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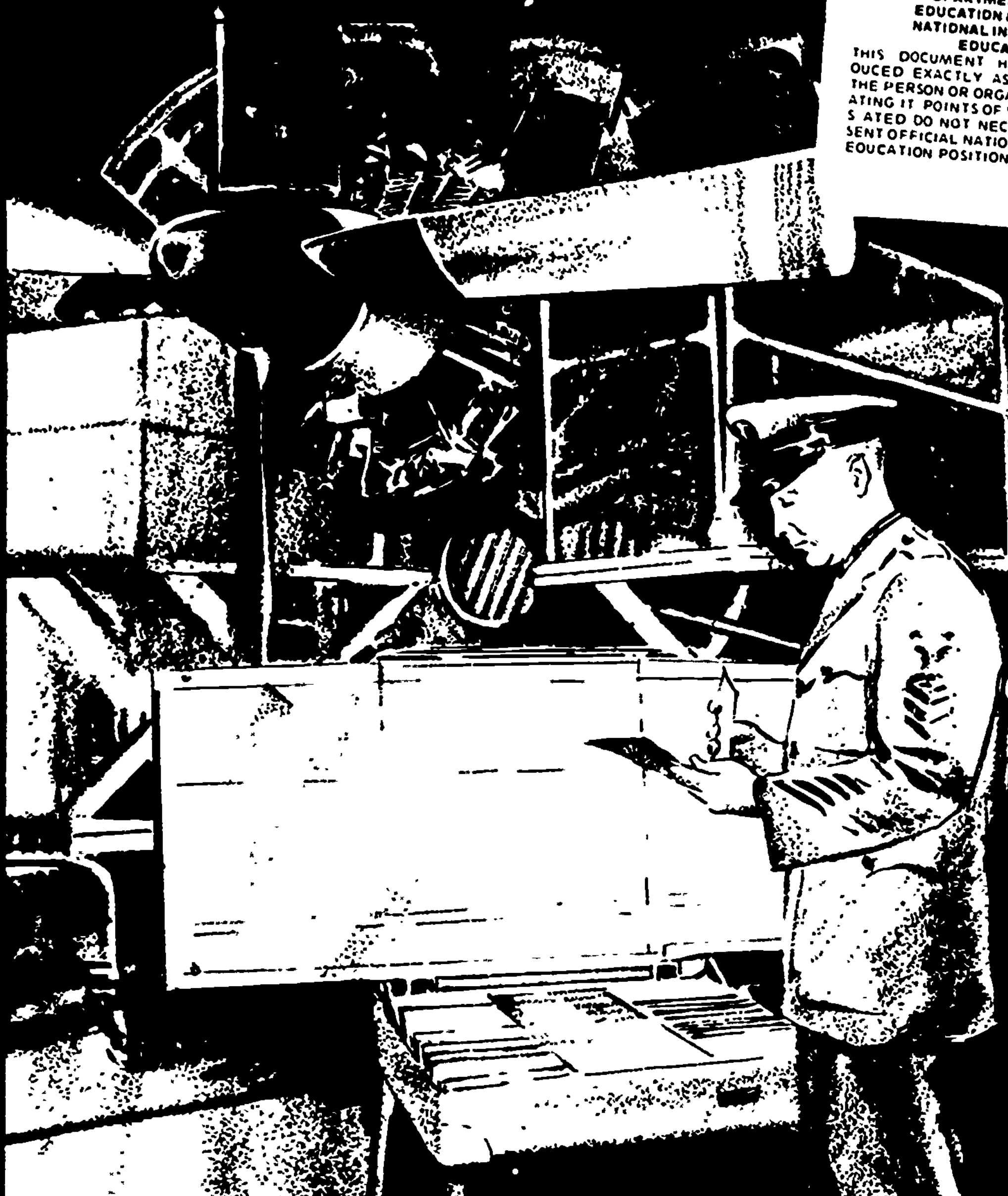
ABSTRACT

The profusely illustrated rate training manual is one of a series of training manuals prepared for enlisted personnel of the Navy and Naval Reserve who are studying for advancement in the Aviation Machinist's Mate R rating (ADR 1 and ADRC). Chapter one provides information helpful for use in advancement. Chapters two through ten consist of units on aviation supply, work center supervision and administration, reciprocating engine systems, reciprocating engine troubleshooting, engine analyzers, reciprocating engine removal and installation, fuel system maintenance, propeller operation and maintenance, and helicopter maintenance. A subject index is included. (Author/BP)



AVIATION MACHINIST'S MATE R 1 & C

NAVAL EDUCATION AND TRAINING COMMAND

RATE TRAINING MANUAL NAVEDTRA 10344-B

PREFACE

This Rate Training Manual is one of a series of training manuals prepared for enlisted personnel of the Navy and Naval Reserve who are studying for advancement in the Aviation Machinist's Mate R rating. As indicated by the title, the manual is based on the professional qualifications for the rates of ADR1 and ADRC, as set forth in the Manual of Qualifications for Advancement, NavPers 18068 (Series).

This training manual was prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training Support. Technical review of the manuscript was provided by the personnel of the Aviation Machinist's Mate School, NATTC, Naval Air Station Memphis, Millington, Tennessee. Technical assistance was also provided by the Naval Air Systems Command.

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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.

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CHAPTER 1

AVIATION MACHINIST'S MATE R RATING

This training manual is designed to aid the ADR2 in preparing for advancement to ADR1 and the ADR1 in preparing for advancement to ADRC. It is based primarily on the professional requirements or qualifications for ADR1 and ADRC, as specified in the current edition of the Manual of Qualifications for Advancement, NavPers 18068. In preparing for advancement examinations, this manual should be studied in conjunction with Military Requirements for Petty Officer 1 & C, NavPers 10057 (Series).

In preparing this training manual, every effort has been made to cover professional matters adequately and yet within reasonable bounds. It has been designed to give the prospective ADR1 and ADRC a good working knowledge of all subjects covered by the professional qualifications for advancement. It includes some new material required as a result of new or revised maintenance programs and qualification changes.

The remainder of this chapter is devoted to information which should be helpful in preparing for advancement. It is strongly recommended that this material be studied carefully before beginning intensive study of the remainder of the manual.

ENLISTED RATING STRUCTURE

The present enlisted rating structure includes two types of ratings: general ratings and service ratings.

GENERAL RATINGS are designed to provide paths of advancement and career development. A general rating identifies a broad occupational field of related duties and functions requiring similar aptitudes and qualifications. General ratings provide the primary means used to identify billet requirements and personnel qualifications. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

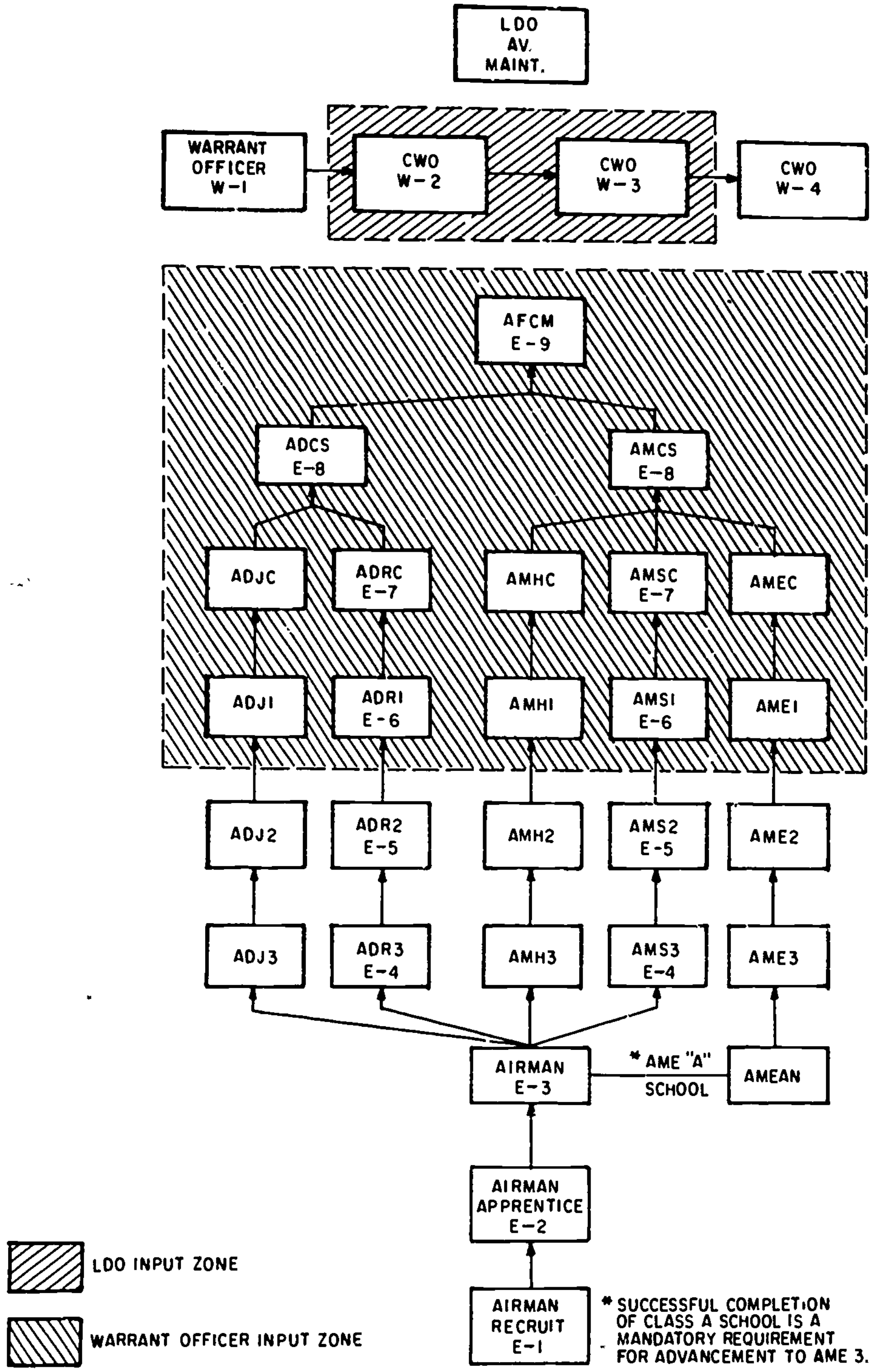
Subdivisions of certain general ratings are identified as SERVICE RATINGS. These service ratings identify areas of specialization within the scope of a general rating. Service ratings are established in those general ratings in which specialization is essential for efficient utilization of personnel. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

THE ADR RATING

The Aviation Machinist's Mate rating is composed of two service ratings and one general rating. The service ratings are Aviation Machinist's Mate J (ADJ) and Aviation Machinist's Mate R (ADR). The two service ratings apply to personnel in pay grades E-4 through E-7. The general rating is known simply as the Aviation Machinist's Mate rating and applies only to pay grade E-8 (ADCS). At pay grade E-9 the AD rating loses its identity and the ADCS advances, along with the AMCS to Master Chief Aircraft Maintenanceman (AFCM). Figure 1-1 illustrates the paths of advancement from Recruit to Master Chief Aircraft Maintenanceman (AFCM), Warrant Officer (W-4), and Limited Duty Officer.

Shaded areas in figure 1-1 indicate career stages from which qualified enlisted men may advance to Warrant Officer (W-1), and selected Commissioned Warrant Officers (W-2 and W-3) may advance to Limited Duty Officer.

Aviation Machinist's Mates R maintain aircraft reciprocating engines and their related systems including the fuel, oil, ignition, propel-



AM.1

Figure 1-1.—Paths of advancement.

ler, and exhaust systems; preflight aircraft; conduct periodic inspections on reciprocating engines and related systems; test, adjust, remove, replace, preserve, and depreserve engines and engine accessories including carburetors, magnetos, pumps, and other components of the engine and its systems, and supervise reciprocating engine work centers.

In addition to the above listed requirements the Chief and First Class Aviation Machinist's Mate R must be qualified to supervise and direct periodic inspections; maintain logs and records and prepare reports; order and identify publications; identify and order aircraft parts, tools, and equipment, maintain current shop files of directives and other publications; maintain inventory records; use schematic diagrams, drawings, and charts in troubleshooting and correcting powerplant system malfunctions; review and evaluate completed inspection forms and reports; analyze reports of discrepancies and malfunctions and determine corrective action; organize and administer a program of safety instructions applicable to aircraft powerplants and related systems; supervise the man-hour accounting program; interpret directives from higher authorities; schedule and assign workload; and maintain quality control of work performed.

A wide variety of assignments is available to the ADR1 and ADRC. In addition to the various types of maintenance activities afloat and ashore to which ADR personnel are assigned, the ADR1 and ADRC are eligible for assignment to instructor duty as well as a number of other desirable shore billets. Most of these billets are under the management control of BuPers and are directly associated with training. Others are associated with research, testing, or evaluation. Some of the more desirable billets to which the ADR1 and ADRC may be assigned are described in the following paragraphs.

1. Instructor duty is available to both the ADR1 and ADRC at NATTC, Memphis, Tennessee, in all of the AD schools. In addition to the AD schools, the ADR1 and ADRC may be assigned to instructor duty with a unit of the Naval Air Maintenance Training Group (NAMTG). Units of NAMTG are located at shore stations on both coasts. Personnel assigned to this duty are first sent to Naval Air Maintenance Training Group Headquarters at Memphis for a period of indoctrination and instruction prior to being assigned to one of the many units.

Instructor billets are normally filled on a voluntary basis. Detailed information concerning assignment to instructor duty is contained in the Enlisted Transfer Manual, NavPers 15909 (Series).

2. Chief, Senior Chief, and Master Chief Petty Officers are eligible for assignment for duty with the Naval Education and Training Program Development Center (NavEdTraProDevCen), Pensacola, Florida. NavEdTraProDevCen was recently established by consolidating the following former activities: Naval Examining Center, Great Lakes, Illinois; Navy Training Publications Center, Memphis, Tennessee; Navy Training Publications Detachment, Washington, D.C.; and Naval Correspondence Course Center, Scotia, New York. AD's assigned to NavEdTraProDevCen assist in the preparation and revision of Rate Training Manuals, Nonresident Career Courses, and Navy-wide Advancement Examinations for the ADR and ADJ ratings.

3. Recruiting duty billets are available to both the ADR1 and ADRC. These billets are located in various towns and cities throughout this country and in some possessions.

4. Attache duty is another possibility. This duty may be performed at numerous places throughout the world.

There are a number of special programs and projects to which enlisted personnel may be assigned. Some of these involve research, others may involve testing or evaluation. An example of such an assignment is with the Personnel Research Division (PRD), Naval Aviation Integrated Logistic Support Center (NAILSC), NAS Patuxent River, Maryland. Their mission is to develop recommended personnel requirements for squadrons operating and maintaining the latest types of weapon systems.

For a listing of other special programs, reference should be made to the Enlisted Transfer Manual. Others are also announced from time to time in BuPers Notices.

Personnel may indicate their desire for assignment to a specific program or project by indicating it in the "remarks" block of their Rotation Data Card.

As a petty officer you are already aware of the importance of the ADR rating to naval aviation. Pilots and aircrewmen depend upon the ADR for the efficient operation of the aircraft. As aviation progresses, improved powerplants must be developed. Thus, the ADR's job involves new and greater responsibilities, and at all levels he must possess greater technical skills than ever before.

When advanced to ADR1 and ADRC, even more responsibilities are to be yours. As a senior petty officer you must possess more than technical skills. You must assume greater responsibilities not only for your own work, but also for the work of others who serve under you. Briefly, the ADR1 and ADRC must be a skilled mechanic, supervisor, inspector, and instructor, as well as an accomplished military leader. Senior Petty officers are therefore vitally concerned with the Naval Leadership Program.

As a result of the Naval Leadership Program, a considerable amount of material related to naval leadership for the senior petty officer is available. Studying this material will make you aware of your many leadership responsibilities as a senior petty officer and will also be of great help in developing leadership qualities. It will not in itself, however, make you a good leader. Leadership principles can be taught, but a good leader acquires that quality only through hard work and practice.

As you study this material containing leadership traits, keep in mind that probably none of our most successful leaders possessed all of these traits to a maximum degree, but a weakness in some traits was more than compensated for by strength in others. Critical self-evaluation will enable you to realize the traits in which you are strong, and to capitalize on them. At the same time you must strive to improve on the traits in which you are weak.

Your success as a leader will be decided, for the most part, by your achievements in inspiring others to learn and perform. This is best accomplished by personal example.

ADVANCEMENT

By this time, you are probably well aware of the personal advantages of advancement– higher pay, greater prestige, more interesting and challenging work, and the satisfaction of getting ahead in your chosen career. By this time, also you have probably discovered that one of the most enduring rewards of advancement is the training you acquire in the process of preparing for advancement.

The Navy also profits by your advancement. Highly trained personnel are essential to the functioning of the Navy. By advancement, you increase your value to the Navy in two ways; first, you become more valuable as a technical specialist, and thus make far-reaching contributions to the entire Navy; and second, you become more valuable as a person who can supervise, lead, and train others.

Since you are studying for advancement to PO1 or CPO, you are probably already familiar with the requirements and procedures for advancement. However, you may find it helpful to read the following sections. The Navy does not stand still. It is possible that some of the requirements have changed since the last time you went up for advancement. Furthermore, you will be responsible for training others for advancement; therefore, you will need to know the requirements in some detail.

HOW TO QUALIFY FOR ADVANCEMENT

To qualify for advancement, a person must:

1. Have a certain amount of time in grade.
2. Complete the required Rate Training Manuals either by demonstrating a knowledge of the material in the manual by passing a locally prepared and administered test or by passing the Non-Resident Career Course based on the Rate Training Manual.
3. Utilizing an appropriate Personnel Qualification Standard (when applicable) as a guideline, become qualified and demonstrate your ability to perform all the practical requirements for advancement by completing the Record of Practical Factors, NavEdTra 1414/1.
4. Be recommended by his commanding officer, after the petty officers and officers supervising the work have indicated that they consider him capable of performing the duties of the next higher rate.
5. Demonstrate KNOWLEDGE by passing a written examination on (a) military requirements, and (b) professional qualifications.

Remember that the requirements for advancement can change. Check with your educational services office to be sure that you know the most recent requirements.

When you are training lower rated personnel, it is a good idea to point out that advancement is not automatic. Meeting all the requirements makes a person ELIGIBLE for advancement, but it does not guarantee his advancement. Such factors as the score made on the written examination, length of time in service, performance marks, and quotas for the rating enter into the final determination of who will actually be advanced.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement? You must study the qualifications for advancement, work on the practical factors, study the required Rate Training Manuals, and study other material that is required. You will need to be familiar with the following:

1. Manual of Qualifications for Advancement, NavPers 18068 (Series).
2. Record of Practical Factors, NavEdTra 1414/1.
3. Bibliography for Advancement Study, NavEdTra 10052 (Series).
4. Applicable Rate Training Manuals and their companion Nonresident Career Courses.

Collectively, these documents make up an integrated training package tied together by the qualifications. The following paragraphs describe these materials and give some information on how each one is related to the others.

"Quals" Manual

The Manual of Qualifications for Advancement, NavPers 18068 (Series), gives the minimum requirements for advancement to each rate within each rating. This manual is usually called the "Quals" Manual, and the qualifications themselves are often called "quals." The qualifications are of two general types: (1) military requirements, and (2) professional or technical qualifications. Military requirements apply to all ratings rather than to any one rating alone. Professional qualifications are technical or professional requirements that are directly related to the work of each rating.

Both the military requirements and the professional qualifications are divided into subject matter groups. Then, within each subject matter group, they are divided into PRACTICAL FACTORS and KNOWLEDGE FACTORS.

The qualifications for advancement and a bibliography of study materials are available in your educational services office. The "Quals" Manual is changed more frequently than Rate Training Manuals are revised. By the time you are studying this training manual, the "quals" for your rating may have been changed. Never trust any set of "quals" until you have checked the change number against an UP-TO-DATE copy of the "Quals" Manual.

In training others for advancement, emphasize these three points about the "quals";

1. The "quals" are the MINIMUM requirements for advancement. Personnel who study MORE than the required minimum will have a great advantage when they take the written examinations for advancement.
2. Each "qual" has a designated rate level–chief, first class, second class, or third class. You are responsible for meeting all "quals" specified for the rate level to which you are seeking advancement AND all "quals" specified for lower rate levels. This manual is written to provide additional or add-on information to that contained in ADR3 & 2, NavPers 1034 2-A, and it is recommended that the material in this 3 & 2 manual be reviewed.
3. The written examinations for advancement will contain questions relating to the practical factors AND to the knowledge factors of BOTH the military requirements and the professional qualifications.

Record of Practical Factors

Before you can take the Navy-wide examination 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 requirements and the professional qualifications. A special form known as the Record of Practical Factors, NavEdTra 1414/1 (plus the abbreviation of the appropriate rating), is used to keep a record of your practical factor qualifications. The form lists all practical factors, both military and professional. As you demonstrate your ability to perform each practical factor, appropriate entries are made in the DATE and INITIALS columns.

As a PO1 or CPO, you will often be required to check the practical factor performance of lower rated personnel and to report the results to your supervising officer.

As changes are made periodically to the "Quals" Manual, new forms of NavEdTra 1414/1 are provided when necessary. 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. Keep this in mind when you are training and supervising other personnel. If a person demonstrates proficiency in some skill which is not listed in the "quals" but which is within the general scope of the rating, report this fact to the supervising officer so that an appropriate entry can be made in the Record of Practical Factors.

When you are transferred, the Record of Practical Factors should be forwarded with your service record to your next duty station. It is a good idea to check and be sure that this form is actually inserted in your service record before you are transferred. If the form is not in your record, you may be required to start all over again and requalify in practical factors that have already been checked off. You should also take some responsibility for helping lower rated personnel keep track of their practical factor records when they are transferred.

A second copy of the Record of Practical Factors should be made available to each man in pay grades E-2 through E-8 for his personal record and guidance.

The importance of NavEdTra 1414/1 cannot be overemphasized. It serves as a record to indicate to the petty officers and officers supervising your work that you have demonstrated proficiency in the performance of the indicated practical factors and is part of the criteria utilized by your commanding officer when he considers recommending you for advancement. In addition, the proficient demonstration of the applicable practical factors listed on this form can aid you in preparing for the examination for advancement. Remember that the knowledge aspects of the practical factors are covered in the examination for advancement. Certain knowledge is required to demonstrate these practical factors and additional knowledge can be acquired during the demonstration. Knowledge factors pertain to that knowledge which is required to perform a certain job. In other words, the knowledge factors required for a certain rating depend upon the jobs (practical factors) that must be performed by personnel of that rating. Therefore, the knowledge required to proficiently demonstrate these practical factors will definitely aid you in preparing for the examination for advancement.

Personnel Qualification Standards

Personnel Qualification Standards (PQS) are presently being developed to provide guidelines in preparing for advancement and qualification to operate specific equipment and systems. They are designed to support the advancement requirements as stated in the "Quals" Manual.

The "Quals" and Record of Practical Factors are stated in broad terms. Each PQS is much more specific in its questions that lead to qualification. It provides an analysis of specific equipment and duties, assignments, or responsibilities which an individual or group of individuals (within the same rating) may be called upon to carry out. In other words, each PQS provides an analysis of the complete knowledge and skills required of that rating tied to a specific weapon system (aircraft and/or individual systems or components).

Each qualification standard has four main subdivisions in addition to an introduction and a glossary of PQS terms. They are as follows:

100 Series—Theory
200 Series—Systems
300 Series—Watchstations (duties, assignments, or responsibilities).
400 Series—Qualifications cards.

The introduction explains the complete use of the qualification standard in terms of what it will mean to the user as well as how to use it.

The Theory (100 Series) section specifies the theory background required as a prerequisite to the commencement of study in the specific equipment or system for which the PQS was written. These fundamentals are normally taught in the formal schools (Preparatory, Fundamentals, and Class A) phase of an individual's training. However, if the individual has not been to school, the requirements are outlined and referenced to provide guidelines for a self-study program.

The Systems (200 Series) section breaks down the equipment or systems being studied into functional sections. PQS items are essentially questions asked in clear, concise statement (question) form and arranged in a standard format. The answers to the questions must be extracted from the various maintenance manuals covering the equipment or systems for which the PQS was written. This section asks the user to explain the function of the system, to draw a simplified version of the system from memory, and to use this drawn schematic or the schematic provided in the maintenance manual while studying the system or equipment. Emphasis is given to such areas as maintenance management procedures, components, component parts, principles of operation, system interrelations, numerical values considered necessary to operation and maintenance, and safety precautions.

The Watchstation (300 Series) section includes questions regarding the procedures the individual must know to operate and maintain the equipment or system. A study of the items in the 200 series section provides the individual with the required information concerning what the system or equipment does, how it does it, and other pertinent aspects of operation. In the 300 series section, the questions advance the qualification process by requiring answers or demonstrations of ability to put this knowledge to use or to cope with maintaining of the system or equipment. Areas covered include normal operation; abnormal or emergency operation; emergency procedures which could limit damage and/or casualties associated with a particular operation; operations that occur too infrequently to be considered mandatory performance items; and maintenance procedures/instructions such as checks, tests, repair, replacement, etc.

The 400 series section consists of the qualification cards. These cards are the accounting documents utilized to record the individual's satisfactory completion of items necessary for becoming qualified in duties assigned. Where the individual starts in completing a standard will depend on his assignment within an activity. The complete PQS is given to the individual being qualified so that he can utilize it at every opportunity to become fully qualified in all areas of his rating and the equipment or system for which the PQS was written. Upon transfer to a different activity, each individual must requalify. The answers to the questions asked in the qualification standards may be given orally or in writing to the supervisor, the branch or division officer, and maintenance officer as required to certify proper qualification. The completion of part or all of the PQS provides a basis for the supervising petty officer and officer to certify completion of Practical Factors for Advancement.

NavEdTra 10052

Bibliography for Advancement Study, NavEdTra 10052 (Series) is a very important publication for anyone preparing for advancement. This publication/bibliography lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement. NavEdTra 10052 (Series) is revised and issued once each year by the Naval Training Command. Each revised edition is identified by a letter following the NavEdTra number; be sure you have the most recent edition.

The required and recommended references are listed by rate level in NavEdTra 10052 (Series). It is important to remember that you are responsible for all references at lower rate levels, as well as those listed for the rate to which you are seeking advancement.

Rate Training Manuals that are marked with an asterisk (*) in NavEdTra 10052 (Series) are MANDATORY at the indicated rate levels. A mandatory training 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 mandatory training manual; or (3) in some cases, successfully completing an appropriate Navy School.

When training personnel for advancement, do not overlook the section of NavEdTra 10052 (Series) which lists the required and recommended references relating to the military requirements for advancement. All personnel must complete the mandatory military requirements training manual for the appropriate rate level before they can be eligible to advance. Also, make sure that personnel working for advancement study the references listed as recommended but not mandatory in NavTra 10052 (Series). It is important to remember that ALL references listed in NavTra 10052 (Series) may be used as source material for the written examinations, at the appropriate levels.

Rate Training Manuals

There are two general types of Rate Training Manuals. Rate Training Manuals (such as this one) are prepared for most enlisted rates and ratings, giving information that is directly related to the professional qualifications for advancement. Subject matter manuals give information that applies to more than one rating.

Rate Training Manuals are produced by field activities under the management control of the Naval Training Command. Manuals are revised from time to time to keep them up to date technically. The numbering system is being changed from NavPers to NavTra. The revision of a Rate Training Manual is identified by a letter following the NavPers or NavTra number. You can tell whether any particular copy of a Rate Training Manual is the latest edition by checking the number in the most recent edition of List of Training Manuals and Correspondence Courses, NavTra 10061 (Series). NavTra 10061 is actually a catalog that lists current training manuals and courses; you will find this catalog useful in planning your study program.

Rate Training Manuals are designed for the special purpose of helping naval personnel prepare for advancement. By this time, you have probably developed your own way of studying these manuals. Some of the personnel you train, how. :, may need guidance in the use of Rate Training Manuals. Although there is no single "best" way to study a training manual, the following suggestions have proved useful for many people:

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

2. Set up a regular study plan, 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 training manual intensively, get acquainted with the entire manual. Read the preface and the table of contents. Check through the index. Thumb through the manual 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 clear picture of the scope and content of the manual.

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 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 each unit, write down questions as they 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, ask yourself some questions. Does this information tie in with past experience? Or is this something new and different? How does this information relate to the qualifications for advancement?

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 referring to the training manual, write down the main ideas you have learned from studying this unit. Do not just quote the manual. If you cannot 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 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 training manual. You will probably find it helpful to take other courses, as well as those based on mandatory training manuals. Taking a course helps you to master the information given in the training manual, and also gives you an idea of how much you have learned.

10. You should note that occasionally reference is made in the Rate Training Manual to publications which contain information relative to the rating, but which are not listed in NavTra 10052 (Series). These are known as secondary references and should be reviewed in conjunction with your study of the Rate Training Manual to better prepare yourself for advancement.

INCREASED RESPONSIBILITIES

When you assumed the duties of a PO3, you began to accept a certain amount of responsibility for the work of others. With each advancement, you accept an increasing responsibility in military matters and in matters relating to the professional work of your rate. When you advance to PO1 or CPO, you will find a noticeable increase in your responsibilities for leadership, supervision, training, working with others, and keeping up with new developments.

As your responsibilities increase, your ability to communicate clearly and effectively must also increase. The simplest and most direct means of communication is a common language. The basic requirement for effective communication is therefore a knowledge of your own language. Use correct language in speaking and in writing. Remember that the basic purpose of all communication is understanding. To lead, supervise, and train others, you must be able to speak and write in such a way that others can understand exactly what you mean.

Leadership and Supervision

As a PO1 or CPO, you will be regarded as a leader and supervisor. Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical, on-the-job language that can be understood and followed by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their jobs correctly. At the same time, you must be able to explain to officers any important problems or needs of enlisted personnel. In all military and professional matters, your responsibilities will extend both upward and downward.

Along with your increased responsibilities, you will also have increased authority. Officers and petty officers have POSITIONAL authority—that is, their authority over others lies in their positions. If your CO is relieved, for example, he no longer has the degree of authority over you that he had while he was your CO, although he still retains the military authority that all seniors have over subordinates. As a PO1, you will have some degree of positional authority; as a CPO, you will have even more. When exercising your authority, remember that it is positional—it is the rate you have, rather than the person you are, that gives you this authority.

A Petty Officer conscientiously and proudly exercises his authority to carry out the responsibilities he is given. He takes a personal interest in the success of both sides of the chain of command . . . authority and responsibility. For it is true that the Petty Officer who does not seek out and accept responsibility, loses his authority and then the responsibility he thinks he deserves. He must be sure, by his example and by his instruction, that the Petty Officers under him also accept responsibility. In short, he must be the leader his title—Petty Officer—says he is.

Training

As a PO1 or CPO, you will have regular and continuing responsibilities for training others. Even if you are lucky enough to have a group of subordinates who are all highly skilled and well trained, you will still find that training is necessary. For example, you will always be responsible for training lower rated personnel for advancement. Also, some of your best workers may be transferred; and inexperienced or poorly trained personnel may be assigned to you. A particular job may call for skills that none of your personnel have. These and similar problems require that you be a training specialist—one who can conduct formal and informal training programs to qualify personnel for advancement, and one who can train individuals and groups in the effective execution of assigned tasks.

In using this training manual, study the information from two points of view. First, what do you yourself need to learn from it? And second, how would you go about teaching this information to others?

Training goes on all the time. Every time a person does a particular piece of work, some learning is taking place. As a supervisor and as a training expert, one of your biggest jobs is to see that your personnel learn the RIGHT things about each job so that they will not form bad work habits. An error that is repeated a few times is well on its way to becoming a bad habit. You will have to learn the difference between oversupervising and not supervising enough. No one can do his best work with a supervisor constantly supervising. On the other hand, you cannot turn an entire job over to an inexperienced person and expect him to do it correctly without any help or supervision.

In training lower rated personnel emphasize the importance of learning and using correct terminology. A command of the technical languages of your occupational field (rating) enables you to receive and convey information accurately and to exchange ideas with others. A person who does not understand the precise meaning of terms used in connection with the work of his rating is definitely at a disadvantage when he tries to read official publications relating to his work. He is also at a great disadvantage when he takes the examinations for advancement. To train others in the correct use of technical terms, you will need to be very careful in your own use of words. Use correct terminology and insist that personnel you are supervising use it too.

