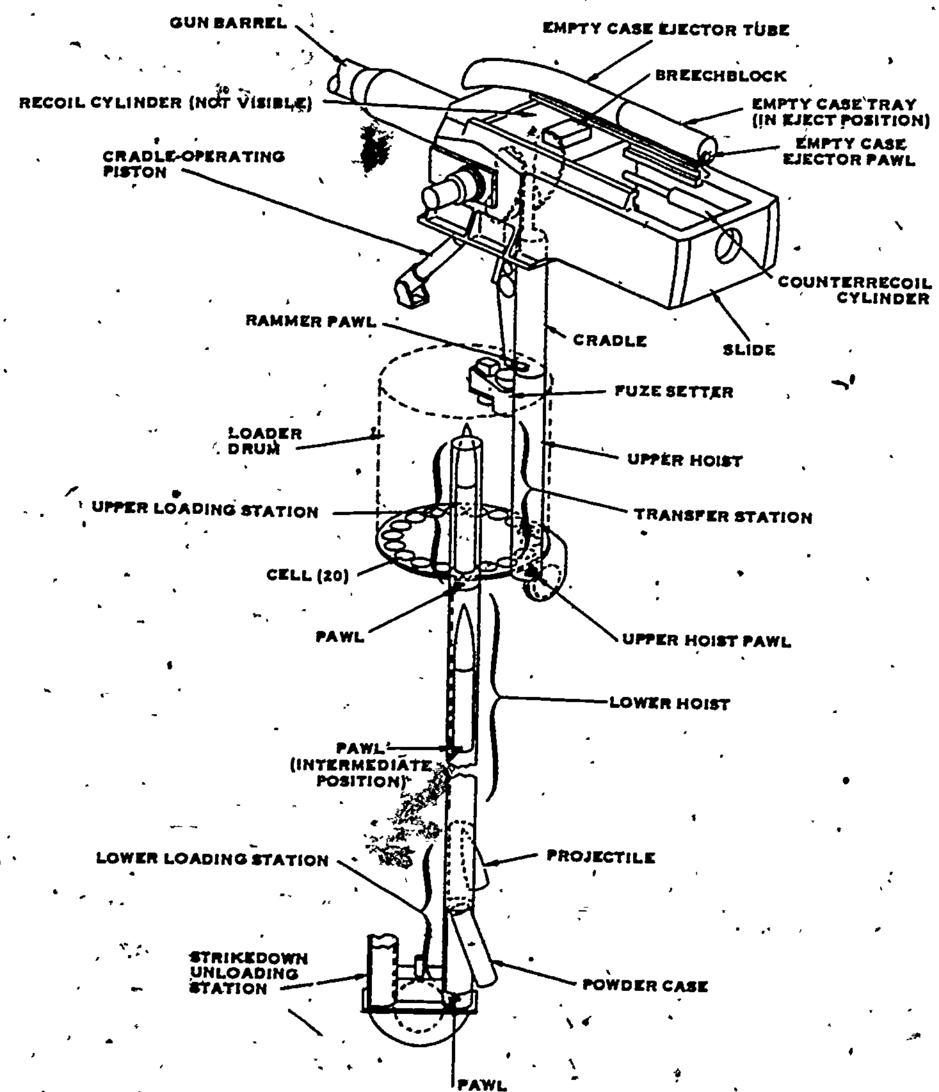
Figure 9-46.—5-inch 54-Caliber Gun Mount Mk 45 Mod 0: General arrangement.

LOAD AND FIRE OPERATION

Before a load-and-fire operation begins, the loader drum may be loaded with the selected type of ammunition. To load the loader drum (fig. 9-47), ammunition handlers manually insert powder cases and projectiles into the lower hoist. The lower hoist automatically raises the rounds to the upper loading station, where an ejector transfers them into empty cells of the loader drum.

With a load-and-fire order in effect, the loader drum indexes until it positions a round of ammunition in the transfer station at the upper hoist (fig. 9-48). At the transfer station, a positioning mechanism aligns the round with the fuze setter mounted overhead. If the projectile has an MT fuze, the fuze setter extends, sets the fuze, and retracts. An ejector then transfers the round into the upper hoist (fig. 9-49).

With the first round ejected into the hoist and the hoist raising, the loader drum indexes clockwise to bring the next loaded cell to the transfer



84.406

Figure 9-47. —Loading loader drum.

station (fig. 9-50). The fuze setter extends and sets the fuze on this projectile while the upper hoist pawl raises the first round into the cradle, which at this time, is at hoist position.

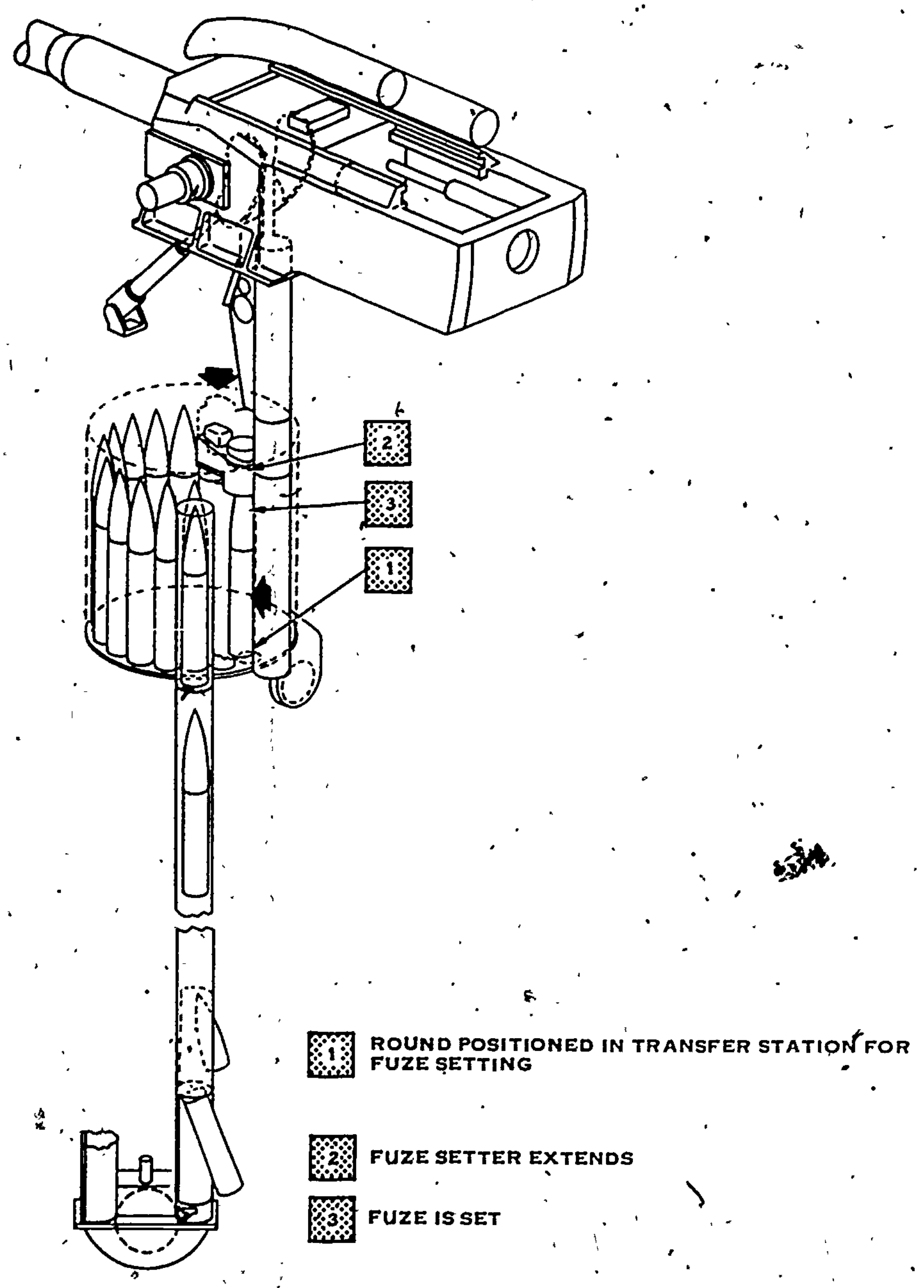
The cradle pawl holds the round while the hoist pawl begins to lower for the second round (fig. 9-51). When the hoist pawl is clear of the cradle, the cradle unlatches and pivots upward (raises) to align the round with the breech bore.

As the cradle raises, a pawl moves the round farther into the cradle and the rammer pawl extends into position behind the round for ramming.

When the cradle latches to the slide, the rammer moves the round into the breech. The breechblock partially lowers to hold the round in the breech while the rammer retracts (fig. 9-52) and cradle unlatches and pivots downward (lowers) to align with the upper hoist. Free from interference, the breechblock closes (fig. 9-53) and the empty case tray lowers.

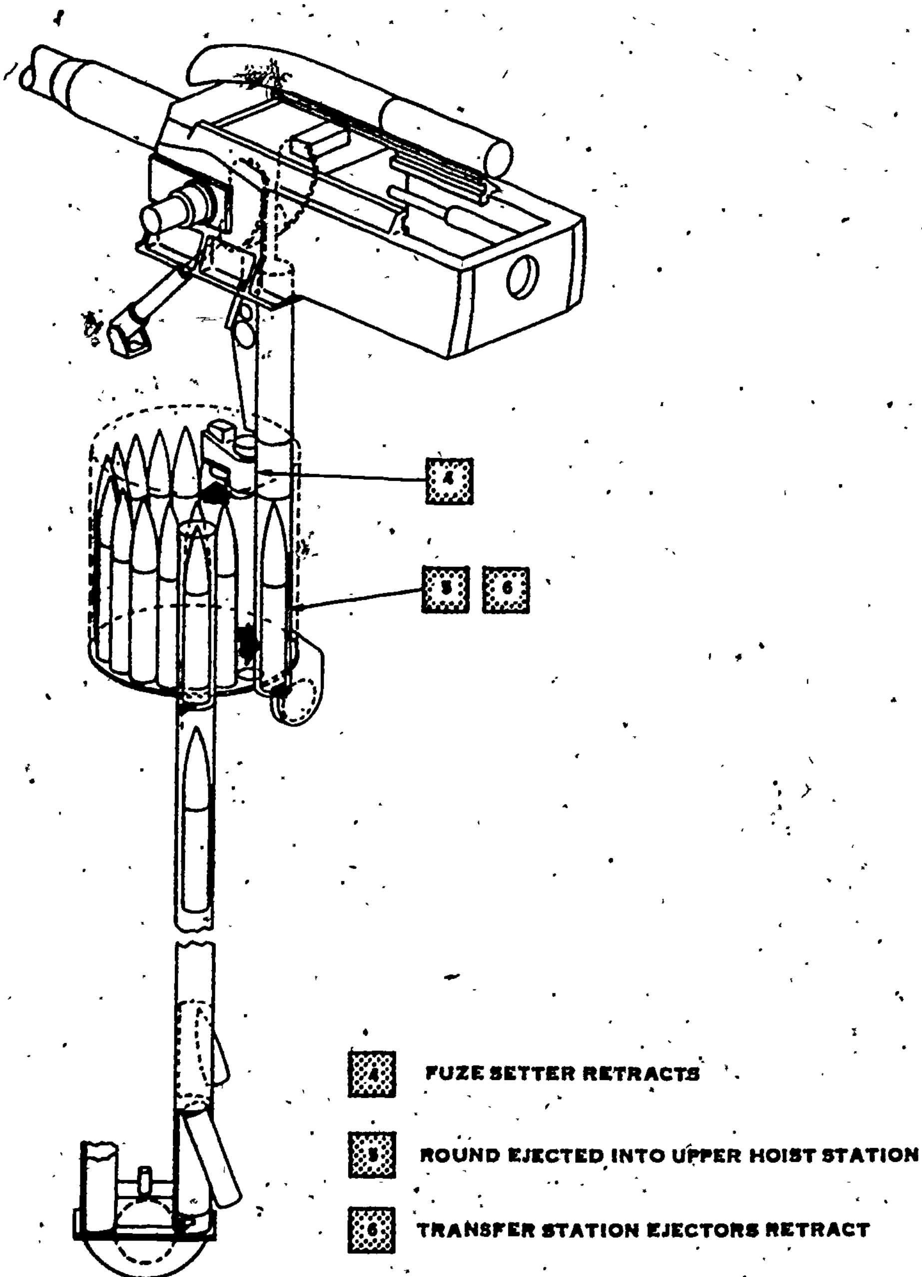
As soon as the empty case tray latches to the gun, the gun fires.

The firing of the powder case causes the gun to recoil (fig. 9-54).



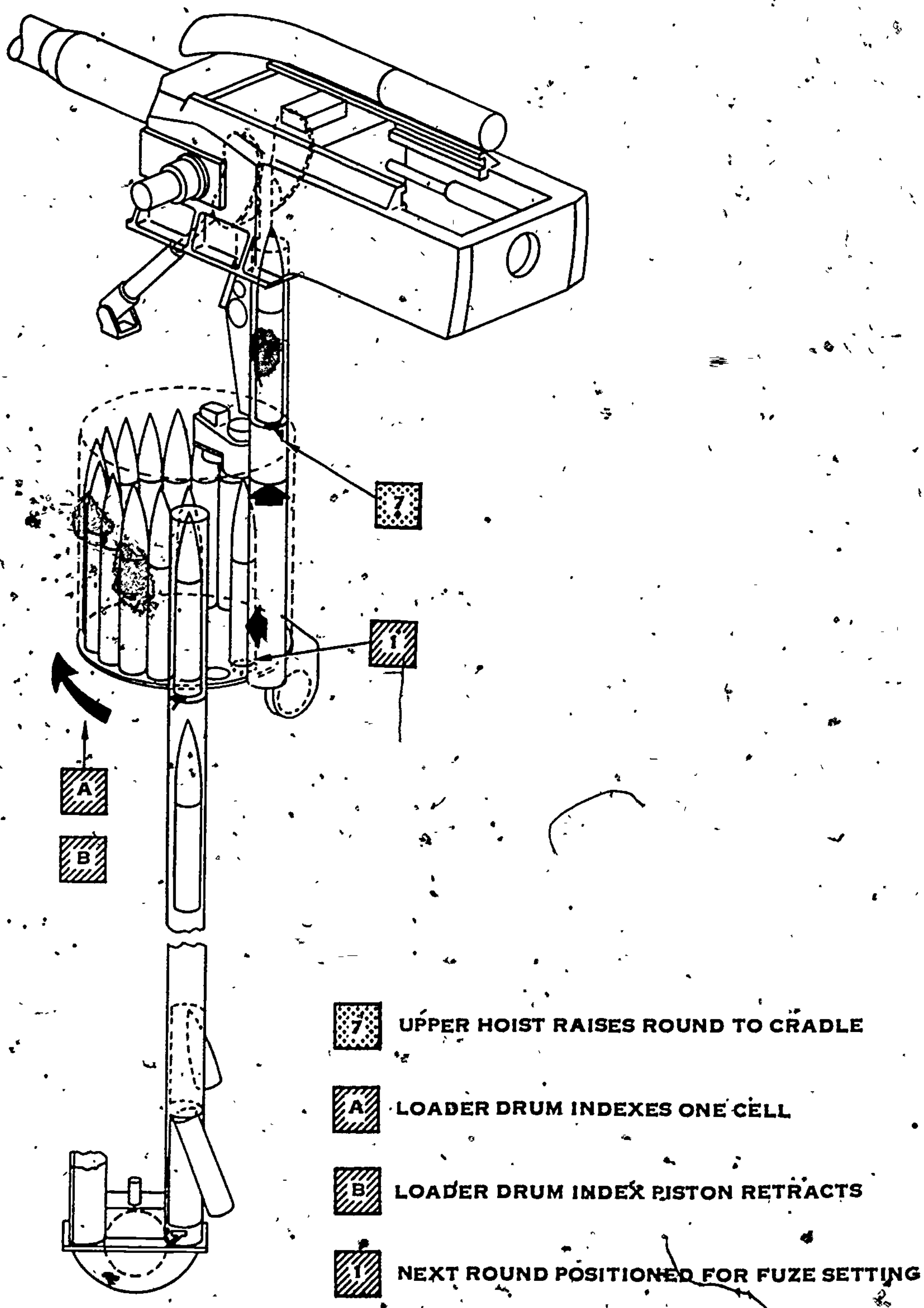
84.407

Figure 9-48.—Fuze set on round 1.



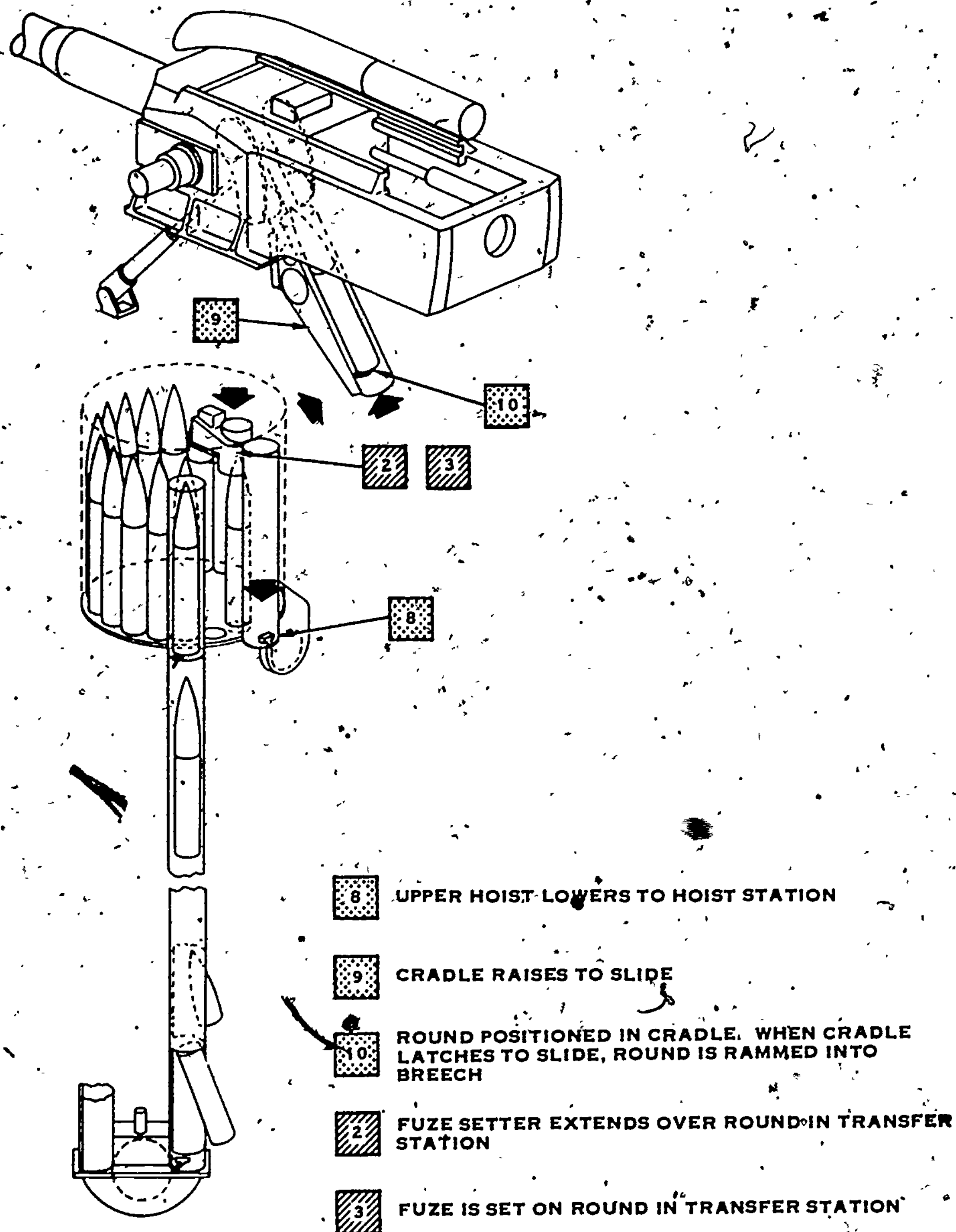
84.408

Figure 9-49. — Ejectors transfer round 1 to upper hoist station.



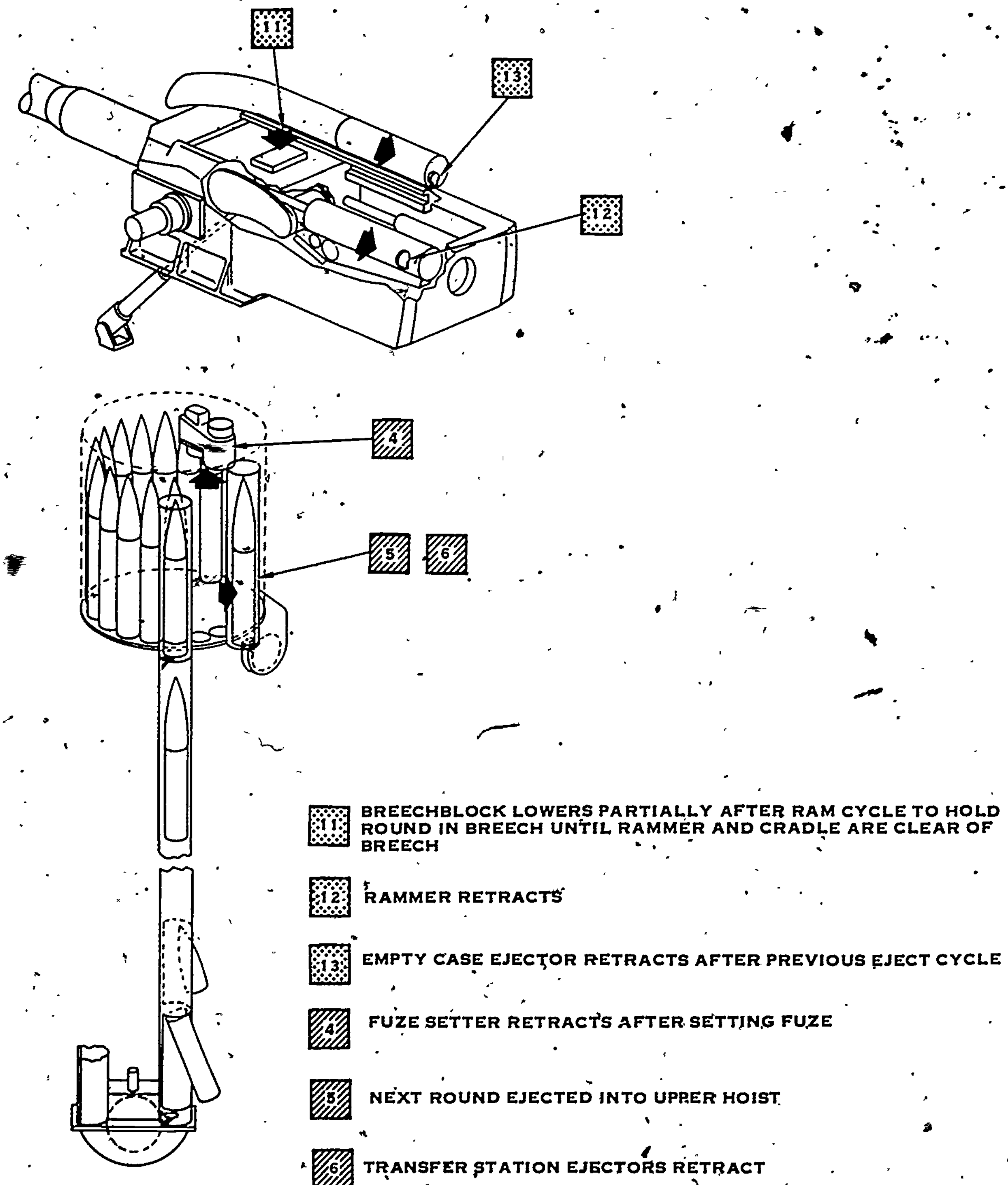
84.409

Figure 9-50.—Hoist raises round 1 to cradle.



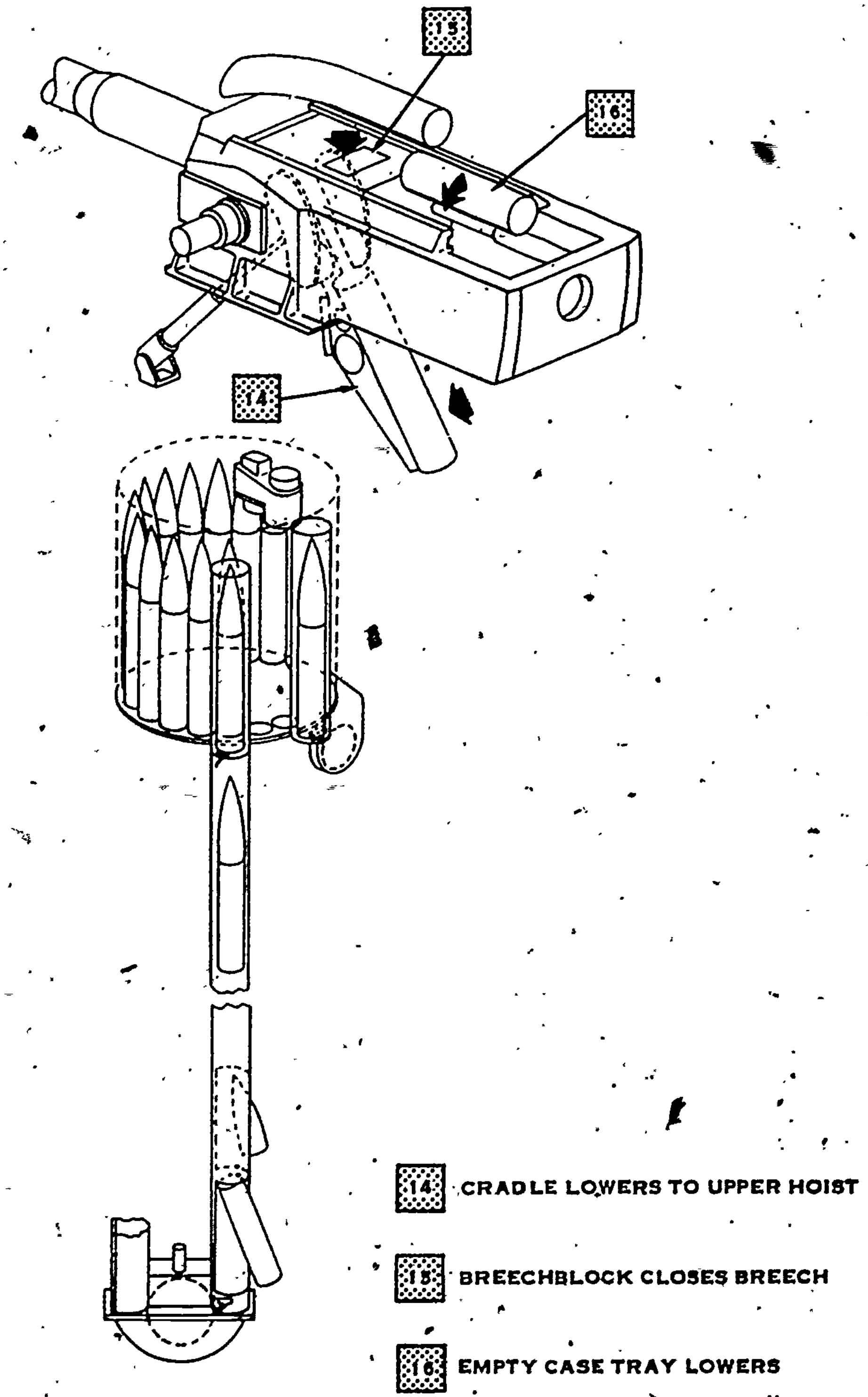
84.410

Figure 9-51. — Cradle raises round 1 to slide; Fuze set on round 2.



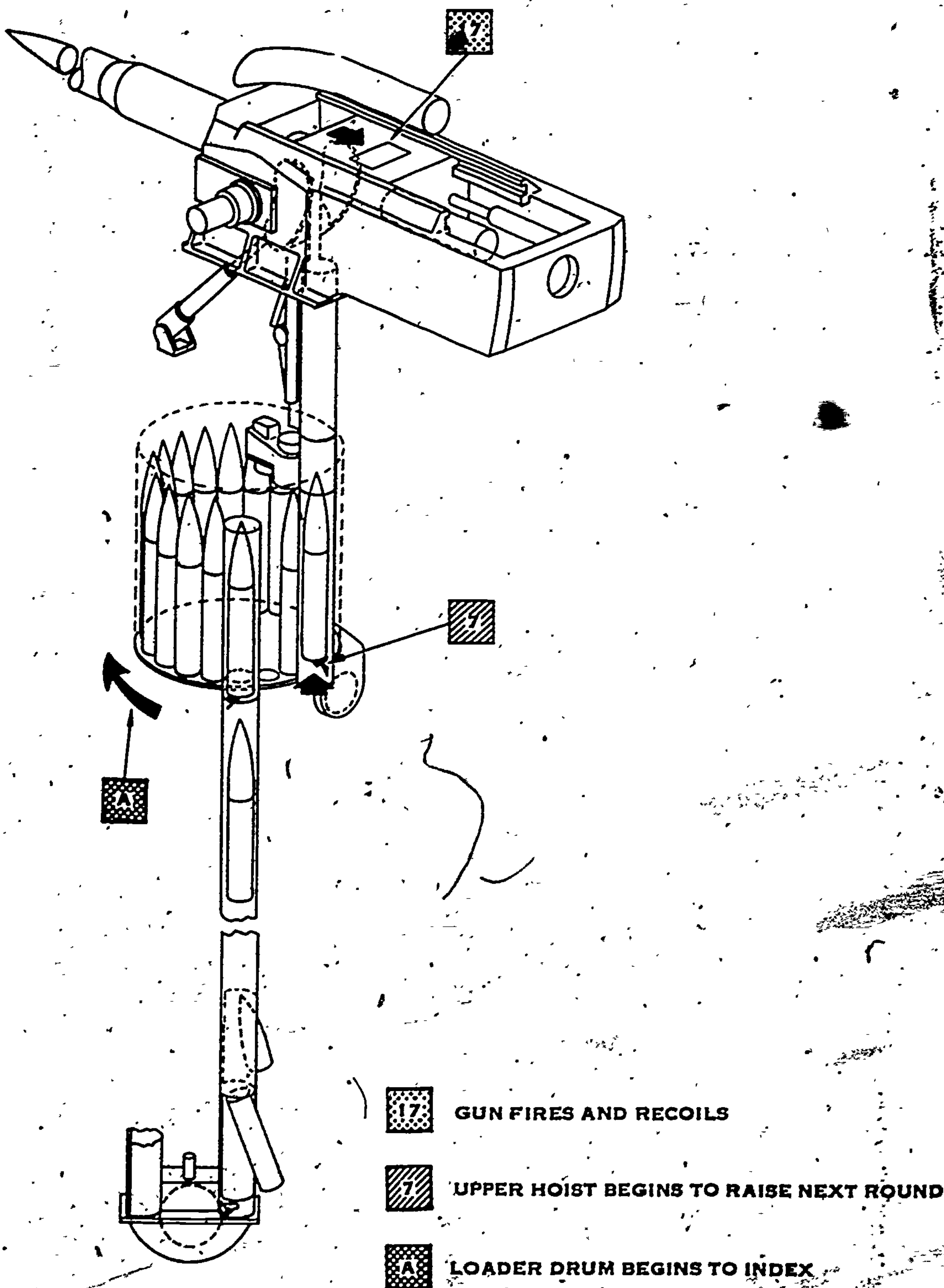
84.411

Figure 9-52.—Rammer loads round 1 into breech; Ejectors transfer round 2 to upper hoist station.



84.412

Figure 9-53. — Breech closes on round 1; Cradle lowers to upper hoist.



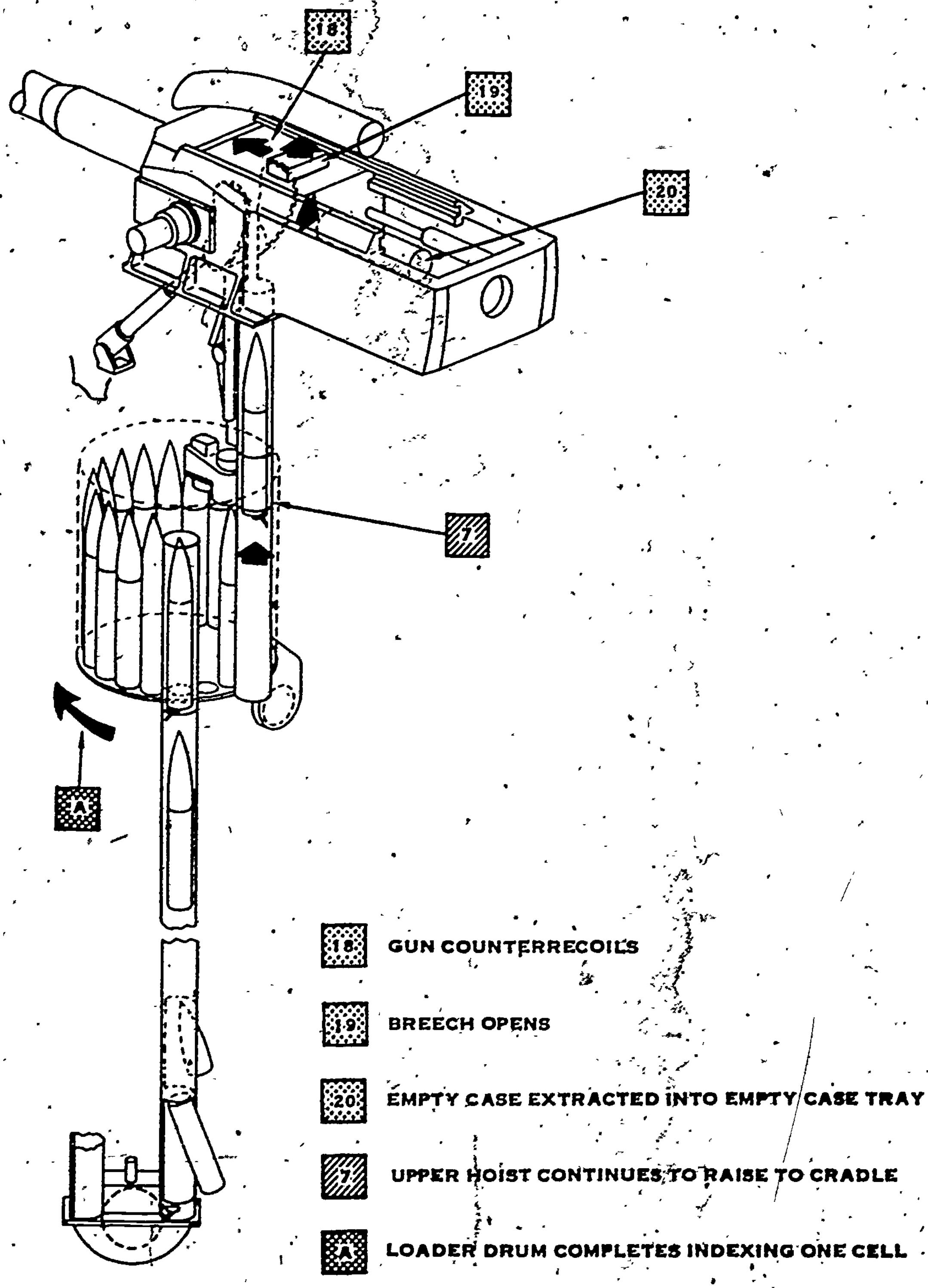
84.413

Figure 9-54.—Gun fires round 1; Hoist raises round 2 to cradle.

At the end of recoil, counterrecoil pistons return the gun to battery (fig. 9-55) position. While the gun counterrecoils, the breech opens (breechblock raises) and the extractors pull the spent powder case from the breech into the waiting empty case tray. The empty case tray raises into alignment with the empty case tube (fig. 9-56), the gas ejector expels the gases, the empty case ejector door opens, and a pawl ejects the powder case from the shield.

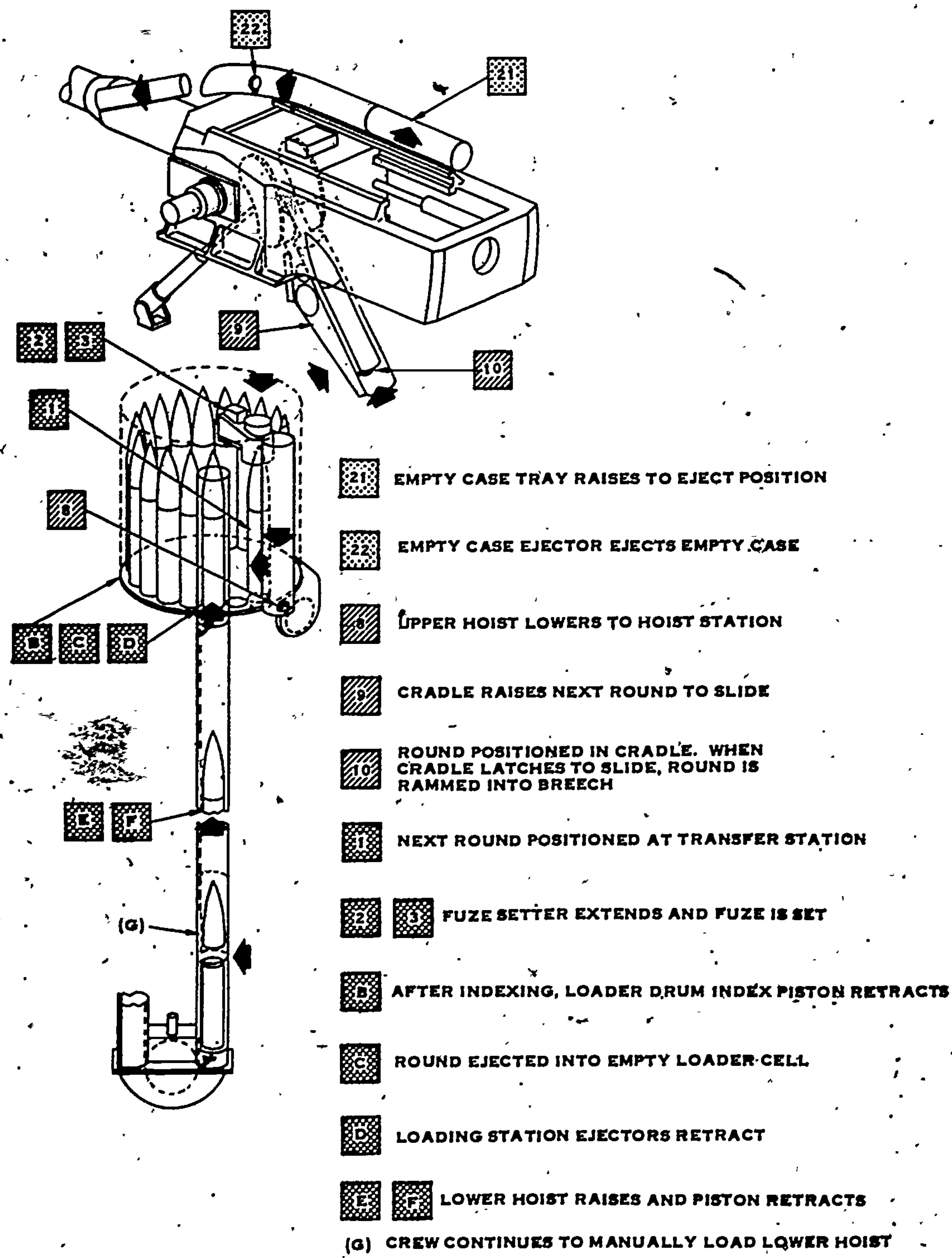
When the pawl of the upper hoist returns to its down position, an ejector transfers the second round into the upper hoist. The loader drum then indexes the next cell (third round) clockwise to the transfer station. This movement positions the empty cell of the first round at the upper loading station and places the empty cell of the second round between the transfer station and the upper loading station. After the upper hoist raises the second round into the cradle, the positioning mechanism in the loader drum aligns the third round with the fuze setter, which extends and sets the fuze. At this time, an ejector transfers another round from the lower hoist into the empty cell at the loading station. This indexing and transferring of rounds continues in the same manner.

The cell between the loading station and the transfer station always remains available for loading a special round (alternate load operation). If Weapons Control orders a special round, the loader drum indexes one cell clockwise and the loading station ejectors eject the round into the empty cell of the loader. The loader drum then indexes counterclockwise two cells to position the special round at the transfer station.



84.414

Figure 9-55.—Extractors remove empty case of round 1.



84.415

Figure 9-56.—Empty case tray raises round 1 case for ejection; Cradle raises round 2 to slide.

CHAPTER 10

BREECH MECHANISMS

From the preceding chapter you learned that the primary purpose of a breech mechanism is to seal off the rear end of a gun tube. Currently all guns in U.S. Navy gun mounts use sliding-wedge breechblocks. Some of these breechblocks must be opened manually when ordered to load the gun for firing, others are opened hydraulically through a piston arrangement connected to the breechblock.

Regardless of their method of operation, all breech mechanisms must meet the following requirements:

1. Be capable of rapid opening and closing.
2. Have a means to keep the propellant gases in the gun chamber.
3. Incorporate the essential parts of a firing mechanism.

In our discussion of breech mechanisms we break down the above listed requirements in a way that will enable you to explain both the hydraulic and mechanical operating cycle of the various breech mechanisms, and describe the function and operation of their gas check systems. We explain the purpose and operation of the firing cutout systems, and the function of firing mechanisms. We also explain how to test firing circuits and firing cutout systems.

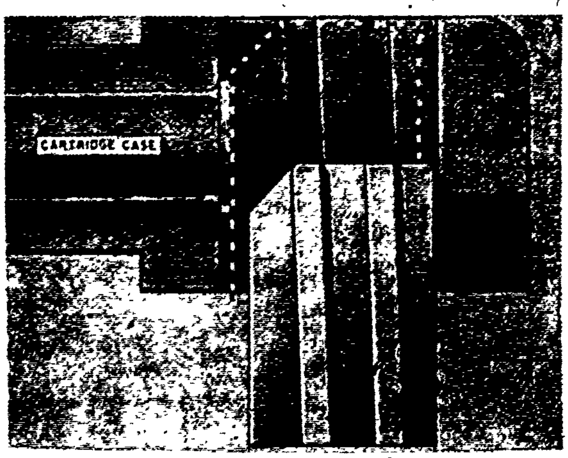
SLIDING—WEDGE BREECHBLOCK

Sliding-wedge breechblocks are used in all case type guns that employ either fixed or separated ammunition. This type breechblock is a heavy steel forging that is sturdy enough to withstand the high gas pressures built up in the gun chambers of the guns they are used on. The largest gun employed by the Navy to use the sliding-wedge breechblock is the 8"/55RF gun.

In figure 10-1 you see (in simplified form) the elements of a sliding-wedge breech mechanism as it looks from the side, with the breechblock or plug in the lowered (open) position. The dotted outline represents the breechblock in its raised (closed) position. If you look carefully, you'll notice that the grooves in which the plug slides up and down are not exactly vertical; they're slanted slightly forward from bottom to top. You can see that, in its open position, the plug is noticeably aft of its closed position. In other words, in rising to the closed position, the breechblock moves forward as well as upward.

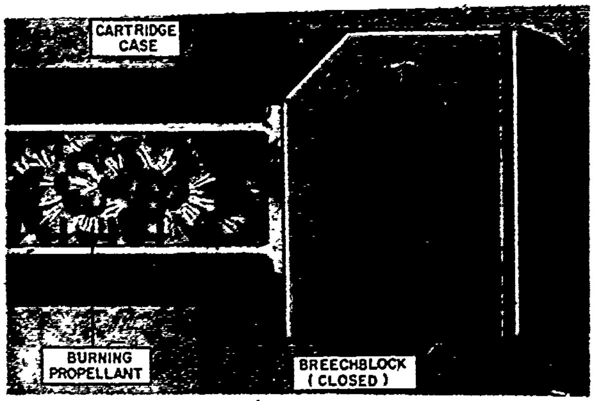
The effect of the breechblock's forward movement as it closes is to wedge the cartridge case into the gun chamber (hence the name sliding-wedge breech mechanism). Wedging the cartridge case in the chamber prevents it from moving rearward, thereby assisting in improving the gas seal.

Guns using case ammunition use the expansion type gas-check system. The major part of this system is the cartridge case. To understand this system, look at figure 10-2. The cartridge



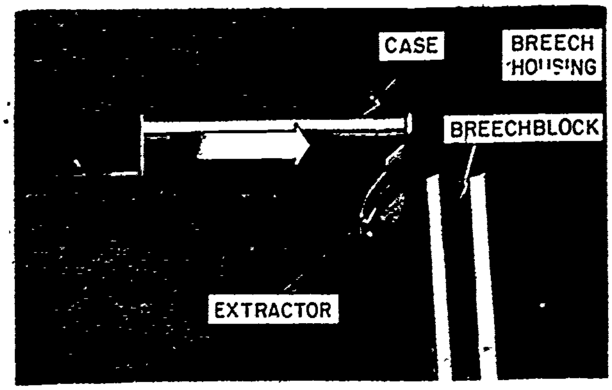
84.145

Figure 10-1.—Principle of the sliding wedge breechblock.



84.156

Figure 10-2.—Sealing the breech by expansion.



84.157

Figure 10-3.—Schematic of case extraction.

case seals off the chamber and the space between the housing and the breech plug, and prevents gases from escaping to the rear. When the propellant is ignited, the powder gases expand the cartridge case against the wall of chamber and the breechblock. The gas can only escape forward, driving the projectile out the bore.

After the gun has fired and the projectile has left the muzzle, we still have to remove the cartridge case from the chamber. Getting the case out of the chamber is a job for the extractors.

Extractor operation is shown in figure 10-3. Only one extractor is shown; there is another on the opposite side. The extractors have lips which fit in front of the rim on the cartridge case. When the breechblock is up, the tops of the extractors are forward, and the bottoms (which have a lug riding in a breechblock camway) are aft. When the breechblock drops, the bottom of the extractor is cammed forward. This causes the top of the extractor to move aft, flipping the cartridge case out of the gun chamber.

The main purpose of all extractors is to exatract the empty case. They differ in design, however, from one type of gun to another. You will study three types of extractors in the remainder of this chapter.

BREECH OPERATING MECHANISM (5''/38)

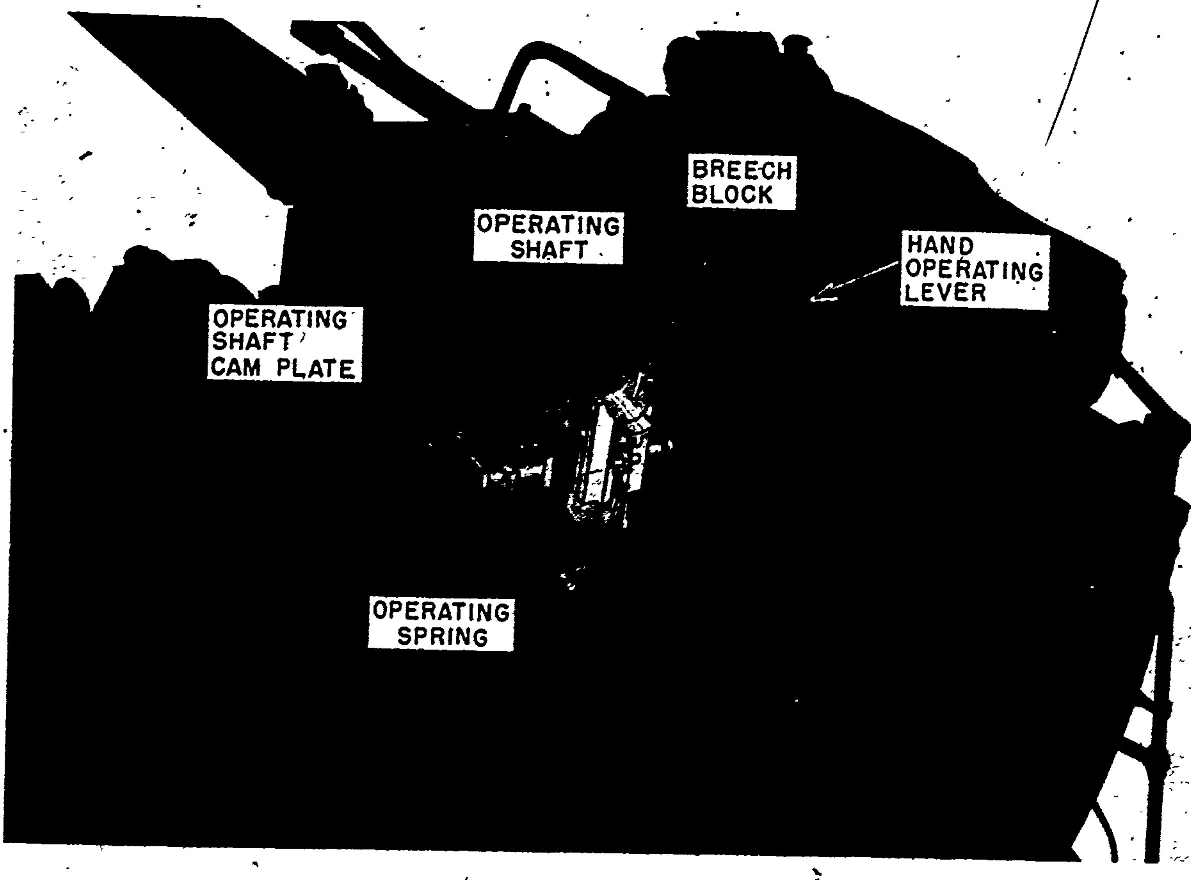
Figure 10-4 shows the basic components of the breech operating mechanism as you would see them if the slide and housing were clear glass instead of steel. The breechblock is closed. Under the breechblock and linked to it is the operating shaft, which is coupled to the operating spring.

The right end of the operating shaft is linked to the hand operating lever on the right side of the slide. At the left end of the operating shaft are the operating shaft crank and the operating shaft cam plate.

NOTE: We are looking at a single mount here. The left-hand gun of a twin mount is set up similarly but most parts are of opposite hand.

A crank arm on the operating shaft is linked to the breechblock by two bearing blocks (not visible in fig. 10-4) that slide in ways in the breechblock. When the arm rotates, the breechblock moves up or down (depending on direction of rotation) in the breechway. The shaft rotates to lower the block either when the hand operating lever on its right is operated while the gun is in battery, or when the crank on its left end is cammed by an operating shaft cam plate as the housing returns to battery after firing. In either case this rotation compresses the operating spring, which is linked to the operating shaft by a chain. The extractors lock the block down until the cartridge case being rammed into the chamber pulls them forward (or they may be unlocked manually by a special tool). In either case, spring thrust pulls the block up, and it is locked closed by the salvo latch (figs. 10-5 and 10-10).

All these movements can be traced out in figure 10-5. The operating spring pulls (arrow No.1), the shaft turns (2), the breechblock rises



84.158

Figure 10-4.—Breech operating mechanism (5''/38).

(3), and the extractors are cammed by the inner lug slot in the block (4). All these movements, naturally, reverse when the shaft is turned (either automatically or by the hand operating lever) in the opposite direction. The cam plate has been omitted from figure 10-5 for clarity.

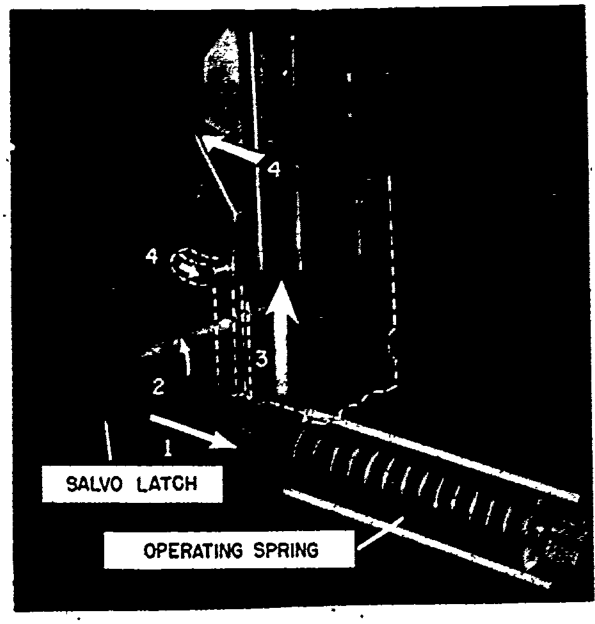
Now let's follow the functioning cycle of the mechanism. As we watch it go through its paces, we'll look first at the breechblock and extractors.

FUNCTIONING OF BREECHBLOCK AND EXTRACTORS (5''/38 BREECH MECHANISM)

Let's begin with the breech open. The breechblock is locked down and the operating shaft crank is under the cam plate. Figure 10-6 shows this condition.

For the moment, disregard the rammer spade and cartridge case in the figure, but notice how the extractors (only one is shown) lock the breechblock down. The breechblock is constantly under the upward thrust of the breech operating spring (working through the operating shaft). Each extractor has at its bottom two cylindrical lugs. The outer lug (fig. 10-6A) is under the constant forward thrust of a spring-loaded plunger (not shown). As the extractor works back and forth, this outer lug oscillates in a small arc in a kidney-shaped slot in the housing, sketched in fig. 10-6C. The inner lug (dotted circle) engages a long camming slot in the breechblock. At the top of the slot is a small flat-topped pallet of hardened metal. When the breechblock is in open (down) position, its upward thrust forces the pallets against the inner lugs of the extractors. Both because the pallet tops are flat, and because of the plunger spring's forward thrust on the outer lugs, the inner lug of each extractor remains seated on its pallet, locking the breechblock down so long as the extractors are otherwise undisturbed.

367



84.159
Figure 10-5.—Motions of breech mechanism components (5''/38).

Now let's put the rammer spade and powder case back into the picture. The rammer pushes the case forward. The powder case rim pulls the extractors forward. This disengages the extractor inner lugs from the pallets. The breechblock unlocks and begins to rise. Figure 10-6B shows the breechblock up about halfway, pushing the rammer spade up, and the extractors rocking forward.

In figure 10-6C the breechblock has closed and locked, and the gun is ready to fire. The extractor lip is fully forward, nested in its cavity in the housing. The rammer spade is pushed all the way up.

Between figures 10-6C and 10-6D the gun has fired. The housing and gun barrel have moved aft in recoil, and have almost completed their forward (counterrecoil) movement to battery. The breechblock automatically begins to move downward, and the inner lug slot pushes the extractor inner lug forward. As a result, the extractor lip begins to rock backward, pulling the cartridge case rim with it. Arrows show how the various parts move. The extractors flip the cartridge case to the rear. When the block is fully down, the extractor inner lugs lock against the pallets, holding the block open, as it was at the start of the cycle.

FUNCTIONING OF CAM PLATE AND SHAFT CRANK (5''/38 BREECH MECHANISM)

Now let's follow the other parts of the breech mechanism during this cycle. We've already seen that the breechblock is lifted automatically whenever the extractors' upper ends are pushed forward. The breech operating spring does this by rotating the operating shaft. The block is lowered by action of the operating shaft cam plate. This is a spring-loaded flat plate hinged to the inner surface of the left side of the slide. Figure 10-7 shows the housing moving forward in counterrecoil. The breechblock is up, as shown by the erect position of the operating shaft crank. When the crank lug contacts the cam plate, the lug follows the outer cammed surface of the plate and forces the crank to rotate. This moves the breechblock down, operating the extractors, and causing them to lock the breechblock open.

In recoil movement, the crank lug merely pushes the cam plate back against its spring as it goes by, and the crank does not turn.

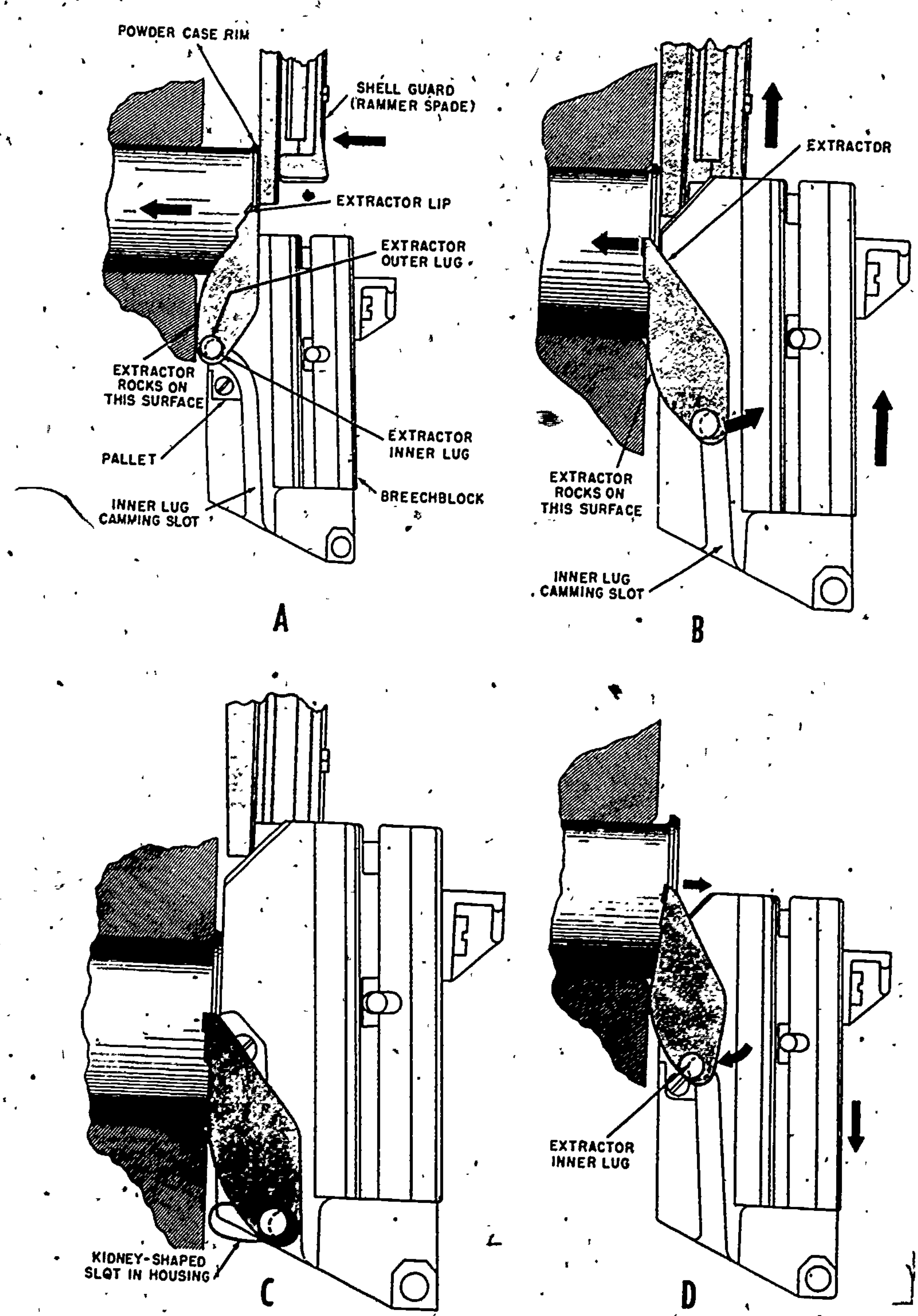
Note that the cam plate functions only to open the breech during counterrecoil. It does not hold the breech open; the extractors do that. A clearance cut in the inner side of the cam plate allows the crank to turn when the breechblock rises while the housing is in battery.

Hand Operation

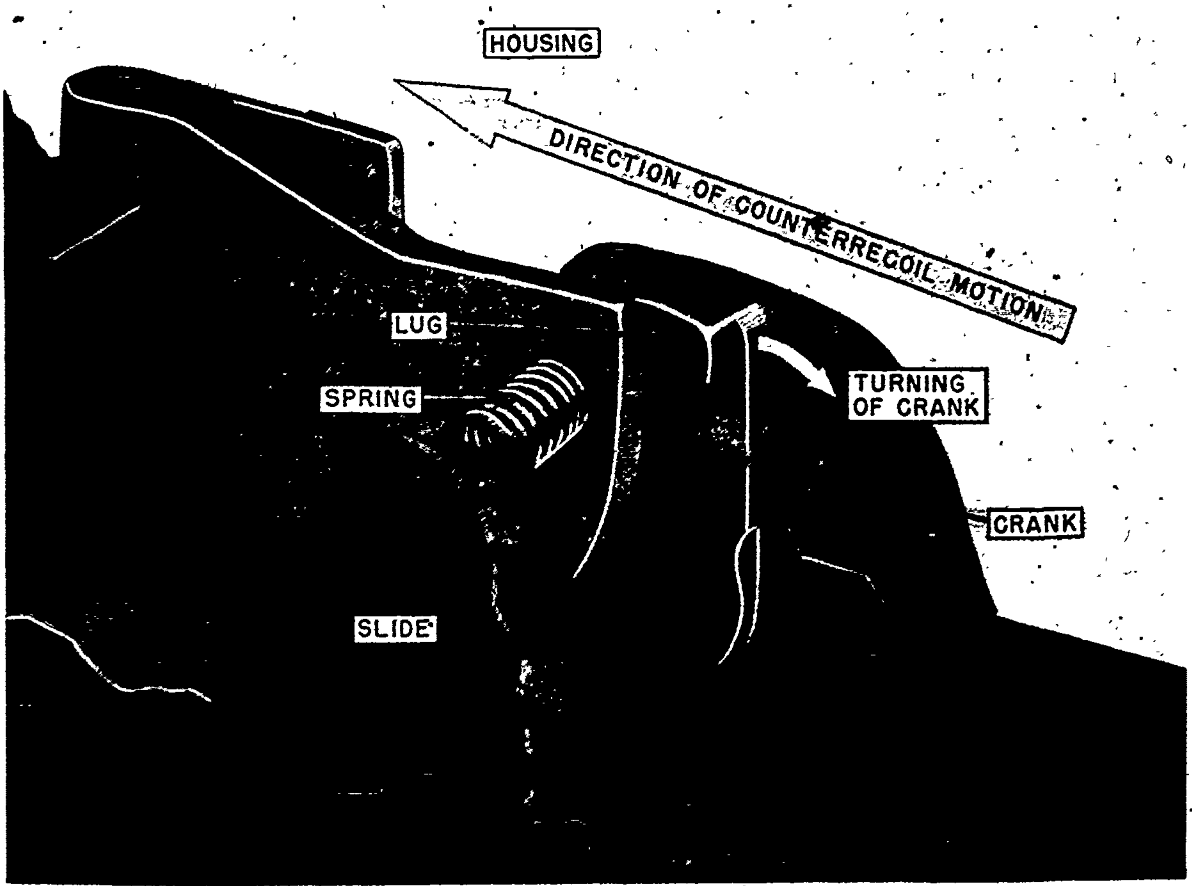
There are times when you operate the 5''/38 breech mechanism by hand. You do that when something goes wrong—if the operating spring or chain should break, for instance. And there are routine occasions for hand operation too —when you open the breech for the first round to be fired, and for inspection, cleaning, or bore-sighting. You use the hand operating lever, which will raise or lower the plug when the gun is in battery. Pulling the lever to the rear opens the plug.

CAUTION: After you've opened the breech manually, return the lever to breech closed (stowed) position where it is locked in place by the lever latch. If the lever is left to the rear, the rising breechblock will make it slam forward, and this can be rough on any part of your anatomy that may be in its path.

To see its working parts, look at figure 10-8 which shows the hand operating linkage as it is mounted on the right side of the slide and, in particular, shows in detail the sliding latch, the lever that sets the sliding latch, the



84.160
Figure 10-6. — 5"/38 breech mechanism; breechblock and extractor action. A. Powder case rim engaging extractor lip; breechblock open. B. Powder case rammed; breechblock rising to wedge case. C. breechblock in closed position; ready to fire. D. Breech opening; beginning of extraction.



84.161
Figure 10-7.—5"/38 breech mechanism. Cam plate and operating shaft crank action during recoil.

operating shaft crank on the operating shaft, and the hand operating crank which is part of the latch bell crank.

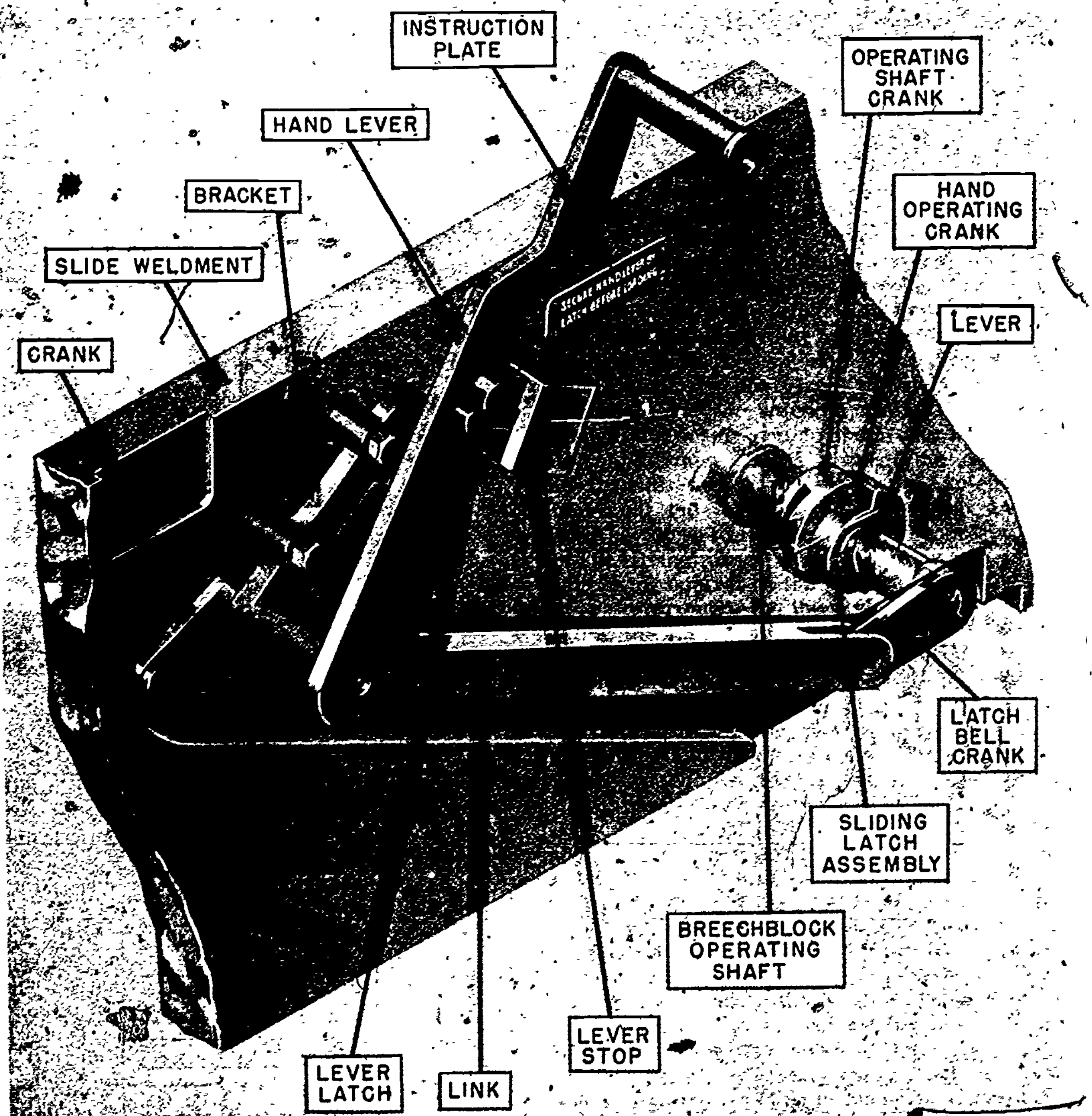
When you pull the hand lever back (to lower the breechblock), the link moves down and to the right (arrow A) and turns the latch crank and the hand operating crank (arrow B). The crank, in turn, pushes the operating shaft crank in the same direction (arrow C), thus lowering the block. Once the block is down, the extractors lock it open.

When you return the hand operating lever to the stowed position, the hand-operating crank doesn't engage anything and the linkage moves in "free wheeling."

The hand operating lever is adequate for routine opening of the breech for the initial round, boresighting, inspection, etc. However, there are times when the breech must be not only opened but closed by hand. That's an emergency measure which might be caused by failure of the operating spring, for example. To do this, you set a sliding latch—a small metal block in the hand operating crank at the right end of the operating shaft. Figure 10-9A shows the latch and the lever used for operating it, with the latch disengaged. Arrow 1 shows how the operating shaft moves in breech opening. Figure 10-9B shows the sliding latch engaged, and arrow 2 shows how the hand operating linkage and the operating shaft turn when the breechblock is raised by the hand lever.

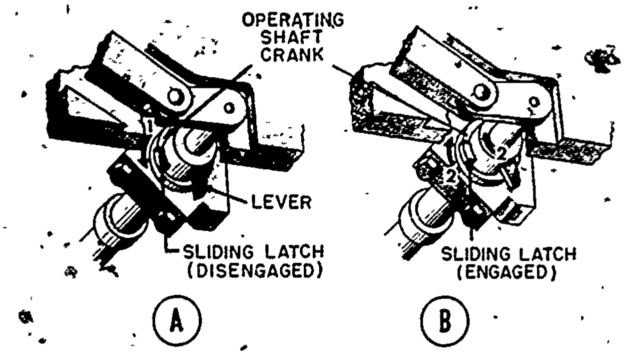
THE SALVO LATCH

Once in a while when a gun is fired, the propelling charge for one reason or another fails



84.162

Figure 10-8.—5"/38 breech mechanism. Hand operating linkage.



84.163
Figure 10-9. — 5"/38 breech mechanism. Function of sliding latch in hand operating mechanism.

to burn. If it is a complete dud, you have a MISFIRE. If it fires after a lapse of a few seconds or minutes, you have a HANGFIRE.

A misfire is a nuisance, but a hangfire is a killer. The worst of it is that the first few seconds after firing the gun, nobody can tell the difference between them. If it is a misfire, your have to remove the defective propelling charge and load another. But if it's a hang-fire, it might explode while your're removing it.

There is a way out of this dilemma. You WAIT. After a period of time, as specified in OP 1591, it is considered safe to open the breech and remove the propelling charge.

The procedure is fairly well cut and dried for single guns, or for guns firing individually. But when two or three guns are firing in salvo, and one gun fails to fire, it might go unnoticed. Suppose that does happen. The gun crew, thinking the gun has fired, falls to and opens the breech. Inside, a hangfire is in progress. Before the breech can be closed again...; but why spell it out? It has happened, and at least once a whole turret crew was wiped out.

That's where the salvo latch comes in. The salvo latch is a device which prevents the unintentional opening of the breech, after the gun is loaded, but before it has been fired. The salvo latch can be opened, of course, but always with the full realization of the potential danger — never as a routine.

The design used on 5"/38 breech mechanisms is automatically opened by camming action when the housing recoils.

The salvo latch (fig. 10-10) is a spring-loaded assembly mounted under the operating shaft in the housing. As shown in figure 10-10A its catch engages a shaft locking lug in the operating shaft crank when the breech is closed, and prevents the crank's rotation. But as the housing moves in recoil (white arrow in fig. 10-10A and B), the salvo latch lug is forced downward by a cam in the slide, and the catch (which is also spring-loaded) springs in under the crank lug so that it cannot engage the lug. The breech is now free to open in counter-recoil; or it can be opened by the hand operating lever if the operating shaft cam plate is retracted for single fire.

To open by hand, pull the salvo latch down until its catch snaps in under the operating crank shaft lug. The breechblock can then be lowered. But it shouldn't be necessary to remind you NEVER to disengage the salvo latch as a routine between rounds, except for prescribed misfire procedure. For drill purposes only, the latch may be locked open so that is won't function... Otherwise, it may be disengaged manually only when the breech is opened for loading the first round, for inspection, or for maintenance.

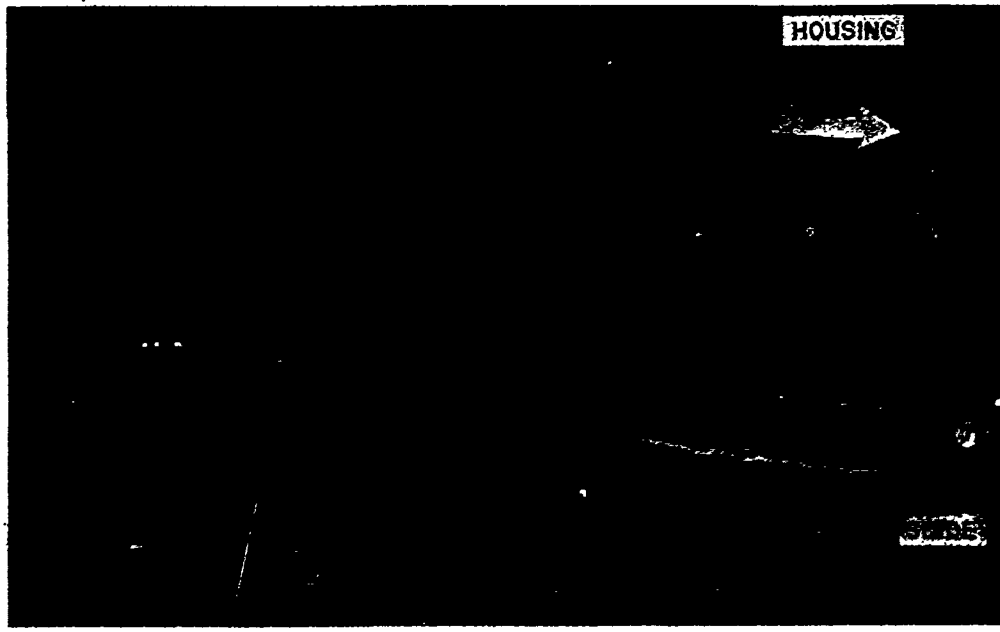
BREECH OPERATING MECHANISM (3"/50 RF)

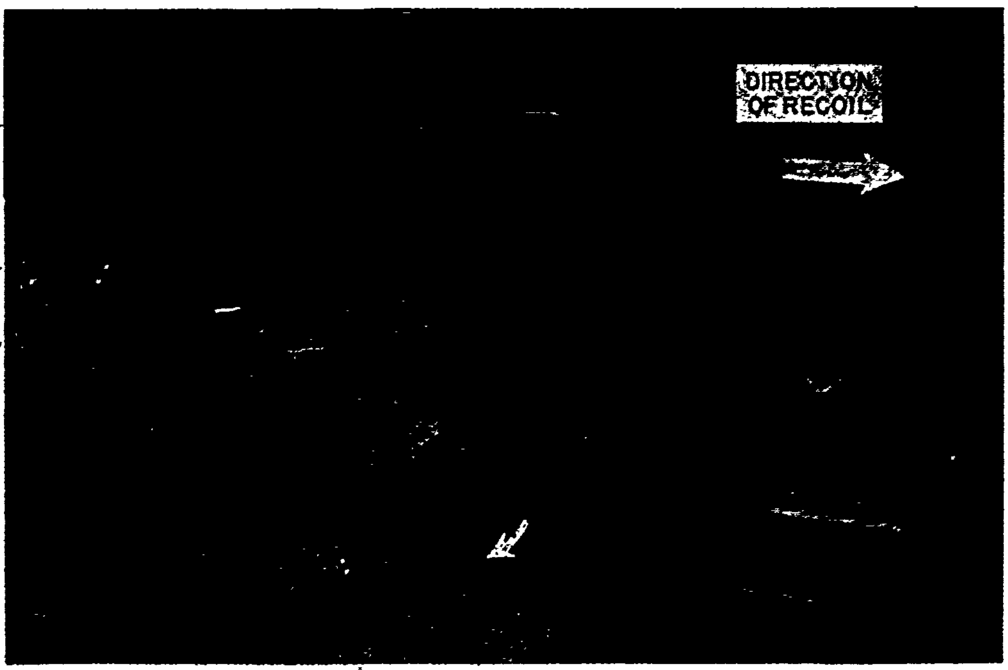
The breech mechanism used on 3"/50 RF mounts resembles in many ways the 5"/38 mechanism just discussed. It is a sliding wedge type breech. A salvo latch locks the breech closed, unlocking it on recoil. The breechblock is lowered in counterrecoil by a cam plate. Breech lowering action causes empty case extraction. The hand operating mechanism is even simpler than that of the 5"/38, as here it operates only to lower the breechblock. Because of these similarities, we will not go through these actions again. There are, however, differences between the two mechanisms.

The major difference between the 5"/38 breech mechanism and the 3"/50 RF is that the latter is synchronized (and sequenced) with an electrically driven automatic loader. For obvious safety reasons, this means that for the breech mechanism to do its job properly, the automatic loader must be operating correctly, and vice versa.

We will not discuss all the mechanical and electrical connections between loader and breech, but will show you the principal parts and discuss their relationship.