You will find the Record of Practical Factors, NavEdTra 1414/1, a useful guide in planning and carrying out training programs. From this record, you can tell which practical factors have been checked off and which ones have not yet been done. Use this information to plan a training program that will fit the needs of the personnel you are training.

On-the-job training is usually controlled through daily and weekly work assignments. When you are working on a tight schedule, you will generally want to assign each person to the part of the job that you know he can do best. In the long run, however, you will gain more by assigning personnel to a variety of jobs so that each person can acquire broad experience. By giving people a chance to do carefully supervised work in areas in which they are relatively inexperienced, you will increase the range of skills of each person and thus improve the flexibility of your working group.

Working With Others

As you advance to PO1 or CPO, you will find that many of your plans and decisions affect a large number of people, some of whom are not even in your own occupational field (rating). It becomes increasingly important, therefore, for you to understand the duties and the responsibilities of personnel in other ratings. Every Petty Officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of others, and plan your own work so that it will fit into the overall mission of the organization.

Keeping Up With New Developments

Practically everything in the Navy—policies, procedures, publications, equipment, systems—is subject to change and development. As a PO1 or CPO, you must keep yourself informed about changes and new developments that affect you or your work in any way.

Some changes will be called directly to your attention, but others will be harder to find. Try to develop a special kind of alertness for new information. When you hear about anything new in the Navy, find out whether there is any way in which it might affect the work of your rating. If so, find out more about it.

SOURCES OF INFORMATION

As a PO1 or CPO, you must have an extensive knowledge of the references to consult for accurate, authoritative, up-to-date information on all subjects related to the military and professional requirements for advancement.

Publications mentioned in this chapter 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 revision, make 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.

There are training manuals and publications that offer other additional background material. The educational services officer will always have the most up-to-date information and training manuals applicable to your rating.

In addition to training manuals and publications, training films furnish a valuable source of supplementary information. Films that may be helpful are listed in the U.S. Navy Film Catalog, NavAir 10-1-777.

ADVANCEMENT OPPORTUNITIES FOR PETTY OFFICERS

Making Chief Petty Officer is not the end of the line as far as advancement is concerned. Proficiency pay, advancement to Senior (E-8) and Master (E-9) Chief, and advancement to Warrant Officer and Commissioned Officer are among the opportunities that are available to qualified petty officers. These special paths of advancement are open to personnel who have demonstrated outstanding professional ability, the highest order of leadership and military responsibility, and unquestionable moral integrity.

PROFICIENCY PAY

The Career Compensation Act of 1949, as amended, provides for the award of proficiency pay to designated military specialities. Proficiency pay is given in addition to regular pay and allowances and any special or incentive pay to which you are entitled. Certain enlisted personnel in pay grades E-4 through E-9 are eligible for proficiency pay. Proficiency pay is awarded in two categories: (1) Speciality pay–to designated ratings and NEC's, and (2) Superior performance pay–for superior performance of duty in certain specialities not covered by speciality pay. The eligibility requirements for proficiency pay are subject to change. In general, however, you must be recommended by your commanding officer, have a certain length of time on continuous active duty, and be career designated.

ADVANCEMENT TO SENIOR AND MASTER CHIEF

Chief Petty Officers may qualify for the advanced grades of Senior and Master Chief Petty Officer which are now provided in the enlisted pay structure. These advanced grades provide for substantial increases in pay, together with increased responsibilities and additional prestige. The requirements for advancement to Senior and Master Chief Petty Officers are subject to change but, in general, include a certain length of time in grade, a certain length of time in the naval service, a recommendation by the commanding officer, and a sufficiently high mark on the Navy-wide examination. The final selection for Senior and Master Chief Petty Officer is made by a regularly convened selection board.

Examination Subjects

Qualifications for advancement to Senior Chief Petty Officer and Master Chief Petty Officer have been developed and published in the Manual of Qualifications for Advancement, NavPers 18068 (Series). They officially establish minimum military and professional qualifications for Senior and Master Chief Petty Officers.

Bibliography for Advancement Study, NavEdTra 10052 (Series) contains a list of study references which may be used to study for both military and professional requirements.

ADVANCEMENT TO WARRANT AND COMMISSIONED OFFICER

The Warrant Officer program provides opportunity for advancement to warrant rank for E-6 and above enlisted personnel. E-6's, to be eligible, must have passed an E-7 rating exam prior to selection.

The LDO program provides a path of advancement from warrant officer to commissioned officer. LDO's are limited, as are warrants, in their duty, to the broad technical fields associated with their former rating.

If interested in becoming a warrant or commissioned officer, ask your educational services officer for the latest requirements that apply to your particular case.

CHAPTER 2

AVIATION SUPPLY

A Chief or First Class Aviation Machinist's Mate R, especially if in a supervisory billet, will find himself increasingly involved in the details of supporting the man on the job. One of these areas is in the field of aviation supply.

Aviation supply personnel are vital members of the aircraft maintenance team; and the ADR as well as personnel in the other aviation maintenance ratings, must work in close harmony with them if successful teamwork is to be achieved. The team must work so that a flow of parts is maintained from the manufacturer to the man on the job–quite possibly an ADR doing repair work on the other side of the world. A correct concept of supply's relationship to the entire organization is essential in the supervision of aircraft maintenance functions.

ORGANIZATION AND FUNCTION OF NAVAL SUPPLY

The command exercising management control over the policies and procedures of the aviation supply organization is the Naval Supply Systems Command. The Commander, Naval Supply Systems Command is usually a rear Admiral who is appointed by the President with the advice and consent of the Senate. He works with the delegated authority of the Secretary of the Navy, and all policies and procedures of the aviation supply organization emanating from him have the full force and effect of SecNav orders.

To better understand the relationship of the Naval Supply Systems Command to the aviation supply system, it might be well to quickly review the development of the Navy supply system.

Prior to 1842 the commanding officers of ships and stations were responsible for the procurement of their own supplies. They were furnished funds for this purpose by the Navy Department and were required to account for all expenditures. In addition to creating an intolerable burden of paperwork on the Navy Department, this procedure had the effect of forcing prices upward, especially when two commanding officers were bidding for some scarce commodity.

In 1842 Congress approved the establishment of a Bureau of the Navy to take cognizance over all matters of naval supply. The primary responsibilities of this infant supply bureau were the procurement, maintenance of custody, and issuance of naval material. They are the primary responsibilities of the Naval Supply Systems Command today. Every function of the Naval Supply Systems Command is directly related to one or more of these responsibility areas.

In the early years of naval aviation when the Navy had few aircraft, the procurement of spare parts was much like the old system whereby commanding officers dealt with the sellers to fill the needs of each command. The pioneer naval aviation project directors had to deal directly with the manufacturers as parts were required.

By 1917 the Naval Aircraft Factory (NAF) in Philadelphia had come into existence and was assigned responsibility for the procuring of aircraft and spare parts. Other responsibilities assumed by NAF included the repair of aircraft, the manufacture of some spare parts, and eventually the manufacture of complete aircraft. There may still be a few aviators around today who earned their Navy wings in the old N3N, built by NAF.

In 1921 the Bureau of Aeronautics (BuAer) came into being and assumed the responsibility of procuring aircraft and aircraft engines. The responsibility for procuring spare parts and other aeronautical material remained with NAF, which until 1941 was the aviation supply center of the Navy.

The Aviation Supply Office (ASO) was established in 1941 under the technical control of BuAer and the management control of the Bureau of Supplies and Accounts. The function of ASO was the procurement, custody, and issuance of aeronautical spare parts and technical material. This is essentially the function of ASO today under the technical control of the Naval Air Systems Command. Management control of ASO is exercised by the Naval Supply Systems Command.

RESPONSIBILITIES OF THE NAVAL MATERIAL COMMAND

The Naval Aviation Maintenance Program is sponsored and directed by the Chief of Naval Operations (CNO). It is administered through the operating chain of command and is provided material and technical support by the Naval Material Command under the direction of the Chief of Naval Material (CNM). The Naval Material Command was established in 1966 with the cognizance over six systems commands. The cognizant system commands are listed below:

Naval Air Systems Command
Naval Electronic Systems Command
Naval Sea Systems Command
Naval Supply Systems Command
Naval Facilities Engineering Command

The Naval Supply Systems and Naval Air Systems Commands are the two systems commands of most interest to the AD personnel. Listed below are some of the important functions of the Naval Supply Systems Command and the relationship to the Naval Air Systems Command:

1. Supervises the procurement, receipt, custody, warehousing, and issuance of Navy supplies and materials, exclusive of ammunition, projectiles, mines, explosives, and medical supplies.

2. Supervises and directs the operation of the supply phases of the Navy supply system and administers the redistribution program of excess personal property within the Department of Defense and the sale of Navy surplus property.

3. Authorizes and supervises the transportation of Navy property.

4. Prepares budget estimates and administers funds for the supply distribution system.

5. Renders an annual report to the Congress of money value of supplies on hand at the various stations at the beginning of each fiscal year, the disposition thereof, purchase and expenditure of supplies for the year, and balance on hand.

6. Coordinates the compilation and arranges for the printing of the Catalogs of Navy Material.

Some additional functions of the Navy Supply Systems Command that are of interest to AD personnel are the general functions of ASO; these include the following:

1. Responsibility for overall determination of requirements, procurement, and distribution of standard aeronautical materials. (Certain materials excepted; such as complete aircraft and engines, complete electronic equipment, major photo equipment, nonstandard and experimental aerological equipment, and items of naval weapons ordnance equipment.)

2. Maintenance of a complete file of ASO and Naval Air Systems Command contracts, letters of intent, amendments, extensions, and change orders, and distribution of all (necessary copies of documents to Navy field) activities.

3. Stock control of aeronautical materials at all aviation supply facilities, including control of packing, preservation and distribution of material under ASO cognizance to, from, and between aviation supply facilities and major supply points.

4. Maintenance of complete records of material on order and followup procedure necessary to effect timely deliveries of all material under ASO cognizance.

5. Maintenance of up-to-date records of existing storage facilities at depots, major supply points, and operating stations for aeronautical materials, and control of influx of materials in aviation supply channels so as not to exceed existing storage facilities.

6. Determination and disposition of obsolete and excess aeronautical material under NavAirSysCom cognizance.

7. Preparation and distribution of the Navy Stock List of ASO, including interchangeability data.

8. Compilation and distribution of some allowance lists subject to approval by NavAirSysCom.

9. Compilation of lists of spare parts to be salvaged from surveyed aircraft.

10. Followup on delivery, stock recording, reallocating as necessary, and distributing change material promulgated by NavAirSysCom.

11. Establishment and maintenance of a statistical unit which assembles, compiles, and analyzes usage data.

12. Maintenance of a representative at each aircraft manufacturer's plant who keeps ASO fully informed, as requested, as to all changes which affect spare parts under procurement.

13. Establishment of an inspection service which inspects aviation supply activities within established naval districts.

APPROPRIATIONS

At one time or another, almost everyone has had the frustrating experience of not being able to draw from supply some item needed immediately; the usual reason given being "We do not have any money left." It takes only a short time to realize that the Navy does not operate with unlimited funds. This section and the following section, titled "Operating Budgets," are presented to further an understanding of the system whereby funds are made available at the user activity level for operating expenses.

The main money pool of the government is the General Fund of the Treasury. Funds come into the General Fund from such sources as income taxes, excise taxes, import-export taxes, etc. The only way for money to be expended from the General Fund is by congressional action, which has to be approved by the President. A bill passed by Congress which includes the expenditure of funds from the General Fund is called an appropriation.

An estimate of the amount of money required for the operation of the Defense Department during a given fiscal year is prepared by Department of Defense fiscal experts well in advance of the beginning of the fiscal year. The Congress studies the proposed budget in the light of world affairs, the current domestic economy, and such other considerations as they see fit, then acts upon it. Congress may increase the amount requested, decrease it, or pass it as is. After presidential action is completed, the money is made available to the Department of Defense to be spent during a specified year. This is known as an "annual" or "one-year" appropriation.

Congress and the President may also approve "no-year" appropriations for special projects such as large construction programs over an unspecified length of time.

Another form of appropriation is the "multiple-year" appropriation for projects which will be completed in a predictable length of time. An example of the use of this type of appropriation is the money appropriated to cover the expenses of the NROTC college programs for the next 4 years.

The appropriation by which the AD is most affected is the "current-year" appropriation. After the appropriation or expenditure authorization is received in the Department of Defense, it is prorated among the services as a percentage of their previously submitted budget estimates. The Navy's share is prorated among the various systems commands and bureaus in essentially the same manner; that is, as a percentage of their estimated requirements for the coming fiscal year. The money to be spent for naval aviation is made available to NavAirSysCom. Here, part of the money is allocated to ASO for the purchase of aircraft spare parts and related equipment in quantities which past usage data has indicated will probably be sufficient for the coming year. These spare parts are furnished to the operating activities at no cost, since their usage has been anticipated and the items paid for in advance. The account from which money was spent to buy these items is known as the Appropriation Purchase Account (APA). Material received in the user activities from this account is known as APA material.

Another part of NavAirSysCom funds is made available to the operating activities in the form of operating budgets.

OPERATING BUDGETS

Funds available within an appropriation account for commitments, obligations, and expenditures are administered through the issuance of operating budgets. An approved operating budget is an authorization granted for the purpose of incurring commitments, obligations, and expenditures to accomplish the mission of an activity. Therefore, an approved operating budget is a subdivision of an appropriation which provides the funding authority for an official to accomplish a specific function or mission.

Approved operating budgets concerning naval aviation are authorizations by NavAirSysCom to the user activities to spend a certain amount of money during a given length of time for specified purposes. User activities are shore commanders.

Operating funds for stations, rework activities, etc., concerned with the operation and maintenance of aircraft and related equipment are allotted to them by the NavAirSysCom as an operating budget. Departments within these organizations normally submit their department budget to the station comptroller who reviews and combines the different department budgets into a recommended station budget. Senior AD's may be called upon to assist in furnishing a realistic estimate of division operating expenses and future needs which the department head may use in formulating the department budget.

Since there is a relatively long period between budget submission and the subsequent receipt of funds, the necessity of accurate estimates of future requirements and strict management of materials for which allotted funds are expended cannot be overemphasized.

Operating Targets

Funds to finance the operation of aircraft are allotted by the NavAirSysCom to the air type commanders. Operating funds for squadrons and units are apportioned to them by their cognizant air type commander as an operating target (OPTAR). An OPTAR is a planned estimate which the air type commander allocates for the financing of aircraft operating costs during a given period of time. OPTAR's are issued on a quarterly basis and unused funds from the previously issued OPTAR revert to the control of the type commander as each new OPTAR is authorized. Type commanders provide OPTAR's to squadrons, units, and ships under their operational control, whether or not the user activity is based ashore.

There are several different types of OPTAR's issued by air type commanders for aviation purposes. Two that are of interest to AD personnel are flight operations and aircraft maintenance funds. These are discussed in the following paragraphs.

Flight operation funds are used primarily for the purpose of financing actual flight operations; therefore, they have application at the Organizational level. These funds finance the following:

1. Aviation fuels and lubricants consumed in aircraft.
2. Liquid oxygen.
3. Aerial film for use in aircraft cameras.
4. Flight clothing and operational equipment authorized in NavAirSysCom Allowance List (NavAir 00-35QH-2).
5. Flight deck safety shoes.
6. Squadron administrative consumable office supplies.
7. Unit identification marks (shoulder patches) for initial issue to newly reported personnel.
8. Material and services required when located at an activity without Navy or Marine Corps Intermediate maintenance capability.

Aircraft maintenance funds are provided to Organizational and Intermediate maintenance activities to finance the cost of various supplies and materials consumed in the performance of aviation maintenance. These funds finance the following:

1. Repair parts, common hardware, lubricants, cleaning agents, cutting compounds, metals, and other materials incorporated into or expended in the performance of aviation maintenance of aircraft, engines, aeronautical components and subassemblies, and Navy maintenance of aviation maintenance support equipment.
2. Fuels and lubricants consumed by aircraft engines in the performance of complete section repairs.
3. Pre-expended, consumable maintenance material.
4. Replacement of expendable or consumable allowance list items with material accountability

codes B and C. (Allowance list and material accountability codes are discussed later in this chapter.)

MATERIAL IDENTIFICATION

In addition to the task of supervising lower rated AD personnel in the performance of routine duties, senior AD's may be assigned maintenance supervisor duties. In some cases, these duties will encompass the task of assisting in the procurement of material and parts used by production personnel. One important area of material procurement is the correct identification of the material and parts required. Since at pay grade E-9, AD's compress with other maintenance ratings and become Master Chief Aircraft Maintenancemen, it is important that senior AD's be familiar with some of the methods of identifying material.

There may be times when a part or some technical material is needed and the stock number is unknown. At other times some material may be on hand and its identity not positively known. A knowledge of the various methods of identifying material other than by stock number will often help speed the completion of a maintenance task. Certain data may be available which do not identify an item but which may lead to positive identification. The following sections discuss some methods of identifying material.

FEDERAL STOCK NUMBERING SYSTEM

NOTE: At the time of printing this Rate Training Manual, the Federal Stock Number (FSN) is being replaced by a National Stock Number (NSN). The NSN is the same as an FSN except for the addition of a two-character code identifying the country having cognizance of the item, i.e., 1234-00-123-4567 (00 denotes United States). The FSN will still appear in numerous publications and manuals; therefore, the FSN is explained in the following paragraphs.

The Defense Cataloging Standardization Act, passed by Congress in 1952, provided for a uniform system of identification, classification, and stock numbering throughout the Department of Defense. Prior to this time there were many stock numbering systems within the Department of Defense and within the Navy itself. It was possible for the same item to be stocked under different stock numbers as Navy general stores, Navy aviation stores, Air Force stores, Army quartermaster stores, and many others. There was no cross-reference system whereby an agency could determine if its excess material was the same as that which was in short supply in another agency.

The federal cataloging system eliminated this situation by placing all like items under a federal stock number bearing a common official government name. This system was made applicable to all agencies within the Department of Defense.

Under the federal cataloging system, federal stock numbers are required for all items that are subject to central inventory management within the Department of Defense. Each Navy item to be stocked under centralized inventory control is assigned a federal stock number which is used in all supply management functions. This federal stock is listed in supply publications in which the item is referenced.

The following paragraphs discuss the various parts of a coded FSN and frequent reference to figure 2-1 will assist in understanding the composition of coded FSN's.

A cognizance symbol consists of a 2-digit code prefixed to an FSN to identify and designate the systems command office, agency, or Navy inventory manager that exercises management control over specific categories of material. Although the cognizance symbol officially consists of two digits, it will be observed that publications and requisitioning procedures frequently drop the first digit for APA material, thus 2R is referred to as R, etc.

Listed in table 2-1 are some of the more common cognizance symbols, together with the type material controlled and the name of the cognizant command or office.

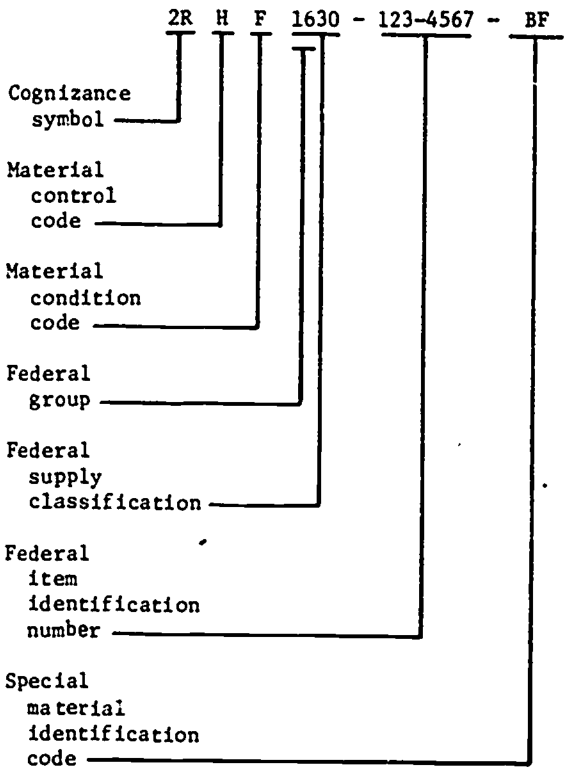
The Federal Stock Numbering System was intended to create and improve standardization of items of military supply in servicewide use and reduce excess inventories which, for the most part, were caused by the lack of standardization. Also, the reduction of excess inventories eliminates substantial financial loss due to material obsolescence.

Federal Stock Number (FSN)

The FSN is an 11-digit number which furnishes positive identification of virtually all items of supply from purchase to final disposition. The 11 digits are uniformly arranged in groups of 4, 3, and 4 digits, with groups separated by hyphens. The 11 digits are made up of a 4-digit federal supply class (FSC) and a 7-digit federal item identification number (FIIN). In addition to the 11-digit number, the Navy supply system utilizes certain code prefixes and suffixes to aid in the performance of various management functions. These codes are of significance only within the Navy and are not used during interservice transactions. When the prefixes and suffixes are used, the FSN is known as a coded FSN.

Figure 2-1 describes the format of a coded FSN, including applicable management codes for an item of supply under the cognizance of ASO.

Material control codes divide inventories into segments reflecting similar demand, repairability, or other characteristics. For example, some material control codes reflect either fast or slow moving demand characteristics, while others denote whether the item is to be repaired by Intermediate or Depot level maintenance activities.



AD.213
Figure 2-1.—Breakdown of coded federal stock number.

Material condition codes classify material in terms of readiness for issue and use, or to identify action underway to change the status of material. For example, one material condition code is used to indicate that a particular item is serviceable and ready for issue. If, after issue from the supply system and through use this item becomes unserviceable, its material condition code would be changed to reflect the requirement for rework, repair, etc. Naturally, upon completion of rework or repair the material condition code would be changed to show that the item is serviceable and ready for issue. Therefore, this code changes from time to time on a particular item depending on the condition of the material.

The federal supply classification (FSC) class is the first four digits of the FSN and is used to group related commodities together. Each item of supply is classified in one, and only one, 4-digit FSC. The first two digits denote the group or major division of commodities, and the last two digits denote the class or subdivision of commodities within a group. Aircraft components and accessories are in group 16; therefore, in the FSC 1630, the 16 denotes an aircraft component or accessory and the 30 indicates a particular class within this group, which is aircraft wheel and brake systems. Other classes in group 16 are indicated as 1610—propellers, 1620—landing gear components, etc.

The federal item identification number (FIIN) consists of the last seven digits of the FSN. It serves to differentiate each individual item of supply from all other items of supply. Therefore, each individual item of supply such as brake, F-4B; brake, P-3A; etc., is assigned a separate FIIN. The FIIN in no way determines the position or sequence of the item in relation to other items. A recent change has replaced the four-character TSMC with a two-letter special material identification code (SMIC). However, like many areas where changes are made, a certain time element is involved; therefore, the TSMC will still be used for some time on many coded FSN's. A SMIC is a management code added as a suffix to an FSN to indicate a

Table 2-1.–Cognizance symbols.

Symbol	Cognizant Activity	Material Controlled
1I	Naval Publications and Forms Center, Philadelphia	Forms
ØI	Naval Publications and Forms Center, Philadelphia	Publications
1R	Aviation Supply Office	Consumable Aeronautical material
2R	Aviation Supply Office	Repairable Aeronautical material
6R	Aviation Supply Office	Aeronautical Support Equipment (IMRL)
8R	Naval Air Systems Command	Major aeronautical systems and equipment
4V	Naval Air Systems Command	Aircraft Engines
6V	Naval Air Systems Command Representatives Atlantic and Pacific	Technical Directive Compliance (TDC) kits
1W	Naval Supply Systems Command	Bulk and packaged liquid fuel
9G	Navy Fleet Material Support Office (FMSO)	Navy owned stocks of defense general material
9Z	Navy Fleet Material Support Office (FMSO)	Navy owned stocks of defense industrial material

primary weapon support item, specialized materials or general/common material. ASO has published a conversion guide which cross references the SMIC with the TSMC.

Many variations of coded stock numbers will be encountered in maintenance work. These variations indicate material management responsibilities for the item; flag certain items as recoverable, consumable, high value, etc.; and identify the condition of the material if it is not ready for issue.

Because the variety of codes is so extensive and the trend to single service management of items has caused so many changes in recent years, a list of codes that might be prefixed or suffixed to a stock number would not be appropriate for this course. The primary things to keep in mind are that the basic stock number, consisting of three groups of numerals, identifies the item from a technical point of view and that the other codes identify material management characteristics.

STANDARDIZATION OF ITEM NOMENCLATURE

As part of the federal cataloging system, each item of supply is assigned an official government name. Maintenance personnel frequently refer to material by trade name or terminology other than the official government name. Alphabetical indexes in the various stock catalogs and other publications are sequenced by official name. To effectively utilize these publications, it is necessary to become acquainted with the proper nomenclature.

The assignment of names to stock items is practically as important as the assignment of FSN's. When items are inducted into the supply system, official government nomenclature must be assigned. Often this item name plus additional descriptive data will differ from names of items previously used. If difficulty is experienced in locating a familiar item in the catalog, it is quite possible that the name has been changed to conform to a more general usage. A few examples will show the importance of correct item nomenclature. It will be found that a "swab" is a small stick with a tiny wad of cotton on one end, and is used by the Medical Department. In order to clean the decks it will be necessary to think of another name for "swab." "Mops" will be found listed in the catalog, together with the correct FSN. Other samples are as follows: "Ceilometer" becomes "Projector, Cloud Height"; "Zipper" has become "Fastener, Slide Interlocking," etc.

NAVAL MATERIAL CATALOGS

Federal and naval material catalogs provide information necessary to identify and procure items of material for operation and maintenance of activities afloat and ashore. The catalog most commonly used by aviation personnel is the Federal Supply Catalog Navy Management Data List.

The Navy Management Data List (NMDL) consists of two separate sections. One section, the Fleet Ballistic Missile Weapons System Supplement, has application only to submarine forces and therefore is of little or no use to aviation maintenance personnel.

The other section, titled the Management Data List, includes basic management data necessary for preparing material requisitions. Also, it is the instrument for publishing data relative to stock number changes, unit of issue, unit price, shelf life of material. number of items contained in a package, and associated information.

The NMDL is designed to disseminate management type information as it relates to an FSN. It is not designed to act as a comprehensive catalog of material in the supply system, identify an item to an FSN, or serve as a shopping guide. Therefore, in order to get the necessary FSN or other needed information for making effective use of the NMDL, additional publications must be used in conjunction with the NMDL. These include the Deleted and Superseded FIIN List, the Consolidated Repairable Item List, and the Federal Supply Catalog Navy Master Cross Reference List.

The Deleted and Superseded FIIN List provides historical data of stock number deletions and supersessions. It should be remembered that the FIIN taken from this list is referred back to the NMDL for the requisitioning data.

The Consolidated Repairable Item List contains a listing of Navy managed mandatory turn-in repairable items. It is prepared to assist in identifying Navy managed mandatory turn-in repairable items and pertinent movement priority designators. Some repairable items under the cognizance of ASO and the NavAirSysCom are not included in this publication. These are listed in the ASO Master Repair List.

The Federal Supply Catalog Navy Master Cross Reference List provides the means of identifying an item from a reference number (part number, drawing number, etc.) to an FSN. The FSN found in this publication should be referenced back to the NMDL for all pertinent information required in requisitioning material.

IDENTIFICATION SOURCE DATA

As previously stated, positive identification of an item of supply has been accomplished when it is identified to its applicable FSN. For the most part, the FSN is not marked on material; however, most material has some type of data affixed to it that can be used for identification purposes. Certain data which do not identify an item but which aid in obtaining positive identification are discussed in the following paragraphs.

Manufacturer's Part Number

Normally, the manufacturers of parts stamp, etch, paint, or otherwise affix a part and manufacturer's code (vendor code) numbers on each item manufactured. The use of these numbers, part and code, and the knowledge of the part's application (that is, on what equipment it is used) normally lead to positive identification of the part's nomenclature and FSN. Due to the possible duplication of part numbers by manufacturers the manufacturer's code (VENDOR) will be used with the part number. The part number and vendor code can usually be found on the part, and/or IPB for the item needed. The vendor's code is a five-digit code. If a vendor code cannot be firmly established in the master file, a code of 99999 will be inserted. As the vendor codes are established, the file will be updated and subsequent issues of the index will reflect the assigned vendor code. After ascertaining the correct part and code number the FSN may be obtained by reference to the appropriate Federal and Naval Material Catalogs.

Drawing Number

A drawing number consists of letters, numbers, or a combination of both which are assigned to a particular drawing for identification purposes. The activity controlling the drawing (normally the manufacturer) assigns the number in conformance with their drawing number system. One drawing may apply to several items; thus other distinguishing data may be necessary to identify the item on the drawing.

Drawing numbers may be used to identify the microfilm available in some technical libraries. Some large assemblies are illustrated in the appropriate Illustrated Parts Breakdown but are not broken down sufficiently to show identifying data for their component parts. By obtaining the drawing number of the larger item and cross-referencing it to the applicable microfilm, sufficient identifying information for the component part may be obtained.

Nameplates

Some aeronautical materials have nameplates attached which provide such information as the manufacturer's name or code, make or model number, serial number, size, voltage, phase, etc. Identification data taken from the nameplate of the old part can be very helpful in identifying and procuring a replacement. Nameplate data is particularly useful when requesting nonstandard material which is not subject to the federal cataloging system.

Markings and Measurements

Special coded markings, other than part numbers, and measurements often aid in the identification of some materials. For instance, compressed gas cylinders are color coded to identify the contents of the cylinders. Sheet metal is stamped with a significant identifying symbol which is repeated at intervals throughout the length of the sheet. This symbol includes the composition, temper, thickness, etc.

Flexible rubber hose is marked with a symbol which is repeated at intervals throughout the length of the hose. Bare wire is separated according to diameter. Tubing has two types of measurements–outside diameter, given in inches; and thickness of the wall, given in thousandths of an inch. Female fittings such as crosses, tees, and couplings are measured across the inside diameter of the threaded opening. The male fittings are measured across the outside diameter of the male threads.

Source Codes

Item Source Codes are symbols which indicate to a consumer a source of supply for an item required to maintain or repair aeronautical articles. Specifically, these codes indicate whether the item is to be requisitioned from the supply system; to be manufactured; to be obtained from salvage; not to be replaced since the next higher assembly is to be installed; or, due to failure, is in need of complete overhaul or retirement of the assembly or equipment from service.

Source codes are assigned to material at the time of provisioning. Known or anticipated usage is the primary factor in the assignment of source codes. The ability to manufacture an item within a naval activity is considered to be of secondary importance. In other words, items are normally source coded for purchase and stocking in the Navy supply system if usage is known or anticipated. Source codes for individual items may be revised as experience and usage develop.

Source codes are published as a column of the numerical index of the Illustrated Parts Breakdown, and in other publications as directed by the NavAirSysCom.

Source codes are provided in six series—P, M, A, N, X, and U.

Source code P series applies to items of supply system stock which are purchased in view of known or anticipated usage.

Source code M series applies to items which are not purchased but are capable of being manufactured at Navy fleet or overhaul activities. These items are normally manufactured upon demand and are not stock numbered.

Source code A series applies to assemblies which are not purchased.

Source code N series applies to items (nuts, bolts, screws, etc.) which do not meet established criteria for stocking and which are readily available from commercial sources. These items are purchased on demand.

Source code X series applies to items not procured and not practical for storage, maintenance, or manufacture.

Source code U applies to items which are not of supply or maintenance stocking significance.

Within each of the source code series, there are one or more subcodes identified by a letter or number appended to the basic code number. These subcodes provide detailed information concerning the procurement or manufacture of various parts within the scope of the particular code series. The applicable Illustrated Parts Breakdown provides ready reference for each of the codes and subcodes as required.

The preceding sections have emphasized some of the many things that may be used to identify or aid in procurement or use of material. The senior AD who is familiar with the methods of identifying material is an asset to a maintenance organization, especially in performing maintenance supervisory duties.

AERONAUTICAL ALLOWANCE LISTS

This title is inclusive of publications identified as Allowance Lists (except advanced base lists), Initial Outfitting Lists, and Tables of Basic Allowances.

Naval Air Systems Command Allowance Lists, Initial Outfitting Lists, and Tables of Basic Allowances are prepared by the NavAirSysCom or the Aviation Supply Office. In nearly all instances ASO has the responsibility for preparation, but in all cases these lists are published by the direction of and approved by the NavAirSysCom. These lists contain the following:

1. The equipment and material (both consumable and nonconsumable) necessary to outfit and maintain units of the aeronautical organization in a condition of material readiness.

2. Substantially all items used with sufficient frequency to justify their issuance to all activities maintaining aircraft or equipment for which the lists are designed.

3. Information concerning stock number, nomenclature, interchangeability, and supersedures.

4. A set of detailed instructions for the application and utilization of the publication.

5. A table of logistic data showing the total weight and cube of all material contained in the list.

In the final analysis, the equipment and spare parts listed in these publications are made available to aircraft operating and maintenance activities in accordance with assigned operational maintenance and logistics responsibilities through appropriate application of allowance lists and outfitting actions. The Aviation Supply Office has the responsibility for continually reviewing and updating allowance lists.

INITIAL OUTFITTING LISTS

Initial Outfitting Lists are publications which indicate the range and quantities of maintenance spare parts considered necessary to support various aeronautical end items. These lists contain repair parts, such as airframe parts, electronic parts, engine parts, and general aeronautical equipment. The material covered by Initial Outfitting Lists is normally retained in supply department stocks until required for issue. This allowance of material is provided to ships or activities and is firm only at the time of initial outfitting. Increases and decreases in both range and/or quantities of material are based upon usage data of each activity concerned. Each series list is designed to support an aircraft, electronic equipment, or some other aeronautical article.

ALLOWANCE LISTS

These are publications which indicate the range and quantities of equipment and material considered necessary for maintenance support of assigned and/or supported aircraft. Generally, these items are inuse items required for daily or continual use, such as aircraft jacks, air compressors, and avionics test equipment.

Publications listing equipment and material required by activities for performance of assigned mission are known as Tables of Basic Allowance. They contain both shop equipment and common supporting spare parts. They cover allowances of tools and equipment required for use by such activities as Fleet Marine Force squadrons and target pilotless aircraft activities.

A complete listing of Aeronautical Allowance Lists, Initial Outfitting Lists, and Tables of Basic Allowance, with NavAirSysCom publication numbers and their effective dates, is contained in NavSup Publication 2002, Section VIII, Part C.

IDENTIFICATION AND TYPES OF ALLOWANCE LISTS

Allowance Lists and Initial Outfitting Lists are identified by the NavAirSysCom publication number 00-35Q (Series), while Tables of Basic Allowance are identified by the NavAirSysCom publication number 00-35T (Series). The following paragraphs discuss some of the various sections of allowance lists.

Section A, Standard Aeronautical Material and Naval Stock Account Material

Section A covers general material such as nuts, bolts, tubing, hose, paint, and other items common to the operation of all aircraft models. Both equipage and consumable supplies are shown in the Section A.

Section B, Aircraft Maintenance Parts

Section B contains airframe, engine, and accessories maintenance parts peculiar to each type of aircraft. A separate section B is issued for each model of aircraft.

Section C, Office Furniture and Laborsaving Devices

Section C lists the items and quantities of office furniture and laborsaving devices for the administrative support of deployable fleet air activities only.

Section G, General Support Equipment For All Types, Classes, and Models of Aircraft

Section G (Series) lists the quantities of handtools, handling and servicing equipment, and material which are made available for maintenance support of aircraft as may be assigned or supported.

Section H, Flight Operational Material

Section H is applicable to air task group commanders and all Navy and Marine squadrons operating aircraft or having aircraft assigned. It contains items and quantities of flight operational material considered necessary to maintain the concerned activities in a continual condition of operational readiness.

Section K, Naval Aeronautical Publications and Forms

Section K outlines the general types and classes of aeronautical technical and training publications and forms which are provided as a commissioning allowance for various Navy and Marine Corps aviation activities. It lists those publications and forms which are issued by the Deputy Chief of Naval Operations (Air) and by the Naval Air Systems Command, but does not include publications provided to aviation activities by other Navy Department systems commands and bureaus, by fleet commands, or by non-Navy offices.

Section R, Aeronautical Electronics Material

Section R comprises Allowance Lists and Initial Outfitting Lists of electronic equipment and material required for the test and maintenance of aeronautical electronic equipments within the Naval Establishment.

Section Z, Special Equipment and Spare Parts

Section Z includes mobile electric powerplant spare parts and equipment and spare parts support for aircraft support equipment.

The foregoing section list breakdown includes only those sections of professional interest to the AD. The complete list includes allowance lists for arresting gear and catapults, photographic, aerological, etc.

ACCOUNTABILITY CODES

The accountability codes used in allowance lists and most Illustrated Parts Breakdowns are known as Material Accountability Recoverability Codes (MARC). MARC's are assigned only to aeronautical provisioned items to reflect the accountability, recoverability, and repair policy determined for an item of equipment or material required for the maintenance, repair, or rework of an end item. MARC is a system whereby a letter of the alphabet is used as a guidepost by personnel working with aviation material. This system helps personnel to determine the proper method of the following:

1. Requisitioning material with regard to inventory control and fiscal accounting procedures.
2. Accounting for material while in use.
3. Turn-in or disposition of material.
4. Repair or overhaul.

The following list defines the various material accountability codes.

B–Exchange Consumables

Code B is applied to items which are consumable or expendable but normally require item-for-item exchange for issue after the initial outfitting. Such items may contain precious metals, may be highly pilferable, or may be high cost items.

C–Consumables

Code C is applied to all other consumable or expendable items which do not require item-for-item exchange for replacement.

D–Equipage, Support Type

Code D is applied to end items of support equipment which are economical and practical to repair on a scheduled basis through a major rework activity. Code D items are maintained on a custodial signature basis and must be surveyed when lost or missing or when beyond economical repair. After initial outfitting, Code D items require item-for-item exchange for replacement. Every effort should be made to repair Code D items locally or through fleet support activities prior to turning in the item to the supply system as non-RFI material.

E–Equipage, Locally Repairable, Support Type

Code E is applied to end items of support equipment which are to be repaired locally by the using or fleet support activity within their assigned maintenance responsibility. Code E items are maintained on a custodial signature basis when in use, require item-for-item exchange for replacement, and require surveying when lost or missing. The cognizant NavAirSysComRep may authorize repair of E items through customer service from a major rework activity in order to meet operational commitments.

R–Equipage

Code R is applied to repairable (except end items of support equipment) items which are economical and practical to repair on a programmed basis through a major rework activity. Code R items are repaired by local activities when the extent of the required repair falls within the maintenance capability of the activity. After initial outfitting, these items are issued only on an exchange basis or when necessary to replace an item expended by approved survey.

L–Equipage, Locally Repairable

Code L is assigned to repairable items (except end items of support equipment) which can be repaired by deployable squadrons within their assigned maintenance responsibility upon consideration of the following factors:

1. Manhours and skills required to perform the repair.
2. Total cost of providing necessary support equipment to perform the repair.
3. Total cost of providing necessary parts to perform the repair.

Items coded L are scrapped when economical repair is beyond local activity capabilities. After initial outfitting, issues of Code L items are made only when exchange procedures provide for turn-in of the replaced items or when necessary to replace an item expended by approved survey.

DEVIATIONS FROM ALLOWANCE LIST REQUIREMENTS

It is the policy of the NavAirSysCom to make available to each Navy activity the authorized equipment and repair parts necessary to insure operational readiness. Allowance list requirements are not mandatory and deviations are approved as pointed out in the following paragraphs.

Type, Force, and major operating commanders, or their subordinate logistics commanders, may authorize deviations from allowance list requirements. This includes one-time in-excess issue of equipment for a requirement not considered generally applicable to other activities of the same type, or for independent operations of detached activities.

Organizational and Intermediate maintenance activities often have requirements for equipment which does not appear on existing allowance lists. In some cases the equipment is requested because it is considered superior to existing equipment or it may be the result of an entirely new requirement: that is, for rework of a component or to perform repairs or services for which no previous capability existed.

In order to assure that each request for deviation is properly reviewed and evaluated for validity and possible application to other maintenance activities, the originating activity should submit an official request to the Naval Air Systems Command Headquarters, via the chain of command (including the cognizant NavAirSysComRep). The following general procedures are followed in approval or rejection for a new piece of support equipment where no previous capability or need existed.

The request, together with complete justification, should be forwarded via the chain of command to the NavAirSysComHq. The request should not be made through supply system channels. The type commander normally identifies, on the forwarding endorsement, the Intermediate maintenance activity which will perform the equipment evaluation if different from the requesting activity.

The NavAirSysComRep normally investigates the request and indicates on the following endorsement the availability of the requested equipment from existing resources. Upon review and approval, the NavAirSysComHq provides the activity concerned with the equipment. This equipment is considered a prototype and is for evaluation. No additional equipment is normally procured until the validity of the need can be determined. During the evaluation, the type commander and cognizant NavAirSysComRep performs monitoring actions and provides additional assistance as required.

The completed documentation of the evaluation is forwarded via the chain of command to the NavAirSysComHq. In the forwarding endorsement, the type commander normally suggests a criteria for allocation of equipment to other activities. Upon review of the evaluation report, the NavAirSysComHq notifies all concerned of the action taken. In case of approval, this includes ASO so appropriate action may be taken to insure updating allowance lists.

AIRCRAFT MAINTENANCE MATERIAL READINESS LIST (AMMRL) PROGRAM

This program has provided for the development of data and documentation needed to determine and establish firm support equipment requirements and inventory control of aircraft maintenance support equipment. It provides for the construction of an Individual Material Readiness List (IMRL) for each aircraft maintenance activity, by name, prescribing items and quantities of aircraft maintenance material required for material readiness of that specific activity to which the list applies. This program also provides for the construction of material readiness lists to indicate the total quantities of each item authorized within stations, logistic areas, and major operating command areas.

Within the AMMRL program there are several material readiness lists; however, only two are discussed here.

The Application Data Material Readiness List (ADMRL) is used to specify the requirements for each item of aircraft maintenance support equipment against each level of maintenance and selected ranges of each aircraft, engine, propeller, and system for which each item is needed. Through the use of electronic data processing machines this data is used to develop Individual Material Readiness Lists.

The IMRL specifies items and quantities of aircraft maintenance support equipment required for material readiness of the aircraft maintenance activity to which the list applies. As previously stated, this list applies to an activity by name. The NavAirSysComRep is responsible for the preparation of the IMRL for each activity in his cognizant area. It is prepared by extracting from the AMMRL those applicable portions which pertain to the specific aircraft and maintenance material assignments of the activity for which the list is developed.

Maintenance/Material Control personnel maintain an updated IMRL to support current and anticipated changes in aircraft maintenance support equipment requirements. Because the IMRL is continually reviewed and updated and approved by the cognizant command, it is the firm mandatory material readiness list of the activity to which the list applies.

SUPPLY ACTIVITY

The mission of the supply activity is to support the operational and maintenance efforts of the activity/ship. Stocks of aviation oriented material carried are tailored and replenished to this end. Positioning, replenishment, and control of stocks of material in maintenance areas are carried out as a result of joint decisions by the Supply and Maintenance Officers concerned. They determine the range, depth, and related procedures. The Naval Aviation Maintenance Program (NAMP) requires that the cost of material used in maintenance be determined and accumulated in such manner and detail that weapons system costing can be measured. Usage is finely defined as to stock number, within component, within system, within equipment/weapon/aircraft, in a particular squadron, located in a specific operational area, at a definite point in time. These data are used as an inventory management tool to determine geographic and strategic distribution of stocks of material. In addition, the data will be invaluable in establishing the material portions of work standards in maintenance.

SUPPLY SUPPORT CENTER (SSC) DIVISION

Maintenance organizations have one point of contact with the supporting supply activity. This single contact point is the Supply Support Center (SSC), which responds to all material requirements of the maintenance organizations. The SSC is an internal organization of the local supply department at the division level and is responsible to the supply officer. It is made up of two sections—the Supply Response Section (SRS) and the Component Control Section (CCS). In addition to these two sections, there is the preexpended bin element which may be organized as a section under the SSC supervisor or as a unit under SRS or CCS.

Supply support is available consistent with the operating hours of the maintenance activities supported. If maintenance is being performed 24 hours a day, then supply support is available 24 hours a day.

The supply support center maintains rotatable pool material which consists of repairable ready-for-issue items reserved primarily to satisfy the requirements of Organizational level maintenance. Items maintained in the pool are capable of being repaired by the local Intermediate maintenance activity, have application relationship to weapon systems supported by local Intermediate maintenance activities, and have an average Organizational maintenance level removal rate of at least one per month. Defective components are turned in to Intermediate level maintenance for repair. The defective components repaired to an RFI condition are then returned to the rotatable pool to replace the components previously issued.

Generally, items included in a rotatable pool are repairable items of supply which are under the issue control of the local supply officer. However, instances may occur when it is desirable to position some items or assemblies (such as a pre-soaked carburetor, built-up wheel assembly, built-up prop, etc.) in the pool for use by Organizational and Intermediate maintenance activities. Pre-positioning of items of this nature is acceptable as long as they aid in decreasing NOR time.

The local supply officer and aircraft maintenance officers concerned determine the range and quantity of each item required in the rotatable pool. Two elements used in this determination are the local repair cycle time and the local removal rate. The local repair cycle time is the average total elapsed time between removal of a component and the complete local repair of the item into an RFI condition. The local removal rate is the average number of defective components removed over a 3-month period, for which replacement RFI components were required.

After the components and the quantity of each that will be included in the pool have been determined, the supply officer publishes an official list of pool items. This listing provides a ready reference for the components carried in the pool. RFI rotatable pool items are withdrawn from the pool by the local supply officer only under the following conditions:

1. When actual usage indicates the item/quantity can no longer be justified as a reservation, and the aircraft maintenance officer concurs.

2. When requested by the aircraft maintenance officer.

3. Only as a last resort to satisfy non-local system requirements.

In order for the rotatable pool to fully serve its intended purpose there must be complete cooperation between the maintenance and supply organizations. Organizational maintenance activities must expedite return of defective components to supply so that these components can be delivered to the Intermediate activity for repair. The Intermediate activity must complete repairs in an expeditious manner so that the repaired components can be returned to supply to be placed in the rotatable pool. Then, the supply organization is able to offer maximum support in the form of RFI components to insure maximum aircraft readiness.

Supply Response Section (SRS)

The Supply Response Section (SRS) is responsible for preparing all necessary requisitions (DD Form 1348) and related documents required to obtain material for local maintenance use in direct support of weapon system maintenance. The maintenance organization verbally notifies the supply organization of the need of such material. When material is available locally, the time frame for processing and delivery is as follows:

Priority	Process/Delivery Time
1-3	1 hour NORS/NFE
4-8	2 hours
9-15	24 hours

The SRS is responsible for physical delivery of RFI material to maintenance organizations, and the pickup of defective components from the Organizational maintenance activity and subsequent delivery to the Intermediate maintenance activity. Actual maintenance personnel are not involved in the physical movement of material between organizations.

This section also performs technical research in regard to completion of requisition documents as well as determining the status of outstanding requisitions and relaying this status to the customer upon request.

The SRS accomplishes these functions through four units–the requisition control unit, the technical research unit, the stock locator unit, and the material delivery unit.

Component Control Section (CCS)

The CCS is responsible for the following functions:

1. Physically maintaining components in the rotatable pool.
2. Maintaining rotatable pool supplemental records.
3. Maintaining a suspense file for all components issued to customers on an exchange basis.
4. Maintaining a suspense file for all components in AIMD.
5. Processing all components received from AIMD.

The CCS accomplishes these functions through four units—the document control unit, the rotatable pool unit, the supply screening unit, and awaiting parts control unit.

Preexpended Bins Section

This section is responsible for establishing and maintaining stocks, in maintenance areas, of common repair parts that are considered to be high usage, low in cost, expended from supply department stock records, and expended from financial records.

MATERIAL CONTROL WORK CENTER

The material control work center in a maintenance activity performs a staff function, and as such provides support and services to the production divisions. It exists for the primary purpose of insuring that maintenance requirements for parts and materials are made known to the supply organization in a timely manner in order to prevent work stoppages and grounding aircraft. Material control insures that parts and materials made available to maintenance are systematically utilized and not allowed to accumulate or to become depleted. It serves as the single point of contact within the maintenance organization for the conduct of business with the supply organization.

The material control work center provides material support to their cognizant organization by accomplishing the following general functions:

1. Pass all requirements for material required for direct support of weapon system maintenance to the SSC. A material control register is maintained for these items.
2. Prepare documents for material required for indirect support of weapon system maintenance. Examples of materials for which documents are to be prepared are aviation fuels and lube oils, rags, and flight jackets. A separate requisition record log is maintained for these items.
3. Maintain liaison with the supporting SSC on maintenance material to insure that material needs of the organization are satisfied.
4. Establish delivery points for all material and insure that material received is expeditiously routed to the applicable work center.
5. Furnish technical advice and information to the supply activity on the identity and quantity of supplies, spare parts, and materials required for maintenance actions.
6. Establish procedures to insure the periodic inventory of tools and the adequate accountability of material and equipment on custody to the cognizant organization.
7. Initiate surveys in the event of loss, damage, or destruction of accountable material.
8. Keep the maintenance control work center advised of the overall supply situation as it affects the activity.
9. Perform cost and allotment record accounting, charting, and budgeting of cost applicable to the cognizant organization.
10. Monitor the operation of toolrooms and maintain an updated IMRL.
11. Maintain inventory control of authorized allowances of material.

The material control work center is responsible for the coordination of material ordering, receipt, and delivery. This is done in such a manner as to insure that the correct material is ordered and that it reaches the work center within the specified time frame.

The foregoing functions of the material control work center apply to both Organizational and Intermediate level activities. Some of the functions which are applicable to one level only are listed in the following paragraphs.

INTERMEDIATE LEVEL

An Administrative Screening Unit has been established in the material control work center of Intermediate maintenance activities. This screening unit does the following:

1. Positively identifies material and determines if it is within the repair capability of the AIMD.
2. Insures that all required documentation is affixed to the component (that is, logs, records, MAF, etc.).
3. Notifies maintenance control of the receipt of defective components for scheduling into the AIMD.
4. Transfers the defective components to the appropriate work center when directed by maintenance control.

All components received in the AIMD material control receive screening to determine if the item is within the check, test, or repair capability of the AIMD. As a result of this screening, components requiring maintenance within the AIMD capability are reported to maintenance control as ready for induction. Items beyond AIMD capabilities are returned to the Supply Support Center with appropriate recommendations for disposition. When work on components in the AIMD has been completed, the components, together with required records, are returned to material control for appropriate routing back into the supply organization.

ORGANIZATIONAL LEVEL

In addition to the general functions, the material control work center in Organizational level activities is responsible for the following:

1. Verification of NORS (Not Operationally Ready Supply) requisitions and maintenance of current NORS status records.
2. Inventory of aircraft upon receipt and transfer and maintenance of inventory records.

When removed components are generated as a result of the maintenance effort, material control insures that the SSC is notified to make a pickup. These components must be accompanied by record cards and logs, when applicable, plus the number two, three, and four copy of the Maintenance Action Form.

MATERIAL CONTROL REGISTER

The Material Control Register is used by Intermediate and Organizational level material control work centers to record all material requested from the Supply Support Center in direct support of weapon system maintenance. Space is provided to record essential information considered necessary to monitor operating target (OPTAR) funds. This information includes part number priority, quantity, price, date and time ordered, and date and time received. Maintenance control uses the time ordered and time received to help determine Not Operationally Ready Supply (NORS) time used in fulfilling readiness reporting requirements.

MATERIAL REQUISITIONING

The Military Standard Requisitioning and Issue Procedure (MILSTRIP) and Uniform Material Movement and Issue Priority System were developed by Department of Defense to provide a common supply language and more effective supply system operations within the military establishment. This system standardizes forms, formats, codes, procedures, and the priority system.

MILSTRIP employs two forms for the requisitioning and issuing of material. The Single Line Item Requisition Document (Form DD1348) is the basic request document submitted to the applicable supply echelon for material requirements. The issue document is the Single Line Item Release/Receipt document (Form DD 1348-1). Form DD 1348-1 is also used to return RFI material to the supply system. As previously stated, these forms will be prepared by the Supply Response Section of supply for all material requested in direct support of weapon system maintenance and by the material control work center for material requested in indirect support of weapon system maintenance.

Under the MILSTRIP priority system the decision to be made in assigning priorities is the urgency-of-need. This, combined with the unit's military importance when applied to the priority number chart (table 2-2), indicates the proper priority number.

Table 2-2.—Priority number chart.

Force/activity designator	Urgency-of-need-designator		
	A	B	C
	Priorities		
I	01	04	11
II	02	05	12
III	03	06	13
IV	07	09	14
V	08	10	15

The force/activity designators represent categories of activities in descending order of military importance, ranging from the combat forces under I to the miscellaneous activities under V. Every activity is assigned one of the five force/activity designators according to their military importance. These designators are as follows:

I – COMBAT–The highest order of military importance. This designator is not used in peacetime unless approved by the President or the Joint Chiefs of Staff.

II – POSITIONED–U.S. Forces positioned and maintained in a state of readiness for immediate combat or direct combat support.

III – READY–U.S. Forces maintained in a State of readiness to deploy for combat.

IV – RESERVE AND SUPPORT–U.S. active and selected reserve forces planned for employment in support of approved joint war plans. This category includes training units and units in training for scheduled deployment.

V – OTHERS–All units not otherwise assigned.

Force/activity designators (F/AD's) are assigned by the Joint Chiefs of Staff or by each Department of Defense component service. The Chief of Naval Operations has authority to delegate assignment of F/AD's (other than I) to Commanders-in-Chief of Fleets. Each activity is advised by the appropriate military commander of the assigned designator which governs the procurement of material for that activity.

The letters across the top of table 2-2 represent different degrees of urgency, in descending order of need, from an extremely serious need under A to routine stock replenishment under C. The urgency designator is selected by the requesting activity. Definitions of the Urgency-of-Need Designators (UND) for aviation units (including IMA's) are as illustrated in table 2-3.

NOTE 1: Requirements of this nature are of such a consequence as to require a report to higher authority of a degradation of the requisitioning unit's capability in accordance with established NORS procedures.

For example, if a squadron or unit has been assigned force/activity designator III and a work center supervisor determines that a part or some material is needed which, if not received, will impare the capability of the aircraft to perform its assigned mission, then the priority assigned must be 03, 06, or 13. Referring to table 2-3, item B (2) describes this particular work center supervisor's situation; therefore, the urgency-of-need designator will be "B" and the priority must be 06.

There are allowable exceptions to the force/activity designated governed priority number system. Medical or disaster supplies and essential clothing may be requisitioned under priorities 03 and 06, respectively, by any activity regardless of its force/activity designator.

MATERIAL TURN-IN

There are two main reasons for turning in material—the first and most common is the turning in of a damaged, wornout, or otherwise inoperative part in exchange for a like RFI item; and second, returning of material for credit, such as excess material or material received in error.

When it is determined that a needed part is an exchange item, the old part should be cleaned of grease and dirt, drained, flushed, or purged as necessary before turning it in. It is the responsibility of the maintenance personnel to attach aircraft equipment condition tags directly to the repairable item. An aircraft equipment condition label is applied to the exterior of the container.

Table 2-3.—Urgency-of-need designators (definitions).

UND	Definition
A	(1) Emergency requirements for primary weapons, equipment, and material for immediate use without which the aircraft concerned is unable to perform assigned operational missions (NORS). (See Note 1.) (2) Items required for immediate end use in direct support of equipment essential to the operation of aircraft (e.g., ground support, firefighting, etc.) without which the aviation unit is unable to perform its mission. (See Note 1.) (3) Items required, to eliminate an existing work stoppage at an Intermediate maintenance activity modifying or maintaining primary aircraft or aircraft equipment. (4) Items required to eliminate an existing work stoppage at an Intermediate maintenance activity performing repair and maintenance on unserviceable high value/critical item repairables. (5) Items required to effect emergency replacement or repair of essential physical facilities of an Intermediate maintenance activity, without which the activity cannot carry out its mission. (See Note 1.) (6) UND "A" may be used for Not Fully Equipped (NFE) requirement only when the item(s) are needed to return mission essential subsystems and equipments to operational status.
B	(1) Item(s) required for immediate end use, the lack of which is impairing the operational capability of the aircraft or organizational unit concerned. (2) Item(s) required for immediate end use to effect repairs to aircraft and aircraft support equipment, without which the operational capability of the aircraft is impaired or effectiveness in accomplishing assigned mission is reduced. (3) Item(s) required for the replacement of mission essential items on allowance/load lists where the last item has been issued out of bin to end use or the quantity remaining is less than the minimum replacement unit. (4) Material required for immediate use to repair unserviceable repairable items identified as high value items or critical items by ASO/NAVAIR. (5) Items required to effect replacement or repair of physical plant facilities in an Intermediate Maintenance Activity without which the effectiveness of the facility is impaired. (6) Items required for immediate installation to effect repair or replacement of auxiliary equipment without which the effectiveness of the assigned mission is impaired. (7) Required to preclude an anticipated work stoppage in performing maintenance on mission essential equipment. The work stoppage is anticipated within 12 days by CONUS activities and 17 days by overseas activities.
C	(1) Items required to repair or replace administrative support equipment or systems not immediately essential to operational mission of aircraft or organization units. (2) Items required for routine stock replenishment. (3) Items required for scheduled maintenance and repair, not immediately required.

All turn-in material should be returned, if practicable, in the container in which the new item was received.

Activities placing items into shipping containers are responsible for the accuracy and completeness of information on the tag and the label, including the necessary obliteration of previous markings on the container which no longer apply. The primary reason for these tags and labels is to provide a means of identification and condition without disruption of packaging or preservation. These tags and labels indicate the required disposition to those processing the material through channels.

When a defective repairable item is turned in, the following forms are required: copies two, three, and four of the multicopy Maintenance Action Form and the Accessory and Component Service Record, when applicable. The supply department uses copy two of the MAF for bookkeeping purposes. Copies three and four of the MAF accompany the item to the Intermediate maintenance activity. When repair is completed by the IMA, copy four of the MAF is attached to the RFI item and the item is returned to the supply system.

If material being turned in is no longer required and is RFI, a Single Line Item Release/ Receipt Document (DD 1348-1) is submitted with the item. RFI means ready for issue in all respects—preservation still intact and item in original or reusable container with seals unbroken.

Parts Kits

Supporting items and material for the maintenance, repair, and rework of selected repairable type items are procured, stocked, requisitioned, accounted for, and used on a kit basis as a single item. These parts kits should not be confused with Change Kits which are issued to perform a one-time modification of an item, nor with Interim Fleet Maintenance Support Kits which consist of a minimum range and quantity of parts and material to support the items until regular parts kits become available as a result of normal provisioning action.

A repair kit consists of a group of maintenance or overhaul parts that are bought, packaged, and stocklisted as a single item regardless of the supply classification of the items contained in the kit. Normally, these parts have either a very low unit cost or have a high replacement rate in overhaul or repair of the next higher assembly. Depending upon the complexity of the item to be repaired, there can be one or more kits needed for its repair. Repair parts kits are designed to serve three separate requirements as described in the following paragraphs.

C KIT (CURE-DATED OR SOFT GOODS).—This kit provides cure-dated items such as diaphragms, packings, and O-rings. The C kit may also contain soft goods not subjected to age controls such as gaskets and seals, plus metallic items such as screws, nuts, and washers required to be removed when cure-dated or soft goods type material are replaced. When mixed categories of cure-dated parts are packaged in a single container, the controlling cure-date of the package is that of the oldest cure-dated part in the package. If cure-dated kits become overaged due to the expiration of the storage limitations, the kit is administratively disposed of as excess material.

D KIT (OVERHAUL).—This kit contains hard good repair parts required at the time of overhaul. This kit does not contain cure-dated parts nor any metallic item which is placed in the C kits, thus both are required at the time overhaul maintenance is being performed.

F KIT (FLEET).—This kit provides those items that are required to be replaced at Intermediate and Organizational maintenance levels. Replacement of F kit items normally does not require special tools or equipment. This type kit does not contain cure-dated parts.

Part numbers for repair kits are listed in the applicable Illustrated Parts Breakdown and, in some cases, the Maintenance Instructions Manual.

CHAPTER 3

WORK CENTER SUPERVISION AND ADMINISTRATION

A Chief or First Class Aviation Machinist's Mate R is likely to be assigned the responsibility of supervising a work center. The work center could be at either the Organizational or the Intermediate maintenance level and might include the line division, quality assurance division, maintenance control, or powerplants.

The importance of the supervisor to the success of an organization cannot be overemphasized. He is the link between policy making and policy execution. The supervisor is primarily concerned with seeing that the job is done, not necessarily performing the work himself. His duties consist primarily of planning and directing the workload and maintenance management of the manhour accounting system within his work center.

Although this chapter deals primarily with the problems of the powerplant work center supervisor, the objectives presented, the problems involved, and the methods of dealing with them may be applied to other supervisory billets to which the ADR might be assigned.

SUPERVISOR REQUIREMENTS

The AD in a supervisory position sets in motion the plans, schedules, and policies of his superiors. His primary concern is seeing that the job gets done, rather than performing the work himself.

To accomplish this end, the supervisor must know his men, assign them work within their capabilities, direct their efforts, and assume responsibility for seeing that each job is done correctly.

The supervisor's objectives are to operate with maximum efficiency and safety, to operate with minimum expense and waste, and to operate as much as possible free from interruption and difficulty. These three objectives are amplified in Military Requirements for Petty Officer 1 & C, NavPers 10057 (Series).

It is important that an AD assigned supervisory duties keep in mind the importance of his new assignment to him personally. It affords him the opportunity to gain practical experience for future promotions. His duties cannot be approached in a haphazard manner. To make right decisions, the supervisor must be knowledgeable, possess integrity, and utilize common sense. He should employ the principles of good leadership in carrying out his assignment. The information provided in Principles and Problems of Naval Leadership, NavPers 15924 (Series), will prove invaluable to the new supervisor until he has gained more experience.

KNOWLEDGE

Effective supervision of a work center requires a competent degree of knowledge concerning all areas of aircraft maintenance that could affect the work center. The senior petty officer must keep abreast of new ideas and be aware of the variety of directives and publications that regulate his actions. He must be knowledgeable of the factors that make him a maintenance manager, of the programs that affect his work area, of his rating, and the weapon system being supported.

Maintenance Management

The Naval Aviation Maintenance Program (NAMP), OpNav 4790.2 (Series), outlines command, administrative, and management relationships and establishes policies for assignment of aviation maintenance tasks. As defined in this instruction, the work center supervisor is responsible for the following actions:

1. Insuring the accomplishment of all assigned work.

2. Insuring maximum utilization of personnel and facilities.

3. Making recommendations concerning work center repair capabilities and facility requirements.

4. Causing all work to be inspected as required.

5. Initiating of material requirements to support the workload.

6. Screening of all source documents, work requests, and associated paperwork to insure accuracy, completeness, and timeliness of submission.

7. Keeping maintenance control informed of work status.

8. Reviewing of daily manhour (when applicable) and maintenance data reports for accuracy and submission of necessary corrections.

9. Insuring that the maintenance department training program is properly supported within the work center.

The supervisor who endeavors to become thoroughly familiar with the contents of the Naval Aviation Maintenance Program Manual, volumes 1-4, will be better equipped to handle the administrative affairs of the work center. By the time most petty officers reach E-5 level, they should be totally familiar with the variety of source documents associated with aircraft maintenance. Use of these documents is covered in Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series). Military Requirements for Petty Officer 1 & C, NavPers 10057 (Series), provides coverage on the various manhour and maintenance data reports as well as other pertinent areas of the NAMP.

Special Programs

The senior AD will by necessity become involved in the variety of special programs that directly or indirectly affect the supervision of his work center. OpNav Instruction 4790.2 (Series) provides amplifying information on selected maintenance programs such as the following:

1. Component repair.
2. Foreign object damage (FOD) prevention program.
3. Corrosion prevention/control program.
4. Navy Oil analysis program.
5. Aircraft fuel surveillance.
6. NavAirSysCom calibration program.

Separate chapters provide in-depth information concerning Quality Assurance, Unsatisfactory Material/Condition (UR) Reporting System, Planned Maintenance System, etc.

Rating

The supervisor who has had varied experience in all aspects of his rating is a definite asset to any command. A complete knowledge of one's rating is not easily achieved. All too often, personnel put in the required training courses and rely on the information retained from the Rate Training Manual to get them by. Study of the latest editions of these manuals and the additional reference material listed in NavEdTra 10052 will assist in the never-ending attempt to stay current. When advancement in rating qualifications change, the alert petty officer notes these changes and strives to correct any knowledge deficiencies that might exist. Curiosity regarding activity correspondence, changes and bulletins, changes to maintenance publications and other maintenance directives, as well as changes to other sources of information which affect the supervisor's work center and/or rating can result in increased ability and confidence.