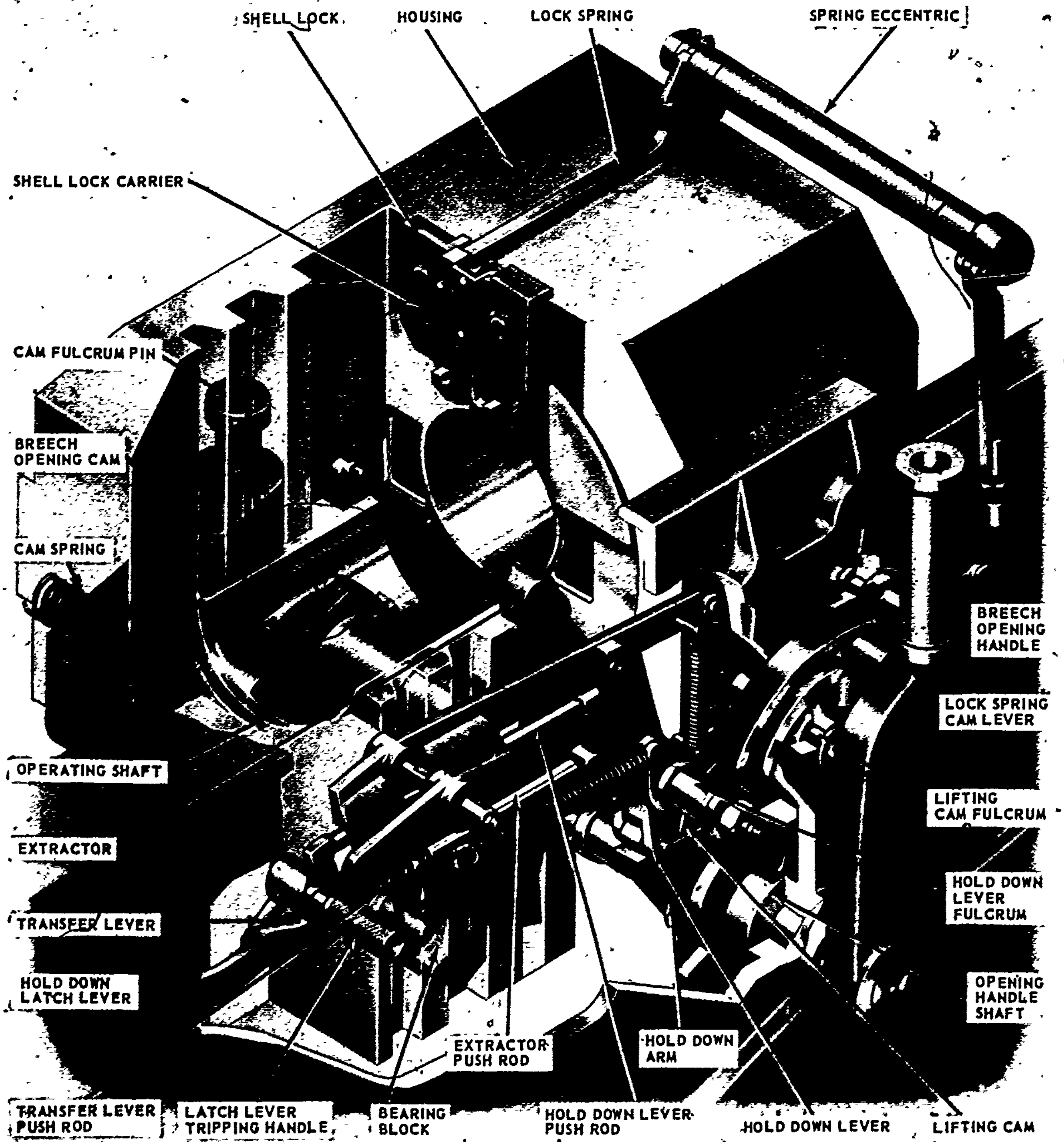
Features of a 3"/50 RF breech operating mechanism, not found on the 5"/38 and earlier 3"/50 SF mounts, are:





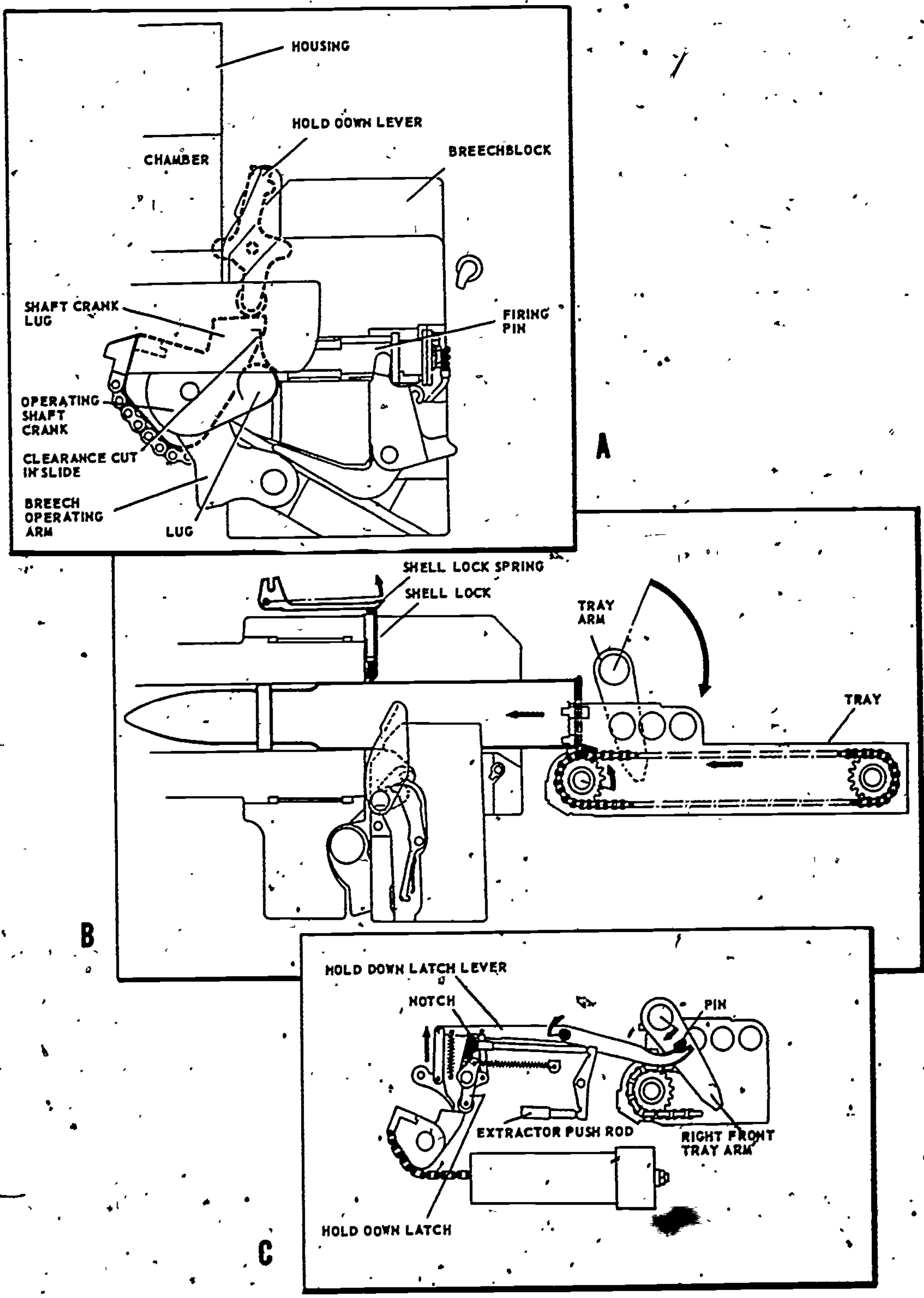
84.164

Figure 10-10. — 5"/38 breech mechanism, salvo latch functioning.



84.165

Figure 10-11. — Breech holddown mechanism.



84.165

Figure 10-11.— Breech holddown mechanism — Continued.

1. A breech holddown mechanism. This device latches the breechblock down until a round is rammed into the chamber. This permits the extractors to be "free wheeling" during loading and be more efficient in their primary job of empty case extraction.

2. A breech interlock mechanism. This device consists of a set of mechanical and electrical interlocks which prevent loading cycles from happening until safety conditions are met.

Breech Holddown Mechanism

The older slow fire 3"/50, like the 5"/38, uses the inner lugs of the extractors to hold the breechblock down until a round of ammunition, being loaded, rocks them off the breechblock pallets. When loading by hand or using the 5"/38 power rammer, the resistance offered by the extractors is negligible. In the 3"/50 RF, however, the round of ammunition is not rammed all the way into the chamber. It is catapulted by a ramming chain only so far, and momentum carries it the rest of the way.

This means that any resistance (such as that offered by extractors) to the round after being turned loose by the ramming chain would seriously affect its forward motion. So, to relieve the extractors of their secondary job (holding the breechblock down) and to make the gun truly rapid fire, the holddown device is used. In figure 10-11 you can see what this device looks like in the gun and how it is unlocked.

Let's follow the actions of the holddown by going through a complete breech mechanism cycle.

In figure 10-11A the breechblock is in its FULL DOWN position. The operating shaft (under spring pressure) is kept from rotating by the holddown lever. In this position the breechblock pallets are about an inch below the inner lugs of the extractors.

In figure 10-11B a round is being catapulted into the gun chamber. The loader's right front tray arm is swinging downward.

In figure 10-11C you see a pin on the tray arm pushing downward on the rear of the holddown latch lever. This causes the front end of the latch lever to rise. The holddown lever, which has been locked by a notch in the latch lever, is released. While the holddown lever is unlocked, it has not yet been moved to release the operating shaft crank. For this action look at figure 10-12.

In figure 10-12, a round of ammunition has swept across the top of the breechblock, engaging the lips of the extractors and carrying them forward. This rocks the extractors, thrusting their bottoms to the rear. The right extractor thrusts its push rod rearward (fig. 10-12A and B).

The transfer lever is rotated and, through its push rod, pushes the holddown lever off the operating shaft crank lug. The operating shaft is released and the operating spring rotates it, starting the breechblock upward.

As the cartridge case was loaded, it cammed the shell lock upward. As the cartridge case seats itself, the shell lock drops down holding the case in the chamber until the breechblock can close behind it.

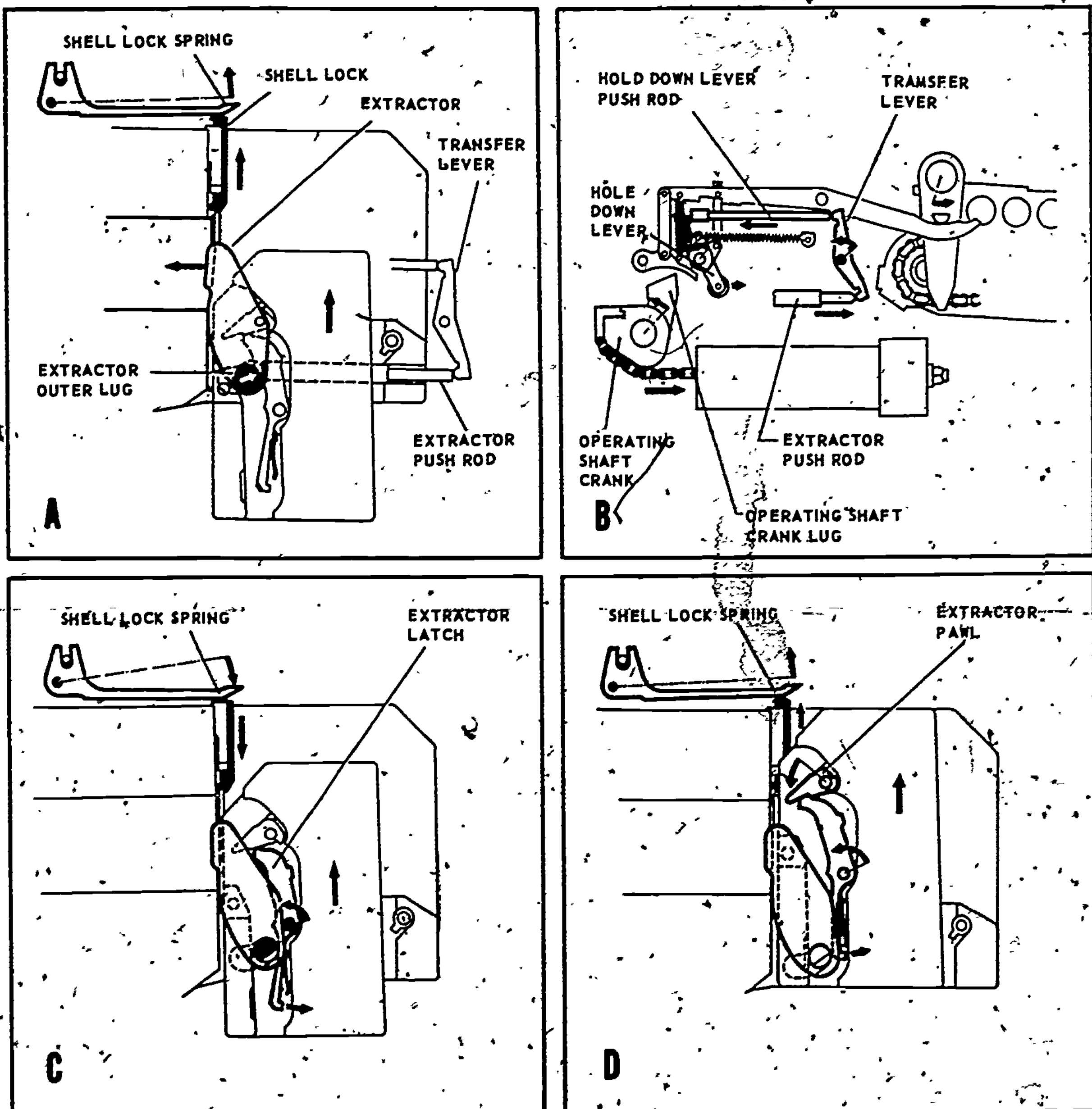
Before going on with the cycle (firing, breech lowering, and case extraction), let's have a closer look at the extractor during the breech closing movements. The extractor camming grooves here are not fixed as in the 5"/38 breechblock. Instead the grooves are made variable as to width by a latch and pawl arrangement. The top of the groove is wide when the breechblock is down waiting for a round to be loaded (fig. 10-12A). This gives free movement to the extractors, the only restriction to their movement being the relatively slight resistance of the holddown lever. Now as the breechblock rises (fig. 10-12C), inner lugs on the extractors force the lower ends of the extractor latches to the rear. This moves the upper ends of the latches forward until they are engaged by small pawls which lock them in the position (fig. 10-12D). The camming grooves are narrow and conventional in shape. When the breechblock lowers, the latches provide fixed camming surfaces to the extractors inner lugs, rotating them and extracting the empty case.

Breech opening starts after the gun has fired, recoiled, and then started to counterrecoil. As with the 5"/38, a breech opening cam contacts a lug on the operating shaft, rotating it and starting the breech lowering action. (see fig. 10-13A).

While the breechblock is dropping, extraction commences. The latches are locked forward by their pawls (fig. 10-13B). As the extractor's inner lugs are cammed forward by the latches' camming surfaces, the extractors rock clockwise, flipping the empty case to the rear.

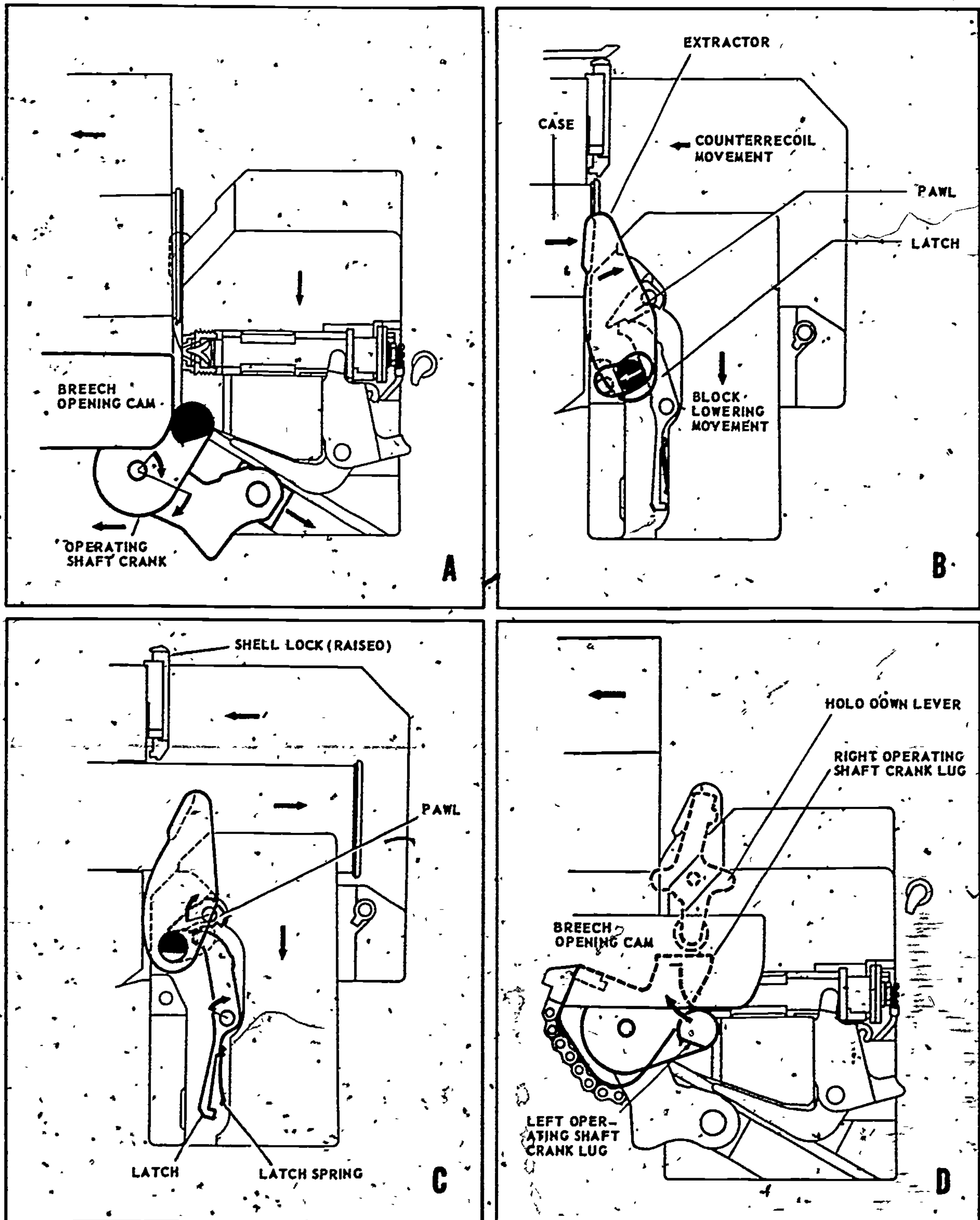
As the block lowers, the latches, of course, move down with it. As the pawls pass over the extractor's inner lugs, they are pushed upward releasing the latches (fig. 10-13C). With the latches released, we are assured that the camming action just described won't function in reverse as the block starts to rise in the next loading cycle.

When the gun has fully returned to battery, the operating shaft rotates slightly as in figure 10-13D. The breechblock comes up until the



84.166

Figure 10-12. — 3"/50 breech mechanism functioning cycle-breech closing. A. Shell lock and extractor actions. B. Holddown lever release. C, D. Latch and pawl actions as breechblock closes.



84.167

Figure 10-13.—3"/50 breech mechanism functioning cycle-breech opening. A. Breech being cammed open. B, C. Extractor, pawl, and latch actions. D. Breech open.

operating shaft crank lug engages the roller on the holddown lever, as it was when the cycle started.

Hand Operation

Opening the breech is simply a matter of unlocking the salvo latch and pulling the hand operating lever to the rear. Be sure to pull the operating lever down as far as it will go. If the breechblock isn't hauled down far enough before you release it, the block may be engaged by the extractors (the inner lugs of the extractors bearing against the pallets of the breechblock), instead of engaging the holddown lever with the operating shaft. The automatic loader is interlocked with a breechblock down switch to prevent cycling unless the breechblock is all the way down. If this switch did not function properly however, a round would be catapulted into "stiff-legged" extractors, and may come rebounding out your empty case chute, base first, across the deck.

Routine closing of the breech on an empty chamber is done like this:

1. Haul down on the hand operating lever all the way.

2. Pull down on the holddown latch lever tripping handle. This takes the place of right front tray arm action in unlocking the holddown lever.

3. Trip the extractors by pushing them forward with a breech closing tool.

4. Ease up on the hand operating lever, permitting the block to rise slowly. Release the lever a couple of inches from its stowed position, allowing the breech closing spring to snap the plug to its full UP position.

THE BREECH INTERLOCK MECHANISM

The breech interlock mechanism is one of several devices on the 3"/50 RF whose actions affect the operation of the automatic loader. Since it is located at, and depends upon the proper actions of, the breech mechanism, it is worth a brief study here.

The purpose of the breech interlock mechanism is to prevent the start of a loading cycle until:

1. The breechblock is down.
2. The empty case is out of the chamber, and
3. The gun is out of battery by not more than 3/32 inch.

The reasons for not cycling a new round into the breech while the breech is up or until the empty case has been extracted are obvious. It would be hard on ammunition, to say the least. As for the third condition, cycling the loader while the gun is out of battery would cause the tray to be slammed down on the breech housing.

In figure 10-14 you see the arrangement of the breech interlock mechanism as used on 3-inch loaders MK 2 Mods 4, 6, 8, 9, and 10. Other mods of MK 2 loaders have slightly different arrangements, but the one illustrated is the most common, and has the basic components and actions of all breech interlock mechanisms.

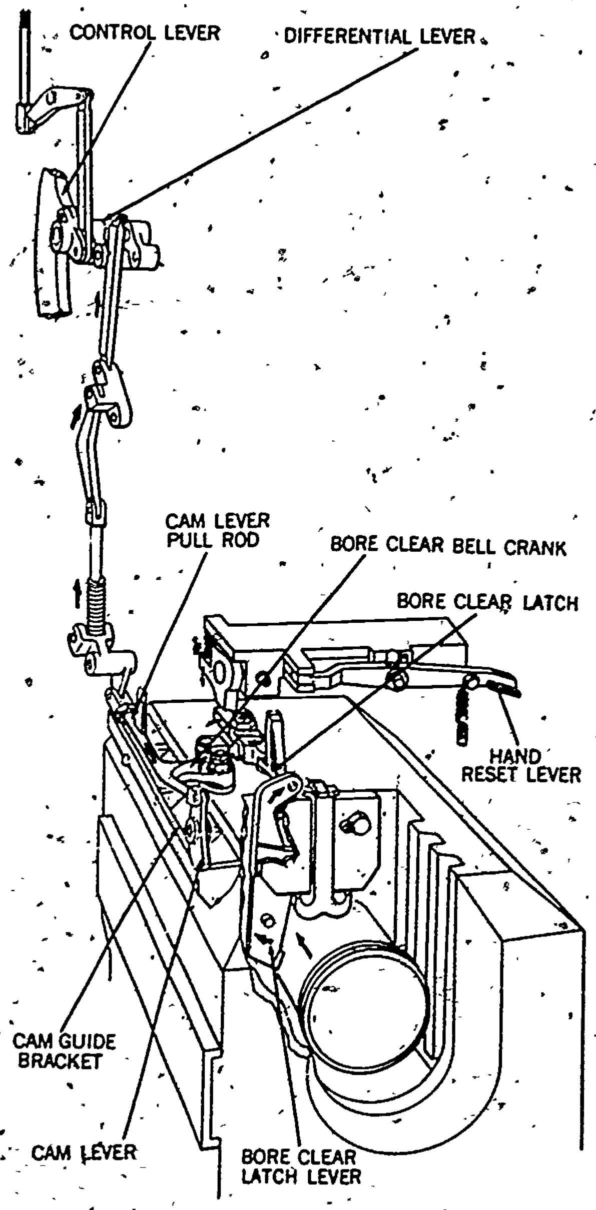
First, a little background. Although the loader motor runs continuously, a cycle cannot start until the motor's output is connected to the loader drive unit by engaging a clutch. Under normal conditions the clutch is engaged when the firing key is closed. But when any of the three unsafe conditions (mentioned earlier) exist, the breech interlock mechanism moves to physically block any engagement of the clutch.

The three main parts of the breech interlock mechanism are the bore clear latch lever, the cam lever, and the breechblock itself.

The latch lever is pivoted near its center. At the top, it is connected to linkage which will block the engagement of the loader drive clutch. At its lower end the latch lever protrudes into the face of the chamber. When a round is in the chamber, the latch lever is cammed to the left, moving linkage to stop a cycle, as already discussed.

Notice that the bore clear latch lever also has a small pin protruding from its lower arm. This pin rides in a camming groove machined into the face of the breechblock. When the block is down, the latch lever is free to move over into the face of the chamber. If all other conditions are satisfactory, a cycle can be started. When the breechblock is up, however, it cams the latch lever clockwise, causing the interlock linkage to move up, blocking a new cycle.

Preventing a cycle from starting while the gun is out of battery is the job of the cam lever. The lever is attached to a nonrecoiling member of the slide. A cam mounted on the recoiling housing forces the cam lever counterclockwise whenever the gun is more than a fraction of an inch out of battery. In such a case, the cam lever



84.168

Figure 10-14.—Breech interlock mechanism 3"/50 RF.

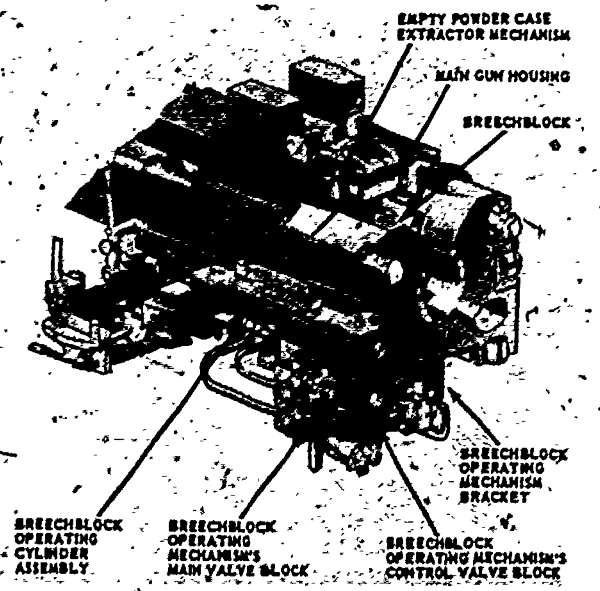
moves the linkage to block the start of any new cycle.

The breech interlock mechanism is designed to clear itself (return to its normal position after a round has been fired) by the recoil and counter-recoil movements of the gun. For the initial loading cycle however (after the breech has been dropped manually), the mechanism is cleared by a hand reset lever.

BREECH OPERATING SYSTEM FOR 5"/54 MK 42 MOUNTS

The devices and their actions used on 5"/54 MK 42 mounts for breechblock operation and case extraction represent the latest development in gun breech design in the fleet today. The breechblock, extractors, and firing mechanism are essentially one large interlocked system, operated as a unit electrically, mechanically, and hydraulically.

Figure 10-15 shows how the major parts of the breech operating system are arranged at the breech end of the gun. The extractors are not shown but we will study them later. The breechblock is in a raised position—driven there by a hydraulically operated piston through the clevis link, a three-cornered pivot link, and a connector link. The firing mechanism permits both electrical and percussion firing. It is cocked by the sear holding the percussion firing spring compressed. The firing pin itself is protruding through the face of breechblock (with the contact spring holding it there) ready for electrical firing. When the breechblock is lowered, the cocking bar will be shoved upward, retracting the firing pin.



84.169

Figure 10-15.—5"/54 Mk 42 breechblock operating system.

Breech Raising And Lowering Cycle

Action during the breech operating cycles can be seen in figure 10-16. These are simplified schematics in which, for a clearer understanding, some valves and linkages have purposely been left out of the picture. A complete rundown on this breech's operation can be found in OP 1764, Vol. 4, chapter 22.

In figure 10-16A the breechblock is in a down position. The breechblock operating piston has 1500 psi working on both faces of its piston, keeping it stationary. The 1500 psi comes from selector valve VW3 in the control valve block.

As a round is rammed into the chamber, a yoke on the rammer spade strikes the upper end of a pivoted lever, causing it to rotate counterclockwise. (See figure 10-16B). As the lever rotates, it pulls the control valve, VW2, in the main valve block upward. A spring-loaded plunger engages a detent groove in VW2's valve stem, keeping the control valve in the up position during the following action.

In figure 10-16B you can see that VW2 has been lifted far enough to cut off all flow of 1500 psi through the main valve block. Sixty psi, however, is opened to the right-hand chamber of the breechblock operating piston. The lefthand side of the breechblock operating piston, PW1, is still being acted upon by 1500 psi from the control valve block. The forces which have been holding PW1 balanced are now unequal, and the breechblock operating piston is forced to the right. Through the operating linkage, the breechblock is pushed up behind the round of ammunition. All other conditions being safely met, the gun fires.

As the gun moves aft in recoil, a roller on the selector valve is cammed down by a sloping surface fixed to the nonrecoiling slide (fig. 10-16C). This action reverses the hydraulic circuits of the breechblock operating system.

A breechblock lowering cycle (fig. 10-16C) commences when the selector valve VW3 moves downward. High pressure (1500 psi) now enters the system through the upper land chamber of VW3, on through VW2, and into the right-hand side of the breechblock operating piston PW1. At the same time, the left-hand side of PW1 has been ported to low pressure through the lower land chamber of the selector valve VW3. The strongest pressure is now acting on the right-hand side of PW1, and it moves left. This causes the operating linkage to move (as indicated by the arrows), and the breechblock lowers.

Empty Case Extraction

Empty case extraction begins during the last fraction of an inch of recoil movement, and coincides with the end of the breechblock lower stroke. In figure 10-17 you can see some of the extraction devices and actions.

As the breechblock reaches its DOWN position, it contacts an extractor control valve VW1. (Before this contact was made, VW1 was UP, preventing high pressure oil from reaching the top of the extractor operating piston PW2). As the breechblock pushes the extractor control valve downward, high pressure oil is ported through its center land chamber to the top of PW2. Following the actions indicated by the arrows, you can see that the extractor linkage pulls the top of the extractors forward, flipping the bottoms aft. This extracts the empty case.

The extractors retract during the final movement of the gun back into battery. When the cam surface of the slide permits the selector valve VW3 (fig. 10-16) to rise, the hydraulic circuits are reversed once again. High pressure to the extractor control valve is cut off and PW2 (under spring pressure) jumps upward. This causes the extractors to retract.

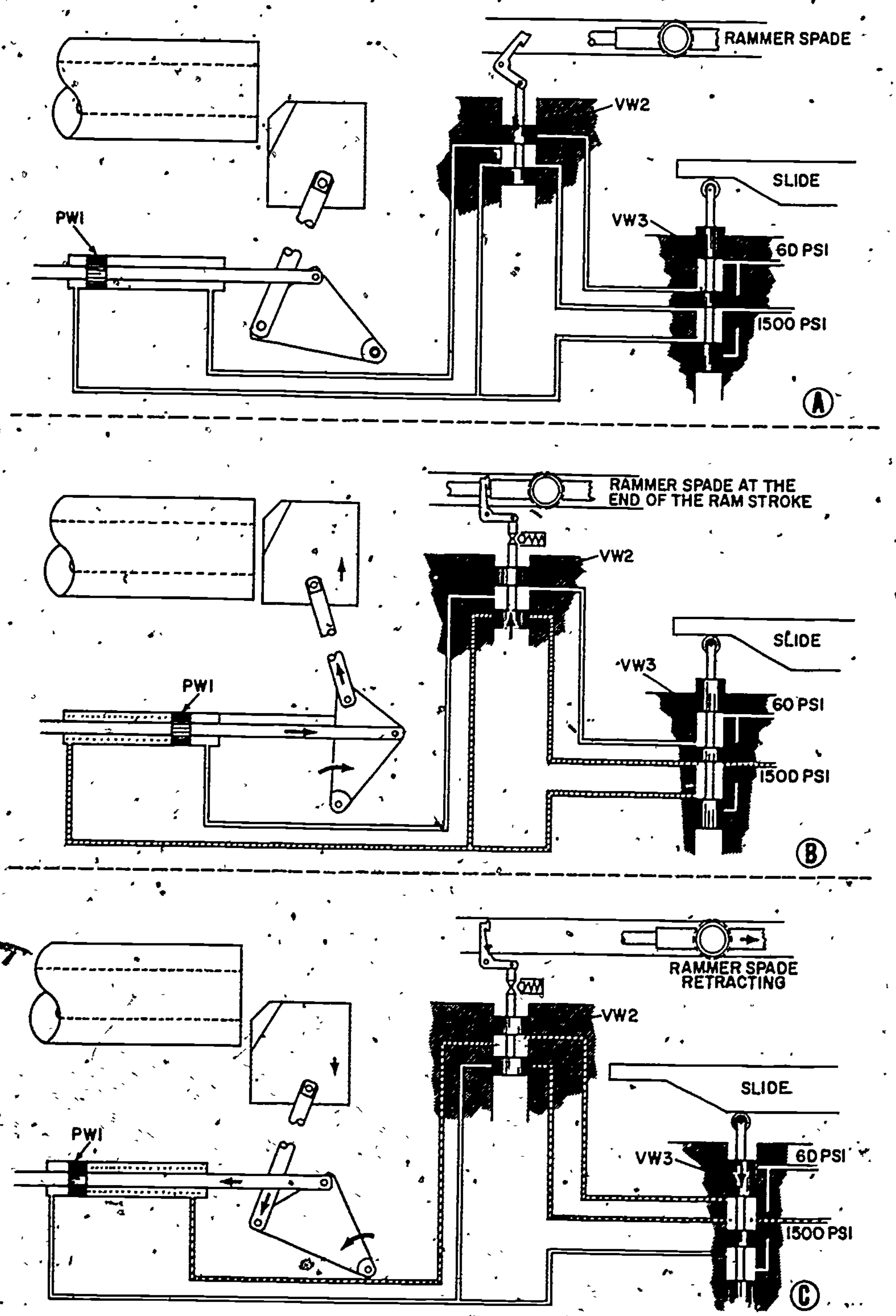
FIRING SYSTEM

The firing mechanism is that part of the firing system house in the breechblock. The 5"/54 firing mechanism is similar in design and function to its counterpart in the 5"/38 gun, and is designed to ignite the primer electrically or by percussion.

The normal method of firing (using combination primers) is electrical, the firing mechanism acting as the final leg of an electrical circuit which leads from the ship's generator to the primer. Percussion firing in this case is the standby (or sometimes emergency) method.

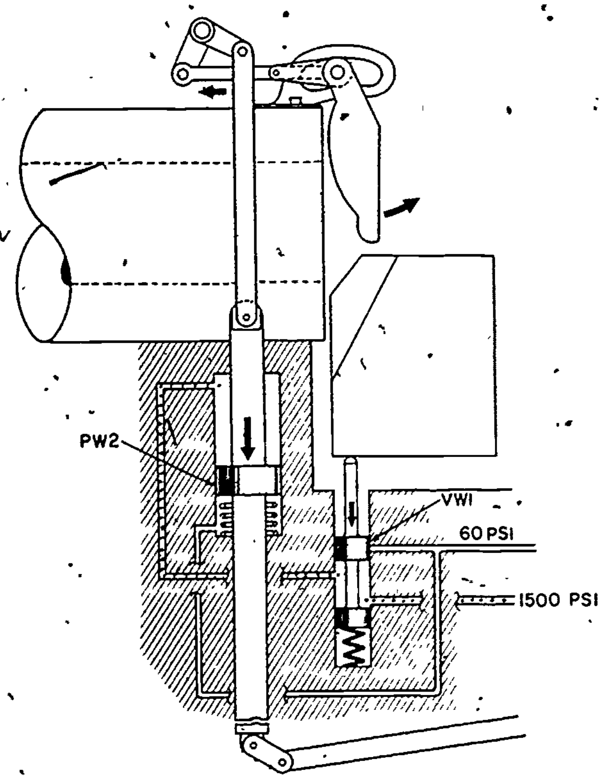
A TYPICAL SYSTEM

For the purpose of this discussion we have selected the 5"/38 system because of its simplicity and the vast number of these systems in the fleet. This system was designed for both electric and percussion fire. The components which make up this type of firing system must operate to stop



84.170

Figure 10-16. — Operating cycle 5"/54 Mk 42 breech operating system. A. System at rest. B. Breech raising cycle. C. Breech lowering cycle.



84.171
Figure 10-17.—Extractor action (5"/54 Mk 42).

the firing of the guns both electrical and mechanical through a firing stop mechanism.

The 5"/38 firing system comprises the:

1. Electrical system,
2. Firing mechanism proper,
3. Percussion firing linkage, and
4. Firing stop mechanism.

Electrical System

Figure 10-18 shows in schematic form the electrical wiring system for a typical 5"/38 mount. Normally, the system works on a.c. from the ship's 115-volt supply. The remote firing key identified in the figure may be a key operated by a crewman in the director, a manually-operated key in plot, or an automatic switch in the stable element in plot. Figure 10-18 is a simplified schematic that doesn't show all details.

A local firing circuit comes from the mount's firing and lighting circuit. Selection of either the remote or local firing circuit is made by the mount captain at the MK 15 control panel.

From the control panel the circuit goes next to a step-down transformer where the 115-volts is reduced to 20-volts. Next in line is a snap switch operated by the pointer. The purpose of this switch is to permit the selection of either the circuit from the transformer (MOTOR GEN position) or, in an emergency, a 6-volt battery located in the mount's upper handling room. If the need arises, the pointer can secure the circuit at this point by placing the switch in the OFF position.

From the snap switch the circuit goes through the pointer's firing key, firing stop switch (firing cut out mechanism), the firing pin, primer, and on to ground through the gun mount structure. Since all switches in the 20 volt secondary circuit are in series, all must be closed before current can reach the primer; the pointer therefore must keep his key closed even when firing is from a remote station.

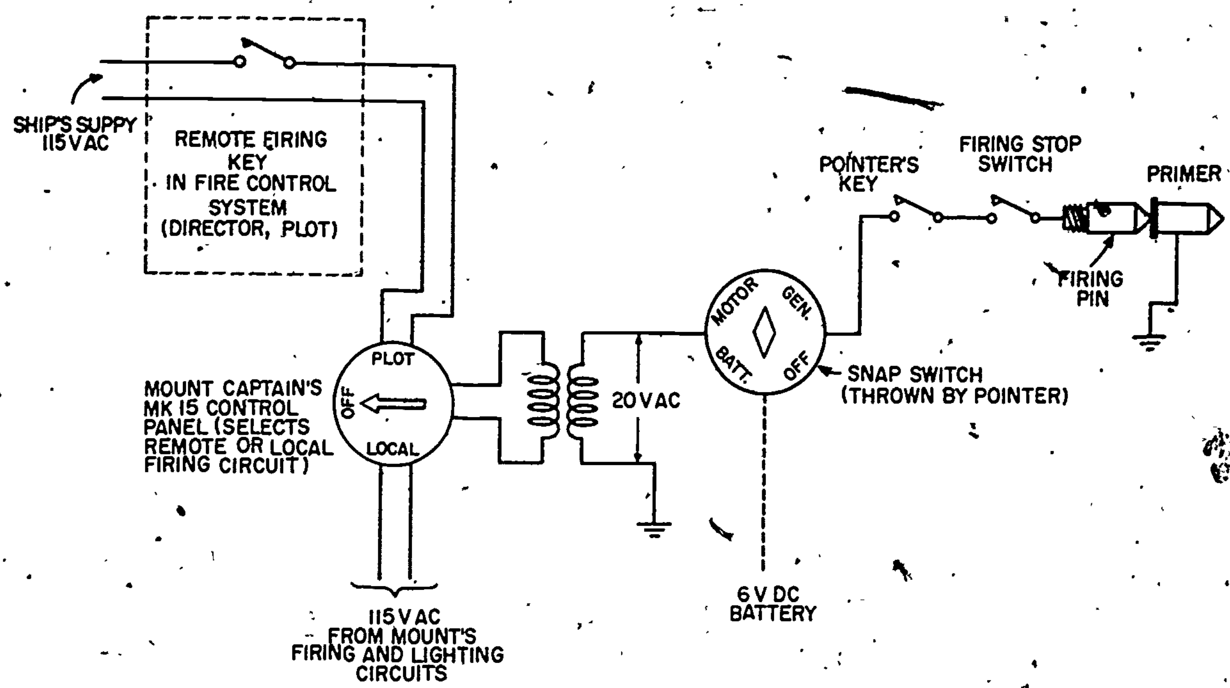
The firing stop switch, like the pointer's key, is always in the circuit and will prevent firing if not closed. Later in this chapter we describe in further detail the firing stop mechanism of which this switch is a part.

The firing stop switch is an electrical interlock that prevents firing when the gun is not pointed in a safe direction. In 3"/50 RF mounts, in the more complicated electrohydraulically operated gun mechanisms like the 5"/54 MK 42, and 8-inch rapid-fire turrets, this principle of electrical interlocking to permit firing only under certain circumstances is elaborately applied.

These are the components of the system, and you will learn more about them later in the chapter. Now, let's look at the firing mechanism itself.

FIRING MECHANISM

Often you'll see the term "firing mechanism" applied to the whole combination of electrical and mechanical elements that in this chapter we've been calling a "firing system". But, strictly speaking, the term "firing mechanism" should be applied only to the independent assembly in the breechblock that comprises the firing pin and the other subassemblies and parts associated with it. Sometimes this mechanism is called the "firing lock". This is an assembly used for firing bag guns. It is similar in purpose but different in



84.172

Figure 10-18.—Electrical firing system. 5''/38 (simplified schematic).

function and construction from the firing mechanism found in the breechblock of a 5''/38 gun assembly, or in the breechblock of any other sliding wedge breech gun.

The 5''/38 firing mechanism is a cylindrical assembly with the firing pin protruding at one end and the cocking handle and firing terminal at the other. Figure 10-19 shows two views — an exterior and a cutaway. The firing pin and terminal are electrically insulated from the other parts by two fiber insulating washers (labeled in fig. 10-19) and the fiber firing pin sleeve.

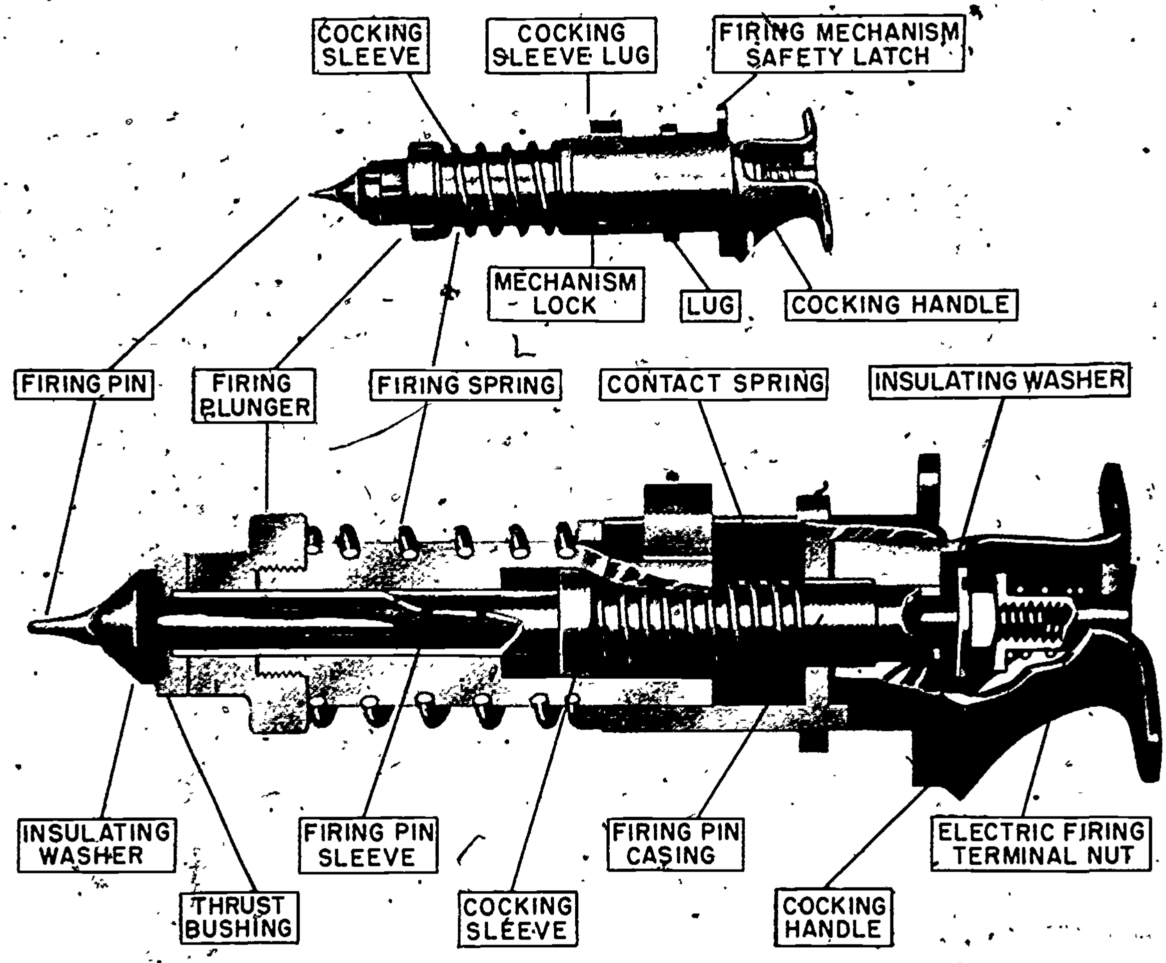
When the firing mechanism is mounted in its place, only the cylindrical mechanism lock is firmly locked to the mounting. The other parts can slide back and forth, as follows:

1. The firing pin with its casing, sleeve, washers, firing terminal, and cocking handle can move as a unit, and is under the continuous forward thrust of the contact spring.

2. The firing plunger, cocking sleeve, and cocking sleeve lug can move as a unit and are under the powerful thrust of the firing spring. When the firing spring is fully compressed, the firing mechanism is cocked. It can be cocked by hand, when mounted or when clamped in a vise, by pulling back firmly on the cocking handle. To lock it in the cocked position, twist the firing mechanism safety latch downward. You must cock and lock the firing mechanism in this way when removing it or installing it in the breechblock. In normal operation, the firing mechanism is cocked and locked by the automatic functioning of the retracting lever and the sear, as discussed later in this section.

Notice that both the contact spring and the firing spring bear against the mechanism lock to exert their forward thrust on the firing pin and firing plunger assemblies.

The firing mechanism fits into a bore through the central part of the breechblock from the front face (through which the firing pin protrudes) to the rear. Figure 10-20 shows the rear face of the breechblock as a phantom so that we can see the mechanisms within. The sear is a spring-loaded rod in a transverse hole opening into one of the grooves in the left side of the



84.173

Figure 10-19.— Firing mechanism (5"/38). Exterior and cutaway.

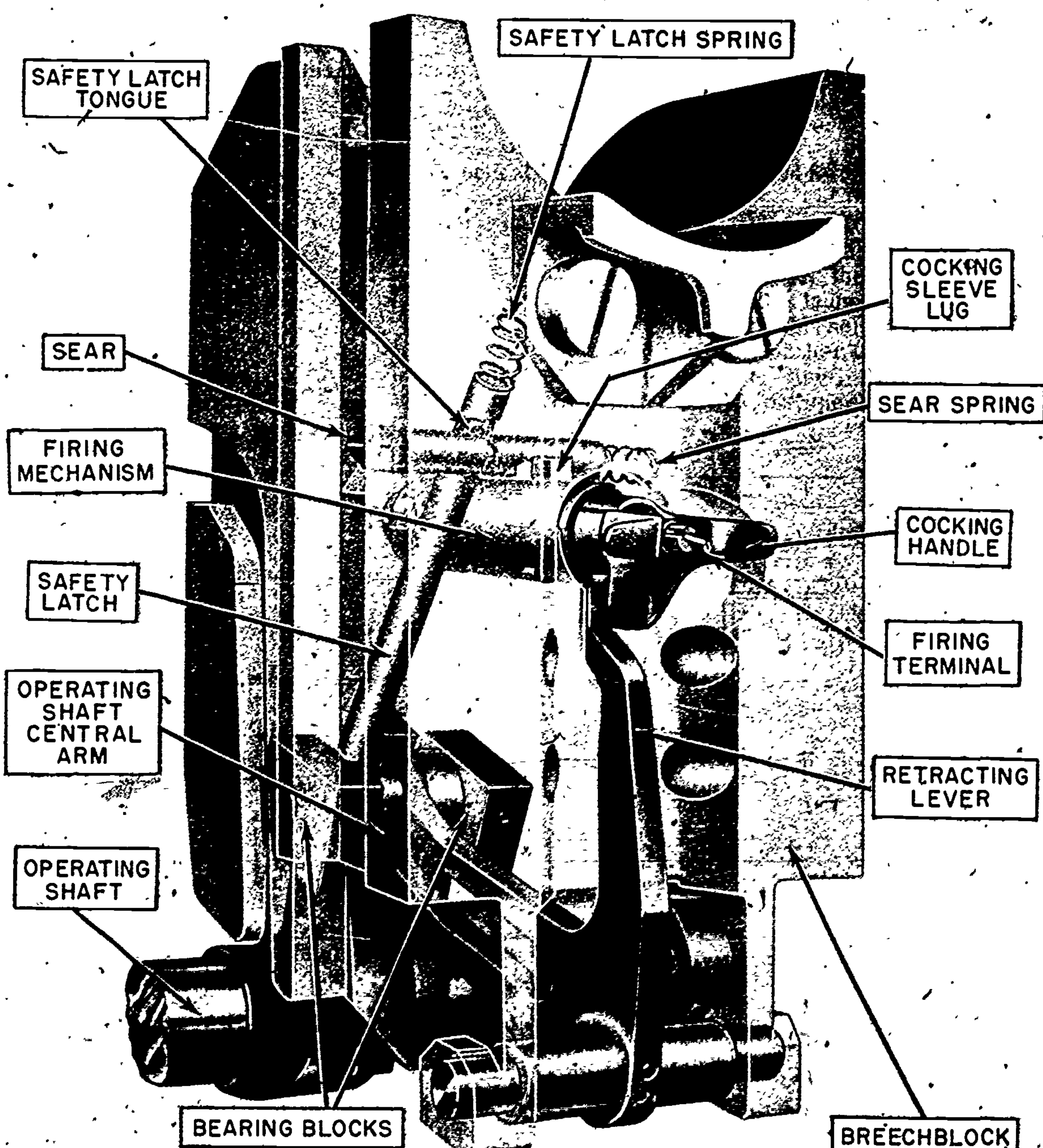
breechblock. It normally engages the cocking sleeve lug. The sear is cut away, however, so that when it is pushed in (to the right, against its spring), the lug is free to move forward.

Also engaging the sear is the sear safety latch, another spring-loaded rod in a diagonal hole drilled in the breechblock. When the breechblock is closed, the lower end of the latch rides on the operating shaft central arm of the breech mechanism.

Where the latch crosses the sear, it is partly cut away, and a ridge (the safety latch tongue) in the cutaway portion can engage an annular groove that rings the sear. When the breechblock closes, the operating shaft central arm cams the safety latch up so that the tongue is disengaged, and the sear can move to the right.

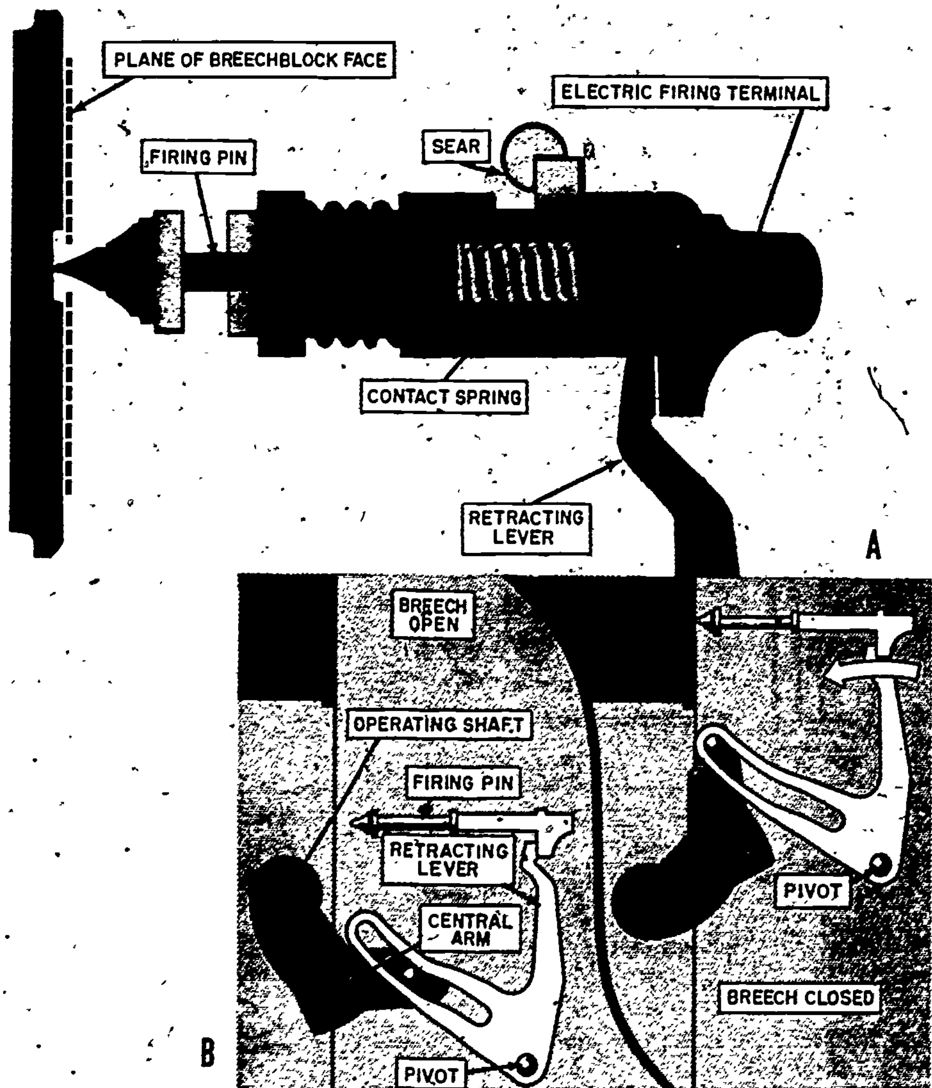
Now let's look into the breech mechanism's functioning in electric and percussion fire, describing the other mechanisms involved as we go along.

ELECTRICAL FIRE.—In electrical fire, the firing mechanism's function is to make good electrical contact with the primer base when the breech is closed. The elaborate system including the firing spring, firing plunger, sear, safety latch, and so on, described a few paragraphs earlier, plays no part in electric firing. In the firing mechanism the parts essential to electrical



84.174

Figure 10-20. — 5"/38 firing mechanism and associated components in breechblock.



84.175

Figure 10-21.—Functioning of 5"/38 firing mechanism in electrical fire. A. Firing mechanism parts. B. Retracting lever.

fire are the firing pin proper, the contact spring, and the firing terminal (fig. 10-21A).

The firing cable is connected to the terminal and moves up and down with the breechblock. The firing current travels through the firing terminal and pin. The contact spring holds the point of the firing pin firmly against the primer to ensure good electrical contact. To do this, the tip of the firing pin must protrude from the face of the breechblock (fig. 10-21A).

However, when the breechblock is in any position other than completely closed, a protruding firing pin tip is a hazard—it can short the firing circuit, foul a cartridge case, or be bent out of alignment and jam. Hence the firing pin tip must be retracted whenever the breechblock is not fully closed. The component that does this is the retracting lever (fig. 10-21B).

The retracting lever rocks on a pivot in the breechblock. It is linked to the central arm so that when the breech is open, its business end pushes the firing pin backward; when the breechblock rises to closed position, the lever rocks the other way so that the contact spring can push the firing pin forward again (fig. 10-21B).

When the breech is open, the retracting lever also cocks the firing spring. Remember this for the discussion on percussion firing which follows.

PERCUSSION FIRE.—In percussion firing, the primer's shock-sensitive base must receive a substantial mechanical impact. As you remember, this is done in small-arms weapons and machine guns by using a firing pin. When the firing control or trigger is operated, the firing pin is driven forward by a strong spring, by camming action, or by the inertia of the forward-moving bolt, and the shot is fired when the pin collides with the primer.

In the 5"/38 firing mechanism the firing pin maintains a firm contact with the primer so long as the breechblock is closed. The impact necessary to set off the primer is developed elsewhere in the firing mechanism; the firing pin merely transmits the blow much as a drift or nail set transmits the blow of a hammer.

To see just how this is done, let us now trace the operation of the percussion firing system on a 5"/38 mount, starting with the foot-firing treadle operated by the pointer, and continuing through its linkage to the firing mechanism in the breechblock.

Structurally, the linkage from the firing treadle to the slide is part of the carriage. The arrows in figure 10-22 show how each part of the linkage moves when the pointer steps on the treadle. The treadle tilts down, swinging the rectangular connection lever assembly aft, and so rotating the firing rod. (The encircled area in the figure encloses a clutch connection, and is part of the firing stop mechanism to be discussed later). A firing rod lever at the top of the firing rod pushes the outer push rod, which runs inboard through the center of the trunnion.

In turn, the outer push rod rotates the lower portion of the pivoted trip plate mounted on the inner surface of the slide. Inward movement of the trip plate is transmitted to the inner push rod in the housing. The inner push rod finalizes the entire purpose of this linkage, which is to push the sear to the right.

You can depress the foot-firing treadle at any time, but note two important safety features of this linkage:

1. The trip plate can push the inner push rod only when the gun is completely in battery.
2. The inner push rod can push the sear only when the breechblock is fully closed.

In short, the whole linkage described does but one thing—it pushes the sear to the right. The sear, in turn, releases the mechanism that causes the firing pin to set off the cartridge primer. Let's now look more closely at how this is done.

The retracting lever pulls back the firing pin when the breech opens, compressing the contact spring. It also compresses the firing spring. When the breech closes, the retracting lever permits the firing pin to move forward again under the thrust of the contact spring. But the firing spring remains compressed because the sear engages the cocking lug, and does not let the firing plunger assembly move forward. (See position I, fig. 10-23A).

When the firing treadle goes down, the sear releases the cocking lug, and the powerful firing spring drives the firing plunger solidly against the thrust bushing and the firing pin.(position II).

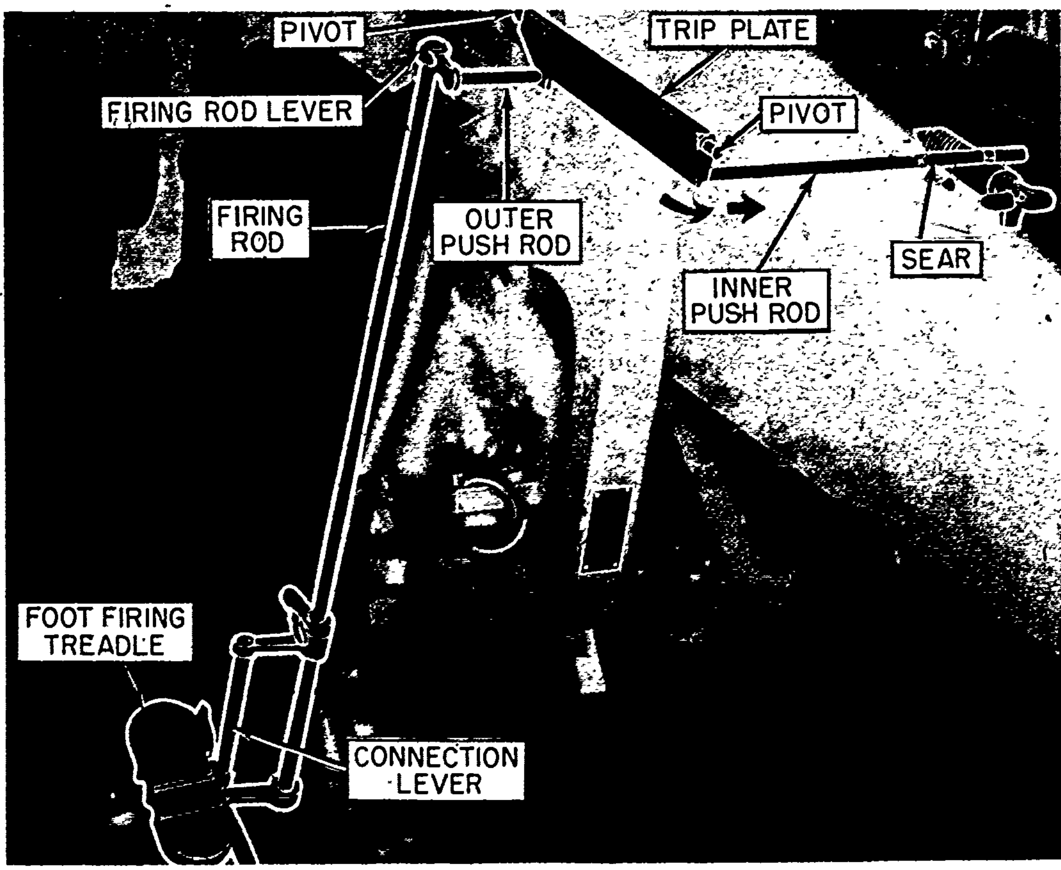
To see how the sear controls movement of the cocking lug, study figure 10-23B. The lug bears against the shoulder of the sear. When the sear is pushed to right (arrow) by the firing linkage, the lug can pass through the cutaway section. When the firing mechanism is cocked again, the sear spring pushes the sear back to the left.

Figure 10-24 shows what the safety latch does. It functions to prevent sear movement when the breech is not fully closed. When the breechblock is even slightly below breech-closed position, the latch is pushed down by the spring (arrow 1) until its tongue engages the annular groove in the sear, thus locking it. Only when the breechblock is fully closed and the central arm has risen to the top of its movement (arrow 2) is the safety latch pushed upward (arrow 3) by a flat spot on the operating shaft central arm. This disengages the tongue, permitting the sear to move when the foot-firing treadle is depressed.

FIRING STOP MECHANISMS

A long-range, heavy weapon like a turret gun or dual purpose gun can do a number of things that a small weapon like a rifle or a caliber .50 machine gun cannot. It can strike a target with a much greater destructive force. Unfortunately, it also can direct destructive fire on the vessel aboard which it is mounted.

The reason for this is that in heavy weapons the gun bore axis can diverge considerably from



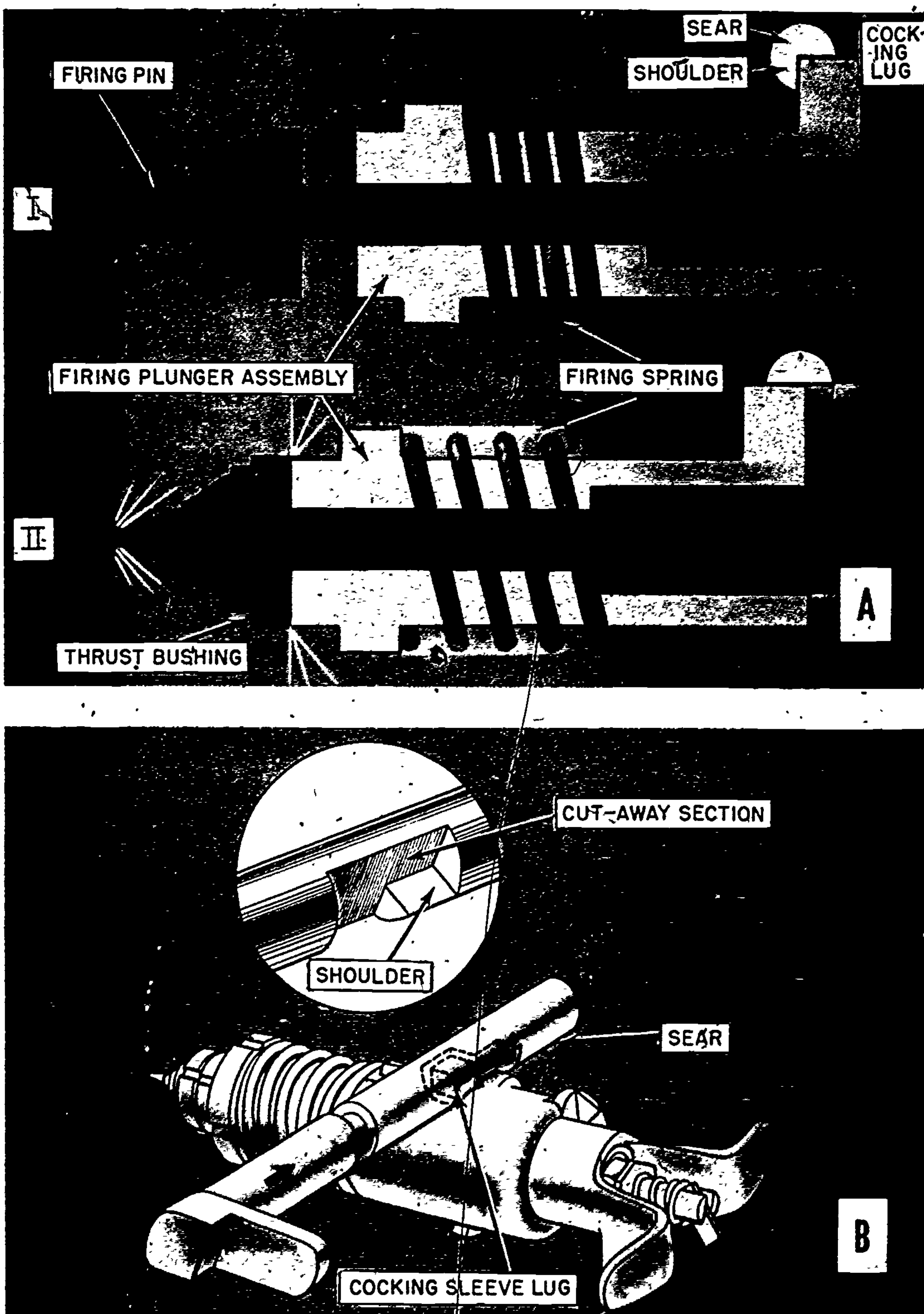
84.176

Figure 10-22.—5"/38 firing system. Percussion firing linkage.

the line of sight to the target. Especially in enclosed mounts where field of view is considerably restricted, a line of sight that looks perfectly clear through the sight telescope may have the gun bore axis right in line with the ship's superstructure, an adjacent mount, a stack, a mast, or a radar antenna. The fire control director, radar and all, cannot prevent this, nor can the computer nor the on-mount sights. In anything bigger than a light machine gun installation, firing into your ship must be prevented automatically.

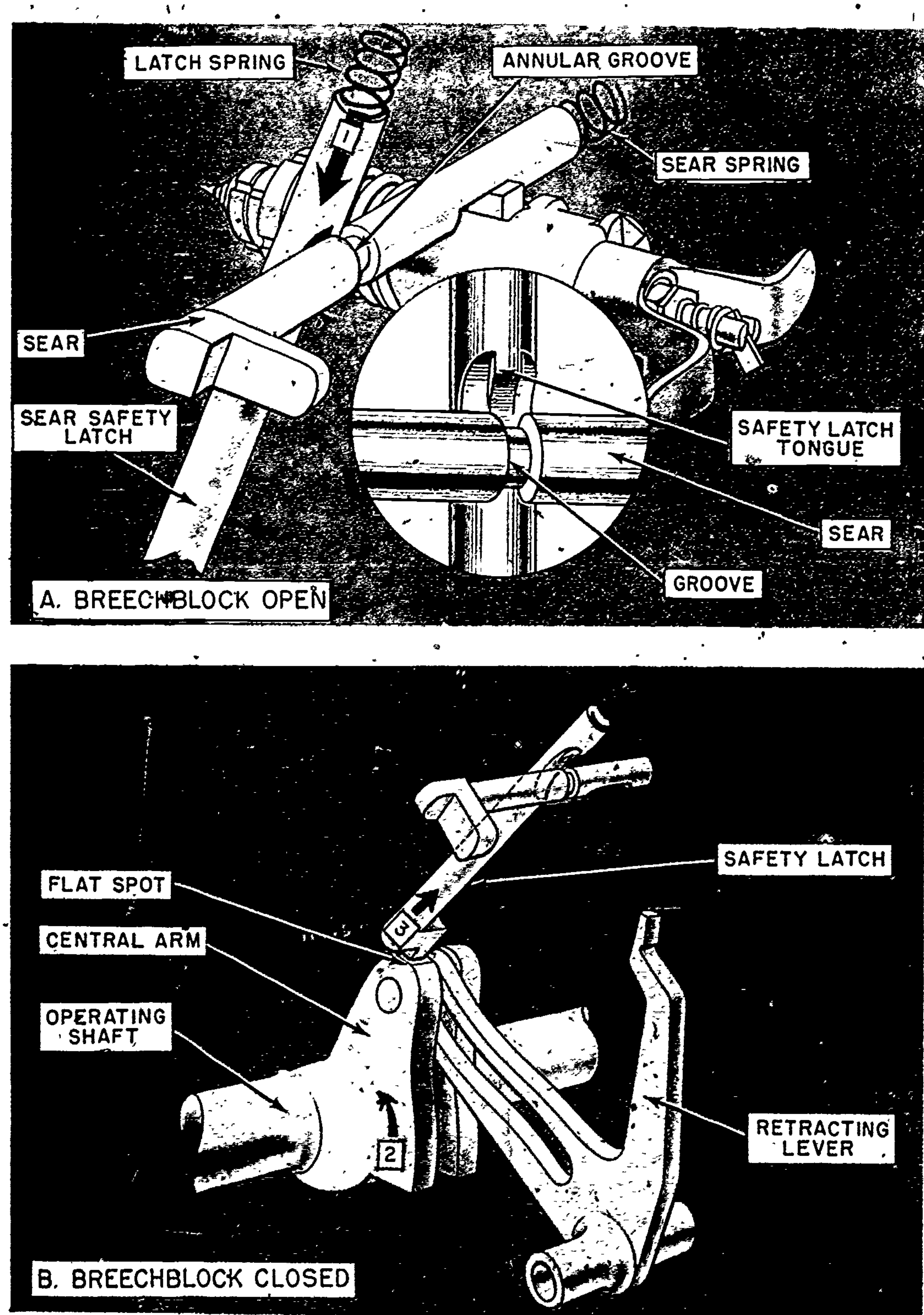
This prevention can be done in several ways. One is to limit mechanically how far the gun can be depressed. This is done on many 20-mm mounts, the depression limit is determined by a circular cam surrounding the stand and the gun cannot be depressed to fire into the ship. Another is to build into the mount power drive provisions for elevating the guns above obstacles on the ship when the mount is trained inboard. But by far the most common way is to equip the mount with a firing stop mechanism, a device which permits the gun to be trained through an unsafe firing zone but interrupts the firing system both mechanically and electrically. Then when the mount is trained once again in a safe direction, the device automatically restores the firing system to normal operation.

In all gun mounts from 40-mm to 5-inch the firing stop mechanisms are similar in principle, though you will find differences in the linkage connecting the firing stop mechanism to the remainder of the firing system. In rapid fire 3"/50 mounts the firing stop mechanism interrupts only the electric firing circuit, and has no effect on percussion fire. (Note: Currently 3"/50 guns use electric firing only). In 40-mm and 5-inch mounts the firing stop mechanism can prevent both electrical and percussion fire.



84.177

Figure 10-23. — 5"/38 firing system. A. Firing mechanism functioning. B. Sear functioning.



84.178

Figure 10-24. — 5"/38 firing system. Functioning of safety latch.

ELEMENTS OF TYPICAL FIRING STOP MECHANISM (5''/38)

The main components of the firing stop mechanism are shown in figure 10-25A. The heart of it is the firing stop cam plate (fig. 10-25B).

The firing stop profile cam plate (fig. 10-25B) is contoured to correspond to the ship's firing and nonfiring zones. Crossing the cam is the elevation input shaft, which moves toward the center of the cam plate when the gun elevates and outward from the center when it depresses. Housed in the lower end of the elevation input shaft is the firing stop plunger which is held in contact with the cam plate by a spring loaded plunger lever.

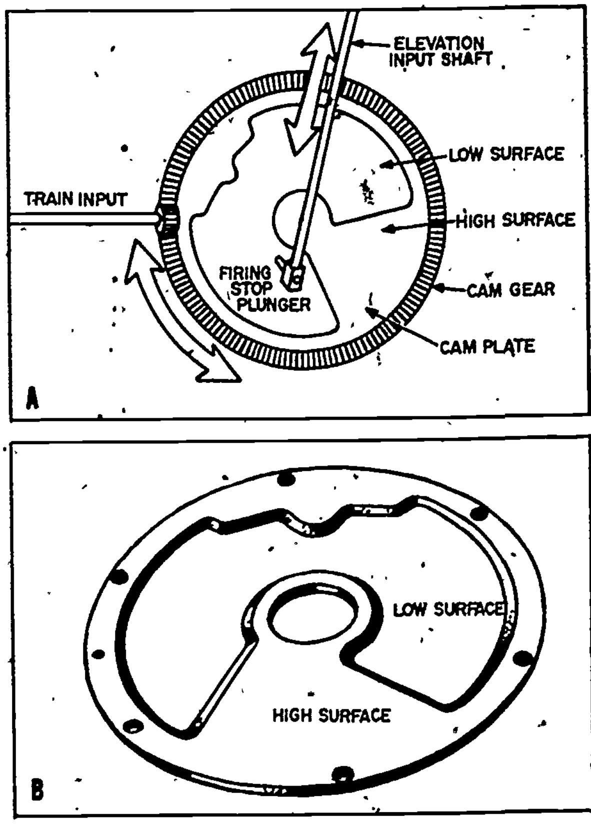
Each position of the firing stop plunger on the cam plate corresponds to a specific position of gun train or elevation.

The firing stop cam plate is so cut that the low places correspond to positions in which the gun may safely be fired; the high places to gun positions in the nonfiring zone in which the ship's structure would be damaged if the gun could fire. The ability of the gun to fire is controlled by the position of the plunger. When it is in the low area, the gun can fire; when it rises to the high area, it breaks an electrical contact in the firing circuit and disengages a clutch in the foot-firing linkage, preventing both electrical and percussion fire (fig. 10-26B). Just where fire is permitted and where it is prevented depends on how the firing cutout cam is cut.

Figure 10-26 shows a 5''/38 mount firing stop mechanism. In view B, the mount has trained to a dangerous position. The plunger has risen and, through the linkage, broken electrical contact and disengaged the clutch to the foot-firing treadle. Differences among 40-mm, 3-inch, and 5-inch mechanisms lie in details of linkage connections to the firing system and to elevation and train gear, and in electrical details. Otherwise all are similar.

NONPOINTING ZONES

Nonpointing zones are zones into which the gun cannot train or elevate. They protect the gun against physical obstructions to the train and elevation movements and prevent firing into the ship's structure. When the gun approaches a nonpointing zone, special circuits within the train and elevation systems cause the gun to elevate and train around the affected zone. When the gun has passed the zone, normal operation resumes.

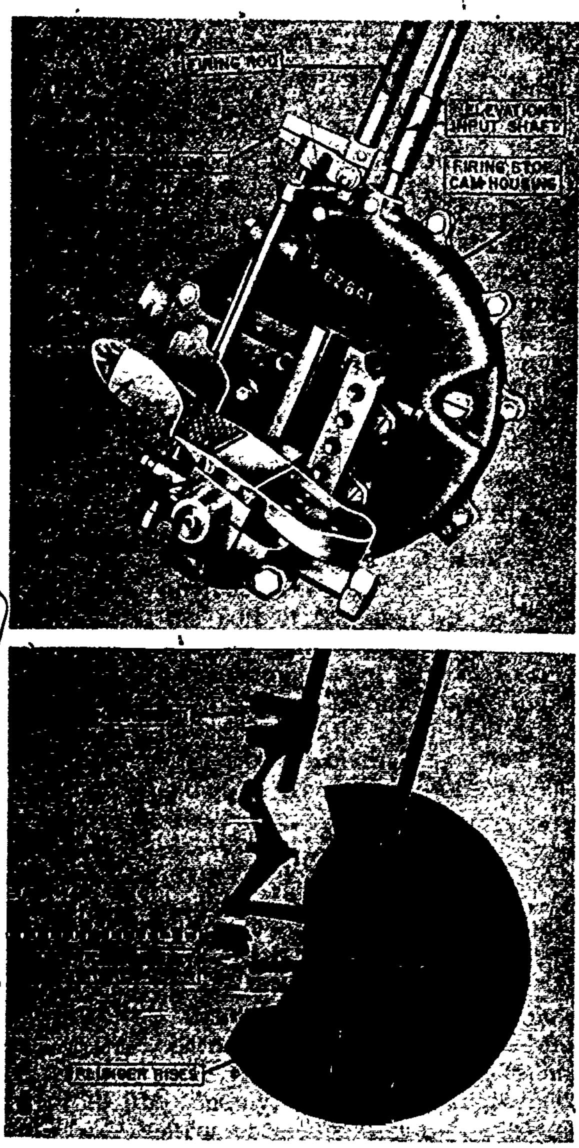


84.179
Figure 10-25.—Principle of the firing stop mechanism. A. Main components. B. Firing stop cam plate.

Figure 10-27 shows a simplified arrangement of nonpointing zones aboard ship. This type of cutout system is used with the 5''/54 MK 9 gun mounts. Nonpointing zones can be arranged with one, two or three levels. The automatic pointing cutout mechanism is located within the train and elevation receiver regulators.

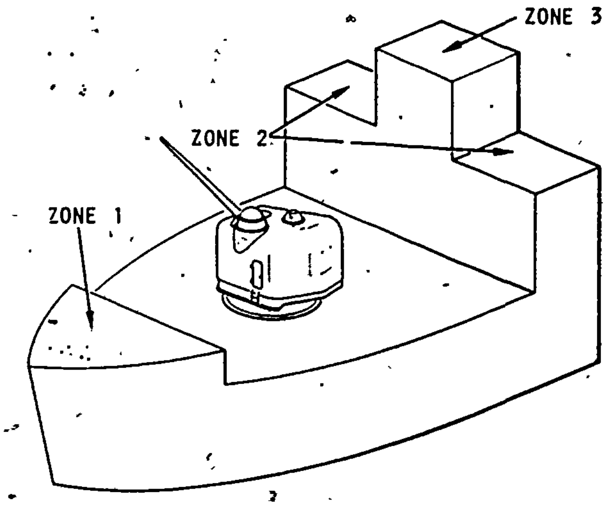
AUTOMATIC OPERATION

The automatic pointing-cutout system actuates the train and elevation limit-stop mechanisms to override gun laying orders. The limit-stop mechanism prevents the gun from driving beyond its designated limits. The limit-stop mechanisms do not interfere with normal gun laying movements within the mount limits.



84.180

Figure 10-26.—Firing stop mechanism for 5"/38 mount. A. Exterior. B. Functioning of interrupt fire.



84.100

Figure 10-27.—Typical nonpointing zone arrangement.

The pointing-cutout system receives position and position-plus-lead signals from the train and elevation systems. When position-plus-lead signals indicate that the gun has moved away from a nonpointing zone, the gun orders resume control of the mount.

Figure 10-28 shows the path taken by the gun as the pointing cutout system combines the train and elevation signals to detour the gun over the nonpointing zones. Numbers on the illustrated route indicate the sequence of events producing the detour.

At point 1, the mount train position-plus-lead switches for the zone open and activate the elevation automatic pointing cutout system. After a short transition period, the gun barrel begins to elevate.

At point 2, the train limit-stop cam is stopped by the limit-stop piston shown in fig. 10-29. After a short transition period, the mount train power drive begins to decelerate.

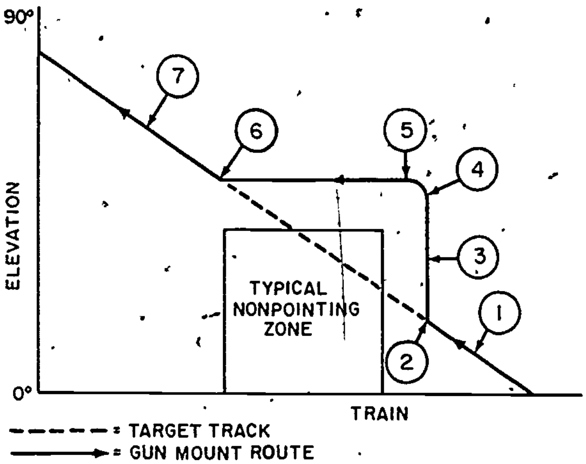
(Note: Because the gun barrel already is pointing below the nonpointing zone, the train automatic pointing-cutout system has already been activated).

At point 3, gun train movements stops and gun elevation movement continues until it reaches a point above the zone.

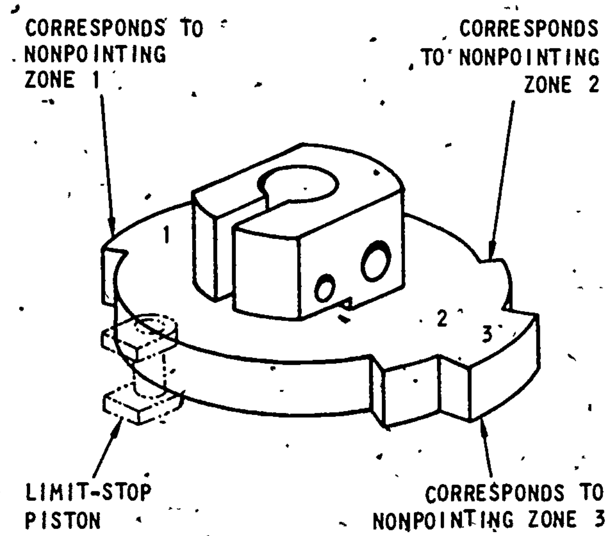
At point 4, a position switch in the elevation receiver-regulator closes, deactivating the train pointing cutout system and permitting the mount to resume training.

At point 5, the elevation power drive is stopped and the train power drive continues driving.

At point 6, the mount synchronizes with the remote elevation order and continues tracking the target.



84.101
Figure 10-28.—Pointing-cutout operation.



84.102
Figure 10-29.—Limit-stop cam.

At point 7, the train-receiver-regulator position switches close, deactivating the elevation pointing cutout system. This action has no effect upon mount operation unless the target's position is below the nonpointing zone. Deactivating the elevation pointing cutout system frees the gun so that it can depress and synchronize with gun order signals.

FIRING CUTOUT

The firing cutout (fig. 10-30) interrupts the firing circuit whenever the line-of-fire of the gun nears ship structure. (Normally, the pointing-cutout prevents this occurrence). Response shafts from the CAB unit B-ends send indications of gun position to the firing cutout mechanism. Whenever the responses indicate that the gun is entering an established danger zone, the firing cutout switch opens the firing cutout circuit. Train and elevation response inputs operate the firing cutout mechanism. The firing cutout mechanism (fig. 10-31) consists of a firing cutout cam, a cam follower, a rocker arm switch actuator, and a firing cutout switch.