Weapon System Being Supported

The number of aircraft accidents, ground accidents, and incidents involving maintenance errors has increased steadily for the past several fiscal years. As the number of errors increased, the most often repeated errors continue to be the same from year to year. Some of the errors cause little or no damage and consequently have not been appropriately advertised. Many maintenance errors can be attributed to failure of the supervisor to properly perform his duties.

A knowledge of the weapon system being supported is a must requirement. The training lectures prepared for use in training personnel within the work center should be a valuable source of information regarding the weapon system. Study of the appropriate volumes of the Maintenance Instructions Manual and completion of courses on the weapon system provided by Naval Aircraft Maintenance Training Groups (NAMTG), which have detachments in the field, will better equip the supervisor to make decisions regarding maintenance of the system. Use of the MIM when performing maintenance applies to both the worker and the supervisor. The complexity of many of today's aircraft systems requires that step-by-step procedures be followed for accomplishing removal, installation, repair, operational testing, etc. It is impossible to commit these step-by-step procedures to memory. Personnel who are unfamiliar with a task that is assigned should readily admit their lack of proper training rather than attempt the task with questionable results. It is not uncommon for a supervisor to find that a subordinate has greater knowledge of a particular system than the supervisor. However, the supervisor must make it a habit to verify any doubtful information and correct any knowledge deficiencies on his part, or he may lose some of the respect necessary to maintain control of his men. This is not to imply that he should be distrustful of his men. Sometimes subordinates feel that information passed on to them by others is correct without verifying it in the MIM. In summary, it is better to admit when you do not know something and then follow through by doing something about it immediately.

SUPERVISION AND LEADERSHIP

The experienced petty officer will soon learn that supervision and leadership are very closely related. The supervisor's role requires that he be a leader, a man of common sense, and a man who earns the respect of others. Many decisions are difficult to make. To be effective in his decision making, the supervisor assembles pertinent facts, policies, and procedures; develops a course of action and evaluates possible alternatives; selects the best course of action, and initiates the required action. When necessary, he consults his own superior prior to taking action. Every supervisor must face problems squarely and make timely and sound decisions. The supervisor who dodges his responsibilities will soon find his control of subordinates slipping away, discipline deteriorating, dissatisfaction with his supervision increasing and effectiveness of the organization suffering.

The supervisor who establishes and maintains a spirit of cooperation within his work center and in the everyday dealings with other work centers and maintenance control will find his job is much easier. Aircraft readiness is the common purpose of the maintenance organization, and all ratings should share a common interest in achieving that purpose. A willingness by each individual to submerge his personal interest in favor of getting the job done is a necessary prerequisite to cooperation. If the supervisor's requests are reasonable, made well in advance (when possible), were understood, and provided all necessary information, his requests will generally induce cooperative action. If cooperation is lacking, check the facts to find out why. If subordinates are at fault, they can be told directly and in a firm manner, taking into consideration the basic principles of good leadership.

The supervisor's duties involve planning, direction, and control. Careful planning is an essential ingredient to effective supervision and minimizes other types of supervisory efforts when carefully executed. Time and effort invested in the process of careful planning is rarely wasted. It can result in job simplification and increased efficiency.

The effective supervisor initiates the planning process by identifying each specific job to be done by his men. With a routine clearly established, he can spend his time on the exceptions that may arise. He knows the capacities, interests, weaknesses, and potentials of his men. Knowing each man's level of technical skill, motivation, ambitions, and personality characteristics will enable the supervisor to (1) assign the right man to the right job, (2) identify the training needed by each man to do a better job, and (3) establish the standard at which each man can be expected to perform.

Once action has been initiated, the supervisor provides direction. This function of supervision is like that of a "foreman." He sees that work is started and knows what is going on at all times. This does not mean that he must always be physically present while the job is being done. Subordinates should be trained to assume responsibility for the job in the absence of the supervisor so that no man is indispensable, including the supervisor. The supervisor should, however, be available when his men are working, and they should know how to contact him. The supervisor should always be present when his men are assigned new tasks, when they have trouble getting a job done, or when other circumstances dictate the necessity for his presence. He must be careful not to over-supervise lest he destroy the initiative of his workers and subordinate supervisors. He receives suggestions and reactions from his subordinates and acts as necessary on them, giving credit when and where it is due. Recognition of each man as an individual is required.

Control of a job refers to the function of checking to see that the job is done as planned–a comparing of performance with plans. Deviations may reflect poor planning. However, procedures should exist whereby changes in plans that could result in improved performance can be implemented to minimize repetition of faulty performance.

The supervisor will be challenged to allocate sufficient time to be expended on planning, direction, and control. A spirit of firmness, fairness, cooperation, decisiveness, harmony, and mutual respect while seeing that the job is done will rarely go unrewarded.

Communications

The area of communications as related to supervision and leadership is singled out here because of its importance. Almost without exception, problem areas regardless of their nature can be attributed to the lack of proper communications. Men like to be kept informed about all the things that affect them. Keeping them informed will improve their morale and generally make them more responsive to the needs of the command. The supervisor can improve morale by keeping his men as well informed as possible concerning need-to-know and nice-to-know information that could affect them, as long as it is not classified.

Communications is a two-way process. The supervisor must be able to convey his ideas, orders, etc., and pass on information, either orally or in writing, in such a manner that it will be clearly understood. He must also be willing to listen to and try to understand the ideas of others. Subjectivity (that is, looking at things only from a personal viewpoint, because of your position, rating, pay grade, or any other reason) will hinder communications. Bias and limited knowledge can limit a supervisor's ability to be objective, and by recognizing this fact, he can listen more objectively.

Ridicule, sarcasm, vulgarity, etc., have no place in good communications. The supervisor who must get loud and resort to such language to get his point across or the job done needs to realize how adversely such action affects his own feelings of importance and respect. When it becomes necessary to orally reprimand a subordinate, do it in private, keeping in mind that he is an individual and as a petty officer he must have the respect of the men under him. If a supervisor reprimands a man in public, both lose respect and are less effective in getting the job done.

Professionalism

It is the responsibility of all senior petty officers to install a spirit of professionalism in their subordinates. Aircraft maintenance is a reasonably complicated profession that leaves little room for error. The maintenance man who gives it less than his undivided attention presents a potential hazard. Of primary importance are the ethical attitudes and considerations involved in performing each maintenance task, the unspoken but carefully adhered to codes governing each man's action.

The responsible petty officer sets the example he wishes others to follow, doing the right thing in carrying out each assignment, including (and especially so) when no one is watching. Undiluted professionalism means that there is no room for ethical lapses or occasional breaches of integrity. The worker who even once shortcuts established procedures, does not follow maintenance manual instructions, sacrifices quality for speed, or performs any other action which could produce a negative judgment towards him lacks the professional integrity demanded in aviation maintenance. The supervisor who condones such action is equally guilty of a less than professional attitude and the results that such actions could cause.

There is no substitute for thorough knowledge of your aircraft, your job, and the procedures associated therewith. Correct maintenance procedures and thorough quality assurance will amost always produce professional results. Aviation safety demands pure, undiluted professionalism from all personnel involved in maintenance.

WORK SIMPLIFICATION

Work simplification is a common sense, systematic method of identifying and analyzing work problems, developing solutions, and installing improvements. In order to achieve maximum efficiency each supervisor must do his part to improve the work situation and achieve maximum manpower utilization. This implies that the greatest possible use of all resources available be made in order to help accomplish an activity's mission. Work simplification is a tool which can be utilized effectively in the accomplishment of this goal. Work simplification might be considered as human ingenuity applied to the work situation. It is the organized use of common sense and creative thinking in the solution of work problems.

If all men had believed that there could be no better way of doing things, we might still be throwing rocks at game for our food and traveling from place to place on foot. Progress in these fields was not made in a single step but in a series of improvements. These changes occurred slowly over the centuries, growing out of a multitude of small improvements.

The supervisor who lives day to day, satisfied that what he did yesterday is good enough for tomorrow, will, in most cases, leave his job no better from having held it. He leaves nothing significant for other personnel to follow him in his job, and he becomes lost in the shuffle of men who are content with merely living and dying.

The majority of improvements in our world did not come by accident; rather, they came as a result of man's ingenuity, growing out of his sense of imperfection and his constant search for improvement. When an improvement is made, no matter how small, it marks its discoverer as a person of imagination with a real and active interest in his work.

The supervisor who believes in and practices work simplification procedures can look with pride upon his contributions or those of people who work with him. This means that the supervisor should never cease to search for improvement and must encourage his workers to try to improve jobs over which he has control.

The supervisor should always watch for areas where work can be simplified. Work simplification pays immediate dividends by increasing both production quality and quantity. It allows the supervisor to meet work schedules more easily and reduces waste by producing with less effort, increases savings in time and manhours, and thus reduces cost of operation. Work methods improvement aids in establishing standard procedures. These standard procedures aid in training both old and new workers, since most workers are easier to train, and learning is much easier if standard practices are used.

It is true that with good leadership personnel can be encouraged to work to the limit of their physical endurance but unless their efforts are used wisely, the most critical resources—manpower—is being wasted. In the final analysis, it is not how hard personnel work but how much quality work is accomplished that matters. Therefore, to help achieve maximum results with minimum expenditure of human effort, the supervisor should always strive to use established work simplification techniques.

Work simplification permits continuous evaluation by analyzing existing methods and procedures with a view toward improving them. There is always a better way of performing a task by using streamlined methods, improved tools, better working conditions, or shorter procedures. However, these better methods are not always apparent. Work simplification should be directed at all work situations where physical effort is expended.

Techniques

There are many techniques for improving work methods. For the most part, these techniques are adaptable to any part of an organization as well as a whole activity. Five of the principal techniques which have been successfully applied to work operations are discussed briefly in the following paragraphs. All of these techniques require the construction, completion, and use of lists, charts, flow diagrams, etc., in order to study and analyze specific areas.

WORK DISTRIBUTION ANALYSIS.–Work distribution analysis is a technique used to analyze objectively the division of work in an organization. In order to obtain the most effective distribution of work, it is necessary for the supervisor to have an overall view of the organization and its operations. The supervisor must clearly understand the work that is being done and be able to see the relationship between the overall operation and the individual work units as well as the contribution that each person makes to the work of the whole organization.

Distribution of work is an important factor in efficient use of manpower. Time and effort are saved if related duties are performed by the same person. Thoughtful matching of assignments and qualifications is important so that personnel are not struggling with work that is too hard for them or wasting their time on tasks that might be performed by a less skilled person. Another consideration is distribution of workload to avoid inequalities, since these result in bottlenecks and other inefficiencies.

Work distribution analysis requires that a Task List be completed for each person whose work is being studied. This list contains, in simple statements, tasks the worker performs regularly and the average number of hours spent on each task per week. Next, a Function List is prepared which lists each function performed by the unit. Each task reported on the Task List must be related to a specific function. A Work Distribution Chart is prepared from the data collected on the Task List and Function List. This chart presents the work performed in the existing organization under current operating conditions. The chart is then studied and analyzed to find answers to questions such as the following:

1. What functions take the most time?
2. Is there misdirected effort?
3. Are skills being used properly?
4. Are personnel doing too many unrelated tasks?
5. Are tasks spread too thinly?
6. Is work distributed evenly?

A careful study and analysis of the work distribution chart should assist in achieving the following results:

1. Elimination of unnecessary tasks.
2. Reduction of time spent on relatively unimportant functions.
3. Elimination of duplication and overlapping of work.
4. Better balance of workloads.
5. Combination of related tasks.
6. Realistic estimate of personnel needs.
7. Better utilization of skills.
8. Reallocation of misassigned personnel.

WORK COUNT ANALYSIS.–Work count analysis supplements the work distribution analysis and is a technique for determining the volume of work in terms of measurable units. Information obtained by counting or measuring the work provides a basis for improving methods and procedures, adjusting work assignments, evaluating performance, and eliminating bottlenecks. Such information is useful in assigning and scheduling work to insure that the workload is equitably distributed among all personnel.

Items of work counted should be definite and comparable. Items counted should also be representative of work usually performed. Only those should be counted that clarify methods employed. Counting may take place where the work comes into Production Control, where a decision is made or action is taken, where a process is completed, or where long storage occurs.

Work count information can be used to accomplish the following:

1. Establish how long it takes to do a given piece of work.
2. Indicate whether the volume of a certain piece of work is sufficient to warrant specialization.
3. Show whether work is distributed evenly among workers.
4. Point out bottlenecks where work piles up.
5. Indicate whether the work center is adequately manned, overmanned, or undermanned.
6. Stimulate interest of personnel by providing comparisons of one person's work with that of another or with his own record during a different counting period.

FLOW PROCESS ANALYSIS.–Flow process analysis is a technique for analyzing flow and sequence of operations. The purpose of this analysis is to reduce time and distances in a process by eliminating, combining, and changing the sequence of steps in the flow of work.

The principal tool of this technique is the construction of a flow process chart which provides a clear and detailed picture of the flow of work. Recording each step in a procedure helps to identify duplication of effort, back-tracking, and other obstacles to the smooth, efficient flow of work.

MOTION ANALYSIS.-Motion analysis is a technique for making maximum use of physical motions. It is a method of studying the motions of individuals in performing their various tasks.

Work distribution and flow process analyses are directed toward improving the division and flow of work. Motion analysis deals with how an individual performs his tasks. It seeks to learn whether the workers are doing their work with minimum fatigue, loss of time, and waste of effort. Improvements are effected by re-arrangement of materials and work area and by proper use of equipment.

The simplest way of gathering data for motion analysis is for the supervisor to watch his personnel at work and note useless motions. Motion analysis should result in the elimination of wasteful motions and consequent loss of work time, reduction of fatigue by lessening the amount of physical effort required to complete a task, and increase the efficiency of personnel.

LAYOUT ANALYSIS.-Layout analysis is a procedure designed to lead to better utilization of space, personnel, and equipment. A study of the layout of a working area can provide useful information for improving the work of individuals, distribution of the workload, and flow of work from one person to another. Its purpose is to determine what space is needed for the operations to be performed and how the available space may be used most effectively. Besides shortening and simplifying motions, it should produce working conditions that are as comfortable and personally satisfactory to the workers as possible consistent with efficient and economical operation.

The layout chart is the principal tool of this type of analysis. This chart consists of a floor plan of the work space, showing doors, windows, electrical outlets, etc. All features that restrict usable space should be included.

The following principles should be kept in mind when studying a work center layout chart:

1. Equipment getting the most use should be located in the most accessible areas.
2. Layout should provide for safe use of equipment.
3. Arrangement of equipment and facilities should allow for effective supervision.
4. Arrangement of equipment should accommodate the necessary flow of personnel utilizing the work area.
5. Maintenance publications should be conveniently accessible to those who use them.
6. Working space allocations should be consistent with working conditions.

INSTALLATION OF IMPROVEMENTS.-Briefly speaking, work simplification means improving methods of doing work or finding a better way. Improved methods usually involve eliminating unnecessary parts of the job, combining and rearranging other parts of the job, and simplifying the necessary parts of the job. By improving methods personnel are able to do better work, with less effort, in less time, without hurrying, with greater safety, and with lower cost. The pattern for achieving the benefits of work simplification is as follows:

1. Select the job to be improved.
2. Break down the job in detail.
3. Question the job and each detail of the job.
4. Develop the new method.
5. Apply and install the new method.

The fact that changes are recommended as a result of a work simplification study does not always mean that these changes will or can be made immediately. There are several reasons why a change that many regard as an improvement may be slow in being adopted.

Most any change will draw objections from a certain number of persons. There are two general types of reasons for these objections. First, many people regard a recommended change as a criticism of the way they have been doing their work and therefore resent it. Most of this type of objection can be avoided if those who will be affected by the change can participate in some degree in the analysis so that the whole enterprise becomes a group activity. If this is not possible, at least a clear explanation should be made regarding reason for the change. Emphasis should be on future advantages rather than criticism of old methods. Secondly, most people have a natural dislike to changing established work habits. If advantages of the new method are clearly explained, this resistance lessens considerably.

Before making any changes it is well to consider carefully all likely effects, for sometimes unforeseen effects may cancel out the beneficial aspects of the change. It is important, for instance, when new equipment or facilities are contemplated, to be sure that advantages of the new installations will outweigh cost. Indirect effects of change upon other equipment or conditions should also be considered.

Effects upon interorganizational relationships should also be taken into account. If work procedures are speeded up in one phase of an operation only to create a bottleneck in another, there will be little or no improvement.

PLANNING WORK CENTER ARRANGEMENT

The average Chief or First Class Aviation Machinist's Mate R may never have the opportunity of planning the layout of the powerplant work center in a new facility. In almost every case, the new supervisor will take charge of an already functioning division or else, when his squadron or unit moves to a new base, he and his crew will usually be assigned to spaces already basically equipped for powerplant repair. In either case, a reevaluation of the layout should include finding out from the applicable allowance lists if the equipment allowances have been changed in any way. There is no use relocating equipments which involve rewiring or plumbing work if improved replacement models are authorized and available.

PURPOSE OF THE WORK CENTER

A basic consideration in planning a work center layout is its purpose. When more than one space is available, the supervisor must decide which space would be most suited for a powerplant work center. Of two spaces identical in size, one may, for example, be completely unacceptable for powerplants due to the location and size of doors or the shape of the area.

A change in assigned aircraft model designation always calls for a reevaluation of the work center arrangement.

The general function of the work center must be considered in the allocation of space and equipment. The ideal work center would contain enough space to have workbenches, engine stands, engine buildup, parts and tool stowage space, propeller section (if required), and ample space for technical publications in a centrally located area. Since this is not normally possible, the supervisor must decide what sections of the work center are to be combined and in what areas of each space the appropriate equipment is to be installed. This decision should be based on factors of safety, economy, functional compatibility, and convenience.

ARRANGEMENT

Following the determination of which work center is to occupy which space or area within a space comes the arrangement of furniture and equipment.

The arrangement of the work center furnishings should be made on the basis of utility rather than appearance. Moving an item of equipment into an out-of-the-way corner may greatly improve the appearance of the work center but at the same time reduce the efficiency of the personnel using the equipment and may possibly create a safety hazard. A good rule to follow is to locate equipment where it can be safely used by the greatest number of people with a minimum of effort in the least amount of time.

Worktables and workbenches should be positioned with respect to fixed equipment so that the equipment most often used is most quickly and easily reached. Electrical and compressed air outlets should be readily available to the workbenches. Needless delays are caused by having to rig unnecessarily long connections from poorly located outlets.

Near workbenches where specific and intricate maintenance functions are performed, consideration should be given to installing special lighting such as explosion-proof, vaporproof, or interference-free type lighting. Under certain conditions, special lighting may also include floodlights for outside work areas and in hangars when improved lighting is required.

Utilization of paint in various colors to emphasize portions of intricate machinery for safety and reflective purposes is known as dynamic painting. Painting in this category should not be utilized for normal building maintenance.

A system of stowing tools must be devised. An intelligent system cannot be set up without first determining from allowance lists what tools will be required for satisfactory operation of the work center. The place for all tools should be marked or otherwise specified, and everything not being used should be kept in that place.

The layout should make provisions for a bulletin board upon which may be posted safety posters, maintenance posters, instructions and notices, plans-of-the-day, and such other information as is appropriate from time to time. The bulletin board should be located in a prominent place in the work center, preferably near the entrance where everyone assigned will have to pass some time or another during the day. Material on the bulletin board should be changed frequently, expired notices promptly removed, the current plan-of-the-day posted early, and other posters and material rotated periodically. If the same material is presented in the same format every day, it will not be long before the men begin to ignore the bulletin board and purposes for having it are defeated. New arrangements are noticed and interest is stimulated with variety.

When aviation Organizational level maintenance activities are moved aboard ship, their working conditions and accommodations are drastically affected. The ingenuity of the supervisor will be required to produce a workable arrangement within very limited spaces. Stowage racks for toolboxes and other work center equipment should be located to accommodate their frequency of use. Some equipment used at less frequent intervals may have to be stowed in voids. An inventory listing of such items, showing their specific location, will be necessary. Security of material stowed in voids, toolboxes, and other equipment will require more attention than when ashore. Gear not properly stowed and afforded appropriate security has a habit of disappearing, and during rough sea states, can be hazardous to personnel and/or other equipment.

Much of the work done aboard ship will have to be done under less than ideal conditions. Confined spaces, reduced lighting during night time flight operations, hazardous conditions on the flight and hangar decks, problems associated with respotting of aircraft to accommodate maintenance, and a variety of conditions peculiar to ship operations will require modifications of procedures used ashore. The supervisor should insure that spaces are utilized to their fullest extent.

Since most Organizational level maintenance is "on aircraft" type maintenance, the limited space of the work center should present only a minor problem concerning the stowage of gear and some personnel congestion during periods when personnel are awaiting work. Consideration of the factors previously discussed under "Work Simplification," and further discussed in NavPers 18359 (Series), could result in a smoother transition from shore to shipboard facilities and vice versa.

SCHEDULING AND ASSIGNMENT OF WORKLOAD

Among the most important factors with which the Chief or First Class Aviation Machinist's Mate R is concerned as a supervisor are the assignment and accomplishment of the scheduled workload. His objective is the satisfactory completion of assigned tasks in a reasonable length of time, utilizing available men and materials as efficiently as possible. In order to achieve his objective, the supervisor must become skilled in estimating the amount of time to allow for the completion of each task and estimating the number of workers required. He must realize the importance of assigning both qualified and unqualified men to the jobs, consistent with his training program. The supervisor must allow for planned interruptions and yet not operate on so tight a schedule that minor, unplanned interruptions completely disrupt his schedule.

ESTIMATING TIME AND PERSONNEL REQUIREMENTS

Most maintenance jobs are of such a nature that the quality and quantity of people assigned to do them directly affect the time that will be required for completion. For this reason, time requirements and personnel requirements are combined and discussed together in this section.

Probably the most important single aid in estimating time and personnel requirements for aircraft maintenance tasks is the Periodic Maintenance Requirements Manual with its related cards, charts, and forms. Extensive time and motion studies of the various inspection requirements have been made and completion times are furnished in manhours or manminutes. These times also reflect routine maintenance, adjustments, and replacement if required in connection with the aircraft inspection. They are calculated on the basis that the most efficient number of men are continuously employed and that all necessary equipment, tools, and parts are immediately available. The supervisor must consider all these factors from the knowledge of his individual personnel, supply, and equipment situation, together with an accurate determination of the extent to which the maintenance task at hand exceeds the inspection requirements if he is to reliably predict the completion time. While this procedure may seem rather involved at first, the new supervisor will find that it is based on sound management principles and that, with experience, his ability to accurately predict time and personnel requirements will speedily improve.

PERSONNEL WORK ASSIGNMENTS

Work assignments should be rotated so that each man will have an opportunity to develop his skills in all phases of the ADR work. When assignments are rotated, the work becomes more interesting for the men. Another good reason for rotating work assignments is that if one highly skilled man performs all the work of a certain type, the supervisor and the work center would be at a great disadvantage in the event the man is transferred. Less experienced personnel should be assigned to work with him in order to become proficient in his particular skill. Also, in order to broaden his knowledge of his rate, the expert on one job should be rotated to other tasks when there is no immediate need for his particular skill.

Strikers should be assigned to various tasks so that they will acquire experience on all kinds of jobs. A special consideration for the assignment of strikers to jobs is that they should be assigned progressively to jobs of ascending levels of difficulty. A striker may be a useful assistant on a complicated job, but he may not understand what he is doing unless he has worked his way up from basic tasks.

ALLOWING FOR PLANNED INTERRUPTIONS

During an average workday, occasions will arise when personnel have to leave their working spaces for one reason or another, thereby delaying the completion of the scheduled work. Some delays can be anticipated; some cannot. Among the delays which can be anticipated are training lectures, immunization schedules, flight schedules, rating examinations, meals, and watches or other military duties.

Before making personnel work assignments the supervisor should determine what delays can be anticipated. It may be possible to arrange assignments so that work interruption is held to a minimum. When estimating the completion time of a maintenance task, the supervisor should allow for these predictable delays.

SUPERVISION OF THE USE OF EQUIPMENT

In order to achieve maximum production within his work center, the supervisor must closely supervise the use of equipment used to support the production effort. Such equipment includes service, maintenance, and test equipment.

As the aircraft becomes heavier, faster, and more expensive, the support vehicles and equipment become more numerous, more complex, and more dangerous. Therefore, this area of supervision requires more and more attention. Even though the supervisor goes by the standard rules, every command has problems peculiar to its location and mission. This requires that he be familiar with the directives and instructions published in his command.

The supervisor should take full advantage of all training programs to assure that each worker attached to his work center knows the specific operating instructions for the particular equipment being used. If his work center is engaged in aircraft servicing, he must insure that his workers know the type of aircraft being serviced and the service procedures for that particular aircraft and that they follow these procedures.

The supervisor must be familiar with all tools and test equipment that are normally used in the work center for work which cannot be performed on the aircraft. He must be familiar with the calibration program and insure that all equipment is tested and calibrated as specified.

Safety is of paramount importance in the use of any equipment. The supervisor must be familiar with all safety precautions pertaining to the use of each piece of equipment and insist that these safety precautions be observed at all times.

Whenever equipment has been used, the supervisor must insure that the equipment is secured and stowed, if applicable, when the work is completed.

VISUAL INFORMATION DISPLAY SYSTEM

The Visual Information Display System (VIDS) is a time management tool which provides a graphic display of vital, up-to-date information on a continuing basis. The system correlates all aircraft status information, particularly awaiting parts and flyable discrepancies and assigns a relative importance to each item. Additionally, the system displays the amount of time anticipated to perform any maintenance and the number of personnel available and engaged in work. The ability to review the overall situation and determine what resources are available enables the supervisor to more effectively and efficiently carry out his duties. This information is displayed on specially configured cardex type boards.

QUALITY ASSURANCE

Commanding officers are responsible for the inspection and quality of material under their cognizance. In a maintenance department, the principal force for securing compliance with quality standards lies NOT in the instruments, instructions, or other facilities for inspection, but in the state of mind of maintenance personnel from the commanding officer down to the workers.

Generating quality in a maintenance organization necessitates a sincere interest on the part of commanding officers, plainly evidenced to the officers and men in their commands. Quality further requires that each maintenance officer and supervisor understand clearly how the accomplishment of a quality job contributes to the effective operation of the organization. Quality also requires that each maintenance worker understand not merely a set of specification limits, but also the intent and the need for these requirements.

The quality assurance organization is concerned with three functional areas—quality management, quality verification, and technical publications.

Quality management is monitored by formulating, implementing, and auditing procedures, instructions, and operations to assure compliance with the policies stated or implied within the NAMP Manual. Quality assurance coordinates their efforts with those of the activity's data analysis group to provide information on maintenance practices and results based on facts gleaned from the various maintenance source documents and associated reports.

Quality verification assures that all material processed and actions taken by maintenance personnel meet prescribed quality requirements. Direct inspection of material and operations as they are performed is necessary on a continuing basis to give adequate assurance that all items processed and maintenance tasks completed meet the prescribed requirements. These quality assurance considerations (tests, inspections, etc.) are included in most weapon system Maintenance Requirements Card decks as well as most Maintenance Instructions Manuals and Overhaul and Repair Manuals (03). Quality assurance verification steps are generally called for at various steps during repair progress in addition to verification of the final product.

Since technical information has a direct relationship towards assuring the quality of work performed, the quality assurance division has the responsibility of operating a master technical library and monitoring of dispersed libraries within the various work centers. Dispersed libraries located within the work centers are necessary to place technical information in the hands of the user who is charged with compliance. The quality assurance division monitors the operation of these dispersed libraries, providing new publications, revisions, cancellations, and such other information that may affect the publications held. A change entry certification is utilized to insure that all change and revision material is entered into the directives and manuals of the dispersed libraries within a reasonable time.

Since the responsibility area of the supervisor is the middle ground between management and men, it is incumbent upon him to initiate and administer a quality assurance program. His main objective is to improve the state of training of his men until their mental attitude is such that top quality workmanship becomes second nature. How successful he is in achieving this objective will be determined by his ability and insight in the following areas:

1. The assignment of the proper number of qualified men to do the jobs, plus-on-the-job trainees.
2. Making provisions for adequate on-the-job supervision and inspection.
3. Allowing adequate time to perform safe, high quality jobs.
4. Assuring himself that current directives and publications on safety and aircraft model concerned are available and complied with.
5. Monitoring the training program with respect to timeliness and completeness of coverage. Eliminating out-of-date training material promptly and introducing important new material as soon as possible after receipt without regard to lesson schedules.

These procedures should result in high quality workmanship by powerplants personnel and meeting of specifications and quality standards in the work.

PLANNING FOR ADVANCED BASE OR FORWARD AREA OPERATIONS

A Chief Aviation Machinist's Mate must be able to prepare for advanced base or forward area operations by estimating aircraft spare parts and supplies, equipment, and manpower requirements for powerplant repairs. In determining requirements for forward area or advanced base operations, it is necessary to consider the following:

1. Mission.
2. Environment.
3. Operating factors.
4. Availability of existing facilities.

A knowledge of the material and manpower requirements as listed in the Advanced Base Initial Outfitting Lists of Functional Components will be very helpful. The functional component is one of more than 300 standardized units of the system which the Navy has developed to enable it to build and operate its advanced bases in the least possible time and with a minimum expenditure of planning and logistic effort.

A functional component is a list of the requirements for the performance of a specific task at an advanced base, and consists of a carefully balanced combination of material equipment, and/or personnel.

Each functional component is classified according to its primary function into 1 of 11 major groups, including aviation. Each major grouping is identified by letter designation and title; the functional components contained in each are identified by a combination letter, number, and title designation. The major group letter for aviation is H.

H components are designed to provide for maintenance, support, and operation of aircraft in an advanced area under combat conditions, and may be combined with other functional components to form several types of air stations.

Complete information and data are given in the abridged and the detailed outfitting lists for functional components.

It should be apparent to the ADRC that the advanced base requirements may not be exactly as they appear in the Advanced Base Initial Outfitting Lists. In order to use these lists as guides, it will be necessary in most cases to alter or tailor them to fit the individual needs of the unit about to deploy.

Other necessary repair parts, supplies, and equipment may be determined from the outfitting and allowance lists for the aircraft or other weapons system to be supported.

It is quite likely that the powerplants supervisor will be required to advise the personnel office in the assignment of individuals to advanced base or forward area operating units. It would seem logical that the number of ADR's assigned to deploy be in the same ratio as the percentage of supported aircraft scheduled to deploy. This may be true if the proposed flight hours per aircraft of the detachment exactly equal the planned utilization of the remaining aircraft and if there are no significant environmental problems to be overcome. The list of personnel assigned to deploy should represent a cross section of the skill levels available unless special maintenance factors indicate otherwise. The selection of personnel should be made as objectively as possible so that the deployed unit may function efficiently without working a hardship on the home group.

SAFETY

Operational readiness of a maximum number of aircraft is necessary if naval aviation is to successfully perform its mission. Keeping its aircraft in top operating condition is the principal function of naval aviation maintenance personnel. It is essential that maintenance work be performed with a minimum of injury to personnel and damage to equipment and aircraft.

Aircraft maintenance is, to some extent, naturally hazardous due to the nature of the work, the equipment and tools involved, and the variety of materials required to perform many repairs and maintenance functions. Factors which can function to increase or decrease these hazards are (1) the experience levels and mental attitudes of assigned personnel and (2) the quality of supervision of the maintenance tasks. Thorough indoctrination of all personnel is the most important single step in maintaining safe working conditions.

The concept of aircraft maintenance safety should extend beyond concern for injury to personnel and damage to equipment and aircraft. Safe work habits go hand-in-hand with flying safety. Tools left in aircraft, improper torquing of fasteners, and poor housekeeping around aircraft can cause conditions which may claim the lives of flying personnel as well as cause strike damage to aircraft. Safety on the ground is equally as important as safety in the air.

A recent type commander letter states in part, "While the increased complexity of our modern aircraft is a factor, it is noted that a large number of maintenance-error caused accidents and incidents are due, not to complexity of equipment, but to lack of supervision and technical knowledge. Many mistakes are simple ones in routine maintenance."

Safety in aircraft maintenance depends largely upon the supervisory personnel. The standards of quality which they establish are directly reflected in the quality of the aircraft maintenance. The primary duty of the senior petty officers is to supervise and instruct others rather than to become totally engrossed in actual production. Attempts to perform both functions invariably result in inadequate supervision and greater chance of error. Supervisors must exercise mature judgment when assigning personnel to maintenance jobs. Consideration must be given to each man's experience, training, and ability.