Train Response Input

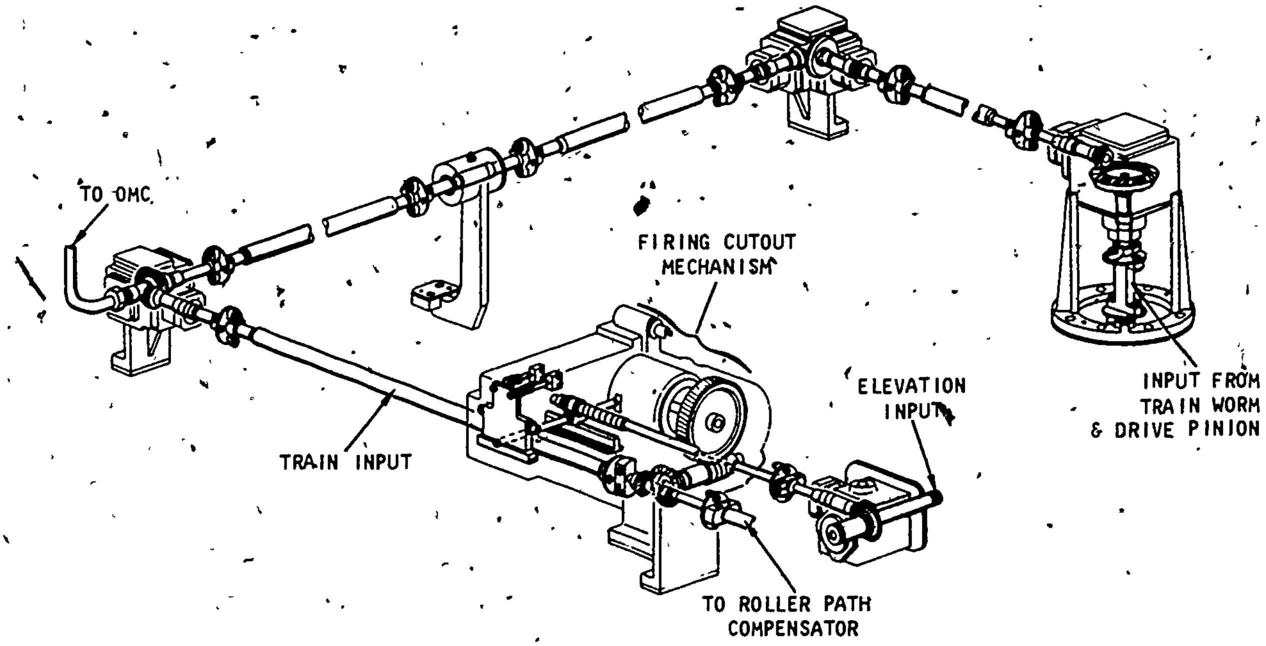
The train input rotates the firing cutout cam through appropriate gearing. The cam rotates at the same speed as the mount so that, as the mount rotates 360 degrees, the cam makes one complete revolution.

Elevation Response Input

The elevation input rotates a worm gear which moves the cam follower back and forth on a guide shaft. A cam follower pin, with a ball bearing on each end, rides in a hole drilled through the cam follower (fig. 10-31). As the cam follower moves along-side the cam, one end of the follower pin rolls along the surface of the cam, and the other end rolls along the bottom of the rocker arm. The follower pin moves at the relative rate of the gun. As the gun moves between its elevation limits, the follower pin moves from one end of the cam to the other.

Rocker Arm And Firing Cutout Switch

The rocker arm pivots on a horizontal pin parallel to the firing cutout cam. A spring on the top of the rocker holds the follower pin firmly against the cam and the bottom of the rocker arm. A firing cutout switch is actuated whenever the cam follower pin pushes the bottom of the rocker to the left.



84.103
Figure 10-30.—Firing cutout mechanism and response gearing.

Firing Cutout Cam

A firing cutout cam is designed and cut for each mount during shipboard installation. An outline of the firing cutout zones forms raised areas on the cam surface. Assume, for example, that the firing cutout zones appear as shown in figure 10-31 and 10-32. The cam is alined to the train and elevation inputs so that the follower pin rolls up on a raised area whenever the gun starts to enter a cutout zone. When the follower pin rolls up on a raised area, the pin and the rocker arm are shifted left (fig. 10-31). The switch actuator opens the firing cutout switch to interrupt the firing circuit (fig. 10-33). When the follower pin moves off a raised area on the cam, the cutout switch closes and completes the firing circuit.

The firing cutout switch operates three indicating lamps. When the switch is closed, a FIRING ZONE CLEAR indicating lamp lights on the EP2 panel. When the switch is open, the FIRING ZONE CLEAR indication goes out, a FIRING ZONE NOT CLEAR indicator lights on the EP2 panel, and a DANGER SECTOR indicator lights on the EP4 panel.

TESTING FIRING SYSTEMS

Testing the firing stop cams shown in figure 10-26 is done in the following manner:

1. Connect a voltmeter or test lamp between the rear of an installed firing mechanism and ground.
2. Complete the firing circuit as for actual firing. Close the pointer's key if you are testing for local fire, and both the pointer's key and the master key if testing by remote fire.
3. Train and elevate the mount around the ship's silhouette, bringing the gun barrels in and out of the nonfiring area.
4. When in the safe firing area, the test lamp or voltmeter should register the presence of the 20-volt firing current. Check to see that the firing linkage movement is reaching the pointer's foot pedal. (This tests for proper action of the percussion firing linkage).
5. When trained into the ship's superstructure, the test lamp or voltmeter should show the absence of a 20-volt firing current. The percussion firing linkage should be disengaged from the pointer's foot pedal.

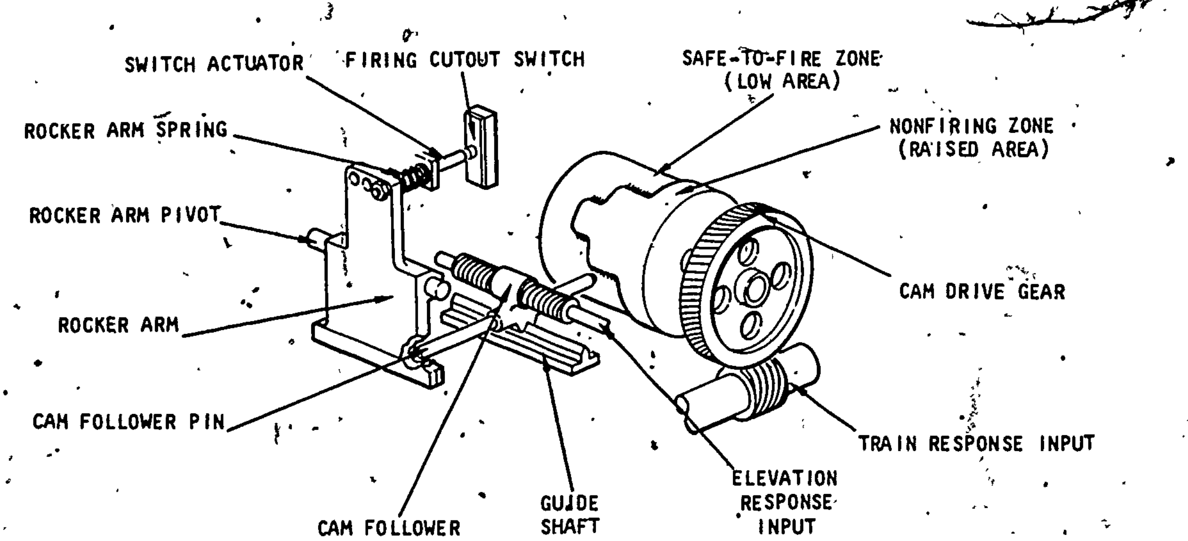


Figure 10-31.—Firing cutout cam.

Once installed and tested, firing stop cams are fairly trouble-free devices. Other than the occasional check just described, there is very little else you can do with them. This is not the end of your maintenance however. Regularly (the frequency depends upon the particular mount) the firing system as a whole must be tested. In large part this deals with the electrical firing circuit.

In testing the electrical firing system, you check:

1. CONTINUITY—that is, does the electrical firing impulse get through to the firing pin?

2. INSULATION—that is, does the electrical firing impulse leak through the insulation so that it either is weak or completely fails to reach the firing pin?

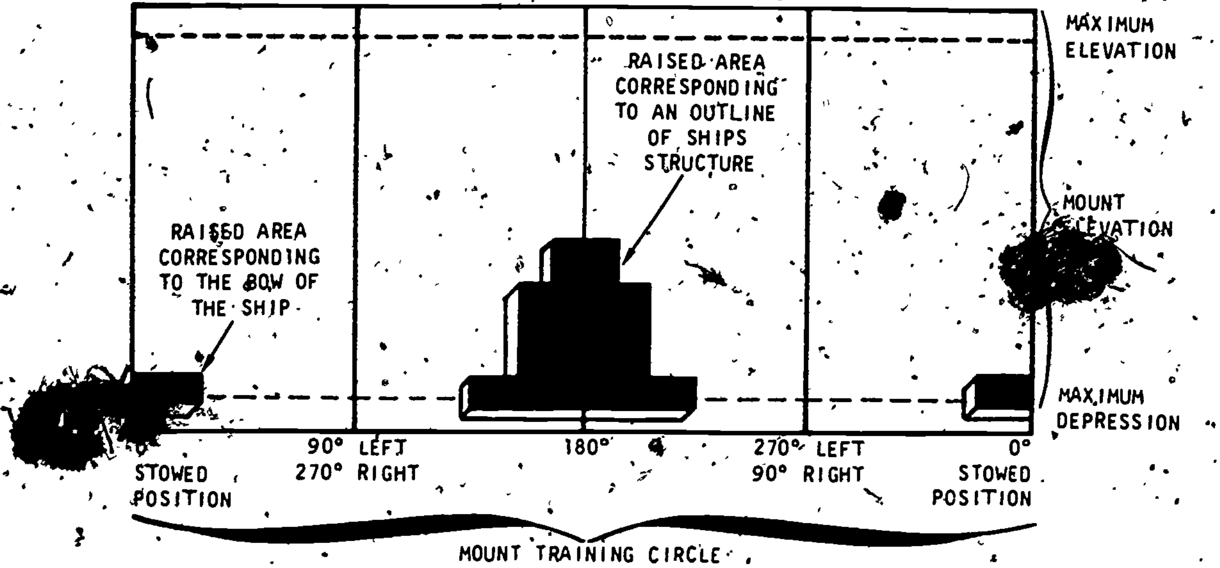
Continuity and insulation are tested without loading the gun.

The continuity test is done with a small test lamp having two insulated leads with metal tips. Hold one tip against the terminal of the firing pin and the other against an unpainted dry spot on the slide or housing. (This is called GROUNDING the lead). When the firing key is closed, the lamp should glow. (See fig. 10-34A).

This test is conducted using not only the pointer's key, but all remote firing keys as well. That is, the keys at the director and in plot.

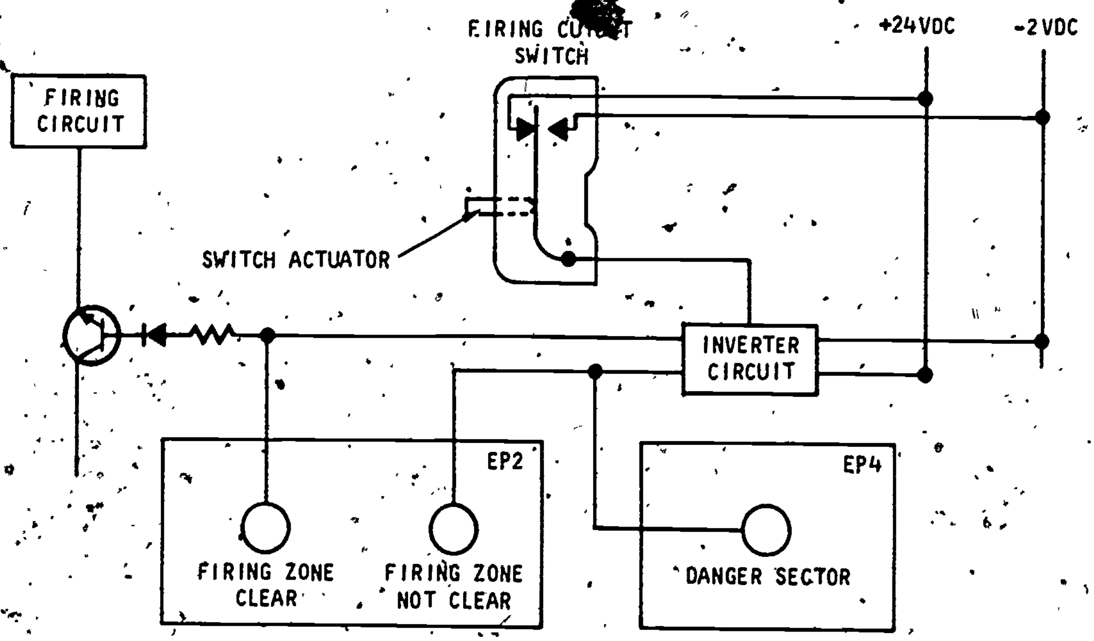
The insulation test involves the use of a megger – an electrical measuring instrument that indicates the resistance of insulation. To make this test, attach one lead of the instrument to the firing terminal and ground the other. (See fig. 10-34B). Then turn the handcrank of the megger. The needle on the instrument should indicate at least one megohm. If the reading is lower, inspect the insulation of the wiring in the firing circuit. Most commonly, when there is insulation failure, it takes place in the firing lead, and that is where you should look first for bare wires, frayed insulation, and so on. Always inspect the firing lead, regardless of test results, to be sure that it isn't kinked, doesn't foul some part of the gun, and hasn't any oil or grease on it.

All the tests mentioned so far have ended at the firing mechanism. The final test is to put a primer in a test case, ram it home (by hand), then kick it out using the foot pedal. Next, put another primer in the test case, and this time use the firing circuit and firing key to set it off electrically. If the primer in either case fails to go off, examine the firing mechanism. The usual electrical casualty is that the firing pin proper is grounding to the breechblock through the firing mechanism. Make sure the firing pin



84.105

Figure 10-32. — Cam surface schematic diagram.



84.106

Figure 10-33. — Firing cutout functional diagram.

84.181

Figure 10-34.—Firing circuit electrical tests (5"/38). A. Testing firing circuit continuity with test lamp. B. Testing firing circuit insulation with megger.

insulation is clean and dry, that the forward and after insulating washers are in place, and that there is no accumulation of grease on the firing mechanism or in its bore in the breechblock.

One final word of caution. You should first remove your tompions before testing the firing circuit with primers. There is sufficient force in an exploding primer to blow your tompions out of the muzzle and over the side.

PREPARATION FOR FIRING

All gun systems require prefiring and postfiring checks as well as routine periodic maintenance and tests. Prefiring checks for the breech mechanisms and associated systems are most important to ensure proper operation and safety during firing. The procedures depend upon doctrine for the mount or turret concerned. Some weapon systems use as guides approved check-off lists; others use appropriate system publications or maintenance requirement cards. Some of the items we have discussed in this chapter apply to all gun systems:

1. Testing firing circuits.

2. Checking breechblock operations.

3. Checking operating lever of breech mechanism to ensure proper operation of the salvo latch.

4. Testing firing stop and cutout systems.

SAFETY

Proper maintenance and operation of the breech mechanism and associated systems are of paramount importance in maintaining safe gun conditions.

CHAPTER 11

ROCKET LAUNCHERS AND PROJECTORS

The history of rocket development covers a span of eight centuries. Both rockets and guns were developed within the same time period but guns attained supremacy because of their greater accuracy.

The intense development of rockets during World War II stemmed from a need for greater firepower that did not require heavy and elaborate substructures to sustain weight and counteract recoil. This need was particularly acute in area bombardment of beachheads and in increased coverage patterns in antisubmarine warfare where accuracy could be sacrificed.

Two of the early rocket systems developed were an antisubmarine ahead-thrown rocket projector called a hedgehog and a barrage launcher designed for installation on medium size landing craft. As the need for new weapon systems increased and fire control systems and rockets became more dependable, new ideas developed which adapted the rocket and missile to replace gun ammunition and depth charges in some types of warfare.

In this chapter we discuss shipboard rocket launchers and projectors.

To advance to Gunner's Mate G 2 you must be able to operate, maintain, repair, and adjust power driven rocket lanuchers and projectors and their associated equipment. You will also have the responsibilities of launcher captain and must be able to supervise crews in the safe and proper procedures for loading, handling, and stowing rocket ammunition.

The discussion here, because it is limited to but one chapter, omits many details. You are responsible for keeping up-to-date on the equipment with which you work. Necessary information is supplied in ordnance OPs and ODs related to that system installed aboard your ship.

This chapter is divided into four parts and includes:

1. Antisubmarine defense
2. Point defense
3. Decoy launching system
4. Safety

ANTISUBMARINE DEFENSE

The Navy's wartime mission is to maintain command of the sea so that we can use it and at the same time deny its use to the enemy. The guided missile adds a new method of attack by enemy naval vessels which can operate hundreds of miles from our shores and still have the capability of launching guided missiles with nuclear warheads against our cities. It is no longer enough to prevent submarine attacks on our own or allied shipping and naval vessels, important as it is, it now becomes necessary to protect our own cities against missile carrying submarines wherever they may be.

Against this threat, unprecendented in the history of warfare, it is the Navy's primary responsibility to maintain constant vigilance and to be continuously prepared to prevent and counter enemy attacks. "Antisubmarine warfare" (ASW) now has an added dimension. The new requirement calls for finding and keeping under surveillance all enemy submarines before they can reach a position within missile launching range of our coasts. Because of this submarine threat, our Navy forces have to be kept at sea for long periods. It should be understood that you as an active duty Gunner's Mate stand a very good chance of being called upon to participate in antisubmarine defense.

Most of what has been developed by way of detecting, locating, and attacking enemy submarines by our surface forces cannot be revealed in this text due to security reasons. In this section we are primarily concerned with the types of equipment used to launch weapons against submarines.

PROJECTOR MK 15 MOD O

The Mk 15 Mod O projector, (nicknamed "hedgehog") is used on older type DEs. It can fire 24 charges in rapid sequence so that they strike the water in a circular pattern about 200 feet in diameter.

The 65-lb projector charges contain their own propelling charge. The hollow cylindrical tail of the charge fits over a rod or spigot on the projector. When the charge's electric primer is ignited by a firing current through the firing pin in the spigot, it sets off the propelling charge. The gas produced by the burning propellant, as it expands, exerts a downward thrust on the spigot and an upward thrust on the projector charge. Since the spigot is supported by the ship, only the projector charge can yield to this thrust, which it does, thereby being hurled into a highly arched trajectory and into the water. The charge's fuze arms after about 15 feet of travel in the water.

Figure 11-1A shows the forward side of the projector with the spigots; figure 11-2 shows the process of loading the spigots, and you can see how the charges fit over the spigots.

General Data

Weight of complete assembly, fully loaded (lb)	18,985
Diameter of salvo pattern (ft)	200
Range (mean distance of pattern (yds)	188
Time of flight (sec)	8
Type of fire	Ripple
Interval between firing pairs of rounds (sec)	0.2
Total number of charges per loading	24
Maximum arc of train (°)	360*
Elevating limits (°) from mean position	+30

*This limit applies when a single train stop is installed. Maximum train possible when two stops are installed is 331°.

Reference publication for Mk 15 mounts is OP 1745.

Construction and Main Components

As figure 11-1 shows, the projector is a rectangular carriage assembly on whose sloping front side are four transverse cradles, each bearing six spigots. The cradles can swing in limited arcs of elevation in trunnion bearings. All the cradles are cross-connected so that they are moved in unison by the elevating gear. The elevating and training controllers, the firing panel, and parts of the power drive mounts on the rear of the carriage. The carriage as a whole rotates in train on a stand bolted to the deck. The lower base ring of the carriage, and the stand, as well as the elevation and train electrohydraulic power drives, are adaptations of the corresponding elements in the 40-mm quad mount.

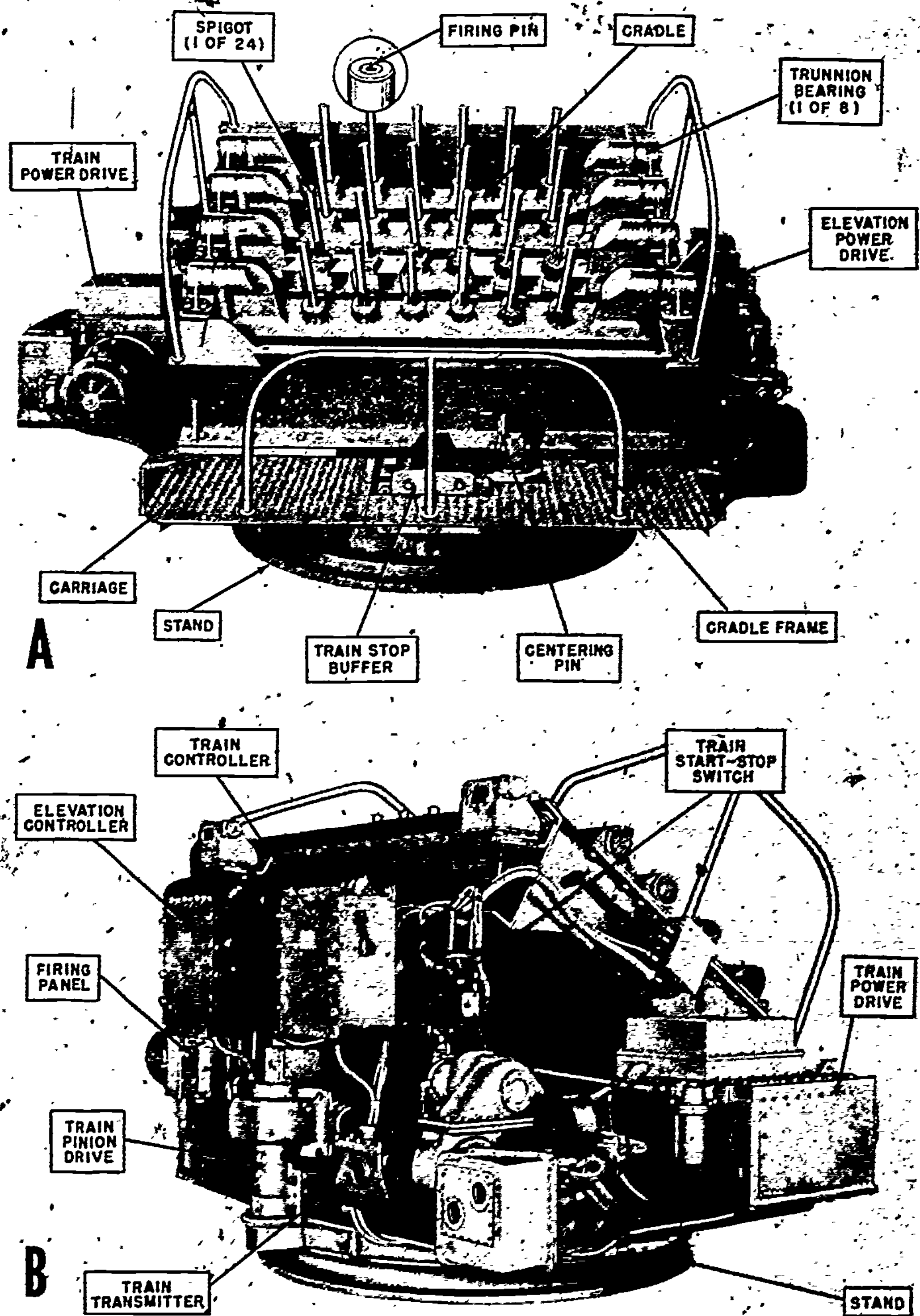
We will now take up each major component of the projector.

PROJECTOR STAND.—The stand is a large circular unit attached to the ship's structure by hold-down bolts. It supports all other projector components and holds the carriage down. Other parts include the bearings in which the carriage turns, and a fixed ring gear which meshes with a training-gear pinion to turn the carriage in the stand. Associated with the stand are two train stop blocks bolted to the deck inside the stand. One block is installed when 360° of train is required; two are used for 331° or less of train.

PROJECTOR CARRIAGE.—The projector carriage consists of two large main structural units, the lower base ring and upper base ring, and includes the projector cradle-frame assembly, elevating and training gear and their power drives, firing cutout mechanism, train stop and buffer, firing panel, and electrical installation.

The cradles are four large parallel I-beam units, transversely pivoted in the frame, and cross-connected so that they move as a single unit. Each cradle mounts six fixed spigot sockets. Each socket holds a 14.5-inch steel rod or spigot on which the projector charge is loaded. Together the 24 spigots make up an upward and outward thrusting "hedgehog" arrangement, which aligns the 24 charges so that when they are fired they produce a circular pattern at the point of impact, as shown in figure 11-3.

The main element of the elevating gear is an enclosed worm-and-worm wheel mechanism at the left side of the cradle frame, which can tilt the cradles through a total arc of 60°.



3.136(110A)

Figure 11-1. — Projector Mk 15 Mod 0. A. Front view. B. Left rear view.

The training pinion, which engages the ring gear in the stand, is driven by a similar arrangement. Both can be actuated either by the hydraulic power drive or manually. Train is limited by the carriage training stop buffer, and assembly of two hydraulic cylinders and pistons which engage the train stops on the deck inside the stand.

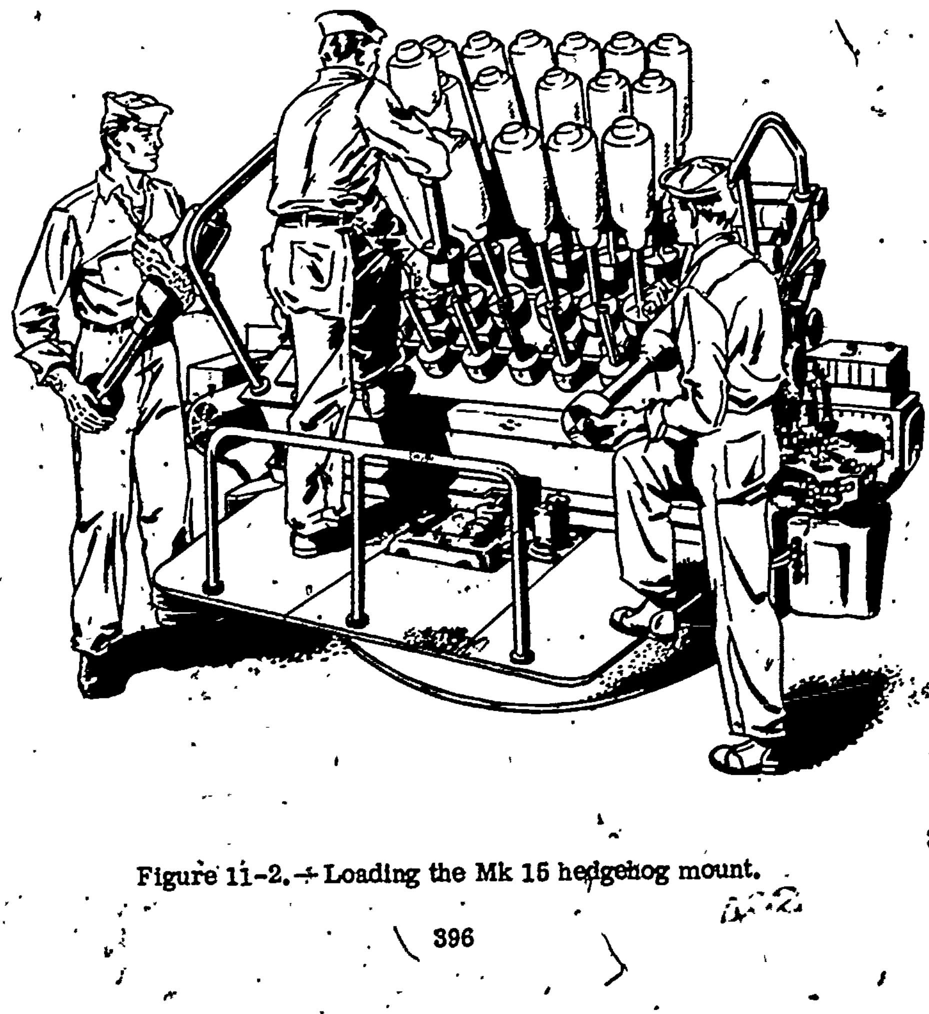
The carriage firing cutout mechanism, a circular cam and follower device that actuates a switch in the firing system, is operated by the train worm drive through a takeoff drive shaft. The firing cutout, like those used with gun mounts, prevents the projector from firing charges into own ship's structure.

POWER DRIVES AND CONTROLS. — Elevation Power Drive Mk 5 Mod 20 is an electrohydraulic type almost identical to that used on 40-mm quad mounts. It combines an electric motor driven hydraulic transmission with an electrohydraulic type receiver-regulator. The train power drive is a similar electrohydraulic assembly — Train Power Drives Mk 6 Mod 14, also derived from 40-mm quad mount equipment.

The train and elevation power drive electric circuits are similar. Both include on-mount 440-v a.c. electric controllers and motors, and 115-v a.c. receiver-regulator synchro units. The power circuits include interlock switches and master pushbutton stations, in addition to the motors and controllers. The 115-v system includes a receiver synchro-control transformer, a lag meter, an amplifier, a starting switch, and a hydraulic transmission stroke-control motor for each of the two power drives. The system works like the 40-mm systems with which you are already familiar.

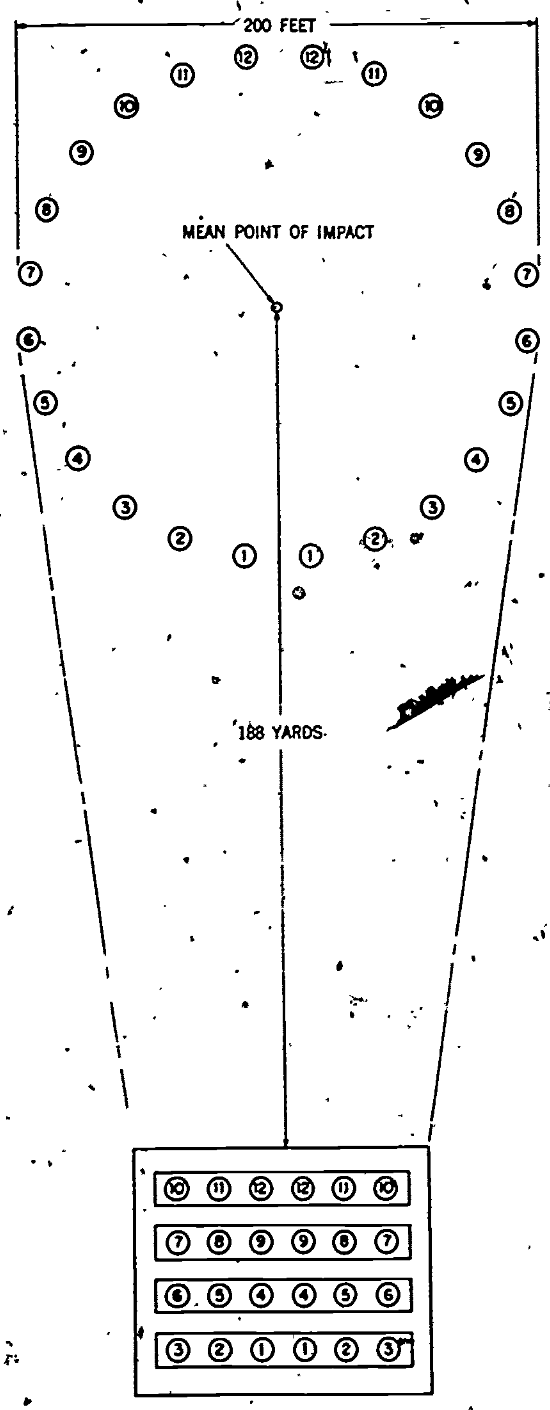
Firing Circuits

Firing a salvo of charges from an Mk 15 projector is different from firing a gun mount, and we give it special attention. The firing



3.136(110A)

Figure 11-2. — Loading the Mk 15 hedgehog mount.



53.196
Figure 11-3. — Projector Mk 15. Pattern of fire of a salvo.

circuit (schematically shown in fig. 11-4A) is a remotely operated system that fires the 24 projector charges in pairs at uniform intervals of 0.2 second. Components of the system are Firing Panel Mk 27, Mod 0 (fig. 11-4B), 24 spigot firing pins, a firing cutout switch, and a 20-wire connection box. The system is divided into two parts; (1) a firing-current-supply circuit that includes a ripple switch through which the firing current passes to the spigot firing pins, and (2) a remotely operated solenoid that actuates a firing key to start the firing current through the ripple switch. The spring-operated, rotary ripple switch is mounted in the firing panel and must be manually wound up prior to each firing cycle. Included in this circuit is a transfer switch that has three positions, S (Safe), R (Ready to fire), and T (Test). The firing-key actuating solenoid, on the back of the firing panel, is energized remotely from the plotting room. The solenoid armature is linked through a rocker arm to the firing key, which fits on a square shaft through the center of the transfer-switch dial. When the solenoid is energized, the armature is pulled up and the firing key down to fire position.

The firing panel (fig. 11-4B), which is the main firing control on the projector, provides for proper distribution of the firing current and for testing the firing pins in each spigot. It houses the solenoid, ripple switch, A.C.-D.C. switch, transfer switch, calibration rheostat, and test indicator.

The circuit of each pair of spigot firing pins is connected to a separate contact in the ripple switch, which has twelve live contacts labeled "1" through "12" consecutively, and two dead points labeled "C" and "F" (fig. 11-4A). The numbers indicate which pair of spigots is connected into the firing circuit. Letter F is the ready-to-fire position; C is the dead position after firing is complete. The switch is mechanically interlocked with the transfer switch to permit firing only when the latter is at ready position. Placing the ripple switch in F position winds up a spring. A pawl and ratchet device holds it cocked. When the solenoid trips the A.C.-D.C. switch, the ratchet releases, and the ripple switch rotates counterclockwise to C position, closing all twelve contacts in succession.

The A.C.-D.C. switch connects the firing-pin circuit to either the 20-v a.c. or 6-v d.c. supply, depending on firing key position. The key may be inserted either (1) with handle to the right (for a.c. firing) or (2) with handle to the left (for d.c. firing). (This can be done only with

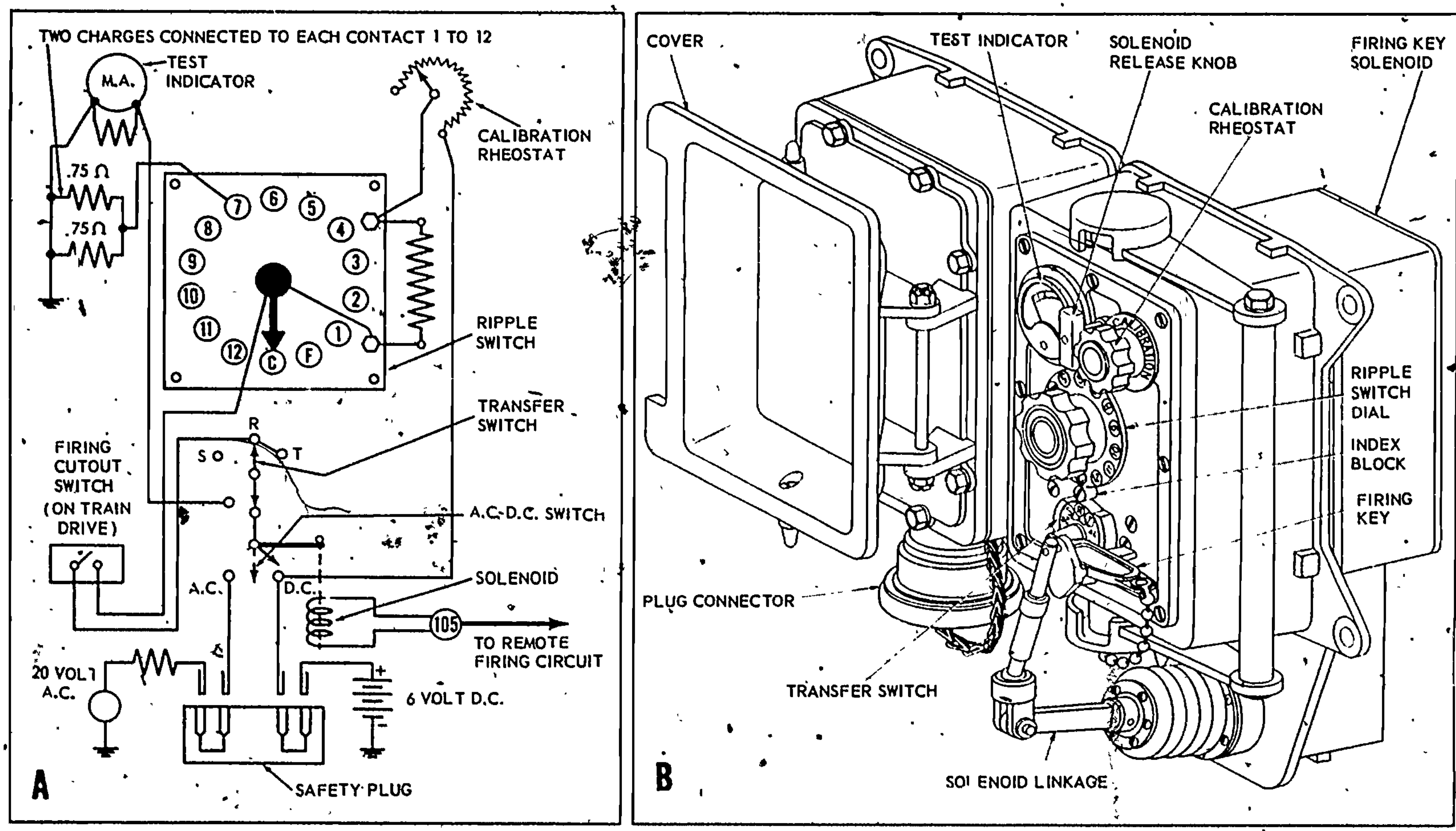


Figure 11-4.—Projector Mk 15 Mod 0. A. Firing circuit (simplified schematic). B. Firing panel Mk 27 Mod 0.

84.232

the test switch at SAFE). The solenoid pulls the key handle down to start firing action. This action rotates the A.C.-D.C. switch to connect the firing current, while a cam on the switch shaft releases the ripple switch ratchet pawl. The solenoid is energized through a separate 115-v a.c. circuit by a remote firing key.

The transfer switch is in the firing circuit between the A.C.-D.C. switch and the firing cutout switch. At S position, the firing circuit is broken, and the firing key may be inserted into the A.C.-D.C. switch. With the switch at R, the circuit is completed. The T position, used for testing with the A.C.-D.C. switch at D.C., has the calibration rheostat and test indicator in the circuit.

The test indicator and rheostat, which are used in testing the continuity of the firing circuit, are respectively a common type of commercial milliameter and a variable resistor. The safety plug, through which both a.c. and d.c. firing currents must pass, is a safety device that must be kept OUT of its socket except when firing or testing is actually going on.

Operation and Crew Stations

To ensure safe handling of the ammunition and safe operation of the equipment, personnel should be thoroughly familiar with OP 2082. Operation of the Mk 15 projector includes four kinds of activities—preparation, loading, aiming, and firing. Normally, aiming and firing require no personnel at the mount, but up to nine men are needed for preparing and loading.

Preparation, which means getting the stowed projector ready for loading, includes removing protective canvas covers from the mount and spigots; withdrawing train centering pin and cradle stowing device; inspecting, cleaning, and lubricating before starting; closing power supply switches, starting and exercising the power drives; and testing control, firing, and transmitter circuits. Loading requires placing 24 explosive charges on the projector spigots. Aiming is normally remote-controlled from the plotting room.

Final preparations for firing include selecting the firing circuit supply, winding the ripple switch, and, finally, after the crew is clear, installing the on-mount and off-mount safety plugs and closing the portable firing cutout key. Closing the remote firing key in plot operates a solenoid which releases the ripple switch, and the 24 spigot pins are energized in pairs at intervals of 0.2 second. All charges are fired within 2.2 seconds, and the final position of the ripple switch opens the firing circuit so that the mount cannot be fired again until the switch is reset manually.

The only method of firing this weapon is from the plotting room There are, however, two methods of elevation and train; automatic control and hand drive. Normally, the projector is trained and elevated in automatic control by the power drives, which are controlled remotely by signals from a plotting room director or from a manually controlled train indicator-regulator near the mount. Hand drive is a manual method of elevating the cradles and training the carriage, for lubrication and service maintenance only.

The on-mount crew for the Mk 15 projector includes a mount captain, two first loaders, two second loaders, and two or more ammunition passers (as required).

The mount captain's duties are essentially the same as those of the crew leader in any other form of gunnery. He supervises preparations for operating, loading, and reloading. He sees that all safety precautions are observed. He checks the condition of the mount and ammunition before firing, and, when satisfied that the projector is correctly loaded, he personally performs the firing-preparation action, selecting the firing current supply, winding the ripple switch, and setting the train and elevation switches for power operation. He must then report "All clear and ready for firing" to the plotting room.

When the firing circuit has been closed, the mount captain reports to the plotting room on the successful launching or misfire of all 24 charges. In the event of misfire he must, after taking the necessary precautions, reset the ripple switch to repeat firing. After this, he must again report to the plotting room. He also supervises circuit testing procedures before and after reloading the projector. At the end of firing operations he supervises securing the mount.

Each first loader receives a projector charge from a second loader, lowers it gently onto a spigot, then rotates it a full turn to ensure good electrical contact between firing pin and cartridge primer. Each first loader, when ordered by the mount captain, removes the fuze caps and safety pins from the 12 charges that he has loaded. This is done if preparation for aiming and firing is imminent.

Each of the two second loaders has different duties in preparing the mount for operation and in loading.

The second loader at the right of the mount secures the carriage in train during loading, and transfers projector charges from an ammunition passer to the first loader on his side. When both first loaders are clear, after loading, he releases the train centering pin. The second loader at the left of the mount locks the cradles during loading, and passes projector charges to the first loader on his side. After loading is completed and both first loaders are clear, he unlocks the cradles.

The ammunition passers break out the charges from the ready-service lockers, inspect them, and pass them to the second loaders. In addition, one ammunition passer acts as starting controlman to operate both the train and elevation controllers, closing the disconnect switches when ordered by the mount captain.

If cradles or the carriage must be manually driven to stow them in preparation for loading, ammunition passers operate the handcranks.

Maintenance

The projector, because of its exposed position and lack of shielding, requires careful routine upkeep, especially lubrication. Follow the lubrication charts carefully, particularly for items which must be lubricated daily, weekly, and before or after firing. But avoid excessive lubrication, which can damage electrical parts, and cause puddles on the deck that make for hazardous footing. Don't lubricate fire control gear; that's for the FT to deal with.

Be sure to open drain plugs periodically to avoid accumulations of moisture and contaminated lubricants.

Periodically check mechanical and electrical parts as called for by the OP. Check and exercise the power drives; they are similar to the drives you are already acquainted with in 40-mm mounts, and have similar requirements.

Fire control transmission checks should be performed as required by the ASW or weapons officer.

Misfire Procedure

In the event of a misfire, the misfiring charge will remain on its spigot after the others have departed. If this happens, hold the firing key down, operate the ripple switch clockwise through its full rotation, then release it. If the charge still doesn't fire, treat it as a hangfire. Keep all personnel at a safe distance, and, if possible, delay further operation for at least 30 minutes after the last attempt to fire while the projector is kept trained on a safe bearing. Then remove the safety plug from the firing panel. After this interval, remove the defective round and dispose of it as recommended by bomb disposal personnel.

Other projectors, a few of which may still be found in the fleet, are the Mk 10 and Mk 11.

Like the Mk 15, the Mk 10 and Mk 11 projectors fire charges from 24 spigots, and these land in a roughly circular pattern. The spigots are mounted on four I-beam cradles which are parallel to the length of the mount instead of traverse to it. The base frames on the Mk 10 and Mk 11 projectors do not train; instead they are secured to the deck. A certan amount of "train" is possible by tilting the trunnion-mounted cradles; they are joined at the after end by a connecting bar linked to a handriven roll correction gear assembly. Naturally, the pattern is distorted when the cradles are tilted; the pattern flattens and approaches a straight line at full tilt. Therefore the ship as a whole is aimed so far as practicable, and the tilting is used to make minor corrections.

The on-mount accessories used with the Mk 10 and Mk 11 projectors are a firing panel and a gun train indicator. An off-mount target designation transmitter controls cradle tilt.

In general, the mount operations for the Mk 10 and Mk 11 projectors resemble those for the Mk 15, so far as loading and firing are concerned although there are some differences in fire control.

POINT DEFENSE

The basic point defense surface missile system (BPDSMS) has been developed to improve the self-defense capability of ships without missile defenses. The BPDSMS provides a tactical weapon for all-weather defense against air and surface targets. This system comprises two major subsystems; Fire Control System Mk 115 Mod 0 and Guided Missile Launching System (GMLS) Mk 25 Mod 0. The subsystems function together to detect and track a target, and to fire and guide the Sparrow missile to target intercept. The GMLS can be operated in three modes; local, remote, and remote-assigned. In local mode, the launcher is controlled from the launcher control panel for missile loading, checkout, and maintenance. In remote mode, the launcher is in a service-ready condition, with the launcher positioned at zero cable twist awaiting assignment to the fire control system. In remote assigned mode, the launcher responds to orders from the fire control system to aim and launch Sparrow missiles.

This system is operated and maintained by personnel in the Gunner's Mate G rating. As gunner's mates we are primarily concerned with the launcher assembly and not the fire control system. In this section we explain the functions of the components making up the GMLS Mk 25.

GUIDED MISSILE LAUNCHING SYSTEM MK 25

The GMLS Mk 25 (fig. 11-5) provides ready service stowage facilities for a maximum of eight Sparrow missiles, means for pre-launch and firing signals to a selected missile, and a launching platform for the missiles. The GMLS also is used for crew training and system check. The GMLS consists of the following major components:

1. Guided missile launcher Mk 128 Mod 0
2. Launcher control panel Mk 288 Mod 1
3. Relay power supply Mk 143 Mod 0
4. Control panel Mk 65 Mod 3
5. Amplifier Mk 40 Mod 4
6. Train and elevation amplidyne motor generator Mk 6 Mod 1
7. Firing power supply Mk 143 Mod 0
8. Launcher area safety switch
9. Sparrow missile

Launcher Mk 128 Mod 0

The guided missile launcher (fig. 11-6) consists of launcher guide, a carriage, and stand. The guide contains eight missile cells, each with a rail that supports and guides the missile during loading, storage, and launching (fig. 11-5). Two doors at the front of each cell open mechanically for missile launching and provide access to the cell for maintenance. The carriage (fig. 11-7) supports the launcher guide and all components that rotate in train. Components of the carriage provide buffer action when the launcher trains and elevates into positive limit stop. These components lock the launcher in train and elevation when stowed, and interrupt the firing circuit when the guides are pointed at the ships structure. The train and elevation power drives are also mounted on the carriage. The stand (fig. 11-8) is a cylindrical flanged steel casting. The inside flange supports the lower thrust separator. The top flange is the attaching surface for the training circle gear. Nine equally spaced lubrication fittings for the trust and radial roller separator assemblies are located on the stand. Two thrust roller separator assemblies (fig. 11-8) are mounted in a concentric and parallel arrangement on the lower base ring. The assemblies consist of an upper and lower roller path, a separator, and cylindrical rollers. The upper separator assembly serves as a holddown and the lower separator assembly supports the weight of the launcher. The radial roller separator assembly (fig. 11-8) is similar in construction to a thrust separator except that the rollers are installed vertically. The radial roller separator is mounted between the stand and the lower outside edge of the lower base ring. This separator absorbs radial (horizontal) loads and maintains concentric alignment of the stand.

Launcher Control Panel (LCP)

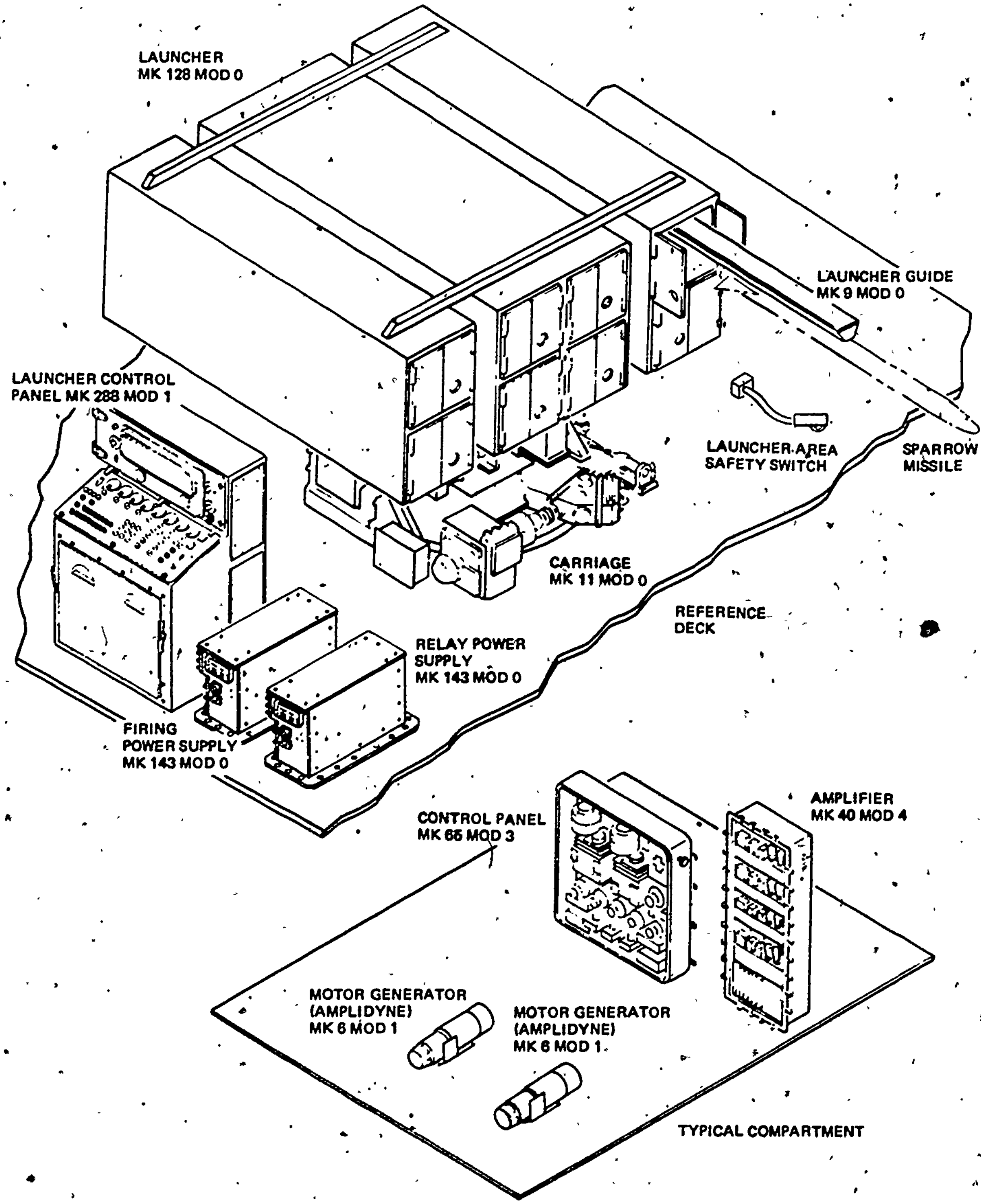
The LCP Mk 288 Mod 1 (fig. 11-9) is a console type assembly that houses controls, indicators, fuses, and electronic equipment for operating the GML. The LCP contains switching circuits for the 60 Hz power circuits, 400 Hz missile warmup circuits, and the 28V. d.c. missile sequencing and firing circuits. All of these circuits except the firing circuit are controlled at either the LCP or the fire control panel (FCP), with the missile firing circuits controlled only from the FCP. The LCP provides controls and indicators for loading, servicing, and testing the launcher. The LCP consists of a launcher operation control panel assembly and a local director door assembly.

The launcher operators control panel assembly contains indicator lights and switches for operating the launcher in local control. Indicator lights show launcher ready status and safe firing zone status. Meters measure missile elapsed time (warmup), and launcher running time.

The local director door assembly contains the train and elevation handwheels for local control of the launcher and a rectangular display window for viewing the indicating dials for cable twist and coarse and fine train and elevation control signals. A safe normal switch is also located on this assembly and is used to deenergize the missile firing power supply when in local or remote operation mode.

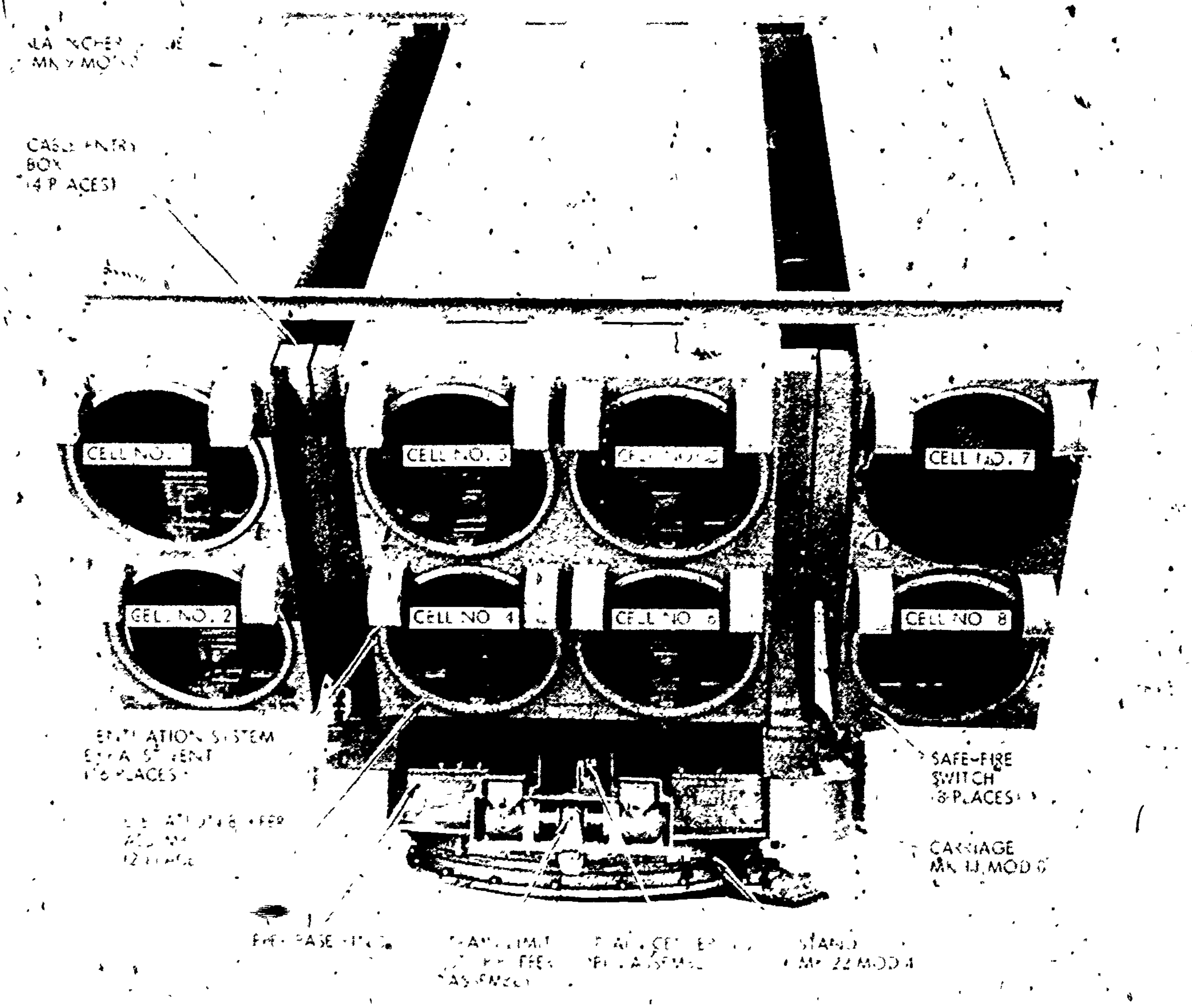
Relay Power Supply

Relay power supply (fig. 11-5) supplies 28V. d.c. for the missile system relays and indicators.



167.606(84A)

Figure 11-5.—Guided missile launching systems Mk 25 Mod 0.



167.607(84A)

Figure 11-6. — Guided missile launcher Mk 128 Mod 0, rear view.

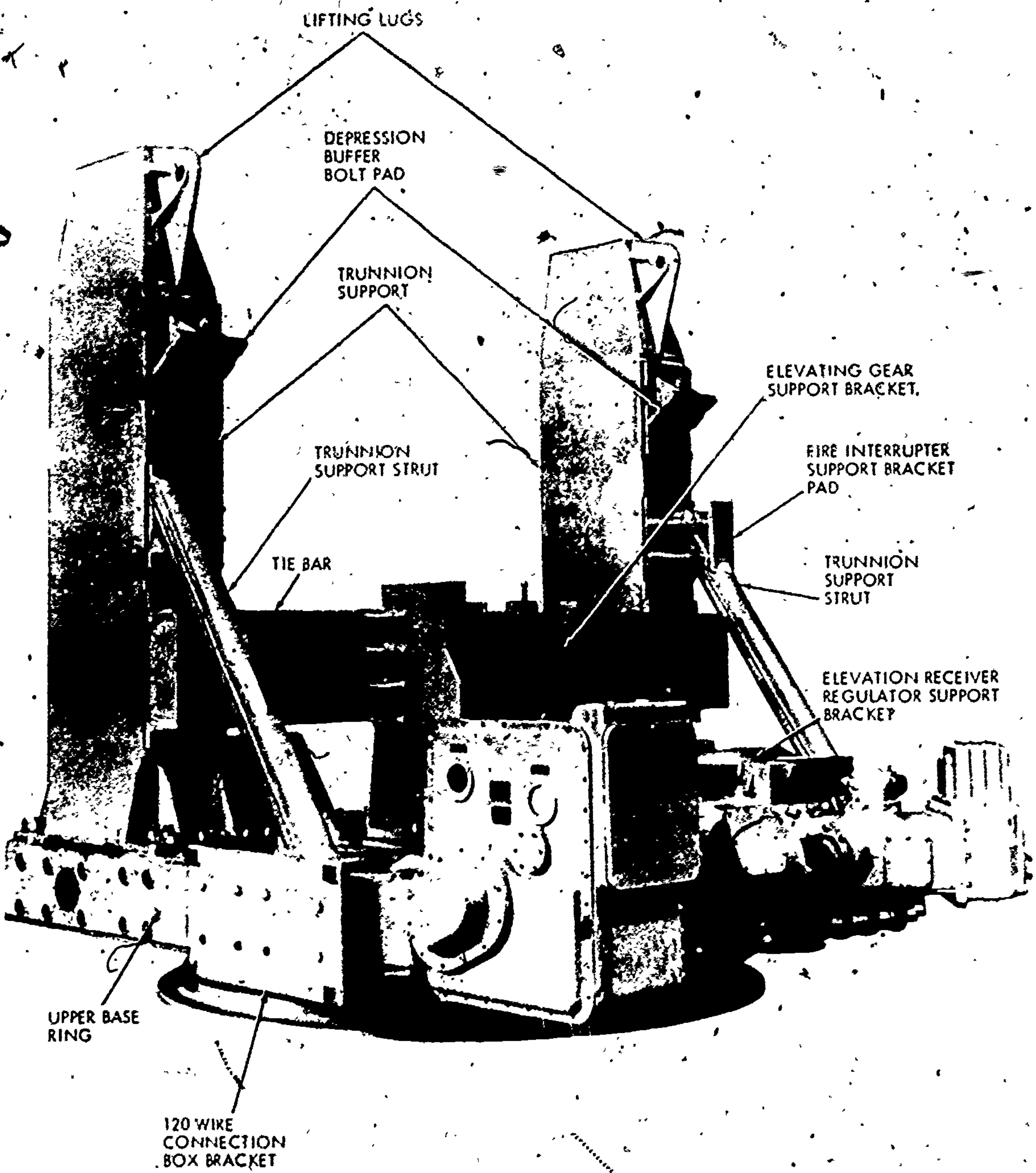
Control Panel

The control panel, Mk 65 Mod 3 (fig. 11-5), receives ship 440V. a.c. 3-phase electrical power and distributes it to the power drive circuits. This panel contains timing relays that control the sequence of motor generator starting and houses the power drive main circuit breaker. The panel also houses plate and filament transformers for amplifier Mk 40 Mod 4 and a step-down transformer for the 115V. a.c. power drive control circuit.

Amplifier

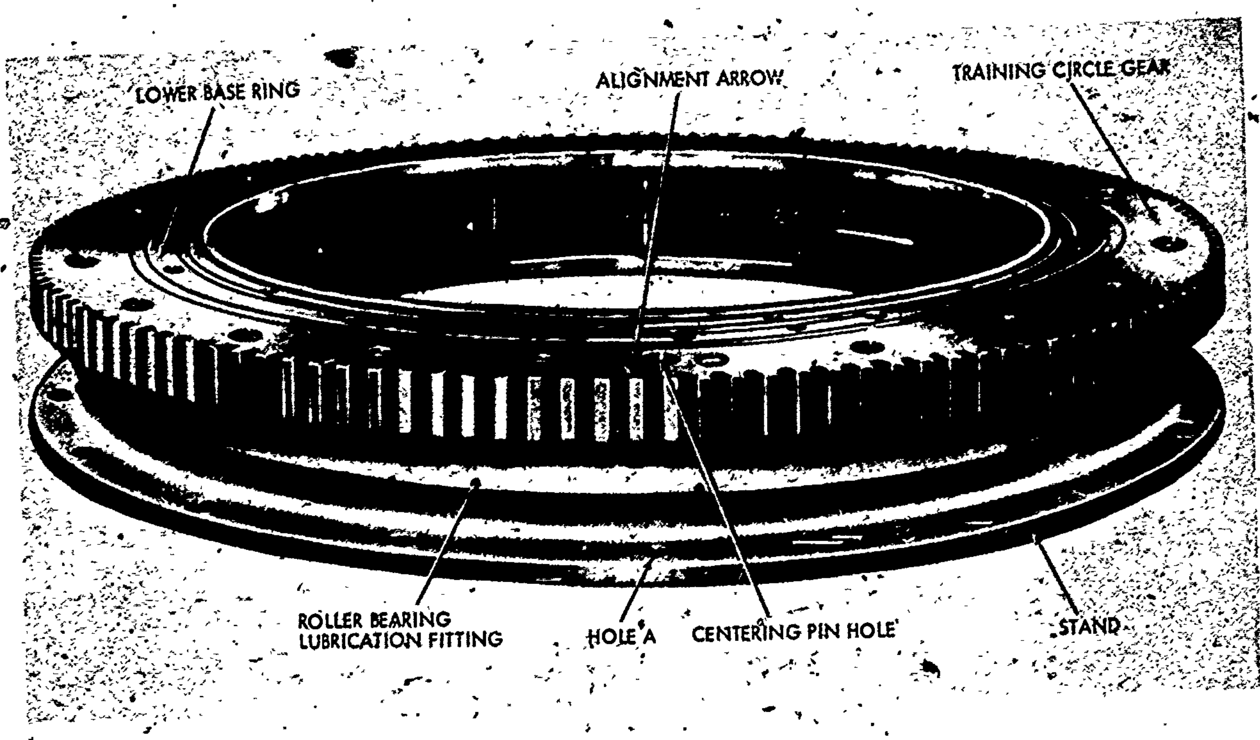
The amplifier Mk 40 Mod 4 (fig. 11-5) contains the elevation and train amplifier assemblies, a power supply assembly, a cable twist control assembly, motor field control assembly, heat exchanger, and terminal board panel. The train

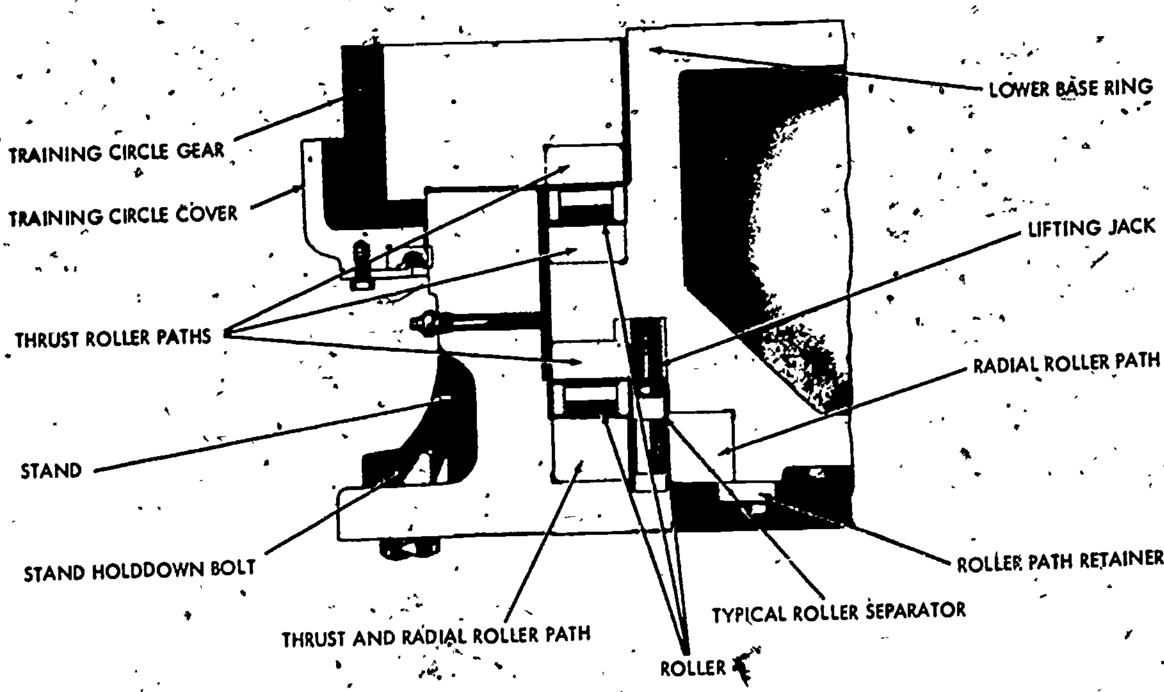
409



84.290

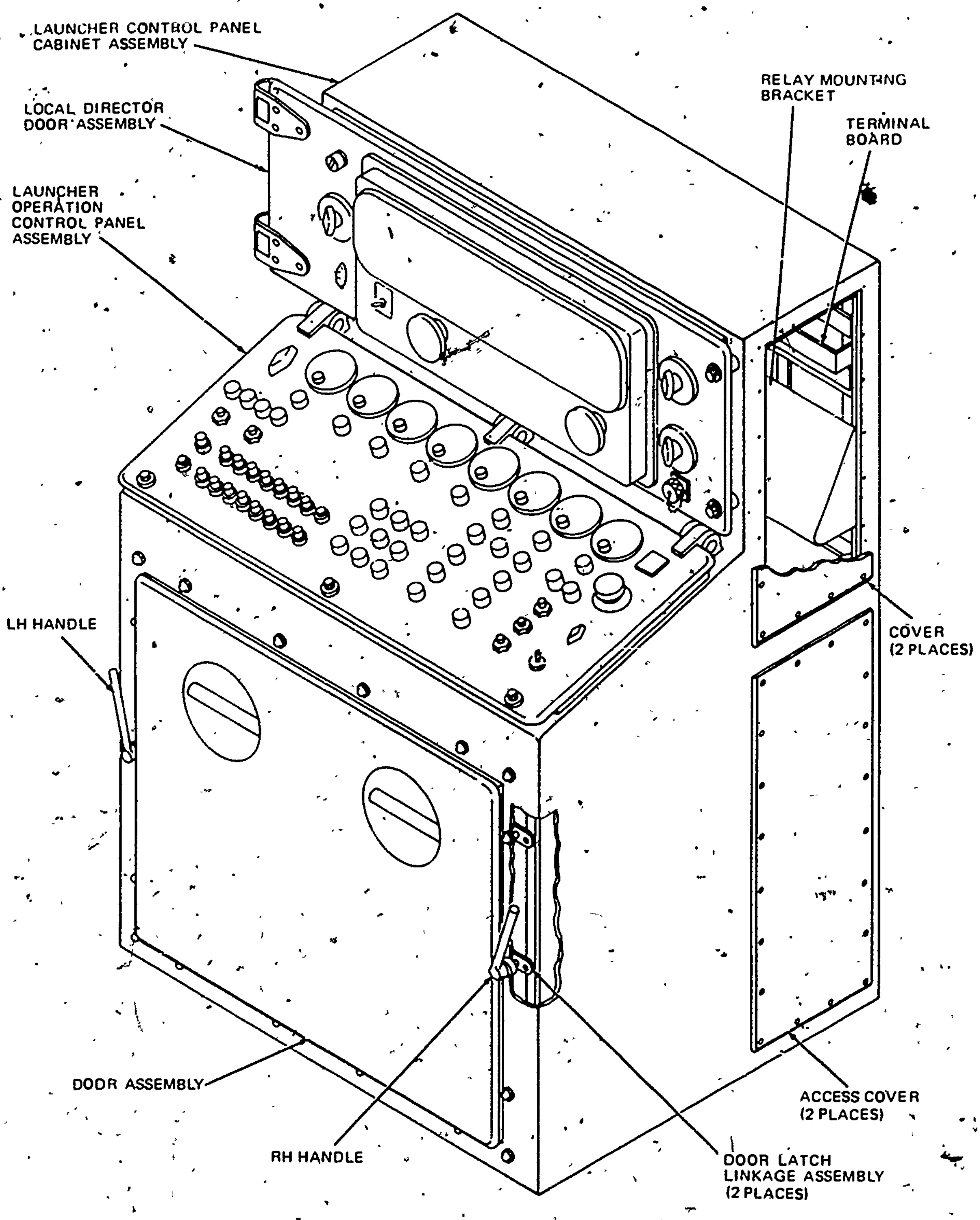
Figure 11-7. — Carriage Mk 11 Mod 0.





84.291

Figure 11-8.—Stand Mk 22 Mod 4.



167.613(84A)

Figure 11-9.—Launcher control panel cabinet assembly.

and elevation amplifiers supply controlling voltages to the motor generators. The power supply furnishes direct current power to the amplifier assemblies and the motor field control assembly. When the launcher is in remote mode operation, the cable twist control assembly ensures that the launcher cannot be stowed with 360 degrees of cable twist. The motor field control assembly supplies the rectified field current for drive motor field excitation. The heat exchanger circulates air for cooling the amplifier components.

Motor Generator

The GMLS employs two motor generator (amplidynes) Mk 6 Mod 1 as shown in figure 11-5. One is used for train, and the other is used for elevation. The motor generator is a motor driven generator amplifier that provides a high-powered, precisely-controlled output to the drive motor. The output is regulated by a low-power input from the amplifier.

Firing Power Supply

Firing power supply Mk 144 Mod 0 (fig. 11-5) provides 28V. d.c. to fire the missile auxiliary power supply and rocket motor squibs.

Safety Switch (SMX-4)

The launcher area safety switch (fig. 11-5) prevents movement of the launcher by the power drives when connected and the safety switch is not depressed. This switch is the observer's safety device, used when personnel are performing maintenance or tests on the launcher.

Sparrow Missile

The Sparrow missile is a supersonic surface-to-surface or surface-to-air boost guided missile that employs semi-active homing guidance. The missile is propelled by a solid propellant rocket motor and carries a high explosive warhead.

Operation

Operation of the Mk 25 GMLS includes three modes of control for loading, testing, and firing a Sparrow missile. Normal aiming and firing are controlled by the FCS when in remote-assigned mode and is the only mode in which a missile can be launched. The procedures for activating all modes of operation are similar except for local control mode. In any other mode except local the LCP can be unmanned after the preoperation procedures have been completed.

Before electrically activating the launcher, preoperation procedures must be performed at the launcher. These procedures include releasing mechanical locks, securing the launcher against inadvertant movement, and closing interlock switches to permit electrical activation of the launching system.

The GMLS is activated from either the FCS (in remote or remote assigned mode) or the LCP in local control mode. As stated early the three modes of operation are local, remote, and remote assigned.

LOCAL MODE.—The local mode of operation is used for loading, testing, and performing maintenance on the launcher. When operating in local mode, the LCP controls and indicates the sequence of operation from turn-on through shutdown. Although the missile control circuits are routed throught the LCP, the panel does not contain any switches or controls for the missile electric circuits.

REMOTE MODE.—The remote mode of operation usually is used in conjunction with, but before, operation in remote assigned mode. Operation in remote mode allows the launcher to remain static (in the stowed or zero cable twist position) while the FCS is searching for a target or while tracking a target that is out of missile range.

REMOTE ASSIGNED MODE.—The remote assigned mode is the only mode in which a Sparrow missile can be launched. Except for the preoperation procedures performed at the LCP, the missile systems activation and operation is controlled entirely from the fire control panel.

Fire Control Panel (FCP)

The FCP is part of the FCS and contains all the necessary circuits for controlling and monitoring the status of the FCS and the GMLS, including each missile in the missile system. The panel operator makes missile system and fire control decisions, initiates the missile firing sequence and fires the missile. The FCP receives target data signals (range, altitude, bearing and speed) from the missile director and provides the operator with a visual indication of target's status.

A fire switch located on the FCP controls the firing of all missiles and, when depressed, generates the motor fire trigger signal that ignites the missile's auxiliary power supply (APS). When the missile's power supply reaches a preset value, a time delay interlock is completed. This interlock completes the 28V. d.c. firing signal circuit to the rocket motor squibs.

The missile is held on the rail by a fire-thru-latch until rocket motor thrust increases to approximately 1450 pounds. The restraint of the fire-thru-latch is then overcome by the rocket thrust and the missile is released. As the missile leaves the rail a missile away switch is closed which permits a sequencing the firing order to the next missile to be fired.

USE OF CHAFF CLOUD DECOYS

The primary application of the Rocket Launching System Mk 28 is to position decoys providing alternate targets for antiship missiles. It is used in conjunction with other electronic equipment that impacts the missile guidance systems. The nature of the decoy is determined by the guidance system of the threat.

In addition, the system can be used when ships engaged in shore bombardment are required to approach enemy shorelines where they may be detected by radar and come under attach by air or by shore gun or missile batteries. Under such circumstances decoy targets sometimes are used to confuse the enemy.

Decoy targets that present false images to enemy radars were first used in World War II when Army Air Force units dropped strips of aluminum foil called "chaff" or "window" from their planes. Attempts to use projectiles carrying chaff heads have been made but have not proved to be successful due to the limited capacity of the projectile. To oppose the effectiveness of enemy missile guidance systems and radars, Rocket Launcher System Mk 28 was developed to position chaff clouds and to have the capability of placing other types of decoys in optimum position.

Chaff cloud decoys are designed to divert enemy radar attention by creating a false target and to provide an alternate target to radar-guided anti-ships missiles. A head containing chaff is attached to a rocket motor to form a surface-to-air rocket. When a variable timer is set and the proper launch angles are selected, the chaff head can be delivered to a pre-determined point in space. When the fuze activates, the chaff-containing head is opened by an explosive charge, releasing millions of aluminum dipoles. The dipoles spread rapidly to form a cloud of chaff that to enemy radar will appear as a target. Several chaff rockets can be fired to produce multiple false targets, or replenish old ones.

The earlier model of the launching system was the Mk 28 Mod 0 which utilized one four cell pod. Later developments have produced the Mk 28 Mod 1 and Mod 5 rocket launching systems.

The Mk 28 Mod 1 and Mod 5 system is a deck-mounted rocket-launching weapon designed to use rockets fitted with chaff filled heads. The Mk 28 Mod 1 system consists of two rocket launcher mounts Mk 36 Mod 1, and associated equipment. The Mk 28 Mod 5 system consists of three rocket launcher mounts Mk 36 Mod 1, and associated equipment.

The Rocket Launching System Mk 28 Mods 1 and 5 is an improved, updated rocket launching system involving redesign of the present Mk 28 Mod 0 system. The Mk 28 Mod 0 system consists of electrically driven launcher mounts controlled by remote and local control panels. The Mk 28 Mods 1 and 5 systems utilize redesigned electro-hydraulic driven launcher mounts, and redesigned control panels which are operationally and functionally improved over the Mk 28 Mod 0 system. The Mods 1 and 5 systems operate either locally, remotely, or in automatic mode in which they are directed in train, elevation, launcher selection, and cell (tube) selection by shipboard computers such as Naval Tactical Data System (NTDS) or Data Correlation and Transfer System (DATACORTS).

Components of the Mods 1 and 5 are the same except for the number of launcher mounts and pods. The Mod 1 has two rocket launcher mounts and four pods. The Mod 5 has three rocket launcher mounts and six pods.

ROCKET LAUNCHER MOUNT MK 36 MOD 1

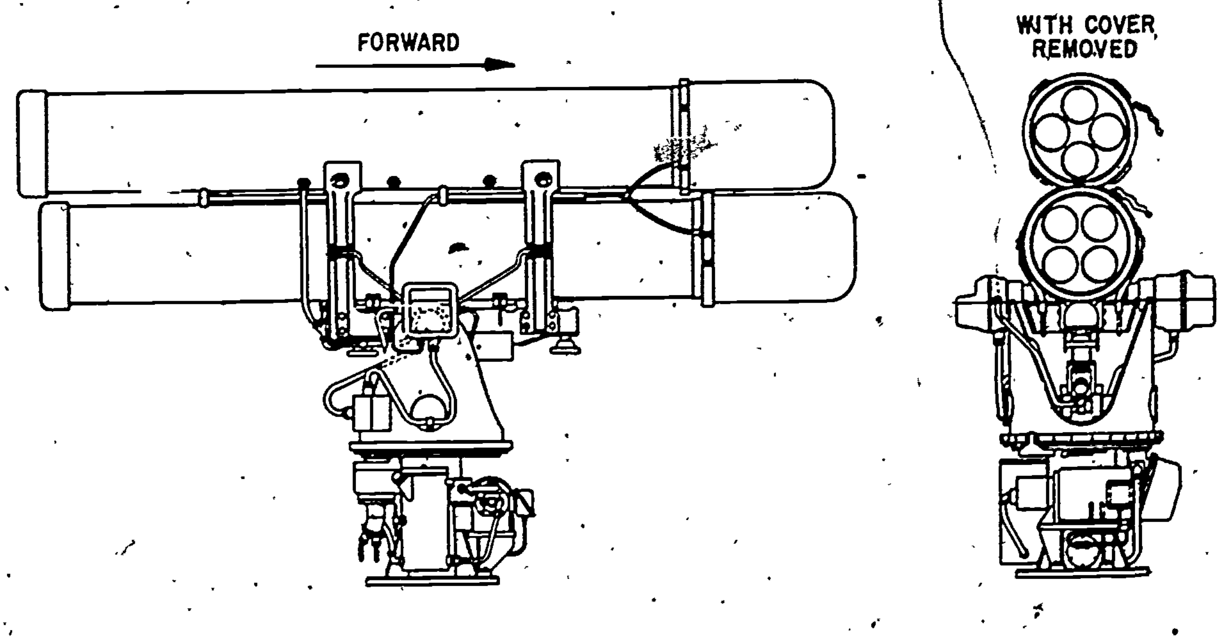
Essentially the launcher mount (fig. 11-10) consists of three structural subassemblies; the stand, carriage, and beam, and other assemblies which are attached to the structural members. The location and relationship of these subassemblies are shown in figure 11-11. The mount supports two rocket launcher pods Mk 44 Mod 0 and 1, and provides the means to train and elevate them. The launcher is equipped with one 3-1/2 HP, 440 V, 60 Hz motor. The motor drives a variable displacement hydraulic pump which can supply 5 gallons per minute (GPM) at a maximum pressure of 1500 psi. Fluid from the pump operates a hydraulic motor to rotate the launcher pods in train, and a piston in a cylinder for operation of the launcher pods in elevation. The train position shaft angle encoder is connected to a binary coded decimal (BCD) readout at the remote control panel where the train angle of the launcher is displayed. The elevation position shaft angle encoder measures the elevation of the launcher pods relative to the deck plane and transmits this reading to the remote control panel BCD readout. The electrical limit switches that prevent firing of rockets are cam operated, and interrupt current to the elevation and train drive hydraulic control valves when preset limits are reached. The hydraulic control valves automatically act to stop the launcher movement in elevation and train approximately 2° before the mechanical stops are reached. The mechanical stops prevent accidental inboard training and back up the electrical limit switches.