Sometimes overlooked in a maintenance program are the considerations generally grouped under the term "human factors." These factors are important in that they determine if an individual is ready and physically able to do work safely and with quality. Supervisory personnel should be constantly aware of conditions such as general health, physical and mental fatigue, unit and individual morale, training and experience levels of personnel, and other conditions which can contribute in varying degrees to unsafe work. Not only is it important that proper tools and protective clothing and equipment are available for use, but also the insistence by maintenance supervisors that they are used is of increasing importance with modern high-performance aircraft. For example, maintenance personnel are sometimes negligent in the wearing of protective hearing devices in high noise areas.

Technical knowledge also plays a large part in a good maintenance safety program. The complexity of our modern equipment demands the attention of well-informed and expert maintenance personnel; otherwise, our weapons systems cannot be operated and maintained.

Technical knowledge is a function of education and training which, incidentally, does not end with graduation from Class A school. Graduation is only the beginning. An ADR worthy of the rating is continually training and learning through self-study and application, and through a personal desire for proficiency and self-betterment. But technical knowledge by itself is not sufficient unless it is coupled with an old-fashioned craftmanship that receives gratification and keen satisfaction in doing any job well. The ADR who wishes to contribute to safety and reliability improvement must know his job and must develop professional pride in the quality of his work.

It is a continuing duty of every person connected with aircraft maintenance to try to discover and eliminate unsafe work practices. Accidents which are caused by such practices may not take place until a much later date and their severity cannot be predicted. The consequences may range from simple material failure to a major accident resulting in serious injuries or fatalities.

There are several areas in which the supervisor can effectively work to minimize accidents incident to aircraft maintenance. Among these are continuing inspections of work areas, tools, and equipment; organization and administration of safety programs; correct interpretation of safety directives and precautions; and energetic and imaginative enforcement of them.

INSPECTION OF WORK AREAS. TOOLS. AND EQUIPMENT

Most accidents which occur in noncombat operations can be prevented if the full cooperation of personnel is gained and vigilance is exercised to eliminate unsafe acts. The powerplants supervisor should diligently inspect work areas. tools. and equipment to detect potentially hazardous and unsafe conditions and take appropriate corrective action. The ADR may be working in the shop, in the hangar, or on the line, and all these areas should be included in the supervisor's inspection. He should check for explosion or inhalation hazards due to improper ventilation of working spaces or careless handling of materials.

Fire hazards present another serious problem. "No Smoking" rules should be strictly enforced. Ground wires should be installed on every aircraft during maintenance to eliminate dangerous static electric buildups. Spilled oil, grease, and chemicals should be wiped up promptly, and all rags used should be disposed of in covered metal containers.

Handtools should be in good shape, of the proper type, and used only for the purpose for which they were designed.

Insure that equipment is operated only by qualified personnel, and that all safety devices and guards are installed and in good condition. The equipment should also be inspected for broken or damaged components. Check to see that periodic maintenance, servicing, and/or calibration are up to date for those equipments requiring it. Details on the Naval Air Systems Command calibration policy are contained in NavAir Instruction 4355.4 (Series).

ORGANIZATION AND ADMINISTRATION OF SAFETY PROGRAMS

In accordance with the Navy policy of conserving manpower and material, all naval activities are required to conduct effective and continuous accident prevention programs. The organization and administration of a safety program applicable to powerplant work centers are part of the requirements of the powerplant supervisor. The safety program must be in accordance with applicable instructions. Work methods must be adopted which do not expose personnel unnecessarily to injury or occupational health hazards. Instructions in appropriate safety precautions are required to be given and disciplinary action taken in case of willful violations.

The safety program will generally involve three areas of attention—the posting of the most important safety precautions in appropriate places, the incorporation of safety lessons in the formal trianing program, and frequent checks for understanding during the day-to-day supervision of work.

Posted safety precautions are more effective if they are easily complied with. For example, a sign on a tool grinder reads "goggles required," so one or more pairs of safety goggles should be hanging within reach at the machine. Similarly, the protective clothing poster in the welding shop should be backed up with readily available aprons, gloves, shields, etc.

Fixed posters and signs should be renewed frequently and not allowed to become rusty, faded, or covered with dust and dirt. General safety posters on bulletin boards and other places should be rotated often to stimulate interest. Appropriate safety posters may be obtained from the squadron or unit safety officer.

The formal safety training sessions should utilize films, books, visual aids, or any other suitable technical material. The men should be told more than just what or what not to do. Each safety subject should be explained in detail. The result of unsafe acts are usually the most dramatic and easiest remembered. Causes of accidents and contributing factors should be reviewed and analyzed. Many good ideas for accident prevention have been developed in training sessions.

An extensive series of lessons may be developed over a period of time as latent hazards are recognized; this will aid in keeping the sessions interesting while avoiding frequent repetition.

It may be well to mention the new man in the work center at this point. A separate safety indoctrination lesson which covers all the major hazards of the work center should be given the new man as soon as he reports for work. No supervisor with an effective safety program and an excellent work center safety record wants to take the chance that the new man will be hurt before attending the complete series of safety lessons.

In the third area of safety program administration–followup–the supervisor will do well to delegate authority to his subordinate petty officers to assist him in monitoring the program. Also included in the followup area is a responsibility of the supervisor to inquire as quickly and thoroughly as possible into the circumstances of accidents and reports of unsafe practices and take action or make recommendations.

INTERPRETATION OF SAFETY DIRECTIVES AND PRECAUTIONS

The safety precautions in Department of the Navy Safety Precautions for Shore Activities are designed to cover usual conditions in shore activities. Commanding officers and others in authority are authorized to issue special precautions to their command to cover local conditions and unusual circumstances. The supervisor will have to apply both sets of rules in the administration of his safety program.

Safety directives and precautions should be followed to the letter in their specific application. Should any occasion arise in which any doubt exists as to the application of a particular directive or precaution, the measures to be taken are those which will achieve maximum safety.

When new safety posters or precautions are posted, it is the responsibility of the supervisor to correctly interpret their application to his men. In this way he will be able to achieve a unity of thought and action in the observance of the required safety rule.

The organization's safety officer is available to assist in interpreting and suggesting ways of implementing various safety directives and precautions. Current directives require that a safety officer or safety engineer be assigned as head of the safety department, division, branch, or section, whichever is applicable, at all shore stations.

In most instances the hazards involved and the applicable precautions for a given type of work are the same whether the work is done afloat or ashore.

POWERPLANT INSPECTIONS

The supervisor should insure that for each maintenance action, qualified personnel are assigned, proper tools are available, and proper techniques are employed. The supervisor must also conduct an effective training program for personnel assigned. During most calendar inspections, the powerplant is removed from the aircraft and taken to a centrally located space to accomplish the inspection. This enables the supervisor to closely monitor the check himself or with collateral duty inspectors. It also affords the supervisor an opportunity to initiate on-the-job training.

Maintenance Requirements Cards (MRC's) are used for periodic inspections. The MRC's provide the maintenance man a ready reference to perform the scheduled maintenance on the powerplant. Each MRC contains one or more detailed maintenance requirements. Illustrations, clearances, tolerances, charts, and part number are included when required. All minimum requirements for the accomplishment of any particular periodic maintenance task are contained in a set of these cards.

Frequent and thorough inspections are necessary to attain efficiency and safety. Working spaces should be checked for cleanliness. By conducting an effective training program and insisting on keeping the working spaces clean and orderly, the supervisor is encouraging orderly thought and systematic work habits which will be directly reflected in high quality workmanship.

Work priorities are centrally controlled by Maintenance Control. Supervisors at every level must know which job is to be given emphasis; thus, work assignments can be controlled and production effort applied to desired projects. Each job is assigned one of the following priorities: Priority 1, Immediate Action; Priority 2, Urgent Action; or Priority 3, Routine Action. Work priorities may vary hourly or daily, depending on the flight schedule and the unscheduled maintenance workload. The supervisor must insure that maintenance control is continually informed of the status of assigned work. He must also insure that quality assurance inspections are performed as required.

TECHNICAL SPECIFICATIONS

The powerplant inspection refers to an inspection to determine the quality and completeness of work performed and material condition. The control of quality is the duty of each division and each individual. It is the task of the quality assurance division to aid the various work centers in the maintenance department in performing this duty. The supervisor must recommend only the best qualified men in this work center to be designated collateral duty inspectors to insure that all weapons systems are maintained to the maximum extent possible.

The responsibility of the supervisor has increased in difficulty with the ever increasing complexity of the aircraft. More and more technical specifications and requirements must be met. It is almost impossible for the supervisor to remember all the technical requirements with which his work center must comply. This can be accomplished by a thorough training program and designating a competent rated man the responsibility of maintaining the publications section of the work center.

WORKMANSHIP STANDARDS

The main goal of the Navy is to be ready at any given moment to perform any mission assigned. To achieve this goal, all weapons systems must be maintained to the maximum extent possible to perform 100 percent of the functions for which they were designed.

Nonavailability of aircraft due to material deficiencies and poor workmanship are major problems. Therefore, good workmanship standards are necessary to pinpoint troubles before they have a chance to cause serious difficulty. A system that includes inspectors who are skilled in the AD rating and trained in good workmanship standards is a vital necessity. This system should include compiling records and information from various sources to gain information on where the greatest difficulty lies and why it is there. The final function of this system is to analyze these facts and point them out to others. It is difficult to find a yardstick to measure the degree of dependability attained. One of the best indications readily at hand is aircraft availability.

PROCURING AND CUSTODY OF MATERIAL

The supervisor is responsible for ordering aircraft maintenance spare parts and material, tools, and other equipment necessary for the accomplishment of assigned maintenance tasks. Necessarily related to this responsibility are requirements for controlling the use of consumable materials, maintaining and accounting for tools and material held on a custody signature basis, and, when required, the preparation and submission of evaluation reports.

AIRCRAFT PARTS

Aircraft parts are generally ordered for two reasons, the first being replacement for parts which are removed from service on a scheduled basis. These are usually parts which by their failure may cause disastrous consequences. The other general need for aircraft parts results from failure, damage, or unsatisfactory operation of an aircraft component. As can be seen, parts in the former category may be ordered in advance so they can be on hand when required, but the latter category may not, as their usage is generally unforeseen. In either event, the ordering procedure is the same.

NOTE: Prior to ordering a replacement for a failed part, the supervisor should always consider his responsibility and capability to effect the repair of the old part. If this capability exists (and is permissible) at his level and the repair is accomplished, it will prevent the expenditure of a great amount of time, trouble, and money required to process such material through higher levels of maintenance.

The first step in ordering is the identification of the desired part. After the item is identified, the supervisor must contact maintenance control and have a priority assigned the needed part. The supervisor will then notify material control of the item needed, the priority assigned, and the delivery point. Material control does not prepare supply documents for material required in direct support of weapons system maintenance. (Normally, material is considered to be required in direct support of weapons system maintenance when the material is to be utilized in completing a maintenance action which has been assigned a Production or Job Control Number.) Such documents are prepared by the Supply Support Center. Material control verbally notifies the supply organization of the need for such material. The local supply organization is responsible for the physical delivery of RFI material to the maintenance organization and pickup of the defective material.

In a more or less predictable length of time, consistent with the priority, the part will be delivered to the shop. Prior to opening the package or breaking the preservation in any manner, the Federal Stock Number and any other identifying data on the package should be double checked against the shop order file to insure that they match. Upon depackaging, another check similar to the foregoing should be made to positively identify the part.

If either inspection reveals any inconsistencies of identification data, it may be that the supply office has substituted an interchangeable item. If so, the substitute item should be checked in the Illustrated Parts Breakdown, Section B Allowance List, or the Interchangeable List for ASO and NavAir Cognizance Repairable Assemblies. If possible, an actual comparison with the old part should be made prior to installation as a further check for suitability.

TOOLS

Ordering of tools is accomplished in much the same manner as in the past. After the tool is identified, a filled-in, rough copy of the requisition form is forwarded to material control or unit supply office. This form may be either a DD 1348, or a locally issued form which provides spaces for the required information. In the material control office or supply office, a smooth copy is prepared, the necessary accounting data added, signed, and forwarded to the main supply activity.

The need for a tool should develop during a periodic tool inventory, when all tools should be cleaned and inspected, and repaired or replaced as necessary.

Unlike aircraft parts, which should be stocked in the work center, the section G allowance lists provide for each Organizational maintenance activity to have on hand a certain quantity of tools. The applicable allowance lists should be cross checked with a current tool inventory and any deficiencies made up as soon as possible. In some cases, it may be determined that some tools on the allowance lists are not needed or that the allowed quantity exceeds actual requirements. In such cases, those tools should not be ordered just to have them collect dust on the toolroom shelves. In addition, excess tools serve to complicate the periodic inventories as well as posing a transportation problem when the squadron deploys.

GROUND SUPPORT EQUIPMENT

Items of ground support equipment (GSE) used for servicing and maintaining aeronautical equipment consists of equipment furnished as organizational property and equipment furnished on subcustody from the supporting service. The Individual Material Readiness List that was discussed in chapter 2 of this manual provides an authorized allowance listing for GSE which may be procured or obtained on subcustody by the supported activity.

Work centers charged with the custody of GSE must insure that proper care is exercised in its daily maintenance, upkeep, and operation. Preoperational/ or Daily Maintenance Requirements Cards are available for use in maintaining most larger items of support equipment. Items on subcustody from the supporting activity are normally recalled to the supporting AIMD for periodic maintenance inspections.

The supporting activity licenses qualified operators and provides GSE training, in addition to that which may be given as part of the work center's training syllabus. All operators of ground support equipment must be qualified and licensed. The license should be carried at all times when operating GSE.

GSE on subcustody to squadrons or other activities remains the responsibility of the reporting custodians. Personnel designated as being responsible for GSE, within the activity having subcustody, must compile utilization on the appropriate GSE card and forward it to the reporting custodian on the last day of the reporting period. Reporting procedures are provided in detail in volume III of the Naval Aviation Maintenance Program, OpNav 4790.2 (Series).

INVENTORY AND RECORDS

When the shop is first set up and the initial allowance of tools and equipment is drawn, inventory cards should be made up on each item. These cards should include the name of the item, quantity, manufacturer, model, stock number, date of acquisition, cost, and dates and nature of repairs and replacement parts.

Some items should be kept in the work center toolroom or special cabinet; others placed in individual toolboxes and issued to the workers. A toolbox inventory record should be prepared in duplicate with the original filed in the work center files and the duplicate copy placed in the toolbox, preferably in an oil and grease resistant envelope.

While each toolbox should be adequately stocked, it should not contain tools in excess of actual requirements. Maintenance personnel must utilize some method of tool accountability following each maintenance action to prevent tools being left adrift. Tools should be etched or marked in some manner that will identify them to a specific work center and toolbox. This acts as a deterent to leaving tools adrift and provides the additional benefit of cutting down on the amount of tool pilferage.

A monthly inventory should be conducted beginning with the toolboxes and ending with the toolroom count. The periodic inventory should be more than just an item count. Since each item is sighted, it provides an opportunity to ascertain if the tools in actual use are being maintained in good repair. If they show evidence of damage or improper use, appropriate corrective action should be taken. The men should be encouraged to make good use of delay time by tool maintenance and equipment servicing.

Aircraft Inventory

In the past, there has always been a problem in maintaining custodial control and location information on command-controlled aeronautical components and aircraft related equipments. In order to maintain an unbroken chain of custodial responsibility incident to the transfer and acceptance of naval aircraft, the Standard Inventory Log was developed by the Navy to be used as an instrument of transfer. In the interest of standardization among the armed services, the Aircraft Inventory Record has been designed by the Department of Defense for this purpose. Records (instead of Logs) are now being prepared by the Navy for new production aircraft and when old Logs are revised.

With remote exceptions, no aircraft may now be transferred or accepted without an Inventory Log or Record. On these occasions, an inventory of the aircraft and its equipment must be accomplished, based on the items of equipment and material contained in the applicable Log or Record.

Although the Log and Record serve the same purpose, there are some minor differences in their format and categorical listings. In general, the determination as to whether items are, or are not, subject to listing in these publications without regard as to whether they are contractor or government furnished and contractor or service installed, is governed by the following:

1. Items essential to the execution of the designated missions of the aircraft, such as armament, electronics, photographic equipment (excluding cameras other than for primary missions), and special instruments, are included.

2. Items of equipment which are rigidly fixed and considered to be a basic or integral part of the airframe, such as engines, propellers, wheels, tires, and brakes, are excluded. In the case of the Aircraft Inventory Record, standard instruments are also excluded.

3. Special equipment items essential to the safety or comfort of the crew such as bedding, liferafts, Thermos bottles, crash axes, and portable fire extinguishers are included. Comparable items which are personal issue or furnished on squadron allowances are excluded.

4. Loose equipment delivered with the aircraft, such as covers, mooring kits, and jack pads, for which stowage provisions have been incorporated in the aircraft, are included.

5. Items subject to pilferage or readily convertible to personal use, such as clocks, Thermos jugs, bedding, and first aid kits, are included. Comparable items which are personal issue or furnished on squadron allowances are excluded.

The Standard Inventory Log is subdivided into groups of equipment (e.g., instrument and navigation equipment, armament equipment, and electronic equipment). The components are listed in alphabetical sequence and according to their location in the aircraft, with the exception of the electronics equipment, in which case all components of an equipment are listed in one place regardless of their location in the aircraft. Stock numbers are also supplied for individual items, and are used for ready reference when replacements are required.

The Aircraft Inventory Record includes a sectional breakdown diagram of the applicable aircraft. This diagram consists of a side elevation and/or the plan view of a wing, or in the case of twinboomed or flying wing aircraft, the perspective view.

To facilitate inventorying, the sections of the diagram are identified by letters, the letter "A" being assigned to the foremost section, "B" to the next, and so on, generally to the rear of the aircraft. The letter "R" as part of the item number, denotes items mounted on the exterior of the fuselage, and the letter "F" denotes items to which access is gained from the fuselage. Subdivisions of sections may be identified by a lower case letter such as "Aa" "Ac" etc.

The equipment list portion of the Record is divided into sections, each of which lists the items pertaining to a particular section of the aircraft, as indicated on the sectional breakdown diagram. Within each section, individual items are numbered as nearly as possible in the sequence of their physical location in the aircraft without regard to their relation to specific equipment. Stock numbers are not supplied as part of the equipment listing in Inventory Records.

One Standard Inventory Log in general is issued as applicable to one aircraft model and designates material and equipment peculiar among the various applicable versions and bureau numbers. The Aircraft Inventory Record is issued as applicable to one aircraft for a specific bureau number.

Blank columns are provided on the inventory pages of the Log and Record, in order that transferring and receiving activities may jointly inventory and indicate the quantity of each item ascertained to be on board the aircraft at the time of transfer. A RECEIPT ENDORSEMENT LOG in the Standard Inventory Log, and a CERTIFICATE AND RECORD OF TRANSFER in the Aircraft Inventory Record are provided so that transferring and receiving activities may sign, indicating by column applicability, the items on board the aircraft.

Upon the transfer of an aircraft, representatives from the transferring and receiving activities jointly inventory and record, in the appropriate column, the quantity of each item which is ascertained to be on board the aircraft at the time of transfer. When a ferry pilot, or a naval vessel is involved in the transfer, two inventories are made, one prior to the ferry flight or embarkation, and one upon completion.

A Report of Inventory Form supplied with the Standard Inventory Log, or the Shortages Form (DD780-2) in the Aircraft Inventory Record, is generally prepared in triplicate, listing missing items with appropriate remarks. The original is retained by the transferring activity and is filed as a permanent record of transfer.

The first carbon copy of the form is left in the Standard inventory Log or Aircraft Inventory Record, as the case may be, and is delivered along with the Log or Record to the activity receiving the aircraft.

The second carbon copy of the report or shortages form is forwarded to the cognizant major operating command (controlling custodian) of the transferring activity for information and any appropriate action deemed necessary.

In the case of missing items, the transferring activity makes every effort to locate the missing items or to withdraw from store the replacement items necessary to complete the inventory. If it is impossible to locate or supply the missing items, the notation "Missing items are not available" is placed in the Report of Inventory Form in the Standard Inventory Log or the Shortages Form in the Aircraft Inventory Record. An explanatory statement signed by the transferring representative is placed with this form, indicating the authority for these shortages. On the basis of this statement, the receiving activity may fill the shortages from stock and account for them in the normal manner.

When the aircraft is abandoned or disposed of by scrapping, the Inventory Log or Record may be destroyed by the activity disposing of the aircraft. When the aircraft is transferred to other U.S. agencies, the Log or Record is also transferred. When the aircraft is sold to a private party, the Inventory Log or Record is forwarded to the Naval Air Systems Command immediately after consummation of the sale and include the signatures of the last custodian (seller) and the purchaser. In order to provide the buyer with inventory information, the Log or Record may be duplicated, provided that it includes no classified information.

Aeronautical Equipment Service Record (AESR)

The AESR is prescribed for use as a service record for aircraft powerplants, auxiliary power units (airborne), airborne gun pods, low-level escape systems, propellers, in-flight refueling stores/packages, quick engine change kits, and gas turbine compressor engines (ground).

The aircraft logbook is a hard-cover, loose-leaf ring binder containing separators and page insert forms.

The AESR is initiated by the activity accepting the equipment from the Navy, and is subsequently maintained by the activity having custody of the equipment at all times. When equipment is installed as part of the aircraft, this record is maintained concurrently with and becomes part of the Aircraft Logbook.

The AESR is maintained similarly to the Aircraft Logbook. Since it is in loose-leaf form, the full identification data and serial number are inserted on each page to insure ready identification when pages are removed for entries or for any other reason.

The following forms make up the complete AESR:

Custody and Transfer Form.
Equipment Operating Log.
Inspection Record Form.
Record of Rework Form.
Technical Directives Form.
Miscellaneous/History Form.
Scheduled Removal Components Form.
Scheduled Removal Component Cards.
Supplemental forms include the following:
Turbine Rotor Disc Assembly Record.
Afterburner Service Record.
Compressor Rotor Assembly Service Record.

For detailed information on these forms as well as other Aircraft Logbook forms and records, reference should be made to chapter 6 in volume II of OpNav 4790.2 (Series).

COST CONSCIOUSNESS

The Navy Cost Reduction Program, NavSo 2486, strives to create an attitude of total cost consciousness and to encourage the development and implementation of cost reducing actions. Maintenance supervisors as well as their subordinates can play a definite role in reducing costs. Areas where costs can be reduced should be identified and action taken through the chain of command. Recognition to the individual responsible for any cost reduction actions will serve to stimulate the cost reduction program.

Personnel involved in procurement of material and equipment and those charged with custody of such items should realize that the overall cost for defense material is tremendous. Costs of weapons systems, associated test equipment/ support equipment, and spare parts necessary to support the weapon system during its expected service life have increased steadily to the point where improved management is necessary. Attention must be given resources, utilization of personnel, accident prevention, etc.

Improved work habits, elimination of unnecessary maintenance tasks, improvements to test equipment, consolidation of functions, greater use of resources, and increased capability for repair of specific items at the lowest level of maintenance are but a few areas that could be evaluated as a means of reducing costs at the working level. Supervisors should be alert to ways of bringing about such improvements and should encourage and assist their personnel in submitting factual beneficial suggestions for consideration and subsequent dissemination.

Materials belonging to the Navy are not procured for personal use of the individual, yet thousands of dollars are lost annually due to poor control of material resources. Proper security of pilferable items will materially reduce costs. Ordering only that material which is actually needed rather than that which "might" be needed is another area that generally could receive attention. The ways of reducing costs are limited only by the supervisor's imagination and ingenuity. Waste, whether it is of manpower, money, or material, costs the taxpayer and therefore affects almost everyone.

EVALUATION REPORTS

The maintenance of today's high-performance aircraft requires more and more special tools, shop equipment, and ground-handling equipment. Most of this special equipment is designed and manufactured by private contractors. The manufacturers frequently request individual fleet activities to conduct performance evaluations on items which have been purchased by the Navy and are new to the industry. This practice is approved and encouraged, but a standard procedure for conducting performance evaluations is necessary.

According to current instructions, the manufacturer's request must be approved by the cognizant COMFAIR before it can be accepted by the fleet activity requested to perform the evaluation. Upon approval, the activity conducting the evaluation will provide the manufacturer, via the COMFAIR, with a report of the evaluation findings, citing any defects or recommendations for improvement. The report should include the manufacturer's name, name of product, model number, size, and/or capacity of the product evaluated, and the specific function for which the product may have been used.

TECHNICAL PUBLICATIONS

Aeronautical publications are the sources of information for guiding naval personnel in the operation and maintenance of all aircraft and related equipment within the Naval Establishment. By proper use of these publications, all aircraft and other aeronautical equipment can be operated and maintained efficiently and uniformly throughout the Navy.

General information pertaining to the major publications of interest to naval aviation maintenance personnel is contained in Aviation Machinist's Mate R 3 & 2, chapter 4, NavPers 10342-A, and knowledge of the material in that text is presumed.

TECHNICAL DIRECTIVES

The Technical Directive System has been established for the control and issue of all technical directives. This system standardizes the method of issuance for such directives and is the authorized means for directing the accomplishment and recording of modifications and one-time inspections of ground support equipment as well as aircraft and other aeronautical equipment. The Technical Directive System is an important element in the programs designed to maintain equipment in a safe and current state of operational and material readiness.

This system provides for two types of technical directives. The types are determined by the method of dissemination. The two types are Formal (letter type) and Interim (message type). In general terms, they are both considered as letter type publications. Such directives contain instructions or information of a technical nature which cannot be disseminated by revisions or changes to technical manuals. However, the accomplishment of a technical directive often necessitates a change or revision to the applicable technical manual. Technical directives are issued in the form of Changes, or in the case of special circumstances, by Interim Changes or Interim Bulletins.

A formal technical directive is issued as a Change, or as an amendment or revision thereto, and, as stated previously, is disseminated by letter. Formal directives are used to direct the accomplishment and recording of modifications to support equipment, as well as aircraft and related equipment. An interim technical directive is issued as a Change or a Bulletin, or as an amendment or revision thereto, and, in order to insure prompt delivery to the concerned activities, is disseminated by message. The interim technical directive is reserved for those instances to correct a safety or operational condition whenever it is considered too important to risk waiting for the issuance of a formal directive.

Each interim Change is superseded by a Formal Change directive which will have the same number as the interim directive. Interim Bulletins are not superseded by formal Bulletins as was previously the case. NavSup Publication 2002. Section VIII, Part D will still have many formal Bulletins listed until they are eventually phased out.

A Change is a document containing instructions and information which directs the accomplishment and recording of a material change, a repositioning, a modification, or an alteration in the characteristics of the equipment to which it applies. A Change is issued to direct that parts be added, removed, or changed from the existing configuration or that parts or material be altered, relocated, or repositioned.

A Change may be issued in parts to accomplish distinct parts of a total directed action or to accomplish action on different configurations of affected equipment.

A Bulletin is an interim document comprised of instructions and information which directs an initial inspection to determine whether a given condition exists. It specifies what action is to be taken if a given condition is found or not found.

Sometimes it is found that a Change or Bulletin is not the complete answer to a problem, and it is determined necessary to amend or revise an outstanding directive. An Amendment is a document comprised of information which clarifies, corrects, adds to, deletes from, makes minor changes in requirements to, or cancels an existing directive. It is only a supplement to the existing directive and not a complete directive in itself. A maximum of three Amendments may be applied to any technical directive, each remaining in effect until rescinded or superseded by a Revision. A requirement for further amendment action necessitates the issuance of a Revision.

A Revision is a completely new edition of an existing technical directive. It supersedes the original directive and all existing Amendments.

Interim Bulletins are self-rescinding with rescission dates of 30 June and 31 December, whichever is appropriate for the case at hand. Rescission is the process by which a technical directive is removed from active files after all requirements have been incorporated and recorded. Rescinding dates are also projected for formal changes. Final rescission action of all technical directives is directed in Part D, Section VIII, NavSup Publication 2002. All activities maintaining files of technical directives should retain all technical directives until they are deleted from NavSup Publication 2002.

Changes and Bulletins are issued by technical personnel of the Naval Air Systems Command and are based on Contractor Service Bulletins, on reports from various Data Services, or letters of recommendation or proposed modifications from field service activities. They are automatically distributed to all activities concerned through inclusion on the Mailing List Request for Aeronautic Publications, NavAir 5605/3.

Changes and Interim Changes are assigned numbers in a numerical sequence by the Technical Directives Control Center, located at the Naval Air Technical Services Facility (NATSF), Philadelphia, Pa. As stated previously, a Formal Change which supersedes an Interim Change will have the same number as the Interim Change. Interim Bulletins are numbered similarly in another number series.

The title of a Change or Bulletin for support equipment is made up of three parts. Part one is the term "Support Equipment;" part two, the word or words "Change," "Interim Change," or "Interim Bulletin;" and part three, the sequential number. When applicable, the words "Rev. A," "Amendment 1," etc. follow the basic directive.

Changes are classified by various "action" categories. Bulletins may also be assigned an action classification, but it is not mandatory. The assigned action category serves as a priority for compliance with the various directives.

The category "Immediate Action" is assigned to directives which are issued to correct safety conditions, the uncorrected existence of which would probably result in fatal or serious injury to personnel, extensive damage, or destruction of property. Immediate Action directives involve the discontinued use of the equipment in the operational employment under which the adverse safety condition exists, until the directive has been complied with. If the use of the equipment will not involve the use of the affected component or system in either normal or emergency situations, compliance may be deferred, but should be accomplished no later than 120 days from the date of issue. Immediate Action directives are identified by a border of red X's, broken at the top center of the page by the words "IMMEDIATE ACTION," also printed in red.

The category "Urgent Action" is assigned to directives which are used to correct safety conditions which, if uncorrected, could result in personnel injury or property damage. This category of directive is identified by the words "URGENT ACTION" printed in red ink at the top of the first page and a border of red diagonals around the cover page.

The compliance requirements for Urgent Action directives specify that the incorporation of the instructions must be accomplished not later than the next regularly scheduled rework or overhaul or, for equipment not reworked or overhauled, on a regularly scheduled basis, not later than 18 months after the date of issuance.

Routine Action directives are issued where there are reliability, capability, or maintainability deficiencies which could, if uncorrected, become a hazard through prolonged usage or have an adverse effect on the operational life or general service utilization of equipment. The compliance requirement specifies the incorporation of the instructions not later than the next regularly scheduled overhaul or rework, or for equipment not reworked or overhauled on a scheduled basis, not later than 18 months after issuance of the directive. If accomplishment of the work requires Depot level maintenance capability, the compliance may be deferred if it will seriously interfere with operational commitments or schedules. Routine Action directives are identified by the words "ROUTINE ACTION" printed in black capital letters at the top center of the cover page.

Record Purpose category is assigned to a technical directive when a modification has been completely incorporated by the contractor before acceptance by the Navy. This category of technical directive merely documents the action for configuration management purposes. Consequently, compliance information is not applicable. They are identified by the words "RECORD PURPOSES" printed in black capital letters at the top center of the cover page.

INSTRUCTIONS AND NOTICES

Instructions and Notices are the two main types of directives provided for in the Directives Issuance System which was designed for the purpose of providing a uniform plan of issuing and maintaining directives. Directives may establish policy, organization, methods, or procedures. They may require action to be taken or contain information affecting operations or administration. All Naval Air Systems Command level (and above) originated directives are distributed by the Navy Department Administrations Office, with certain exceptions. Each level of command below Naval Air Systems Command level has an administration office responsible for distributing that level of command directives to its units or addressees below them.

Instructions and Notices are identified by originator and subject classification. A typical directive identification breakdown follows:

OpNav Instruction 3750.1A. OpNav indicates that this instruction originated in the office of the Chief of Naval Operations. The 4-digit number 3750 is the subject classification number. This particular number indicates the series on Flight Safety. The number 1 indicates the number of issues the originating office has issued on this subject. (Notices do not have this number.) The letter A indicates the number of times this Instruction has been revised; i.e., A for first revision, B for second, etc. If the letters C or S precedes the subject classification number, it indicates the classification of the subject. The letter C indicates confidential and S indicates secret.

There are 13 major subject classification number groups, ranging from the 1000 group to the 13000 group. The 13000 group is set aside for aeronautical and astronautical material.

MAINTENANCE INSTRUCTIONS

The Maintenance Instruction Form OpNav 4790/35 is usually prepared by the cognizant division; however, it may be drafted by a division designated by the Maintenance Officer. These forms have been provided for the use of maintenance departments as the standard form for the interpretation and/or amplification of technical directives and maintenance requirements received from higher authority. The forms may also be used to issue local technical instructions.