Stand Assembly

The stand is bolted to the deck and forms the base of the mount. The train drive mechanism and train position shaft angle encoder are mounted on the stand. A precision bearing surface at the top of the stand supports the carriage and permits it to rotate. A mechanical safety device is used to lock the carriage to the stand to prevent accidental training of the carriage during loading, unloading, or other work on the launcher. A clutch release lever on the train drive mechanism disconnects the power drive and permits manual training. The train angle of the launcher may be read from a fixed pointer on the stand to a graduated dial at bottom of carriage during manual operation.

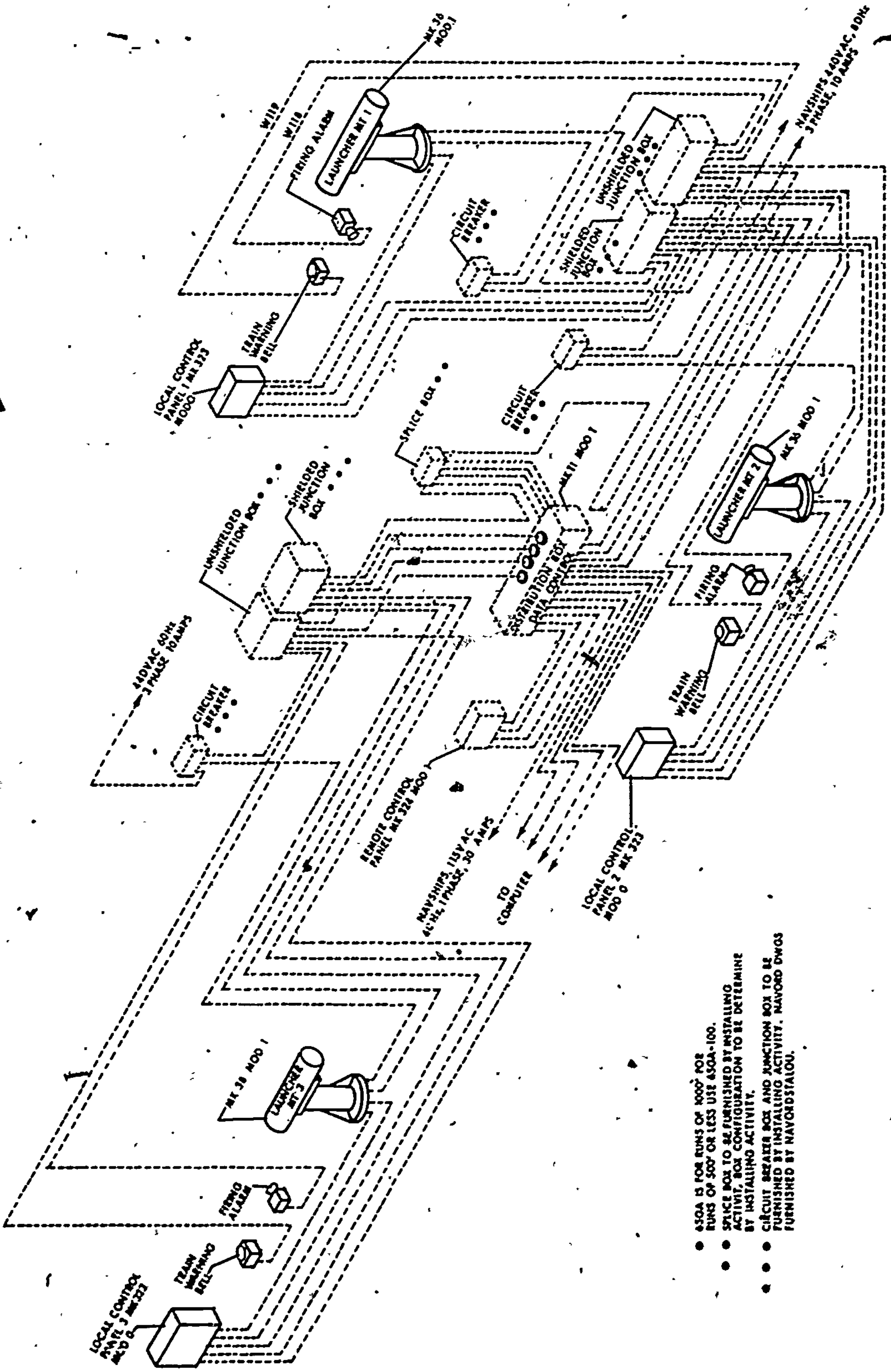
Carriage Assembly

The carriage assembly contains two trunnion bearings used to support the beam assembly. The elevation drive mechanism is composed of a bi-directional hydraulic piston and associated components. The piston output shaft is secured to the beam assembly and the drive mechanism is mounted on the carriage. Position of the piston shaft is determined by hydraulic fluid pressure acting on a differential in area on each side of the piston. The beam assembly is hydrostatically locked when the hydraulic system is not under power and manual operation of the beam assembly is desired. Two manual operated override valves allow hydraulic fluid to be forced (when the beam is manually elevated or depressed) from the piston operating cylinder to tank. In addition to the trunnion bearings and elevation drive mechanism, the carriage provides mounting of the elevation transmitter assembly and the horizon sensor assembly.



84.416

Figure 11-10.—Rocket Launcher Mount Mk 36 Mod 1.



● ASOA IS FOR RUNS OF 1000' FOR RUNS OF 500' OR LESS USE ASOA-100.

●● SPLICE BOX TO BE FURNISHED BY INSTALLING ACTIVITY, BOX CONFIGURATION TO BE DETERMINE BY INSTALLING ACTIVITY.

●●● CIRCUIT BREAKER BOX AND JUNCTION BOX TO BE FURNISHED BY INSTALLING ACTIVITY. NAVORD DWGS FURNISHED BY NAVORDSTALOU.

84.417

Figure 11-11.—Rocket Launching System Mk 28 Mod 5.

Beam Assembly

The beam assembly is mounted on the carriage by means of two trunnions. The top of the beam is fitted with guides, rubber mounting pads, and two handwheel-operated bolts for the purpose of mounting the launcher pods. The elevation shaft angle encoder located in the elevation transmitter is driven by the right trunnion of the beam assembly. The beam assembly is provided with attaching hardware for attachment of the second launcher pod (piggyback) to the beam.

Rocket Launcher Pod

Each launcher mount contains a rocket launcher pod arrangement (two pods, one atop the other). Each pod is capable of individually firing four 5-inch Zuni chaff rockets before having to reload. A safety firing switch located in the pod maintains a ground on the firing circuit when secured by a safety pin. This pin must be removed to enable the firing circuits. Each pod has a cell-loaded sensing attachment (bore clear assembly) which slips on the front end of the pod. The fairing then slips over the attachment. The attachment contains a switch for each cell which is activated by the presence of a rocket in the cell.

REMOTE CONTROL PANEL (RCP) MK 324 MODS 0 and 1

The Remote Control Panel (fig. 11-12) provides for complete control and firing of launcher mounts and for transferring control to the local control panel (LCP) or the computer. The RCP contains thumbwheel controls for selecting the launcher, train and elevation position and the cell desired for firing, indicators showing the response to the orders, push-button indicators for initiating the fire sequence, POWER ON switches for system and launcher enable, and an ENTER switch which must be pressed when certain orders are initiated. The RCP is primarily used to control the launchers when the computer is inoperative.

The RCP Mk 324 Mod 0 provides train and elevation selection, rocket selection and firing control for both launcher mounts of the Rocket Launching System Mk 28 Mod 1. Normally, control of the launching system will be from the RCP with the system in the AUTO mode of operation. In the AUTO mode of operation, the ship's NTDS or DATACORTS computer automatically trains and elevates the launcher (s) to the positions determined by the NTDS or DATACORTS and selects rockets for firing. The RCP can also be used to control and fire the launcher (s) from the remote position when NTDS or DATACORTS is inoperative. The RCP also provides the means of transferring control of the system to the local control panels located near the launcher mounts.

The RCP Mk 324 Mod 0 controls the selection and firing for two rocket launcher mounts and consists of the elements shown in figure 11-12. The RCP Mk 324 Mod 1 is not shown, but differs from the Mod 0 only in the additional READY TO FIRE/FIRE, ALARM, and LAUNCHER #3 switches on the panel.

LOCAL CONTROL PANEL (LCP) MK 323 MOD 0

The LCP (fig. 11-13 contains the necessary controls and indicators to perform functions similar to those of the RCP with the exception that launcher selection cannot be made at the LCP. The LCP contains a key-operated FIRING CIRCUIT SAFE-ARM switch and a key-operated POWER DRIVE SAFE-ENABLE switch. The FIRING CIRCUIT SAFE-ARM switch must be in the ARM position to fire the rockets and the POWER DRIVE SAFE-ENABLE switch must be in the ENABLE position to train and/or elevate the launcher mount, regardless of the mode of operation selected. The LCPs are used to control the launchers when the computer and/or the RCP is inoperative. The LCP is also used during loading, unloading, testing, and maintenance operations.

OPERATION

The procedures for loading chaff rockets in the rocket launcher pods of the Rocket Launching System Mk 28 Mods 1 and 5, along with many other functional details, are too extensive to outline at this time. For the detailed procedures refer to NAVORD OP 4003, Rocket Launching System Mk 28 Mods 1 and 5.

Preparation To Operate

Before operating launcher mounts, ensure the following are accomplished:

1. Remove frangible (breakable) fairings from each end of launcher pods. (Should tactical conditions necessitate, the rockets may be fired through the fairings).

2. Ensure that train mechanism clutch is positioned to ENGAGE.

3. Ensure that removable train positive stop on stand is fastened securely in place.

4. Ensure that train stow lock is positioned to UNLOCK.

5. Ensure that elevation manual operate override valves are closed.

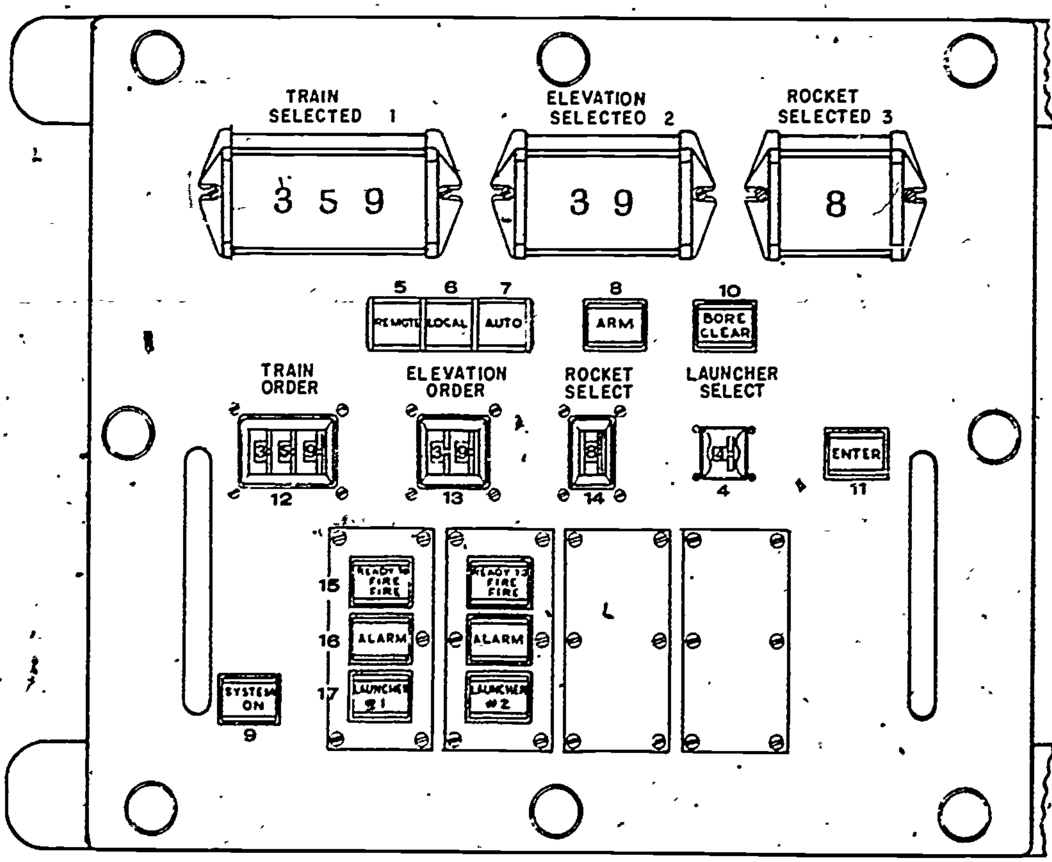
Warning: Ensure that launcher areas are clear of all personnel, tools, test equipment and collapsible life rails before operating rocket launcher. Acoustic and blast hazards exist during firing.

Modes of Operation

The Rocket Launching System Mk 28 Mods 1 and 5 employ any of three modes of operation: Auto, Remote, or Local. The remote control panel operator normally selects the mode of operation for the rocket launching system. In the event of a casualty to the RCP, the LCP operator can select the AUTO mode of operation from the LCP, or operate the launcher mount in the LOCAL mode from the LCP, in the event of casualty to the computer.

Auto Mode (Primary)

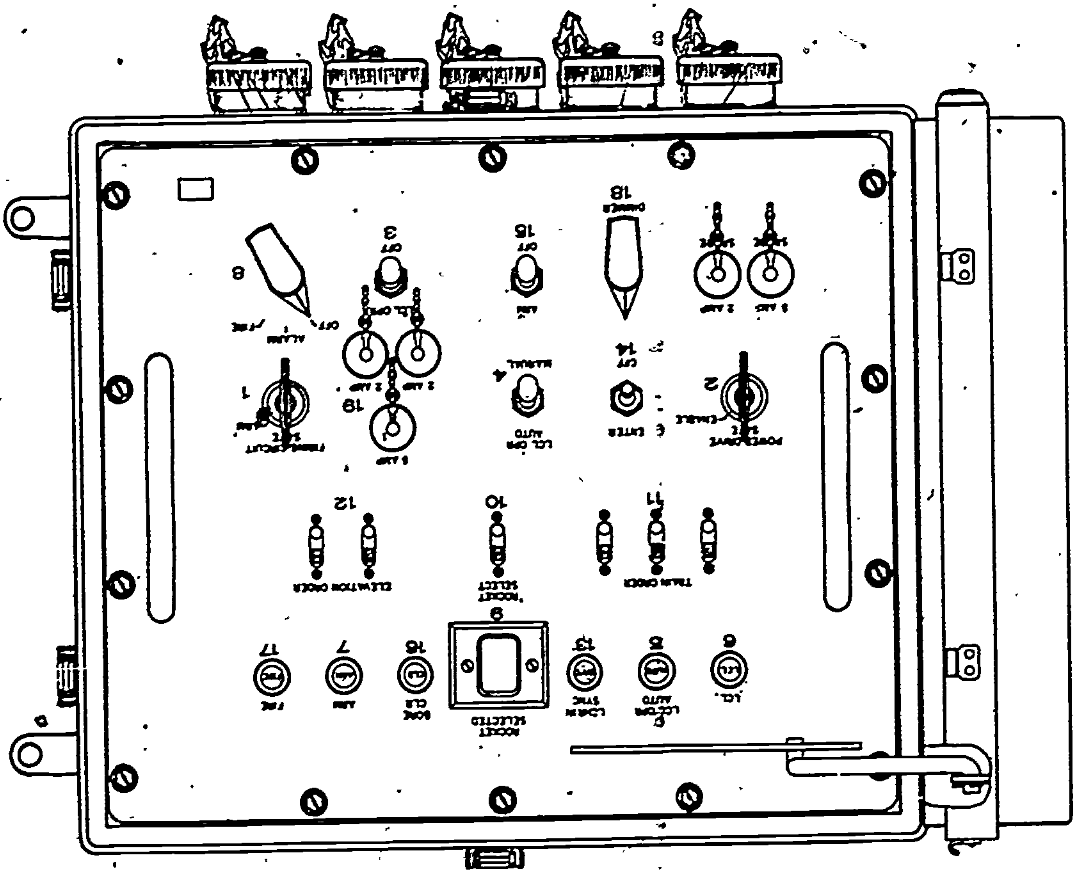
The AUTO (automatic) mode is the normal mode of operation for the rocket launching system. In this mode, the NTDS/DATACORTS computer selects the launcher and the cell to be fired, verifies that the selected cell is loaded, and positions the launcher in train and elevation. At the appropriate time, and after receipt of launcher ready to fire, the computer recommends



84.418

Figure 11-12.—Remote Control Panel Mk 324 Mod 0.

418



84.419

Figure 11-13.—Local Control Panel Mk 323 Mod 0.

firing. Firing is normally accomplished from the RCP.

Remote Mode (Secondary)

The remote mode of operation is intended to be used when a casualty occurs to the NTDS/DATACORTS system. The RCP operator can manually select the launcher mount and the cell to be fired, train and elevate the launcher mount to the desired position, arm the launcher mount, and fire the rocket. Indicators inform the operator of rocket launching system status.

Local Mode

The rocket launching system can be placed in the local mode of operation when either the RCP operator assigns the launcher mount to LOCAL, or the RCP is disabled and the LCL OPR (local operate) switch on the LCP is placed in the LCL OPR position.

Note: When the RCP is disabled, the LCP operator can also select the AUTO mode of operation, if the computer is not also disabled.

All functions performed by the RCP operator can be performed by the LCP operator for the launcher mount associated with that LCP.

LOCAL MODE (LOCAL OPERATE).—If the RCP suffers a casualty, and the rocket launching system is in the REMOTE mode, rocket selection and firing may be accomplished from the LCP.

LOCAL MODE (AUTO CONTROL).—If the rocket launching system is in the AUTO mode of operation and the RCP suffers a casualty, operation may be accomplished from the LCP.

DECOY (CHAFF) ROCKET

The chaff rocket (fig. 11-14) consists of a chaff head and Zuni rocket motor. The rocket is approximately 110 inches long, 5 inches in diameter, and weighs 95 pounds. The motor is shipped in individual wooden or metal containers. (Motors are not shipped in Rocket Launcher Pod Mk 44 Mod 0). The chaff heads, with electromagnetic barriers and warning decals included; are shipped in individual wooden boxes.

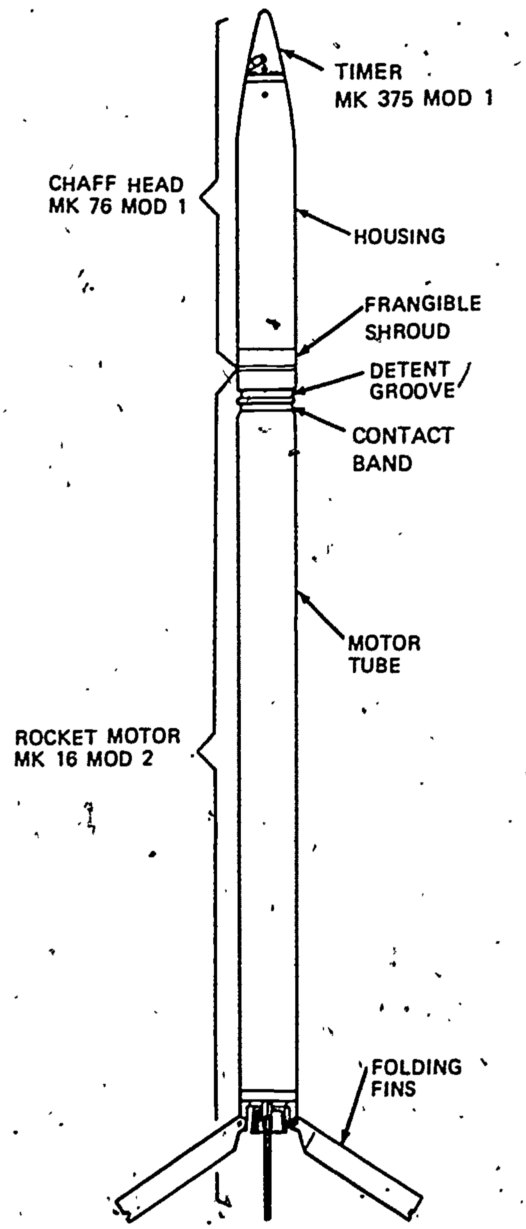
Ready Service Lockers

Decoy rockets are stowed in ready service lockers as shown in figure 11-15. Two men are required to stow all-up rounds in the ready service lockers.

In loading the ready service locker, remember that all rockets are loaded with the fins to the right side of the locker. (Right side when facing front of the locker; the front considered to be the side farthest from the locker lid hinge). The locker holds three rows of five all-up rounds (fig. 11-15). The rockets are loaded and strapped into chocks in the locker. In loading rockets in chocks, always load from the rear of the locker to the front. After loading and securing rockets in the lower chocks, the center chocks are placed in position and the center row of rockets are loaded and secured. The top chocks are then positioned to receive the top row of rockets. After loading the ready service locker, the lid is closed and secured by 12 latches and a lock.

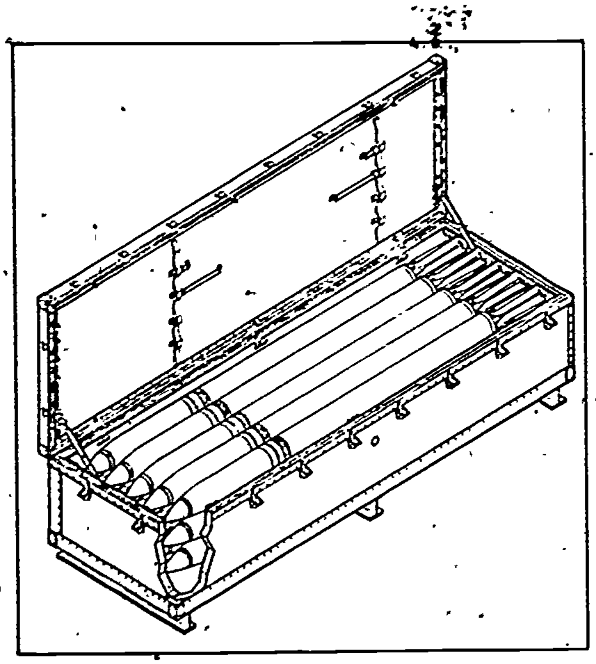
SAFETY

Safety is always a primary consideration in dealing with ordnance equipment—particularly with live ammunition. Rocket launchers, large or small, require a considerable amount of care, both in operation and in maintenance. We'll give some of the important safety precautions associated with systems covered in this chapter. For further information on safety precautions check the proper OPs and ODs.



84.420

Figure 11-14.—Chaff Rocket.



84.421

Figure 11-15. — Ready Service Locker with 15 All-up Rounds Stowed.

ASW WEAPONS

Safety precautions pertaining to the earlier type projectors are pretty much the same as those for the Mk 15, except that those relating to power drives and training gear do not apply to the earlier models.

1. Don't work on the ammunition, especially fuzes, except under the direct supervision of qualified personnel. Set questionable rounds aside. For information on ammunition, see Op 2215, OP 4, and OP 5.
2. Leave fuze caps and safety pins on the ammunition until just before firing, and don't discard them when they are removed. Replace them if firing is no longer imminent.
3. Never leave the projector loaded while the vessel is in port.
4. Always keep the cradle locking device and the train centering pin locked except when actually using the projector. Keep them locked during loading. Release them for any train or elevation movement.
5. Do not tilt the cradles unless at least half of the spigots on each cradle are loaded. Never tilt cradles while personnel are inside the cradle frame.
6. Maintain a safety watch whenever the mount is to be trained, except at general quarters.
7. Never shift the elevating gear or the training gear to hand drive while the mount is moving. And always verify that the mount and the signal are synchronized before shifting to power drive.
8. Live 440-v leads are exposed whenever controller, motor terminal boxes, and some equipment covers are open. Disconnect all power supply switches if electrical equipment is being worked on. Tag switches when men are working on the equipment. Never leave a power switch ON when leaving a control point to investigate power failure.
9. Always open the 440-v power drive supply at each controller whenever personnel mount the projector to load or do any maintenance work.
10. Always keep the safety plug and the firing key out of their receptacles except when actually firing or testing. Always remove the safety plug and firing key before circuit testing a loaded projector. Remove the plug also before shifting the test switch from its test position to S (safe).
11. Remove charges from spigots before testing any of the electrical circuits except when making the routine circuit test prior to firing. (For details on performing tests, see the OP on the equipment).
12. Keep all personnel away from the blast area when either the safety plug or the firing key is inserted into its receptacle while charges are on the spigots. And always keep the firing panel and safety plug dry.
13. Whenever firing circuit or panel wiring is serviced or replaced, check it by performing all tests for the unloaded projector.

GUIDED MISSILE LAUNCHING SYSTEM Mk 25

The following general safety precaution are recommended precautions that personnel must understand and apply during operation and maintenance of Guided Missile Launching System Mk 25 Mod 0.

This launching system employs electrical power that may, in some circumstances, be as high as approximately 750 volts. All electrical power must be considered potentially dangerous, either by causing burns or by electrical shock. Do not replace components with electrical power turned on. Under certain conditions dangerous electrical potentials may exist even though electrical power is turned off due to charges retained by capacitors.

Do not perform maintenance procedures on the GMLS unless accompanied by someone capable of rendering aid. Accidental contact with high voltage could result in unconsciousness. Inadvertent movement of the launcher during maintenance can also result in serious or fatal injury to personnel.

Personnel working with or near high voltages should be familiar with modern methods of resuscitation.

Have observer ensure that launcher area is clear of personnel before closing launcher area safety switch (SMX4). Launcher runaway in train or elevation could result in injury or death to personnel.

The launcher guide is nose heavy when empty and breech heavy when loaded with missiles. Always engage and hold elevation hand crank before disengaging elevation power-off brake to avoid possible personnel hazard.

Improper handling of the missile can result in damage to the missiles and create hazards to personnel. All personnel must be familiar with approved missile handling techniques.

Verify that the missile igniter safe-arm lever adjacent to aft missile lugs is in SAFE. Accidental ignition of the missile rocket motor could result in serious or fatal injury to personnel.

Use extreme care when straightening waveguide clips to avoid flexing walls of motor combustion chamber. Flexing of walls may cause weakening of motor housing.

When moving launcher into elevation, depression, or train limit stops, turn handwheel slowly to prevent equipment damage.

Ensure that the resetting tool latches upon completion of a stroke. Pressure must be maintained on the handle until the stroke is complete and the latch has operated, or until it is determined that it is impossible to complete a full stroke. If unable to complete a full stroke, allow handle to return to forward position under control.

If installed, ensure that phase-C antenna on underside of missile enters opening in aft chock of loader. Ensure that missile motor safe-arm mechanism fits forward of, and does not strike, aft chock of loader. Ensure that missile radome does not strike loader cross brace when missile is placed on loader.

Movement and tilt of the loader must be coordinated to ensure that missile does not hit either guide rail or guide track cover.

ROCKET LAUNCHING SYSTEM
Mk 28 Mods 1 and 5

Personnel assigned to operate or maintain the Rocket Launching System Mk 28 Mods 1 and 5 shall be familiar with naval safety precautions for ammunition handling and launcher operation. In addition, these personnel shall receive a thorough indoctrination in the safety precautions applicable to the launcher.

Whenever any motion of a power-driven unit is capable of inflicting injury on personnel or material not continuously visible to the person controlling such motion, the officer or petty officer who authorizes the unit to be moved by power shall, except at general quarters, ensure that a safety watch is kept in areas where such injury is possible. Also, the officer shall ensure there is telephone or other effective voice communication between the station controlling the unit and the safety watch. Under these conditions, the controlling station shall obtain an all-clear report from each safety watch before starting the unit. Each safety watch shall keep his assigned area clear and, if unable to do so, shall immediately report his unit fouled, and the controlling station shall promptly stop the unit until the area is again reported clear.

Use safety devices provided for the launcher as designated. Keep the safety devices operative and in good order at all times. Inspect all safety devices frequently.

If safety devices are rendered temporarily inoperative on approval of competent authority, use signs or other appropriate means to warn personnel. Do not secure inoperative safety devices. Do not alter safety devices except by direction of NAVORDSYSCOM or other competent authority. Do not allow unqualified or unauthorized personnel to operate the control panels. Trainees or other persons undergoing instruction shall operate panels only under the strict supervision of a qualified and responsible operator.

Keep the covers of switches, circuit breakers, and other electrical equipment securely closed while powder or other explosives are in the vicinity. Do not close circuit breakers that have opened due to an overload. Always have one person available who is familiar with first aid procedures for electrical shock.

Program with extreme care all work to be performed in lethal voltage areas. Do not work on live circuits unless it is absolutely necessary. Under certain conditions, dangerous potential may exist in electronic circuits after the power is shut off. When such potentials are suspected, discharge the appropriate components before touching them.

Before working on any launcher equipment, remove and retain the keys of POWER DRIVE SAFE-ENABLE switch, and FIRING CIRCUIT SAFE-ARM switch on Local Control Panel.

If clothing becomes drenched with hydraulic fluid, change into dry clothing immediately. When in prolonged contact with the skin, hydraulic fluid can injure health.

All safety precautions normally followed in stowing and handling rocket components shall be observed. These include the following:

1. Observe all stowage conditions specified for smokeless powder and high explosives.
2. Do not smoke within 200 feet of exposed rocket ammunition.
3. Keep at least 25 feet away from the rocket launching areas. Do not stand or walk near the front and rear of loaded rocket launchers.
4. Do not tamper with, or attempt to repair, any parts of the round. If the round is damaged or defective, remove the chaff head from the motor and mark the defective part for return to the issuing activity for disposition.

Electromagnetic Radiation

The ZUNI rocket motor requires careful handling to avoid damaging the long thin propellant grain and to prevent accidental ignition of the rocket motor from static or hazardous electromagnetic radiation. When loading or unloading ZUNI launcher pods, any communication antenna radiating more than .5 watts of power within 10 feet of the launcher should be silenced. The Hazards of Electromagnetic Radiation Of Ordnance (HERO) is most pronounced during weapon assembly, disassembly, loading, unloading, and testing. The effects of electromagnetic radiation on a weapon are reduction of the weapons reliability, propellant ignition, and, in some cases, the possibility of warhead detonation. Any weapon that contains electro-explosive devices called EEDs is subject to electromagnetic radiation. EED devices require a small voltage for actuation, these devices are used in some types of VT projectile fuzes and are now used for initiation of booster rocket igniters and warhead detonators. They are also used for missile stage separation in multistage rockets and for reliable high speed operation of switches and valves within a weapon.

Electromagnetic radiation is a term used to describe the energy radiated by radio and radar transmitting equipment. The energy is more commonly referred to as radio waves, radio-frequency energy, or RF energy.

Whenever current flows in an electrical circuit, such as a transmitting antenna, magnetic and electric energy fields are set up in the region around the antenna and radiated into space.

If a conductor is located in the path of radiated waves of energy, a voltage could be induced into the conductor, causing a small amount of current to flow. RF energy emitted from a two-way automobile radio has been known to set off an electric blasting cap. This is the reason for the signs along highways warning motorists to turn-off their radios when blasting is being conducted. Radiation hazard signs are also posted aboard ships warning personnel of radiation hazards, and the distance in which the radiation could effect the health of personnel. The commanding officer's policy for prevention of hazardous conditions to weapons and personnel requires coordination between the appropriate departments of the ship responsible for RF energy transmitting and the personnel responsible for ordnance handling as well as the medical department.

RF energy may enter a weapon as a wave of radiation through a hole or crack in a weapon's skin, or it may be conducted into the weapon by firing leads or other wires that penetrate the weapon enclosure.

The precise probabilities of EED activation are relatively unpredictable, being dependent upon variables of frequency, field strength, geometric orientation, environment, and metallic or personnel contacts with the ordnance items.

Several shipboard incidents involving ordnance items have been attributed to initiation of their EEDs by electromagnetic radiation from the ship's transmitting equipment.

When working on any weapon system component, practice safety while learning and while maintaining the weapons equipment. Read all the safety precautions carefully, and be aware of dangerous situations. Take time to be SAFE.

CHAPTER 12

THE FIRE CONTROL PROBLEM

This is a good time to answer the question that has probably occured to you: "Why am I, a Gunner's Mate, concerned with fire control?" There are two important answers to this.

One is that the field covered by the rating primarily concerned with fire control has been expanding so rapidly, especially since the second World War, that some parts of it have become the responsibilities of other ratings. That's why, for example, the Sonar Technician now operates and maintains some of the gear that used to be identified with the Fire Controlman. Similarly, the Gunner's Mate is responsible for a good deal that used to be in the Fire Controlman's bailiwick — power drives, indicator-regulators, some aspects of battery alignment, and the like. The empire of the Fire Controlman (now the Fire Control Technician) has changed too — it includes electronics, radar equipment, and other subject matter not originally identified with it. So that now you, as a Gunner's Mate, are expected to learn more about fire control — and about hydraulics and electricity — not because you're being remolded into a Fire Control Technician but because these, among others, are now the Gunner's Mate's business.

The second answer has to do with the fact that a Gunner's Mate must be able to qualify as a mount captain. This means you must be proficient enough in fire control techniques and basic knowledge to supervise your mount's functioning in local control.

There's a third answer too, and it has to do with your own future. You may want to earn a Gunner's warrant rank eventually. To qualify, you'll have to know your fire control.

By the time in your career as a Gunner's Mate, you know that the term "fire control" as it's applied in gunnery has nothing to do with how you use the fire extinguisher on the bulkhead. But what DOES it mean, exactly? Naval Ordnance and Gunnery, NAVEDTRA 10783-C, defines fire control as "The practical application of exterior ballistics, and the methods and devices used to control guns and other weapons . . ." Another way to put it, in terms of weapons, missiles, and targets, would be to say that fire control is the process of continuously determining the exact instantanious relationship between a weapon and its target, and then using that information to cause the weapon's projectile or missile to strike or inflict maximum damage on that target.

Fire control is the technique of delivering effective fire on a selected target. It includes the material, personnel, methods, communications, and organization necessary to harass, damage, or destroy the enemy. Within the Navy, however, the term has been customarily restricted to the control of gunfire, while more specific terms such as torpedo fire control and rocket fire control are used for other weapons.

The fundamental problem of gun fire control is to direct the gun in such a way that the projectile will hit the designated target. If the target is stationary and close enough, the problem is not difficult. Complications are introduced by increasing the range, by shooting from a moving platform such as a ship, by shooting at moving targets, and by shooting many guns with centralized control at the same target. The increase in range increases the time of flight of the projectile, allowing gravity to exert its influence over a longer period of time and to cause the projectile to fall more and more below the projected axis of the bore of the gun. The increase in time of flight also permits greater accumulation of errors caused by motion of own ship and target or by ballistic factors such as wind and drift. As battle range and target speed increase, requirements for greater accuracy of measurements and for more exacting computation increases.

EARLY FIRE CONTROL

The development of fire control as a science and as an art has been pretty much the product of the last century and a half. Prior to 1800, there was no need for elaborate fire control, because the guns themselves were inaccurate except at short ranges. Battle ranges of the period were pistol shot (about 50 yards) and half pistol shot (about 20 yards).

Sighting consisted chiefly of setting the guns in azimuth, and of leveling them by eye. Sometimes allowance for the curvature of the trajectory was made by "sighting by the line of metal". This was done by aligning the top of the breech and the top of the muzzle with the point of aim, causing the gun to be elevated by the amount of the taper of the gun from breech to muzzle.

Little attempt was made to regulate initial velocity. Powder charges were estimated, and the projectile load was variable. One shot or several shots were used for a charge, and at close quarters guns were frequently loaded to the muzzle with grape shot.

Nautical gunners became aware of the problem of deck tilt for obvious reasons. One early device for correcting the roll of the ship was a round shot suspended from a spar. The gunner watched this improvised pendulum swing with the roll of the ship and just before it was parallel to the mast, he applied his slow match to the touch hole of the piece. Another practice depending upon the roll of the ship was that of firing at the crest of the roll to increase the range.

MODERN FIRE CONTROL

Today, fire control instruments used in conjunction with guns are limited in range and accuracy only by the inherent accuracy possible with projectiles fired from guns. And the whole scope of fire control itself, as a technique for destruction so that guns will do the maximum damage to the enemy, has been broadened. Where fire control once meant only control of gunfire, it now applies to control of guided missiles, rockets, and weapons directed against underwater targets. In this chapter we will cover the gun fire control problem as it relates to you as a Gunner's Mate.

BALLISTICS

Ballistics is the science of the motion of projectiles. It is divided into two branches, interior and exterior ballistics. Interior ballistics is that branch of the science which relates to the motion of the projectile while in the gun. The initial velocity (I.V.) of the projectile is a result of the forces involved in the general term, interior ballistics. Exterior ballistics pertains to the projectile after it leaves the gun. Obviously I.V. is the one value common to both interior and exterior ballistics.

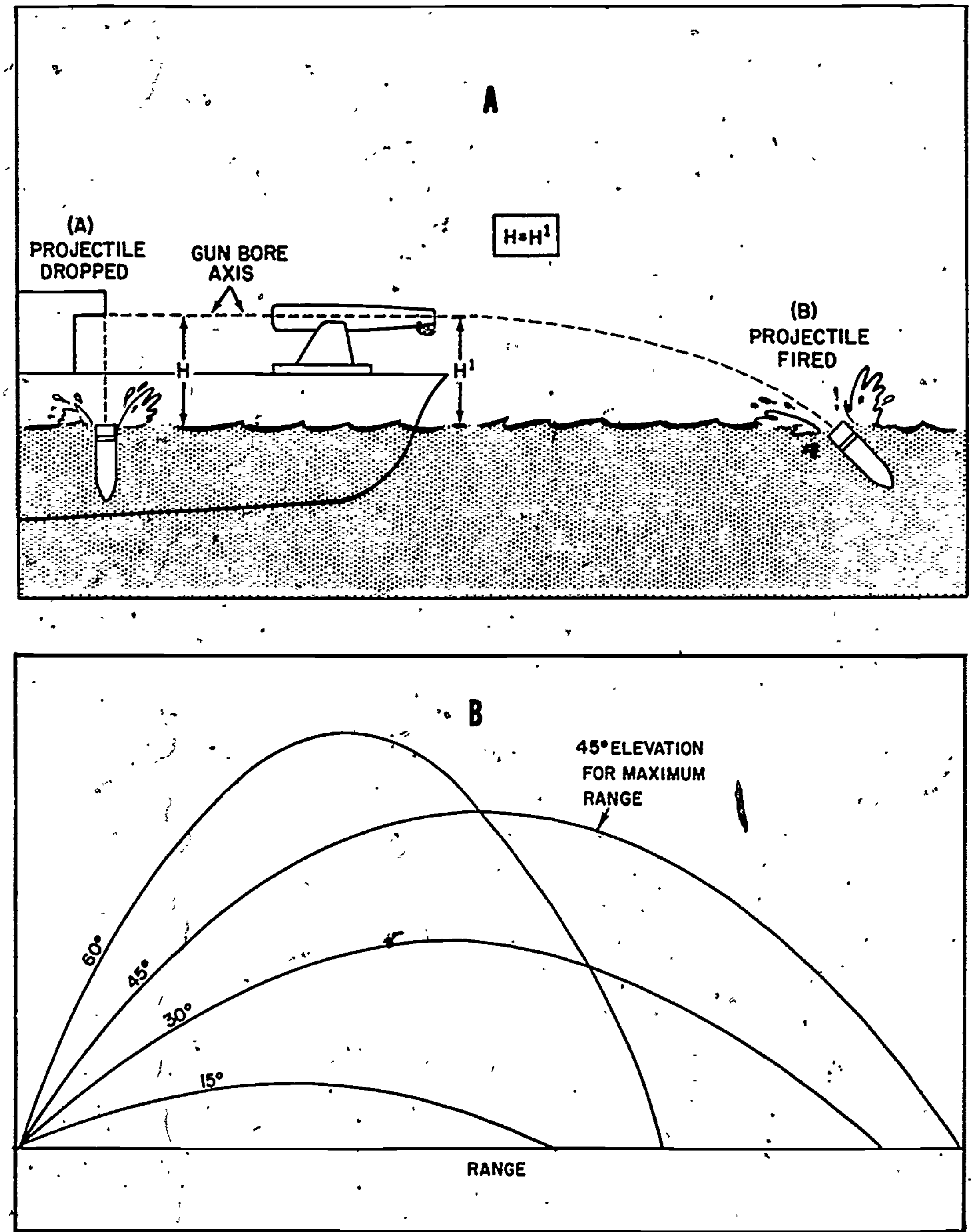
Gun design is essentially a compromise. The gunner wants maximum I.V. for great range and flat trajectory; the designer must consider the strength of his gun, and desires minimum wear and erosion. Interior ballistics includes the study of (1) the combustion of the powder, (2) the pressure developed within the gun, (3) the variations in pressures and velocities with changes in any of the "conditions of loading," and (4) erosion of the bore.

EXTERIOR BALLISTICS

1. MOMENTUM. As you remember from Newton's laws of motion, any material object has inertia and, if moving, tends to continue its motion at constant velocity (i.e., at constant speed in a straight line). The important values in determining the momentum of a projectile are its I.V. (initial velocity) and its mass. I.V. is measured in feet per second (usually abbreviated fs) as the projectile leaves the gun muzzle. Mass is conventionally measured in pounds (a convenient measure, if not strictly correct scientifically). If no other factors affected its motion, any gun projectile would have a straight-line trajectory. Note also that all naval guns (except a few special purpose devices) are designed to make the projectile spin at high speed on its long axis. This makes the long axis of the projectile tend to maintain a fixed altitude in space while in flight.

2. GRAVITY. On the earth's surface (and this effect varies only slightly in different localities and at different altitudes up to several miles) all material objects are subject to the earth's gravitational attraction, which pulls them toward the earth's center. Any unsupported object therefore tends to fall at a constant acceleration of about 32 feet per second. Gun projectiles are unsupported (except rocket assisted projectiles (RAP)) once they leave the gun's muzzle; unlike rockets, they are not supported by propellant thrust. They therefore fall with the same acceleration as if they had been dropped, not fired.

The idea may be novel to the student, but the fact is that a projectile fired from a horizontally aimed gun will strike the surface of the sea at the same instant as a similar projectile that has merely been dropped from the same height above the water. It is of course true that the fired projectile will hit the water some distance away (part A fig. 12-1).



12.3(110A)

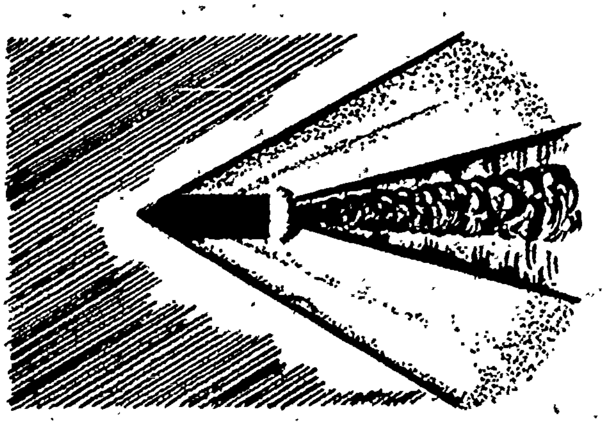
Figure 12-1.—Projectile trajectory as affected by gravity.

Under the influence of momentum and gravity (but of no other factors) the trajectory of a projectile will be one of a family of symmetrical curves called parabolas. For a given I.V. and projectile mass, the projectile travels farthest from the gun if the gun barrel is elevated to make a 45° angle with the horizontal (part B, fig. 12-1).

3. AIR RESISTANCE. As figure 12-2 (based on an instantaneous wind-tunnel photograph) shows, a projectile traveling at a speed of up to 3,000 feet per second creates a considerable disturbance in the air. At such speeds, air at sea-level density is far from insubstantial, and its resistance significantly slows the projectile throughout its flight. Air resistance affects the trajectories of all projectiles, but its effects, which depend on air density, are much greater on less massive ones.

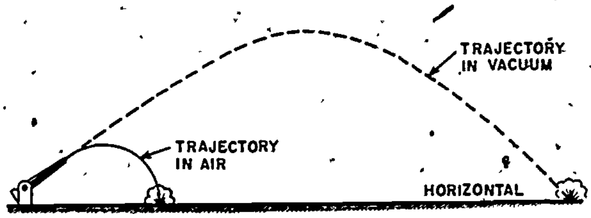
The trajectory as affected by momentum, gravity, and air resistance is still more or less parabolic, but is not symmetrical; the projectile is traveling slower as it approaches the end of the trajectory, and (fig. 12-3) it falls at a larger angle with the horizontal (tending toward 90°).

4. WIND. Wind is air movement. Movement of the air with respect to the earth is called true wind. Air movement caused by the motion of a ship is called relative wind for that ship. Apparent wind is the vectorial sum of these two winds, and it is the quantity read from the ship's anemometer. Wind speed is measured in knots, and wind direction in degrees from the reference (true north, or ship's bow) clockwise to the direction from which the wind is blowing. By



84.199

Figure 12-2.—Portrait of a projectile in flight.



12.4

Figure 12-3.—Comparison of vacuum and air trajectories.

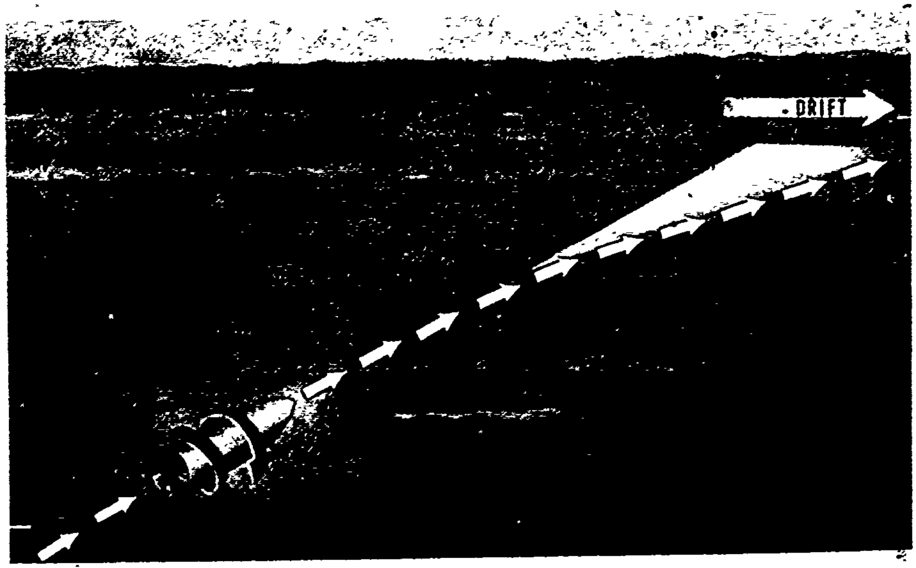
vectorial analysis, apparent wind can be resolved into relative wind and true wind. True wind is the wind input to fire control computers. True north is the reference for true wind, thus true wind is independent of ship's movement; however, both relative wind and apparent wind depend on own ship's course and speed.

In fire control computers, true wind is resolved into two components with respect to the line of fire. One, called range wind, lies in the line of fire and may either accelerate or decelerate a projectile. Cross wind is the other component; it blows at right angles to the line of fire moving the projectile to the left or right of its planned trajectory. These components and their effects are automatically computed, and automatic corrections are made to the gun's position in train and elevation.

A ship's anemometer measures surface wind, but a projectile's trajectory passes through various altitudes. These altitudes, primarily because of air density and temperature, have different wind velocities than those on the earth's surface. A ship's meteorologist can tract the flight of a balloon and measure the velocities and directions of tropospheric winds. (The troposphere being that portion of the atmosphere which extends outward about 7 to 10 miles from the earth's surface). Or, periodic wind reports are often received by radio from a shore station which has better wind measuring facilities. Most ships do not have a meteorologist on board; they have to depend on reports from other ships or stations.

When all winds are taken into account, they are combined mathematically into one wind direction and speed which would have the same total effect. This is the ballistic wind that is introduced into the fire control computations.

5. DRIFT. Drift (fig. 12-4) is a deflection of the trajectory to the right, and is caused by the interaction of gravity, air resistance, and the



84.200

Figure 12-4.—Clockwise projectile spin causes drift to the right.

projectile's clockwise spin. (Counterclockwise spin would deflect the trajectory to the left, but all naval guns, except the 45 caliber pistol, have clockwise rifling). Drift is directly proportional to range. It is independent of wind.

INTERIOR BALLISTICS

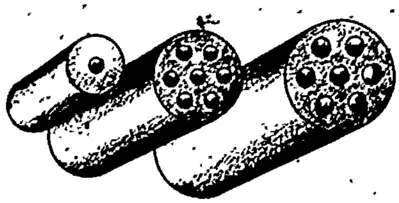
Propelling charges are designed to burn in the chamber of the gun in such a way that they develop maximum projectile velocity without excessive heat, pressure, or erosion. Ideally, the most efficient propellant for a gun is so balanced that the charge is entirely consumed immediately before the projectile leaves the muzzle.

To approach this ideal, propellant burning rate must be controlled so that the propellant is suited to the specific gun in which it is to be used. The dominant factor in determining burning rate of a given propellant composition is the surface area per unit weight of propellant. The greater the area per unit weight, the faster the burning rate. (Other but less significant factors include the percentage of nitration, moisture content, content of volatiles, and the stabilizer used).

As you know, gun propellant compositions are manufactured as homogeneous cylindrical grains of uniform diameter, length, and number of perforations (fig. 12-5), with larger grains for larger caliber guns. For a given muzzle velocity, larger caliber guns require a slower burning propellant than smaller caliber guns, since the distance is proportionately longer and the powder must burn for a longer time. Other things being equal, larger grains have smaller area per unit weight, hence slower burning rate.

Propellant powder grains for guns 40-mm and larger have 7 perforations. Since burning rate climbs rapidly in smaller size powder grains, there is only one perforation, or none at all, in grains for calibers smaller than 40-mm.

A propellant's potential is the total work that the gases of combustion could perform while expanding from the solid state to the space they would occupy when fully expanded to atmospheric pressure and when cooled to a specified temperature.



53.144

Figure 12-5.—Perforated propellant powder grains.

In the average conventional gun, some 60 percent of the potential disappears in muzzle loss; 30 percent is transmitted to the projectile, and all other losses—such as heating the projectile and gun, causing the gun to recoil, and so forth—amount to about 10 percent.

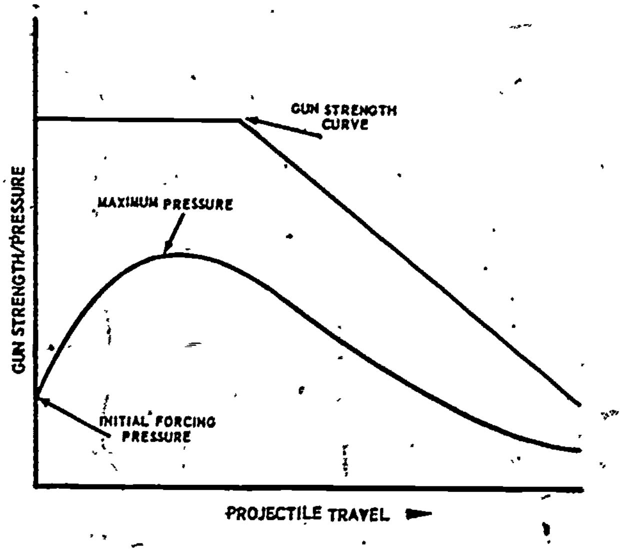
Strength Vs. Pressure Relationships

Figure 12-6 illustrates a basic principle of gun design. The figure may be taken as typical of the strength-pressure relationship in modern guns. Note that the high breech strength is carried well forward of the point of maximum pressure. The gun strength at every point must exceed the powder pressure at that point by an amount that will provide a suitable margin of safety.

The curve as it appeared in figure 12-6 shows pressure beginning at a value well above zero. This indicates the pressure build-up that occurs after the propelling charge begins to burn but before the projectile begins to move. (The x-axis in the figure represents projectile movement in the bore, not time or bore length). The projectile begins to move only after the propellant gas reaches the initial forcing pressure required to initiate movement of the projectile in spite of projectile inertia and the engagement of the rotating band in the rifling.

Note that the gun strength curve is represented as a straight horizontal line above the area between the point of initial forcing pressure and the point of maximum pressure. It does not vary in parallel with pressure curve. The reason is that the same pressure that the expanding gases exert against the base of the projectile is exerted equally against all interior surfaces of the gun behind the projectile. Hence the breech part of the barrel must be designed for the maximum stress to be imposed.

After the projectile passes the point of maximum pressure, it continues to be accelerated by gas pressure until it leaves the muzzle. The total area under the curve, up to the point where the projectile leaves the gun, is a rough measure of initial velocity, and the pressure remaining at the muzzle is an indication of the muzzle loss. A high muzzle pressure increases muzzle flash.



110.57

Figure 12-6.—Typical gun strength and pressure curve.

Changes in Conditions of Loading

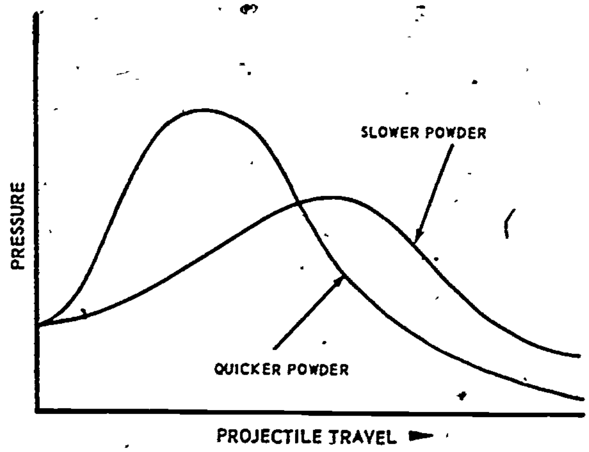
The term "conditions of loading" means the powder used, the weight of charge, the density of loading, the volume and form of the powder chamber, and the weight of the projectile.

a. Powder used and weight of charge. Powders are termed quick and slow in reference to their rate of combustion in a particular gun. For instance, a small-grain powder is quicker than a larger grain of the same shape since all the grains would be consumed in a shorter time. Not only will the larger grain increase the time required for burning the charge, but it will also cause maximum pressure to be lower and to be reached later in the travel of the projectile. The gun pressure curves shown in figure 12-7 compare slow powders and quick powders where the same weight of charge was used.

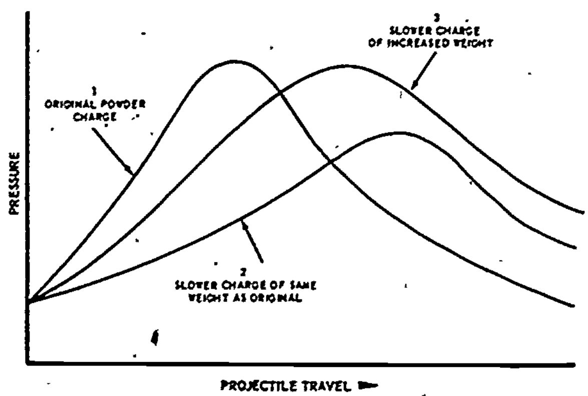
Within limits, the muzzle velocity for a particular gun may be increased without causing excessive pressure by increasing the size of the charge and at the same time using a powder that burns more slowly. See figure 12-8.

b. Density of loading. Density of loading is the ratio of the weight of the charge of powder to that of the volume of water which, at standard temperature, would fill the powder chamber. It is a measure of the amount of space in which the gases of combustion may expand before the projectile begins to move.

A high density of loading leaves but little space for initial expansion; consequently pressure builds up rapidly. The maximum pressure behind the projectile is reached early in the projectile's movement through the bore. With lower density of loading, more expansion of the gases may take place before the projectile starts to move. The



110.58
Figure 12-7.—Typical gun pressure curves showing variation due to quickness of powder, same weight of charge.



110.59
Figure 12-8.—Typical gun pressure curves showing methods of obtaining increased muzzle velocity in a gun without increasing maximum pressure.

maximum pressure is achieved later, and this maximum is lower than that with high density of loading. (Compare the curves in figure 12-9). Other factors remaining equal, increased density of loading increases maximum pressure, muzzle velocity, and muzzle loss.

The densities of loading at present vary between 0.4 and 0.7, depending on the caliber of the gun and on whether the charge is case, stacked bag, or unstacked bag. Since the specific gravity of smokeless powder is about 1.6, the following relationship holds:

$$\text{Density of loading} = 1.6\text{v},$$

where

v = the proportion of the total chamber volume which is filled by the charge.

Hence it is apparent that a loading density of 0.4 would require a charge filling 25 percent of the chamber volume, and a loading density of 0.7 would require a charge filling 45 percent of the chamber volume.

In the following example we find the charge filling percent of the chamber volume for a loading density of 0.4.

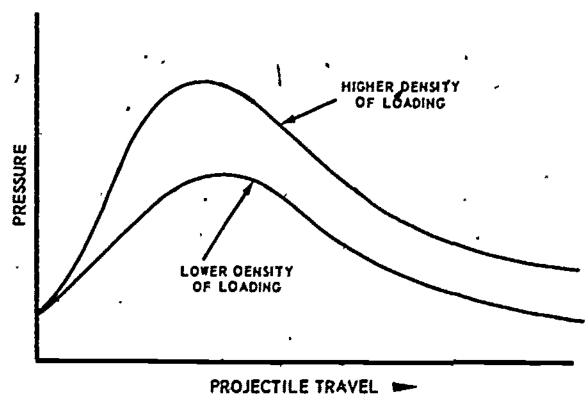
$$D = 1.6v$$

$$0.4 = (1.6)v$$

$$v = \frac{0.4}{1.6}$$

$$v = .25$$

When the density of loading drops markedly below the above figures, irregularities of muzzle velocity may be expected. The pressure builds up irregularly instead of smoothly, and the high point may be reached at the wrong time.



110.60
Figure 12-9.—Typical gun pressure curves showing variations due to density of loading.

A practical example of the importance of loading density would be a projectile lodged part way down the bore of the gun, greatly increasing the effective chamber volume. Besides greatly lowering density, and causing pressure beyond the area of maximum barrel thickness. A normal powder charge used to dislodge a projectile so positioned might cause the gun to burst, or at least bulge, immediately behind the projectile.

Very high density of loading, on the other hand, may cause detonation of the propelling charge, again resulting in a burst gun.

c. Volume and form of powder chamber. The designers of the gun, having established first the desired muzzle velocity, then the limiting maximum pressure allowable in the gun (determined from study of gun construction), can proceed to determine the volume and form of the powder chamber and the weight of the charge. In a particular gun, the volume and form of the powder chamber change only because of erosion at the origin of rifling and improper seating of the projectile, causing irregular muzzle velocity.

Projectiles differing in weight—for example, high-capacity and armor-piercing types—can be fired from a given gun. High-capacity projectiles, being lighter, will have a slightly higher muzzle velocity.

Erosion

Erosion is the deterioration and wearing away of the bore surface caused by firing projectiles through it. Erosion is not merely the direct effect of friction which causes the bore surface to wear away as the projectile passes through. The exact mechanics of erosion are not known with precision, but the following are recognized as the principal causes:

1. The bore surface becomes intensely heated in firing, and the rush of hot gases across this hot metal has a scouring effect.
2. The hot powder gases react with the metal, changing the carbon content on the surface of the bore. Since this surface is designed with an optimum carbon content, any change results in a weakening of the metal.
3. The alternation of intense heat and rapid cooling affects the temper of the metal.
4. The propellant gases are forced into and out of the pores in the metal surface as they open and close during the expansion and contraction which accompanies such drastic temperature changes.
5. Heat cracks may develop.
6. Gases escaping around the projectile act as high-velocity jets, scouring the bore and causing damage, especially where there are heat cracks.

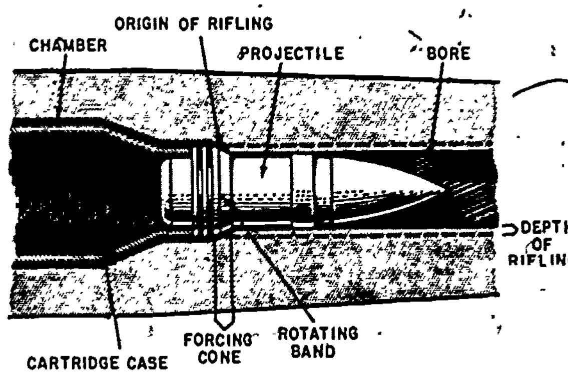
EFFECTS.—Erosion is always greatest at the origin of rifling (fig. 12-10), and the tops of the lands wear away faster than do the bottom of the grooves.

Erosion at the origin of rifling, in guns using separate loading ammunition, tends to permit the projectile to seat farther and farther toward the muzzle. This reduces the density of loading and therefore the I.V. In guns using fixed ammunition, this effect does not apply, but, in all guns, erosion at the origin of rifling permits gas to escape around the projectile and this in turn increases erosion.

As the lands wear, not only does more gas escape around the projectile but the rifling engraves the band less deeply, reducing materially both the initial forcing pressure and the resistance of the projectile to the gas pressure. The effect is a material drop in muzzle velocity.

CONTROL OF EROSION.—All erosion factors are related to (1) the temperature of the expanding gases and (2) the duration of their confinement in the bore. Hence larger guns, with their slower powders and longer barrels, suffer more erosion per round fired than smaller guns. On the other hand, smaller guns have a higher firing rate, which permits less cooling time between rounds.

Chromium plating of gun bores has reduced erosion effects; the use of molybdenum will probably make for even better erosion resistance



84.235(110A)

Figure 12-10.—Erosion areas in a gun chamber and bore.

431

in the future. Some smaller guns are cooled by water jackets around the barrels, and there have been experiments on introducing a coolant between the tubes and the liners of larger guns. Also reducing the heat of explosion will aid in erosion control.

There is much more to interior ballistics than has been taken up in this section, but you have read enough here to grasp the general nature of this branch of gunnery. Here are repeated the main points of the discussion, by way of summary:

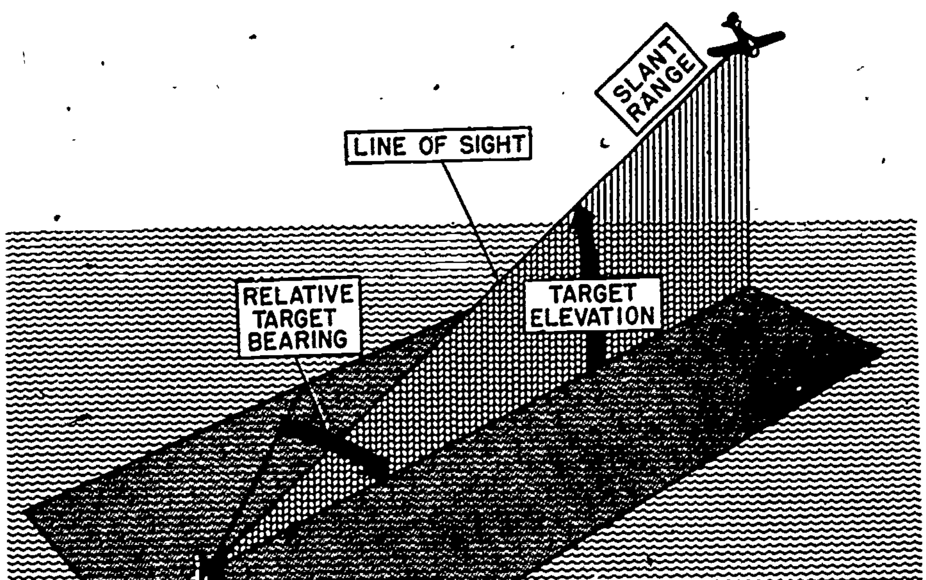
1. Using the same weight of charge, a slow powder produces a smaller maximum pressure than a fast powder, and attains this maximum pressure later in the travel of the projectile.
2. Increasing the weight of a charge of powder of a given grain size increases the maximum pressure attained and causes this maximum to occur earlier in the travel of the projectile.
3. Because of muzzle loss and irregularity of velocity, slow powders are less efficient than fast powders.
4. The muzzle velocity of a given gun may be increased within limits by using larger charges of slower propellants.

FIRE CONTROL PROBLEM

TARGET POSITION

In the fire control problem, target position at any instant is measured in terms of target bearing (a horizontal angle measured from a vertical reference plane), target elevation (a vertical angle measured from a horizontal reference plane), and range (a linear distance measured along the line of sight (LOS) to the target (fig. 12-11).

As you noted at several points in connection with the discussion of exterior ballistics, the effect of the factors listed in the preceding article depends on, among other things, range. Another way of putting it is to say that they depend on time of flight—i.e., the time lapse between the projectile's departure from the gun



84.197

Figure 12-11.—Relative target bearing, slant range, and target elevation.

432

muzzle and its impact or explosion. During this time the factors that determine the projectile's trajectory have their effect; obviously, the longer the time of flight, the greater their effect. Other things being equal, at any specified I.V., time of flight is proportional to range. This is one reason that it is important to know the range to target (generally measured in yards) as accurately as possible. Range to an air target, as measured along the LOS, is called slant range to distinguish it from range measured on the surface.

There are two kinds of target bearings. Relative target bearing is the angle, measured clockwise in degrees and minutes, between a vertical plane through the centerline of own ship and the line of sight to target. (This is illustrated in fig. 12-11). True target bearing is measured similarly, but from a vertical plane containing a line to true north. Figure 12-12 shows the distinction and relationship between true and relative bearings, and demonstrates that true bearing is the algebraic sum of own ship course and relative bearing.

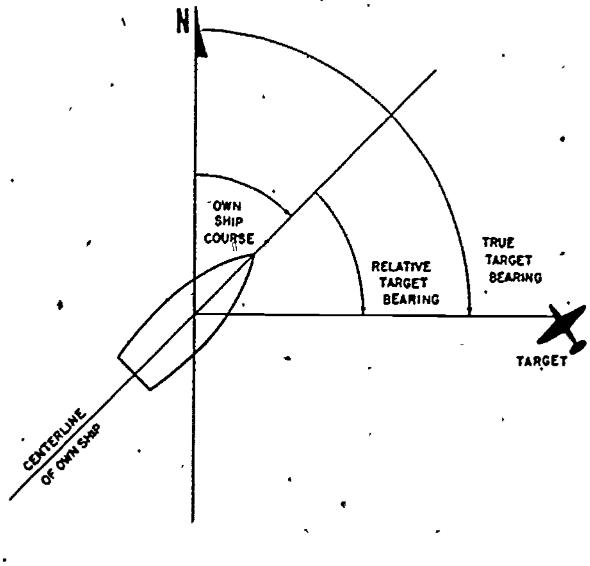
For the location of an air target with respect to own ship, one more value is needed—target elevation (generally measured in minutes of arc from the surface horizontal plane).

If now we were to assume that the target and own ship were stationary with respect to each other, it would be necessary to correct only for exterior ballistic factors and the gun would be laid for a hit on the target. However, such a situation is rare. Target movement with respect to own ship is a part of every practical fire control problem, and it becomes increasingly important as ranges decrease and target velocities increase. (You can expect some air targets to be moving at over 600 knots). In fact, at very close ranges (in the neighborhood of 2,000 yards or less) the ballistic factors are completely overshadowed in importance by corrections for target velocity, and many of the ballistic factors are not even considered in fire control systems designed for close-range work. This is true because at short ranges:

(a) time of flight is short.

(b) angular velocities (i.e., changes in target bearing and target elevation) increase as target range decreases, even when target speed as measured in knots remains the same.

(c) time available for arriving at solutions to the fire control problem is so short that there is time only for essential steps in solution.



110.61

Figure 12-12.—Relationship between true bearing, relative bearing, and own ship course.

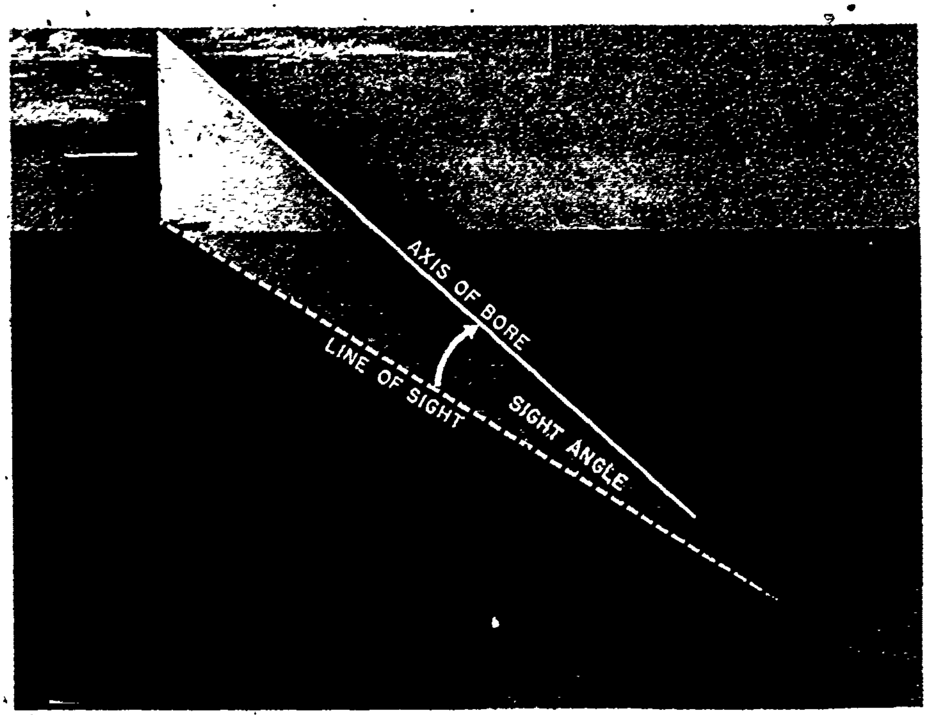
Sight Angle and Superelevation

The angle by which a gun is elevated above the line of sight to a surface target so that the projectile's trajectory will pass through the target is called SIGHT ANGLE. (See fig. 12-13). The angle is measured in minutes between the axis of the gun bore and the line of sight. As range increases, so does the amount of sight angle necessary.

With an air target the principle of sight angle still applies. Look at figure 12-14, where you see sight angle in more detail. You can see it is still the angle by which the gun must be elevated above the line of sight to get a hit. Your line of sight itself is elevated here to meet the target. Sight angle is shown to be made up of two smaller angles. One is lead. This corresponds to the target's relative motion during the projectile's time of flight. The other segment is SUPERELEVATION. Superelevation is the angle by which the gun must be further elevated to compensate for the projectile's curve downward due to gravity.

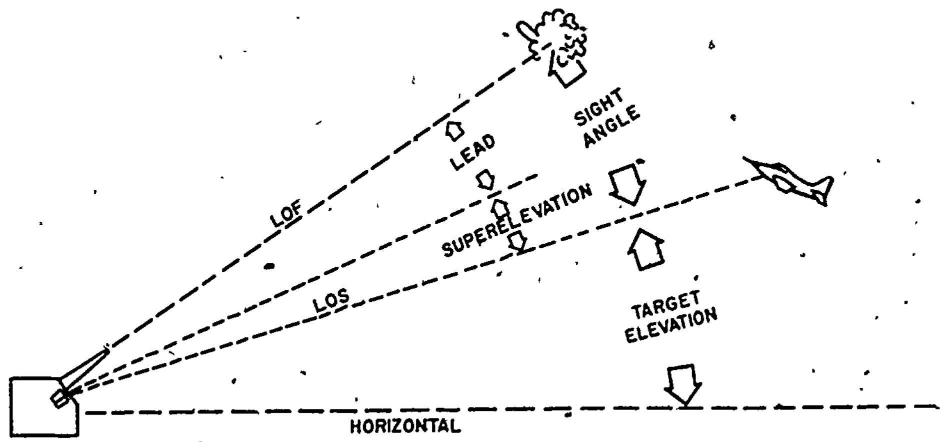
Like sight angle as a whole, superelevation increases with longer ranges. (See fig. 12-15A). But as target elevation increases, superelevation decreases. See figure 12-15B.

If you think about it, this is common sense. Consider an extreme case—a target directly above you.



84.198.3

Figure 12-13.—Sight angle.



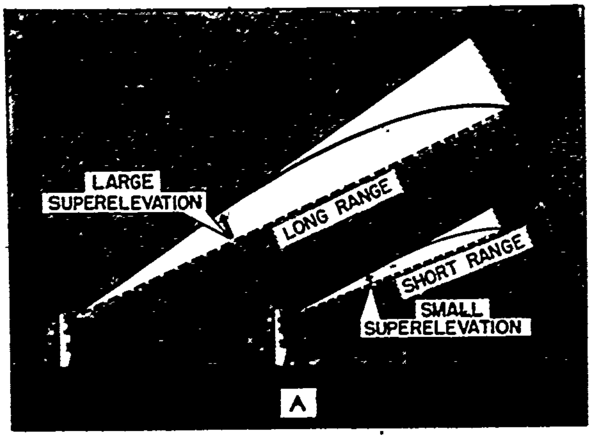
84.201

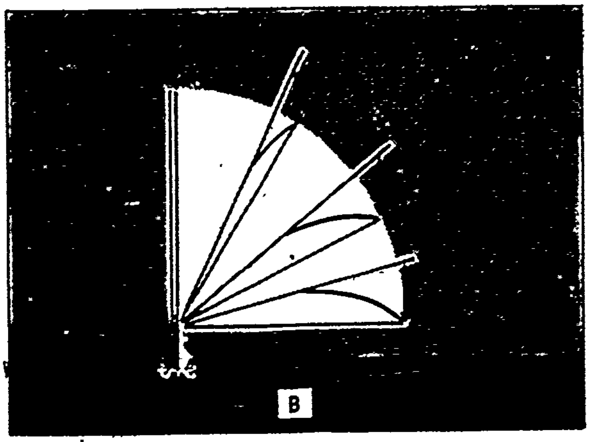
Figure 12-14.—Target elevation and superelevation.

Neglecting all other factors but gravity, it is obvious that a gun fired at such a target would have to be aimed directly along the line of sight.

Gravity would still pull downward at the projectile, but its pull would be directly in line with the trajectory, which would therefore be straight. Hence no superelevation needs to be introduced. As the line of sight is moved away from the straight-up direction, the downward force of gravity is exerted at an increasing angle to the axis of the gun bore, and therefore has more effect on the shape of the trajectory. This is exactly what view B of figure 12-15 shows.

434





84.202
Figure 12-15.—Effect on superelevation of: A. Increased range, B. Increased target elevation.

Sight Deflection

The axis of the gun bore is not only offset from the line of sight vertically, but horizontally as well. This horizontal angle between the LOS and the gun bore is known as SIGHT DEFLECTION. You can see in figure 12-16 that it is made up of three values, two of which you have already studied. You know that because a projectile drifts to the right, the gun must be offset to the left. Wind is another value in sight deflection. Wind blowing across your line of fire calls for another small offset (to the left in the illustration).

The third, and major, value in the sight deflection angle is the lead angle. Lead angle is proportional to the relative motion of the target across your line of sight during the projectile's time of flight.

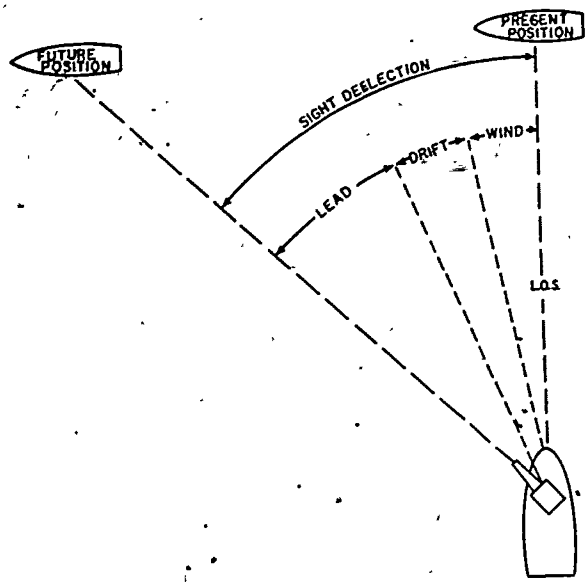
Unlike sight angle, target elevation, superelevation, and target bearing, deflection is measured in mils. One mil is an angle whose target is less than .001 or the unit of angular measurement of the angle subtended by one yard at a distance of 1000 yards.

The mil has a very useful property. If a distant object appears to you to be exactly one mil wide, then its real width is exactly 1/1000th of the range. (See fig. 12-17A). For example, suppose you see a buoy 1,000 yards distant. You sight at it through a telescope in whose reticle (a glass plate in the telescope optical system) are lines one mil apart. With the scope, you see that the buoy is just one mil, or 1/1000th of the range, wide. And since you know that 1/1000th of the range is one yard, that's how wide the buoy is. Figure 12-17B shows other examples of the mil's usefulness in estimating lateral distances at known ranges.

BALLISTIC VARIABLES. In the following list of ballistic variables, we indicate the effect on sight angle and sight deflection when increasing the variable.

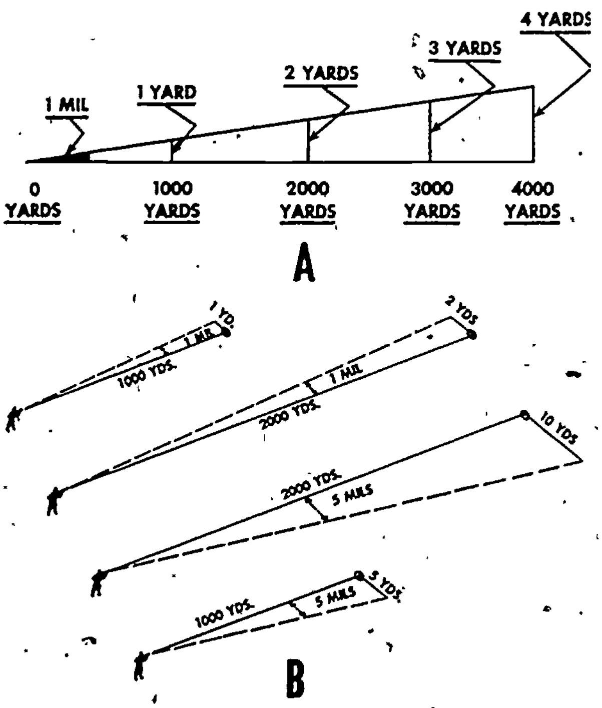
Variable	How compensated as variable increases
Projectile momentum	
(a) Mass (weight)	Increase sight angle.
(b) I. V.[1]	Decrease sight angle.
Gravity (itself a constant, but its effect is a function of time of flight).	Increase sight angle with increased time of flight.
Air resistance	Increase sight angle.
Wind	Depends on wind direction. If wind tends to increase range, reduce sight angle (and vice versa); add deflection and sight angle as needed for cross winds.
Drift	Add left deflection.
Earth's rotation and curvature.	Varies with range, latitude of gun, gun bearing. Both sight angle and deflection may be affected.

[1]In practice, as the gun wears, I.V. decreases, hence sight angle must be increased to compensate.



84.203

Figure 12-16.—Sight deflection.



55.145

Figure 12-17.—The mil. A. What it is. B. How to use it.

INHERENT CORRECTIONS

The miscellaneous factors that we here lump under the label INHERENT CORRECTIONS, include correction for:

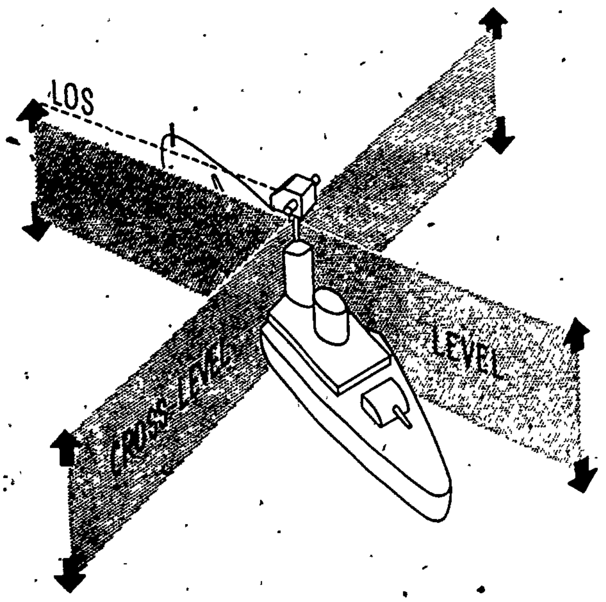
1. Motion of the gun platform (i.e., the ship's rolling and pitching motions as it floats on the water).
2. Parallax—caused by distance between fire control system elements located at different points aboard ship.
3. Divergence of gun mount roller paths from the deck reference plane.

These factors are called "inherent" because they are unavoidable in any system designed, within the limitations of contemporary techniques, to function when installed over most of the length of a warship that spends its lifetime on the surface of the sea.

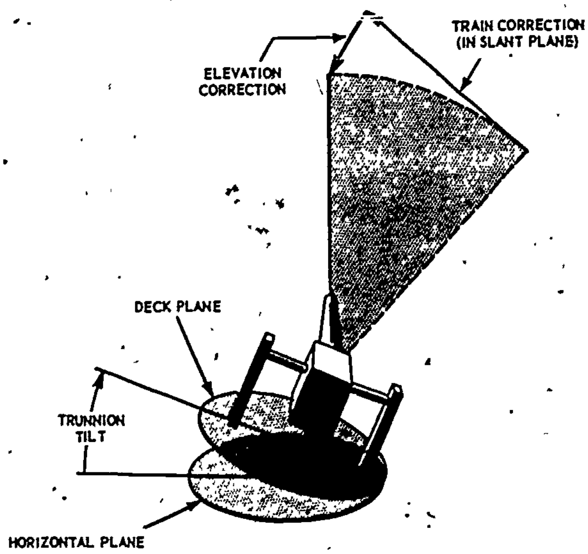
Gun Platform Motion

As you remember, the essence of fire control is to position the gun barrel so that the projectile's trajectory will culminate in its collision with the target. We may (as we did earlier in this chapter) assume for purposes of analysis that the deck on which the gun mount stands is stable, but in practice it is not generally possible to make this assumption. Nor is it practicable to stabilize the deck itself. Instead, either of two alternative correction methods is used. One requires that the gun be continuously repositioned by its power drive so that it maintains the desired attitude regardless of the ship's roll and pitch. The other (much less frequent) is to control the firing circuit so that as the ship rolls and pitches the firing circuit is energized only during those instants when the gun happens to be in the position required for hitting the target.

Two kinds of correction are required for the affects of ship's roll and pitch. One is correction in level and crosslevel (fig. 12-18). (Level angle is the angle that the deck plane, which pitches and rolls with the ship, makes with the horizontal, as measured in a vertical containing the LOS. Crosslevel angle is measured at right angles to level angle). Crosslevel causes trunnion tilt. As the gun mount tilts with the ship's motion, the gun no longer elevates in a plane perpendicular with the horizontal. This introduces errors, both because the gun doesn't elevate to the proper angle, and because elevation in a plane not perpendicular to the horizontal



12.46
Figure 12-18.—Level and crosslevel.



12.45
Figure 12-19.—Corrections for trunnion tilt.

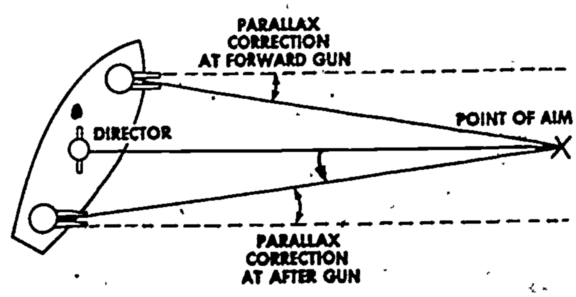
causes it to shift in train. Thus, if the right trunnion is at a chosen instant lower than the left, elevating the gun by x number of minutes with respect to the horizontal will require more than x minutes of elevation in its tilted plane and, in addition, the barrel after elevation will be displaced to the right of the plane it was before elevation. Figure 12-19 shows the corrections required to compensate for trunnion tilt.

Parallax

Because a gun is displaced from its controlling director, the gun can train out on the same bearing as the director and still not be trained on the target, unless a parallax correction is made. Parallax is the angle formed by the lines of sight of the director and the gun. It is measured in both the horizontal and vertical planes. It is different, of course for every gun, and individual corrections must be made at each gun. Figure 12-20 illustrates the most common difference, horizontal parallax, and the corrections that must be made to compensate for it.

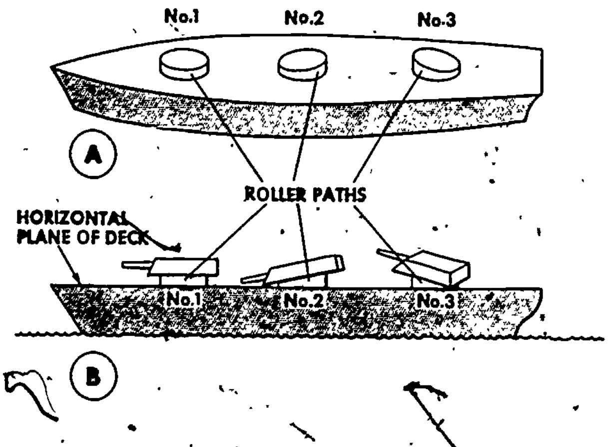
Roller Path Tilt

Ideally, the roller path of each gun mount should be parallel to that of the director used as the reference. Although the tilt of the gun mount with respect to the reference is in modern naval construction always small (rarely over a degree, and usually much less), it must be corrected. Some tilt is unavoidable because a ship's hull is supported much differently in dry dock than it is when afloat. Individual corrections are required for each gun mount. The correction is made in elevation, but its magnitude depends on the angle to which the mount is trained. Figure 12-21 shows in exaggerated form the effect of roller path tilt.



12.48
Figure 12-20.—L.O.S. of gun and director.

Each of the three gun turrets in the diagram is nominally at zero elevation, and should be parallel to the horizontal plane of the deck.



12.47
Figure 12-21.—Effect of roller path inclination (much exaggerated).

But only No. 1 is really at zero. If these were 16" turrets and No. 2 was tilted 1 minute when the ship is afloat, it would produce an error of 1200 yards in range. To compensate for roller path tilt, a device is installed in each gun mount or turret which automatically causes the gun to elevate or depress enough to compensate for the tilt of the roller path at every point to which it is trained. The device is known as a roller path compensator, and the setting differs from one mount to another. The exact tilt of the roller path is measured with respect to some reference plane (usually the battery director roller path). The magnitude of the roller path tilt correction, and the mount train angle at which the maximum correction is to be applied, are both inserted into the compensator unit. Through a gear shaft mechanism, the compensator unit's output is mechanically combined with the output of the vertical parallax correction unit. This algebraic sum is applied to the gun elevation order in a mechanical differential. Checking and resetting the compensator is part of battery alignment procedure, which will be explained in a later chapter.

Solving the Problem

As you remember from the beginning of this section, the fire control problem consists essentially of three groups of variables. In a given fire control system, some individual variables may either be taken into account or neglected depending chiefly on target velocity (with respect to own ship) and range, and on desired accuracy and speed of solution. The main steps in solving the fire control problem are:

1. MEASUREMENT of each of the variables to be taken into account.
2. COMPUTATION of what gun position must be in relation to an LOS from own ship to target so that the projectile will hit the target, and transmission of this information to the gun mounts. (This computation and transmission may also include projectile fuze setting if required).
3. POSITIONING THE GUNS in accordance with this information and energizing firing circuits as required.
4. OBSERVATION of effects of firing and correction of fire control information.

Now consider each of the steps in somewhat more detail.

Measuring Variables

Ideally, each variable in the fire control problem should be observed and accurately measured, then entered in the computing system. As a practical matter, some may be estimated and "cranked in" (i.e., put into the system manually), and some may be considered as having a fixed relationship to another variable (for example, the effect of gravity has such a relationship to time of flight), so that they don't have to be measured. (We have already noted that in all but the most refined systems some variables are omitted entirely because they are not considered essential to a solution of practical accuracy).

1. Ballistic variables are measured and entered into the fire control system computer as I.V.
2. Gravity has a fixed relationship to the time of flight, which in turn has a known relationship to range. Its effect is therefore "built into" the computer as a specially shaped cam (in electromechanical computers) or electrical network (in electronic computers).
3. Air resistance is in most medium and long range systems determined by fire control personnel who plot observed air temperature and barometric pressure on a nomogram and then determine the required correction. (Air density correction nomograms are printed in range tables. A range table for each gun and for each projectile type fired by the gun presents a

tabulation for each 100-yard increment of range, such characteristics of the trajectory as angle of elevation, time of flight, angle of fall, and striking velocity).

The correction is put into the computer as part of I.V.

4. Wind is a factor in medium and longer range systems; it is generally neglected in simple relative-rate systems designed for use at short ranges. In long and medium range systems ballistic wind is a required input to the computer.

5. Drift is treated like gravity.

6. Earth's rotation and curvature are figured from range tables and their effects are cranked into the system as direct increments to sight angle and deflection. The computer does not solve for these. In any case, these values are used only against surface targets at extreme ranges.

Target position and relative motion of target and own ship are important factors in all gun fire control systems, but for high-speed targets at shorter ranges they dominate the fire control problem.

Target position is fixed by three coordinates — bearing, elevation, and range. All three can be measured optically in a linear rate system. The first two are established when the sight telescope in the director are on target. Angular values of director train (an angle nearly equal to relative target bearing) and director elevation (an angle measured with respect to the deck plane, vertically to the LOS) are sent to the fire control system computer by data transmitters (synchros). A linear value of range is measured at the rangefinder and also sent by synchro to the computer.

Parallax correction is important only in more elaborate systems, in which some of the gun mounts being controlled are located at some distance from the director. In the case of the computer Mk 1A a special section of the computer develops parallax correction for a base length (i.e., the distance between director and gun mount) of 100 yards. This is called the unit parallax correction. For this or any other base length, the closer the target the greater the angular correction needed for parallax. However, the base length assumed for the unit parallax correction is not likely to be correct for any one gun mount since obviously the parallax correction ought to be greater for mounts further from the director than 100 yards, and less for mounts that are closer. Consequently, there is in each gun mount a set of change gears which converts the unit correction to the correction required, based on the ratio between the assumed base length and the actual base length. Parallax is also computed to compensate for vertical distance between mounts and director but, since all mounts are more or less equally far below the directors, the computed correction is fed equally to all.

Roller path tilt correction is usually performed mechanically by a device built into each gun mount. In this case the computer in the fire control system has nothing to do with this correction which is different for each mount.

NAVAL GUNFIRE SUPPORT

In World War II, naval task forces frequently carried out bombardments of enemy installations on shore. After the ineffective results noted during the Tarawa operation in November 1943, shore bombardment techniques were gradually improved and refined through successive landings at Roi-Namur, Eniwetok, Saipan, Guam, Peleliu, the Philippines, Iwo Jima, and Okinawa. Later, the Korean war gave frequent opportunity for the application of the techniques learned in World War II — in particular, the use of naval gunfire to support troops landing on defended enemy territory.

Opposed amphibious landing is one of the most hazardous types of military operation. Until World War II, many military authorities believed that such an operation was too hazardous to be attempted. In part, this belief was based on the Allied failure in the amphibious, Dardanelles (Gallipoli) campaign during World War I. Analysts ascribe the failure at least partially to inadequate naval preparation before the campaign.

To be successful, naval gunfire support for amphibious operations must be carefully planned in advance, and must be executed with skill and dispatch. It is vitally important in the period after the troops have landed but before adequate artillery can be brought into action. Its full exploitation can be achieved only if ground, naval, and air personnel understand the organization, basic techniques, capabilities, and limitations of naval gunfire support, and follow the standard procedure which has been agreed upon by the joint services.

PURPOSE

Naval gunfire is delivered from ship's batteries, not only in support of troop operations, but also to support related naval and air operations, such as mine warfare activities, air-sea rescue operations, reconnaissance and demolition operations, demonstrations, feints, raids, flak suppression during air strikes, and interdiction of coastal roads, railroads, airfields, and troop assembly areas. All these activities rest on the same basic principles as the naval gunfire support of amphibious operations.

The basic task of naval gunfire support units in an amphibious operation is to support the seizure of the objective by destroying or neutralizing:

1. Shore installations that oppose the approach of ships and aircraft to the objective.
2. Defenses that may oppose the landing.
3. Defenses that may oppose the postlanding advance of the troops.

These tasks are carried out in the preparation of the objective for the landing, the support of the landing, and in postlanding support.

This section takes up the fundamentals of naval gunfire against shore targets, both in support of troop operations and for other purposes.

CLASSIFICATION OF GUNFIRE

Naval gunfire against land targets may be classified in various ways. The classifications are interrelated; terms from several types of classification must be used for a full description. These classifications are based on:

1. Effect sought:

a. DESTRUCTION. Deliberate and accurate fire, usually delivered at short range, for the purpose of destroying a target, usually a material object.

b. NEUTRALIZATION. Rapid, fairly accurate rate fire delivered for the purpose of hampering, interrupting, or preventing enemy fire, movement, or action. Destruction of weapons and personnel is secondary. The effect of neutralization is comparatively temporary; such fire may have to be repeated.

c. HARASSING FIRE. Sporadic fire delivered during otherwise quiet periods to prevent enemy rest, recuperation, or movement, and in general to lower enemy moral and combat efficiency.

d. INTERDICTION FIRE. Fire designed to prevent or curtail the use by the enemy of an area, bridge, defile, airfield, route of communication, etc.

e. ILLUMINATING FIRE. Gunfire employing illuminating projectiles (star shells) to illuminate the enemy, to detect his movement, to aid our own observation, or to facilitate own troop movements.

2. Tactical use:

a. CLOSE SUPPORTING FIRE. Gunfire delivered on enemy targets which, because of their proximity, present an immediate and serious threat to the supported unit. (Close supporting fire may be as close to friendly troops as 300 yards enfiladed, (see 4.d following) or 600 yards when the target axis is not parallel to the line of fire.

b. DEEP SUPPORTING FIRE. Gunfire delivered on objectives not in the immediate vicinity of friendly forces, to neutralize or destroy enemy reserves and weapons, and interfere with enemy command, supply, communications, and observation.

c. PREPARATION FIRE. A heavy volume of prearranged neutralization fire, delivered just prior to a landing or a ground attack by friendly forces on enemy positions.

d. COUNTERBATTERY FIRE. Gunfire delivered against active enemy guns and fire control stations for the purpose of silencing the guns.

e. PREARRANGED OR SCHEDULED FIRE. Gunfire formally planned and executed against targets of known location. Such fire is usually planned well in advance and is executed at a predetermined time.

f. CALL FIRE. Gunfire delivered at the request of troop units ashore, or of some spotting agency. Call-fire missions must not be interrupted without permission of the unit requesting the fire, except in case of emergency.

g. OPPORTUNITY FIRE. Gunfire delivered without formal planning or troop request on newly discovered targets, or upon transitory targets. Targets of opportunity may present themselves to the firing ship at any time, but fire must be delivered only with due regard for safety of friendly troops. Ships delivering fire on targets of opportunity close to own troops require approval of the troop echelon concerned before opening fire. Ships executing deep support missions must assure themselves that the target of opportunity is within their assigned sector of responsibility.

h. RECONNAISSANCE FIRE. Gunfire is delivered in areas where camouflaged positions are suspected or in vital areas where natural cover prevents observation and/or gathering of photo intelligence.

i. FLAK SUPPRESSION FIRE. Gunfire is used to suppress AA fire immediately prior to and during an air attack on enemy positions.

j. DEFENSIVE FIRE. Is delivered by direct and general support ships to protect against counterattack.

k. ISOLATION FIRE. Is generally a scheduled fire used to destroy or interdict road or rail routes and other lines of approach or communication. It is used to prevent, reduce or disrupt the movement of enemy forces, supplies and communications to a landing beach or other specific objective area, and to assist in isolating that area for as long as necessary.

l. PROTECTIVE FIRE. Is delivered by support ships during the period of reorganization after the capture of a position.

m. SCREENING FIRE. Uses smoke projectiles delivered to obscure the enemy's vision of own and friendly units and their deployment, movement or maneuvers.

3. Technique of delivery:

a. DIRECT FIRE. Gunfire delivered on a target itself as a point of aim for laying the guns or director. Direct fire is usually used on targets which can be seen (by optics or radar) from firing ship.

b. INDIRECT FIRE. Gunfire delivered on a target which is not itself used as a point of aim for laying the guns or director. Indirect fire is always used on targets not visible from the ship. This fire is spotted by air spotters or shore fire control party spotters assigned for this specific purpose.

4. Type of fire:

a. AREA FIRE. Gunfire delivered in a prescribed area. Area fire is generally neutralization fire.

b. PRECISION FIRE. Gunfire used for registration (to obtain corrections for increasing the accuracy of subsequent fire) and for attack and destruction of point targets.

c. DEFILADE FIRE (reverse-slope fire). Gunfire delivered on targets located behind some terrain feature, such as a hill or ridge, which masks the target (fig. 12-22, part B).

d. ENFILADE FIRE. Gunfire delivered on a target in such a manner that the range pattern of

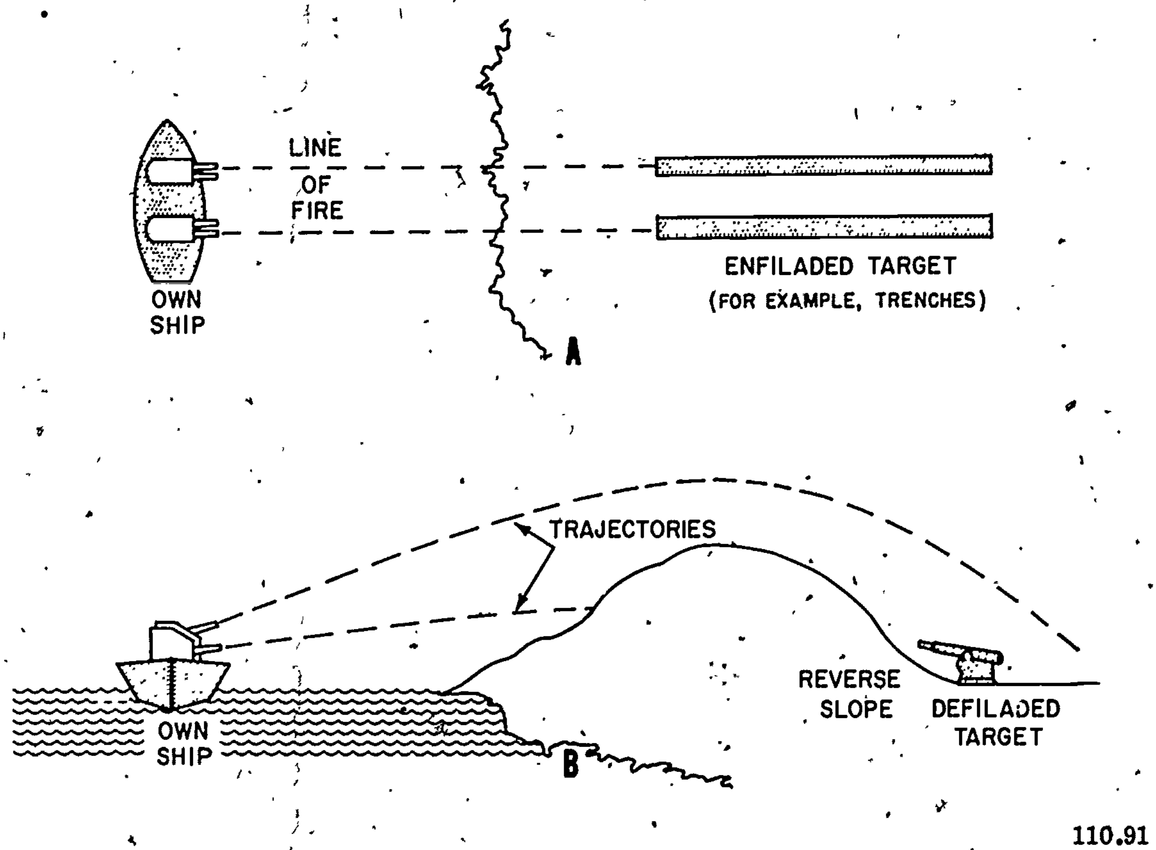


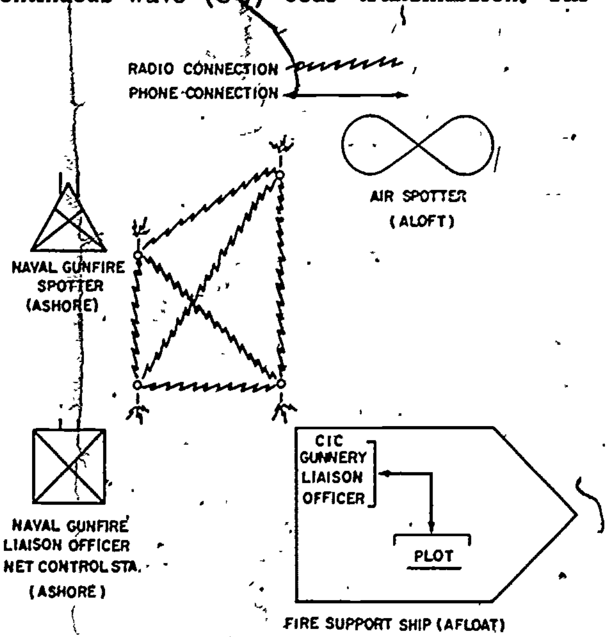
Figure 12-22.—Types of target.

the fall of shot coincides with the long axis of the target (fig. 12-22, part A).

COMMUNICATIONS

The subject of external communications in shore bombardment is a complex one in which the weapons liaison officer (WLO) plays a major role. It is obvious that this section can do scarcely more than acquaint the student with one corner of this ramified specialty, and even this corner cannot be thoroughly explored here — only surveyed rapidly with attention to a few essentials. Two- or three-day shore bombardment schools are available within the fleet which instruct a ship's "team" in the specifics of shore bombardment communications and procedure.

Figure 12-23 illustrated schematically the communication net (i.e., the participating stations) for a single ship in support of a battalion of troops ashore. The WLO aboard a ship (typically a batallion would be supported by a destroyer) is located in CIC, where he is connected by battle telephone with plot and the main battery director (the officer usually wears the phones himself) and by radio with the other stations in the net. Most often the radio contact is by voice radio-telephone (R/T) rather than by continuous-wave (CW) code transmission. The officer's voice does not go on the air; he communicates through a radio-telephone operator (not shown in the figure in CIC) who functions as his talker and also logs the spots and other information received as he gets it.



110.93

Figure 12-23.—Shore fire control spotting net. Schematic.

The radiotelephone transmissions are usually frequency-modulated (FM) in the very-high-frequency (VHF) band (e.g., 20 to 60 megahertz) or ultra-high-frequency (UHF) band (e.g., 200 to 300 MHz), though other bands may be used. The shore fire control party uses a portable battery-powered transceiver which can be carried on the back of one man. With a low power output, which is all that is possible in such equipment, the range is only a few miles, but this is all that is necessary.

The air spotter usually is in a relatively low-speed spotting fixed-wing aircraft (often a light civilian-type one or two-place plane) or in a helicopter. The spotter and his shore fire control party are in a forward position where they can observe the target area. The naval gunfire liaison officer is usually in a location further from the target area.

Most of the communication takes place between the spotters and the ship. The naval gunfire liaison officer sets up the net but in general does not participate directly in its functioning unless components in the net are changed, or unless it is necessary to control it for other reasons.

In general, so far as shipboard communication operations in shore bombardment are concerned, if communications are carried on through CIC, CIC follows these procedures:

1. Locates on the chart the target assigned by the shore fire control party.
2. Furnishes bearing, range, and elevation to control and plot.
3. Checks the computed solution with CIC's plotted solution.
4. Relays spots received from the shore fire control party to control and plot.
5. Plots forward lines continuously and accurately.

OPERATIONS

Naval gunfire has many capabilities, advantageous for troop support in landings, which conventional land artillery does not possess. These include:

1. AVAILABILITY. Gunfire support ships are continuously available before, during, and after

the landing, as long as the zone of action ashore is within the range of the ship's guns.

2. MOBILITY. Within the limitations of navigation, ships can move rapidly from one area to another as the situation ashore develops. At the same time, the most favorable ranges and lines of fire can be fully exploited, and enemy counterfire can be evaded.

3. HIGH RATE OF FIRE. Power loading mechanical ammunition supply makes it possible to deliver a large volume of fire in a short time. This characteristic is of great value in neutralization missions, where it is necessary to saturate the target area with a large volume of fire.

4. HIGH MUZZLE VELOCITY AND FLAT TRAJECTORY. Naval guns, particularly those of heavy caliber, have great penetration and destructive power, especially against installations presenting vertical surfaces.

5. SMALL DEFLECTION PATTERN. The comparatively small dispersion of deflection of naval guns makes them valuable for close support of troops when the line of fire can be made parallel to the troops' front line (enfilade fire, (fig. 12-22, part A).

Selection of Weapons

Selection of the guns or weapons to be used in naval gunfire support is determined by the nature and size of the target to be engaged, and by the proximity of friendly troops to the target. The 5-inch gun is normally used for close supporting fire; its rapid rate of fire and relatively small pattern size make it an excellent weapon for neutralization and destruction of targets immediately in front of advancing troops. Destroyers are usually assigned close supporting fire duties because their maneuverability permits them to shift positions easily and quickly and to take positions close inshore for direct fire on targets in coastal areas.

Eight-inch guns, with their great accuracy at long range, are normally reserved for deep supporting fire. The lethal bursting radii of projectiles from these guns limit their employment in close support. Moreover, ships mounting these guns (cruisers) are hampered in responding quickly to fire commands because they are less maneuverable than destroyers, and their fire control organization is more complex. The larger ships also have additional duties. Destructive power of large-caliber projectiles makes them particularly effective against heavy installations ashore.

Six-inch guns are suitable for either close or deep support, but the light cruisers mounting these guns are better adapted for deep support use since their maneuverability is restricted.

Three-inch and 5-inch guns of DEs and APDs are suitable for harassing fire missions of the sort often expected against areas remote from our own troops such as towns, harbors, and coastal air strips. The use of these ships for this purpose provides a necessary feature of support, and releases ships with more accurate fire control equipment for use where precision fire is required.

Three-inch guns are effective for area neutralization where heavier guns are not required. The guns are particularly effective against shoreline targets, especially enemy personnel in caves. When such fire is controlled by the dual-purpose gun directors, it is accurate and effective at short ranges; when not so controlled, larger safety margins with respect to own troops must be allowed.

Selection of Projectiles and Fuzes

Selection of the projectile type to be used in support of troops depends upon the type of target and the effect sought on that target. Because in shore bombardment a battery is likely to be shifted frequently and rapidly from one target to another (quite likely of different type, requiring a change in ammunition), ammunition-handling personnel should be prepared to change projectiles and fuzes on very little notice.

High-capacity (HC) projectiles are especially for use in shore bombardment. They have great explosive content (at the expense of penetrative ability) and produce a heavy blasting and fragmentation effect. HC is therefore suitable for neutralization or for destruction of relatively light installations.

Antiaircraft common (AAC) projectiles are similar to HC projectiles in explosive and penetrative qualities. Their effective bursting radius of 35 to 50 yards fits them for close-support neutralization fire.

Armor-piercing (AP) and common (COM) projectiles are designed to penetrate armor plate before detonating. Their use in shore bombardment is limited to fire on fixed enemy defenses such as concrete pillboxes and block-houses which cannot be reduced by HC projectiles.

White-phosphorus (WP) projectiles have been found very useful for screening, incendiary, and antipersonnel effect. They may also be used as "identifying or marker shot" to identify salvos, to permit spotting when the impact burst is invisible due to foliage, or to give a prearranged signal to the troops supported.

Illuminating (ILLUM) projectiles are used to provide illumination only.

Fuzes used with HC, AAC, and WP projectiles may be selected to meet different objectives. Mechanical time fuzes may be used to provide air bursts for maximum effect against personnel and light equipment. They should be set to burst 25 to 50 feet directly above the target. Proximity fuzes, which require no advance setting, accomplish the same purpose with greater accuracy and less difficult fire control, as they compensate automatically for variations in ground elevation. Point-detonating fuzes also require no advance setting but produce a lower and more concentrated burst, often desirable for demolition. Base-detonating fuzes are, of course, required against armored or other heavy structures.

Target Intelligence

Before undertaking any bombardment of land targets, a thorough familiarity with the terrain and hydrographic features of the objective, and with the location of profitable targets, must be acquired. The study of available charts, maps, aerial photographs, radar PPI simulations, mosaics, and other pertinent information will be necessary for rapid, effective troop support. Normally these charts, maps, photographs, and target information are furnished each fire-support ship prior to the operation. The systematic destruction of defense requires the continuous assembly and evaluation of targets known beforehand, and of those discovered in the course of the operation. Damage assessment must be based upon visual observation and photo analysis. A common error is over-optimism as to the effectiveness of naval fire against land targets.

Effective support of troops by naval gunfire depends on certain operating principles and techniques of delivery—what might be called tricks of the trade, or recommended operating practice. This article briefly discusses a number of these principles and recommended techniques.

PREREQUISITES TO EFFECTIVE SUPPORT FIRE. Prerequisite to effective support are proper alignment of the fire control system and gun battery, rapid and reliable internal and external communications, and well-trained ship control, fire control, and gun control personnel.

For optimum effectiveness, personnel aboard a firing ship should be thoroughly familiar with the land areas the ship is assigned to cover. This can be achieved through repeated firing, observation, and analysis. Consequently, it is best to avoid shifting ships to different areas of responsibility once their personnel have become acquainted with the areas originally assigned.

COUNTERBATTERY FIRE. The first duty of naval gunfire in all phases of support is immediate and effective silencing of heavy enemy weapons which open fire on our forces. Hence a counterbattery plan anticipating all contigencies must be in constant readiness, and fire-support ships must be ready and alert at all times for the delivery of this fire. If the source of enemy fire is not known, heavy counterbattery fire on suspected sources is delivered until the enemy battery is located. The whereabouts of friendly forces must be kept in mind during such an attack.

USE OF ILLUMINATING PROJECTILES (star shells). Illumination of land areas by naval star shells is effective in preventing enemy counterattacks, infiltration, and the movement of enemy troops at night. Its morale-boosting effect on our own troops generally results in requests for exorbitant star-shells expenditures to produce unnecessary illumination of the land area throughout the night. Except during actual enemy counterattacks, star shells fired at a reduced rate and at irregular intervals normally discourage enemy movement. Maximum benefit from the limited supply of star shells available requires judicious control and coordination by troop units to avoid silhouetting own forces ashore and afloat. When delivering illumination fire, the line of fire must be so adjusted with relation to our front lines that friendly troops are not endangered by star shell bodies. Searchlight illumination for troop support is generally unsuccessful; it almost invariably draws enemy fire on the ship employing it.

Close cooperation between ships and the troop units assigned for support is essential, for information between supporting ships and troop units can ensure intelligent and effective fire support. Of particular importance is the safety requirement that all fire-support ships maintain an up-to-date plot of own-troop front-line positions as periodically announced by landing force elements. This not only prevents endangering own troops, but permits selection of the most suitable line of fire with respect to troop lines, and safeguards friendly aircraft operating in the area.

SPOTTING

As the study of exterior ballistics has indicated, not all the factors which affect the flight of a projectile can be precisely evaluated in advance of firing. Even with the best fire control equipment available, experienced gun crews, and efficient fire control personnel, the opening shots may not hit the target. It is therefore necessary to apply corrections (or spots) to the initial firing data to bring the shots on the target. The corrections are applied to gun-laying data for subsequent rounds fired. This technique is called spotting.

DEFINITIONS

The terms defined below relate to gunfire and spotting:

SLOW FIRE: Firing deliberately delayed to allow for application of spots, or to conserve ammunition.

RAPID FIRE: Firing is NOT delayed to apply corrections.

SALVO: One or more shots fired simultaneously by the same battery at the same target.

SLOW SALVO FIRE: Guns are loaded on command and fired together at a fairly slow rate.

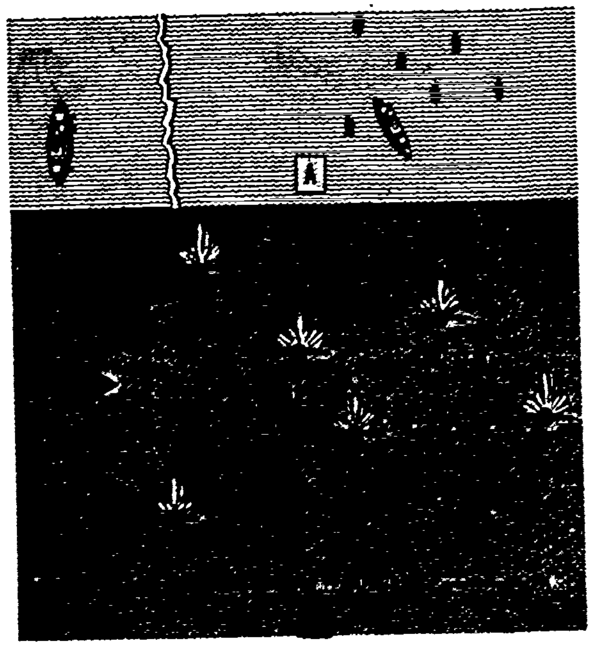
RAPID SALVO FIRE: Guns are loaded on command and fired together at a RAPID rate. (Both slow and rapid salvo fire are used to establish a hitting range to a surface or land target).

RAPID CONTINUOUS FIRE: The fastest firing method for 5-inch guns. The pointer's firing key is locked in the closed position. Rate of fire depends only on the loading speed.

RAPID PARTIAL SALVO FIRE: For a turret (6-inch and above), synonymous with rapid continuous fire for a 5-inch gun. (Both of these types of fire will most often be used after the hitting range has been established or, in the case of the 5-inch gun, against aircraft).

MPI: Mean Point of Impact. Is the geometric center of the points of impact of the various shots of a salvo. Excludes wild shots (fig. 12-24).

PATTERN: Area covered by the points of impact of the shots (except wild shots). The pattern in range is the distance measured parallel to the line of fire between the point of impact closest to the battery and the one farthest away, excluding wild shots. The pattern in deflection is the distance, measured at right angles to the line of fire, between the point of impact farthest to the right and the one farthest to the left, excluding wild shots.



53.119

Figure 12-24.—Salvo pattern.

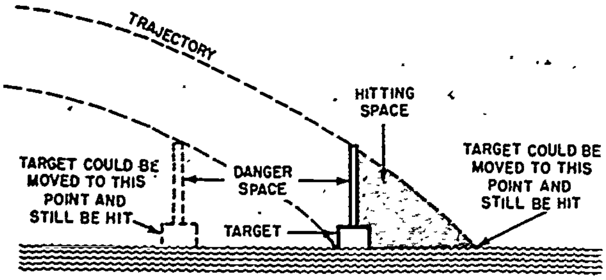
DISPERSION: Distance of the point of impact of that shot from the MPI. Dispersion in range is measured parallel to the line of fire, and in deflection at right angles to the line of fire, in a horizontal plane. Dispersion in range is positive when the shot falls beyond the MPI. Dispersion in deflection is positive when the shot falls to the right of the MPI. The algebraic sum of the dispersions in range (or deflection) of the several shots of a salvo must equal zero. (See definition of MPI).

APPARENT MEAN DISPERSION: In range (or deflection) the arithmetical average of the disperson in range (or deflection) of the several shots of the salvo. Excludes wild shots.

TRUE MEAN DISPERSION: Arithmetical mean of the dispersions in range (or deflection) of an infinite number of shots, all assumed to have been fired under conditions as nearly the same as possible and excluding wild shots.

HITTING SPACE: In range, the area behind the target in which a shot through the target will land (fig. 12-25).

DANGER SPACE: Distance in front of the target, measured parallel to the line of fire, that the target could be moved toward the firing point, so that a shot striking the base of the target in its original position would strike the



92.57

Figure 12-25.—Hitting space and danger space in range.

top of the target in its new position (fig. 12-25). At most ranges, danger space is virtually equal to hitting space.

STRADDLE: Obtained when some of the shots fall short and some beyond (or right and left) of the target. Wild shots are not considered. The target in view A of figure 12-24 has been straddled.

ERROR OF MPI: Distance from the target (fig. 12-24) or other reference point, such as the center of the hitting space, measured (in a horizontal plane) parallel to the line of fire for range and at right angles to the line of fire for deflection.

THE SPOTTER

The primary function of the spotter is the correction of range and deflection errors of the MPI so as to bring the shots on the target. Prompt and accurate correction of initial errors may be the deciding factor in a naval engagement. He bases these corrections on his own observations combined with those of the fire control radar operator. As a rule, in good visibility the spotter will estimate the necessary deflection correction, and range corrections will be obtained from the radar.

If radar fails, optical spotting must substitute. In the initial discussion of the spotter's problems, it will be assumed that radar is not available.

ALLOWING FOR SPLASHES: With a high-speed surface target, the spotter should bear in mind that the apparent MPI in deflection should be held abaft the point of aim to allow for target travel while the splashes are forming. Do not assume that full splashes form instantaneously at the impact of a salvo. The time lag is only a few seconds at most, but is sufficient to allow considerable movement of a fast target.

Spotter Qualifications

A good spotter should have the following qualifications:

1. An even, calm temperament, not excitable under stress.
2. Sound judgment.
3. Decisiveness.
4. Alertness.
5. Normal eyesight, hearing, and speech.

Visual Estimate of Target Course and Speed

Besides his primary function of correcting the fall of shot, there are other functions which the spotter must perform before and during firing. In general these are:

1. Describe the enemy forces (general bearing line, number of ships, deployment, etc.
2. If he is also acting as the control officer, he estimates the values of range, target angle, and target speed, and keeps plot informed of all changes to these values.
3. Keep control informed of the tactical situation.

There are other duties which the spotter may be required to perform. Their exact nature will vary with different types of ships. The spotter's detailed duties and spotting procedures are prescribed in the ship's Weapons Department Organization Manual, and in fleet doctrinal publications. (NWIPs, etc.)

To arrive at a solution of the fire control problem, the computer must have target course and speed. Often the spotter can, by observation through binoculars, get this data.

To determine target course, the spotter must be able to estimate accurately target angle (i.e., relative bearing of own ship as seen from the target).

To estimate target angle, the spotter must know the structural details of all likely targets. Silhouettes of all probable targets are furnished each ship. The spotter should study the details of these visual aids, not only for the purpose of recognizing the enemy, but also for estimating target angle. In estimating target angle, the spotter should make use of prominent objects such as bridges, breaks in the deck, stacks, masts, and other features. By observing the opening and closing of the apparent distance between such details the spotter can estimate the angle the enemy ship makes with the line of sight.

Target speed can at least be only roughly estimated. Here again, knowledge of enemy ships is valuable, particularly in regard to maximum speeds. Target's speed may be estimated as about 1 or 2 knots less than the maximum speed of the slowest ship in the formation.

To make the best speed estimates, you must have extensive training and experience. The aids used by a spotter in a direct estimation of target speed are smoke from the stacks, bow wave, and stern wake.

METHODS OF SPOTTING

As in other operational communications, there is a prescribed terminology and message sequence for spotting. The examples below show the general practice at the present time.

SURFACE FIRE. For surface fire, only range and deflection are spotted. The correction necessary to bring the MPI on the target is given in the following terminology sequence.

1. Deflection correction—RIGHT or LEFT, in mils.
2. Range correction—ADD or DROP, in yards.

Where no correction is necessary, the designation NO CHANGE is used. Typical examples of spot transmissions by telephone are RIGHT 10, ADD 1,000 or DROP 500.

AA fire. For air targets, corrections to bring the burst on the target are needed in three dimensions. Even well-trained personnel find it almost impossible to estimate errors rapidly in three dimensions. AA spotting is therefore generally limited to correcting for obvious system errors.

The proper terminology for spotting in AA fire is as follows:

1. Deflection correction—RIGHT or LEFT, in mils.
2. Range correction—ADD or DROP, in yards.

Deflection and evaluation spots normally are made by the control officer. Range spots will be made by the rangefinder or radar operator.

NAVAL GUNFIRE SUPPORT. In shore bombardment, as in AA fire, spots in three dimensions may be necessary. The terms are the same as in the preceding paragraph, but the units are not the same. When naval guns are used to support landing operations, joint forces are involved. The Navy, Army, and Air Force have a standardized spotting terminology for joint operations which differ from the above, in that all corrections for indirect fire area spotted in yards. At the computer, deflection and elevation spots must be converted to angular units before being applied to the computer.

There are three methods of visual spotting:

1. Direct.
2. Bracket-and-halving.
3. Ladder.

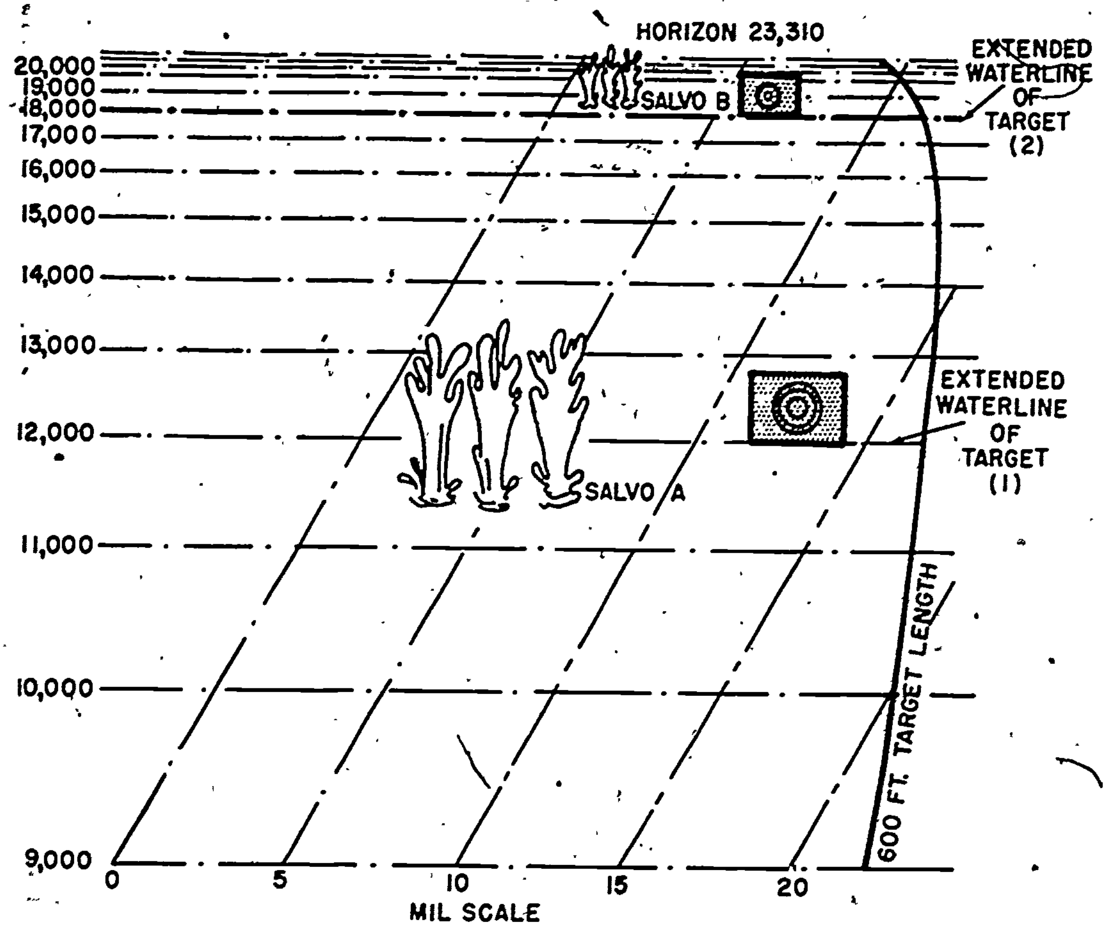
The method used depends on the type of battery firing, type of target, visibility, and range.

Direct Method

Spotting by the direct method is, as its name implies, the spotting of salvos (splashes) direct to the target. This is the most desirable procedure, but its use is limited to shorter ranges and conditions of good visibility. For reasonably accurate visual spotting at a range of 15,000 yards, a spotting height of 120 feet is required. The splash must be relatively close to the target, and the rangekeeper set-up fairly accurate.

A thoughtful analysis of the problem with reference to the spotting diagram in figure 12-26 reveals that the greatest limitation of the direct method in visual spotting is in range. Deflection spots can be made with equal accuracy at any visible distance. If, then, air observation is available, and the plane spots in range with the ship spotting in deflection, the direct method can be used by the battery at any range at which a portion of the splash is visible to the shipboard spotter. Air spotters cannot spot accurately in deflection unless they have a line of sight containing the firing ship and the target.

Spotting the fall of shot at very short ranges differs from other spotting problems in that range errors are not difficult to judge. However, in determining deflection errors at short ranges, consideration must be given to the travel of the target and the spotter's position relative to the line of projectile flight. For example, with the firing ship and target on opposite courses, target to starboard, a shot fired with correct deflection but long in range will appear to the spotter to



92.58

Figure 12-26.—Practice diagram for range spotting.

be in error to the left of the target. Special short-range splash diagrams aid the spotter in this type of firing.

Bracket-and-Halving Method

Bracket-and-halving is used at long ranges when no air or radar spot is available. At great distances it is difficult to tell if a splash is short of or over a target, unless the two are in line. If the splash and target are not in line, the first spot is made in deflection only. When target and splashes are in line in deflection, a range spot is made in such a direction and amount as to "cross" the target definitely. The direction of the next spot is reversed, and the size of the spot is cut in half. This "halving" is continued until a straddle is obtained, at which time it may be appropriate to shift to rapid partial salvo or to rapid continuous fire. The spot should not be reduced below pattern size.

Ladder Method

When ranging is difficult and visibility poor because of fog, smoke, or darkness, the ladder technique is valuable. Ladders are not particularly adaptable to fast-moving targets. There are many variations of this technique, but the basic procedure is:

1. Fire is deliberately opened short.
2. Suceeding salvos are fired to approach the target in steps not less than pattern size.
3. As soon as the target is crossed, the steps are reversed and halved until the target has again been crossed.

After the target is straddled, a rocking ladder may be used with slow timed fire, or with rapid partial salvo or continuous fire. In a rocking ladder the pattern is shifted back and forth across the target by small arbitrary successive spots, such as +100. 0, -100,............ introduced at the computer. Its effect is to increase the pattern size, which may be valuable when firing against a target capable of rapid maneuvering. The rocking ladder can be used in conjunction with air or radar spotting, so long as the spotter is kept informed that this technique is being used.

When the rocking ladder method is used, the computer operator in gun plot automatically introduces the arbitrary spots into the computer. The spotters job at this time is to observe the effects of the arbitrary spots and report any changes in target course and speed.

SPOT PYRAMIDING

Spot-pyramiding is the application of a new spot before the effect of a previous spot has had time to become apparent. It can occur only in rapid fire, when the interval between shots or salvos is less than the time of flight plus the spotting interval. In that case, when a salvo lands, there are one or more other salvos in the air. Suppose the spotter makes a spot on the salvo which has just landed. This spot is applied and a new salvo is fired. Then one or more of the salvos which were already in the air lands, and the spotter, forgetting that his previous spot has not had time to show its effect, spots again. This spot is applied to the next salvo fired with the result that this salvo is overcorrected and will probably miss, as will subsequent salvos until the spotter sees his mistake and spots back again.

The time of flight clock signal helps to avoid pyramiding. A button on a mechanical time clock is pressed in the plotting room when the salvo on which a spot is applied is fired. The clock has been preset to ring just before the time of flight of the projectile ends. Before the salvo lands, the mechanism sounds a buzzer. This information is then relayed to the spotter via sound-powered phones.

Because spot pyramiding is common and has a disastrous effect on accurate control of fire, the mean used to prevent it must be carefully and correctly operated. For example, if the time-of-flight mechanism operator forgets to press the button for a spotted salvo, and the spotter waits for the signal, he may continue to wait after it becomes apparent that his previous spot was incorrect.

When modern fire control systems are being used to solve the fire control problem, the rate control process is used to make constant corrections to the solution. If spots are applied at the same time as rate control corrections, the effect is the same as pyramiding of spots. Under normal circumstances, AA fire is rate controlled. Hence spotting of air bursts is rare.

SPOTTING WITH RADAR

Radar spotting has proved to be both accurate and reliable within the range of surface batteries. Radar provides a means of spotting which is independent of conditions of visibility, so that blind spotting is possible with blind firing.

Shell splashes appear on the scope as flucuating echoes which last for several seconds, depending on the size of the projectile and the range. The large column of water thrown up by the projectile produces the echo. Salvos produce larger or multiple echoes on the scope.

If the projectile stays within the vertical limits of the radar beam, its flight to the point of impact can be followed on the scope on main sweep. The projectile produces a small, weak, moving echo which begins at the edge of the scope and moves out in range toward the target. At the point of impact the echo stops and grows larger as the splash builds up. Echoes from direct hits or near misses will not be lost in the target echo, while salvos which straddle the target may envelop the target echo in the midst of the splash echoes on the scope, thereby making it impossible to distinguish individual splashes. Range errors can usually be estimated by radar with greater accuracy than by optical spotting, but deflection spotting with radar is difficult, especially when the error is small. Near misses sometimes merge with and are indistinguishable from the target pip. Consequently, repeated salvos can land with a 2-mil to 5-mil error which is not separately distinguishable but may not be hits. Target practice is used to determine the minimum deflection error that can be detected on a particular radar. When radar is the only means available for deflection spotting, deflection "rocking ladder" should be used. The order of preference in spotting surface fire is usually: RANGE — radar, air, and visual; DEFLECTION — visual, radar, and air.

449

In night action, or action under reduced visibility, radar normally spots for both range and deflection.

Secondary methods are used by the director and in fire control plot when gun orders cannot be received at the gun mount due to fire control equipment failure. In earlier linear-rate systems, the director can be driven manually in event of power drive failure. Range, bearing, and elevation data can be sent to plot by telephone if synchro transmission fails, as can firing orders to the mount if the firing circuit fails. In the event of stable element failure, some older fire control systems can be stabilized manually by a crewman who keeps a telescope LOS aligned with the horizon. If synchro transmission fails with any computer inputs or outputs, data can be introduced manually or read from dials and telephoned from plot, but neither stable element nor computer can function without the proper supply. When any failure prevents data from reaching the gun mount, secondary methods must be used at the gun mount.

LOCAL CONTROL

So far in discussing fire control, we have concentrated on the primary methods of battery operation. These are the ones most commonly used, and the ones which permit employment of the ship's armament with the greatest efficiency. But battle damage, personnel losses, and accidents can disable any system to the extent that some secondary operating methods are essential if the system is to keep operating at all, even if not at full efficiency. Aboard ship you will not only employ such methods in battle operations, but also in training for such emergencies.

All 3-inch gun mounts and larger are equipped with adjustable sights. With these, it is possible to offset the gun bore axis from the LOS to the desired sight angle and deflection. This function is performed by a crewman called the sightsetter, who mans the sight-setting indicator. In gun mounts 5-inch and larger, this unit contains hand-cranks and gearing for physically moving the sight optical units (or moving optical parts within the sights), and two sets of dials (fig. 12-27A and B). One set, driven by the sight gearing, displays present sight angle and deflection. The others are synchro-driven to display sight angle and deflection ordered by the computer, (3"/50 mounts do not have the synchro-driven dials). Even in automatic operation the sightsetter mans his station and cranks the sight gearing to keep the sight indicator dials matched up with the computer-controlled dials so that the LOS of the gun sights remains on target although the gun bore axis is offset in accordance with the sight angle and deflection components of gun order. In 3"/50 and 5"/38 mounts, an extra range dial coupled to the sight angle crank reads directly in yards of range to a surface target.

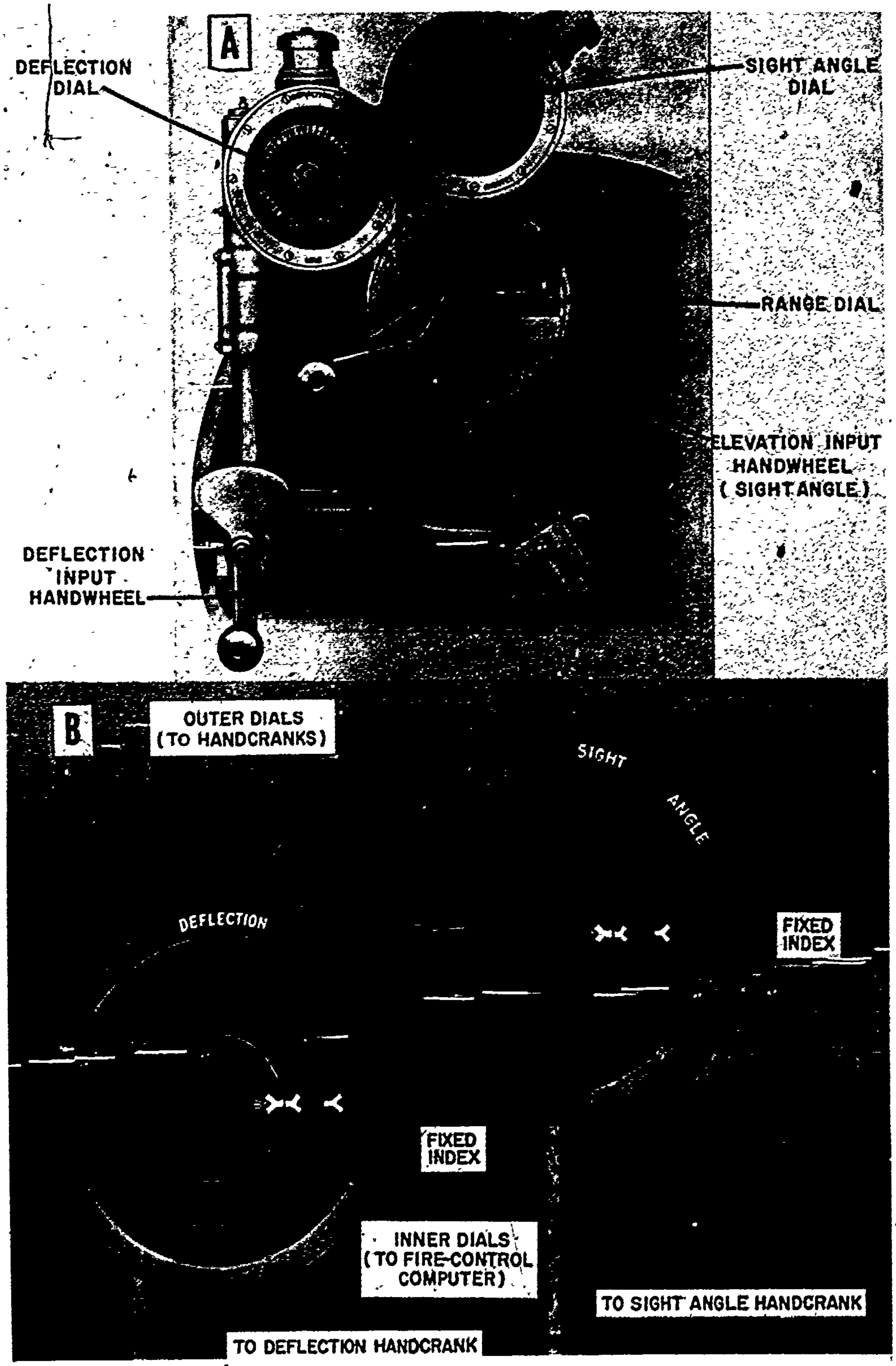
In all types of secondary (local) control the gun must be laid by gun-laying personnel on the mount. In older types like 40-mm and 5"/38 mounts the pointer on the left side of the mount elevates and depresses the gun while the trainer (on the right) trains the mount. Each gun layer has a gun sight. They may either control the mount power drive or position the mount by their own muscular effort (manual operation).

In 3"/50 RF mounts, and automatically loaded 5"/54 mounts, there is no provision for complete manual operation. The mount can be operated in local, but only if the power drive is functioning. Manual operation is limited only to maintenance and stowing movements. In the 3"/50 gun mounts, either of the gun layers can take over complete local control of gun positioning whereas in the 5"/54 Mk 42 gun mounts, this is accomplished by one man control unit operator.

In local control, gun layers must work with the sightsetter. Here is the basic procedure:

1. The gun layers position the mount so that their lines of sight are on target, and they continue positioning it to keep on target.
2. Most mounts have synchro-driven dials (as in fig. 12-27, part B) which indicate computed sight angle and deflection. The sightsetter cranks in sight angle and deflection until the outer dials (positioned by his handcranks) match the inner (synchro-driven) dials. This action simultaneously repositions prisms in the sight optical systems, causing the telescope lines of sight to shift off target.
3. The gun layers drive the mount to keep on target. This automatically offsets the gun bore axis by the angles that the sightsetter has cranked in.

Figure 12-27, Part A, shows the handcrank arrangement, Part B shows in more detail how the dials look when matched. The fixed index shows the angular values actually cranked in. It is used when there is no synchro transmission under



84.211.2

Figure 12-27.—A. Sight-setting component arrangement. B. Sight angle and deflection dials.

these conditions, the information is either transmitted by phone or comes from the mount captain, based on his estimate of range, ballistic corrections, and lead.

On mounts 5-inch and larger, the sights are carriage mounted. The sights therefore train with the carriage, but the carriage doesn't elevate. To make the sights elevate with the gun, they must be driven by a mechanical linkage from the elevating gear. Thus the sight angle prisms in the optical systems must be positioned by the algebraic sum of two inputs—gun elevation and sight angle. This is the function of a mechanical differential in the sight angle gear train.

Mounts smaller than 5-inch have slide-mounted sights that elevate and train with the gun barrel. The differential is not needed. Nor do mounts smaller than 5-inch have synchro receivers for sight angle and deflection. When necessary, computed sight values are transmitted by phone.

In normal-local control operations, all firing is controlled at the gun or mount. Guns are loaded and fired on command of the gun or mount captain. Pointer, trainer, and sightsetter are responsible for correct gun laying, but pointing and training are done by means of the sight telescopes. When the pointer and trainer are on target, the pointer closes his firing key to fire the gun. The gun captain also is the spotter.

Following are brief discussions of the duties of gun crew members.

1. The POINTER operates a handwheel that elevates and depresses, or points, the gun. He looks through a telescope (pointer's sight), with horizontal and vertical crosshairs, which moves as the gun moves. This telescope is also capable of independent movement, over which the pointer has no control.

Because of this, when the pointer has the crosshairs of his scope on target, he may be looking at the target, but his gun is elevated above it. The angle between his line of sight and a line through the gun bore is the sight angle.

The pointer does not set the sight angle. It is his business to keep the horizontal crosshair on the target. When the gun is in local control, he fires when the two wires that intersect are at the point of aim.

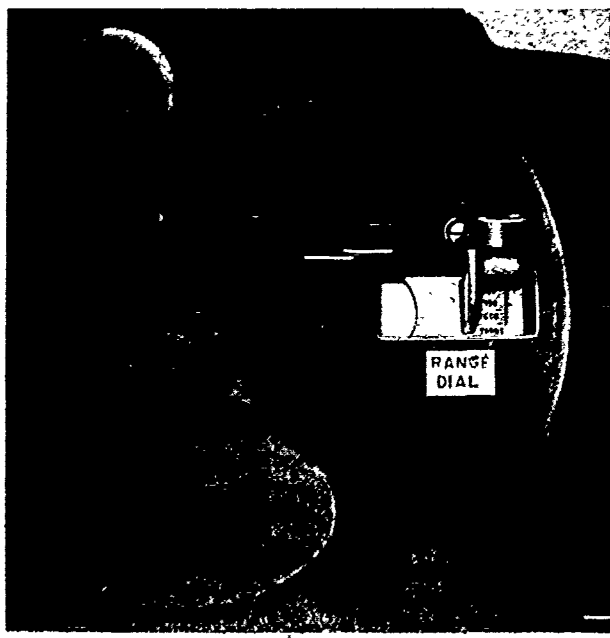
2. The TRAINER operates a handwheel that turns (trains) the gun from side to side. He also has a telescope (trainer's sight) with crosshairs. Like the pointer, the trainer has no control over his telescope, except, of course, that as he trains the gun mount, the scope trains with it. It is the trainer's business to keep his vertical crosshair on target.

3. The SIGHTSETTER is the man who is responsible for moving the pointer's and trainer's sights with respect to the gun. He has a handcrank for sight angle, and another for deflection angle (fig. 12-27A). Zeroing is done by handcrank. Sight angle is zeroed by turning the elevation input handwheel until the sight angle dial reads 2000 minutes (fig. 12-27). Deflection is zeroed by turning the deflection input handwheel until the deflection dial reads 500 mils.

As stated before, deflection spots are made in mils; they are applied by means of the deflection input handwheel. Range spots are made in yards by means of the elevation input handwheel, which also moves the range dial (graduated in yards). (See figs. 12-27 and 12-28).

The correct phraseology for range is Add (Drop) ———————— yards. All spots are given to the sightsetter by the mount captain. When the spots are cranked into the sightsetter's regulator, the word is passed to the mount captain using the phraseology "Deflection Set, Range Set".

As we already know spots in deflection are made in mils. Since this is important to the



84.84

Figure 12-28.—The range dial.

spotter, let us cover this subject once again. A mil is an angular measurement which will correct deflections of 1 yard for each 1000 yards of range. (See fig. 12-17). Thus, 1 mil will move the fall of shot 1 yard at 1000 yards range, 2 yards at 2000 yards, 3 yards at 3000 yards, and so on. How the mil is used when spotting shall be covered later in this chapter when we show an example of how the spotter solves the problems related to spotting.

To estimate the range to a surface target, you must have a reference point whose range you know. In day time the horizon is the logical thing to use for reference. If the range to the target can not be obtained from the battery officer, CIC, gun plot or from various lookout's, then you must use the horizon for your reference. For example, if your eye level is 30 ft. above the water line, the horizon would be approximately 12,750 yds. away. If height of eye is 25 ft., the range would be approximately 11,550 yds., see figure 12-29. The key to estimating ranges is the appearance of the main deck of the target in relation; to the horizon. If the target is on the horizon, the range will be 12,750 yds. if your eye level is 30 ft. above the water line. (It must be understood that all ranges are approximations). As the target moves toward your ship, more water can be seen between the target and the horizon. If the amount of water is the same between your ship and the target and from the target to the horizon, the target will be halfway between your ship and the horizon or half the range to the horizon about 6,350 yds. This method will be much better than haphazard guesses and should put your opening salvo close enough to the target so you will be able to make spot corrections. The first step after firing your first round is to spot the fall of shot in deflection so that the next round will be moved closer to the center of the target. Once this is done you can then use the target for estimating range spots, the distance between the fall of shot and the target.

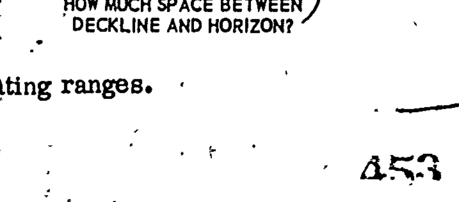
The DIRECT METHOD of spotting will be used to explain the principles of spotting. Using this method you make corrections to bring your splashes directly onto the target. This method works reasonably well at close range with good visibility.

SPOTTERS PROBLEM

In the following example you are the mount captain. You have received orders to engage an enemy destroyer on a bearing of 270 degrees relative. Your job is to put that destroyer out of action before he can damage your ship. The type of ammunition selected is A.P. projectiles. Before you take the destroyer under fire, you check to see that you have the following equipment set up properly. The fuze setter should be set on safe and the sightsetter's dials set to 500 mils for deflection and 2,000 minutes for sight angle, (zero setting for local spotting) when you make sure that the ammunition hoists are loaded with the correct type of ammunition, you and your crew are now ready to take the destroyer under fire.

First you must estimate the range to the target. Using the horizon as a reference, you estimate his range at 3,500 yards, for example. For your first salvo leave the deflection dial at 500 mils or zero. Pass on to your sightsetter the following orders: "Deflection zero, range 3,500". The sightsetter sets these estimates into the sightsetter's regulator and notifies the mount captain of the fact by the following words "Deflection Set, Range Set". On your command the gun is loaded. The pointer and trainer elevate and train the mount, to bring their respective crosswires on the target. When on target, the pointer fires. (See fig. 12-30). If, for example, the fall of shot appears to be about 400 yards beyond and 15 yards

HEIGHT OF EYE IN FEET	APPROXIMATE DISTANCE TO HORIZON IN YARDS
20	10,300
25	11,550
30	12,750
35	13,750
40	14,750



80.228

Figure 12-29.—Estimating ranges.

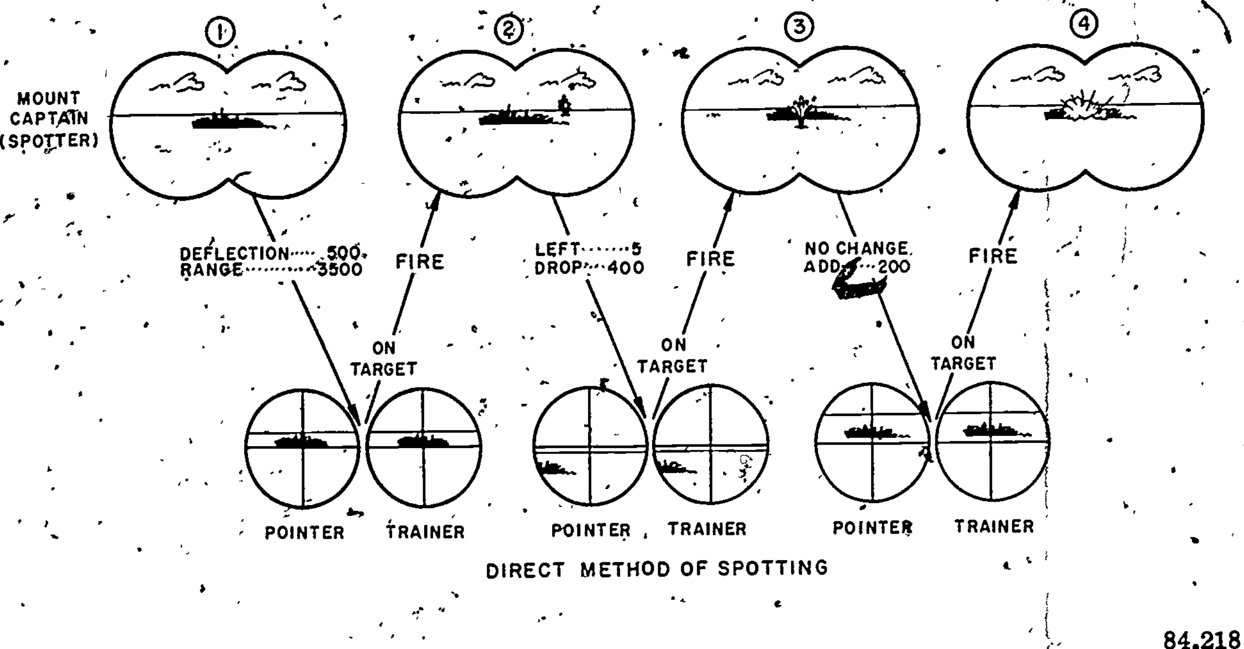


Figure 12-30.—Direct method of spotting.

to the right of the target, pass on to the sightsetter, "Left 5, Drop 400". Five mils deflection will move the splash 15 yards at 3,000 yards range.

The gun is loaded again. You receive "Set" from the sightsetter. The pointer and trainer position their crosswires back on the center of the target, and when on target, the pointer fires. You observe this fall of shot (fig. 12-30) to be directly in line but short of the target. You estimate that the splash is 200 yards short. Your order to the sightsetter is "No Change; Add 200". As this correction is entered into the optical system, the gun is loaded. When you receive "Set" from the sightsetter and "ON target" from the pointer and trainer, the pointer again fires. If you see that your spotting has resulted in a hit, you order "No Change, No Change" and "Rapid, continuous fire". This type fire is maintained until the target is destroyed or until cease fire orders are received from the director officer.

SAFETY

On 1 October 1951, one 5-inch 38-caliber gun aboard a destroyer fired into another mount. As a result, 6 men were killed and 15 wounded.

In the investigation that followed, the commanding officer and the weapons officer stated that they were unaware that such an accident was possible. If they had known that one gun could fire into the barrel of another, they would have — as prescribed by the general safety precaution — issued additional precautions intended to prevent such an accident. As it was, no warnings or precautions dealing with this hazard had been posted.

The mount captain had not complied adequately with safety requirements, for he did not use his sight port to observe the line of fire to ensure that it was safe. The gun of mount two, the mount hit, was trained and elevated to a "ready" position. In this position, the gun barrel could be in the line of fire of mount one. Mount two was not firing; it was not to fire until after mount one had completed its firing. For safety, therefore, mount two should have been held "ready" at its normally secured position at zero degrees train. If it had been held "ready", no accident would have occurred.

The cut-out cam is designed to prevent firing into fixed objects of the ship's structure. These include turrets, mounts, launchers, torpedo tubes, and cranes in their stowed positions only. Personnel must see that such items do not endanger the line of fire. In this case, any one of several responsible individuals — the commanding officer, the mount captain, or safety observer — could have prevented the accident. No mechanical defect existed. The failure was human.

At the time of this casualty, the precaution read:

When using director train. while firing at gunnery exercises, an observer from the firing ship for each gun or turret shall cause the firing circuit to be broken whenever the gun or turret is trained dangerously near any object other than the designated target.

The precaution has since been revised to its present form, to remove any doubt as to its meaning. The change was made partly as a result of this case.

Ships will cease the firing of any gun whose line of fire is endangering any objects other than the designated target. These objects include friendly ships and aircraft and own ship's structure together with the mounts and launchers and their barrels, fixed or moving. This stipulation applies to objects in the vicinity of the firing point, throughout the trajectory, and in the vicinity of the target. Turrets, mounts, guns, and launchers which are not firing, while others are firing, shall be trained and elevated if manned, or secured if unmanned, in a manner that will provide the greatest amount of safety from the firing. This position of greatest amount of safety of the unmanned mounts will generally be that position which the firing cutout mechanism cams of the firing mounts were cut to clear.

CHAPTER 13

FIRE CONTROL INSTRUMENTS AND TECHNIQUES

A ship's weapon system is defined as: the combination of a weapon (or weapons) and the equipment used to bring the destructive power of the weapon against the enemy. It includes units to detect, locate, and identify the target; deliver or start delivery of a weapon to the target; control delivery unit or weapon; and destroy the target. Weapons systems are made up of a combination of fire control systems that could include either gun, missile, or underwater fire control.

In this chapter we explain the equipment that makes up a gun fire control system (for example, radar, directors, computers, and stable elements). For a ship's weapon system to inflict maximum damage on a target, information received at the gun mount or turret must be continuous and accurate. In a gun fire control servosystem, synchros are used to transmit and receive remote gun orders from a controlling director to the mount or turret under its control.

Some gun fire control directors use a sight mechanism that helps compute the necessary gun corrections to ensure a target kill. Since gun sights play an important role in gun laying both at the director and gun stations, the construction and functions of some of these sights will be explained.

The fuze-setter located in the gun mount or turret plays an important part in a fire control system. The relationship of the fuze setter to the fire control system also is discussed. We begin this chapter explaining the purpose and functions of gun sight mechanisms.

GUNSIGHTS

The primary purpose of any sight on a gun or director is to establish a line of sight from the observer to the target. When the target is distant, the sight may in addition provide an enlarged immage of the target to improve accuracy.

Optical instruments used in naval gun fire control systems present a magnified image of the target to the observer's eye. At the same time, the observer sees an image of a reticle or reference mark, located inside the instrument itself. By accurately superimposing the reticle image on the target image, the observer can establish an accurate line of sight to the target.

Gun sights can be grouped into three general types.

1. Simple sights without optical system
2. Telescopic sights with fixed optical components
3. Sights with movable optical components

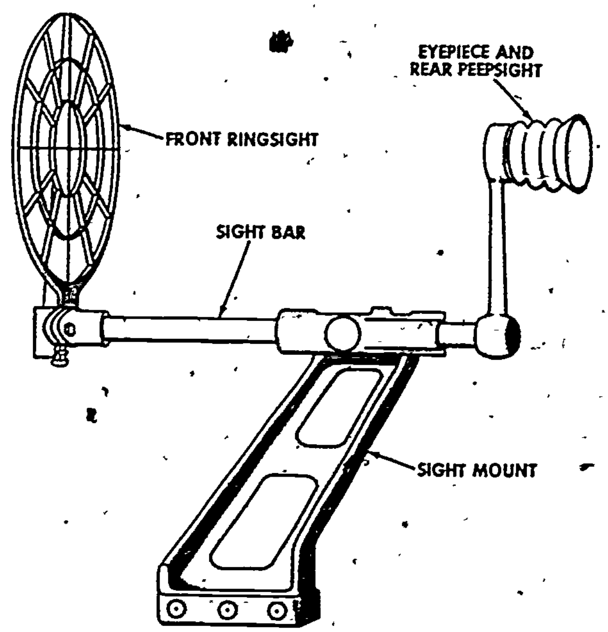
SIGHTS WITHOUT OPTICS

An example of sights without optics is the peep sight used on infantry small-arms weapons, or the ring sight (figure 13-1) installed for emergency use on some antiaircraft gun mounts. The observer looks through the eyepiece. When he has the target in line with the center of the front sight, the line of sight to target is parallel with the gun bore. To provide for ballistic and other fire control corrections, the observer must offset the line of sight so that it diverges from the gun bore by a certain angle. He can judge the amount of offset in this simple sight by using the concentric rings and spokes of the sight instead of the sight's center to align the line of sight to target. Use of this type of sight is restricted to targets at short ranges in emergencies when other methods are not available. Effective use of the sight to direct gunfire requires considerable training, and at best it is not as accurate as other systems.

SIGHTS WITH FIXED OPTICS

For longer ranges the eye needs optical aid, which means a telescope. Figure 13-2

456



84.206

Figure 13-1.—Open ring sight.

shows several types now in use in naval armament. The optical system of the straight telescope (A in figure 13-2) is quite similar to that of a conventional terrestrial telescope, except that it includes a reticle—a glass plate on which is etched a pattern of two lines at right angles, one vertical and one horizontal. When the target appears to be located at the intersection of the two lines (which are called CROSSHAIRS or CROSSWIRES, although they're usually made of neither wire nor hair) the telescope is on the line of sight to the target.

SIGHTS WITH MOVEABLE OPTICS

In enclosed mounts where some arrangement must be made for the line of sight to get through the mount shield, and in mounts where (fig. 13-2C) construction doesn't permit location of telescopes where the pointer and trainer can use the straight type conveniently at all elevations, you find prismatic telescopes. A prism can reflect light or "bend" the line of sight (fig. 13-3) as required without losing accuracy. Figure 13-2B illustrates a telescope with two prisms, for use where armor prevents installation of a straight telescope.

Sights may be installed on a gun slide so that they train with the mount and elevate or depress with the gun. Such slide-mounted sights are found on gun mounts smaller than 5-inch. But in mounts 5-inch and larger, the sights are carriage-mounted; they train with the gun, but as part of the mount structure they cannot elevate and depress with it (fig. 13-4). A way to solve this problem is to move some of the optical parts of the sight to shift the line of sight in deflection and elevation, without moving structural parts. In 5-inch mounts, this is done by moving prisms (fig. 13-2C). The shafts to the prisms are operated by the gun elevating gear and handcrank at the sightsetter's indicator regulator.

SIGHTS AND RANGES

As you know, the caliber of a naval gun is related to the range at which it is designed to be most useful. The big ones are used against targets a dozen miles or more away; the light machine gun batteries come into their own when the target gets within some 2500 yards, or closer. And so on.

You know also that, by and large, the bigger guns are used against bigger, slower targets. Sinking a surface target (and if it's a warship it can withstand a lot of pounding) requires the heavy punch of heavy guns. But in bringing down an air target, speed is the thing. A light gun can be brought into action more speedily than a heavy one, and can shift more readily with the target's evasive maneuvers.

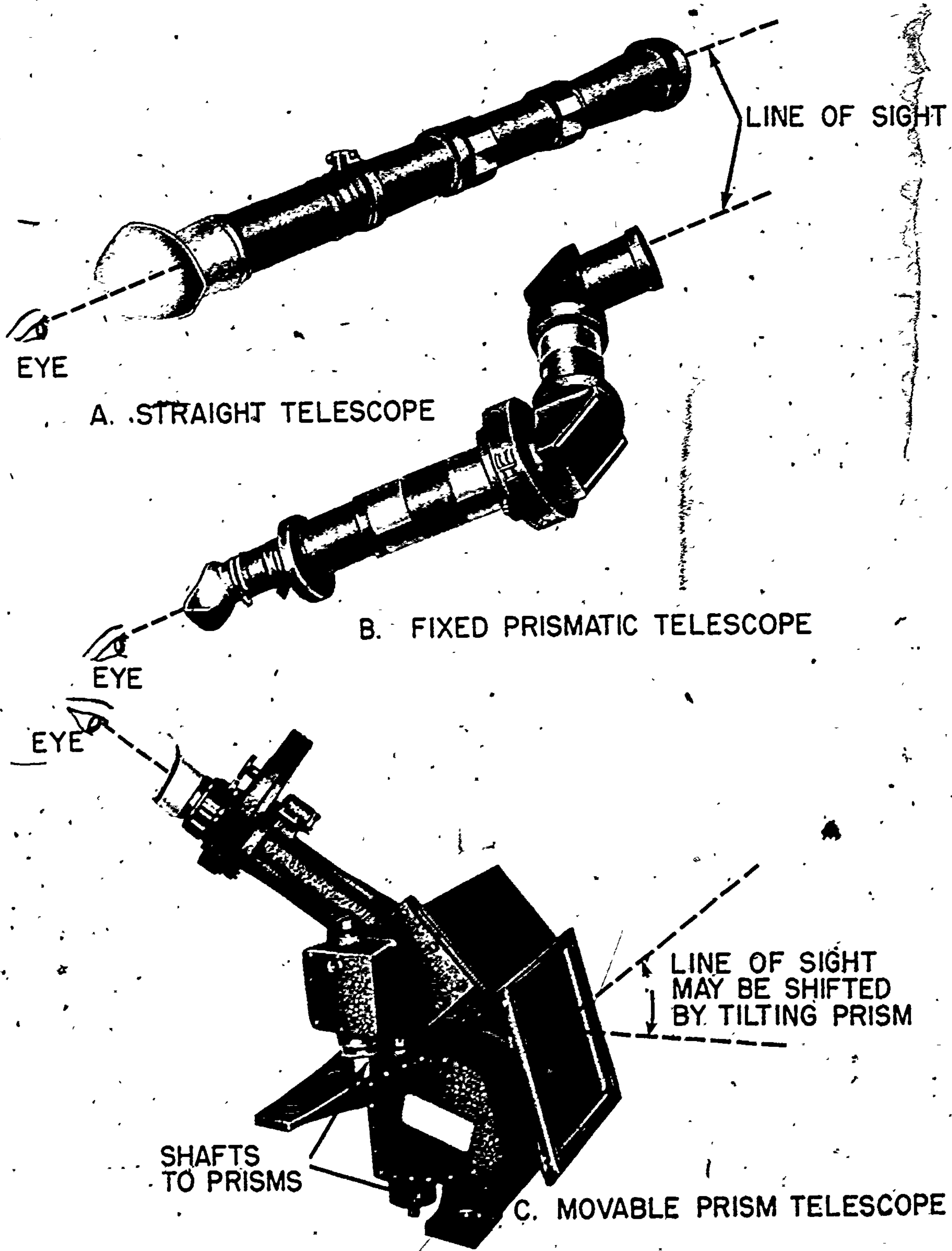
The sights (and other fire control gear) used with a ship's armament must be designed in view of these requirements.

Specifically, the fire control equipment for heavy armament is designed primarily for high accuracy because that's the main requirement at long ranges. To obtain such accuracy, the equipment must have powerful optical units or long-range radar.