A review of the draft should be conducted by the Quality Assurance Division as well as the maintenance/material coordinator prior to the approval by the Maintenance Officer. The Maintenance Instruction must be prepared carefully, because it is the instrument the division officer uses to direct his men. Command directives in the form of messages are often so brief, that to be understandable at the working level they need considerable amplification and background information. On the other hand, lengthy and detailed directives prepared for all aviation activities may be received. Only parts of these directives may be applicable locally, and the directives need condensation and selection to adapt them to local conditions. The three purposes that a Maintenance Instruction may be used for are as follows:

1. A SAMI (Single Action Maintenance Instruction) may be prepared when a directive or situation dictates that specific work must be performed on a one-time basis. By their nature, SAMI's have a limited period of applicability, and positive action must be taken to cancel SAMI's which have served their purpose.

2. A CAMI (Continuing Action Maintenance Instruction) may be prepared when a directive or situation dictates that specific work must be performed at recurring intervals contingent upon elapsed time or upon the occurrence of a particular condition or incident. When the work ordered may be performed on an aircraft or piece of equipment at recurring intervals, it is properly the subject of a CAMI. It is important that it be clearly stated when the prescribed action is taken and that positive control be exercised to insure that the work is actually performed. If the aircraft model concerned is maintained under the calendar inspection system, using MRC's (Maintenance Requirements Cards), any new maintenance inspection requirements should be considered for inclusion in the MRC deck rather than as CAMI material. A copy of these requirements, generated by other than CNO and NavAirSysCom, with reference, should be submitted with an Unsatisfactory Material/Condition Report (OpNav Form 4790/47) to be considered for inclusion in the next revision to the MRC's.

3. A TIMI (Technical Information Maintenance Instruction) may be prepared when a directive or situation dictates that technical information must be promulgated within the activity. When it is necessary to disseminate information, such as techniques and local policy, which does not direct the performance of specific work at intervals, but which is sustaining in nature, a TIMI may be properly issued; e.g., information on hydraulic fluid contamination.

MANUAL PUBLICATIONS

To attain a satisfactory state of readiness, technical manuals are developed, published, and distributed concurrently with the weapon system or equipment that they cover. Periodic changes and revisions are issued as necessary to insure that manuals continually reflect equipment changes and current operational and support concepts and procedures. Technical manuals released under the authority of the

Commander, Naval Air Systems Command, are considered the only authorized source of the information provided, and the instructions they contain are mandatory.

The variety of manual publications available to the AD are designed to provide all essential information necessary to understand the operational theory, troubleshoot and service the system, and maintain the weapon system and/or its associated components.

General Manuals (00 Series)

As indicated by the title, this series of manuals includes information of interest to all naval aviation personnel. In the final analysis, some publications in this series may not be considered as actual technical manuals; however, they furnish aircraft maintenance activities with valuable required information. Manuals included in the general (00) series that are of interest to the AD are the three parts of the Naval Aeronautical Publications Index (00-500A, 00-500B, 00-500C.), Initial Outfitting Lists and Allowance Lists, and the Aviation Training Literature.

Aircraft Manuals (01 Series)

The following types of manuals are prepared and issued for each model of aircraft used by the Navy:

NATOPS (Naval Air Training and Operating Procedures Standardization Program) Flight Manual, herein referred to as Flight Manual.

Maintenance Instructions Manual.

Structural Repair Manual.

Illustrated Parts Breakdown.

Periodic Maintenance Requirements Manual, including related Maintenance Requirements Cards and Sequence Control Charts.

NOTE: The Periodic Maintenance Requirements Manual (PMRM) is being replaced by Periodic Maintenance Information Cards.

The NavAirSysCom also provides a series of General Engineering Manuals, applicable to all aircraft models, and available to aircraft maintenance activities. These publications are concerned with such subjects as Corrosion Control, Aircraft Structural Repair, Aircraft Hardware, and Aircraft Cleaning. As previously stated, these publications are of a general nature and are used in conjunction with the specific aircraft model manuals. These general manuals are grouped at the beginning of the 01 series manual listing in NavSup 2002, Section VIII, Part C.

A maintenance Planning Manual is issued (for newer models) to serve as the maintenance officer's source of information on maintenance management with respect to the particular weapons system. It contains information on what the total maintenance plan for the weapons system is, what facilities, equipment, material, space, and personnel will be needed, and what resources, including technical information, services, training, supply support, etc., are available and how to obtain them.

FLIGHT MANUAL.–The Flight Manual contains complete operating instructions for the aircraft and its operational equipment. Emergency operating instructions as well as normal operating instructions are provided. Although Flight Manuals are issued primarily for the use of pilots and aircrewmen, they provide valuable operational information to maintenance personnel as well.

Two methods of updating Flight Manuals are by regular change notices and by interim manual changes. Regular change notices are issued periodically and cover routine changes and instructions. Interim manual changes cover vital operating instructions and are issued when immediate action is necessary.

Flight Manuals for newer aircraft models are identified by -1 in Part III of the publication code. For example, NA 01-85SA-1 identifies a Flight Manual for the S-2.

MAINTENANCE INSTRUCTIONS MANUAL.–The Maintenance Instructions Manual (MIM) contains most of the essential information required by aircraft maintenance personnel for service and maintenance of the complete aircraft. It includes the data necessary for troubleshooting and maintaining the powerplant, accessories, and all systems and components of the aircraft.

Instructions in the Maintenance Instructions Manual include such typical service and maintenance operations as the following:

1. Routine servicing.
2. Lubrication requirements.
3. Cleaning.

4. Adjustments.
5. Minor repairs.
6. Removal and replacement of components.
7. Testing.

The Maintenance Instructions Manual for all current production aircraft is made up in volumes, each volume being individually bound and issued separately. This permits each work center in an activity to have its own applicable volume, or volumes at hand for ready reference.

Classified maintenance information is not included in the regular volumes of the Maintenance Instructions Manual. Essential classified information is contained in separate volumes or supplements of the Maintenance Instructions Manual which are classified "confidential." These volumes are usually bound in red in order that they may be readily identified and should be handled in accordance with the Department of the Navy Security Manual for Classified Information.

The various volumes of the Maintenance Instructions Manual cover such areas as the following:

General Information and Servicing.
Airframe Group.
Powerplant and Related Systems.
Armament and Photographic Systems.
Electrical Systems.
Communication and Radio Navigation Systems.

The first volume, usually titled General Information and Servicing, is designated primarily for the plane captain; however, this volume contains a great deal of information important to all maintenance personnel. It contains a general description of the aircraft, all information pertaining to servicing the aircraft, and necessary information which is not contained in other specialized volumes.

Each of the specialized system volumes (airframe, powerplants, electrical, etc.) of the Maintenance Instructions Manual is further divided into four sections, as described in the following paragraphs.

Section I is the same in all volumes of a particular aircraft Maintenance Instructions Manual. This section provides an introduction to the manual and usually supplies a list of the changes applicable to the particular volume concerned.

Section II describes the system and components as well as their operation.

Section III provides such maintenance coverage as removal and installation procedures and troubleshooting charts for the Organizational level of maintenance.

Section IV provides component repair procedures for the Intermediate level of maintenance.

The different aircraft manufacturers may group the material in the various volumes of the Maintenance Instructions Manual under different titles. For example, the Survival and Environmental Systems MIM for one model aircraft may be contained in one volume; whereas, another model aircraft may have two or more volumes to cover the same subjects.

As previously stated, the complete MIM for an aircraft consists of several separately bound volumes. Each volume is assigned an individual publication code number for identification purposes. The complete MIM is divided into groups of volumes (categories) containing related data or related systems.

Maintenance Instructions Manuals are identified by -2 in Part III of the publication code. Additional dash numbers are used to identify the different groups or categories. Point numbers are used to identify subsystems or related data to these groups or categories. For example, NA 01-75PAA-2-4 is the code number for the P-3A MIM for the Powerplant and Related Systems. NA 01-75PAA-2-4.1 signifies the MIM for Powerplant Buildup for the P-3A.

STRUCTURAL REPAIR MANUAL.—This manual is prepared primarily for personnel of the AM rating and is used as a guide in making structural repairs to the airframe. It contains general information such as airframe sealing, control surface rebalancing, general shop practices, damage evaluation and support of structure, and a description of the structure through the medium of indexed illustrations and repair drawings.

The Structural Repair Manual for most new aircraft is published in two volumes. This is not due to its size but is to suit its usage by different facilities. Volume I is for use at all levels of maintenance. Volume II supplements volume I and contains information used only at Depot level facilities.

ILLUSTRATED PARTS BREAKDOWN.—This is actually a parts catalog which lists all the parts of the complete aircraft. The purpose of the Illustrated Parts Breakdown (IPB) is to assist supply, maintenance, and overhaul personnel in the identification, requisitioning, storing, and issuing of parts for the applicable aircraft.

The Illustrated Parts Breakdown for older aircraft, like the Maintenance Instructions Manual, may be found in one volume. The Illustrated Parts Breakdown prepared for current production aircraft contains several volumes which usually correspond to the volumes in the Maintenance Instructions Manual.

A - 4 in Part III of the publication code identifies the Illustrated Parts Breakdown. The individual volumes are identified by an additional dash and number. An example of the code number for an Illustrated Parts Breakdown in current use is NA 01-85SAD-4-5. This is the code number for the Powerplant and Related Systems volume of the S2D IPB.

Each volume of the Illustrated Parts Breakdown is divided into at least two sections and sometimes three—section I, Introduction; section II, Group Assembly Parts List; and section III, when used, Numerical Index. Section I contains detailed instructions for the use of the Illustrated Parts Breakdown. Section II includes illustrations of all parts of the applicable aircraft and its systems, equipment, and special support equipment subject to separate maintenance.

The latest type Illustrated Parts Breakdown has a separate volume for the Numerical Index. The Numerical Index contains an alphanumeric listing of all parts in the Illustrated Parts Breakdown or volume. In addition to part numbers, the Numerical Index contains figure and index numbers and source code data.

Study of the Introduction (section I) will provide all the necessary information required to properly use the Illustrated Parts Breakdown.

PERIODIC MAINTENANCE REQUIREMENTS MANUAL.—This manual contains the planned scheduled maintenance requirements for the particular aircraft concerned and is the controlling document for the planning and accomplishment of related work tasks through all levels of maintenance. The maintenance requirements it contains are set forth in a manner that specifies the equipment to be inspected or examined and the conditions to be sought in each instance. The Periodic Maintenance Requirements Manual (PMRM) does not contain instructions for repair, adjustment, or other means of rectifying defective conditions, nor does it contain instructions for troubleshooting to determine causes of malfunctions.

The requirements prescribed in the Periodic Maintenance Requirements Manual are considered to be the minimum necessary under any condition to assure timely discovery and correction of latent defects and compliance is mandatory. Due to varying operational requirements, climatic or environmental conditions, cognizant commanders may increase the scope or frequency of inspections or examinations as required to properly and safely support operations.

Like most technical manuals, the Periodic Maintenance Requirements Manual is divided into parts or sections. These parts/sections cover such areas as Fleet Maintenance Requirement, Progressive Aircraft Rework Requirements, Component Removal/Replacement Schedule, Scheduled Removal Component Card, and Functional Test Flight Requirements.

The Periodic Maintenance Requirements Manual is updated by periodic change notices and revisions. This manual is identified by a -6 in Part III of the publication code. An example of a code number for the S-2 Periodic Maintenance Requirements Manual is NA 01-85SAD-6.

Periodic Maintenance Information Cards (PMIC).—These cards (which are gradually replacing the Periodic Maintenance Requirements Manuals) contain the component removal/replacement schedule and SRC card requirements covering Organizational and Intermediate levels of maintenance. Items to be replaced are indicated in unit operating hours, calendar time or cycles as appropriate, and are listed by system as arranged in the Maintenance Instructions Manual. Only those items that have a forced removal interval and those requiring an SRC card are listed. As with the PMRM, the planned maintenance requirements prescribed by the PMIC are considered to be the minimum necessary, and compliance is mandatory. In instances where conflict may exist between the requirements contained in the cards and other maintenance directives bearing prior dates, the PMIC take preference.

In addition to the Component Removal/Replacement schedule and SRC requirements, the PMIC also contains a maintenance reference table specifying those directives which have been incorporated in the PMS publications since the last routine change or revision.

The Periodic Maintenance Information Cards are updated by Rapid Action Changes. These cards are identified by a -6 in Part III of the publication code.

Aircraft Components and Related Equipment Manuals

These manuals are not limited to but include Accessories Manuals, Instrument Manuals, Armament Manuals, and Electronics Manuals. The 03 series manuals cover all types of accessories; Instrument Manuals are covered in the 05 series; the 11 series manuals are concerned with Armament and related equipment; and the 08 and 16 series pertain to Electronics Manuals.

The manufacturer of each item of equipment (carburetor, altimeter, bomb rack, radar set, etc.) is required to provide adequate instructions for operating the item and maintaining it throughout its service life. These manuals therefore contain descriptive data; detailed instructions for installation, operation, inspection, maintenance, and overhaul; and an illustrated parts list. All manuals pertaining to these different items of equipment available for issue are listed in numerical order (by publications number) in the applicable section of Part C, Section VIII of NavSup Publication 2002. They are also listed in 00-500A, but in alphanumeric order according to model, type, or part number. In 00-500B, these manuals are listed under the aircraft in which the item is installed.

Aircraft components and related equipment manuals are used to supplement information found in the aircraft Maintenance Instructions Manual. For example, when the Maintenance Instructions Manual does not give instructions for repairing a particular item, reference should be made to the applicable item manuals.

If a component or piece of equipment is relatively simple, all the necessary instructions may be contained in a single manual. More complex items may require two or more manuals. For example, one manual may cover operation, service, and overhaul instructions, while the parts breakdown is contained in a separate manual.

Support Equipment Manuals (17 and 19 Series)

The 17 and 19 series of technical manuals cover most types of support equipment. The manufacturer of each item of support equipment is required to furnish adequate instructions for operating the equipment and maintaining it throughout its service life. Like aircraft Maintenance Instructions Manuals, these publications, prepared by the manufacturer, are issued under the authority of the NavAirSysCom and are then official Navy publications.

Support Equipment Manuals are stocked, cataloged, listed, and located in the same manner as aircraft components and related equipment manuals.

Included in the 17 and 19 series of technical manuals are the Maintenance Requirements Cards for various ground support equipment.

UPDATING TECHNICAL MANUALS

The methods for assuring that technical manuals are maintained current to the extent necessary to maintain their validity or remove them from active status include issuing of Changes, Rapid Action Changes, Revisions, Supplements, and Appendices or by recision or replacement of a complete manual.

Changes, Rapid Action Changes (RAC), and Revisions are used to update a manual by replacing, adding, or removing changed pages in the manual.

Supplements are issued when it becomes necessary to augment or change data in basic manuals that is not adaptable to the inclusion of individual change pages or when the use of change pages is not suitable or practicable. Changes and Revisions are normally issued instead of Supplements except in emergency circumstances where Supplements must be utilized because of the critical time element.

Supplements issued for the Naval Aeronautic Publications Index provide an example of a situation where it would be impractical to issue Change Pages vice a Supplement. Supplements are issued as separate manuals and may be cumulative or noncumulative. Cumulative Supplements include all the data contained in Supplements previously issued and supersede the preceding Supplement. The supplement will be sectioned in a manner appropriate to the manual which it supplements and will be identified by the same manual title and number as the basic manual with the word "Supplement" printed at the top of the title page.

Appendices are issued when it becomes necessary to include information in a manual that is not part of the normal sequence outlined in the contents, such as charts, tables, listing of codes, etc. Such material becomes an integral part of the affected manual.

CHANGES.—Changes are issued when only parts of the existing manual are affected. The change pages replace the correspondingly numbered pages. When the Change is a Formal Change, all replaced pages must be removed and discarded. If the Change contains additional data that cannot be included on the replacement page, additional pages are issued. The page numbers issued to additional pages are the preceding page number plus capital letter suffixes in consecutive order or page numbers continuing in numerical sequence, depending on the circumstances.

A Formal Change alters a portion of a manual already in existence and does not constitute a large enough change to warrant issuance of a Revision. The Formal Change replaces, adds, or deletes pages and/or illustrations and the change pages are prepared to be collated into the manual without disrupting the manual format and sequence. The Formal Change is issued to include new models of equipment or add new procedures and to change existing equipment and procedures which do not create an emergency situation.

Manuals consisting of eight pages or less and those which do not include a title page are replaced by a complete revision of the manual in lieu of change page insertions.

RAPID ACTION CHANGES.—Rapid Action Changes (RAC's) are manual changes used to expedite the dissemination and incorporation of essential and urgent operation and maintenance information to technical manuals. Utilizing an interim RAC, information impacting safety of flight, hazards to personnel, grounding of aircraft, mission capability, equipment damage, or maintenance capability will be disseminated via naval message and incorporated into the affected manuals immediately.

A Manual Change Page followup will then be required within 15 days of release of the message. Information of a less urgent nature is promulgated by printed Rapid Action Change Pages. This type RAC is subjected to printing within 30 days after problem resolution and is limited to 12 pages or less.

The RAC system has phased out the previous Interim Manual Change. However, it does not affect the procedures for issuing and incorporating Formal Changes. The RAC merely supplements the Formal Change procedures to provide for rapid issue of urgently required data that was previously held up by the procedures involved in complying with the normal change system.

CHANGE ENTRY CERTIFICATION.—It is not feasible for every work center to have a copy of every publication that is used by the particular work center; however, they should have the publications most often used such as Maintenance Instruction Manuals, Illustrated Parts Breakdowns, and certain General Manuals. All publications held by the work center should be checked out (issued) from the activity's technical library, which functions as a part of the quality assurance division.

The technical library utilizes technical publications location cards to account for each publication held in the library as well as those issued to the various work centers. By using this system, the technical library can maintain reasonable control of all work center publications and applicable Revisions, Changes, etc., can be procured and issued as necessary to keep all publications current.

When Changes for a particular publication are received, technical library personnel check the location card and issue the Change to all holders of that publication, utilizing a Change Entry Certification Form. When the Change has been incorporated, the certification portion of the form is completed by the holder and returned to the technical library. This provides a record that the Change has been incorporated in the applicable publication. Most technical library systems dictate a maximum time allowed for incorporation of the Change to discourage "putting off" incorporation of Changes, which have presented a problem on more than one occasion. Publications that were not current have been used to perform maintenance tasks resulting in situations that are potential flight safety hazards.

Quality Assurance is charged with the responsibility of making periodic spot checks of each work center's publications to ascertain that the publications are updated properly.

NOTE: That portion of the text affected by the current Change or Revision is normally indicated by a heavy vertical line in the outer margin of the page.

Conversion Of Manuals To Microfilm

A relatively new concept in supplying maintenance activities with certain types of technical data has been accomplished by the use of microfilm. As a means of improving updated manual availability and reducing storage space numerous maintenance manuals and illustrated parts breakdowns are being placed on 16mm microfilm. The microfilm is stored in cartridges and a label on the cartridge indicates the numbers of the manuals inclosed. In the future it is intended that microfilm will be issued to users in lieu of hard copy manuals.

Microfilming is the photographic art of reproduction of text or pictures at ratios of reduction too great for reading or viewing without optical assistance. A reader or some type of projector is required in order to enlarge the microfilm for reading.

There are many different makes and models of microfilm readers and reader printers. Some have printing capabilities while others do not. Those with the printing capability generally will provide a permanent copy in a matter of a few seconds. Coverage of the operation of all the various models is not appropriate for this training manual. The Filmac 400C model covered in this section is widely used in the Navy.

The Filmac 400C cartridge reader printer (Fig. 3-1), manufactured by the Minnesota Mining and Manufacturing Company, provides a fast means of viewing 16mm cartridge microfilm and also prints a copy of the frame being viewed in a matter of seconds. This particular model is practically automatic; therefore, very little training is required to properly operate and maintain it. Like any delicate machine, the operating instructions provided by the manufacturer should be closely followed and the machine should not be abused.

The 400C reader printer operates on standard 110-volt alternating current. It is controlled by an ON-OFF switch located above the viewing screen on the front of the machine. This switch controls the projection lamp, which illuminates the viewing screen and also the cooling blower.

This machine incorporates an automatic microfilm threading process; therefore, loading and threading microfilm is a simple task. Loading a cartridge of microfilm into the machine consists of inserting the cartridge into the holder with the open end toward the right. The cartridge is then pressed flat against the holder until the cartridge lock clicks. Threading is accomplished by turning the speed control knob counterclockwise and depressing the thread lever for approximately 2 seconds, or until images appear on the viewing screen. Microfilm advancement is stopped by returning the speed control knob to the center position.

A counter registers the frames or images as they advance; therefore, by referring to the indexed cartridge, the approximate location of a frame can be determined and the microfilm rapidly advanced until this frame number corresponds to the counter reading. Rapid advancement of the microfilm is accomplished by turning the speed control knob counterclockwise—the farther the knob is turned, the faster the microfilm advances. The microfilm is wound back into the cartridge by turning the speed control knob clockwise.

Scanning a cartridge of microfilm in search of a specific frame can be accomplished by two different ways. One way is by the use of the handwheel located on the right-hand side of the reader printer. The other way is by use of the appropriate scan button. An arrow on each of the two scan buttons indicates the direction of microfilm travel. Once the desired frame is on the viewing screen, the focus ring is used to bring the image into sharp focus.

To make a print or copy of the frame of microfilm being viewed is a simple process. First

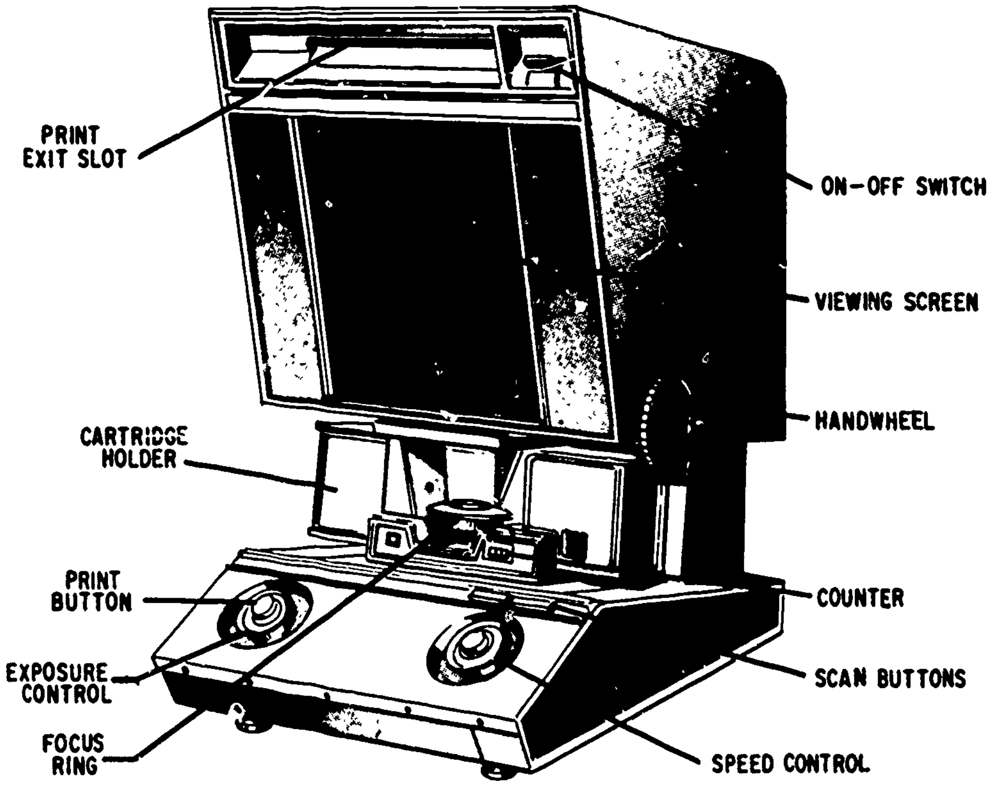


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Figure 3-1.—Microfilm reader printer.

of all, the image on the viewing screen should be centered and in proper focus. This can be accomplished by use of the handwheel and focus ring. Next, the exposure control knob must be set for proper exposure.

NOTE: Lower exposure control knob settings give light prints, and higher settings give dark prints. Experience with the reader printer will, for the most part, provide the operator with the setting to be used on the exposure control knob.

The print button is then pressed momentarily and the print comes out the print exit slot.

Prior to microfilm cartridge removal, the speed control knob should be rotated clockwise until all microfilm is wound back into the cartridge. To remove the cartridge, simply push back on the cartridge lock and remove the cartridge from the holder.

This reader printer uses a special type of copy paper and will not operate when the supply of copy paper is exhausted. It also uses an activator solution in the printing process. Under normal use, a bottle of activator solution is adequate for one roll of copy paper. It is a good practice to install a new bottle of activator solution each time a new roll of copy paper is installed. The operator's instructions manual provided by the manufacturer gives complete details for loading both copy paper and activator solution. In addition, this anual gives instructions for routine cleaning and maintenance that can be performed by the operator.

PROCUREMENT OF PUBLICATIONS

The publications covered in the previous section are specifically prepared to assist maintenance personnel; however, either through a lack of knowledge of their existence, the procedures for obtaining them, or plain indifference by supervisor personnel, the mechanic is often deprived of the benefits publications are intended to provide. Since the use of publications in performing maintenance tasks is mandatory, they must be on hand and used consistently.

Detailed information concerning the availability of aeronautic publications may be found in the Naval Aeronautic Publications Index. The complete index is made up of five parts, as follows:

NavSup 2002, Section VIII, Parts C and D—Numerical Sequence List.

NavAir 00-500A—Equipment Applicability List.

NavAir 00-500B—Aircraft Application List.

NavAir 00-500C—Directives Application List.

NavAir 01-700—Airborne Weapons/Stores, Conventional/Nuclear, Checklists/Stores Reliability Cards/Manual Index.

NOTE: The latter part is not used by ADR personnel and is therefore not covered in this section.

NavSup 2002, Section VIII, Parts C and D, contains a complete numerical listing of all available naval aeronautic publications distributed by NavAirSysCom and stocked for issue as of the date of publication. This numerical listing contains all available publications by publication number, stock number, and title. Publications are subdivided into subject groups according to type of aircraft or equipment, or component thereof.

Part C (manual publications) contains its table of contents, as well as the instructions for using both Parts C and D of NavSup Publication 2002. Included in these instructions are the method for procuring aeronautic publications, the forms and procedures required for ordering publications, and explanations of certain codes used in the Index. Also a listing of canceled publications for Part C is contained in the last pages of Part C.

Part C is divided into subject matter groups, and all publications within a group are then listed in numerical order. For example, all manuals in the 00 series are listed first, then followed by the 01, 02, 03, etc., through the 51 series. The listing includes the publication code number, stock number, title, date of latest issue or revision, security classification, requisition restriction code, and basic or change code.

Part D (letter type directives) contains a table of contents, a general alphabetical cross-reference listing, and a listing of Air Force-Navy code cross-references. Part D is divided into a number of subsections. Included among those of interest to the Aviation Machinist's Mate are powerplant, propeller, accessories, and support equipment. Listed in the powerplant section are all General, Turbojet, and Reciprocating Engine Bulletins and Changes. The accessory section contains a listing of all Accessories Bulletins and Changes. The support equipment section contains a listing of all Support Equipment Bulletins and Changes.

The Numerical Index must be used to completely identify and, therefore, to order required publications. However, the other parts of the Index (discussed in the following paragraphs) must be used to determine what publications are available for a specific item of equipment and to check the applicability of publications to specific equipment.

When an applicable publication number is found in one of the other parts of the Naval Aeronautic Publications Index, it can be easily located in the Numerical Index. Here, it can be more completely identified as to title and nomenclature, stock number (for manual type publications), security classification, and any restrictions concerning the requisitioning of the publication. In addition, the date of the latest issue or revision of the publication is listed. This provides a means whereby the issue and/or revision dates of the publications on hand in an activity can be checked against the dates listed in the current issue and supplement (discussed later) of the Numerical Index, thus assuring that the publications are current.

Equipment Applicability List

Basically, the Equipment Applicability List, NavAir 00-500A, is a cross-reference index listing of Naval Air Systems Command (NavAirSysCom) publications (manuals, changes, and bulletins) of aircraft components and related equipment according to model, type, or part number.

Since this index contains several thousand entries, one volume would be very cumbersome to use. For this reason, this index is divided into several volumes. At the time of this writing, there are seven volumes.

With the exception of several small sections in the first part of Volume 1, the Equipment Applicability List is one continuous index of model, type, or part numbers in alphanumerical sequence.

In addition to an Introduction, which explains the headings at the top of each page, the other sections in the first part of Volume I pertain primarily to manuals for aircraft, weapons systems, and aircraft engines. Therefore, the publication numbers are listed according to aircraft, aircraft engine, and weapons system designation.

The Equipment Applicability List should be used when attempting to determine what publications (manuals, and technical directives) are available on a particular item of equipment, and the manufacturer and part number of the item are known.

Aircraft Application List

The Aircraft Application List, NavAir 00-500B, contains a listing of all manuals grouped according to their application to an aircraft. This part of the index does not contain listings of any letter type publications, and all manuals are listed by publication code number only.

A list of basic numbering categories is provided in the front of the book. This list may be used in determining the general type of equipment covered in a publication. For determining the specific item of equipment covered by a publication and the title of the publication, reference should be made to Part C of Section VIII in NavSup Publication 2002.

The Aircraft Application List is especially handy for determining what manuals are available for a particular model of aircraft. Included under each model is a complete listing of applicable manuals. This listing includes all allowance lists, aircraft manuals, engine manuals, accessories manuals, etc., pertaining to that particular model of aircraft.

Directives Application List By Aircraft Configuration

The Directives Application List by Aircraft Configuration, NavAir 00-500C, contains a listing of the active Naval Air Systems Command letter type technical directives with respect to their applicability to aircraft. The lists in this volume are arranged by aircraft series; i.e., Attack, Cargo/Transport, Fighter, etc. Within each series the lists are arranged by technical directives code.

Each List in the Naval Aeronautic Publications Index is updated at regular intervals by the issuance of a new list. In addition, some of these Lists are kept current by the periodic issuance of supplements between issues of the Basic List. The dates and intervals of the issuance of new Lists and supplements have changed from time to time in the past.

At the time of this writing, the Numerical Index (Parts C and D of NavSup Publication 2002) is issued annually in September. Supplements are issued bimonthly between each basic issue. The Equipment Applicability List, NavAir 00-500A, is issued annually in November. This List is kept current by the issuance of quarterly supplements between each basic issue. The Aircraft Application List, NavAir 00-500B, is issued in March and September, and the Directives Application List by Aircraft Configuration, NavAir 00-500C, is issued in January and July of each year. Supplements are not issued for these Lists.

Supplements list all aeronautic publications distributed during the previous period, and those publications that have been superseded, canceled, or revised. Supplements are cumulative, that is, all material from the preceding supplement is incorporated in the latest supplement; therefore, at any given time, not more than one supplement is in effect for any List. Naturally, the reissue of a basic List cancels the outstanding supplement.

Supplements for the Numerical-Index (Parts C and D of Section VIII of NavSup Publications 2002) are identified by the word "supplement" printed near the upper right-hand corner of the cover. Supplements to the NavAir 00-500A Series publications are identified by the word "supplement" printed in the middle of the cover page.

Procurement Methods

There are five main methods of procuring publications relating to naval aircraft maintenance.

The first method is initial outfitting. The Naval Air Technical Service Facility will provide the prospective commanding officer of a newly commissioned or reactivated ship, station, or activity an outfitting of general aeronautic publications. Normally this outfitting will be furnished 2 months prior to commissioning unless otherwise requested.

The second method is aeronautic technical publication outfitting. An Aeronautic Technical Publication Outfitting Allowance consists of those publications applicable to a particular model of aircraft. Initial distribution is provided by the Naval Air Technical Services Facility to a newly commissioned or reactivated activity. Upon change in mission or aircraft custody which requires a different set of publications, the activity must submit a request to the Naval Air Technical Services Facility for an Aeronautic Technical Publication Outfitting Allowance, applicable to the model designation of the aircraft involved.

The third method of procuring publications is through inclusion on automatic distribution lists. The Naval Air Technical Services Facility normally provides for the distribution of certain future issues of new and revised publications directly to affected activities. Activities desiring to receive future issues of new and revised publications must submit NavAir Form 5605/3, Mailing List Request for Aeronautic Publications, to the Commanding Officer, Naval Air Technical Services Facility, 700 Robbins Avenue, Philadelphia, Pennsylvania 19111. Work center supervisors desiring to receive particular issues, reissues, and revisions of publications should make their requirements known to the maintenance office and/or the activity's technical publications library so that they may be included on the next submission of NavAir Form 5605/3.