Optical Rangefinders

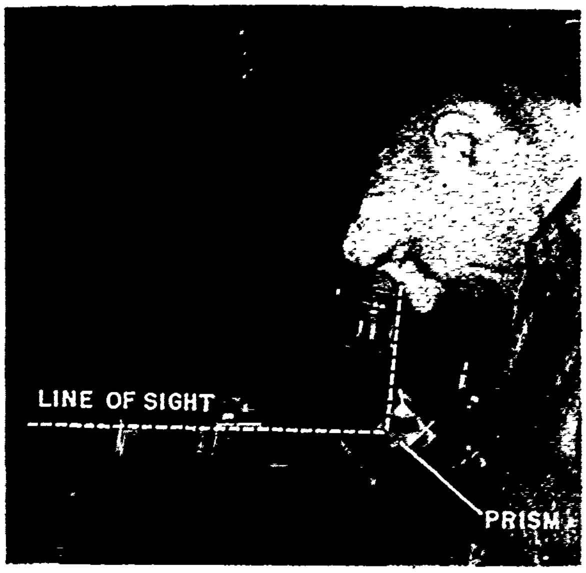
In dual-purpose battery directors (like the Mk 37 or Mk 68) and in main battery directors, a rangefinder located on the director can be used for determining ranges to a surface or land target when radar is not used.

The rangefinder is a long metal tube with eyepieces at its center and a window near either end. Inside the tube are lenses, prisms, reticles, and other optical parts, plus precision mechanisms for moving some of them. Rangefinders are shown in figures 13-5 and 13-6.



84.207

Figure 13-2.—Three types of gunsight telescopes.



84.208

Figure 13-3.—Using a prism to bend the line of sight in a telescope.

A recent development in the field of rangefinders is the use of a laser beam for determining ranges. Some of these devices are currently in use in the fleet. The operation of the laser beam rangefinding device is classified, so will not be explained in this text.

In this course we cannot go too deeply into the complexities of fire control rangefinders, but you should know something about them.

Every two-eyed human has stereoscopic vision. To see how it works, try this little exercise:

Hold an arm straight out horizontally. Raise your index finger. Now move the finger slowly toward your nose, keeping both eyes on it. By the time the finger reaches your nose, the "lines of sight" from your eyes to your finger converge sharply (fig. 13-5A).

Next, look at some object 200 yards away. Now the lines of sight for the two eyes are practically parallel.

Obviously, then, the closer the object, the greater the convergence; the farther away, the more nearly parallel the lines of sight become.

Measuring the convergence of the lines of sight actually provides a means of measuring range. But the distance between your two eyes is small, and it's difficult to get the swiveling of your eyeballs to register on a dial where it would be easy to measure. So the optical system of a rangefinder in effect separates the rangefinder operator's eyes (fig. 13-5B) by a distance equal to that between the rangefinder's end windows. When the optical parts in the instrument are moved to get its lines of sight to converge on the target, the amount of movement registers on a dial calibrated in yards of range. The rangefinder also magnifies, like a telescope—but with a super 3-D effect.

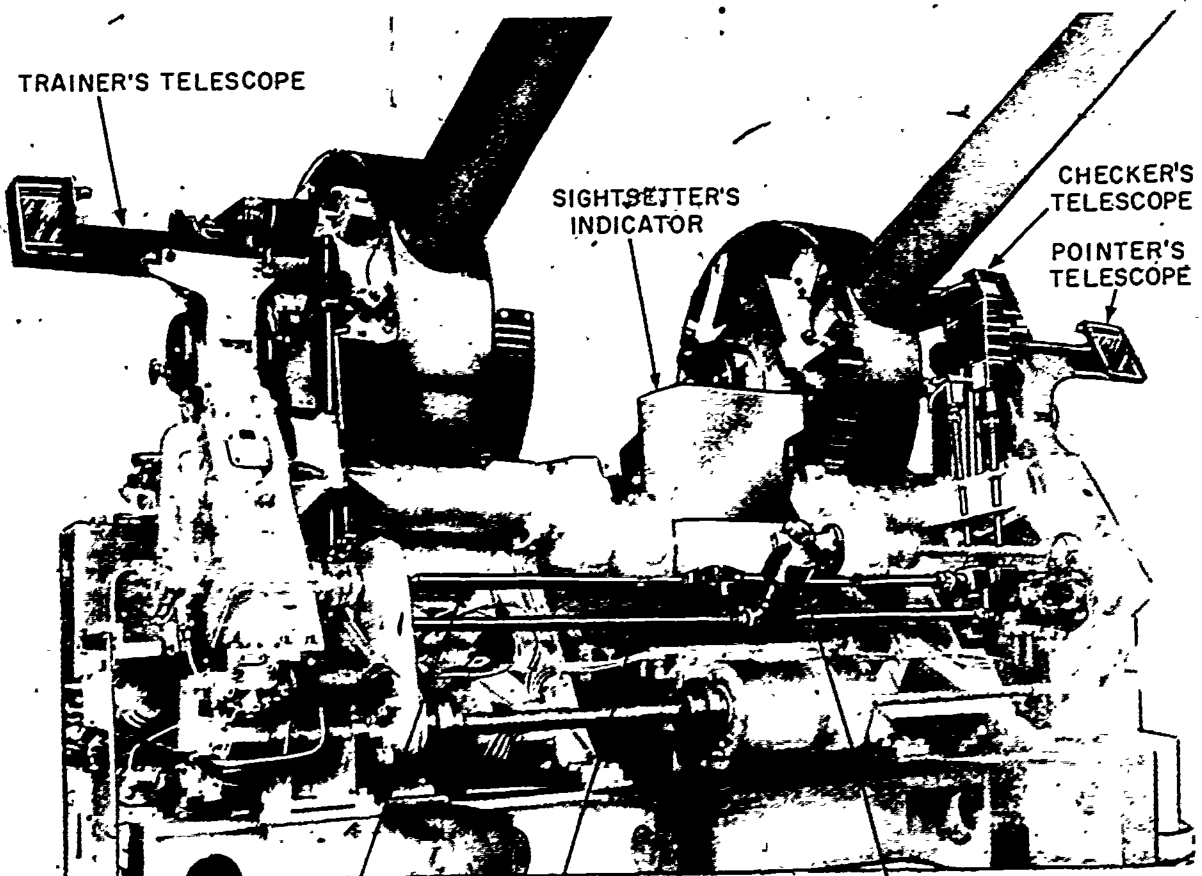
In the stereoscopic rangefinder, the reticle pattern is composed of ranging marks (fig. 13-6A) apparently floating in space at various distances. In operating the rangefinder, the observer turns a knob until the large diamond at the center of the pattern seems to be superimposed upon, and at the same distance as, the target (fig. 13-6B). Then the range can be read directly of a dial in the rangefinder. (The smaller diamonds in the pattern, which seem to float in space at different ranges, are used in spotting).

Fire control equipment for machine gun batteries is designed primarily to provide rapid solutions to the fire control problem. The optical systems need not give powerful magnification but, because of the rapid movement of nearby air targets across the line of sight, they must give wide-angle vision. The radar must be suited to close ranges.

Sights For Larger Guns

In larger and longer range weapons, a rapid solution to the fire control problem is still necessary (a slow solution is never an advantage, more time allows a more exact solution). Approximations that aren't a major disadvantage with lead-computing sights, however, cause serious inaccuracies at longer ranges. Because accuracy is the primary requirement, a more exact FC system is necessary. Computing sights, therefore, are not used; the sights provided merely function to precisely offset the axis of the bore from the line of sight. Under normal conditions, target location (elevation, bearing, and range) is determined by a remotely located station. The fire control problem itself is solved elsewhere, and the gun is positioned in elevation and train by power-driven units under the control of signals transmitted from the point where the fire control problem is solved.

Well, then, why have sights in gun mounts at all?



84.209

Figure 13-4.—Carriage-mounted sights.

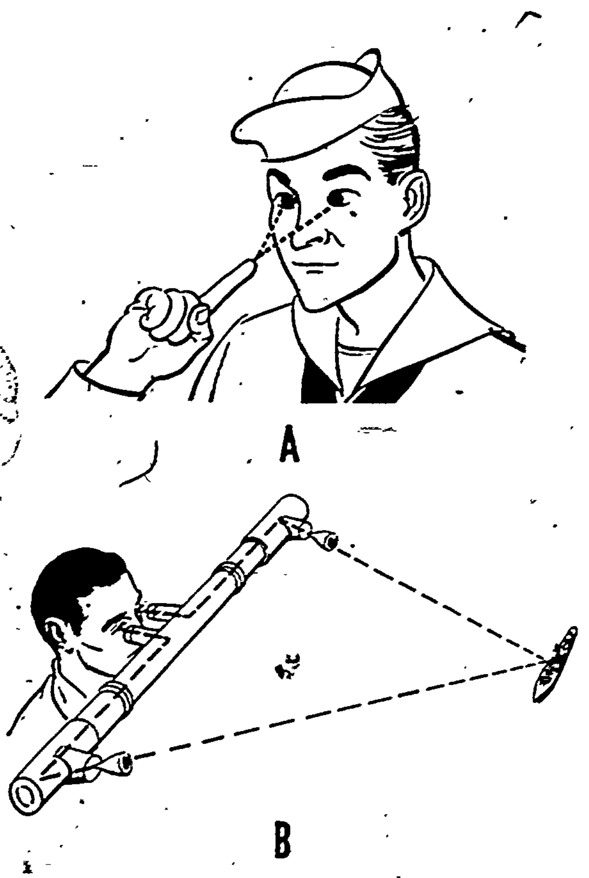
There are two main reasons. One is that the gun mount may not always be controlled in the manner described above because of real or simulated casualty. Another is that watching the target through the sights permits a check on the accuracy and performance of the remote-control system.

Figure 13-7 shows how the sights and sight setting equipment are used in one method of local control.

The pointer and trainer are using their handwheels to keep the target centered in their telescopes. The fire control system computes sight angle and deflection which are transmitted, electrically, to the dials at the sight setter's regulator. As he cranks in this information (by manually matching his dials) gearing moves the prisms in the telescopes. The pointer and trainer see this movement as a shift in target position. As they turn their handwheels to get back on target, the axis of the gun bore is offset from the line of sight by the computed sight angle and deflection.

Another form of local control which utilizes the telescopes within the gun mount was explained in chapter 12 under local control spotting.

Sight angle and deflection are also sent to the sight setter's regulator even when the mount is in full automatic control. In this case, by keeping his dials matched, the sight setter returns the optics from the line of fire back to the target. This enables the check sight observer to see the target area through his telescope. He functions as a safety observer, and can act to stop fire in the event that the gun's fire represents a hazard to friendly forces.



55.289
Figure 13-5.—Principle of the optical rangefinder.

So far in this chapter we have discussed some of the fire control instruments that employ optics. In the next section we explain some of the equipment that make up a gun fire control system. We first explain centralized fire control, how it started, and why it is necessary.

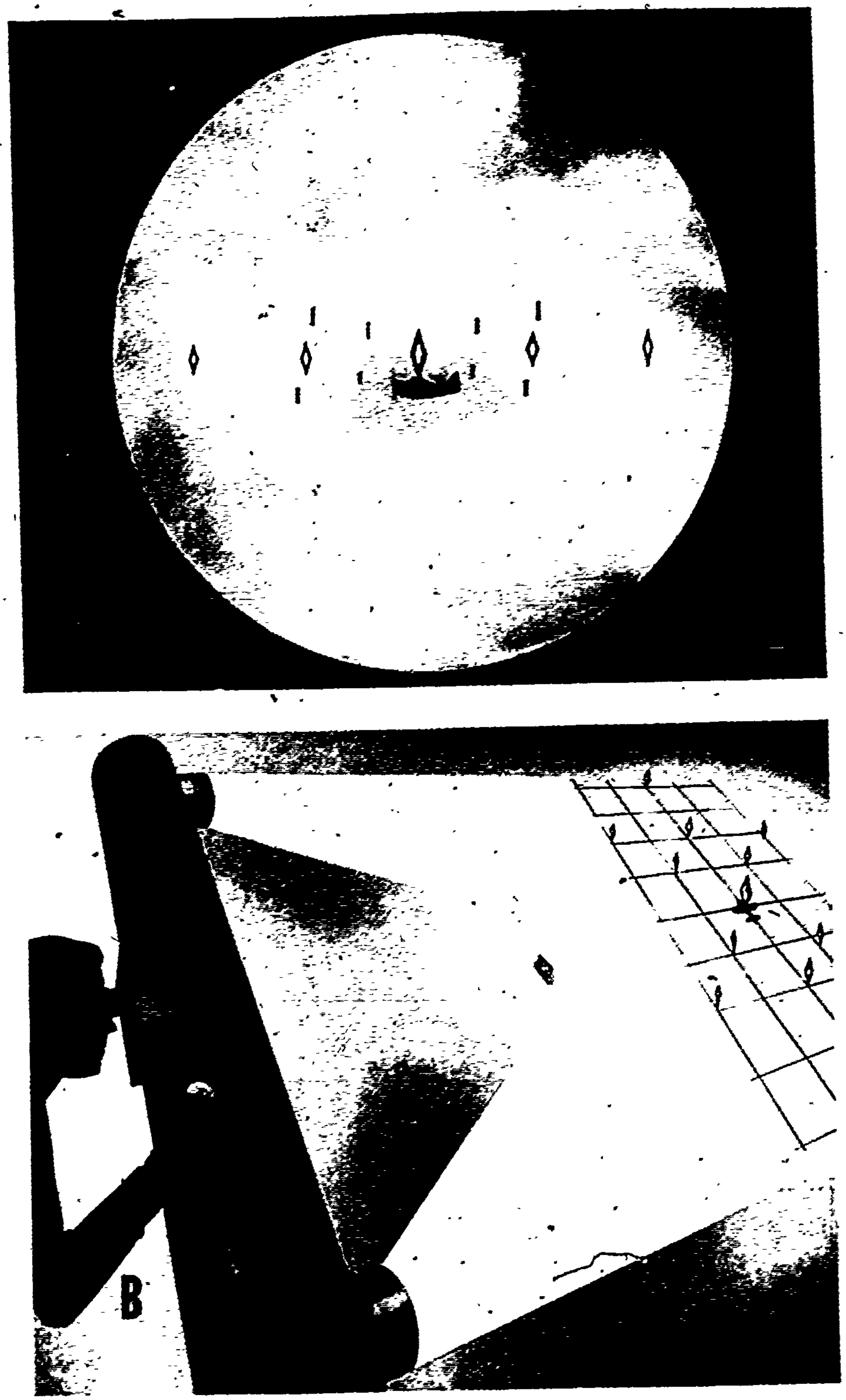
CENTRALIZED FIRE CONTROL

The guns on the Navy's big ships have no monopoly on fire control. The operator of any weapon that throws a missile, whether ashore, afloat, or aloft, uses some kind of fire control technique. But in the Navy, some aspects of fire control have always been under centralized control rather than under the control of the gun crew. Even a hundred and fifty years ago, when our Navy was new and gunnery was primitive and limited to very short ranges, ships mounting sizable batteries ordinarily fired them in salvo, at the order of some officer standing at a point of vantage—in the rigging, for example. And as time has passed and ordnance equipment and fire control techniques have improved, the trend to centralized control has continued so that now not only firing but also the positioning of weapons is controlled from a central point. Yet, this trend has not eliminated control of firing and gun-laying at the mount (local control), although this procedure is now only a secondary method. What advantage is there in centralized control of a warship's guns? What's wrong with letting each gun crew lay and fire its gun independently in local control?

There are several disadvantages to local control. The smoke of their own firing, to say nothing of spray and mist and their position close to the surface of the water, make it difficult for the pointer and trainer of the gun mount to see the target. Each gun crew has to make its own estimates of range, drift, wind, target course and speed, and so on. Some may do this well, but not necessarily all. Some may even fail to identify the enemy, and select the wrong target. Besides, if a number of other weapons are also firing at their target, how can gun crews know if their own shots are hits, or if they're close, or how much or in which direction to apply correction?

Compare this with centralized control, which eliminates all or most of these troubles. The central control point is high in the ship's structure, and has the maximum visibility. Its equipment for identifying and determining the location and movement of the enemy is more efficient and specialized than what you could install in a gun mount, and it is manned by experts in the proper techniques. The guns of each battery or mount or turret can be fired all at once in SALVO, so that the splashes of the projectiles as they hit the surface of the water form a pattern (fig. 13-8). If the target is not in the pattern, the guns can be shifted for more accurate laying. In the gun crew, you can do most of these things too—and in local control you MUST know how to do them—but centralized control makes it possible to do them far more efficiently, as you will see.

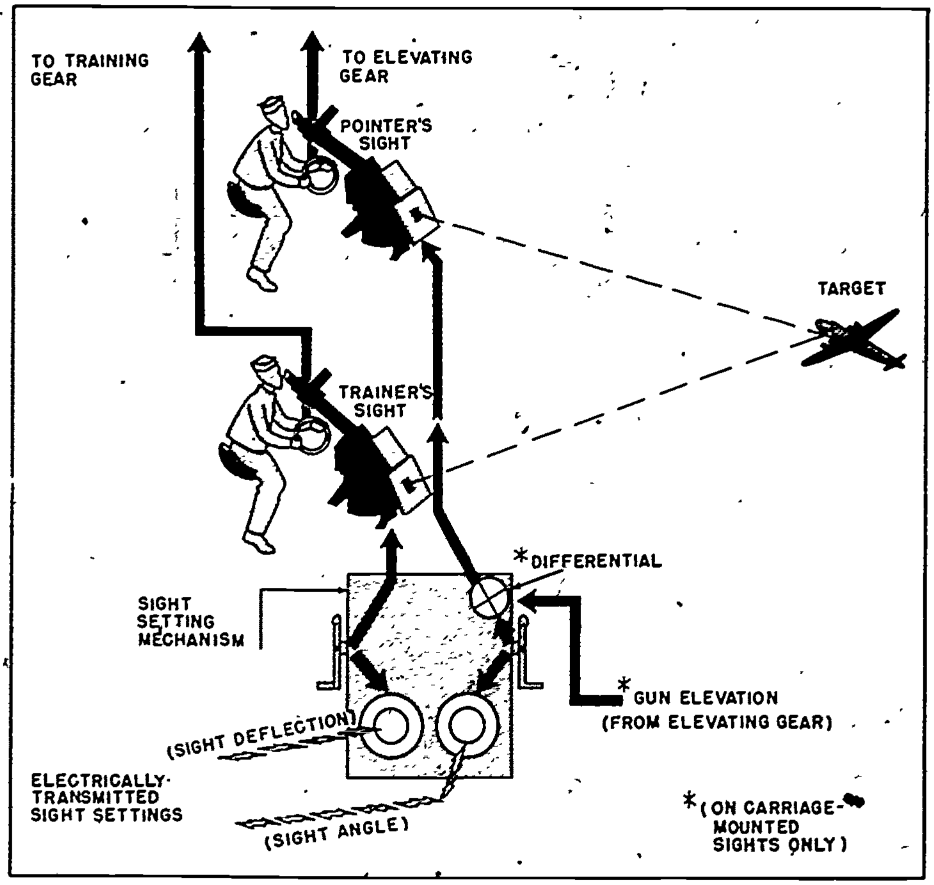
Let's now examine more closely the techniques and equipment used in centralized fire control. Because it's simpler, let's begin with remote control of firing.



84.214

Figure 13-6.—Stereoscopic rangefinder—A. Reticle pattern. B. Measuring range.

462



84.211.1
Figure 13-7.— Functioning of sighting equipment on a typical gun mount (3-inches or larger).

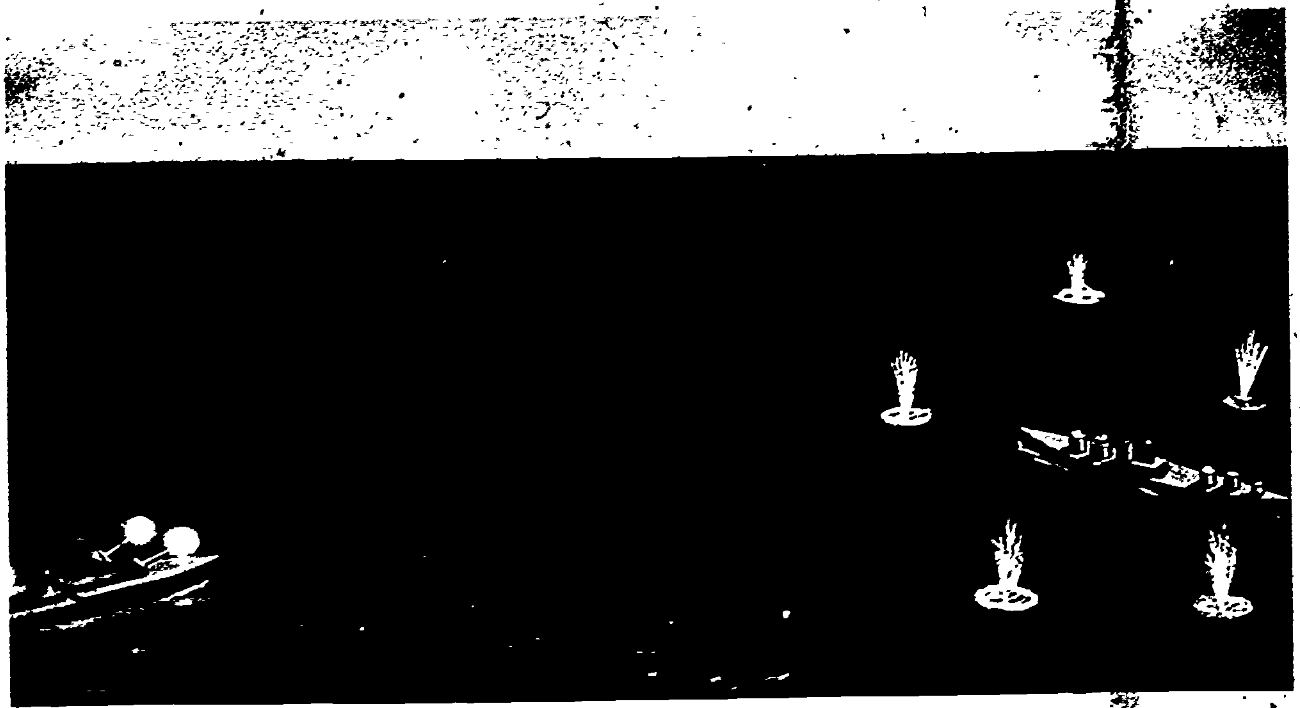
GUNFIRE BY REMOTE CONTROL

In the antique kind of "fire control," an officer gave a firing signal, but each gun was fired by a member of its own crew. Even with today's advanced remote control techniques (except in the 5"/54 Mk 45 mount), a mount or turret crew member (normally the pointer) still has a part to play. If fire is remotely controlled, he closes a firing key which is in the firing circuit. The actual firing impulse originates elsewhere, but it cannot reach his mount or gun unless he closes his key. If firing is in local control, his firing key actually does control fire. So bear in mind, as we discuss remote control firing, that there is always some crew member at the mount or turret who must keep his part of the firing circuit closed in order for the guns to fire.

But let's get back to how remote control of fire developed. In the old days, on small ships with relatively few guns, gunners often could hear their officer shout, "Fire," or at least see him give the signal with his cutlass; but sometimes they could not. On bigger ships, where the command to fire in salvo was relayed down the line, exact synchronization of salvos was impossible.

When effective ranges were relatively short, inaccurate fire was relatively easy to correct, and this failure of all guns to fire in exact synchronism was not serious. But as ranges increased and fire control instruments became more precise, ragged salvos made it hard to determine how well the splash pattern approached the target, because they were not all visible at the same time. What was needed was a signal that could be transmitted to the whole battery

463



53.119.1

Figure 13-8.—Pattern of a salvo about a target.

at once, so that the whole battery could fire simultaneously. The human voice and the waving cutlass were no longer enough.

Electricity provided the answer. First it was buzzer fire. With a buzzer at each gun mount, closing a circuit at a central point caused all the buzzers to sound at once, and all guns could be fired by a single signal.

Yet this was not the final answer. As you know, most guns of the old days were fired by igniting a powder train which led into the propelling charge in the breech. A little later, firing was done by a percussion mechanism to ignite the powder train. Either way, there was some delay and variation in the actual instant of firing. Besides, there were the delay and variation in reaction time of individual members of the gun crews. Buzzers improved matters, but these difficulties persisted. That is why, though the buzzer type salvo signal is still used, it's a secondary method.

The primary method of firing by remote control is to close a circuit which itself sets off the propelling charge. This is master key fire. In master key fire, when the guns in a mount are ready to fire, the mount pointer closes his firing key. When the firing keys in all mounts are closed and the proper moment arrives, the master key is closed and all guns fire at once.

GUN LAYING BY REMOTE CONTROL

Remote control of gunfire, valuable as it is, is not the final word in centralized control of armament. For maximum effectiveness, gun laying must be remotely controlled too. The steps in the process are as follows:

1. Determination of target position and movement.
2. Transmission of this information to a computer, which works out how the guns must be layed for hits on the target.
3. Transmission of gun laying information (called gun orders) to the gun mounts.
4. Control of the gun mounts to lay the guns in accordance with the gun orders from the computer.
5. Correction of gun position on the basis of observed effects of fire, (spotting).

TYPES AND METHODS OF GUNFIRE

The firing impulse can get to the guns in the mount or the battery in a number of different ways. We can recognize several methods of fire, or ways in which the firing signal or impulse gets to the guns. In pointer fire, it's done by the pointer at the gun itself, generally by closing a key that sends an electric current into the gunfiring circuit (electrical firing), or by stepping on a pedal that operates a firing pin in the gun (percussion firing).

Master key firing is handled from a control station at some distance from the gun fired, either by somebody operating a key or button, or automatically by a mechanism that closes the firing circuit whenever the ship, as it rolls and pitches, reaches a certain angle.

We also recognize several types of fire (the way in which the firing of one or a number of guns is arranged).

A salvo is the firing of one or more guns simultaneously on the same signal, at the same target. Salvos are normally fired at regular intervals, spaced so as to permit reloading and (where necessary), relaying the guns. Salvos may be fired by entire batteries, or by individual mounts or turrets.

To conserve ammunition, reduce the intervals between salvos, or speed up the process of spotting, partial salvos or split salvos may be fired.

The split salvo is firing fewer than the full number of guns in a mount or turret. Three turrets may participate in a split salvo, for example, if only one gun in each turret fires. In the partial salvo, all the guns in a turret or mount fire at once, but not all the turrets or mounts in the battery participate (for example, when No. 1 turret of a 3-turret battery fires all of its guns, while the rest of the battery remains silent).

Batteries do not always have to fire in salvo. In continuous fire, each gun in action fires individually when ready, regardless of whether other guns are ready.

There are other types of gun fire such as slow fire, rapid fire etc. These methods were explained in chapter 12.

GUN FIRE CONTROL SYSTEMS

The techniques used to solve the gun fire control problem by a specific fire control system is specialized within certain limits dictated by the primary use of that system. There are three broad classes of gun fire control systems:

1. Surface systems, used against either surface targets (ships) or shore targets.
2. Dual-purpose systems, used against either surface targets, shore based targets or AA targets (aircraft).
3. Antiaircraft (AA) system, used against AA targets only.

A surface gun fire control system, which is designed primarily for surface fire or shore bombardment, could be used against aircraft that are within the elevation limits of the turret guns, but such action requires corrections or interconnections with a dual-purpose fire control system to obtain additional target elevation corrections which are not necessary for the system's normal operation.

TYPES OF FIRE CONTROL

A ship's weapon system can be operated in several different ways by employing specific fire control equipment for each type of gunfire necessary to damage or destroy an enemy target. This flexibility permits gunfire to be maintained in the event of a casualty and also makes it possible for one battery to fire simultaneously at different types of targets.

The different types of fire control are distinguished by the source and transmission route of the gun orders and are classified as to type by the system they employ. For each type of fire control the ship's weapon doctrine specifies the fire control instruments to be employed. Types of control are listed as follows:

1. Primary fire control prescribes the utilization of the principal system. This is the system provided to control before damage occurs to this system.
2. Secondary fire control prescribes the utilization of an alternate system to give greater flexibility of control.
3. Auxiliary fire control prescribes the utilization of a system provided solely to substitute for a primary system in case of damage.
4. Local fire control provides for the control of a single gun mount or turret from a local station in or adjacent to the mount or turret.

In primary, secondary, and auxiliary fire control, mounts and turrets can be operated in the automatic mode of operation whereas in local control all gun laying must be accomplished individually.

In any fire control system, detecting a target is the start of the fire control problem. In the next section we discuss fire control techniques and introduce various fire control equipment and explain their functions. The first step is detection.

SEARCH RADAR AND IFF

Aboard ship, radar equipment has two general applications—for search and for fire control. Search radar displays are centered in CIC. Although we are primarily concerned with fire control radar, you must understand the target detection and acquisition process in order to know something about search radar. The three types most commonly used in surface ships are air search, height-finding search, and surface search.

An air search radar's primary function is warning of the presence of aircraft at extreme ranges. It is called a two-coordinate radar since it measures only range and bearing.

Height-finding radars are three-coordinate radars. They are capable of discriminating between targets that are close together, and they are capable of measuring range, bearing, and altitude. The altitude quantity is converted in the weapon direction system to an angle of elevation for use in directing fire control directors to the target. Three-coordinate radars eliminate the need for large sector searching in elevation by the fire control directors, thereby decreasing their target acquisition time.

Surface search radars measure the range and bearing of surface contacts to assist in navigating the ship or to send surface target information to the weapon direction system. They are also effective in detecting low flying aircraft since their radar energy is concentrated at low angles of elevation. In search radar units, any target smaller than a geographical feature has no discernible shape. On a radarscope the target presentation is in the form of a blip, not a true picture. This is especially true of aircraft targets. When aircraft come within search radar range, there is nothing in the blips to indicate whether they are friendly or enemy. To deal with this problem we have a system called Identification Friend or Foe (IFF). The IFF equipment aboard ship functions in conjunction with a search radar, but the IFF system also includes equipment aboard the aircraft. The radar beam from the interrogating ship "triggers" automatically the IFF equipment on the friendly target. The latter then transmits a coded signal which shows up on the interrogating ship. The interrogating ship and the target must carry matching IFF equipment. For security, we use coded signals.

FIRE CONTROL DIRECTOR

Remote control of gun laying begins, as we have seen, with locating the target and determining the rate and direction of its movement. In the preceding chapter you learned that target position is determined in terms of range, target bearing, and (for air targets) target elevation. Similarly, target movement is determined in terms of the rate of change of these three kinds of information.

In the modern fire control system the function of determining target location and movement is performed by a director. For the moment, you won't be too far off base if you think of a director as a "gun sight without gun" whose position in train and elevation with respect to the ship can be accurately determined. When it's on the target, it establishes the line of sight to the target. The director also is fitted with transmitters which can convey signals corresponding to its position to the other parts of the fire control system.

Those are the essentials of the director. All directors have them. The gun fire control director is designed to control turrets used against surface targets and dual purpose guns used against either air or surface targets. It's primary function is to determine target position in terms of:

1. Director Train (B' r). The angle between the fore-and-aft axis and the vertical plane containing the line of sight, measured in the deck plane, clockwise from the bow.
2. Director Elevation (Eb). The elevation of the director's line of sight above the reference plane, measured in the vertical plane containing the line of sight.
3. Present Range (R). The distance of the target from own ship, measured in the line of sight.

Briefly, the director's secondary function is to be the control station for the entire fire control system. Normally, all units operate by remote control from the director. As long as the problem is being solved correctly, only the gun-loading crews have work to do. When changes in the problem setup are necessary, the director crew can accomplish them by remote control. To control the entire system, the director is equipped to:

a. Spot service projectile fire
b. Spot illuminating projectile (star-shell) fire
c. Correct computer calculations.

NOTE: The fire control symbols used in this chapter are meaningful symbols in the fire control world. Refer to OP 1700, Standard Fire Control Symbols for an explanation of the symbols used in fire control.

Director Radar

The director radar is the eye of the gun fire control system. It can search for, detect, acquire, and track a target. It receives target designation data from the weapon direction equipment and uses this information to acquire and track a designated target. The radar set tracks the target to solve the gun fire control problem. Director radar can operate as a search radar if circumstances require. Weapons direction equipment receive their information from search radar. Search radar displays are centered in combat information center (CIC).

STABLE ELEMENT

In chapter 12 we discussed the effects of roll and pitch on the fire control problem. Let us briefly review the subject before going on to discuss the instrument that compensates for roll and pitch.

Look at figure 12-18, you see a ship upon the sea; it pitches and rolls in a complex motion with the surface movement of the water. If you consider these movements as related to the line of sight of a director, you can divide them into two components, level and crosslevel. Level is that line in the same direction as the line of sight, crosslevel is that line at right angles to or across the line of sight.

In all our previous discussions, we generally have neglected these continuous changes in level and crosslevel. At short ranges and with fast-moving targets like aircraft, they are relatively unimportant, which is why they can be neglected. But in the Mk 37 system and others that deal with longer ranges, they must be taken into account.

It's impossible to stop the movements of the sea. It's not practical to stabilize a warship's hull so that it won't pitch and roll. But we can get the fire control system to deal with the problem by adding level and crosslevel movements as corrections to the solution of the problem. First, the exact amount of these changes with respect to the horizontal must be determined. Two ways have been used to determine them.

One is to sight on the horizon. A line of sight to the horizon is depressed very slightly below a true horizontal plane. The amount of depression depends on the height of the observer above the water, and is known with great precision, so the correction needed to put the line of sight into a horizontal plane is easy to add. In the Mk 34 director there is a special telescope for sighting on the horizon for the crosslevel correction.

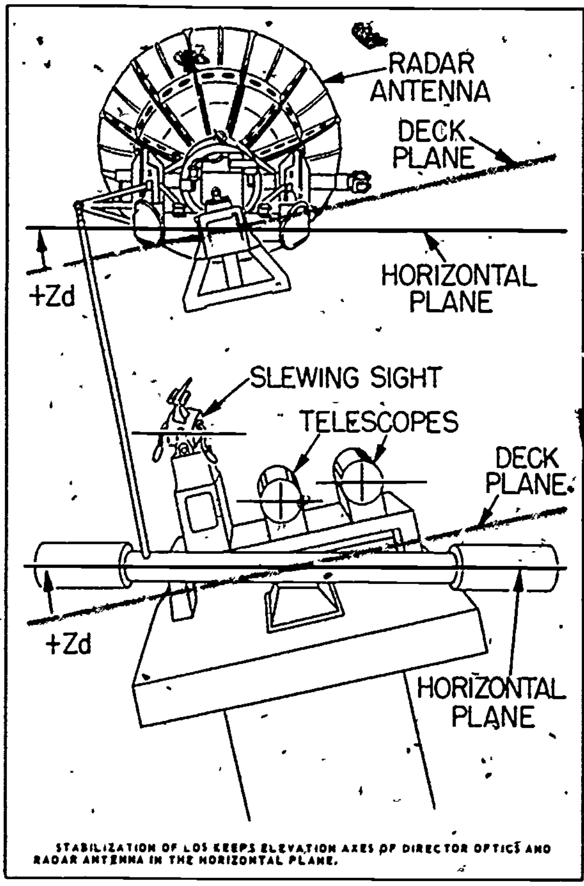
But sighting on the horizon is a secondary method for determining a horizontal plane. The primary one is to use a gyroscopic device—the stable element. (Main-battery fire control systems use a stable vertical, which is similar in principle but different in detail). In the stable element the gyro remains erect to define the vertical (and hence the horizontal) plane, and the level and crosslevel angles are "picked off" from it by electromagnetic units. Of course, the level and crosslevel angles are measured with respect to a line of sight on a specific bearing, so target bearing is an input to the stable element, and its outputs are level and crosslevel.

Director optics and radar antenna are stabilized both in level (L) and crosslevel (Zd). Crosslevel stabilization is done by a servo-controlled crosslevel synchro signal, received directly from the stable element (fig. 13-9). A crosslevel drive rotates the telescope, the whole rangefinder, and the radar antenna about the line of sight by Zd. Thus, the telescope crosshairs, the rangefinder, and the radar antenna are kept horizontal so that director elevation is measured in the vertical plane.

There are two general methods of using the level and crosslevel angle values. With the synchro system, these values can be used to keep the guns layed continuously to land shots on target (for continuous fire). The ship may roll, pitch, yaw, and weave around but the guns will remain fixed in their attitude, except to allow for movement of the target, and can be fired at any time.

Or, when roll and pitch are extremely heavy, making it difficult especially for the larger guns to stay on target, a certain selected value of level or crosslevel is cranked into the stable element. The guns are fired automatically by the stable element or the leveler in the director when, as the ship rolls or pitches, the actual gun elevation momentarily agrees with the selected value (selected level fire or selected crosslevel fire).

The stable element is a vital adjunct of the computer. In most gun fire control systems these

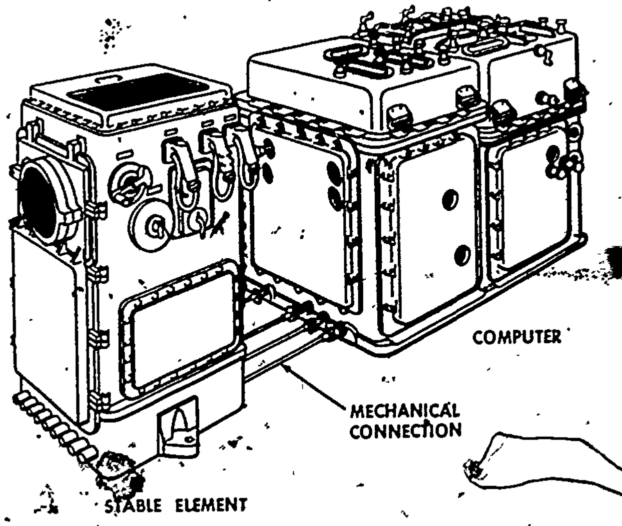


55.243(110A)
Figure 13-9.—Crosslevel stabilization.

two units rely on mechanical connections only (fig. 13-10). Most other units of a fire control system are linked by electrical transmission lines or synchros.

THE COMPUTER

Actually, we cannot say much about the workings of a computer, it is beyond the scope of this course. Think of it as a big box (fig. 13-10) with dials and cranks with a series of small mechanical adding machines inside. Some computers operate from electronic components; the type shown in figure 13-10 is classified as an electromechanical computer and is used in the Mk 37 fire control system. From certain input information the computer computes a continuous solution to the fire control problem, and functions to:



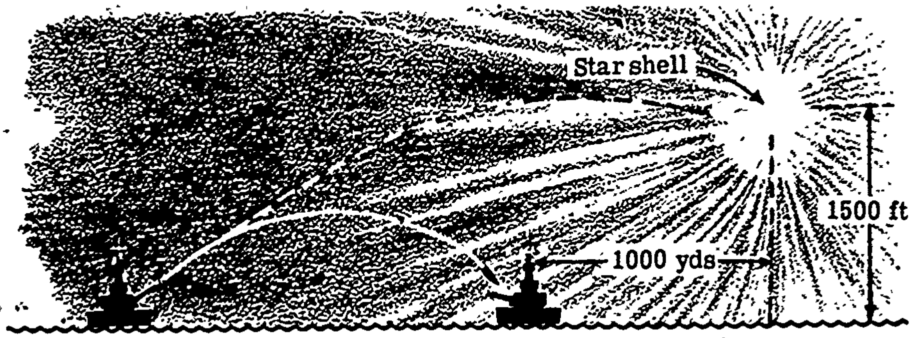
53.105
Figure 13-10.—Mk 37 fire control system: Stable element and computer.

1. Control positioning of turrets and dual purpose guns and transmit fuze settings and gun sight information for either surface or AA fire.
2. Aid the director crew in keeping the LOS on target.
3. Permits the star shell computer, an independent accessory, part of a dual-purpose battery to be set continuously for illumination of a surface target while firing other mounts at the target.

With star shell computer, it is possible to direct one mount for maximum effectiveness in firing illuminating projectiles (star shells). Star shells must be aimed, and time fuzed to burst above and beyond a surface target as shown in figure 13-11. This type of illumination silhouettes the target so that the director control officer can identify it and spot destructive fire. This computer makes such fire possible by controlling some mounts for illumination purposes and others under control of the main computer for destructive fire.

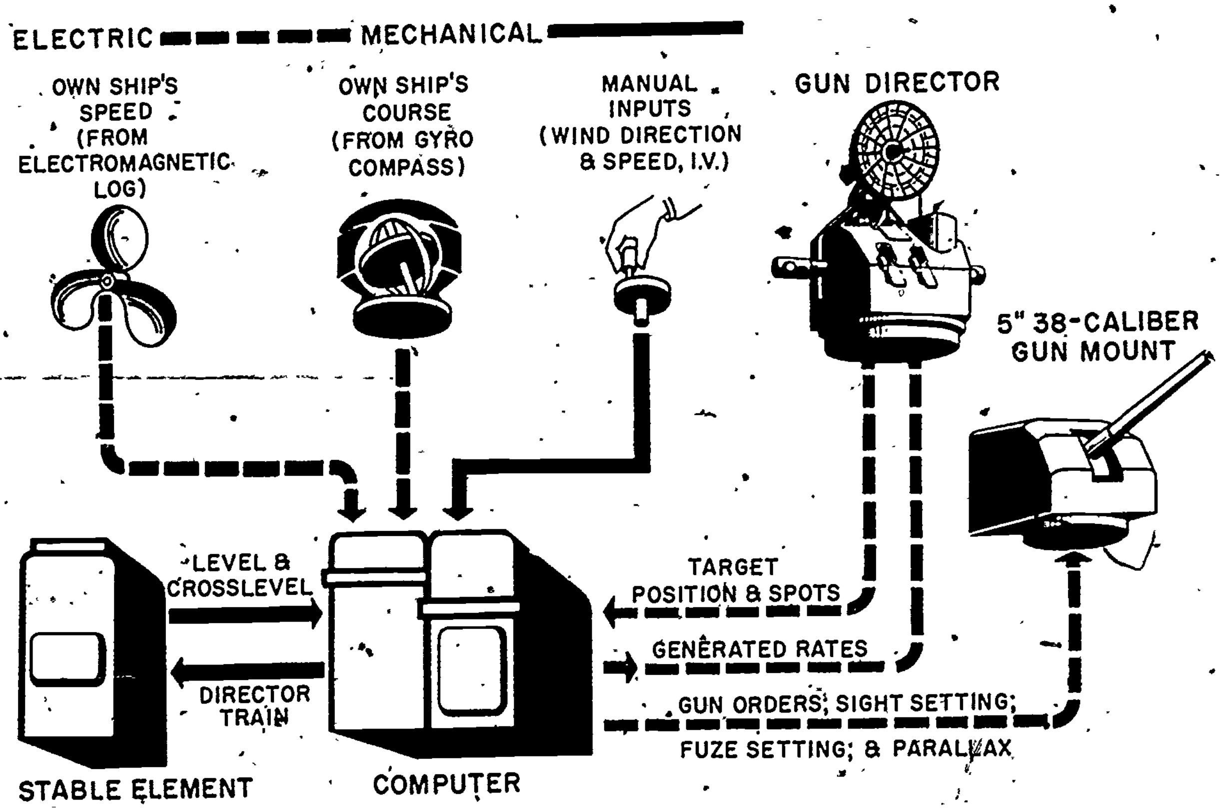
DATA FLOW

To help you visualize the system in operation, look at figure 13-12, which shows you the flow of all data and positioning orders.



92.19

Figure 13-11.—Star shell shoot.



53.114

Figure 13-12.—Data flow in Mk 37 system.

The computer is at the heart of the system. From the director, target elevation, target bearing, and range and spotting data (corrections based on observation of gunfire) go into the computer. The electromagnetic log and gyrocompass supply own ship course and speed. Some factors, like target course and speed, may be telephoned from the director and cranked into the computer by its crew. Other factors cranked in are wind data and initial velocity (I.V.). At the right of the computer you see its output to the gun mount: gun orders (elevation and train), fuze setting, sight setting, and unit director train into the stable element, which determines level and crosslevel angle, sending these values back to the computer.

Note also the line from computer to director, labeled GENERATED RATES. These rates include generated elevation, generated train, and generated range. "Generated" means that the computer has worked these values out, as against "observed" values, which are what the director crew actually read off their dials. What is meant here is simply that the computer, having worked out a solution to the fire control problem, sends it aloft to drive the director. If the solution is correct, the director tracks the target on its own, and its crew does not have to crank it unless it goes off target.

Corrections for drift, air density, and some other factors are normally made by cams inside the computer, and therefore do not show in the diagram.

That in a nutshell, gives you the essentials of a modern dual-purpose fire control system.

TRANSMITTING INFORMATION ELECTRICALLY

Thanks to the synchro, transmission system units of a gun fire control system need not be close together. Information is passed from one unit to another by means of synchros and servosystems. In chapters 7 and 8 you learned the principles of synchros and servosystems and how they fit into the ordnance field. Accuracy of a ship's weapon system depends upon the correct operation of a synchrosystem. Since most units of a gun fire control system are widely separated, the synchro becomes the controlling unit as well as the controlled unit. The word synchro (synchronous) means happening at the same time, the only delay from the remote controlling station and the weapon under control is the time it takes an electrical signal to travel from one station to another.

A point to remember is that Navy weapons controlled from remote stations must use synchrosystems for their control. We remember from chapter 7 that the most important advantage of synchros over mechanical gearing is their flexibility. Wires connecting one station to another can easily lead around an obstacle in its path without resorting to mechanical linkages or shafts.

Each unit of a gun fire control system uses some type of servosystem for their control. To explain the operation of any one fire control unit servosystem is beyond the scope of this chapter.

FUZE SETTERS

As you know, many projectiles are fitted with time fuzes. These must, before they are fired, be set to explode at the right time. This is done by the fuze setter, which is a part of all fire control systems designed for batteries 5-inch and larger.

The fuze setting is transmitted by synchro to the fuze setter at the gun mount. This may be located at any of several places. For example, some mounts and turrets have a fuze setter in the projectile hoist. It may be in the gun slide. Or it may be a separate unit containing three fuze-setting pots, mounted on the gun carriage behind the pointer. All types are controlled by fuze-setting indicator-regulators (fig. 13-13).

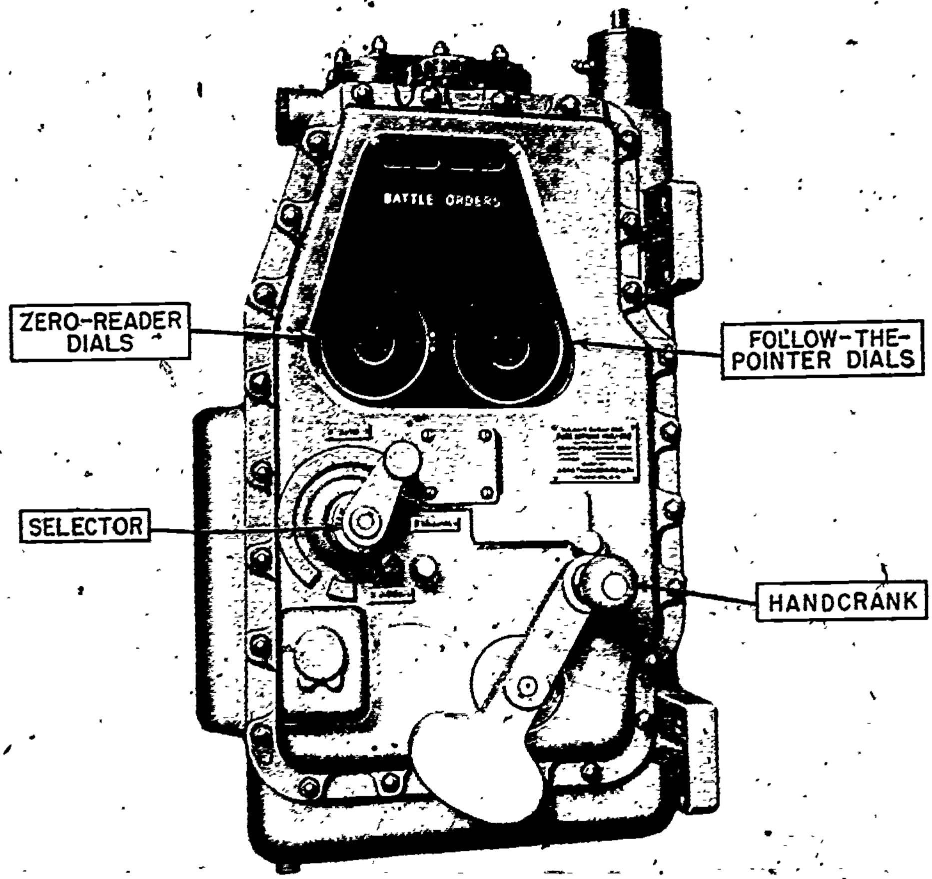
Each fuze-setting indicator-regulator can provide automatic or manual fuze setting. Manual control is governed either by matching dials, or by positioning them at the required setting. The instrument is normally set by remote control from the computer.

The selector sets up the indicator-regulator either for automatic or manual control. The handcrank is linked to the fuze-setting mechanism only when the selector is set for manual. You then crank to match the dials, or to position them as required.

The zero reader dials and the follow-the-pointer dials are coarse and fine reading respectively. The innder dial of each group is attached to its corresponding synchro shaft, and bears a single index mark. Each ring-dial graduation represents one second on the zero-reader and .02 second in the follow-the-pointer dial.

MOUNTS AND TURRETS

The computer solves the fire control problem and computes continuous information for the gun mount or turret in the form of gun orders. These orders are sent to indicator receiver regulators at each gun mount or turret to provide correct information so that the weapon can be positioned to hit the target for surface action and to explode at a predicted position for AA target. The order signals are received by the gun station's position



4.192

Figure 13-13.—Fuze-setting indicator-regulator.

synchros, which in turn control the power drive servosystem. Power drive fundamentals were explained in chapter 8.

COMPONENT LOCATION

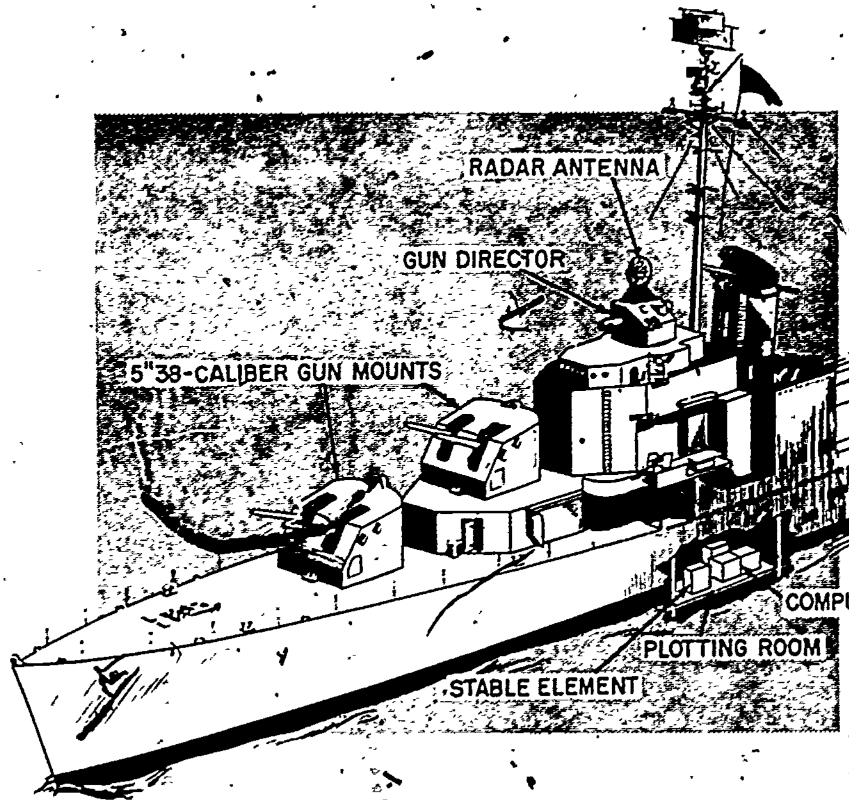
The location of the components of a gun fire control system are shown in figure 13-14. Most of the destroyers and auxiliaries have just one gun fire control system, however, some of them have two systems, and smaller auxiliaries have none. Larger ships such as battleships, carriers, and cruisers have two or more systems.

Directors are installed high in the ship's structure, while stable elements and computers are installed below decks in protected plotting rooms. All elements are connected by a synchro transmission system, and are tied into this transmission system at one or more switchboards located in the plotting rooms.

Normally, each director in a multiple installation controls a designated group of guns and is connected to a designated computer. However, switching arrangements permit any director to control any or all guns and to connect to any computer.

The flexibility of a ship's weapon system also depends upon successful communications between widely separated units of a gun fire control system. In spite of casualties to both men and equipment some type of communications must be maintained. Communications can be transmitted in many different ways. Voice and other audible communications are the primary methods, but visible signals can be employed if other methods fail.

471



84.216

Figure 13-14.—Mk 37 system, destroyer installation.

COMMUNICATIONS

As you already know from your study of Basic Military Requirements, a ship's battle communication system is built around the sound-powered telephone — a phone powered by the sound of the user's voice.

Sound-powered telephones are part of the interior communication (IC) system. Also included in the IC circuits are synchros and relays that position dials and other devices that transmit orders or otherwise control units of the weapons systems. Because synchros and relays have been discussed earlier, however, we say no more about them here. Therefore in this section we will discuss the organization and use in weapon control of the ship's sound-powered telephone system.

Battle (sound-powered) telephones are set up as groups (circuits) of connected stations, rather than as individual stations. When you plug in, you are automatically connected with all the other manned stations on your circuit. Circuits are in turn organized into systems. The three systems of battle telephone circuits are the primary, the auxiliary, and the supplementary.

Primary circuits are the main channels of communication for controlling armament and maneuvering the ship. Primary circuit symbols consist of a number, two letters, and another number — for example, 2JQ3. Let's briefly take up the elements of the symbols. The first number indicates the battery, as follows:

1—Surface battery circuits
2—Dual-purpose battery circuits
3—Heavy machine gun circuits

The letter indicates the function of the circuit:

JB—Spotters
JC—Control
JK—Fuze setters
JN—Illumination control
JP—Group control
JQ—Sight setters
JW—Range control

473

The last number in the symbol indicates the corresponding group, mount, or turret number. Circuit 2JQ3, for example, is the sight setters' circuit for group 3 in the dual-purpose battery.

All primary circuits for the ship's armament can be interconnected on switchboards in the plotting rooms, as well as by other control switches. (By and large, the other sound-powered phone circuits have no switchboards, though some interconnecting can be done by control switches at various stations). These facilities are important for tying circuits together, for transferring control from one point to another, for providing emergency communications, and for isolating circuits or individual stations (in case of casualty, for example). You're not concerned with how the switchboards are operated—that's up to the crew at the switchboard.

The auxiliary battle telephone system is a standby which parallels the more important primary circuits and is intended for use in case of casualty to them. It has no switchboards. Each auxiliary circuit is designated by the letter X, followed by the symbol of the circuit for which it is a substitute. Thus, the surface battery control auxiliary circuit is given the symbol X1JC. Since the auxiliary circuit is not continuously manned like the primary, it is generally equipped with handsets rather than headsets.

Supplementary circuits are those not important enough to be in the primary system. They are identified by X (numbers) J. In turrets, the first digit corresponds to the number of the turret—for example, turret 2 would have circuit numbered X201J, X202J, and so on.

In mounts and turrets, supplementary circuits are mostly concerned with the ammunition supply system. Thus, in enclosed twin mounts, X17J connects the top and bottom of the lower ammunition hoist. Turrets have more supplementary circuits. The Salem class 8-inch turret, for example, has nine, one of them connecting the turret officer with gun positioning and sight-setting stations, and with the safety watch; others interconnecting the ammunition supply system with the gun captains and turret officer.

Supplementary battle telephone circuits have no switchboards, but at gun captains' and mount captains' stations are switches that can interconnect different supplementary circuits, or tie them in with primary control circuits.

NOTE:

1. The crewman assigned to a phone station is the one primarily responsible for seeing that his phones are at the station and in working order. It's up to him to see that defective phones are turned in to I. C. electrician's shop for repair.

2. When on the job as gun or mount captain, the entire gun or mount is your responsibility. A lot depends on how your men handle their phones, how they talk into them, and how well they maintain circuit discipline. And, in turn, their efficiency at the phones is influenced by the example you set for them. The best way to keep them on the ball is to stay on the ball yourself.

ANNOUNCING SYSTEMS

The shipboard announcing system is a network of public address systems made up of MC circuits. They are electrically powered, with transmitters (microphones) and reproducers (loudspeakers) spotted throughout the ship. The major system for the ship as a whole is the 1MC. This general announcing system is used by the OOD. to pass orders and information, and to transmit the general alarm and chemical attack signals.

Those announcing systems of special interest to you as a Gunner's Mate are the 17 MC on dual-purpose enclosed mounts, and the 11 MC—13MC in turrets. The 17 MC provides the Mk 37 director officers amplified voice communications to their 5-inch mounts. New construction and modernized vessels do not have the 17MC, and the system will gradually disappear from the fleet. The turret MC systems are controlled by the turret officer in each turret. The systems transmit the turret officers' orders to strategically placed loudspeakers.

Both mount and turret announcing systems can be tied in with the general announcing system 1MC. Three-inch and smaller mounts are not served by an MC system other than the 1MC.

AUDIBLE SIGNAL SYSTEMS

Besides these voice communication systems, modern naval ships are equipped with several systems of audible signals.

1. United States Navy Safety Regulations require that before any turret or enclosed mount is moved in train, a warning signal must be sounded on the train warning signal circuit (TW), except during GQ. The TW circuit is independent of all other IC circuits. It consists of either a pushbutton control switch, or a manual switch,

wiring, power supply, and bells outside the turret or mount.

2. The call signal system (circuit E) parallels supplementary battle telephone circuits and voice tubes. It consists of interconnected power-supply units or magnetos, selector switches, and buzzers or bells.

3. The order to cease fire is normally given by sounding a claxon. Cease-fire signal circuits are:

Main battery	1U
Dual-purpose battery	2U
Heavy machine gun battery	4U
Light machine gun battery	5U
Rocket battery	9U
Sector control	45U

The (45U) circuit is a combination of 4U and 5U, but the armament is divided into groups by sectors rather than by sizes of weapon. Thus all AA fire from both heavy and light machine guns in any sector can be controlled by one station. This circuit can also be interconnected with the headsets of the gun crews, so that they hear the cease-fire in their phones as well as on reproducers at the mounts. Dual-purpose mounts hear it through the 17MC system.

4. The salvo signal is a loud buzz. In secondary-battery mounts it is transmitted by the 17MC system. In turrets, salvo signal buzzers are installed on the gun deck level.

5. The intraturret emergency alarm is an independent circuit used to warn of danger or serious casualty in the turret. It consists of a number of small electric sirens that can be put into operation from any of several stations in the turret. The turret officer's booth has a switch for silencing the sirens.

FIRE CONTROL SYSTEM MK68

Gun Fire Control System Mk 68 is an elaborate, sophisticated, and complex system designed to control 5"/54 and 3"/50 guns, and to be entirely automatic during the acquisition, tracking, and firing phase of an engagement. Variations from full automatic are possible to meet certain tactical situations and emergencies. These modes of operation will be discussed later. Also various modes are developed to meet these tactical situations. This may cause some variance in the system described here, and in the one in which you are assigned. For this reason, system OPs should always be consulted for maintenance problems.

Basically, GFCS Mk 68 performs the same functions as GFCS Mk 37 except that it has supersonic target speed capabilities. At first glance it appears much more complicated, as there are over 500 dials, handcranks, indicator lights, and similar operating control. Most of these, however, are for checks and test purposes and for placing the system in standby position. In actuality it is designed to operate very simply, and with fewer personnel than the Mk 37. Testing and maintenance have also been simplified through plug-in module design, built-in testers, and test panels. Figure 13-15 shows a typical Mk 68 system layout aboard a DLG.

From the standby condition, if there is an accurate target designation (TD), it is only necessary to press the TD button on the director officer's control panel to start operation. The director then slews to the designated target position. As the director comes "On Target", the radar automatic tracker takes over and keeps the director on target and starts the computer. Indicators at the director officer's control panel and at the radar console light to show that the computer has started. Firing can commence as soon as a solution is reached (depending on which time-constant change gears are being used), and either the director officer, tracker, or plot firing key is closed. The director officer selects the mode of operation and at any time can acquire control from any other station. Modes of operation are:

1. Auto-track
2. Console
3. Director officer's control
4. Tracker's control
5. Handwheel
6. Local control (indirect fire)

Auto track is the preferred mode.

SYSTEMS COMPONENTS

Systems components and primary data flow are shown in figure 13-16. These components will be discussed separately as to their function in the system. As you can imagine, a detailed functional description cannot be given in this text. Coverage will have to be limited to a block diagram description of system function and operation. Symbols used to describe fire control functions will be those found in the system OPs, which may differ from those used in other systems.

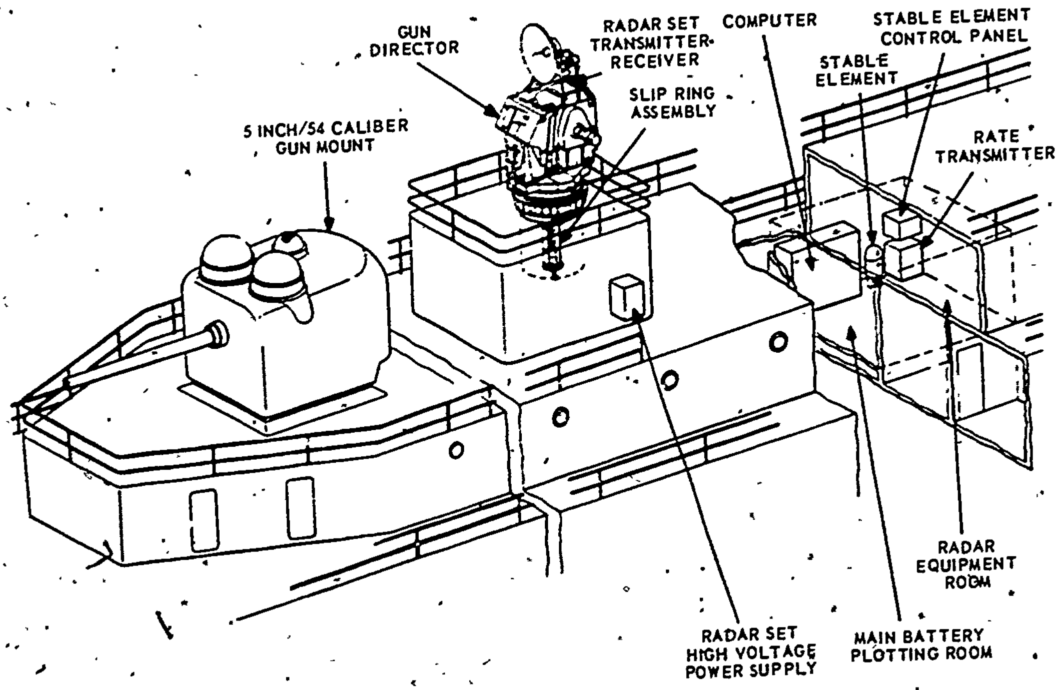


Figure 13-15.—Arrangement of GFCS Mk 68.

DIRECTOR MK 68

The gun director (fig. 13-17) is an amplidyne-controlled, power-driven, three-axis unit positioned in train, elevation, and cross-level in response to various order signals. The director as a unit is positioned in train and stabilized in cross-level. Only the rangefinder, telescope, binocular mount, and radar antenna are positioned in elevation. The three stations of the director operating personnel are enclosed within a blast-resistant shield.

The director is equipped with a telescope and a rangefinder for optical tracking, and is designed for various other methods of control for tracking in range, bearing, and elevation. This provides the flexibility required for effective director operation under varied conditions.

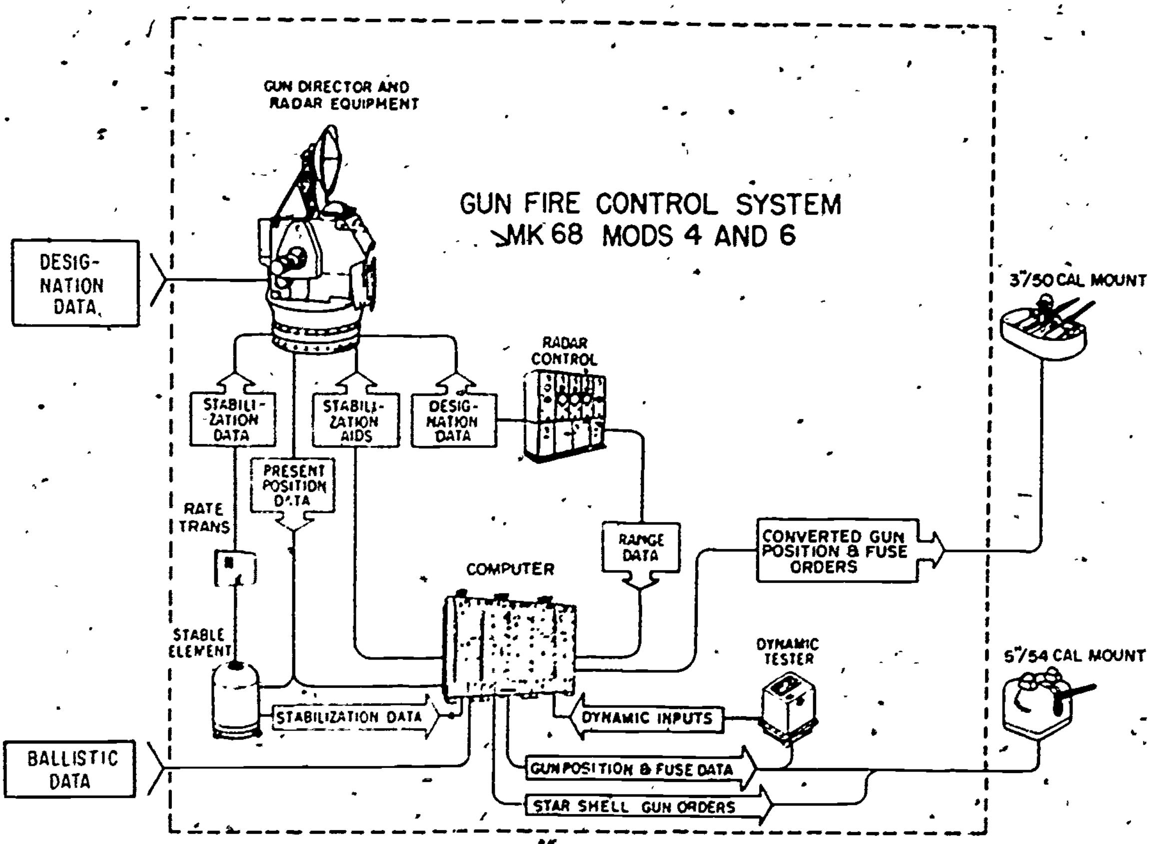
The director normally tracks a target under automatic radar control. Alternate methods of control include power operation by means of handwheel or one-man control units, and computer control with regenerative aiding.

The director is provided with heating, anti-icing, and defrosting equipment so that it can be operated effectively under widely varying climatic conditions.

TRAIN MOVEMENT.—The telescope, open sight, rangefinder, and radar antenna mount are fastened to the shield and move with it in train. The entire director is rotated about an axis perpendicular to the deck plane to move the director line of sight in train. The electrical connections between the stationary ship structure and the rotating director are made through a slipring assembly in such a manner that train movement is unlimited in either direction. This feature eliminates the necessity for train limit stops and electrical limits.

ELEVATION MOVEMENT.—The telescope, open sight, rangefinder, and radar antenna are mounted so that their lines of sight may be elevated with respect to the shield. The elevation axes of these components are all parallel and the lines of sight of each component are perpendicular to its elevation axis. For practical purposes, all of the elevation planes are parallel. The lines of sight and the radar beam are all moved through the same elevation so that they remain parallel.

The director elevation gearing can move the lines of sight and the radar beam from a depression angle of 25 degrees to an elevation angle



166.122

Figure 13-16.—Gunfire control system Mk 68 data flow.

of 95 degrees. Limit stops and electrical limits in the power drive protect the drive mechanisms from damage that would result if these limits were exceeded.

The telescope is constructed so that the instrument body does not move in elevation. Elevation of the telescope line of sight is effected by rotating an objective mirror mounted on bearings inside the telescope body.

The open sight contains a binocular and peep sight at the end of the sight arm. The line of sight is moved in elevation by rotating the open sight about an axis parallel to the telescope elevation axis.

The rangefinder line of sight is moved in elevation by rotating the entire rangefinder about its longitudinal axis. An independent elevation mechanism in the rangefinder drive permits rangefinder elevation to be offset from director elevation when it is necessary to adjust the reticle pattern with the target.

The radar antenna is supported above the shield by a radar antenna mount. The radar beam is moved in elevation by rotating the entire antenna about an axis parallel to the elevation axes of the optical equipment.

A level angle is geometrically added to the elevation of the lines of sight and radar beam to cancel the effect on elevation of roll and pitch of the ship. The level angle is generated by a stable element below decks and is automatically transmitted to the director.

CROSS-LEVEL MOVEMENT.—The director shield is mounted on trunnions so that the entire shield can be rotated in cross-level to keep the elevation planes of the lines of sight and radar beam in a vertical position regardless of the rolling and pitching of the ship. The axis of the crosslevel trunnions is parallel to the deck plane.

The director crosslevel gearing can move the shield through an angle of 34 degrees each side of the zero position. Limit stops and electrical

476

limits in the power drive and buffers on the director pedestals protect the crosslevel drive and shield from damage that would result if these limits of movement were exceeded.

Primary control of firing is at Control Panel Mk 110 Mod 1. A two-section, three-position selector switch controls firing and cease firing circuits. When this switch is in the NORMAL position, the gun firing circuit may be completed at one of two positions in the director shield: the director officer's firing key or the tracker's one-man control. When the selector switch is in the CHECK position, both gun firing and cease firing circuits are open. Opening these circuits results in a check fire tone signal being sent to gun positions, which indicates that firing is temporarily suspended. When the selector switch is in the CEASE position, the cease firing circuit is completed, sending a tone signal to the gun positions indicating that firing is indefinitely suspended. All firing circuits from director to gun positions are completed through the fire control switchboard.

The director is equipped with two one-man control units. Each unit may be used for slewing the director or for one-man tracking in both train and elevation. The one-man control unit is rotated about a vertical axis to control the director train rate and the handgrips are rotated about a horizontal axis to control the elevation

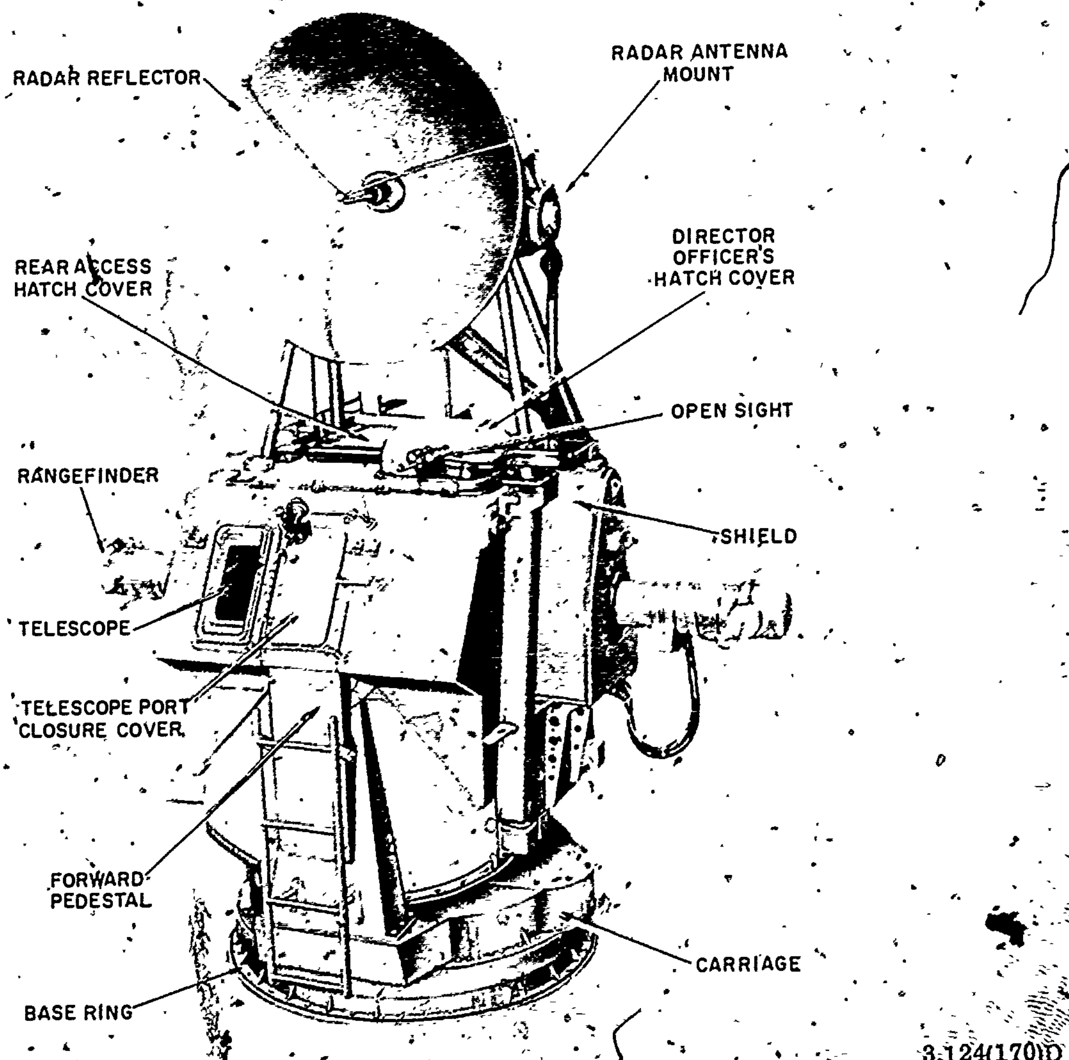


Figure 13-17.—Gun director Mk 68 Mods 2 and 3, front view.

rate. The rates generated are proportional to the amount of rotation.

RADAR MK 53

Radar Mk 53 is a part of Gun Fire Control System Mk 68 and is similar to radar Mk 35 used with GFCS Mk 56, in that it affords control of the entire GFCS from the radar console. Besides automatic tracking signals from the radar error circuits, range, bearing, and elevation handwheels and slew controls are provided on the radar console for manual search, acquisition, and tracking in the console mode of operation, and for modifying TDS signals in TDS mode. In the automatic tracking mode (normal mode), the director position is controlled by the angle tracking loop. The video signal is applied to the angle error detecting system which determines the tracking error and generates bearing and elevation error signals. These error signals are applied to Amplifier Mk 76, which supplies power to the director amplidynes.

COMPUTER MK 47

Computer Mk 47 is housed in two aluminum sections bolted together to form a single cabinet. The computer is entirely transistorized and all operating controls, switches, and indicating dials are conveniently located on the front of the computer.

Computer Mk 47 computes gun orders and fuze setting orders for 5"/54-caliber guns, and data for use in the star shell computer and in the converter from information furnished by the remainder of the system. Its operation is entirely automatic during acquisition and tracking except when manual rate control or local control is employed.

The computer utilizes target present position data to determine a line of fire that will hit the predicted target position at the end of time of flight. Gun and fuze-setting orders based on this determined line of fire are then computed and transmitted to the 5" gun mounts.

Automatic control is provided in the three primary modes of computer operation; Surface, AA-Sonic, and AA—Supersonic. For surface targets, the computer can also be operated by local control, by manual rate control, or by the optical range mode.

COMPUTER MK 116

Computer Mk 116 Mod 4 is designed for use with Computer Mk 47 Mod 9 in Gun Fire Control System Mk 68 Mod 8. The computer functions in three different modes of operation. In NORMAL 3"/50 mode, it operates with Computer Mk 47 to derive gun orders for 3"/50 caliber guns, and transmits these gun orders directly to the 3-inch gun mounts. In STAR-SHELL 5"/54 mode, it operates with Computer Mk 47 in Surface mode to derive 5"/54 caliber gun orders and fuze-setting orders for star-shell fire, and transmits these orders directly to the 5-inch gun mounts.

The primary function of computer Mk 116 is to produce gun orders for the 3"/50 caliber battery. It contains a prediction and ballistic section to determine target position at the end of time of flight, and a deck tilt section to convert and transmit gun orders in the proper coordinates.

CONVERTER MK 20

Converter Mk 20 is used with Computer Mk 47 (when it's not supplied with Computer Mk 116) to convert 5"/54 caliber gun orders to gun orders for 3"/50 caliber mounts. The converter is installed in the plotting room adjacent to Computer Mk 47. All power and information necessary to perform the conversion computations are received from Computer Mk 47. Therefore, Converter Mk 20 will operate only when Computer Mk 47 is on and transmitting gun orders. Operation of the converter is automatic except for setting in the value of initial velocity for the 3"/50 caliber guns being controlled and applying spots during surface fire.

STAR-SHELL COMPUTER MK 1

In systems not supplied with Computer Mk 116, Star-Shell Computer Mk 1 is used to compute star-shell gun orders and fuze setting orders for 5"/54 caliber gun mounts. It can be operated in two modes; controlled fire or search. For controlled fire mode, employed when a specific target is to be illuminated, Computer Mk 47 must be operating. In search mode the star-shell computer can be operated independently of Computer Mk 47.

STABLE ELEMENT MK 16

The primary function of Stable Element Mk 16 and associated equipment is basically the same as that of Stable Element Mk 6. That is, to provide a stabilized reference plane independent of ship's movement. The construction and operation, however, are quite different.

The stable element contains the sensitive element, gimbals, pendulums, pickoff coils, and servo mechanisms that maintain the gyro at a true vertical and generate synchro signal outputs of level and crosslevel. These signals are used in Computer 47 deck tilt corrector section to compute position angle and true target bearing.

SAFETY

The after main battery director of a cruiser was training during a director check. The sightsetter left his assigned station without permission. Suddenly a scream was heard. The sightsetter was found with his body jammed between the irregular projections of the director and the director shield, a space of from 5 to 8 inches. The sightsetter died from extreme multiple-injuries to his respiratory system.

This case demonstrates the always present danger existing in the close confines around mounts, turrets, directors, etc. on Navy ships.

During a practice run of a destroyer a member of the gun crew of a 5-inch 38-caliber mount was seated on the right gun captain's platform. The right gun was not to be fired. The man's left leg was placed beneath the right gun slide. At command, the mount elevated and the breech of the right gun descended and crushed the man's leg. It had to be amputated.

You should acquaint yourself thoroughly with the safety regulations provided in OP 3347, and with those regulations posted aboard ship, before operating fire control equipment. You will be taught how to apply many of these precautions while you are learning to operate fire control instruments. The following list of general precautions will assist you.

1. Always inspect all training and elevating areas to make certain that all persons are clear, and that the areas are free of obstructions before operating directors, turrets, guns, or missile launchers.
2. Always use warning bells provided before training or elevating gun mounts, turrets, or launchers during routine work and practices (except during GQ).
3. Before leaving directors, turrets, guns, or launchers always train and elevate them to their securing positions; place all controls in the inoperative position, and deenergize all power supplied to them.
4. Whenever possible, have the regular operators posted at their stations before operating a director, turret, or a gun from a dummy director.
5. Slew directors and guns only when it is necessary during practices.
6. All telephone stations should be manned when operating systems automatically or remotely.
7. Notify all operators and persons concerned before shifting a system to automatic control from local control.
8. Never operate directors, turrets, or guns in automatic without having the regular operators posted at their stations.
9. Do not hesitate to stop any person from operating fire control equipment if he may cause a casualty to himself, the equipment, or to any other person.

CHAPTER 14

MAINTENANCE

Maintenance means everything you do to "keep 'em firing". It means knowing your equipment and keeping it in shape to do its job. In this chapter we shall take up maintenance in terms of the specific work that you will be expected to do with guns, mounts, and rocket launchers. Your job is to have every gun ready to operate at all times and to keep every weapon in the fight during action.

In time of war preventive maintenance saves more than time and repairs. You probably remember the poem that tells how, for want of a missing horseshoe nail, a battle was lost. The horse's shoes should have been inspected, and the missing nail replaced – just a matter of preventive maintenance. Of course, we don't use horseshoe nails aboard modern warships, but you see the analogy. Maintenance can mean the difference between victory and defeat, both ashore and afloat. If anything goes wrong with the fighting equipment of a ship, it is out of action until repairs can be made, and then it might be too late. You have been around enough to know that a ship's fighting equipment is very complicated, with many parts dependent on other parts. A great deal of money and inventive ingenuity have gone into that equipment. But if it is not in working order when needed, it is worthless.

PREVENTIVE AND EMERGENCY MAINTENANCE

There are two main classes of maintenance work. The most important, which accounts for most of the maintenance work you do, is routine maintenance. That includes regular lubrication, record maintenance, and advance planning. The purpose of routine maintenance is not so much to repair troubles and malfunctions as they arise; but to prevent them before they appear. This kind of maintenance is therefore often called preventive maintenance. It is based on the well-known principle that an ounce of prevention in the form of adequate routine maintenance is worth a pound of cure in the form of repair, replacement, and overhaul.

Preventive maintenance isn't dramatic or exciting. There's no glamour in a grease gun. But taking a little trouble and time to do the preventive routine maintenance now will save a lot of trouble and time later by heading off breakdowns and time-consuming repair jobs.

In your preventive maintenance work you have a job very much like that of a coach who is assigned to keeping a team of highly trained athletes in top fighting form. For both men and machines, it's daily attention to the details that is important. For machines, these details are things like inspection, lubrication, and tightening and adjusting of parts. To let any of those things go means trouble, just as there's trouble for an athlete who breaks training.

In addition to the daily or weekly maintenance chores, machines need regular overhual. This may be called corrective maintenance, to correct existing or potential deficiencies. You can see that this is really also preventive maintenance, its main object being the prevention of breakdowns.

In spite of the best preventive maintenance, sometimes your equipment will malfunction or break down altogether. Then it will need emergency maintenance — the urgent repair and overhaul work required to get it into working order in a hurry. Effective routine maintenance will keep this kind of work to a minimum, but there are times — in battle, especially — when you must expect casualties and breakdowns, and must be prepared to deal with them.

A Gunner's Mate's emergency-maintenance job resembles a doctor's – with the difference that the Gunner's Mate is expected to get his "patient" back into action a lot faster. To do that, the Gunner's Mate, like the doctor, must do two things:

1. Find out what the trouble is, and where it is. The doctor calls this diagnosis; we call it

trouble-shooting. Sometimes the casualty or malfunction is obvious; sometimes it's hidden. You locate and identify it first, and then:

2. Fix it. This may mean anything from a simple adjustment to a full-blown overhaul job, involving disassembly, replacement, repair, reassembly, realignment, and readjustment.

The more you know about how your equipment works, the better you will be at troubleshooting and repair. Experience is a great teacher, but you can't wait until your gun breaks down in battle to find out how to repair it. Study of the troubleshooting methods and repair techniques, will give you the background of knowledge you need to combine with practice to make you an efficient repairman for your guns.

MAINTENANCE BY SHIP'S FORCE, TENDER, AND NAVY YARD

Most of the maintenance work on armament aboard ship is done by the strikers and Gunner's Mates themselves as part of the ship's routine. This is called ship's force maintenance.

The ship's force, however, hasn't the facilities or the skill to perform certain less frequent but equally necessary maintenance operations. Examples of this type of operation are repair of gunsight or boresight telescopes, and calibration of pressure gages. Work of this kind is done aboard repair ships and tenders which have the equipment and skilled personnel (Opticalmen and Instrumentmen, for instance) that are required for this type repair work.

Lastly, there are some jobs, like major overhaul of hydraulic systems, or repair or replacement of roller paths in heavy AA mounts, that are customarily done in naval shipyards. Such work may be done by yard workers, by the ship's force, or by both. Maintenance work done in yards rather than afloat is termed Navy Yard maintenance.

Routine overhauls are scheduled far ahead of time at a specified Navy Yard for each ship. To get the most out of the overhaul work, records of mishaps, signs of defects, or poor operation of gunnery equipment must be kept so that each of the items can be taken care of during the overhaul. Records of all work done by the ship's force must also be kept. Keeping the records is part of your job; the weapons officer must have this information to plan the overhaul work.

Work by tenders and repair ships also is scheduled, so it must be planned for ahead of time. Authorized alterations (Ordalts) are also made aboard these ships when possible, though some may be accomplished by ship's force but supervised and verified by the Naval Ordnance Systems Support Offices (NOSSO) (PAC/LANT). Ordlats requiring special team efforts will be accomplished under the direction of NOSSO and supported, as required, by the In-Service Engineering Agent and/or contractor representatives. Ordalts usually state by whom the work is to be done. Changes of a minor nature are authorized by NAVORD Instructions (NAVORDINST).

The upkeep period is time assigned to a ship, while moored or anchored, when the ship's force and other forces afloat can work to perform upkeep duties without interruptions.

Special assistance in maintenance, especially for new equipment, may be obtained from contract service engineers who are specifically trained for specific equipment, or from mobile ordnance service units, which consist of military personnel who have been trained to handle certain equipment and can be assigned to instruct others in its use and care.

GENERAL MAINTENANCE

Back home, you may have kept your old jalopy running by puttering with it in all your spare time, and learning from your mistakes. You have seen enough of gun mounts and turrets with their complex and powerful but sensitive machinery to know that modern weapons require special skill to maintain. Mistakes are far too costly (in men and money) to take a chance. You can't just turn loose an eager beaver with a screwdriver and leave it to his ingenuity to do a maintenance job.

Some maintenance jobs must be done more often than others. For example, on your 5"/38 mount you check the differential piston every day to be sure there is enough fluid in the counterrecoil system, but you bleed and refill the counterrecoil system once a month.

Purpose and Use

The Navy uses Maintenance Requirement Cards (MRC), in the Planned Maintenance Subsystem to make sure that routine maintenance jobs are done at the required regular intervals (weekly, daily, monthly, etc.) and that no steps are forgotten.

You will obtain the MRCs from the Gunner's Mate under whom you work. You will use the MRCs as a guide when actually doing the work. These

MRCs specify all the routine maintenance jobs that are required for a given mount or turret, leaving as little as possible to the imagination. The individual maintenance items for tasks are classified by frequency — how often they are to be done.

Daily maintenance is concerned mostly with lubrication, inspection, and checking. On a 5-inch mount this would begin with the gun itself, and work down through the rammer, elevating and training gear, hoist, and handling rooms. To do the lubricating, you must have the lubrication chart, (there may be several) for that piece of equipment. A sample lubrication chart is shown in figure 14-1.

In the weekly, monthly, quarterly, semiannual, and annual routines, there is usually more work involved in each item — bleeding and refilling the counterrecoil mechanism, flushing and relubricating as required, cleaning filters, etc.

The pre-firing check is scheduled to take place before the battery goes into action, so that all mounts will be fully checked and prepared for firing. In wartime, when the guns must be kept always ready to engage the enemy, the before firing routine is merged with the daily routine.

Finally, there is the post-firing routine, which takes place at the end of every day of firing, and corresponds more or less to the similar routine that you learned about in connection with small arms.

In practice, you'll find that the maintenance jobs are cumulative — that is, when you do the monthly items, for example, you will also do the weekly and daily items; quarterly items automatically include the daily, weekly, and monthly items.

INSPECTION AND TESTING EQUIPMENT

You have already learned a good deal about inspection and testing ordnance material in earlier chapters of this manual — inspecting smokeless powder and other ammunition, sprinkler systems, small arms, etc. Inspection and testing are inseparable from maintenance. The higher you rise in your rating, the more responsibility you will have for inspection and testing. There are the operational tests, in which you put the equipment through its paces to be sure it has been put together right and is in working order. Other tests require special testing equipment, and you should be able to use nonelectrical testing equipment such as bore erosion gages and boresighting equipment, as well as electrical testing equipment (meggers, test lamps, etc.).

Tools and Their Uses, NAVEDTRA 10085-B, covers various measuring tools and gages used by Gunner's Mates G. In other chapters of this manual you have read about more specialized tools, such as the head-space gage, pressure gages (air and hydraulic), boresighting and tramming equipment. How much testing you will do with this special equipment depends mostly on the individual situation; your chief may be doing most of it.

Record keeping always goes along with inspection and testing. You remember that you must record your daily inspection of the ammunition magazines.

Maintenance of the recoil and counterrecoil systems usually is done by your chief, but you should be able to read the air pressure as shown on an air pressure gage. (See Basic Machines, NAVEDTRA 10624-A, if you need a review on pressure gages).

Checking of lost motion in gun sights will be done in connection with boresighting, with a leading Gunner's Mate in charge of the crewmen at the different stations. Each man at his station sets the crosshairs of his sight as directed. When you are ready to learn more about the how's and why's of this operation, you can read about it in the more advanced texts.

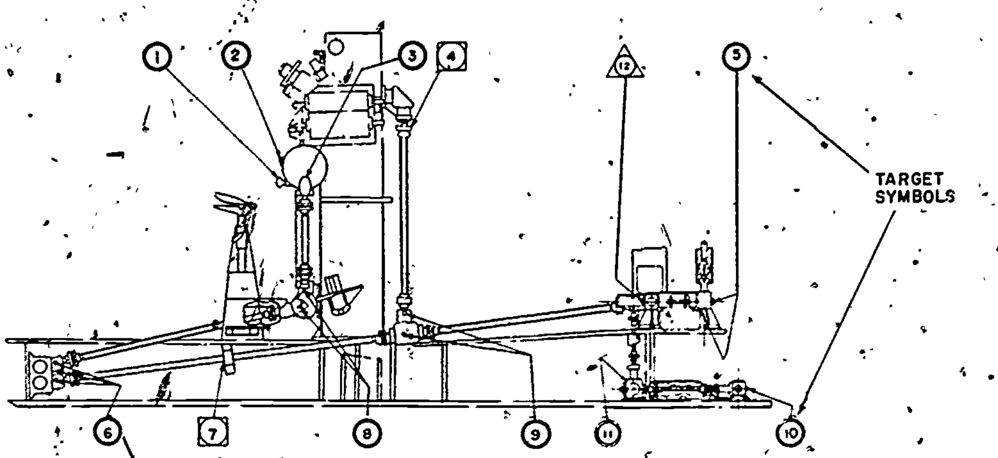
LUBRICATION

If you grew up in a city, perhaps the only connection you had with lubrication was taking the family car to the garage or the gas station for greasing and oil change. But is you grew up on a farm or had a car that you had to keep in running condition yourself, you are well aware of the need for regular lubrication of all moving metal parts. If your car ever burned out a bearing, you've had a lesson that you are likely to remember. And since you have been in the Navy, you've heard a great deal about the importance of lubrication. We won't let you forget it.

LUBRICANTS

Lubricants are of two general classes — oils and greases. Oils are fluids; greases are semisolids at ordinary temperatures. Both have several qualities that determine their suitability for a particular lubrication job. One of the most important is viscosity.

Viscosity is the measure of the internal friction, or resistance to flow, of a liquid or semisolid. It varies with the temperature as well as



AT ASSEMBLY

4 RESPONSE GEAR ADJUSTING COUPLING (COAT WORM TEETH)

WEEKLY OR 30 HOURS OPERATION (MINIMUM)

1 SHIFTING LEVER

2 HANDWHEEL HOUSING (CHECK LEVEL AND REPLENISH)

3 HANDWHEEL HANDLES

5 INBOARD HOUSING ASSEMBLY (1 FILL PLUG, 1 DRAIN PLUG)

6 TRAIN ORDER AND RESPONSE HOUSING (3 FITTINGS, 1 LEVEL PLUG)

8 TRAIN ORDER GEAR HOUSING (1 FITTING, 3 LEVEL PLUGS)

9 INTERMEDIATE RESPONSE GEAR HOUSING (1 FITTING, 1 LEVEL PLUG)

10 TRAIN INPUT FRONT HOUSING (FILL THRU COVER, 1 LEVEL PLUG)

11 TRAIN INPUT REAR HOUSING (FILL THRU COVER, 1 LEVEL PLUG)

12 WORM AND WORMWHEEL HOUSING (2 FILL PLUGS, 2 DRAIN PLUGS)

MONTHLY OR 120 HOURS OPERATION (MINIMUM)

7 PILLOW BLOCK ASSEMBLY

GENERAL LUBRICATION INSTRUCTIONS — REFER TO O.D. 3000

APPLICATION — EXERCISE PARTS WHILE LUBRICATING

REPORTS. — SHIPS EXPERIENCING ANY DIFFICULTY WITH OPERATION OF THE EQUIPMENT DUE TO LUBRICATION IN ACCORDANCE WITH THIS CHART SHOULD SUBMIT A DETAILED REPORT TO THE BUREAU OF ORDNANCE WITH COPY TO THE NAVAL GUN FACTORY.

CHECK-OFF LISTS. — REDUCED SIZE PHOTOPRINT COPIES OF THESE CHARTS MAY BE OBTAINED FROM THE NAVAL GUN FACTORY FOR USE AS PERIODIC CHECK-OFF LISTS.

REFERENCE CHARTS. — FOR LUBRICATION OF PLAN ABOVE AND PLAN BELOW SHELF PLATE SEE DR. NO. 509299. FOR LUBRICATION OF RIGHT SIDE ABOVE SHELF PLATE SEE DR. NO. 509301.

SYMBOL SPECIFICATIONS

- △ INDICATES WORM GEAR LUBRICANT (O.S. 1400)
- ○ INDICATES LIGHT MINERAL OIL (NAVY SYMBOL 3050 OR 2135)*
- □ INDICATES BEARING GREASE (14-G10 (ORD))

*LUBRICANTS ARE SHOWN IN ORDER OF PREFERENCE

6IN. TRAINING GEAR MK.3 MOD.1
(47 CAL. DOUBLE PURPOSE TWIN)
LEFT SIDE ABOVE SHELF PLATE
(LOOKING OUTBOARD)
LUBRICATION CHART
509300

84.278

Figure 14-1. — Lubrication chart, showing lubrication symbols, schedules of lubrication, and other instructions.

with the nature of the substance. Petroleum jelly (vaseline) can hardly be said to flow at room temperature, but it can be melted to a rather thin liquid. On the other hand, many kinds of oil flow readily at ordinary temperatures, but become much thicker when they're cold.

Viscosity is expressed in terms of S.S.U. UNITS. (S.S.U. means "Seconds, Saybolt Universal" and represents the number of seconds it takes a given quantity of the lubricant at a specified temperature to pass through the Saybolt Universal Viscosimeter or Viscometer). The higher the S.S.U. number of a lubricant at a given temperature, the more viscous the liquid. The Navy uses the S.S.U. measurement, rather that the S.A.E. (Society of Automotive Engineers) Grades used to designate lubricants in the automotive industry.

The viscosity index (V.I.) is an indication of the variation of viscosity of the lubricant with variation in temperature. The higher the index, the less the viscosity varies with the temperature; thus a high index is a desirable quality. You want a lubricant that won't solidify and gum up in cold weather, nor liquify and leak away in hot weather.

Viscosity index can be improved up to a point by putting chemical additives into the oil. (Additives are put in by the manufacturer. Don't try to brew up your own special oil by adding anything to it).

The flash point of a lubricant is the temperature at which it gives off flammable vapors. The fire point (always higher than the flash point) is the temperature at which it will take fire if ignited. The pour point (of an oil) is the lowest temperature at which it will pour or flow.

Oiliness is the characteristic of an oil which prevents scuffing and wear. You might think this depended on viscosity, but a complicated relationship of many factors is involved. Certain substances have been found which increase the oiliness of a lubricant.

Chemical stability concerns a lubricant's ability to "take it". Certain oils and greases tend to deteriorate under influence of high temperatures, exposure to air or water, or introduction of impurities. A lubricant with good chemical stability will resist such deterioration. You can often detect deterioration by change in color, formation of varnish or gum deposits, or consistency (of grease), hardening (of grease), or by other telltale signs. Change in viscosity can be more accurately measured by viscometer, but serious change is easy for the expert to detect.

These signs of deterioration mean that the lubricating and corrosion-preventing qualities of the substances are impaired. You'll find it useful to know the signs of deterioration in oils and greases well enough to recognize them when they appear.

Lubricant preservatives, and hydraulic fluids, all protect metal against corrosion, at least to a certain extent. Corrosion prevention is, of course, the main function of a preservative. The corrosion-resisting qualities of lubricants and hydraulic fluids can be improved by adding chemicals called inhibitors. In general, inhibitors are added to the substance by the manufacturer before delivery to the Navy.

Other qualities or properties of lubricants are: dropping point, penetration, neutralization number, work factor, viscosity change, and aniline point. Chemists in lubrication work need to understand the meaning of the terms; we list them only to impress you with the fact that just any oil will NOT do.

Functions of Lubricants

Now that we have discussed some of the qualities of lubricants, you can see how they apply to the jobs that lubricants have to do. Lubricants are used for three purposes to reduce friction, to prevent wear, and as a protective cover against corrosion.

As a protective cover against wear and tear, the use is equally obvious when you consider the matter friction. Lubricants form a layer or film between the metal surfaces, which actually keeps the metals from touching. The moving parts "ride" on the lubricant. In the instance of two metals surfaces sliding across each other where space cannot be provided for ball bearings, the lubricants themselves serve as "liquid bearings". In all mechanical devices, lubrication is necessary to counteract friction as much as possible. Only the presence of a thin film of lubricant to separate metal surfaces keeps modern machinery going. If the film disappears, you have hot-boxes, burned-out and frozen bearings, scored cylinder walls, leaky packings, and a hoist of other troubles, the least of them being excessive wear. All of these troubles are the result of direct metal-to-metal contact without adequate lubricant. Lubricants do not move naval guns and equipment but they keep them movable.

Types and Properties of Lubricants

Lubricants for naval ordnance systems are selected on the basis of necessary or desired characteristics including:

1. Maximum reduction of friction between bearing surfaces.
2. Corrosion inhibiting properties.
3. Stability over a wide temperature range.
4. Ability to withstand high pressures.
5. Low volatility at operating temperatures.
6. Resistance to oxidation.
7. Resistance to emulsification.
8. Resistance to environmental contamination by the particular application.

Because proper lubrication is an absolute necessity, selecting high quality lubricants, those having the right viscosity and other properties for each job, is of vital importance. For many applications liquid lubricants such as petroleum or synthetic oils are suitable, particularly if the lubricant can be retained; as in an oil bath or gear box, or in a forced feed system. In conditions where oil cannot readily be retained or additional protection against corrosion is needed, greases are used. In applications where the operating temperature is too high for satisfactory lubrication by oils or greases, graphite, molybdenum disulfide, or bonded dry film made from these materials may be used.

Special lubricants which are required for specific naval ordnance operational requirements must be approved before they are used on naval ordnance equipment. Specifications and stock numbers for special lubricants, approved lubricants, and oils are listed on tables in Lubrication of Ordnance Equipment, OD 3000 (latest revision).

Specifications

When the Navy buys oils and lubricating greases, they must specify what they want. To make sure that the supplier knows exactly what is wanted, a detailed description of the items to be purchased is forwarded to the supplier in the form of specifications or specs. These specs are printed by the Department of Defense and relate standardized specifications which indentify by name, numbers, and letters lubricants, preservatives, hydraulic fluids and many other items used in operation and maintenance of ordnance equipment. An example of an item you may have used in MIL-C-372, cleaning compound, solvent, for the bore of small arms and automatic aircraft weapons. Most materials used for military equipment by the various armed services are now purchased under federal or military specifications.

MILITARY SYMBOL OILS

Military symbol (MS) oils are petroleum-base oils covered by certain military specifications. They contain no corrosion inhibitors Some of these oils are used in ordnance systems for oil bath, oil can, or forced-feed lubrication where the equipment is enclosed or otherwise protected from a corrosive environment. The symbol used to designate these oils is a four digit number in which the first digit indicates the series or type and the last three digits indicate the approximate saybolt viscosity.

The following illustrates how to translate the symbol system of oil MS 3050.

MS 3050 indicates a general purpose oil (series 3) having a viscosity of approximately 050 at 210° F.

Viscosities are measured at 130° F for all series 2, series 8, and series 9 oils. All other series are measured at 210° F.

The following series of MS oils are approved for use in naval ordnance equipment:

Series	Type
1.	Lubricating Oil, Aircraft Engine
2.	Lubricating Oil, General Purposes
3.	Lubricating Oil, Cylinder, Mineral

GREASES

Lubricating greases are a mixture of soaps—commonly, calcium soap or sodium soap—and lubricating oils. The oil may be a mineral oil (petroleum base) or a synthetic oil.

The purpose of the soap is to make the oil "stay put" at the point of application. The soap traps the oil within its mass, but the actual lubrication is done largely by the oil in the grease. The heat of friction "squeezes" the sponge, melting the grease, and releasing the oil to perform the lubrication.

Greases are classified according to the kind of soap used in making them. Each kind of soap has specific properties:

Calcium (lime) soap grease will not absorb moisture or emulsify (separate into its original ingredients). Consequently, it is specified for general lubricating purposes where bearings are exposed. However, calcium-soap grease has a low melting point, and is not suitable for hot-running bearings.

Sodium-soap grease emulsifies in the presence of moisture but has a higher melting point. It should be protected from moisture. It is used for ball and roller bearings.

Other kinds of soap bases used in greases are aluminum soap and lithium soap, with others added to the list as found by experimentation and tests at laboratories.

Graphite grease, as the name implies, contains graphite. The graphite acts as a mild abrasive to smooth roughened wearing surfaces; as a filler to smooth over any pits in the surfaces, and as a friction reducer. However, because of its abrasive action, graphite grease should not be used in bearings that are in first-class condition—except under high temperatures at which ordinary greases would be destroyed. Technically, since graphite grease contains no soap, it is classed as a lubricant oil, but it looks and is applied like other grease. Molybdenum disulphide, Spec. MIL-M-7866, can be used instead of the graphite grease.

Gear lubricants are a mixture of high-viscosity oils and just enough sodium soap to cause "jellying". Gear lubricants are suitable for high gear-tooth pressure and moderate speeds where the design of the case is such that ordinary oil cannot be retained.

As with oils, the viscosity of greases varies with temperature. If temperature changes make it necessary to change oil, check your lubrication chart to find out whether you have to change the grease too.

ALTERNATES AND SUBSTITUTES

If the lubricant prescribed in the OP for a piece of equipment is not available, you may find it necessary to use either an alternate or a substitute lubricant.

A substitute lubricant is one that will fill the need for a limited time, but does not have all the essential properties of the prescribed lubricant. As soon as the prescribed lubricant becomes available, all of the substitute must be removed from the equipment, which must then be completely relubricated with the prescribed material.

An alternate lubricant is one whose characteristics closely resemble those of the prescribed lubricant so that its removal is not necessary when the prescribed material is available.

Alternates and substitutes for prescribed lubricants (as well as for cleaning materials, hydraulic oils, and preservatives) are listed in OD 3000, lubrication of Ordnance Equipment.

If none of the listed lubricants is available and you must choose a substitute, keep in mind that the substitute should be as near as possible to the specified lubricant in lubricating and rust-preventive qualities, viscosity, and ability to withstand the temperature ranges of the equipment.

In brief, when the prescribed stuff is not to be had, use an alternate if you can, substitute if you must.

Breechblock Lubricant

Lubricant MIL-L-16785 is a specified mixture of castor oil, spec JJ-C-86, and MS 2135 oil used to prevent galling of the bearing surfaces of either sliding or interrupted-screw type breechblocks. The lubricant is applied by brushing or swabbing, after which the excess is removed. During continuous firing operations, the lubricant should be applied frequently.

LUBRICATION INSTRUCTIONS AND CHARTS

Lubrication instructions are issued for all naval ordnance equipment requiring lubrication. Such instructions may be issued as lubrication charts, maintenance requirement cards, instructions, ordnance publications, or combinations of these. It is the policy of the Naval Ordnance Systems Command, whenever practicable, to prepare lubrication charts with complete lubrication instructions for all equipment. These charts are prepared on drawing forms with drawing numbers assigned, (fig. 14-1).

Lubrication charts generally indicate the approved lubricants and related materials, points and required frequency of application, and the target symbol of the specific lubricant and related material. The charts also contain additional information relating to lubrication, draining, filling, cleaning, and other maintenance functions.

LUBRICATING TARGET SYMBOL

Lubricants to be used are identified by target symbols at each point requiring lubrication, (fig. 14-1). These symbols signify the type of oil or grease to be used. OD 3000 (latest revision) identifies the symbols and reflects the current changes of each symbol. The target symbols shown on figure 14-1 are numbered and indicated different points to be lubricated. The numbers reference the names of the parts and how many places on each part require lubrication.

On many old ordnance lubrication charts the lubricants listed are identified by superseded, cancelled, or replaced specifications, such as 14G10 (ORD) shown on figure 14-1. As stated earlier, all lubricants are now under military specifications and carry a MIL number. To cross reference these numbers, refer to the target symbols shown in OD 3000, make sure that you have the latest OD. For example, the bearing grease indicated in figure 14-1 by the superseded numbers 14G10 (ORD), also is indicated in OD 3000 by the intervening number MIL-G-16908 (BUORD), and now carries the current specification MIL-G-7711.

LUBRICATING TOOLS

Some lubricants are applied by smearing them on the surfaces to be lubricated, but you'll most often use a tool (grease gun, oiler, or grease pump) especially designed to put lubricant into the equipment through a lubrication fitting.

Grease Guns

Grease is applied by a grease gun or pump through a nozzle that is designed to match the fitting.

Although ordnance plants and repair shops have electrically or pneumatically powered equipment, you probably will have to depend on your own right arm for power to operate lubricating equipment. In this section we shall therefore take up only the hand-powered lubricating equipment you are likely to use.

There are various types of grease guns in use in the fleet. One type uses a grease loaded cartridge refill that can be inserted in the grease gun by removing the cap. This type gun is quick and simple to load without a mess. However, they are a bit more expensive to refill than the other types. Another style being used is loaded by removing a cap that comes off with the handle and stem, and filling the body with grease, using a paddle or spatula. As you might expect, this method of loading can be messy, and it also exposes the lubricant to dirt and moisture. A faster and cleaner kind of gun (fig. 14-2A) is loaded by removing the cap nut from the end of the hollow handle and forcing grease in through the handle with a hand gun loader (fig. 14-3A), or a bucket-type lubricant pump (fig. 14-3B).

The hand gun loader is a 25-pound container equipped with a hand-operated pump and fitting that mates with the opening in the handle of the grease gun. The bucket-type lubricant pump makes use of a loader adapter and loader valve when it is used for loading a grease gun. One pound of lubricant is delivered with every seven full strokes of the pump. The loader will deliver lubricant only when the gun is placed on the loader valve. You can see how much less messy the loader is than the paddle, and how it protects the lubricant against contamination. Besides you don't have to run back to the storeroom to refill your gun.

Different nozzles can be attached to the grease guns for different types of fittings. The lubricant pump also has various couplers and adapters that attach to the hose, so that the pump can be used on different fittings.

Grease guns can be used for oil if the point to be lubricated has the proper fitting, or an oil gun (fig. 14-2E) may be used.

A lever-type grease gun (fig. 14-2C and D) is being introduced; it gives more positive lubrication than the Zerk grease gun.

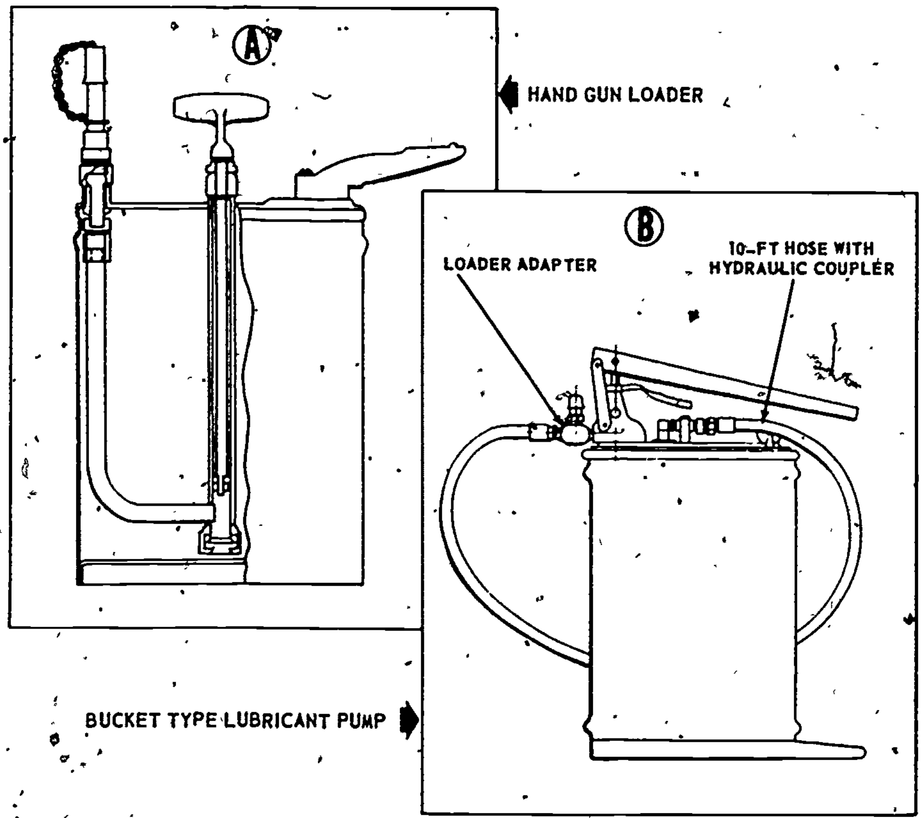
When you need to apply large quantities of grease—as, for example, in a 3"/50 roller path—a grease gun is too small. The bucket-type hand-operated lubricant pump (fig. 14-3B) holds the same amount of grease as the hand gun loader, and is fitted with a pump operated with a lever. It has a 10-foot hose with a hydraulic T-handle adapter and a 90° adapter for working in cramped spaces. With this pump you can build up a lubricant pressure of 3,500 psi, and deliver a pound of lubricant every 20 full strokes.

The hand-operated lubricant pump can handle any type of lubricant generally required on naval ordnance equipment except greases of calcium-soap type.

If you can arrange it, use several grease guns—one for each type of lubricant you will need. Then you can save time by taking care of all the fittings requiring a specific type of lubricant before going on to apply the next type. For example, if you're working a a 5"/54 mount, take care of all the fittings around the gun house that require MIL-G-7711 before working on those that take MIL-L-18486. After you've finished with the gun, rammer, hoist upper end, and so on, repeat the sequence of application down in the handling room.

Figure 14-2.—Hand-operated grease guns.

AAA



83.121

Figure 14-3. Hand-operated grease pumps. A. Hand gun loader. B. Bucket-type lubricant pump.

If the number of grease guns on the mount is limited, it may be worthwhile to pool the grease guns from several mounts. If even that is impossible and you are obliged to use one gun for more than one lubricant, be sure the gun is as empty as you can make it before adding a different lubricant. Mixing lubricants is not good practice.

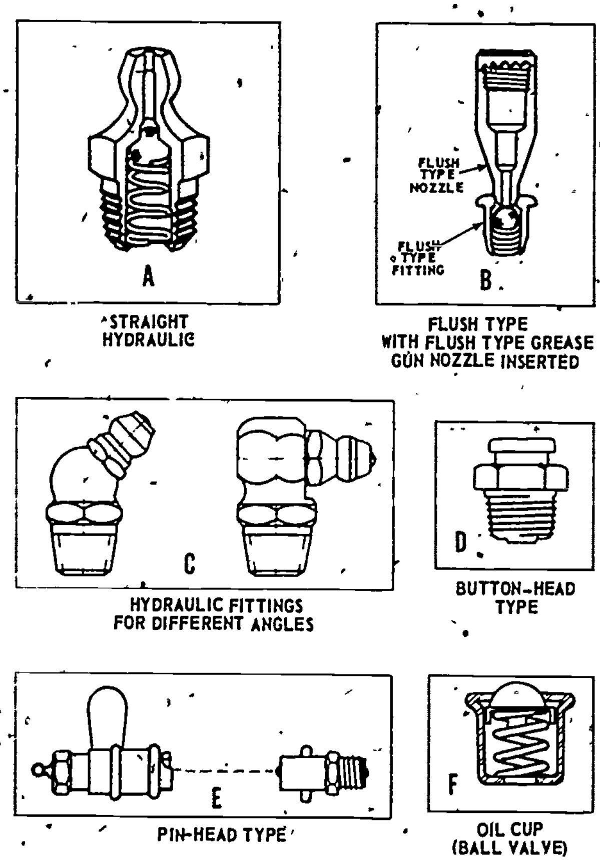
FITTINGS

Grease fittings are of several types—hydraulic (unofficially called the Zerk fitting, after its inventor), button-head, pin-type, and flush (fig. 14-4).

The hydraulic fitting protrudes from the surface into which it is screwed, and has a specially shaped rounded end that the mating nozzle can grip. A spring-loaded ball acts as a check valve. The nozzle will not slip off the fitting during lubrication, but can be easily disengaged by a quick forward-backward movement. Push-type (Zerk) hydraulic fittings are being replaced by commercial button-head and pin-type fittings which provide more positive connection with the grease gun. Figure 14-4, part A, shows a cross-section view of a straight hydraulic fitting, and part C shows hydraulic fittings made for different angles. They are made to fit most any angle with different threads and body lengths.

The oil cup with ball valve (fig. 14-4F) is the most popular type for oil fittings.

When using a gun equipped with nozzle for hydraulic-type fittings (fig. 14-2A, C), just place the nozzle on the fitting and push forward on the handle. This slips the nozzle onto the fitting and at the same time builds up hydraulic pressure in the gun, forcing the grease out of the nozzle. Then relax the pressure. A spring forces the handle back, ready for the next stroke. Three strokes are usually enough. Only one hand is needed to work this type gun. The grip action of



84.122

Figure 14-4.—Lubrication fittings.

the nozzle coupler holds the nozzle firmly to the fitting until pulled free. The Zerk grease gun can be used with the button-head fitting by adding an adapter.

The flush fitting (fig. 14-4B) is flush with (or below) the surface into which it is set, so that it will not foul moving parts. It is used also where there is not sufficient clearance to install protruding fittings. The flush fitting also has a ball-type check valve. When using a gun equipped for flush-type fittings, you must exert a steady pressure against the grease-gun nozzle to keep it in contact with the flush fitting while pumping lubricant since the nozzle has no grip on the fitting. Otherwise, the method of use is much the same as with hydraulic fittings.

As with other routine jobs, it helps to have a standard operating procedure that you can habitually follow. Here's one that will be helpful:

1. First, consult the lubrication chart and locate the fitting.
2. Clean the fitting carefully with a lintless cloth.
3. Apply the correct amount of the specified lubricant. (Be careful of the amount you apply—too much will cause excessive heat in the bearing and strain the grease retainers, while too little is on a part with too late).
4. Wipe all excess grease from around the fitting.
5. Check off the fitting on your chart. A fitting must not be missed just because it is battered or frozen. A battered fitting must be replaced. A "frozen" fitting probably means that the oil holes throughout the bearing are clogged. This means tearing down the bearing and cleaning all parts carefully. Grease that fitting even if it requires an hour of extra work!

Plastic protective caps often are provided for use on hydraulic fittings to prevent the entrance of dirt or water, and to protect the fittings during ice removal, painting, and similar operations. The caps also prevent the greases from hardening in the fitting during the long periods of stowage.

AUTHORIZED CLEANING AND PRESERVING MATERIALS

As a Gunner's Mate G, most of your cleaning and preserving work will be done on metal surfaces, principally steel. The preservatives must protect the metal against rust and corrosion; the cleaning materials must clean the surface before the preservative is applied.

Rust is caused by the slow burning (oxidation) or iron. When iron or steel rusts, it combines slowly with the oxygen in the air.

Technically, corrosion is not exactly the same as rust, since its meaning includes metal being eaten away be acid, or by the action of salt water, or other substances. Rust and corrosion are dangerous and destructive saboteurs that attack unguarded metal at the slightest opportunity.

The way to protect metal from rust and corrosion is to protect it from the air. Paint is a good protective, but many metal surfaces, such as moving parts, cannot be painted.

The lubricants used on moving parts serve as rust preventives to some extent, but often this protection is not enough. These are temporary preservatives for protecting metal from water and weather. Light oils and greases are applied to exposed gun parts and mounts as temporary protection against corrosion. Bright steel work, such as a gun breech, should have such protection. Slushing oils, available in several grades, are provided for this purpose. All old oil and dirt should be cleaned from the part and the surface thoroughly dried before new oil is applied.

Some lubricants (for example, preservative lubricating oil for use in small arms and light machine guns) have preservative additives (rust inhibitors) and can serve for short-term preservation, but NO preservative is intended for use as a lubricant.

When lubrication is not desired, there are special preservatives (permanent type) which may be brushed or sprayed on the surface to be protected, or in which the small parts of a mechanism may be dipped. After treatment, the preserved mechanism can be stored for a long period. (The length of time depends on the characteristics of the preservative, the kind of storage, etc.).

A rust preventive that can be used either to protect exterior surfaces or (as when pumped through a hydraulic system) for preserving interior surfaces, tubes, etc., is the thin-film polar-type compound, which is available in sereral grades. Hard-film compound, also in several grades, is for metal exterior surfaces only.

Rust preventives are NOT lubricants and should not be used instead of lubricants. Before treating metal surfaces with rust preventives, BE SURE TO REMOVE ALL TRACES OF RUST AND CORROSION, AND ALL OF THE OLD LUBRICANT.

BE SURE TO REMOVE ALL OF THE RUST PREVENTIVE before adding lubricant to ordnance equipment that has been stored with rust-preventive compound coating. OP 1208 (latest revision), Instruction for Inactivation, Preservation, Maintenance, and Activation of Ordnance in Vessels in an Inactive Status, gives step-by-step instructions for removing preservatives from guns and other ordnance equipment.

OD 3000 contains a chart of all cleaning and preserving materials authorized for use on ordnance materials. This OD contains charts that give the specification number, characteristics, applications, standard Navy stock number and container size, and substitutes, while the text elaborates on the use of each item. Some of the materials will be described briefly.

Soap and water are one answer to the problem of removing all dirt and traces of old oil or grease from metal surfaces to be treated with rust preventives, paint, or other preservative. Wash away all soap, then, see that the surfaces are DRY, and finally, apply rust preventives (or paint) without delay. It's sometimes hard to get at pockets or cavities in which water collects; be sure they are not neglected.

Dry-cleaning solvent (Varsol or Stoddard Solvent) is useful for cleaning away old grease, oil, and rust preventives. However, it's hard on rubber (use soap and water on that) and it must not get on optical lenses. Because of its irritating, flammable fumes, it should be used only where there is plenty of ventilation and where there are fire extinguishers handy. Diesel fuel or kerosene can also be used for the same purposes as dry-cleaning solvent.

Ehtyl alcohol is a good cleaning agent for optical parts.

Rifle-bore cleaner, which we have discussed in connection with small arms, is also useful for removing powder fouling in large weapons.

It's extremely important to clean off every trace of corrosion before applying preservative or paint. Once it has started, corrosion can continue even under a coat of paint or preservative.

Light traces of rust can be removed with a polishing cloth, oily or dry.

Iron rust can be dissolved but the materials used also attack the metal, so rust solvents may not be used without the specific authorization of the responsible ordnance officer. If it is necessary to use a rust solvent, take particular care to remove every trace of the solvent after it has removed the rust. Otherwise the solvent itself may act as a corrosive beneath a rust-preventing coat. The correct method for using these rust solvents (Metal Conditioner, MIL-M-10578, Type I, for unplated barrels; Type III for plated barrels) is given in OP 1208.

When using abrasives to remove rust, be careful to select the proper type (see OD 3000) and use it sparingly.

NEVER use abrasives without permission from the proper authority. Only experienced personnel may use abrasives or wire-brushing. Carelessly used abrasives can do more damage than rust. A few strokes of even a fine abrasive would destroy the accuracy of many close-fitting parts which are machined to close tolerances, and would lead to costly replacements. Always be extremely careful to keep grit from getting into bearings or between sliding surfaces.

After the rust has been removed, the parts must be thoroughly cleaned and dried. Avoid leaving your own fingerprints on the metal. Cleaned surfaces should not be touched by bare hands before the rust preventive is finally applied.

When the surface is clean and dry, you are ready to start applying paint or preservative. The official instructions for painting on United States naval ships are found in a NAVSHIPS publication and type commander instructions.

STOWAGE OF LUBRICANTS

Lubricants and related materials may be stowed for long or short periods before use. Although they are relatively stable, they are not inert, and proper stowage methods are important.

Many factors contribute to the deterioration of materials in stowage. The nature of their constituents makes them more or less susceptible to chemical and physical changes, which are accelerated by elevated temperatures, humidity, exposure, and the presence of certain catalysts. Principal physical changes are separation and contamination.

Oxidation is the most common chemical reaction in stowed materials. It occurs when the material is exposed to air, particularly moist air, and is accelerated by high temperatures and the presence of certain catalysts. Materials containing soluble additives may deteriorate by decomposition or precipitation of the additive. These and other chemical changes can produce such harmful substances as acids, gases, water, insoluble gum, and sludge. Animal and vegetable oils are generally more susceptible to chemical change than mineral oils.

Physical changes include separation of oils from the soap component in greases, and separation of insoluble additives from the parent material in oils. These changes may not be as serious as chemical changes since thorough mixing may restore the material to a usable state.

Rain, melted snow, and water vapor in the atmosphere can contaminate materials which are exposed or improperly sealed. Water vapor trapped in the container prior to sealing can condense when the ambient temperature drops.

Generally, containers used to package materials supplied under specification requirements are suitable for stowage purposes. The effects of overheating, insufficient ventilation, and proximity to dangerous materials must be considered when handling and stowing lubricants and related materials. Good housekeeping in handling and stowage areas should be stressed at all times.

Containers, when stowed, should be handled carefully to avoid breakage. If they are stacked, overloading of the lower ones should be avoided, as this may open seams and permit loss of material. To prevent accumulation of water in their upper ends, drums should be stowed on their sides.

Lubricants and related materials should be segregated from explosives and other dangerous materials.

Before containers are stowed, inspect for corrosion, leakage, and complete closure of all plugs, caps, and covers. Remove all corrosion and repaint the affected areas.

During stowage, inspect containers frequently for leakage and corrosion. If tests indicate that the contents of leaking containers are in satisfactory condition, the materials should be transferred immediately to serviceable containers. Remove and destroy leaky containers.

Inspect stowage areas for adequate drainage, foundations, and properly placed undamaged tarpaulins. Correct all deficiencies found during inspection, immediately.

Vapors from oils, greases, solvents, and similar products are flammable. When combined with air in certain concentrations, they may form explosive mixtures which can be ignited easily by a spark, open flame, or lighted cigarette. To prevent accumulation of flammable vapors, stowage areas must be properly ventilated. To safeguard against fire and explosion, display warning signs prominently, keep oil-fire extinguishing equipment available, and keep interiors of stacks open to permit entry of fire-fighting equipment. Use spark-enclosed forklift trucks only.

Flammable materials such as oils, greases, and solvents, packed in metal containers or overpacked in fiberboard or wood boxes, are best protected when stowed in special nonflammable buildings. A temperature range of 40° to 80° F is the most desirable for stowage.

When space is limited, it may be necessary to stow lubricants and related materials in a general stowage warehouse. In this case, use end bays whenever possible.

If the lack of indoor stowage facilities necessitates stowing materials outdoors, protect containers from the weather with tarpaulins or sheds to reduce the likelihood of contamination by water. When tarpaulins are used, lash them in place securely and position them so that air is free to circulate around the containers.

Vapors from lubricants and related materials may frequently have a toxic effect on the human system. Take every precaution to prevent excessive concentrations of such vapors in the air.

The following safety precautions should be observed when you are working with materials that have toxic effects:

1. Provide sufficient mechanical ventilation to reduce the concentration of toxic fumes to a safe level. When possible, ventilation should include an exhaust for fumes as well as intake for fresh air.

2. When a safe level of ventilation is doubtful, workers in the compartment should wear an air line respirator provided with a pure air supply.

3. Men working in a compartment where fumes may be above a safe toxic level should always work in pairs so that one man remins outside the compartment as a safety watch at all times. The man outside should have a respirator so he won't be overcome if he has to go into the compartment to bring out an overcome man.

4. Under no circumstance is 1,1,1-trichloroethane (methyl chloroform) to be used in a closed compartment.

As a petty officer you must see that the regulations are observed by the men in your charge.

ELECTRICAL EQUIPMENT MAINTENANCE

Your guns are under director control for the most part, locating the target, sighting, training, elevating, and firing the guns, all by electric power. You need a practical knowledge of how to make repairs on electric wiring, and how to make electrical tests of your gunnery equipment. Of course, the more you know about how electricity works, the better you will understand why repairs have to be made in certain ways. The topics in which you need to ~~have~~ a basic understanding include: principles of static electricity, series circuits, parallel circuits, series-parallel circuits, magnetism, electromagnetism, electromagnetic induction, voltmeters and ammeters, generators, d.c. motors, a.c. motors, transformers, firing and lighting circuits, and techniques for tinning and splicing wires. See Basic Electricity, NAVEDTRA 10086-B, for an explanation of the basic principles of electricity, and of how they are applied to such things as circuits, generators, motors, and transformers.

Basic Electricity has illustrations showing how to make different kinds of splices of electric wires and how apply insulation over the splices. Tools and Their Uses, NAVEDTRA 10085-B, also has instructions for soldering electrical connections, and shows how to strip insulation from electric wires with a knife and with side-cutting pliers.

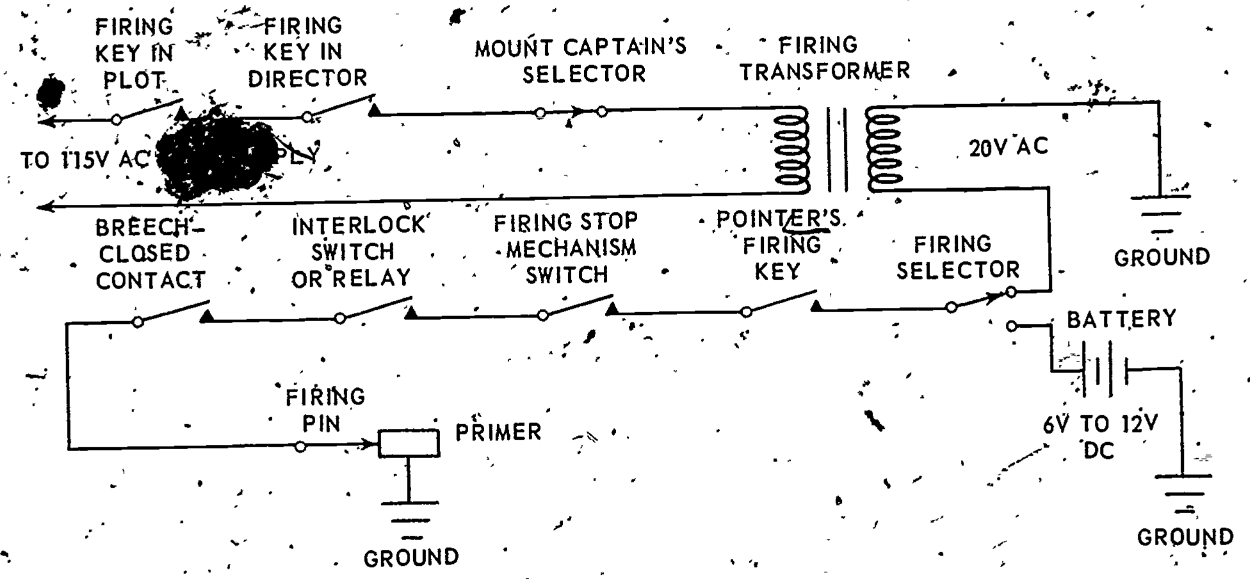
USING WIRING DIAGRAMS

As a Gunner's Mate you are required to have a working knowledge of electricity and be able to trace and identify symbols of a circuit wiring diagram. These diagrams will help you locate the source of trouble if your electric equipment fails to operate properly.

The OPs for your equipment contain the wiring diagrams that apply[illegible]glance they look very intricate; you[illegible]le to recognize the symbols used b[illegible]can trace a circuit. Blue-print Reading and Sketching, NAVEDTRA 10077-C, contains a chapter on electrical and electronic blue-prints; that chapter will help you a great deal in reading wiring diagrams. The symbols used have been adopted by the Defense Department, and all branches of the service use them. Military Standard, Electrical Electronic Symbols, MIL-STD-15 1A, dated 1963, lists the symbols in current use. If the drawing you are using is older than that, you must use an earlier issue of MIL-STD to interpret the symbols. The great increase in electrical and electronic equipment on shipboard made revision of the symbol system necessary.

Figure 14-5 shows a simple schematic type of wiring diagram. A schematic diagram shows the scheme of the wiring and not the actual placement of the parts in the equipment. The schematic diagram is helpful in troubleshooting because the electrical parts are placed in the sequence of operation. In figure 14-5 trace the circuit, beginning with the ship's 115-v a.c. supply. This highly simplified representation does not show all the switches, etc., in a firing circuit. When you can trace the circuit on this simple sketch, try a more complex one, such as the elevation controller circuit on a 3"/50 mount (OP 1698). Then try a wiring diagram (not schematic). The elementary wiring diagram shows all the wires and connections. The wiring diagrams in OPs are usually foldout and, to trace a complete circuit, you may have to put several diagrams together. The letter symbols used in the diagram are usually explained in a legend attached to it but you need to be familiar with some common electrical symbols to interpret even the simplest diagram. Basic Electronics, NAVEDTRA 10087-C, shows most of the commonly used symbols for elementary wiring diagrams. Schematic diagrams formerly used a different set of symbols.

As mentioned before, symbols have been changed and standardized in the last few years. More than likely, the OPs for your guns will have



84.280

Figure 14-5.—Electric firing circuit (schematic).

the old symbols on their wiring diagrams. The changes in symbols are not likely to cause you confusion for long: whether M or MOT is used, for example, you'll know it means MOTOR.

TESTING FIRING AND LIGHTING CIRCUITS

The firing circuits of your guns have to be in perfect working order. They must be checked every day. Even though the firing mechanism is freshly cleaned, the continuity and insulation of the firing circuit must be tested. For this, you will use an ohmmeter or a megger (megohmmeter), or a small test lamp. The continuity and insulation of the circuit can be tested without loading and firing the gun, but position the gun in a safe direction before beginning the test. Both the motor-generator circuit from the director and the local battery circuit must be tested for continuity. The testing meters are described and illustrated in Basic Electricity.

Continuity Test

Use a small test lamp (usually 20-volt) which has two insulated leads with metal tips. Hold one lead against the terminal of the firing pin and the other against any dry, unpainted metal part, on the slide or housing (to GROUND the lead). When the firing key is closed, the lamp should glow. On the motor-generator circuit, the lamp will glow more brightly than on the battery circuit. If there is no glow, there is a short or open somewhere; it must be located and repaired, and the test made again.

An ohmmeter can be used to check the continuity of any circuit that is not energized. When the test leads of the ohmmeter are connected to any two points in the circuit, the meter will indicate the resistance between those points. The ohmmeter contains both an ammeter and a battery. If the circuit to be tested has continuity, current will flow from the battery, through the test circuit, and through the meter. The meter is calibrated to show the resistance of the circuit under test. Many ohmmeters have a choise of several ranges, selected by a rotary switch, so that the scale will show the circuit resistance in ohms, or in thousands of ohms, or some other multiple.

Insulation Test

All circuits must be given a ground test every day as a check on the insulation. Moisture and excessive heat are the greatest causes of insulation breakdown. Once the insulation breakdown starts, there is a leakage of electricity, which further breaks down the insulation, until there is a ground or short. Use a megger to make the test. The meggers usually furnished to ships are rated 500 volts.

To make the test, attach one lead of the megger to the firing pin terminal and ground the other lead. Turn the hand crank of the megger at the rated speed (shown on the instrument). The needle on the dial should point to at least 1 megohm. If the reading is lower, inspect the insulation of the firing circuit. The insulation failure is most often found in the firing leads, so look there first for bare wire, frayed insulation, and oil or grease on the insulation. Always inspect the firing leads, regardless of the test results, to make sure there are no kinks, no oil or grease on the insulation, and no entanglement with other gun parts. Oil or grease may be removed by wiping with a cloth dipped in inhibited 1.1.1-Trichloroethane (Spec. O-T-620).

CAUTION: Do not breathe the fumes of solvents. Be sure there is adequate ventilation where you are using them.

If any frayed or worn insulation is found, splice in a new piece of insulated wire. Locate, if you can, the cause of the excessive rubbing against the wires, and remove it.

Testing Percussion Firing Mechanism

To test percussion firing on case guns, you use a test primer. The test primer fits into the primer hole in the base of the short case used for testing.

Here is how the test is made:

1. Position the gun in a safe direction. Remove the tompion or muzzle cover.
2. With the operating handle of the gun, lower the breechblock all the way.
3. Insert the short case (with test primer mounted) into the chamber and ram it home by hand.
4. Depress the foot firing pedal. You should hear a distinct bang as the test primer is detonated. If you don't, first make sure that the firing cutout is not the cause of failure. Do this by training and elevating to another position in which you know the gun is supposed to fire safely. Then, as you depress the foot firing pedal watch the firing shaft that connects the firing stop mechanism to the trunnion; it should turn as the foot firing pedal is depressed. If it does, and the test primer still doesn't fire, you have a malfunction in the firing linkage or mechanism to deal with.
5. If the primer tests OK, open the breech and remove and stow the case.

Test primers are used also in testing electrical firing, to supplement the test lamp and megger checks described above.

Testing Lighting Circuits

You know at once if there is anything wrong in a lighting circuit—the lights go out. In a turret or gun-mount, the men at the different stations need to report immediately if any light is out. The next step is to find the source of trouble. It may be in the fuse box, in which case you just need to replace the fuse. (When replacing the fuse, be sure to use a fuse puller of the proper type and size for that particular fuse. Be sure to replace the fuse with one of the proper rating). If replacing the fuse does not remedy the trouble, look for loose connections, broken or frayed wires, dirty contacts, acid or paint on the insulation. These circuit defects not only cause light failure or weak and flickering lights, but are a fire hazard and should be repaired immediately. The wiring diagram can show you the location of the wire. Dirt, oil, or corrosion at a connection act as insulation and reduce the amount of electricity that can pass through, and thus cause a light to be dim. WITH THE POWER OFF, clean and tighten the contacts. Then check the lights again. If replacing the fuse, and cleaning and tightening all connections does not remedy the trouble, there must be a short circuit. Breaks in the wire are most likely to occur at sharp bends or kinks. Trace the wire to locate the break, and repair it. Splicing the wire, soldering the splice, and taping it with friction tape are operations that you should be able to perform. The methods are described and illustrated in Basic Electricity.

Splicing is only a temporary means of repair. Any wire that is damaged shall be replaced. In many weapon systems spare wires are installed in a system to provide for fast permanent repair.

HYDRAULIC EQUIPMENT MAINTENANCE

You have learned about basic theories of hydraulic machinery operation in Basic Machines, NAVEDTRA 10624-A. Frequent reference has been made to the use of hydraulic equipment in other chapters of this text. Hydraulic gear will require a good deal of the time you spend on maintenance. Here are some general considerations that you'll do well to bear in mind when you're assigned to take care of hydraulic equipment.

EXERCISING AND INSPECTING HYDRAULIC GEAR

When your hydraulic system is working properly, the best way to keep it that way is to give it a workout every day. This workout should include operation in all types of control: automatic, local, and manual. If the mount isn't operated at least daily, the valves may seat and stick. So remember — to keep it in working trim, work it. In cold temperatures, the hydraulic equipment may have to be exercised as much as 15 minutes every hour.

Observe all safety precautions just as if actual firing were taking place — keep a safety watch posted to be sure no one gets in the way of moving machinery.

Even with filters in the system, water should be drained from low portions of the system frequently. The OP for the equipment has diagrams of the hydraulic system which show the location of the petcocks.

Venting of air should also be done frequently. Small cocks are located at various places in the hydraulic system. Open the cock so the air can escape; when the flow of liquid becomes steady, close the cock. Do this with each venting cock in the system.

Petcocks to check the oil level in the supply tanks should be checked daily. Checking the oil level is the first thing you do when anything seems wrong with the hydraulic system. Read and record pressure shown on pressure gauges in the system.

Note any leakage of oil. Report leakage that is more than seepage around joints and valves. If there is excessive leakage around oil seals, disassembly is necessary to replace the seals. You will need the applicable OP for instructions in disassembly and reassembly. Consult with your chief on such repairs.

The hydraulic system of any naval gun is too complex to give details here; you need the OP for your gun to become familiar with it.

DRAINING AND REFILLING HYDRAULIC EQUIPMENT

When it becomes necessary to drain the entire hydraulic system of an equipment, warm up the power transmission fluid (hydraulic oil) by operating the equipment for an hour or two. Then let the fluid drain out completely. Once you start draining, do not operate the equipment. Do not discard the oil unless you have been specifically told to do so. Sometimes it is passed through the filter one or more times and reused.

When all the old oil is drained out, you flush the system with the same fluid the system normally uses (unless otherwise specified in the OP or OD). NEVER FLUSH THE SYSTEM WITH KEROSENE or diesel fuel oil. Some of it will stay in the system and dilute oil. Besides, kerosene contains some components that will corrode metal parts. Note: Fluid MIL-F-17111 is specified as power transmission (hydraulic) fluid and is used in most of the hydraulic systems employed with ordnance equipment.

You can use the same flushing oil over and over again to prevent waste.

When refilling a system, remember two things: First, use only the oil specified by the OP; and second, always filter the oil when putting it in the system, even though you are pouring it directly from the original container. A filter is often provided with the spare parts. Use it. Even a little dirt or lint can cause plenty of trouble — enough to necessitate complete disassembly and cleaning in extreme cases.

It's just about impossible to pour oil into a hydraulic system without trapping some air. Air is the natural enemy of any hydraulic system. It is one of the most compressible things there is, so the moment you get air into a hydraulic system, you change the whole character of its operation. Therefore, any time you fill a hydraulic system, you must VENT it carefully. Vent plugs at high points should be left open during filling until it is necessary to close them to prevent oil flowing out.

You'll find detailed procedures for venting each type of equipment in the OP on the equipment, but here are some helpful hints that apply in most cases:

Generally, air-vent ports are built into the equipment at high points in the system. The basic procedure is to open the vents and run the equipment slowly until you can't see any more bubbles coming from the vents. Then close the vents briefly, and gradually step up the speed of operation, opening the vents once in a while to let out trapped air. When the equipment settles down to operating smoothly under all conditions, without knocking, you can assume that the air is out.

FILTERING HYDRAULIC OIL

Before filling a hydraulic system or replacing fluid after flushing, the fluid to be placed in the system must first be strained through a No. 200 (74 micron) sieve or, preferably, a finer sieve, No. 400 (37 micron), to remove the coarse particles that may be present. A 37 micron filter will remove particles as small as 0.0015 inch. In addition, it is recommended that the fluid be pumped through a portable filtering device with a self-contained pump such as that illustrated in figure 14-6. This procedure is especially recommended for hydraulic equipment containing servo or other systems, and having valves or other controls with close tolerance parts. Care should be taken to use the proper filter element to prevent the removal of additives. Where micronic type filters are specified for hydraulic equipment, a 10 micron filter element may be used. These filters use replaceable elements of cellulose, felt, or other fibrous materials and are capable of filtrating out particles of 0.0004 inch or less.

Types of Filters

The types of filters are: metallic or mechanical (including wire screen strainers), absorbent-inert (contain Fuller's earth), and absorbent-inactive (contain Fuller's earth and other clays).

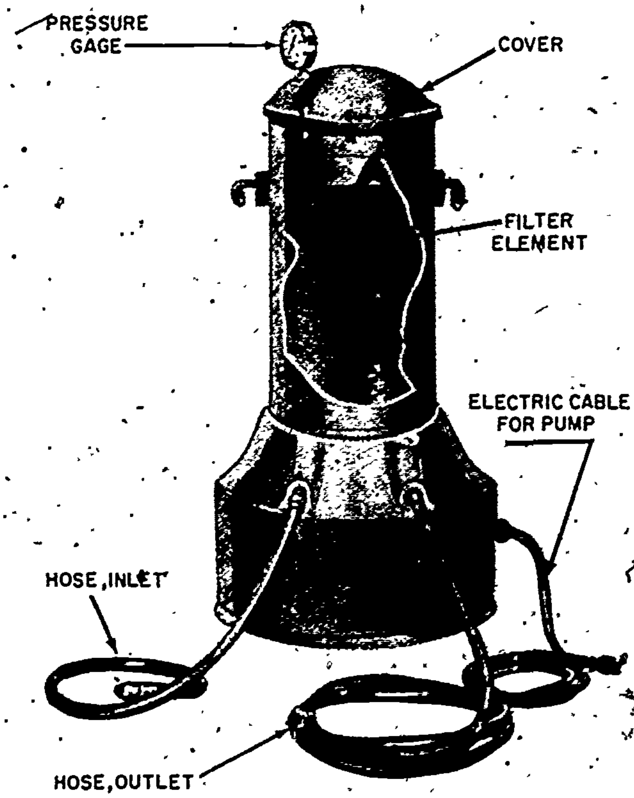
Some filters are installed in the system so the hydraulic fluid is filtered continually as it circulates (full flow filters; a by-pass filter filters only part of the oil). The filter packs of these units become clogged and must be removed and cleaned or new packs installed. OD 3000 describes and illustrates a self-cleaning metal plate filter, with replaceable filter elements, and a compressed-disc type of filter. The filtering elements of the compressed-disc type can be removed for cleaning. Practically all filters have a drain plug for removal of sediment and water.

STARTING A NEW OR REPAIRED SYSTEM

After a repair or replacement has been made in a hydraulic system, or when starting up a new system for the first time, set the controls at neutral and start the motor. Allow the system to run for 10 minutes in neutral. The circulation will be small and will be only leakage through the valve-block ports and past valve surfaces. However, it will remove particles that might otherwise cause scoring.

After this run, examine the screens or filters. If there's any evidence of foreign matter, drain the system and refill.

Not until the filters remain clean after operation do you start moving the controls gradually to build up speed and power. Watch for symptoms of valve sticking, and for leaks. At the first sign of such conditions, stop operations, find the trouble, and remedy it. Don't try to "work out" stiffness, lag, vibration, or any other trouble.



5.17(84A)

Figure 14-6. — Portable filter equipment.

The oil of all hydraulic systems should be checked at least one monthly (new installations, daily) for evidence of acidity and sludge.

When drawing test samples at drain points, inspect for water and for evidence of rust.

If there's evidence of acidity, water, or rust and sludge, drain the system and flush with clean hydraulic oil.

GASKETS, OIL SEALS, AND PACKING RINGS

Leakage of fluids from hydraulic systems is objectionable and must be minimized by using gaskets, seals, and packing. The types of sealing used in hydraulic systems vary in design and material. Seals, gaskets, and packing are designed to perform a different type of sealing function depending on the type of equipment. Packing and seals are used to seal opening around moving parts against fluid leakage. Gaskets are used to seal joints of nonmoving parts.

Types of Sealing Materials

Some of the materials used for gaskets and oil seals are neoprene, oil-treated paper, cork, annealed copper, and leather. The selection of gaskets and oil seals depends on the type of oils used in a system and the functions and type of equipment. Two of the most common types of oil seals used in hydraulic systems are the Garlock and the copper molded ring seal. The Garlock seal is used on rotating or reciprocating shafts where there is little hydraulic pressure. Copper molded ring seals are used mainly with flange fittings subject to high pressure.

Packing used in hydraulic systems is used as a seal around shafting and valve stems which are either rotating or sliding parts of the equipment. There are three different types of packing used in hydraulic system: the chevron packing to seal a unit tighter, a "U" packing is used as a seal in a groove of a flange fitting, and a rope packing is used in a stuffing box around stems of simple valves. For a better understanding of the purpose and types of sealing materials used in hydraulic systems study Fluid Power, NAVEDTRA 16193-B.

WORKING WITH HYDRAULIC PIPE AND TUBING

Preparation and Cleaning

Whenever hydraulic equipment is delivered aboard ship, it has all the openings closed with shipping covers or plugs. Keep these plugs in place until immediately before you connect them with their mating parts. Wait until all the dirty work on the equipment is finished and cleaned away before you make such connections. When you're overhauling a unit, plug all piping, ports, and other openings as soon as they have been disconnected.

New pipe is also shipped plugged to exclude dirt. Although it's presumably clean, it must be recleaned before it is assembled into the system. New pipes are cleaned with acid solution to remove oxides, but this cleaning is normally done before the pipe or tubing is brought aboard. Check the interior of the pipe by running a clean rag through it. If it is not clean, use a metal cleaner recommended in OD 3000.

Next, soak the pipe for 10 minutes in BOILING WATER.

Then turn a high-pressure stream of fresh cold water through the pipe, and dry it thoroughly afterward. Be careful not to leave threads from your drying rags in the pipe.

Finally, seal both ends of the pipe until it's ready to install. Always oil steel pipes after cleaning to prevent rusting.

Observe the following precautions when using organic solvents:

Observe ventilation and fire precautions pertaining to organic solvents. Keep acids and alkalies off skin and clothing and wear goggles to protect your eyes.

NEVER POUR WATER INTO ACID — the mixture will boil violently and may explode. Always pour the acid into the water.

If acid does splash into your eyes, or onto your body, WASH THOROUGHLY AT ONCE with clear cold water. It is wise to head for sick bay immediately after you wash off the acid.

Acids should be handled or used only in glass or lead containers. Wear goggles and rubber gloves when you handle acids or work near them. Your clothes will last longer if you wear a rubber or asbestos apron.

Making Bends

All tubing should be accurately bent and fitted so that you don't have to spring the tube into place. High-pressure tubing which has a length greater than 100 diameters should be supported by brackets or pipe clamps. Otherwise excessive vibration will develop.

The piping and tubing normally is furnished with the correct bends in them, but it is possible to bend them aboard. The pipe fitting shop is equipped to make the bends on larger pipes, but you can make them on the smaller sizes. Review Tools and Their Uses, NAVEDTRA 10085-B, on the use of external and internal spring-type benders for making bends in soft tubing (such as copper) 1/4-inch to 5/8-inch in diameter. Larger copper pipe, thin-walled, up to 1-1/2-inch, may be bent hot when packed with dry sand. The Hull Technician is qualified to do this work. Different materials require different treatment. If the metal is over-stretched on the outside of the bend, the tube will be too weak to withstand the pressure in the hydraulic system; a "wrinkle" bent too sharply on the inside bend will break the metal.

Cutting and Threading

Pipe and tube cutting is a fairly simple operation. The tools most frequently used are a hacksaw, pipe cutter, tube cutter, or oxyacetylene cutting torch. Refer to Tools and Their Uses for illustrations and methods of using the first three tools. The Navy supplies two sizes of pipe cutters, which are used on pipes or tubing over 1/4-inch inside diameter. Tube cutters are similar to pipe cutters but are used to cut tubing 1/8-inch to 1/4-inch in diameter.

All methods of cutting tend to leave burrs on the cut edge, especially on the inner rim of the pipe or tube. Remove the burrs with a pipe reamer or a file.

After you have cut the pipe length you need, it will require threading. Pipe threads taper to provide a tight fit for the pipe connection. External threads are cut with a die and die stock. Cutting threads on the inside of the pipe is called tapping, and is done with a tap and tap wrench. A pipe vise is necessary to hold the pipe securely while you work on it.

The chapter on cutting operations in Tools and Their Uses has instructions for cutting both internal and external threads on pipes. It contains tables of sizes of pipe and pipe tap drills. Another table gives you the length of thread required to give a tight connection on each size pipe. Review the chapter on measuring if you need to refresh your memory on how to measure pipe size. It is important that you select the correct size of tap or die, and the the tools are in good condition. Pipe threading is a precise operation and you must be careful or you'll make chipped or imperfect threads.

Making Joints and Connections

For threaded joints, perfectly cut threads are essential for a tight joint. There must be no dirt, chips, etc., on the threads. Wirebrush the threads to remove any such material, and finish with a jet of air under pressure. Eliminate friction to make assembly easy, but place the lubricant or pipe dope only on the male threads so it will not squeeze into the pipe. Make the last few turns with a wrench, but don't try to force the joint with an oversize wrench.

Flanged joints are often made with gaskets. Be sure you have the size, shape, and material specified for the joint. All parts must be clean and free of any dirt, particles or grit. If there is preservative on the flange faces, wipe it off with a solvent-soaked rag. The flange faces must be in perfect alignment. Insert two bolts, diametrically opposite, and set them up fairly tight. Insert other pairs of bolts similarly until all are set, then tighten all of them, using the specified torque.

When making up connections, tubing should not be welded, brazed, or soldered unless the design calls for it. Such connections make proper cleaning difficult or impossible. If a joint is gasketed, the inner diameter of the gasket must be cut back to prevent the gasket material from fraying into the system. Threaded joints which require cement should be seated at least three turns before cement is applied—and then use the cement sparingly.

REPAIR EQUIPMENT

Each Gunner's Mate G must be familiar with the techniques and tools required to maintain, repair, and adjust ordnance equipment. He must be able to select the proper general purpose tools and special tools and know the safety rules applicable for their use. Repair equipment tools can be classified as follows:

1. General purpose handtools
2. Power tools
3. Measuring tools and gauges
4. Torque tools
5. Special tools

HANDTOOLS

General purpose handtools are hand-powered and hand-operated. They are designed to perform mechanical operations. Examples of typical handtools are hammers, screwdrivers and saw. General information about handtools is in Tools and Their Uses, NAVEDTRA 10085-B.

POWER TOOLS

Power tools can either be electrically or pneumatically powered and are hand-operated. They are designed to save time and manpower. Examples of power tools used by the Gunner's Mate are soldering guns, electric drills, and pneumatic grinders.

MEASURING TOOLS AND GAGES

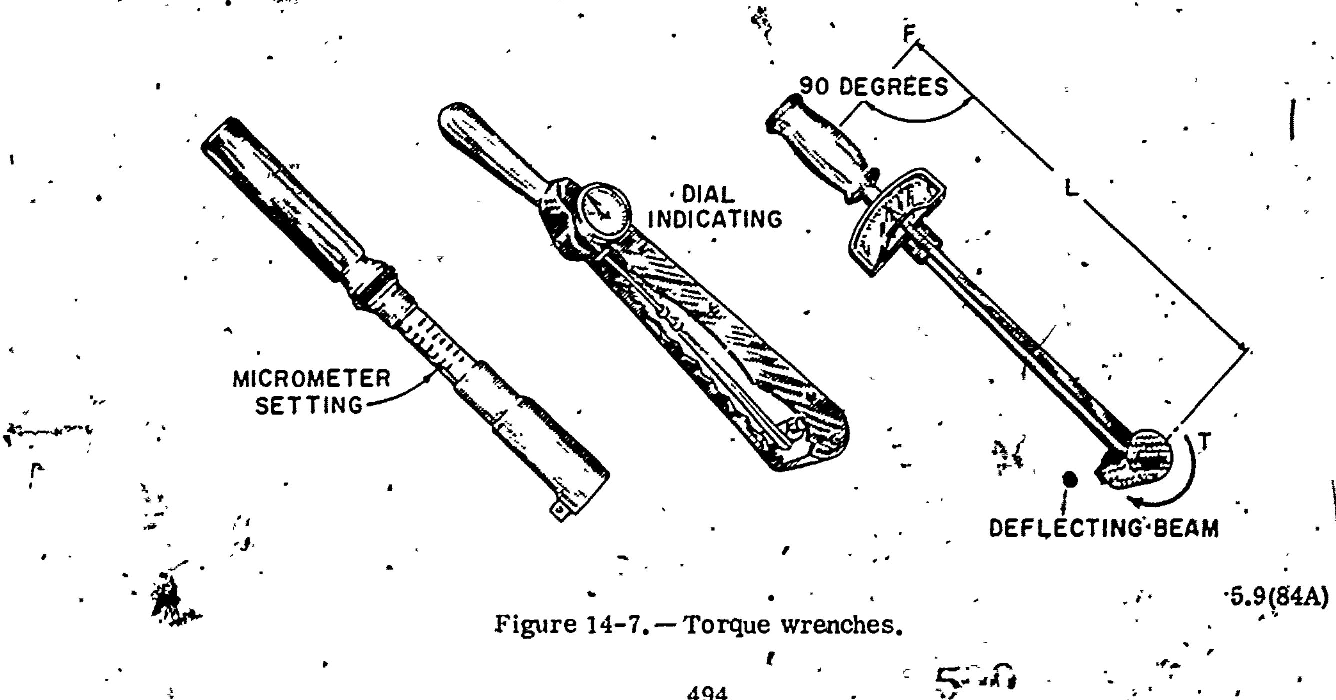
Measuring tools and gages are used for measuring and for layout work. Accurate measurements are essential for proper fitting and trouble-free equipment operation. Measuring tools and gages range from a simple ruler to a highly accurate micrometer. Tools and Their Uses gives a detailed discussion on all types of measuring tools and gages which includes the common steel rules, calipers, micrometers, dial indicators, feeler gages, and depth gages. When studying Tools and Their Uses, pay particular attention to reading micrometers and how to make feeler-gage readings. These two measuring tools are used for testing, checking, and adjusting many types of electrical, mechanical and hydraulic units used with ordnance equipment.

TORQUE WRENCHES

There are times when, for engineering reasons, a definite pressure must be applied to threaded fasteners (nuts and bolts, as they are commonly called). This pressure can properly be applied by a torque wrench. Proper torque aids the locking of all types of thread locking fasteners. After tightening, nuts and bolts are held by the static friction of the nut and bolt head against the surface of the items being held together and the friction on the threads of the nut and bolt against each other. This friction is caused by the clamping force created by a slight stretching of the bolt when the nut is tighteded. The metal being slightly elastic will pull back towards its original dimensions creating large clamping forces. Excessive tightening will cause the metal to pass its limit of elasticity and cause a permanent stretch.

The principle of torque is based on the fundamental law of the lever, that is, force times distance equals a moment, or torque, about a point. Torque is often called a torsional or twisting moment. It is a moment which tends to twist a body about an axis of rotation. If a common end wrench is used to tighten a bolt for example, a force times a distance, a torque is applied to overcome the resistance of the bolt to turning.

Figure 14-7 shows three torque wrenches, the deflecting beam, dial indicating, and the micrometer setting type. The deflecting beam which operates on the deflecting beam principle is probably the simplest and most common type evolved from the three principles listed in the preceding paragraph. The primary component is the beam or measuring element. It is alloy steel and may be round, double round, straight flat, or tapered flat. To one end of the beam is attached a head piece containing the drive square (tang) and fixed pointer mounting. A yoke is attached to the other end. Mounted on the yoke is the torque scale handle and, when provided, the signaling mechanism. As a force is applied to the handle, the beam deflects



5.9(84A)

Figure 14-7. — Torque wrenches.

with the scale. The pointer remains fixed, hence a torque is indicated on the scale.

The torsion bar or rigid case type wrench, also shown in fig. 14-7, has its actuating element enclosed in a rigid frame with a removable access cover. The deflecting beam, used in some rigid case wrenches, is similar to that explained above.

The third torque wrench shown is the micrometer setting type. To use the micrometer setting type, unlock the grip and adjust the handle to the desired setting on the micrometer type scale, then relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull in a clockwise direction with a smooth, steady motion.

There are several different types of torque wrenches, but all of them have two basic parts—something that will deflect with the load and something to show how much the sensing element has deflected.

The torque wrench should be calibrated frequently. One that hasn't been recently calibrated and isn't normally stored in its protective case is a dangerous tool. You can't expect to get a meaningful reading from a precision instrument which has been abused. The flat and round beam types will normally give true readings as long as their pointers indicate zero and the drive heads are tight. Because this type can be kept in calibration, they are recommended for shipboard use.

Other type wrenches that indicate by means of dial indicator or by releasing or signaling when a preset load is reached are more sensitive to shock and dirt, hence should be calibrated whenever possible. A minimum of 30 days between calibration is recommended. Never check one torque wrench against another.

An important point to remember is: "Always use the proper size wrench;" the one with the desired torque near the 3/4 mark of full scale.

When torquing, the critical maneuver is the application of force to the wrench handle. It must be applied slowly and evenly until the desired torque value is indicated on the wrench scale. When installing a unit which is circular or has more than one side, the bolts should be cross torqued. It may be necessary to cross torque two to three times before an even torque is reached, but be sure the maximum torque is not exceeded.

Nuts and bolts should be tightened to the torque reading required by the installation drawings. The formula often used is that torque in foot-pounds is 0.2 times the bolt diameter times the desired bolt load. A load of about 60 percent of the yield stress of the bolt material is used for most naval applications. However, bolt load varies depending upon whether the bolt or stud is used to support the load itself or to hold together two load supporting members. Installation drawings will indicate the torque value specified by the designer.

If the bolts are loaded in tension, the torque must be great enough to maintain tightness when the assembly is unloaded and not so large that the bolts yield under load. With this type of loading, all bolts must be equally torqued to share the load.

NOTE: Always inspect for clean lightly oiled threads and clean surfaces before torquing. Discard all hardware with burred threads. For more detailed information on the use and care of torque wrenches refer to NAVSHIPS Technical Manual, Chapter 9090.

SPECIAL TOOLS

Special tools are used only for one purpose and only on one type of equipment. They are supplied by NAVORD, and instructions for their proper use are provided in publications applicable to the specific type of equipment.

NONSPARKING TOOLS

Nonsparking tools are common handtools and special tools made from nonferrous metals (metal not containing iron). These tools are used by the Gunner's Mate when working on or around explosives. These tools are generally made from a copper alloy (bronze). However, they may be made from other nonsparking materials. Since these tools are made from a relatively soft material, care must be exercised when using them to prevent breakage or distortion of the tool. Nonsparking tools should be stowed in separate tool boxes and should not be used as common handtools.

RULES APPLICABLE TO REPAIR TOOLS BEFORE A JOB

Before a job is started, all work procedures should be planned and the proper tools selected to complete the job. Tools not actually needed for a job should be properly stored in tool boxes or tool lockers.

The quality and type of all tools shall conform with Navy standards.

All tools in active use must be properly maintained. Defective tools may not be used.

Portable electric and pneumatic tools must be kept in the best condition possible. These tools should be checked frequently by the toolkeepers for defective switches, electric cords, control valves and hose connections.

To increase leverage, extensions to tool handles may not be used.

PRESSURE GAGES

Pressure gages are used frequently in conjunction with ordnance equipment. Accurate pressures are necessary to obtain proper operation of hydraulic, pneumatic, and nitrogen accumulator systems used in ordnance equipment. Pressure gages also are used with hydraulic test kits and magazine sprinkling systems. These gages are the means of accurately measuring pressures in pounds per square inch (psi). Pressure gages are used in weapon systems to measure hydraulic fluid pressures (oil gage), magazine sprinkling system pressure (water gage), counterrecoil system pressure (air gage), and accumulator systems pressure (nitrogen gage).

The two most common types of gages used with ordnance equipment are the Bourdon and Schroeder pressure gages. The theory of operation of these gages is explained in Fluid Power, NAVEDTRA 16193-B.

Following are some precautions to be observed when using pressure gages.

1. Do not allow pressure to remain on gages that are permanently installed in hydraulic systems.

CAUTION: Never use an oil gage for testing air pressure, nor an air gage for testing oil pressure. A diesel action may occur! Diesel action is the ignition of oil by air which causes combustion.

2. Never use a gage on any system in which the maximum pressure exceeds the maximum designated range of the gage.

MAINTENANCE OF GUN BORES AND CHAMBERS

Every gun used in the Navy has a bore and chamber. Taking care of them is one of the first duties of the Gunner's Mate G.

Care of the bore and chamber is no one-a-year or once-a-month matter. They must be cleaned, dried, and inspected before firing; then cleaned, inspected, and oiled weekly. They must be gaged periodically, and the bore must be decoppered when necessary.

Maintenance of the bore and chamber is an important job — not ordinarily a very difficult one, but one that must be done in the way and at the times required. In your basic training you learned the proper methods for caring for your rifle and pistol. Chapter 4 of this manual told you how to care for other small arms weapons.

Frequent reference has been made throughout the book of the need for keeping your guns cleaned and lubricated.