NAVAIR Form 5605/3 consists of four separate parts:

Part I contains requirements for General Allowance Lists, Indexes, and General Series Technical Manuals and Directives.

Part II contains requirements for Aircraft/ Engine Allowance Lists, and Airframe and Power Plant Technical Manuals and Directives.

Part III contains requirements for Aircraft Component Manuals.

Part IV contains requirements for Ship Installation Technical Manuals and Directives.

Instructions for submission of NAVAIR Form 5605/3 are printed on page 1 of each part. The parts may be submitted separately or as a group, as long as the appropriate block in the instructions is checked to indicate the reason for submission. The newly submitted form will place an activity on the mailing list for FUTURE ISSUES of Basic, Revised, or Changed manuals/ directives only. It is not used as an order blank for existing manuals/directives.

The fourth method of procuring publications is by ordering individual publications direct. The Single Line Item Requisitioning System Document (DD Form 1348 or DD Form 1348M) is used by activities when requisitioning manual type publications on a one-time requirement. Letter type publications may be ordered on DD Form 1149 Standard Requisition and Invoice/ Shipping Document, on a one-time requirement. The use of DD Form 1348, DD Form 1348M, or DD Form 1149 will not result in being placed on the distribution list to receive future issues or revisions of the publication ordered. Unless otherwise directed, individual publications are ordered from the Commanding Officer, (1051), Naval Publications Form Center (NPFC), 5801 Tabor Ave., Philadelphia, Pennsylvania 19120.

A limited number of publications may be ordered utilizing telephone requisitioning procedures. This is accomplished by contacting the customer service branch of the Naval Publications Forms Center. The same information as would be placed on an order form should be obtained prior to placing the telephone call, thereby improving accuracy and expediency over this communications media.

Although Interim Changes and Bulletins are listed in NavSup Publication 2002, Section VIII, Part D, they are not available for issue through the Publications Supply System. They are listed only for informational purposes.

Operating activities requiring copies of Interim Technical Directives should submit requests to the appropriate controlling custodian. Other activities requiring copies of ITD's in addition to the initial NavAir distribution, should submit requests to the appropriate Naval Air Systems Command Representative.

Instructions issued by Washington headquarters organizations such as OpNav, BuPers, SecNav, NavAir, etc., are listed in the Consolidated Subject Index of Unclassified Instructions, NAVPUBINST 5215 Series. They are requested on NavSup Form 1205 from the Supply and Fiscal Department, Washington, D.C.

Requests for instructions from other than Washington headquarters organizations may be initiated on NavSup Form 1205 or by submitting a letter request in accordance with the originating activity's 5215 index of instructions.

NavAir Specifications and Standards and NavAir Standard Drawings are listed in NavAir 00-25-544 and NavAir 00-25-543, respectively. The Department of Defense Index of Specifications and Standards (DODISS) and related documents, Part I (alphabetical listing) and Part II (numerical listing) provide a more complete listing of specifications and standards of interest to work center supervisors. Specifications, standards, and drawings are ordered on DD Form 1425.

In addition to the NavAirSysCom, other commands publish a variety of material which may be useful. There is no hard and fast rule for procurement of this material. If the item desired is not listed in the cognizance symbol I catalog (NavSup 2002) and no other source is known, send the request by letter directly to the publishing command.

Fleet and type commanders publish a limited amount of material, normally relating to operational problems in their respective areas. This material is usually supplied automatically to activities on the standard mailing list. If other requirements exist, a letter request may be submitted to the applicable fleet or type commander.

Situations may arise in both Organizational and Intermediate levels of maintenance which require the use of engineering drawings. Technical information of this type is normally supplied to these levels of maintenance in the form of microfilm reproductions of the actual drawings. Engineering drawing reproductions provide all the necessary information to construct, assemble, and install a part or an assembly. Aircraft and equipment manufacturers provide NATSF and Naval Air Rework Facilities with engineering drawings for use by engineering and repair personnel. These activities are also provided with microfilm and Vandyke (blueprint) copies of engineering drawings.

For the most part, microfilm copies of engineering drawings are provided in filmstrip and in single frames mounted on aperture cards. Aperture cards are standard size EAM cards and have printed and keypunched identifying information concerning the frame of microfilm which they contain. It is conceivable that reproductions of engineering drawings may, in the future, be provided in cartridge form for use by the Filmac 400C reader printer previously discussed.

Most aircraft and equipment IPB's contain manufacturer's engineering drawing numbers for various components. If microfilm of a particular drawing is required and the drawing number unknown, then the aircraft or equipment company technical representative should be consulted for this information.

In most cases the requirement for microfilm will be on an as-needed basis; therefore, large stocks will not normally be maintained in the technical library of Organizational and Intermediate activities. The various work center supervisors will normally notify the person in charge of the technical library of their requirement for microfilm.

All requests for complete sets of engineering drawings should be forwarded to the Commanding Officer, U.S. Naval Air Technical Services Facility (EDD), 700 Robbins Avenue, Philadelphia, Pennsylvania 19111, on a DD Form 1149. When a complete set of drawings for an aircraft or equipment is requested, the individual drawings need not be listed; however, the request must be accompanied with a statement of justification. Individual drawings may be obtained either from NATSF or the nearest NAVAIRREWORKFAC, via the cognizant

NAVAIRSYSCOMREP. Requests for classified and unclassified drawings must be submitted on separate forms. Since approximately four and a half million drawings are available from NATSF, proper submission of requests for copies of these drawings is essential to avoid delay in receipt.

SECURITY OF CLASSIFIED PUBLICATIONS

The problem of security of classified publications in the work center files is generally limited to ways and means of stowing, using, accounting for, and disposing of such publications in accordance with existing directives. The basic Navy security directive relative to the safeguarding of classified information is the Department of the Navy Supplement to the DOD Information Security Program Regulations, OpNav Instruction 5510.1 (Series). Its provisions apply to all military and civilian personnel and to all activities of the Naval Establishment. The application of security measures regarding shop files may be further influenced by locally issued directives which supplement the basic directive.

All personnel in the Naval Establishment are individually responsible for assuring that knowledge of classified information which they prepare or handle is made available only to persons who have clearly established a legitimate "need to know." Classified material is procured for the work center files because it is needed during the performance of some related maintenance function. Use of these publications by powerplant personnel should be anticipated and steps taken to procure security clearances for selected personnel most likely to require the information.

The supervisor must initiate procedures that insure him positive control of all classified publications for which he is custodian. The first problem of custody is stowage. The Navy Security Manual discusses stowage containers of varying degrees of integrity. Also provided in the manual are specific requirements for safeguarding combinations and keys for locks as these, to various extent, affect the protective capabilities of the different types of containers.

Classified publications that are no longer required in the work center should be returned to the Classified Material Control Officer for disposition by transfer or destruction, as appropriate.

MAINTAINING WORK CENTER FILES

There are two general categories of records required of all work center supervisors. These include records required by the activity for operational purposes and those needed by the work center chief for the efficient management of his work center. It is advisable to keep the system of records as simple as possible and still maintain the necessary control. Too few records, however, can lead to uncertainty, encourage guessing, and sometimes lead to embarrassing situations. In order for records to be of maximum benefit and provide adequate control, it is necessary that records and publications be filed in the work center in such a manner that they may be quickly located.

The Navy has adopted a filing system which provides a definite place for every piece of correspondence and uniformity in filing systems throughout the Naval Establishment. In the relatively few years this system has been in use its merits have greatly exceeded any real or imagined disadvantages. The filing system is an integral part of the Directives Issuance System. The 13 major subject classification group numbers are further subdivided into primary, secondary, and sometimes, tertiary breakdowns. Each subject group symbol must have 4 or 5 digits to be complete. Example of subject classification number breakdown:

13XXX–Aeronautical and Astronautical Material.

134XX–Systems, Components, and Accessories.

13430–Arresting and Launching, Provisions for.

13430.1–Airplane Arresting Hooks, Inspection and Replacement.

While directives (Instructions and Notices) utilize the standard subject group classification numbers and breakdowns of the Directives Issuance System, many other types of publications do not. When file materials other than Instructions and Notices are received in the shop, they should be assigned a file symbol based on the subject group classification number. The correct application of file symbols assures uniformity in filing.

Personnel who have a working knowledge of the subject classification system and the manner in which all records are filed can locate required material expeditiously at any activity to which they may be assigned.

The most important filing operation is classifying (assigning file symbols) since it determines where papers are to be filed so that they may be located quickly. Each paper received in the work center for filing should have the work center file symbol assigned regardless of whether or not a file symbol already appears on it. The proper coding should be determined by the most important, definite, or concrete subject mentioned; the purpose or general significance of the document; the manner in which similar documents are sought; and the file symbol under which other documents of a similar nature are filed.

The actual filing responsibility should be assigned to one person in the work center. All material awaiting filing should be placed in one basket only; and to avoid accumulations, should be filed daily.

When material could be properly filed under two or more headings, one or more cross-reference forms should be inserted in the files at the appropriate places to indicate just where the document is filed. The cross-reference should indicate the following:

1. Originator of the letter, serial number, file symbol, and date.
2. Addressor of letter.
3. Subject of letter.
4. Addressee of letter.
5. Where letter is filed.
6. Brief of letter or applicable part of text.

Extra copies of the basic document may be used instead of the cross-reference form. Cross-referencing, while serving a useful purpose, should be kept to a minimum to conserve space.

Another handy tool for keeping work center files in good order is the "file out" card. This may be a locally prepared form that is inserted into the files whenever a piece of file material is charged out to another office, work center, or person, to help keep track of its whereabouts. All "file outs" should be checked periodically to prevent misplacement of material. Care must be taken that records are not released to unauthorized persons.

A ready index should be provided in the work center so that material may be more easily located. The index should be set up according to the 13 major subject classifications in the Directives Issuance System and further subdivided into categories corresponding to the list of standard subject classification numbers contained in SecNav Instruction P5210.11 (Series), Standard Subject Identification Codes.

REQUIRED READING AND MAINTENANCE INFORMATION RECORD

Certain directives and publications are routed to the various work centers as maintenance information, and copies of such maintenance information must be disseminated and retained until it is no longer applicable. Information should be placed in a required reading file that is available to all hands in the work center. When new material is received, it is placed in the "active" required reading file until it is read and initialed by each man in the work center. It may be necessary for the work center supervisor to amplify or clarify some information so that it will be properly understood.

Once all personnel in the work center have read and initialed the material, it is placed in the "standing" required reading file for use in indoctrinating new personnel and for periodic review by those personnel who may require it. Newly assigned personnel should read and initial both the active and standing files. If copies of directives or publications are not available for required reading file, a cross-reference sheet indicating the general content of the subject matter and its location is utilized to insure that personnel are thoroughly aware of all information that could affect their actions.

TRAINING OF PERSONNEL

Training of personnel is a necessary function and one of the most important responsibilities of senior petty officers. A Chief Aviation Machinist's Mate and to some extent a First Class, will have regular and continuing responsibilities for the training of others. Even if a supervisor is fortunate enough to have a group of men who are highly skilled and well trained, he will find that training is still necessary. For example, the training of strikers and lower rated men for advancement examinations is a continuing, never-ending process. The Navy rotation policy being what it is, the best men will eventually be transferred and replacements will, in most instances, require training before they can be relied on to take their places as effective members of the organization. These and similar problems require the powerplants supervisor to be well versed in the several aspects of training–able to set up as well as conduct an effective training program for assigned personnel.

ORGANIZING A TRAINING PROGRAM

Organizing a training program involves such considerations as planning lessons and job plans, selecting and qualifying instructors, making arrangements for classroom space, phasing the training program with the scheduled workload, procuring visual and other training aids, and determining teaching methods for each lesson or lesson series.

The subject matter areas to be included in the training program are (1) material relating to maintenance of aircraft supported, (2) general material r.quired by the men for advancement examinations, and (3) material relating to safety. In most cases lessons will fall under more than one of the subject area

Once it has been . ermined what publications will adequately cover the subject areas, the material must be divided into lessons, and lesson guides prepared. The lesson guides for each lecture are prepared in accordance with the standard format provided in OpNav Instruction 4790.2 (Series). The lectures are numbered to provide a means of recording each man's progress within his individual training folder. A training syllabus sheet should be prepared for each man in the work center to provide a handy index to the state of training of the work center personnel as a whole.

Whether the supervisor teaches the lessons himself or assigns other petty officers to conduct them depends on the state of training of his first and second class petty officers. A requirement for advancement for third class petty officers and nonrated personnel is satisfactory completion of the correspondence course based on Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series). This course sets forth some of the basic principles of training in general and teaching in particular.

An advancement requirement for second and first class petty officers is satisfactory completion of the correspondence course based on Military Requirements for Petty Officer 1 & C, NavPers 10057 (Series). The latter course expands and amplifies training theory and introduces job analyses, training aids, and testing. For the first time in his career the prospective First Class Aviation Machinist's Mate is required to demonstrate his ability to formally teach, use various training aids, and prepare and administer written tests. In order to demonstrate correct instructional techniques, the supervisor may elect to teach certain lessons himself or assign them to a competent instructor for the same purpose. Later he may assign less proficient petty officers as instructors so that they may acquire the experience necessary for completing their practical factors for advancement.

If at all possible, training sessions should be conducted at the same time of day and on a regular schedule. Factors to consider when scheduling lessons are usual flight schedule, meal hours, watches, availability of classroom, and aircraft inspection schedule.

Some lessons are better suited for one type of instructional technique than others. The type of presentation for each lesson should be planned in advance. This will also facilitate the rotation of the lessons among the petty officers who require experience in teaching.

The effectivity of aviation technical training is greatly enhanced by the use of training aids. The supervisor should always be on the alert for scrap material that can be converted to training aids with minimum expense. He must be aware of the existence of applicable training films and, if they are available, schedule them for showing in conjunction with specific lessons. The squadron or unit safety officer or station safety engineer may usually be depended on to supply training aids in support of shop safety presentations.

When planning a training program, the supervisor should decide where the classroom sessions should be conducted. The space selected should preferably be in a quiet area or at least one with a minimum of noisy distractions. The area should be large enough to accommodate the expected student load and be well lighted. Adequate ventilation will help keep the men awake and interested in the presentation. Convenience is another factor in the selection of classroom space. Some of the desirable space characteristics may, on occasion, have to be sacrificed in order to find a classroom nearer to the working area.

TRAINING PROCEDURES

Training procedures are of two general types–formal and informal.

Formal training is conducted in the classroom through lectures, supplemented by required reading and implemented by the use of all available visual aids. A schedule of training is prepared and published periodically by the maintenance officer. It lists the time of the training, the location of the classroom, the names of the men who are to attend, the subject of the lesson, and the name of the instructor.

Lesson guides are prepared by the division officer and chief or first class petty officers who are qualified to do so. The lesson guides should contain the title, objective(s), time to be consumed in presenting the lesson, list of instructional aids, list of references, outline for presentation, and a summary of the lesson.

When a petty officer has been assigned to instruct a given lesson, it is his responsibility to procure a copy of the lesson guide and from it prepare his lesson plan. Lesson plans are prepared by each individual instructor based on the lesson guide; and though they may differ from instructor to instructor, they must adequately cover the subject.

Informal training is the practical instruction of men in the performance of maintenance tasks by means of demonstration and imitation under personal supervision in the work center or on the operating line. Nearly every maintenance task that is undertaken presents an opportunity for on-the-job training. The experienced men of the division are utilized as fully as possible in demonstrating and imparting their skills to the less experienced.

Under this system, the trainee has the opportunity to actually do the job under the supervision of an experienced petty officer. The only equipment necessary is the job itself. It is necessary, of course, that the instructor have an interest in the job and the skill to do it well. The striker or trainee will learn by seeing the job performed, and he will gain experience by having a chance to participate in the accomplishment of the job.

The nature of informal training makes regular scheduling impracticable. Actually, it is done at every opportunity. A training syllabus is prepared under the guidance of the maintenance officer, with content and scope corresponding with practical factor requirements of the personnel. On-the-job training is reported by the leading petty officer instructors and supervisors to the division officers on the training syllabus at regular intervals so that a close watch may be made on individual progress. The records are for review by higher authority and will point out the need for training in special areas as well as certain practical factors. The degree of success in on-the-job training depends on the degree of recognition by each individual of his responsibility to his outfit to impart his skill and knowledge to the man who is trying to learn.

TRAINING DOCUMENTATION AND RECORDKEEPING

Maintenance activities, except those that are specifically excluded, should comply with the manhour accounting procedures outlined in OpNav Instruction 4790.2 by submitting manhour accounting cards to reflect the accomplishment of formal inservice training. Procedures for submitting manhour accounting cards are provided in Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series) and OpNav Instruction 4790.2.

The Individual Training Syllabus Sheet provides a record of formal lectures attended by each man in the work center. A report of practical training (OJT) should be made to the division officer at regular intervals. This will indicate to the division officer that a man has fulfilled a satisfactory level of skill to justify completing of the various items listed on the individual's practical factors for advancement sheet. The formal training syllabus record and the record of practical training will indicate that required training has been completed in all areas or that a need for special training exists and further certifies when the individual may be considered qualified for advancement.

CHAPTER 4

RECIPROCATING ENGINE SYSTEMS

The basic engine used for discussion in this chapter is the R3350-32W. The R3350-32W engine is a turbo-compound, 18-cylinder, air-cooled, radial, reciprocating powerplant. This engine incorporates three blowdown turbines for exhaust gas power recovery, a reverse low flow torquemeter system, a two-speed supercharger, a low-tension ignition system with automatic spark advance, an impeller ignition system, and a water injection system. When the manual spark advance is incorporated on the R3350-32W engine, its designation becomes R3350-32WA.

The R3350-34 is the same basic engine as the -32W, except it incorporates a manual spark advance and a direct fuel injection system.

TORQUE CELL

The torque cell is contained in the front crank ase section of the engine. It is connected to a gage in the cockpit through passages in the engine internally and by an electrical transmitter externally. The gage will read either BMEP or torque cell oil pressure depending upon the installation. The torque cell is composed of the following units: the stationary reduction gear and adapter, the stationary reduction gear support, a support oil ring, a stationary piston, two piston oil seal rings, piston to front section oil seal rings, 24 steel balls which are retained loosely in sockets in the reduction gear support and the stationary reduction gear and adapter, and the torquemeter boost pump.

The torquemeter boost pump is a gear type pump mounted on the top of the crankcase front section. It is used to boost the engine oil pressure to the desired pressure needed to operate the torque cell under all operating conditions. The torquemeter system is illustrated in figure 4-1.

The torque cell is formed by the forward face of the stationary reduction gear adapter, and the rear face of the torquemeter piston and its rear oil seal ring. With the exception of leakage between the stationary reduction gear adapter and the stationary reduction gear support oil seal ring, all the boost pump oil output is continually entering the torque cell through a hole in the piston. Oil leaves the torque cell through metering slots in the stationary reduction gear adapter and back to the engine pressure oil system through 18 holes in the piston.

There is a definite relationship between the position of the adapter metering slots relative to the piston rear oil seal ring and the torque cell oil pressure. The reduction driving gear turns in a clockwise direction, and, through the reduction gear pinions, tends to turn the stationary reduction gear and adapter in a counterclockwise direction. However, rotation of the stationary reduction gear and adapter is very limited and is converted to forward movement by means of the torquemeter balls and ball sockets. (See fig. 4-2.)

Boost pump oil entering the torque cell tends to force the adapter to the rear. At any given power setting, these two forces are opposing each other and will attain an equilibrium as the adapter metering slots will regulate the torque cell oil pressure which is transmitted to the BMEP or torque cell pressure gage. In this way, an accurate method of determining actual horsepower output of the engine at the propeller shaft can be assured and a system of cruise control can be set up so that the maximum range can be obtained. A simplified diagram of the torquemeter system is shown in figure 4-3.

The general procedures for checking the torquemeter system for malfunctions are discussed here. For more detailed and specific information concerning the procedures to be used, consult the appropriate engine publication. If the torquemeter is thought to be giving

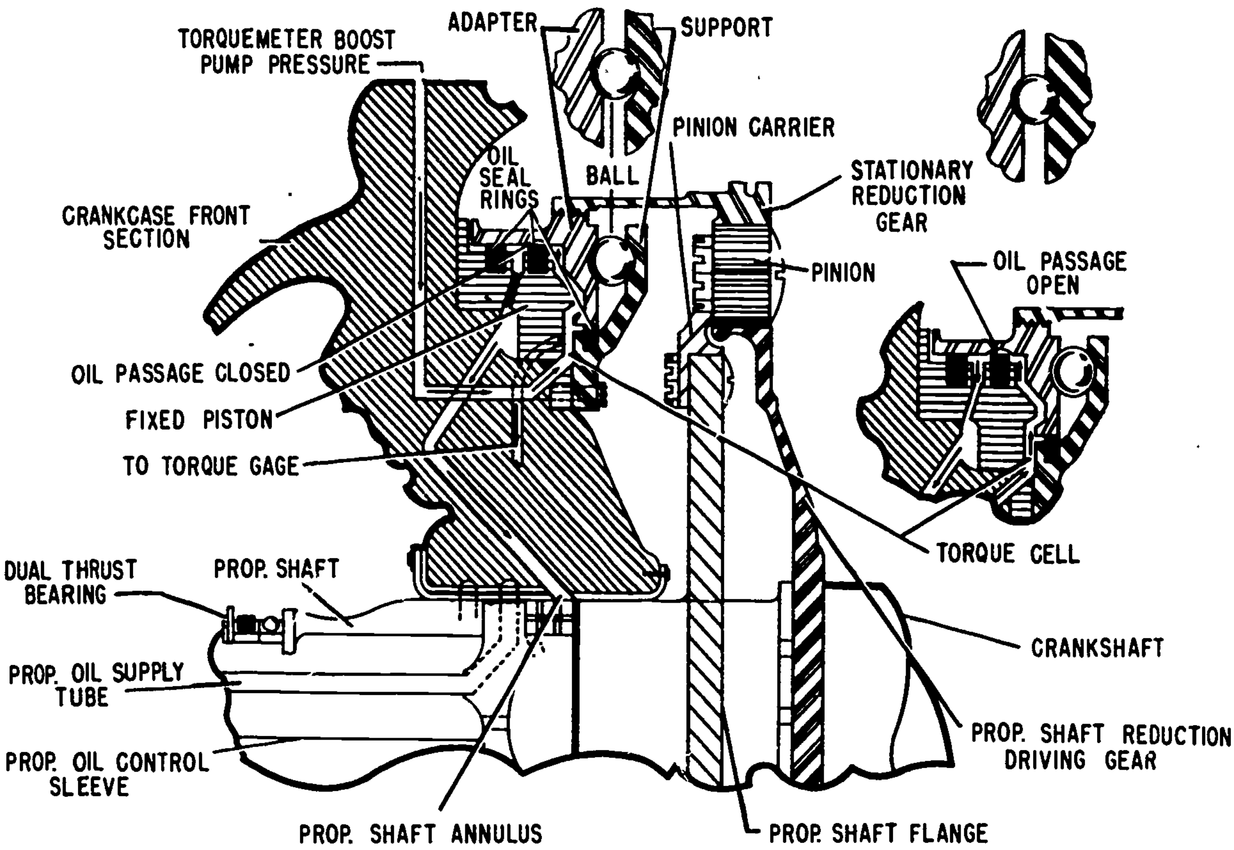

Figure 4-1.—Reverse low flow torquemeter system.

improper readings, first check the BMEP gage, its transmitter, and its connecting wires and connections. When it has been established that the trouble is not in the gage or related equipment, check the MAP gage, the tachometer, flowmeter, and their transmitters and connections.

When it has been determined that the trouble is definitely not due to faulty instruments, an internal torquemeter check may be made. The leakage check is made by attaching an adapter, pressure gage, filter, cutoff valve, and hand pump to the BMEP gage connection on the nose section of the engine. Pressure is built up with the hand pump to the engine manufacturer's specifications. Then the cutoff valve is turned off. A pressure drop in excess of that recommended by the manufacturer would indicate internal leakage either in the internal lines or in the torque cell itself. A further check of the internal system can be conducted to determine which of these two units are at fault. If it is determined that the fault is not in these previously named units, a comparison check can be made between the bad engine and the good engine(s) on a multiengine aircraft.

SUPERCHARGER CLUTCH SYSTEM

The R3350 engine supercharger is a single-stage, two-speed supercharger. The two-speed impeller drive has a low speed ratio of 6.46:1, and a high speed ratio of 8.67:1. A cutaway

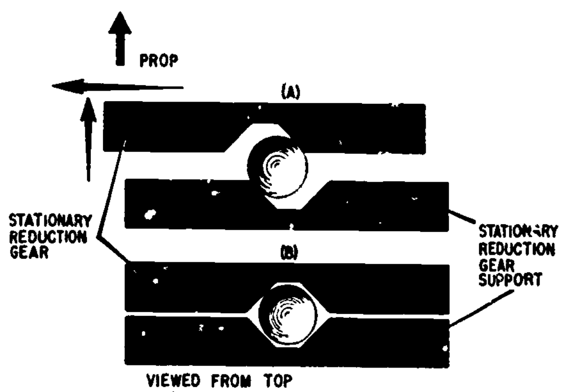

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Figure 4-2.—Action of the torquemeter balls. (A) Torque applied to the stationary reduction gear; (B) no torque applied to the stationary reduction gear.

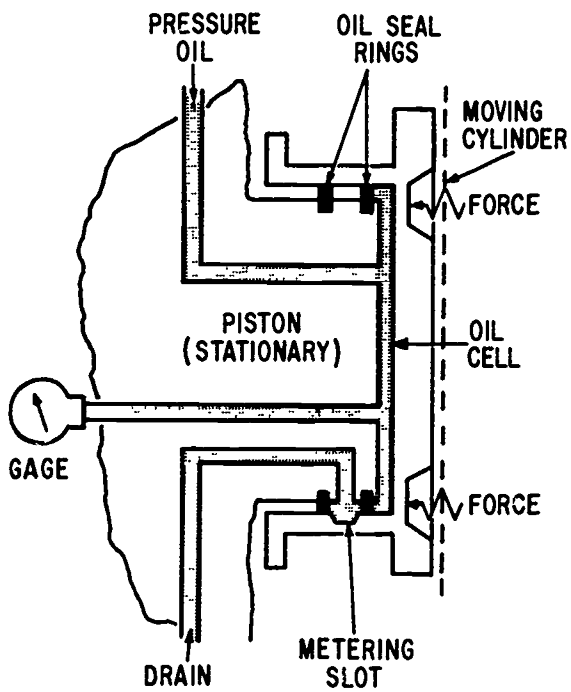

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Figure 4-3.—Torquemeter system diagram.

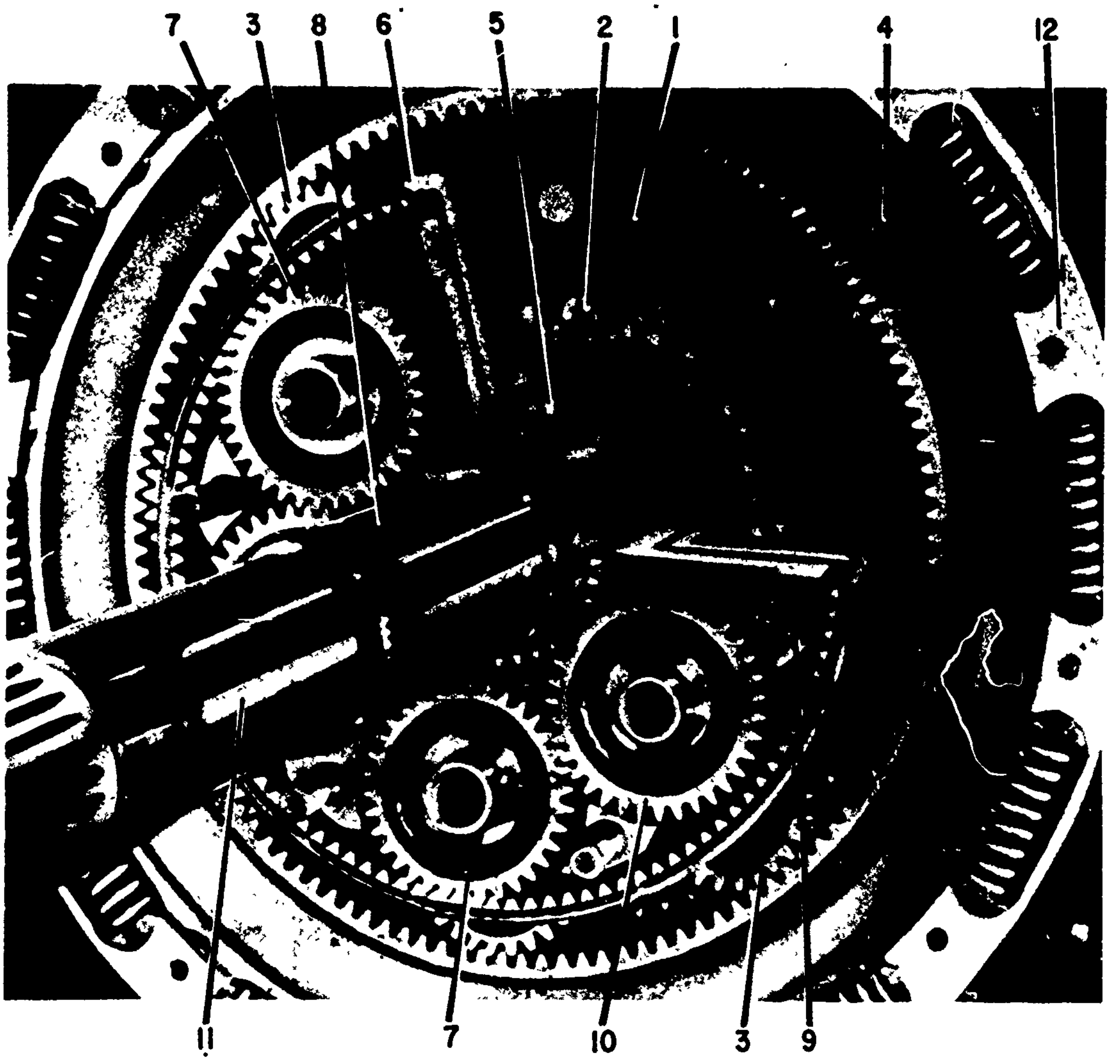
view of the impeller drive is shown in figure 4-4. Basically, the two-speed impeller drive consists of two planetary gear trains (primary and secondary) in series, an intermediate g. r, a roller clutch, and an oil-operated plate clutch. Figure 4-5 illustrates the principle of operation with the component parts in their relative positions.

The primary pinion carrier is supported by and splined to the accessory drive and starter shaft, and thus turns at crankshaft speed at all times. As the primary pinion carrier revolves, the pinions, which are meshed with the stationary gear, rotate on their trunnions and turn the impeller intermediate drive gear (sun gear) in the direction of crankshaft rotation approximately 2.7 times faster than the crankshaft speed. The impeller intermediate drive gear, being driven by the primary pinions, in turn, drives the secondary outer pinion gears.

The secondary outer pinion gears, along with the secondary inner pinion gears, are mounted on the secondary pinion carrier, which is splined to the roller clutch. The secondary outer pinion gears transmit the drive to the secondary inner pinion gears, which mesh with the gear at the end of the impeller drive shaft. The outer impeller shaft is splined to the other end of the inner impeller drive shaft and it in turn has the inducer and impeller splined to it. This completes the drive line through the supercharger gearing system to drive the impeller.

During operation the secondary pinion carrier revolves slowly in the same direction as the intermediate gear. If the secondary pinion carrier is stopped from rotating, the impeller will revolve at a faster speed. This is how the two speeds in the impeller are obtained. For high speed, the secondary pinion carrier is forced to remain stationary. For low speed, the secondary pinion carrier is allowed to rotate, but not freely. It is held to the crankshaft speed by the roller clutch. A simplified diagram of the secondary gear system is shown in figure 4-6.

The driving force from the intermediate gear, which is turning at approximately 2.7 times crankshaft speed, can be transmitted by the secondary pinions to the impeller shaft. However, the impeller will not rotate if the secondary carrier is allowed to rotate freely. Since



1. Primary pinion carrier.
2. Clutch rollers.
3. Primary pinion gears.
4. Stationary gear.
5. Intermediate (sun) gear.
6. Intermediate (bell) gear.
7. Secondary outer pinion gears.
8. Inner impeller shaft.
9. Secondary pinion carrier.
10. Secondary inner pinion gears.
11. Accessory drive shaft.
12. Impeller stationary gear support.