TOOLS USED

With the exception of one or two small-arms weapons, for which maintenance tools are usually issued separately, every naval gun is equipped with certain basic maintenance tools and accessories. Larger guns and mounts are, of course, equipped with more elaborate sets of tools, but all sets include as a minimum the implements that are required for care of the bore and chamber.

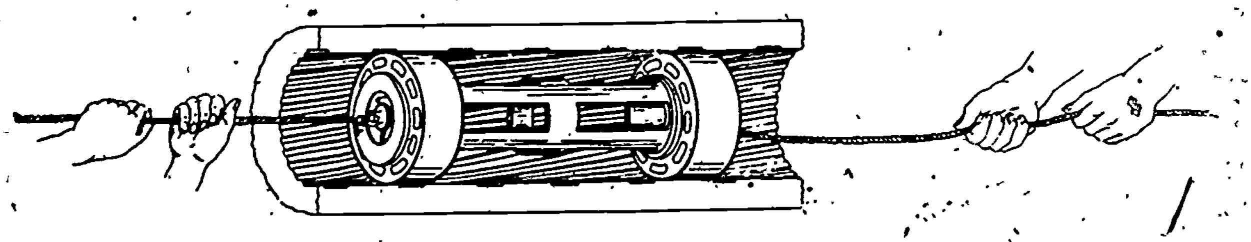
Cleaning Gear

The bore and chamber maintenance tools and accessories issued for the 5"/54 are typical of such implements. The bristle sponge, and the wire bore brush with the sectional handle and the lapping head, are the basic cleaning instruments.

The sectional handle is a wooden rod with couplings at both ends that can be fitted either to similar couplings on other sections, or to bore maintenance tools like lapping heads, gages, etc. In the 5"/54 set, there are several of these sections supplied so that, by joining one to the other you can make a pole of any appropriate length for the job at hand. The number of sections supplied with any gun makes accessible any part of the bore.

The bristle sponge is a cylindrical brush used for cleaning the bore and chamber. It fits onto the end of the sectional handle. When stowed, it is covered with a canvas protecting cap.

The lapping head is a cylindrical block on which can be mounted four removable spring-loaded segments. It is intended only for relatively slight constrictions. In stubborn cases you will



84.107

Figure 14-8.—Checking for bore constrictions with bore plug gage.

need to use the wire bore brush. Its stiff steel wire bristles are effective in all but the very worst cases. Do not use the wire brush on chromium plating in barrels.

The tompion is used to keep dirt out of the gun bore and chamber. It is not used when there is a likelihood of condensation forming in the barrel with muzzle plugged. It is also not used in war-time, when there might not be time to remove it before firing. Sometimes plastic or canvas covers are used over the muzzle; the guns can fire through them if necessary (unless heavily ice-coated or if supersensitive nose fuses are used).

Gages

The bore plug gage shown in figure 14-8 is a metal cylinder accurately machined so that it just passes through the bore when the gun is new. After the gun has been put to active use, constrictions may develop in the gun bore. The bore plug gage is used to locate these constrictions. The gage shown in figure 14-8 is the type used in large caliber guns. On guns of 5-inch or smaller, the bore plug gage fits onto the end of a section handle in the same manner as the previously covered accessories.

The bore erosion gage is used in the gun barrel to measure the amount of erosion of the metal caused by firing.

Inspection Instruments

Visual inspection of the bore and chamber both precedes and follows cleaning operations. A light, of course, is very helpful in seeing inadequately cleaned areas, pitted areas, rust or corrosion, deformed lands on rifling grooves, cracks, or other deviations. A bore searcher is used on 20-mm and larger guns. Look for corrosion at the muzzle end caused by salt spray.

If the chromium plating in the chamber of bore appears pitted, the weapons officer will decide if it is bad enough to need replating.

PREPARATION FOR FIRING

To prepare the gun for firing, the bore and chamber must be inspected and cleaned. Removal of lubricant and muzzle cover or tompion are but some of the operations in the preparation for firing.

Removing the muzzle cover or tompion is easy. To clean out the bore, however, the lubricant coating must be wiped away. In small arms, as you remember, this is done with a cleaning rod and a patch. In larger guns, you use the sectional handle instead of a cleaning rod, and clean toweling wrapped around the bristle sponge in place of the patch. But the idea is exactly the same.

These instructions apply to guns that have been in use and were given after-firing care when last used. If you are preparing a gun barrel that has been taken from storage, or if it is a new one, you have much more work to do. The preservative used on new or stored barrels must be removed with dry-cleaning solvent. When every bit of the preservative has been removed, all the solvent must be wiped out of the gun. (See OP 1208).

CAUTION: Observe ventilation and fire precaution rules when using dry-cleaning solvent. Remember also that solvent is drying and irritating to the skin and destructive to rubber and insulation.

AFTER-FIRING CARE

After-firing care is more elaborate than prefiring care. Every time a gun is fired, something besides the cartridge case is left behind. Deposits of corrosive salts (powder fouling) are left on the interior of the bore and chamber. As the rifling cuts into the projectile rotating band, some of

503

the rotating band's metal is left behind as a deposit of copper in the bore (metal fouling or copper fouling). Both kinds of deposits are harmful and must be removed. Powder fouling causes corrosion. Copper fouling causes narrowing or constriction of the bore. Constriction will cause poor performance of time fuzes and increase dispersion of projectiles.

Steel constriction is most likely to occur in guns with steel liners. If it resists removal by lapping and polishing, you have a job for a repair installation. Steel constriction can cause the barrel to burst if the gun is fired without removing the constriction. It is not a deposit of metal like copper fouling, but is caused by shoulders of the liner overriding those of the tube, forcing the walls of the liner inward.

The first problem in after-firing cleaning is the removal of powder fouling. Method 1 uses Rifle Bore Cleaner, MIL-C-372; Method 2 uses soda ash — water solution to dissolve the propellant residues. Method 1 is used on small arms, 20-mm and 40-mm guns, and sometimes on 3"/50, 3"/70, and 5"/54 guns. It is the method to use where it is impractical to rinse with water, or where water would cause damage, as on electric wiring. Swab the bore and chamber with the bristle bore sponge or a patch saturated with rifle bore cleaner. Then wipe out with Solvent, P-D-680, Type 1.

Method 2 for cleaning gun bores is used for larger guns, though rifle bore cleaner may be used. The large quantity of cleaner required makes the soda ash — water solution preferable from an economy standpoint. Make a solution with 1 pound of Soda Ash, O.S.-571, per gallon of hot water. Saturate the bristle bore sponge, and sponge out the bore and chamber. Follow with a rinse of fresh hot water.

CAUTION: Keep soda ash solution off adjacent mechanisms. It must not be used to clean aluminum or aluminum alloy parts or zinc-base die castings.

After either cleaning method, dry the chamber and bore thoroughly with the bristle bore sponge wrapped in clean toweling. Be sure to get into all crevices; compressed air may be used for these. Then proceed with these steps:

1. Gage the bore. If it tests OK, go on to step 3. If the bore gage does not pass freely, report it to your leading petty officer, or use the bore lapping head, depending on the standard operating procedure in your division.

2. After using the bore lapping head on the constriction, wipe out the bore and again try the bore gage. Repeat lapping if necessary, or use other methods of removing the constriction, as directed. When the bore gage passes, rinse out the bore and chamber with fresh hot water and dry thoroughly with the bristle bore sponge wrapped in clean toweling. IT IS FORBIDDEN TO FIRE THE GUN UNLESS THE BORE GAGE HAS BEEN PASSED.

3. Apply a coating of the prescribed oil to the bore, using an oil-soaked cloth wrapped around the bristle bore spong.

4. Secure the gun and install the tompion or muzzle cover.

When you inspect the bore after cleaning, you may see dark patches or rings called smoke rings discoloring parts of the bore. These are not serious.

Areas adjacent to the breech should be cleaned of propellant residue by scrubbing or wiping with the rifle bore cleaner, then wiping with solvent, followed by thorough drying.

Method 2 cleaning (soda ash — water solution) may also be used on unpainted surfaces of deflector paltes, shields, guide port shields, blast shields, launching rails, guides, and other components of rocket launchers, projectors, and missile launchers on which the use of this method is appropriate. Danger of getting water into complex equipments and wiring will determine whether you can use this method on this equipment. It must not be used where the solution might be trapped in bolted or riveted assemblies or subassemblies.

Weekly Maintenance

Weekly maintenance is principally concerned with inspecting the bore and chamber to find signs of corrosion, and renewing the coating of oil. Decoppering and gaging may also be done at the time of weekly inspection although they are usually a part of the before-and-after firing routine. Weekly maintenance is particularly important during periods when the gun is not being fired every day.

GAGING

The plug gage, described earlier, is used with guns 3-inch and larger for detecting constriction of the bore. After the bore has been cleaned, attach the gage to the extended sectional handle and pass it carefully through the muzzle until it clears the chamber end. If it passes through smoothly, the bore is not constricted.

If the bore has been constricted by copper fouling or distortion of tis surface, the gage will not pass. The next step is to mark the part of the sectional handle that is flush with the muzzle end to locate the constriction. Then draw out the gage, remove it from the sectional handle, and attach the lapping head in its place. Push it into the gun bore up to the mark you placed on the handle, and rotate it in the constricted area. Use the cylindrical segments for the lands and the rifled segments for the grooves. A mixture of pumice and oil may be used as an abrasive. Continue lapping until the bore gage will pass freely. NEVER try to force the gage through the bore; it may stick, with damage to both bore and gage.

On guns 8-inch and larger the plug gage is too massive to be conveniently managed with a sectional handle. Instead, it is drawn through the bore with line.

The plug gage is the gage you will use most in maintenance of gun bores. But there are other gages, too—headspace gages, breech bore gages, and star gages.

Information about the types and uses of gages is in system OPs and ODs.

Decoppering

We have already described the use of lapping heads and a fine wire brush (0.003 in wires) to remove copper deposits in gun barrels. If the constriction is not removed after a few trials with the lapping head, the decoppering head may be used. These are mechanical or abrasive methods.

Firing decoppering shots is another method of removing copper deposits. (It may not be used for guns with liners). Your chief will help you in preparing special decoppering rounds when the weapons officer thinks it advisable to use them.

If there is metallic lead in the propellant, there is much less copper fouling when the round is fired. However, the lead causes flash, and the more lead, the brighter the flash, which you don't want. To keep the flash to a minimum, the lead in most charges is kept to a minimum. Propelling charges now being manufactured contain lead salts for decoppering effect. Eventually, every shot fired will be a decoppering shot.

Another possible method of removing copper deposits from gun bores is with chemical solutions. However, these are not approved for use aboard ship so this method will not be described here. It is given in OD 3000.

Be sure to check that the bore is clear after an decoppering, especially after firing a decoppering shot.

Special decoppering rounds may be prepared aboard ships by adding lead foil to a standard propelling charge. When the decoppering round is fired, the added lead foil vaporizes and a thin lead deposit settles on the surface of the gun rifling. This thin lead coating discourages any copper deposits from a projectiles rotating band from sticking to the gun rifling. A decoppering action will continue as long as vaporized lead is deposited whenever a gun is fired.

SAFETY

The primary reason for the vast amount of information available on the subject of safety precautions is simply the desire to prevent accidents. Research has shown that a majority of all accidents came about through sheer carelessness. Not only is there a loss of time involved in an accident, but also there is an accompanying loss of either equipment, material, or, in the extreme case, life itself. Aside from these important considerations, there is a vast amount of money wasted in replacing damaged equipment, making investigations, paying for hospitalization or funerals, and for man-hours not worked during convelescence. These are but a few of the problems faced every day by the Navy because personnel fail to heed the posted and required safety precautions.

Safety is everybody's job. Awareness of danger, knowledge of how to avoid it, and constant vigilance are the three basic requirements for the prevention of accidents while you are working on or operating ordnance equipment.

Safety is both a result and a reflection of good training. The crews of a gun mount may be trained so that every man thoroughly knows how to do his job; however, the crew still cannot be considered well trained unless every man is safety conscious. Safe working habits must be impressed upon every crewman through proper instructions, constant drills, and continuous supervision. Carelessness, cockiness, and lack of training have led to disaster while working with all types of ordnance equipment and material.

Practical safety features are incorporated into Navy equipment to eliminate potential hazards to personnel. Since familiarity with equipment leads to carelessness, observation of all safety notices and rules is mandatory. NO RELAXATION OF VIGILANCE SHALL EVER BE PERMITTED.

Each piece of ordnance equipment has a specific list of safety precautions to be observed during operation and/or maintenance. Study these thoroughly before attempting to operate or repair any piece of equipment with which you are not familiar.

The following safety rules are but a few of the many that must be observed when operating or working on hydraulic or pneumatic systems.

Never disconnect hydraulic lines or disassemble hydraulic equipment when the hydraulic system power motor is running.

Never disconnect hydraulic lines or disassemble hydraulic equipment until the accumulators have been manually dumped to tank.

Never manually actuate switches, solenoids, relays or valves on hydraulic systems under pressure unless you are competent and qualified to perform these actions.

Report hydraulic leaks immediately so that they may be repaired at the first opportunity.

If clothing becomes drenched with hydraulic fluid, immediately change into dry clothing for hydraulic fluid is injurious to health when in prolonged conctact with skin. It is also a fire hazard. Immediately wipe up all spilled fluid.

Do not direct a high-pressure air jet at any part of the human body; this may be fatal.

All personnel taking part in and observing operation of power equipment shall remain alert, keep clear of moving parts, and be thoroughly familiar with the safety precautions applicable to that equipment. At no time will skylarking be allowed in the vicinity of operating power equipment.

Hydraulic systems operate under hydraulic pressures ranging from approximately 100 psi to 2,000 psi. Some pneumatic systems operate in approximately the same range of pressures as hydraulics. These pressures are dangerous and can be hazardous to personnel.

Safety precautions must be observed when performing maintenance, testing, and operating ordnance hydraulic and pneumatic equipment. The high pressure liquid or air can cause major injuries to your face, hands, and other parts of the body by jets of air or liquid escaping from valves or pipe connection which are highly pressurized.

The following summary of safety precautions is intended to be general in nature but their importance should not be misunderstood.

Do not service or adjust live equipment without the presence of another person capable of rendering first aid.

Never measure potentials over 600 volts by means of flexible test leads.

Do not tamper with interlocks or any other equipment safety feature.

If possible, use only one hand when working on live circuits.

Never use electrical or electronic equipment known to be in poor condition.

Do not allow unqualified personnel to operate the control panels. Trainees or other persons undergoing instructions shall operate only under the strict supervision of a qualified and responsible operator.

Except for General Quarters, always sound the train warning bell and get an all-clear signal before training and/or elevating the gun mount (before each time the equipment is to be moved).

Whenever any power drive unit that is capable of inflicting injury to personnel or material, not continuously visible to the person controlling such motion is moved, the officer or petty officer authorizing the unit to be moved by power shall ensure a safety watch. The safety watch shall be omitted in general quarters, but must be maintained in area where such injury is possible, both inside and outside the unit being moved. There shall be telephone or other effective voice communication established and maintained between the station controlling the unit and the safety watch.

There are a few basic rules that you should keep in mind when using wrenches. They are:

1. Always use a wrench that fits the nut properly.

2. Keep wrenches clean and free from oil. Otherwise they may slip, resulting in possible serious injury to you or damage to the work.

3. Do not increase the leverage of a wrench by placing a pipe over the handle. Increased leverage may damage the wrench or the work.

4. Provide some sort of kit or case for all wrenches. Return them to it at the completion of each job. This saves time and trouble and facilitates selection of tools for the next job. Most important, it eliminates the possibility of leaving them where they can cause injury or damage to men or equipment.

5. Determine which way a nut should be turned before trying to loosen it. Most nuts are turned counterclockwise for removal. This may seem obvious, but even experienced men have been observed straining at the wrench in the tightening direction when they wanted to loosen it.

6. Learn to select your wrenches to fit the type of work you are doing. If you are not familiar with these wrenches, make arrangements to visit a shop that has most of them and get acquainted.

The following precautions should be observed when using torque wrenches:

1. Do not use the torque wrench as a hammer.
2. When using the micrometer setting type, do not move the setting handle below the lowest torque setting. However, it should be placed at its lowest setting prior to returning to storage.
3. Do not use the torque wrench to apply greater amounts of torque than its rated capacity.
4. Do not use the torque wrench to break loose bolts which have been previously tightened.
5. Never store a torque wrench in a toolbox or in an area where it may be damaged.

Be throughly familiar with all posted safety precautions and those listed in the OP pertaining to the equipment to which you are assigned.

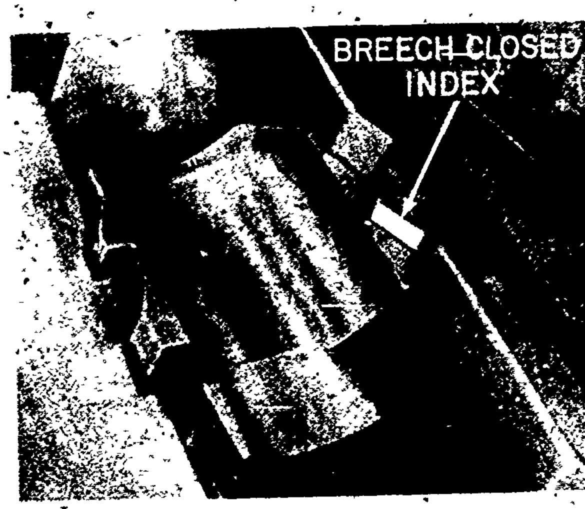
Don't think that once you have learned all applicable safety precautions you can set back and take things easy. Review the precautions periodically, particularly those for jobs seldom performed. Try to improve upon any rules in effect. Safety is everyone's responsiblilty, not just those who drew up the regulations. Most accidents are caused by men who are so familiar with their job they think they can take short cuts; by men who don't know the applicable precautions; by practical jokers; or, in the majority of instances by plain carelessness.

SPECIAL SAFETY MARKINGS

Index marks and safety lines are painted on or near ordnance equipment and are used by the GMG to indicate a complete mechanical function and to indicate safe areas.

An example of the index mark is the breech-closed index painted on the gun housing (fig. 14-9). The index mark shows at once whether the breech-block rises promptly to full breech-closed position, or is sluggish or sticks. The 5"/38 also has index marks on the housing and slide to indicate full return to battery and breech completely closed. These index marks tend to wear off, and require periodical freshening up. Be careful not to get the paint on any other part of the sliding surfaces.

Safety lines mark off safe working areas. Circular safety lines are painted on the deck around a gun mount to indicate the areas you should stay out of when the gun is being trained. "Blast area" lines are painted on the decks around rocket launchers, to show how far away you must get to be safe from the hot rocket blasts. Similar safety lines are necessary to show safe working areas around overhead conveyors and other machines that may be dangerous to men who fail to keep away from working parts.



84.279

Figure 14-9.—Breech-closed index (5"/38 gun).

THE 3-M SYSTEM

From our study of Military Requirements for PO 3/2, NAVEDTRA 10056-C, we learned about the Navy Maintenance and Material Management (3-M) System now being implemented in the fleet.

This subject is not covered in detail in this publication. We only review some of the objectives of the 3-M system and its subsystems, which include the Planned Maintenance Subsystem (PMS) and the Maintenance Data Collection Subsystem (MDCS).

The 3-M system is designed to (1), to reduce the complex maintenance requirements of shipboard equipment to simple procedures that are easily identified and managed; (2), to define the type of maintenance required (preventive or corrective); (3), to schedule and control its performance; (4), to describe the methods and tools used; and (5), to prevent or detect impending casualties.

An effective 3-M system permits a ship to forecast and plan man-power and material needs, schedule maintenance, estimate and evaluate material readiness, and detect areas for improving training and maintenance techniques.

3-M SUBSYSTEMS

The 3-M system is a combination of five subsystems of which two are primary for shipboard personnel. These two subsystems are the Planned Maintenance and the Maintenance Data Collection Subsystems. These sybsystems when used properly will:

- Increase reliability. Equipment will suffer fewer breakdowns due to a detailed and orderly maintenance schedule.

- Increase economy. Preventive maintenance saves the cost of casualties and expensive repairs.

- Enable better planning. The 3-M system takes into account shipboard operations, upkeep, availabilities, and contingencies and facilitates efficient and convenient programming of work.

- Increase support. By providing feedback information, all elements which support the fleet will function better.

The MDC subsystem reduces paperwork aboard ship superseding various currently used reports and forms.

The Planned Maintenance Subsystem uses the Planned Maintenance System Manual, OPNAV 43 P1, a cycle schedule, quarterly schedule, weekly schedule, and a set of maintenance requirement cards (MRC).

Planned Maintenance Subsystem

The maintenance requirement data are collected from the fleet, systems commands, equipment manufacturers, and other sources for all weapon systems and their associated equipment. After the maintenance requirements for a given system have been determined, the necessary maintenance procedures are listed on standard Maintenance Requirement Cards (MRCs), and they are distributed to the fleet. Eventually, every ship will receive MRCs for every piece of ordnance equipment aboard ship. MR cards are explained in Military Requirements for PO 3 & 2.

Maintenance Data Collection Subsystem

The Maintenance Data Collection Subsystem provides a means of recording maintenance actions (planned or corrective) in a form suitable for machine processing; this permits evaluation of equipment performance, repair parts used, delays incurred, reasons for the delays, and man-hours required to maintain the equipment.

The Planned Maintenance Subsystem differs from the Maintenance Data Collection Subsystem in that the PMS tells when, how, and by whom the maintenance is to be performed; the MDCS informs the collection center what was done, who repaired the equipment, how long it took, and what repair parts were required to accomplish it.

REPORTS AND RECORDS

The 3-M system is probably the most important material record of the weapons department aboard ship. However, in ship's where the 3-M system has not been fully implemented, ordnance history cards may still be in use. The weapons officer is responsible for maintaining these records in an up-to-date and useful manner.

The retained copies of the 3-M system schedules now are the principal sources of maintenance information on new construction. On older vessels, in addition to the retained copies of the 3-M schedules, material history is maintained on ordnance history cards. How maintenance history records are maintained depends on the type ship and how much change over from old type maintenance system to the 3-M system has been accomplished. Many of the former sources of maintenance history are replaced by the 3-M system. Various logs are also used in the weapons department for maintenance history information.

Ordnance History Cards

A complete material history of an ordnance unit is important in determining maintenance, operational practices, safety precautions, and equipment capability. These cards can also be used as inventory records and should be grouped in a binder so that all cards for a given piece or ordnance, a gun mount for example, are located together for easy ordnance inventories. Information can be obtained for these cards from battery logs, smooth logs, and a visual inspection of the equipment.

LOGS

An ordnance log is a book which you record chronologically information about tests, overhauls, repairs, alterations, maintenance work, and operating performance on certain ordnance equipment.

A well-kept log is handy to YOU as a casualty reference. If a casualty occurs that has happened before, the log can be consulted for the method of repair previously used. If a certain type of repair method has proved unsatisfactory, repetition of that method can be prevented by referring to the log. When a new man takes over a piece of ordnance equipment or the system itself, he can refer to the equipment logs and become familiar with the equipment's peculiarities.

The type commanders administrative inspection check off list determines the minimum requirements for logkeeping on your ship. It is expected that with the advent of the 3-M system the number of logs to be kept will be drastically reduced. However, because the documentation under the 3-M system does not give adequate life history of specific equipment, many rough and smooth logs are still required. Aboard a destroyer, for example, the weapons officer could require a minimum of four types of logs as follows:

1. Battery log (rough log)
2. Weapon system log (smooth log)
3. Small arms log
4. Magazine log

Battery logs (rough logs) are handwritten entries in a notebook type ledger, containing such information as:

1. Tests
2. Routine maintenance not covered
3. Work schedules
4. Boresight and tram readings
5. Rounds fired

This ledger is used as a source of information for each mount, turret, rocket launcher or missile launcher containing the Mk, Mod, serial number etc. of all the major components of a system. There is no prescribed form for making entries except those set up by your weapons officer. Log entries should be neat, clearly dated, and arranged in orderly sequence so that the reader (weapons officer) can see where each entry begins and ends.

Weapons System Log

A weapon system log (smooth log) contains sections devoted to ordnance equipment by battery or by system. Data included are:

1. System battery alignment
2. Star gage data
3. Erosion data
4. Rounds fired for each gun barrel (listed by serial number) of each gun system
5. The type of projectile and powder charge used
6. The powder index number and a record of ESR (Equivalent Service Rounds)
7. Bench mark readings
8. Train and elevation position readings
9. Roller path readings
10. Boresight data

Most smooth logs use a standard format for each type of entry.

Small Arms Log

The small arms log should show all pertinent information on all small arms aboard ship. It should list the weapons by serial number and type. Log entries should include any repairs, modifications, and types of casualties to each weapon, results of small arms inventories, and the location of each weapon.

Magazine Log

The magazine log should show the quantities of ammunition stored in each magazine and handling room. Ammunition should be identified by types, marks, and mods of all its components (primers, fuzes, etc.), and the lot and index numbers of all projectiles and propelling charges. It should also show the results of all tests and inspections of ammunition, sprinkler system tests, daily magazine inspections and daily temperature readings.

The weapons officer also maintains a smooth ammunition ledger, an accounting system for ammunition, in which are recorded all receipts and expenditures as they occur.

SOURCES OF MAINTENANCE INFORMATION

It would be impractical to try to squeeze into this chapter the many details you must know to perform maintenance, troubleshooting, disassembly, and reassembly to ordnance equipment assigned to you. Since there are many different marks and mods of equipment performing the same function but having different working parts, the Naval Ordnance Systems Command prints a publication requirement list for every active duty ship now in service. This list is based on the major units installed and lists all the OPs, ODs, FMs, and TMs needed for repair, maintenance, test, and operation of the ordnance equipment. Copies of all the publication listed in these ODs are furnished to the vessel as part of the original commissioning allowance. If additional copies are required, they can be ordered through the appropriate supply point.

OP-O

OP-O is the index of the Naval Ordnance Systems Command ordnance publications. It lists by number and subject the ordnance publications (OPs) and ordnance data (ODs) used in the Navy. OP-O also lists all current revisions, changes, and supplements to OPs and ODs as well as those in preparation, cancelled, obsolete and those for special projects.

The information in OP-O is currently being entered in the automated data files of the Ordnance Logistics Information System (ORDLIS). When this is completed, a new OP-O will be distributed containing both the subject and numerical index. OD 39397, Index of Technical Manuals for Conventional Ordnance, will be discontinued when ORDLIS can support an automatic output for OP-O.

As of this writing, the first official index titled Numerical Index of Naval Technical Manuals, to be developed from ORDLIS has been published. This publication is a numerical index only. The issuance of an accompanying subject index has been delayed pending the completion and validation of the necessary cross-reference files by the cognizant In-Service Engineering Agents. This validation of files is now underway and a complete revision of OP-O is expected to be issued in the near future.

ORDNANCE PUBLICATIONS

Ordnance publications (OPs) are used by the operating forces and contain descriptions of ordnance equipment and their component parts; instructions on how to operate, maintain, disassemble, reassemble, test, and adjust the equipment. All OPs have a section on safety instructions both for operating the equipment as well as general and specific safety orders when troubleshooting. The OPs are published by NAVORDSYSCOM; each under its own OP number. They may be prepared by some other naval activity, by the manufacturer, or by the Command itself. Any changes to OPs are issued by NAVORDSYSCOM. Changes issued to the fleet are numbered and a record of all changes are listed on a change record sheet posted in the front of every OP. The information on these sheets includes the change number, the date the change was made, the title or brief description of the change, the signature of the person making the change, and the signature of a validating officer.

ORDNANCE DATA

Ordnance Data (ODs) are a kind of catchall. They are used for publishing advance information or instructions on ordnance equipment installation and alignment data, parallax data, and other miscellaneous information, such as tables of weights and dimensions. Formerly, ODs were used for publication of test and inspection data. Ordnance Reports are now used for this purpose. ODs are numbered consecutively by the issuing agency. ODs, like OPs, are listed in OP-O.

One OD that is required reading for you, and for all other Gunner's Mates, is OD 3000, Lubrication of Ordnance Equipment. It is the one OD that your ship's library of ordnance publications must not be without. Other ODs may be useful to you, depending on the type ship you are aboard and its armament; but for that information you should consult OP-O. If they are not already in your ship's library, they can be ordered.

Revisions

Revisions are made to OPs and ODs when the original publication becomes obsolete due to many design changes to the equipment. Revisions are numbered and the latest revision supersedes the previous one. When revisions of OPs are made available, be sure you check the new OP for the purpose of the revision. In come cases, a revision may replace other OPs or ODs and their supplements. A statement in the front of each revised OP or OD states which publications are made obsolete by the revision.

Changes

Changes may consist of pen and ink changes, complete page changes, or changes to drawings and sketches. Changes are made to OPs and ODs after Ordlats have been completed or when errors and inaccuracies are found in a publication.

Supplements

A supplement is an addition to an OP or OD which reflects changes to equipment or its operation made since the OP or OD was published. The original publications are still used; the supplements describe only the differences between the major assemblies, or the differences between the the Mks and Mods of gun mounts, turrets, missile launchers, and rocket launchers.

Supplementary Sources

At times, during the course of your work, you may require information not covered in OPs or ODs. Where you find this information depends upon the type of ordnance equipment you are working with. If you are working with demolition equipment, Explosive Ordnance Demolition Bulletin (EODB) could help you. Other types of publications are Special Weapons Publications (SWOPs), NAVORD Instructions and Notices for general policy matters, and such other publications as ORDALTS-OO, which supplies information on all ORDALTS for aircraft, shore stations, and all classes of vessels.

The Army prepares several publications that are also applicable to Navy Ordnance. These include field manuals (FMs), Technical manuals (TMs), technical bulletins (TBs), and joint publications of the Army, Navy and Marine Corps. These publications are listed in The Index of Military Publications Army Pamphlets No. 310-3 and 310-4 or Marine Corps publications SL 1-3.

ORDNANCE DRAWINGS

To do any kind of maintenance work on your equipment, you've got to know it well. One way to learn about it is to study the hardware itself. It's a good way, too, and there's really no substitute for it. But you'll learn faster, and you'll learn more, by also using certain source materials. This manual is such a source; so are the OPs and ODs and other publications. But there's one other kind of source material for this information. In many ways, they are the most valuable—ordnance drawings.

All manufacturers of ordnance equipment make drawings of all ordnance equipment that they manufacture. Copies of these drawings, reproduced by blueprinting, xerox process, or in some other way, are supplied to every naval ship or installation that has the equipment or for some other reason requires copies of prints of the drawings. Many drawings are also reproduced in OPs and other technical manuals. Many of the drawings you'll see are made by NAVORD, but many others are made by the contractors who manufacture the equipment for NAVORD.

TYPES OF DRAWINGS

Drawings differ depending on their purposes. The main types of drawings, as classified according to purpose by NAVORD, are:

1. General arrangement drawings. This kind of drawing shows the complete equipment assembled. It indicates general appearance and relationships of important component assemblies, and identifies the drawings that describe the components of the equipment.

2. Installation drawings. These show such features as mounting pads and brackets, shock mounts, points for entrance of cabling and mating mechanical parts, type of cable required, dimensions of mounting hardware needed, and directions for how to orient the equipment and secure it to its place on bulkhead or deck. One variety of this type of drawing, called an outline drawing, shows overall dimensions and clearances required for operating and servicing equipment.

3. Assembly and subassembly drawings. These show the constructional details of the assemblies of which the complete equipment is made up. In general, you can think of an assembly (or subassembly) as any group of two or more parts assembled to make up a unit. An assembly drawing is intended to enable a properly equipped shop to make up the finished assembly from the prescribed parts and assembly and finishing materials.

4. Detail drawings. When you disassemble any piece of equipment far enough, you eventually get down to individual pieces that cannot be disassembled any further. These are represented by detail drawings, which give all the information

that a properly equipped shop will need to make the piece exactly as required.

5. Wiring drawings. The main purpose of a wiring drawing or diagram is obvious from its name—it shows you how to wire a piece of equipment, or a system. There are several varieties of wiring diagrams.

An external wiring diagram shows how to connect an item of equipment to the ship's wiring system or to other pieces of equipment. It shows terminal boards, binding posts, plug, jacks, and other connection points and devices, and identifies them by letters and numbers. Lines denote the electrical conductors to be installed. The drawing shows the size and type of wire to be used; the kind of insulation, shielding, duct work, and armoring specified, as applicable; length needed; where ground connections are to be made; where joints must be soldered, welded, or clipped; and so on. And it specifies the kind of current (a.c. or d.c., and frequency) and voltage for each conductor.

An internal wiring diagram does the same for wiring inside an equipment. It also identifies and shows where the fuses are, the size and type to be used, and their circuits. It locates, and identifies with standard symbols, all lamps, motors, synchros, resistors, capacitors, transformers, chokes, switches, relays, and all other electrical components in the equipment, and gives their electrical values, as applicable. It identifies all the terminals and connection points. This is one of the most useful kinds of drawing for electrical maintenance and troubleshooting.

An elementary wiring diagram is about halfway between the diagrams we've just discussed and the schematic to be taken up shortly. It shows terminal and connection points, component locations and values, and so on, but it also is arranged so that it's much easier to follow and understand the circuit than with the usual wiring diagram. But note that the elementary, like the pure schematic, has little respect for the actual sizes and shapes of parts or equipment, or for their physical location or orientation. The traceability of the circuit is a much more important consideration.

6. Schematic drawings. About the only general statement you can make about schematic drawings or diagrams is that their primary purpose is to help the user understand the functioning of the equipment. In ordnance, schematics of electric, hydraulic, and pneumatic systems are of great importance in assisting you as a repairman. Schematics often have very little to do with the actual physical appearance of construction of the equipment diagrammed.

7. Lubrication drawings. A lubrication drawing or chart for naval equipment is often a general arrangement drawing, or a group of them showing several views, in which lubrication fittings and other points are called out by labels. The OP on every equipment normally has a lube chart in its appendix.

8. Tool drawings. Special tools such as spanner wrenches for specific marks and mods of guns, or such special tools as extractor trip devices for 5"/38 mounts are described in drawings—usually assembly or detail type. Such tools are always listed in the OP.

9. Lists of drawings (LD's). A list of drawings, as mentioned above, is considered by NAVORD to be a variety of sketch. In itself, this detail of classification isn't especially important in your job, but it's worth remembering that an LD looks like and is treated like a kind of engineering drawing rather than like a publication.

LD's are in a sense the key to the drawing system used by NAVORD. Beginning at the top of the system, a master list of drawings or master LD is prepared for each major ordnance equipment (such as a gun mount or turret). This list includes all components of the equipment concerned. Each component is itemized by assemblies, subassemblies, and details on a separate LD.

The identifying number for each component LD is given, together with the general arrangement drawing number, on the master list of drawings for the equipment. Each component list of drawings also shows the special tools required for servicing that component. By reference to the list of drawings and the drawings for the mark and mod of a given assembly or subassembly, it is possible to work down to an individual part and to identify the correct nomenclature, drawing, piece number, design dimensions, tolerances, and all other necessary information.

How You Use Drawings

When we refer to a "drawing" or "engineering drawing" without qualification, we usually refer to an assembly, subassembly, or detail drawing. Such drawings, as we have seen, explain how to manufacture some part or assembly. And they are also valuable guides for you in overhauling and repairing equipment. These drawings are valuable not only because they show how parts fit (though this is very important itself), but also because they describe and enumerate the fastening hardware you need to put the assembly together (including the proper bolts, nuts, patent fasteners, pins, and so on). They also show the minor but essential parts that the assembly must have so that it will continue to function as the designer intended it to. A watertight enclosure will leak if it hasn't the exact gasket called for in the drawing; screws may loosen if they haven't been assembled with the lock washers specified in the drawing; and nuts will work free if they haven't been secured with the cotter pins listed in the drawing.

The other types of drawings are equally valuable. General arrangement drawings are good references for the exact nomenclature of major units and as guides to drawings on component assemblies. Installation and outline drawings contain just the information on clearances and dimensions that ship's personnel require when a new piece of equipment is to be installed, and they show how to arrange the piping and wiring to be connected to it. External wiring diagrams show just how to hook equipment into the ship's wiring; after installation, they help in troubleshooting for faulty circuits and malfunctioning components, and in electrical alignment of synchros and other data transmission devices. Internal wiring diagrams are equally valuable for making circuit checks in case of trouble in the equipment. Elementaries are helpful in training personnel, and can be used in checking circuits. And LD's are valuable guides in tracking down the particular piece of information you may be looking for.

Every ship carries copies of drawings on its equipment, in the form of blueprints and photoprints. These copies are assembled into sets, each set covering one item. Photoprints are usually bound in books. Aboard ship, both blueprints and photoprints are called "ordnance drawings".

These drawings are available to you either in a special file in the repair shop or in the custody of your department head. Make use of them; they'll help you to become familiar with the ordnance you will overhaul. (Remember to treat confidential drawings as you would any other confidential publication).

Down in the lower right-hand corner of each drawing you'll find a "drawing number". On each detail pictured in the drawing, you'll find another smaller number. These are the "piece numbers". These numbers identify both the hardware and the drawing. Sometimes you'll find a letter after the piece number showing how many times that piece has been changed or modified since the original design.

Every part of every ordnance device (unless it's very small) has a part number stamped on it. The first number is the drawing number; the second is the piece number. For example, you'll find numbers like 120460-2. Read that, "drawing number 120460, piece number 2".

Look for these numbers, and use them. Refer to them when you report on a particular piece, or when you order new parts.

ILLUSTRATED PARTS BREAKDOWN

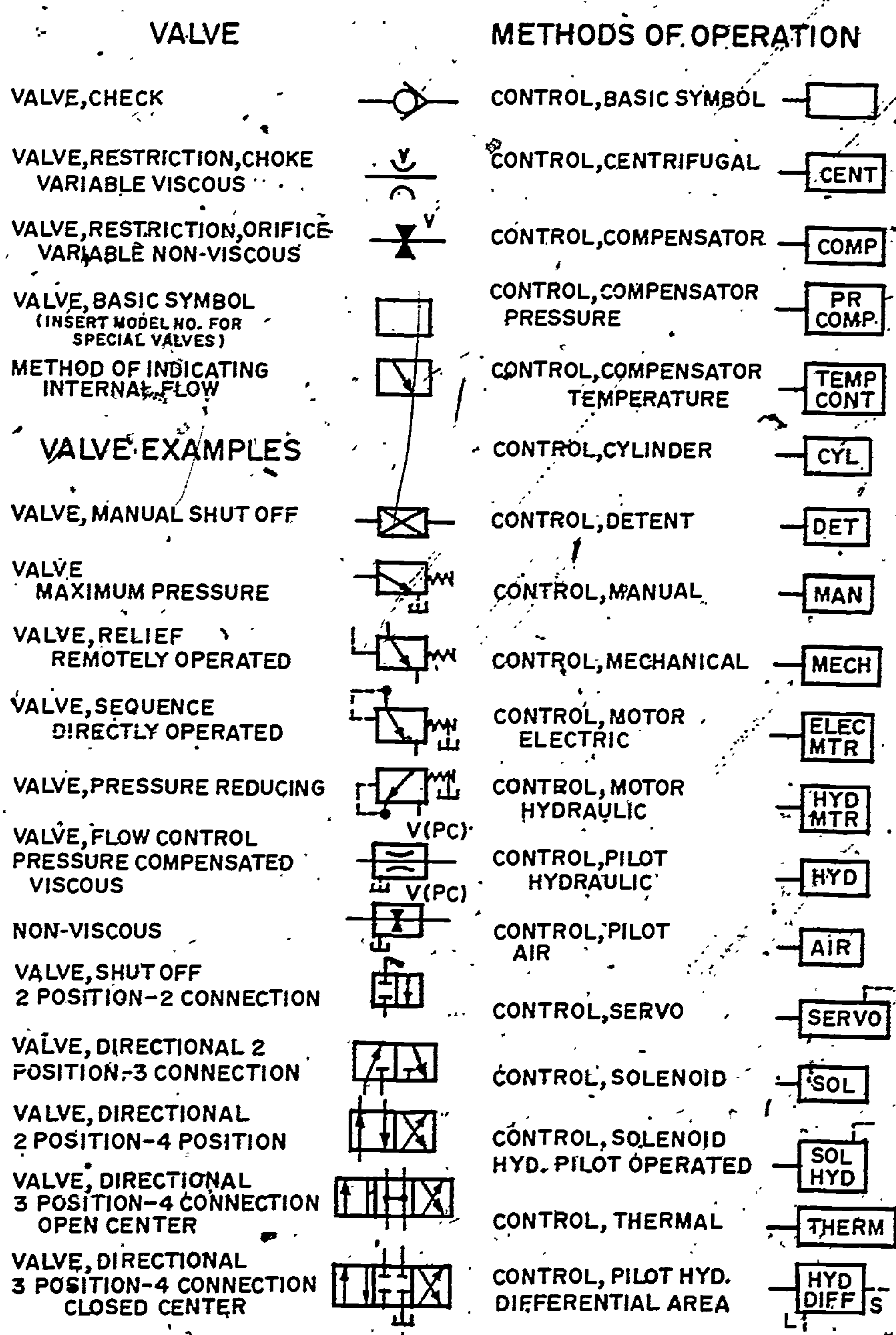
An Illustrated Parts Breakdown (IPB) is an ordnance publication usually in the form of an OP which describes and illustrates all components used in ordnance equipment. An IPB is broken down into sections which identify component parts by major assemblies, subassemblies, and detailed parts. All illustrations in these publications have figure and index numbers for proper repair part identification. The figure number represents a unit, the index number identifies just one part of that unit. Each unit has an identifying number and accompanying each number are the name and description of the part it represents. There are many index numbers within a unit—as many as 500 separate parts. When a Federal Stock Number (FSN) cannot be found for a part, an IPB will furnish the supply department information which can help identify the part. An example of information obtained from an IPB is as follows: IPB number OP-1764-IPB, vol. 3, figure number 11, index number 32, identifying number 177004-116, name and description, screw, slotted, filed, No. 6-32 by 3/8 in., quantity used in assembly 2.

Some IPBs have a cross reference section which converts the identifying number to a part number or FS number. These cross references are not the latest FSN; the appropriate section of the COSAL should list all the latest FS numbers. An index of IPBs is listed in OP-O.

HYDRAULIC DIAGRAMS

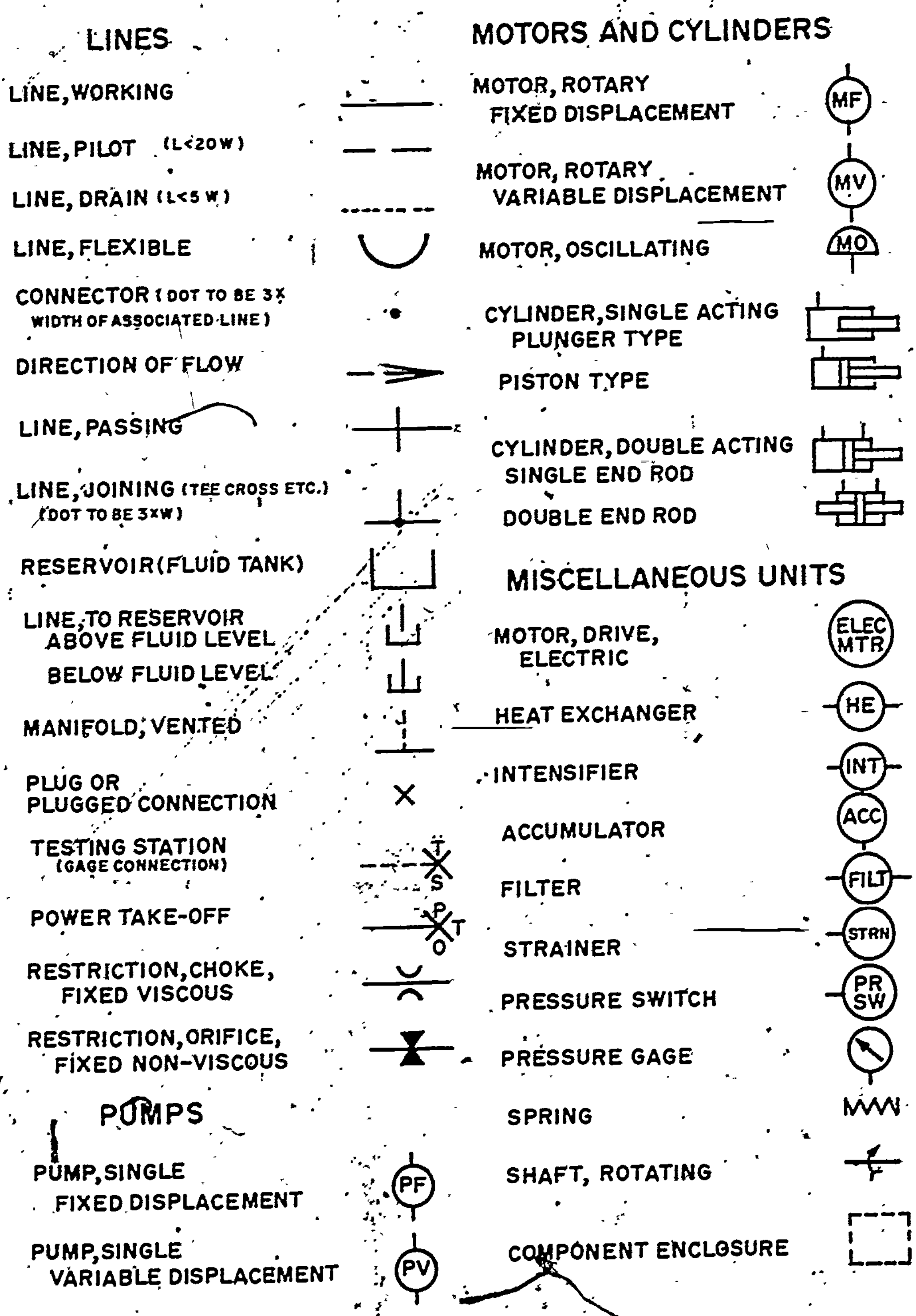
Hydraulic symbols are used throughout the world in design, operation, and maintenance of fluid power systems. A thorough knowledge of hydraulic symbols will enable you to read and understand hydraulic circuit diagrams and other drawings of hydraulic circuits.

Hydraulics today have many and varied applications; therefore, a standardized set of symbols was agreed upon at a joint industrial conference of industry leaders. This conference



11.330(84A)1

Figure 14-10A.—Schematics, and Graphic Symbols.



11.330(84A)2

Figure 14-10B.—Graphic Symbols—Continued.

recommended a system of designating symbols that all commercial manufacturers are presently using. These symbols for fluid power diagrams are listed in MIL-STD 17-B-1.

Graphic symbols (fig. 14-10) provide clearcut circuit information, and well prepared circuit diagrams show every part of a hydraulic circuit clearly. Symbols are available for most commercial components.

Hydraulic symbols show connections, flow paths, and function of the component represented. Symbols do not indicate location of ports, direction of valve movement, or position of control elements.

Hydraulic symbols may be rotated or reversed without altering their meaning, except in the case of vented lines and lines to the reservoir, where the symbol must indicate whether the pipe terminates above or below the fluid level.

Line width does not alter the meaning of symbols. A symbol may be drawn any suitable size, and size may be varied for emphasis or clarity.

Letter combinations used as parts of graphical symbols are not necessarily abbreviations. These combinations may be memorized.

Where flow lines cross, a loop is used except within a symbol envelope. In multiple-envelope symbols, the flow condition shown nearest a control symbol takes place when that control is actuated. Each symbol is drawn to show the normal or neutral condition of a component, unless multiple-circuit diagrams are furnished showing various phases of circuit operation.

Arrows within the symbol envelopes show the direction of fluid flow. Double-ended arrows indicate reversing flow.

External ports are located where flow lines connect to the basic symbol, except where a component enclosure is used. When the enclosure symbol is used, external ports are at the intersections of flow lines and the component enclosure symbol.

The basic symbol for a pump is a circle. Lines connected to the circle represent pipes of lines connected to the pump. Rotating shafts in pumps are indicated by curved arrows on the side of the shaft nearest the viewer. Shafts may be shown to rotate in one or both directions. Pump controls are indicated by a rectangular box attached to the pump enclosure, with the means of controlling the pump printed inside the box. Letters shown in the pump envelope denote pump characteristics.

The basic symbol for a fluid motor is a circle, with an abbreviation inside the circle to indicate the type of motor. There are also symbols to show connected pipes, shaft rotation, and controls, when applicable.

The basic symbol for a hydraulic valve is a rectangle, sometimes called the valve envelope. As in pumps and motors the envelope represents the valve enclosure or body. Lines within the envelope show flow directions between the valve inlet and outlet openings. Single-envelope symbols are used when only one flow path exists through the valve. Flow lines within the envelope indicate static conditions when the actuating signal is not applied.

Multiple-envelope symbols are used when more than one flow path exists through the valve. The envelopes can be visualized as being moved to show how flow paths change when the valve element in an envelope is shifted to its various positions.

Multiple-envelope valves consist of an envelope for each operating position, internal flow paths for each valve position, and external ports at the normal or neutral valve position.

A component enclosure may surround a symbol or group of symbols to represent an assembly. It is also used to convey more information about component connections and functions. The enclosure indicates the limits of the component or assembly. External ports are assumed to be on the enclosure line without loops or dots.

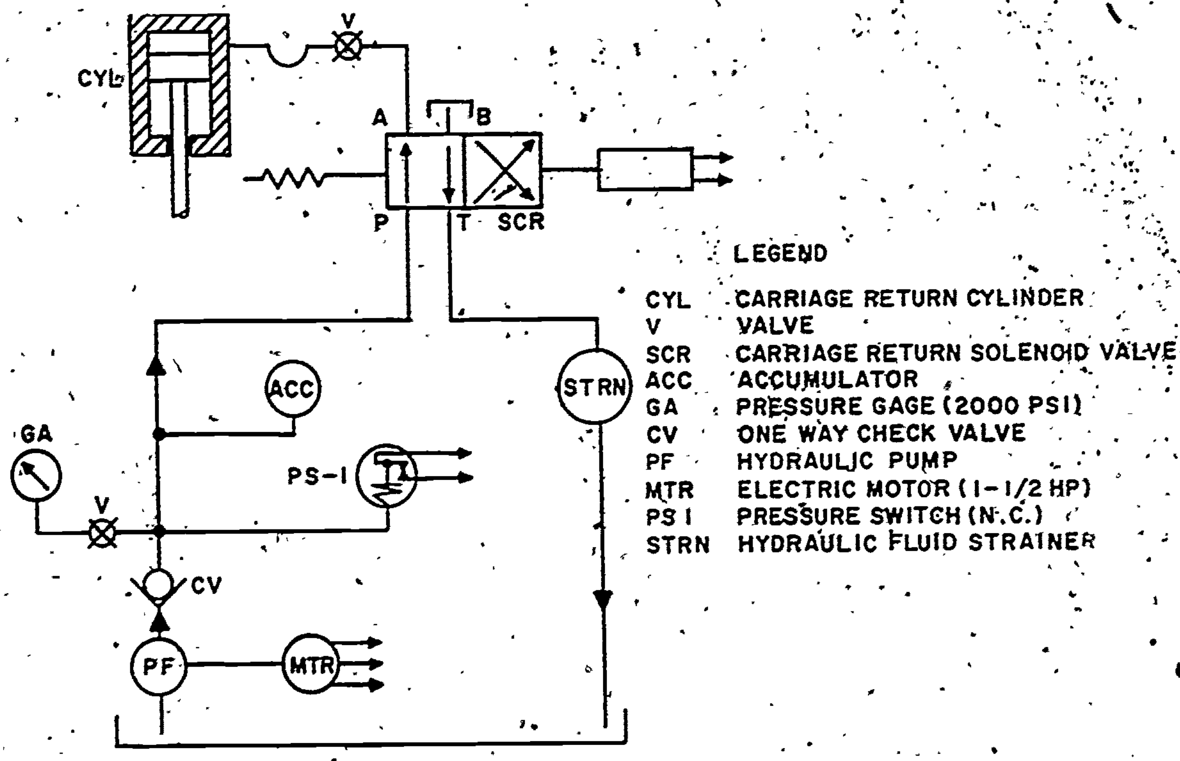
There are five major types of hydraulic diagrams: graphical diagram, circuit diagram, cutaway diagram, pictorial diagram, and combination diagram.

A graphical diagram shows each piece of hydraulic gear, including pipe connections, and uses approved symbols. It also shows the function and control of each component.

A circuit diagram uses approved symbols to show each piece of hydraulic gear and pipe connections. In addition it contains a component list, pipe size, and data on the sequence of operation. The title box contains the drawing number, title draftsman's name, and other information. The circuit diagram also gives complete information for assembly, testing, and operation.

A cutaway diagram shows the principal internal working parts of all hydraulic components in the circuit; it also shows controls and actuating devices, piping, and the function of each independent component.

A pictorial diagram shows each hydraulic component in its actual shape (according to the



84.116

Figure 14-11.—Carriage Return Hydraulic Fluid Flow Diagram.

manufacturer's drawing), and all piping, and general arrangement of all piping.

A combination diagram uses combinations of graphical, cutaway, and pictorial symbols. Interconnecting piping is also shown.

Figure 14-11 illustrates how JIC (joint industrial conference) symbols are used in a hydraulic flow diagram. There are many other varied applications of other types of symbols used in OPs printed before the current standards became effective. Each OP or OD should explain the purpose and function of each symbol used in the hydraulic or mechanical drawing. Blueprint Reading and Sketching, NAVEDTRA 10077-C; Fluid Power, NAVEDTRA 16193; MIL-STD-12C (Abbreviations for Drawings); and MIL-M-38784 (Technical Manual Preparation) give some elementary information on the theoretical background of drafting, on how to read drawings of all types, how to sketch, what type of information is found in a title box of blueprints and schematics, and additional information on symbols used in electrical, electronic, and pneumatic sketches, blueprints, schematics, block diagrams, and mechanical drawings.

PART NUMBERS

When ordnance parts are identified through the use of Illustrated Parts Breakdown (IPB), ordnance drawings, or from part of manufacturer's numbers stamped on the parts, a Federal Stock Number (FSN) for each part is required before the parts can be requisitioned. These numbers (FSN) are listed in the Coordinated Shipboard Allowance List (COSAL) which has a cross reference section that converts a part number to a FS number.

The COSAL establishes the shipboard allowance for installed and portable equipment, equipage, and supporting material. Each COSAL is prepared for an individual ship and enables that ship to have a maximum self-supporting capability for an extended period of time.

Ships are issued a separate COSAL for each category of material. The index to all COSALS is issued by the Naval Supply Systems Command.

Normally, one copy of the ordnance COSAL is kept by the supply department and one copy by the weapons department.

If an FSN for a part cannot be found, the part can be requisitioned by the drawing and piece number and any other identification such as the equipment's Mk and Mod, the manufacturer's name, the amperage and voltage rating, the name of electrical parts, and the serial number of the major unit from which the part was removed. Additional information about a part can also be obtained from equipment IPBs.

For the proper supply procedures for requisitioning repair parts and standard stock items, refer to the effective edition of Military Requirements for PO 3/2, NAVEDTRA 10056.

BATTERY ALIGNMENT

As you already know, the bore of the gun is the first part of the projectile's trajectory. Whether the projectile hits its target depends in part on how the gun is aimed.

Aiming, in turn, depends on the sights and on the rest of the fire control equipment. Today's Navy uses the best guns and the best sighting and fire control equipment. But guns plus sighting are no guarantee of accurate fire — unless they are lined up to work together.

The process of lining up the guns (or the rocket launchers and projectors) of a battery with the sighting and fire control equipment that directs its fire is called battery alignment. It's a big and important job calling for the cooperation of Gunner's Mates and Fire Control Technicians.

The complete gun battery alignment job is complex, involving not only the gun mounts and turrets but the director, computer, fire-control radar, and data transmission. The best general reference on battery alignment is OP 762. In this course we're mainly concerned with two phases of battery alignment – boresighting and tramming. We take up boresighting first.

BORESIGHTING

Boresighting is the procedure used for adjusting gun sights so that, at zero deflection and sight angle, the lines of sight through the gun sights will either be parallel to the axis of the bore, or will intersect the bore axis at a specified range.

The gun sight lines of sight and the axis of the bore of a gun can intersect at only one point. Thus a gun can be boresighted with perfect accuracy at only one range. The sights will be in error at other ranges. To minimize this error, weapons of relatively short range, like machineguns, are boresighted at the range for which the weapon is best adapted—the MEAN BATTLE RANGE. You will find, therefore, the 20-mm guns, for example, are boresighted so that at zero deflection and sight angle, the lines of sight through the sights and the axis of the bore converge at about 1,000 yards.

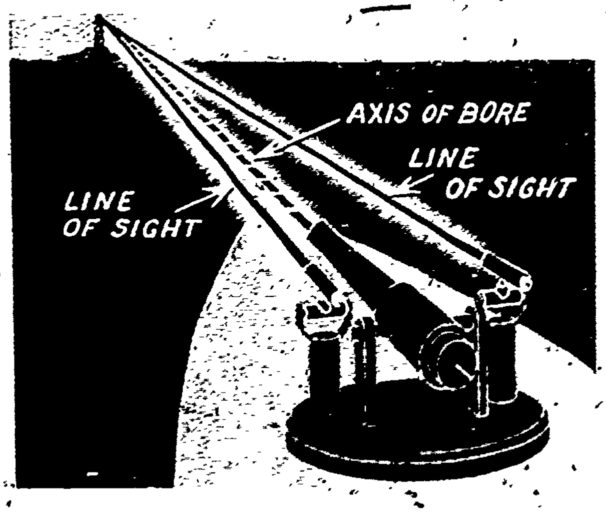
Guns 5-inch and larger have mean battle ranges of several miles. Their sight telescopes, however, are located only a few inches or at most a couple of feet from the gun barrel. The result is that at such ranges, the lines of sight through the sights and the axis of the bore converge very little — so little that they can be considered parallel, for all practical purposes. Such guns are therefore often boresighted either "at infinity" (which means that the target is considered to be an immeasurable distance away) or at very distant targets — distant enough so that their exact range is unimportant. A star or other heavenly body is at "infinite" distance for boresighting; a ship or landmark near or on the horizon is also distant enough to be a suitable boresighting target.

Boresighting On Distant Target

In figure 14-12 you can see how the basic method of distant-target boresighting works. Here, the target at which the lines of sight and the axis of the bore intersect is a distant lighthouse. The target could as well be some other distant but clearly defined landmark, or a heavenly body like the moon or a star. Or it could be set up at the prescribed "mean battle range". The boresighting procedure is the same.

The weapons officer or one of his ranking assistants will decide on the exact range and target to be used in boresighting. Boresighting procedure varies in detail from one gun to the next, but its fundamental steps are:

1. Establish the axis of the bore.
2. Check for and eliminate lost motion and looseness in the sight mechanism.
3. Sight the axis of the bore so that it is aimed at a specific target set at the prescribed distance (either "infinity" or the battle range).
4. Set sight angle and deflection at zero.
5. Sight through the telescopes without disturbing the dial settings.
6. Check the work.



84.281

Figure 14-12.—Boresighting on a Distant Target.

That, as far as fundamentals are concerned, is all there is to the basic method of boresighting. In practice, though fundamentals are the same all the time, there are some complicating details.

The most important of these is concerned with the first step—establishing the axis of the bore. You don't just open the breech and squint through. Since this is a precision operation, you must use a precision optical instrument—the boresight telescope. We'll go into further detail on boresight equipment later in this chapter. First let's briefly consider a method of boresighting somewhat different from the basic distant-target method most often used.

Boresighting With Batten Board

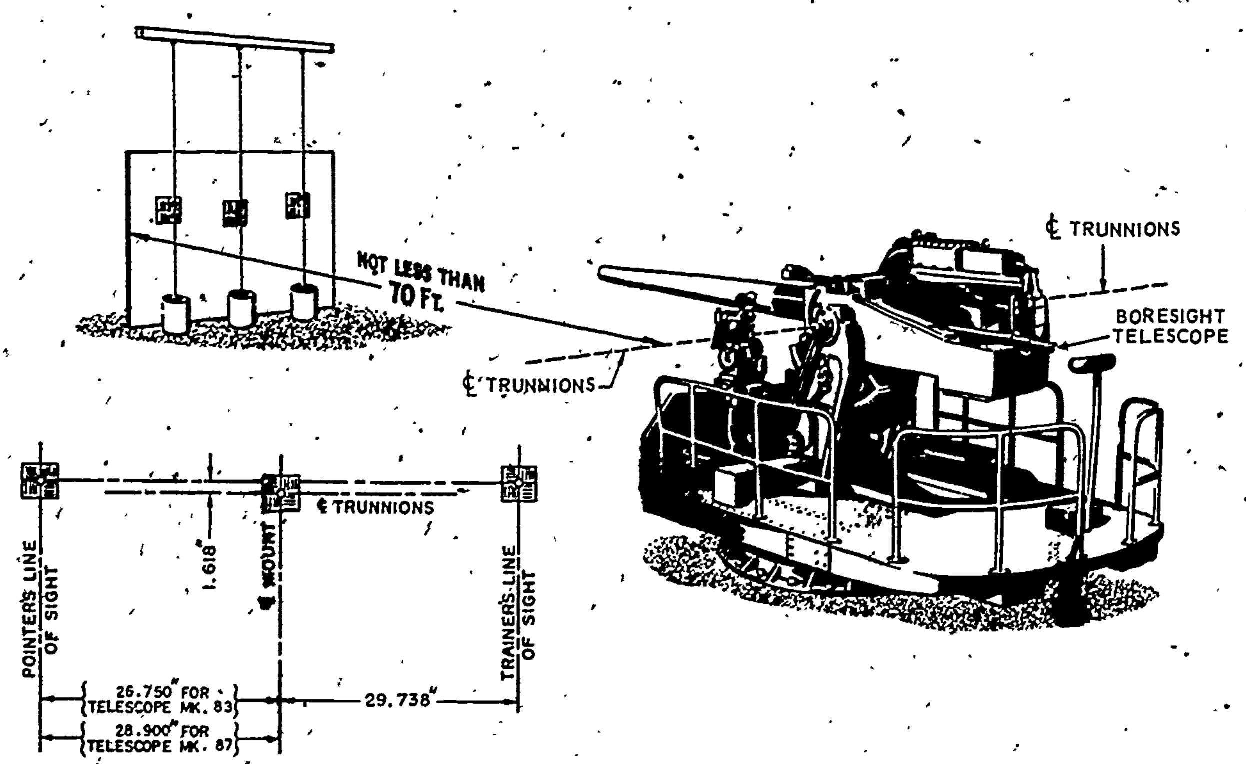
Boresighting can be done by use of a batten board. A batten board is a flat (usually wood) panel on which target markings are tacked or painted. The batten can be set up on the ship's deck, or it can be attached to the gun muzzle. Batten boards are used generally when the ship is in drydock or under construction. Their main advantage over distant-target boresighting is that they can be used to check on the accuracy of sight mechanisms at more than a single sight angle or deflection setting. Boresighting on a distant target checks sight accuracy only at zero sight angle (2,000 on most sight angle dials) and zero deflection angle (500 on most deflection dials). Batten boards also can be used where limited visibility makes distant-target boresighting impracticable.

Batten board boresighting can be done in two ways. Each has its own special uses. One method is to set up the batten board on its own support, with target markings painted on it or attached to it. In figure 14-13 we see such a set-up for a 5"/38 open mount. The exact dimensions for the target pattern are shown at the left. The targets are spaced to correspond with the spacing of the telescope lines of sight and the gun bore axis, with sights at zero sight angle and deflection. Three plumb bobs are suspended in front of the targets. (The bobs are immersed in water in the buckets; this quickly damps out any tendency to vibrate). The lines are long enough to accomodate a gun elevation of at least 30°. The lines and batten are set up about 70 feet from the mount. Then the mount's roller path must be made horizontal, and finally the mount is trained and elevated and sight cross-hair movement is observed to see how well it coincides with the lines on the batten. The procedure (here given only in brief summary) is elaborate and painstaking, and because of the requirement that the roller path be horizontal, you're not likely to have to do it aboard ship. This method's main purpose is to establish the accuracy of gun movement in train and elevation.

Another variety of batten board is used for varifying the accuracy of sight movement in elevation and train. This batten is a frame carefully aligned and secured to the chase of the gun. Figure 14-14 shows the set-up for a Mk 39, 5-inch mount. The principle of this boresighting procedure is to plot targets and line-of-sight traces vertically and horizontally on the board, then to check the accuracy with which the sights follow the traces by cranking them vertically and horizontally and watching the crosshairs. The batten can also be used to check for lost motion. However, unlike the separate batten board method, the chase-mounted batten boresighting procedure can be performed aboard ship.

Both batten board boresighting methods are relatively rare, and we won't go into the detailed procedures here, (see the OP on the gun mount if you are called upon to boresight with a chase-mounted batten). But you are expected to know how to boresight on a distant target.

We've considered briefly and in a general way the principles of boresighting. Now let's look at the equipment that's used in boresighting. The main item is the boresight.



84.282

Figure 14-13.—Boresighting With Separate Batten Board.

The boresight is an optical instrument for establishing the axis of the bore of a gun and for sighting along it. There are two main types.

Breech-bar Boresights

In this type, a boresight telescope is mounted in the center of the gun breech by use of an adapter. Crosshairs in the telescope are lined up with the gun axis through the use of a muzzle disc. The muzzle disc contains five pin holes, one center hole and four holes evenly spaced outboard of the center hole. The telescope crosshairs are aligned with these holes and true alignment with the gun axis. After the telescope crosshair alignment, the muzzle disc is removed and the gun can be boresighted on a target. Three kinds of boresight telescopes for breech-bar boresights are now in use in the Navy. Any of the three can be used in any breech-bar boresight. The other components of each breech-bar boresight can, however, be used only with the weapon for which they are intended. Only the telescopes are freely interchangeable. Figure 14-15 shows a breech-bar boresight installed in the breech of an 8-inch bag-type gun.

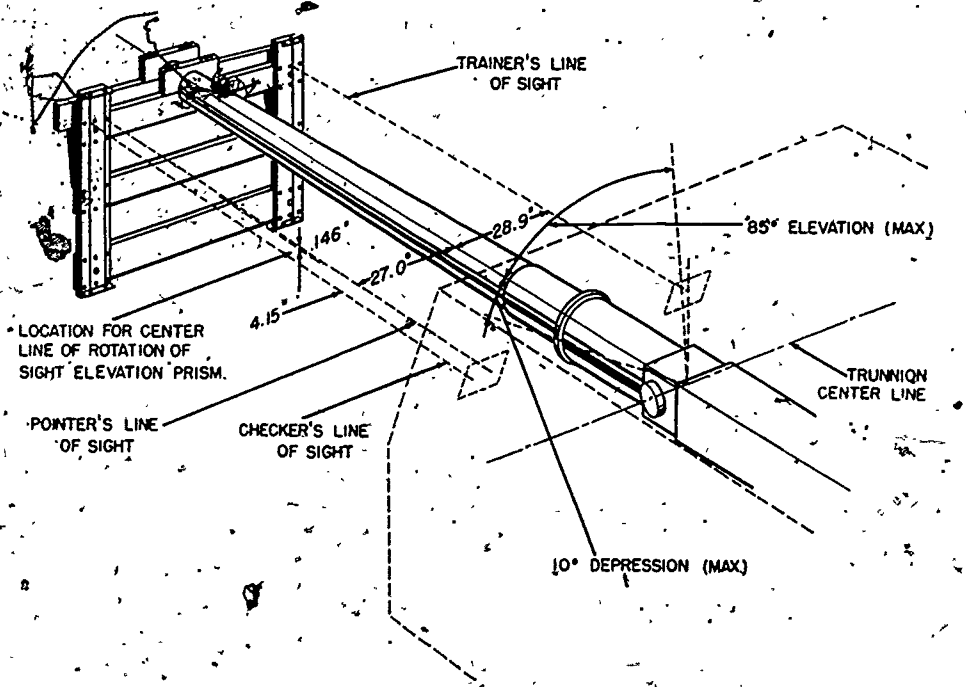
Boresights With Self-contained Optics

This class includes a variety of boresights. The feature common to most of them is that, when installed, they convert the entire gun barrel into a boresight. Some have no lenses – they consist merely of crosshairs in an adapter at the muzzle and a small peephole (for instance, a little hole drilled in the center of the base of a cartridge case) at the breech, the line of sight, as it runs through the peephole and the intersection of the crosshairs, coincides with the bore axis. Other boresights have optical lenses in adapters that mount at breech and muzzle; thus the gun barrel becomes, in effect, a giant telescope.

TRAMMING

Tramming is the procedure for verifying train and elevation dial accuracy on gun mounts and turrets.

576



84.283

Figure 14-14.—Boresighting With Chase-mounted Batten Board.

When you measure gun elevation and train, you specify the angle in degrees and minutes between the axis of the bore and:

1. A plane parallel to the roller path of the director (for elevation angle).
2. A plane through the centerline of the ship and perpendicular to the plane of the director roller path (for train angle).

This may sound complicated but, if you remember the chapter on fire control earlier in this course, you'll find it easier than it sounds.

To make train and elevation angle measurements accurate, gun mounts and turrets must be very carefully aligned when they are installed. To keep such measurements accurate, the Gunner's Mate checks the dials on his mount that register angles of train and elevation with the actual position of the mount by means of a tram and tram blocks.

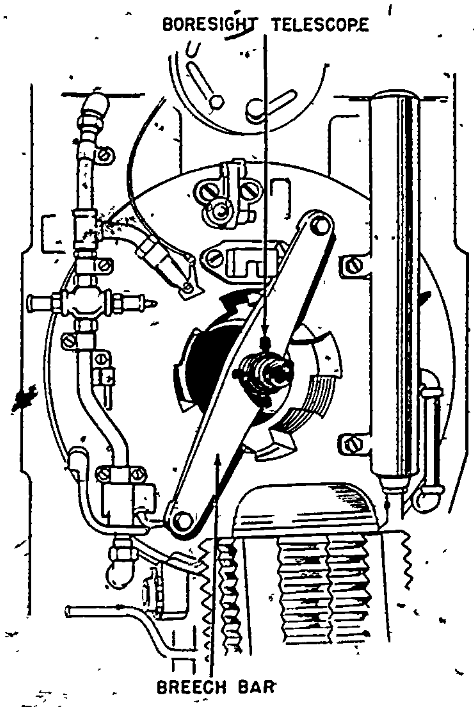
The basic idea of tramming is to position the gun at a known angle of elevation or train (depending on which you're checking), then see that the elevation-angle or train-angle dials register exactly the angle the mount is elevated or trained to. There is only one elevation angle and one train angle at which any mount can be trammed. These angles are recorded in the battery or mount log.

Tram blocks are steel blocks welded or bolted to the mount in pairs, one pair for tramming in elevation, and the other for tramming in train. As you can see in figure 14-16 one of the pair of blocks for checking elevation is welded to a part of the mount that elevates (the slide); the other is welded to a part that does NOT move in elevation (the carriage). Similarly, one of the pair for tramming in train is welded to a part that moves in train (the base ring), and the other to a stationary part (the stand) secured to the deck.

A typical tram block for a 5"/38 mount is shown in cross section in figure 14-17. Imbedded in the block is a short steel pin whose outer end is cupped to take the tram. The tram block face is covered with a metal cap and packed with grease to prevent corrosion. The block is uncovered only for tramming, and is repacked when the cover is replaced.

The tram bar itself has two rounded ends. One is part of the body or barrel, but the other is part of the spring-loaded sleeve or rod that can move within the barrel. A small window-like hole in the barrel has an index line scribed across it.

521



84.284

Figure 14-15. — Breech-bar Boresight Installed In Bag-type Gun (8-inch).

A line scribed on the sleeve can be matched up with the barrel index line by moving the sleeve in the barrel.

When not in use, the tram is kept stowed in its container with a tram gage. The tram fits between the cupped ends of the gage. When it is in the gage, the scribe marks on barrel and sleeve should line up exactly. This verifies that the tram is the right length.

Here are the main steps for tramming in train:

1. Remove the tram from the gage, first checking to be sure that the gage indicates the tram is OK.

2. Set the mount parallax indicator (if any) at zero. Train the gun until the train-angle indicator shows that the mount is at the approximate train angle for tramming. The value of the angle may vary for different mounts. You should be able to find the exact value of the angle entered in the battery log, or it may be inscribed on the tram blocks themselves.

3. Uncover the tram blocks for tramming in train. Clean away excess grease and seat the ends of the tram firmly in the pins of the blocks. Train the mount if necessary to do this.

4. With the tram ends seated, train the mount carefully in manual to compress the tram until the scribe marks on barrel and sleeve line up exactly. The mount is now trammed in train.

This step sounds easy, but requires caution. If the tram hasn't been properly seated in the blocks, or if the gun isn't moved carefully while the tram is in place, the tram can snap out with enough force to cause injury. Don't let it happen to you. This caution applies to tramming in elevation as well as in train.

5. Take a reading on the train-angle indicator dial. It should agree exactly with the value you were given in step 2 above. If it does not, the indicator needs adjustment. The adjustment procedure varies with different mounts, and is not described here.

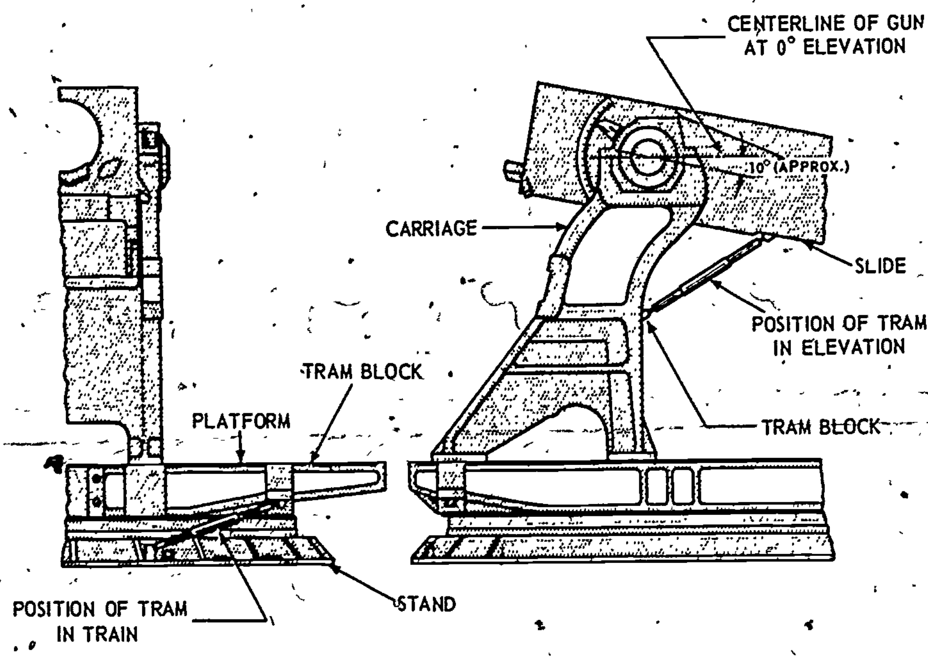
Tramming in elevation is similar to tramming in train. However, on mounts equipped with roller path compensators, you'll have to train the gun to a point at which roller path compensation is zero. There are in theory two such zero points in the roller path of every mount, but many mounts that cannot train a full 360° will actually have only one usable point of zero compensation. The exact train angle at which the point is located should be recorded in the fire-control log. Your weapons officer or chief can tell you what it is, or show you how to read the roller path compensator so that you can find it yourself.

Once you've trained the mount to the correct angle, the procedure in elevation is similar to the one for tramming in train, except that you use the elevation tram blocks, controls, and angle indicator. The same tram is used in both cases.

In tramming, a crew of two is enough — one man at the controls, one at the tram.

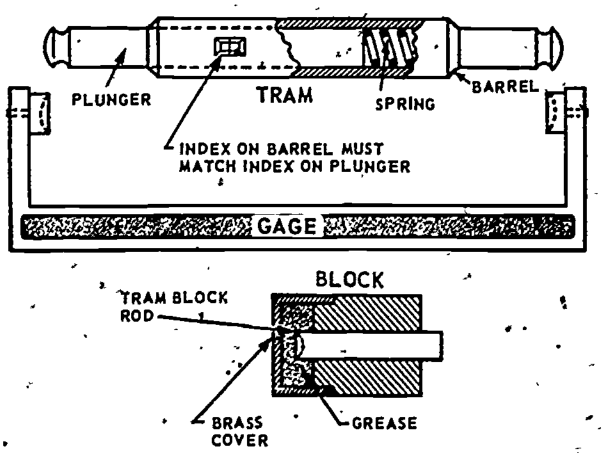
The tram and tram blocks pictured in figures 14-16 and 14-17 are the type you will most often come across. Older mounts may have tram marks instead of blocks, and a one-piece nonadjustable tram with accurately machined points that you register with the marks when the mount is trammed.

Tramming to check the accuracy of train and elevation indicators is your responsibility as a Gunner's Mate. Tramming is used also in director checking and aligning sights. In these jobs you work with your chief and with Fire Control Technicians but the essential tramming operation remains the same.



55.312

Figure 14-16.—Tramming a 5"/38 Single Mount In Elevation and Train.



84.285

Figure 14-17.—Tram, Tram Gage, and Tram Block (detail).

MANDATORY TURN-IN REPAIRABLES

Since you will no doubt encounter the terms "mandatory turn-ins" and "repairables" in the process of obtaining replacement parts from supply, it will be helpful if you understand the purpose of the program and your responsibilities to it.

When any of your equipment fails, your primary concern is to locate the trouble, correct it, and get the equipment "back on the line". In most instances this involves tracing the trouble to a defective part, preparing a NAVSUP 1250 (or DD 1348), obtaining the replacement part from the supply storeroom, installing it, and throwing away the defective part. When the defective part is expensive and repairable, we encounter the repairables program.

A large number of parts can be economically repaired when they fail. This results in savings of dollars and time since it is quicker and cheaper to repair an item than to contract for an buy a new one—provided that the old item is promptly returned in a repairable condition.

For the program to work as intended, you and others have certain responsibilities. At the time your request for mandatory turn-in item is presented to supply, they must inform you that the defective item is to be returned. At this point your responsibilities begin. You must:

1. Remove the defective part without damaging it.

2. Provide adequate protection to the part so that it will not be further damaged before it is turned in to supply. The most effective way, for all concerned, is to place the defective part in the same container in which you received the replacement part.

3. Resist the temptation to cannibalize the part for components which you might possibly use sometime in the future.

4. Return the defective part to supply as soon as practicable.

When the required part is not in the storeroom, supply must then take appropriate action to obtain it. The failed part must still be returned and should be turned in prior to receiving the replacement part. This way the failed part can enter the repair cycle and be available for reissue that much sooner. The only exception should be when the failed part will permit limited or reduced operation of an equipment until the replacement is received.

SAFEGUARDING CLASSIFIED MATTER

The security of the United States in general, and of naval operations in particular, depends in part upon the success attained in the safeguarding of classified information. Security is not a separate burden to be imposed on personnel, but an integral part of the routine duties performed by personnel. The ideal to be sought of all personnel is that they automatically exercise proper discretion in the discharge of their duties and do not think of security of information as something separate and apart from other things. In this way, security of classified information becomes a natural element and poses no additional burden.

You will find some basic information on security in chapter 7 of Military Requirements for Petty Officer 3 & 2, NAVEDTRA 10056-C. In Seaman, NAVEDTRA 10120-E, you learned about logging classified mail, and how to handle classified correspondence. Some general pointers on security of classified information were given in Basic Military Requirements, NAVEDTRA 10054-C.

Publications giving any information on nuclear weapons or components have the additional classification of RESTRICTED. The material may be marked Confidential Restricted Data, Secret Restricted Data, or Top Secret Restricted Data. There is also Formerly Restricted Data. These also have the additional line "Atomic Energy Act of 1954" just below the classification. The old restricted classification, not applied to nuclear information, has been discontinued.

Complete instructions on classified matter are contained in the Information Security Program Regulation (DOD 5200. 1-R) and OPNAVINST 5510.1E, "Department of the Navy Supplement to the DOD Information Security Program Regulation". These publications are those with which you should become familiar. Use them as the authoritative source of reference whenever a question of security arises.

INDEX

525

526

U.S. GOVERNMENT PRINTING OFFICE: 1975— 640-703:46