Figure 4-4.—Impeller drive.

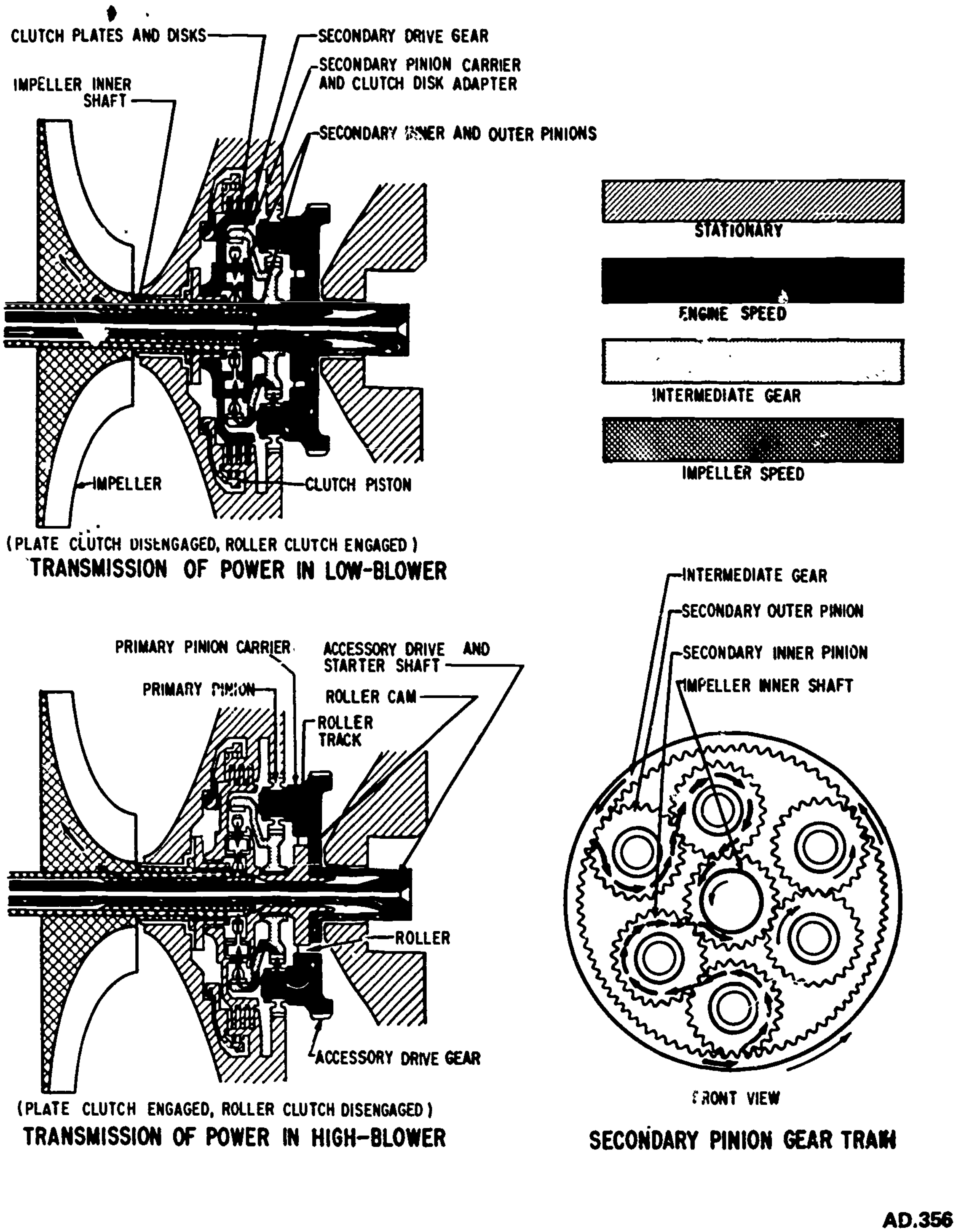
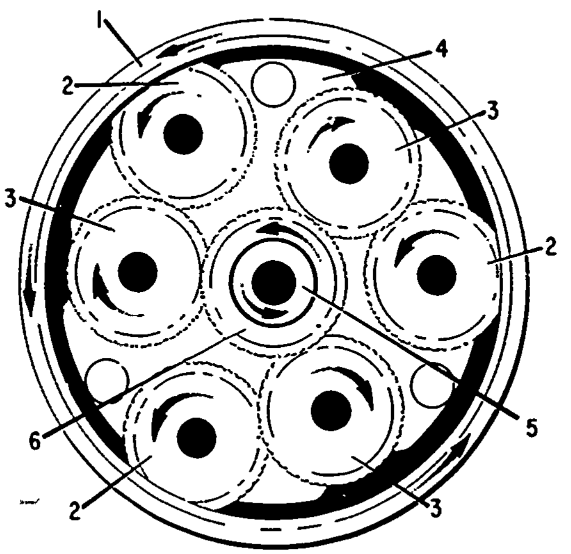


Figure 4-5.–Two-speed impeller drive.



1. Intermediate bell gear.
2. Secondary outer pinion gears.
3. Secondary inner pinion gears.
4. Secondary pinion carrier.
5. Accessory drive shaft.
6. Impeller shaft (inner and outer).

Figure 4-6.—Secondary gear system.

the impeller is under a load of air at all times when it is operating, the driving force would simply spin the secondary pinion carrier while the secondary pinions walked around the intermediate bell gear if the rotation of the secondary pinion carrier were not restricted by some means. When the secondary pinion carrier is slowed down, part of the driving force is used in rotating the impeller. When the secondary pinion gear is stopped completely, all the driving force is used in rotating the impeller. If the secondary pinion carrier is allowed to turn slowly, the impeller will slow down. If the secondary pinion carrier is stopped, the impeller will speed up. Thus, high and low speeds of the impeller are obtained.

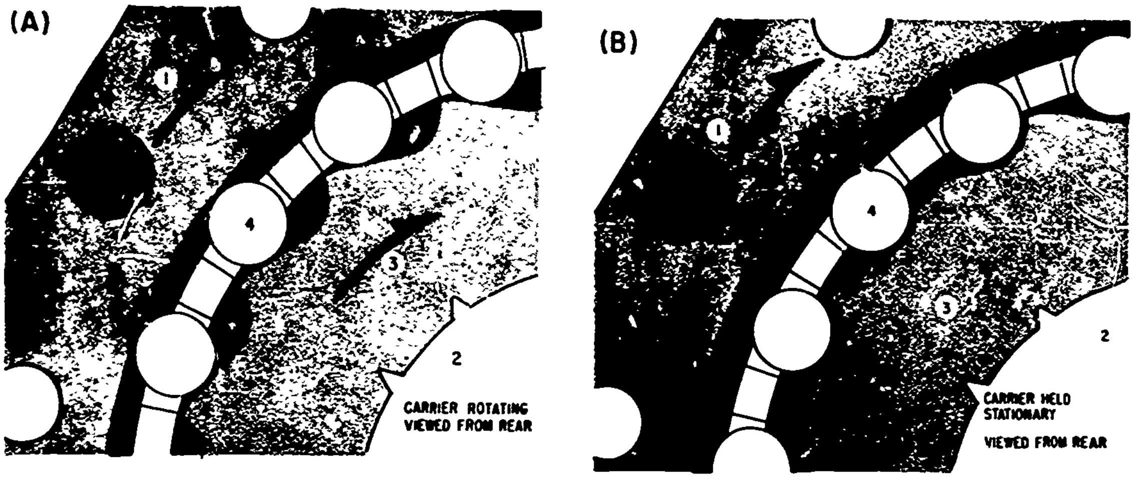
For low impeller speed the carrier is allowed to rotate, but not freely. The carrier is held to crankshaft speed by means of the roller clutch. The action of the roller clutch is shown in figure 4-7. The outer race of the roller clutch is formed by the primary pinion carrier. The inner race is splined to the secondary pinion carrier. When the secondary carrier is allowed to rotate, it is locked to the primary carrier by automatic action of the rollers on the ramps as shown in figure 4-7(A). This locking action holds the rotation of the secondary carrier to crankshaft speed. When the secondary carrier is held stationary, the clutch rollers are automatically disengaged as shown in figure 4-7(B).

The secondary carrier is held stationary by the action of an oil pressure plate clutch. The plate clutch assembly includes a clutch disk adapter (which is bolted to the secondary carrier), clutch plates and disks, clutch housing, clutch support, piston, and oil rings. A selector valve is provided and mechanically linked to the cockpit to give the pilot a means of controlling the action of the clutch.

The clutch has five plates and four disks. The disks have splines on their internal diameter which are splined to the clutch disk adapter. The plates have splines on their outer diameter which are splined to the clutch support. A ringlike piston fits against the plates. The clutch housing is fastened to the clutch support. The space between the housing and the piston forms a chamber into which oil under pressure can be admitted. Two oil rings provide a seal for the piston. This clutch assembly is bolted to the crankcase by the clutch support.

When the clutch control valve is in the low-blower position, the oil supply to the clutch piston is shut off and the five stationary plates are disengaged from the four disks, allowing them to rotate and in turn permitting the secondary pinion carrier to rotate in the same direction as the primary pinion carrier. This permits the roller clutch to engage, locking the two carriers and allowing them to turn at crankshaft speed. Since the intermediate gear cannot turn the secondary pinions as fast while their carrier is rotating as when it is stationary, the impeller rotates at only 6.46 times crankshaft speed while it is in low-blower position.

When the clutch control valve is in the high-blower position, oil at 70 plus or minus 5 psi is admitted to the forward side of the clutch



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1. Primary pinion carrier.
2. Secondary pinion carrier.
3. Clutch inner race.
4. Clutch rollers.

Figure 4-7.—Roller clutch. (A) Engaged; (B) disengaged.

piston. This oil pressure forces the piston to lock the clutch plates, thus holding the secondary pinion carrier stationary. When the secondary pinion carrier is held stationary, the intermediate gear, still turning at approximately 2.7 times faster than the crankshaft, turns the impeller shaft through the secondary pinions at a ratio of 8.67:1.

The operation of the impeller drive mechanism should be checked in accordance with the appropriate technical publications. Whenever a check is made of the impeller drive mechanism, the supercharger control lever should be always moved smoothly and rapidly. Failure to comply with this precaution may result in a warped or frozen clutch and thus an engine change. To check the supercharger operation, proceed as follows: Open the throttle to 1,600 rpm, and move the supercharger control lever to the HIGH ratio position. Then advance the throttle to obtain field barometric pressure (30" MAP), allow the engine to stabilize, and then shift to LOW ratio. A sudden decrease in manifold pressure will indicate proper operation of the supercharger. If there is no indication of the blower shifting, a check should be made of the linkage to the engine and of the selector valve. The valve may be removed for cleaning or replacement. Also, a pressure test point is provided on the engine to check oil pressure to the oil pressure plate clutch.

POWER RECOVERY TURBINES

The R3350-32W and -34 engine models incorporate three interchangeable exhaust power recovery turbines (PRT's). Figure 4-8 is a cutaway view of the power recovery turbine used in compounding these engines. Each of these turbines is clamped to adapters that are mounted on the supercharger front housing and spaced 120° apart.

OPERATION

The PRT's utilize the energy of the exhaust gases coming from the cylinders and transmit

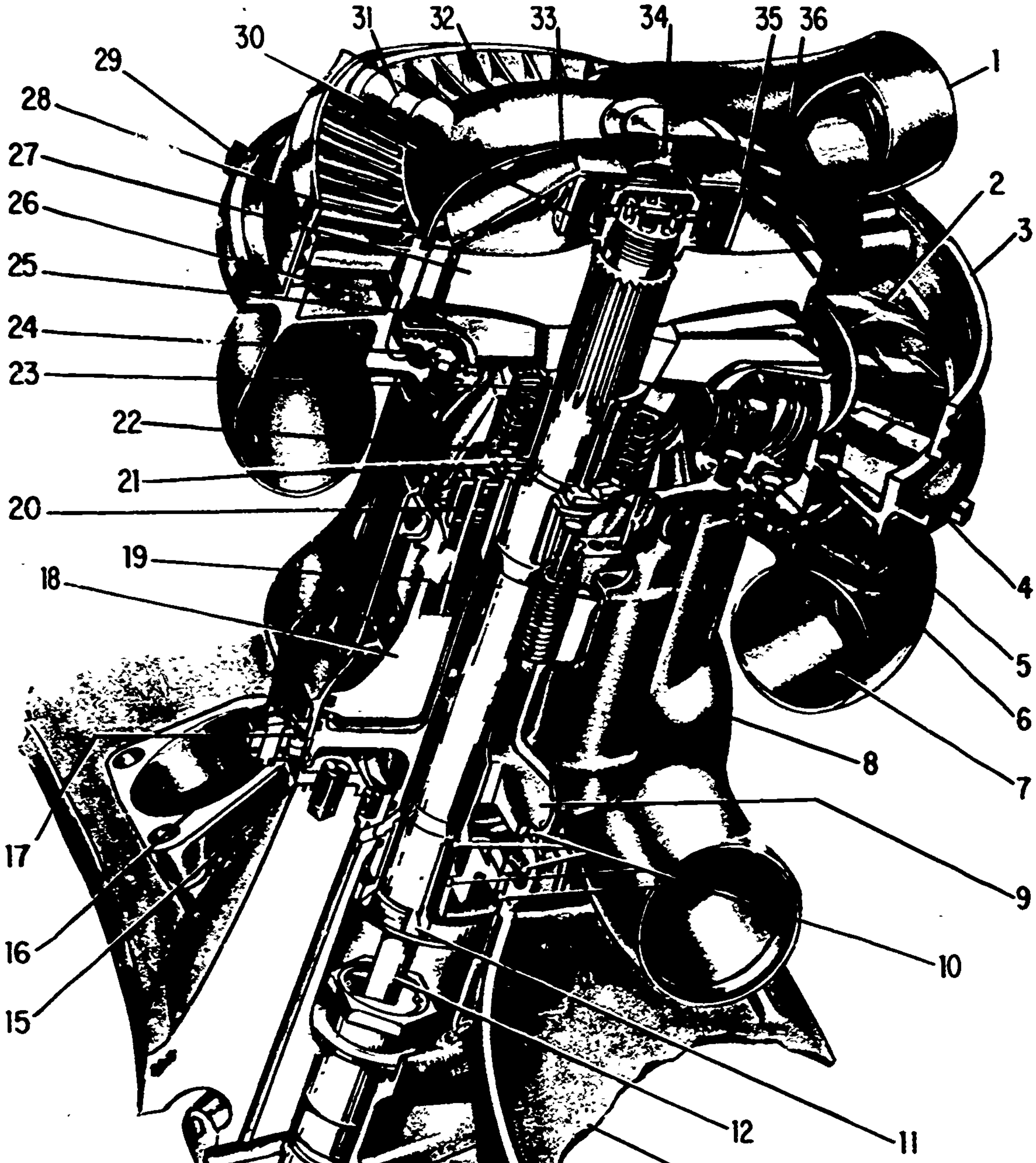

Figure 4-8.—Power recovery turbine (cutaway view).

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Nomenclature for figure 4-8.

1. Cooling shield assembly.
2. Nozzle solid vane.
3. Cooling shield flange ring.
4. Nozzle flange.
5. Labyrinth seal.
6. Inlet pipe retaining bolts, nuts, and washers.
7. Inlet pipe.
8. Cooling air duct.
9. Shaft support.
10. Shaft support and adapter packing rings.
11. Lower thrust washer.
12. Gear coupling.
13. Supercharger front housing.
14. Shaft gear.
15. Mounting pad.
16. Clamp.
17. Nozzle support and adapter locating pins.
18. Shield and seal assembly.
19. Shaft.
20. Vibration damper.
21. Upper thrust washer.
22. Shaft oil seal ring.
23. Cooling air impeller spacer.
24. Nozzle assembly to nozzle support cap screws.
25. Cooling air impeller.
26. Nozzle split vane.
27. Turbine wheel.
28. Turbine wheel buckets.
29. Flight hood locating lug.
30. Wheel retaining nut.
31. Cooling shield support.
32. Outer shield.
33. Intermediate shield.
34. Pylon support.
35. Cooling shield inner flange.
36. Inner shield.

this energy back to the engine crankshaft. They will add approximately 150 horsepower per turbine for a total of 450 horsepower to the horsepower output of the engine at maximum allowable power. Each PRT utilizes the exhaust gases from six cylinders–three front and three rear. (See fig. 4-9.)

The gases enter the turbine at the nozzle assembly and cause the turbine wheel to spin at high speed. A hollow shaft, splined to the turbine wheel, passes through a support clamped to the adapter on the supercharger front housing. A vibration damper assembly, consisting of spring-loaded plates and disks, assists in dampening the lateral vibration and the whip of the turbine shaft. A coupling, splined at each end, connects the turbine shaft to a bevel drive gear in the supercharger front housing. The drive gear meshes with a larger bevel gear, connected by a drive shaft to the fluid coupling impeller. The fluid coupling rear half (runner) is connected by a splined shaft to a pinion, which meshes with the PRT crankshaft drive gear coupled to the engine crankshaft. Figure 4-10 illustrates the transmission of the exhaust gas energy to the turbine wheel and back to the crankshaft.

To prevent damaging effects from the high temperatures of exhaust gases, cooling air is drawn from a duct between the cylinders and conducted to the turbine assembly. A tube and duct assembly delivers the air between the nozzle support and the cooling air shield. An impeller is provided to force the cool air through the assembly and to discharge it, together with the exhaust gases, from the outer shield outlet. Cooling air is sealed under the turbine wheel by the labyrinth seal facing the underside of the impeller. The seal prevents the mixing of the exhaust gases and cooling air until both are discharged from the outer shield. Oil from the turbine drive shaft is kept from entering the stream of cooling air by the bellows-loaded seal, which fits tightly in the turbine shaft oil seal support.

Oil under reduced pressure, is brought from the pressure control valve located in the supercharger front housing by way of internal passages to the PRT fluid coupling support. From the fluid coupling support, oil flows through passages in the supercharger front housing to an annulus in the turbine coupling gear shaft bushing and through passages in the support to the fluid drive shaft. From the coupling gear

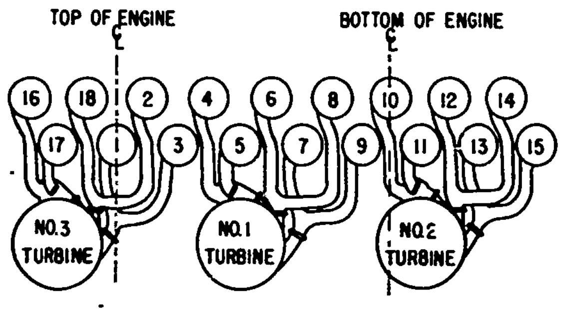

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Figure 4-9.—Exhaust system arrangement.

shaft bushing, a passage in the front supercharger housing carries oil to the fluid drive shaft. The oil entering from either end of the shaft lubricates the bushing on the shaft and passes through a set of holes into the fluid coupling, supplying the necessary pressure for operation.

When the engine is being started, before oil pressure is built up in the fluid coupling, the impeller will not drive the runner. When sufficient oil pressure is built up in the coupling after starting, the runner will then follow the impeller with a certain amount of slippages which will act to absorb any undesirable amount

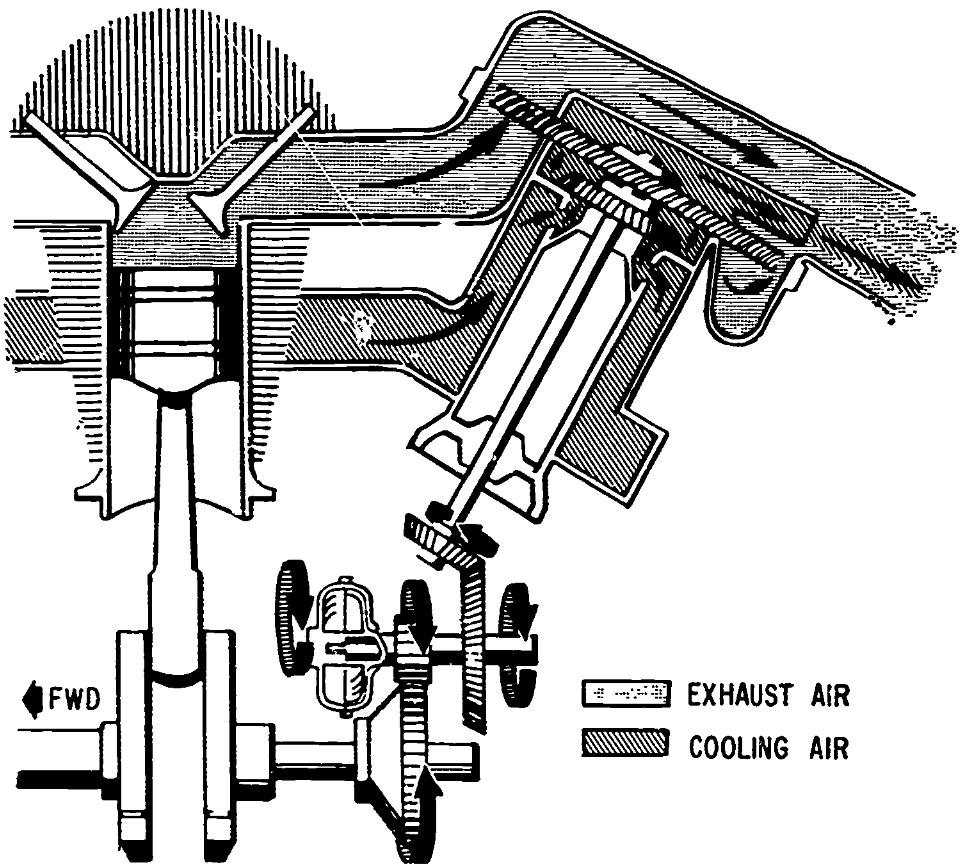

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Figure 4-10.—Transmission of exhaust energy back to the crankshaft.

of vibrational conflict between the crankshaft and the PRT unit. As engine rpm increases, the amount of slippage between the runner and the impeller decreases. The fluid coupling is a vortex type, giving a swirling action to the oil to prevent sludge formation which might freeze the halves of the coupling together and nullify their effect.

PERIODIC INSPECTION

The periodic inspections of the PRT's are performed at the time intervals specified in the applicable technical instructions. Damage from the hot exhaust gases usually occurs in three major component parts of the PRT's: in the cooling shield assembly, turbine wheel, and the exhaust nozzle assembly.

CARBURETION

The objective of all carburetion is to mix with the air going into the engine the proper weight of fuel for all operating conditions in accordance with a predetermined mixture formula. The basic requirements of a carburetor are the same, regardless of the type of carburetor employed or the model engine on which it is installed. Therefore, in the following paragraphs the model 58-CPB11 carburetor and the model PR-58S2 master control are covered as typical controls, and the model PR-58T1 injection carburetor is covered for comparison.

MODEL 58-CPB11 CARBURETOR

The model 58-CPB11 carburetor is of the direct metering pressure type. This carburetor meters fuel at the desired fuel/air mixture to suit a wide variety of engine operating conditions. It maintains the fuel/air ratio automatically, regardless of any changes in the air density which results from changes in pressure or temperature. Provision is also made to enable the pilot to manually lean or enrich the fuel/air mixture.

Components

This carburetor breaks down into three major components. They are the fuel metering unit, the air metering unit, and the main body unit.

1. Fuel Metering Unit. The fuel metering unit is attached to the rear side of the carburetor. It consists of the pressure regulator assembly, mixture control assembly, manual mixture control valve, metering jets cover assembly, discharge vent line assembly, and the solenoid primer. The pressure regulator assembly regulates the pressure of the fuel being delivered to the jets by use of a spring and diaphragm-controlled valve. This valve is balanced (double-seated) to neutralize the effect of fuel inlet pressure. The movement of the pressure regulator valve is controlled by changes in the various fuel and air pressures applied to the three diaphragms of the pressure regulator assembly: the pressure regulator fuel diaphragm, the air diaphragm, and the fuel balance diaphragm

The pressure regulator fuel diaphragm is exposed to the pressure of the fuel which has passed through the pressure regulator valve. The air diaphragm is the largest of the diaphragms and is subjected to air pressures applied to both surfaces. One side of the diaphragm is connected to impact pressure (low suction) in the main venturi; the other side, to the throat (high suction) of the boost venturi. The fuel balance diaphragm is exposed to the fuel at discharge pressure. This force tends to open the pressure regulator valve. At idling speeds or periods of low airflow through the carburetor, the position of the regulator valve is determined by a system of springs.

Vapor traps are located in the top of the fuel metering unit to eliminate vapors accumulated in the fuel at the inlet screen and also after the fuel passes through the pressure regulator valve. The fuel vapors are vented back to the main service tank or tanks of the aircraft.

The manual mixture control is located on the left end of the fuel metering unit and controls a disk type selector valve which directs the fuel flow to the proper jets to supply the engine with the correct amount of fuel for all operating conditions. This valve is also designed so that the mixture strength can be manually leaned for better fuel economy. There are three jets located in the mixture control housing. Jets A, Y 2, and C restrict fuel flow through ports 1, 2, and 3, respectively, of the manual mixture control valve seat. Jet L restricts fuel flow to the solenoid primer valve.

The B valve is located in the mixture control housing. It is spring loaded and diaphragm actuated. In RICH, port 4 is open, allowing reduced regulated pressure to act on the B valve diaphragm. In NORMAL and MANUAL LEAN, E bleed is open and port 4 is closed. Pressure in the reduced regulated fuel chamber overcomes spring tension and discharge pressure to control the action of the B valve. (See fig. 4-11.)

The idle valve, located in the mixture control housing, is operated by the throttle control to meter the fuel flow during idling operation. As the throttle is opened, the idle valve will open further to permit more fuel flow to the engine. An adjustable stop pin assembly is located on the left side of the throttle body to provide for adjusting the airflow through the throttle body to attain the desired idle rpm. The idle mixture strength may also be adjusted here on the throttle linkage to attain the desired opening of the idle valve in relation to the throttle position.

The idle valve also performs the function of an acceleration pump whenever the throttle is rapidly opened. Whenever this occurs, the piston on the rear of the idle valve causes a momentary and sudden increase of the pressure in the balance chamber, which results in an increased pressure regulator valve opening.

Bleeds E and F are also located in the mixture control valve housing assembly, bleeds G and H in the pressure regulator body assembly, and bleed K in the main body assembly. Bleed E, in the mixture control valve seat, governs the fuel flow to the back side of the B valve diaphragm during normal operation. Bleed F controls the pressure balance between the two sides of the B valve diaphragm. Bleed H supplies fuel to the

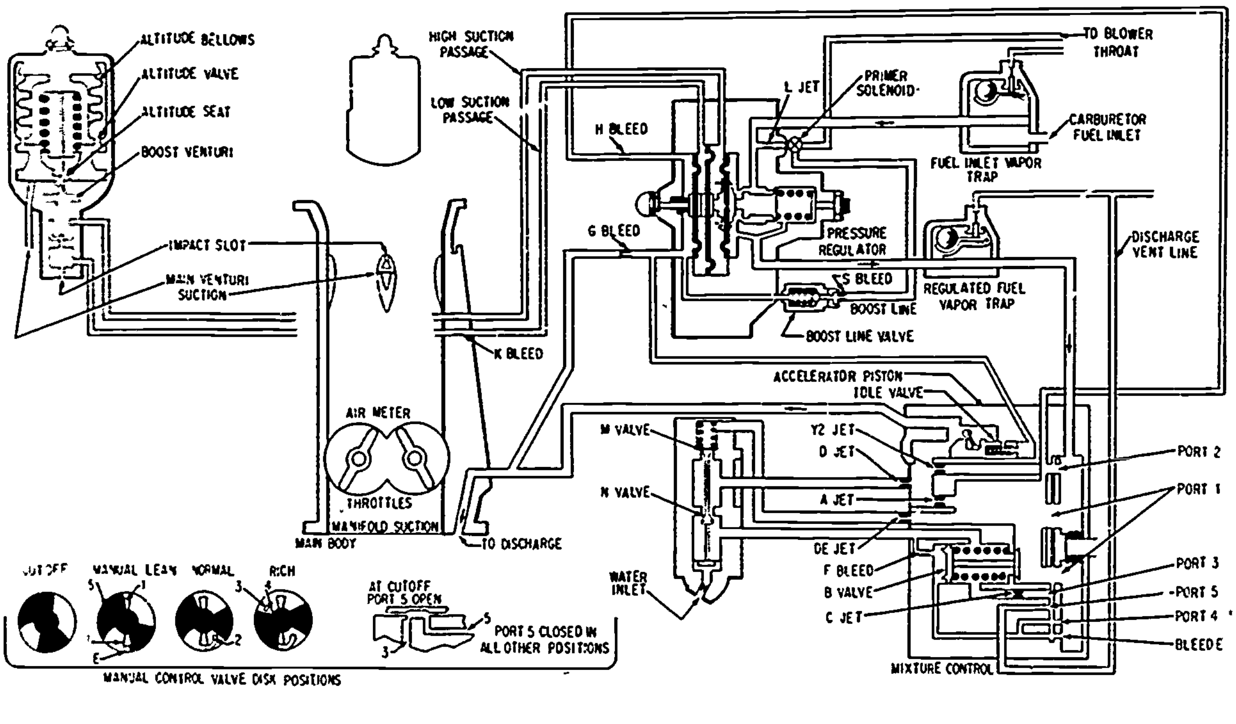

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Figure 4-11.—Diagram of the 58-CPBII CECO carburetor.

fuel balance diaphragm chamber, while bleed G governs the flow of fuel from the fuel balance diaphragm chamber. Bleed K prevents impact pressure surge to the low-suction side of the air diaphragm.

The solenoid primer valve is connected externally to the fuel balance chamber by a boost line and a fuel boost check valve. When the solenoid primer valve is actuated, it will provide fuel for positive filling of the fuel balance diaphragm chamber. Fuel flow to the solenoid primer valve is limited by jet L and from the solenoid primer valve to the fuel boost check valve by bleed S.

Valves M and N and jets D and DE are housed in the metering jets cover assembly, which is located on the mixture control assembly. Valves M and N are actuated by the diaphragm of the derichment valve assembly; valve M is normally closed and valve N is normally open. When water injection is applied, valve N is closed to prevent flow of fuel through the B valve and the C jet to the discharge port; and permits a predetermined restricted flow from the DE jet through the D jet by opening valve M.

2. Air Metering Unit. The air metering unit consists of the main and boost venturi and the automatic mixture control. The main venturi is divided by a streamlined bar extending across the inside of the main body. The boost venturi is located in the air metering housing. The automatic mixture control is also located in the air metering housing. It is a bellows-controlled, contoured needle valve. The bellows will respond to changes in the air density and as a result will cause the needle valve to move up or down and act as a variable bleed to control the volume of air flowing through the boost venturi.

3. Main Body Unit. The main body unit is a hollow magnesium casting which houses the air metering unit. The fuel metering unit is attached to the rear of the body and has end plates attached to its left and right sides. The fuel discharge port is located at the bottom of the body at the center of the rear flange. The main body unit houses the driver and driven throttle assemblies, which are supported by bearings located at the center and at both ends. The main body unit also furnishes the foundation upon which the necessary linkages, adjustable stops, etc. are mounted.

Operating Principles

Airflow to the engine is controlled by the throttle valves and measured by the venturi. When the air passes through the venturi, it increases in velocity, thereby creating a partial vacuum or suction at the throat of the venturi. As the velocity is determined by the amount of air flowing, and the suction is in proportion to the velocity, the suction may be considered a measurement of the airflow. A boost venturi is used to amplify the main venturi suction. Air flowing into slots in the top of the main venturi is directed through the boost venturi and altitude valve and is discharged into the throat of the main venturi. The amount of air passing through the boost venturi and producing the amplified suction is in proportion to the main venturi suction or to the amount of air being used by the engine.

The measurement of airflow, as indicated by venturi suction, is used to control fuel flow through the action of the pressure regulator assembly. The regulator assembly consists of a pressure regulator valve and three diaphragms arranged in series. The valve is actuated through the movement of all three diaphragms.

The air diaphragm, which is the largest of the three diaphragms, is exposed on one side to airscoop pressure (low suction) and to boost venturi suction (high suction) on the other side. This differential pressure across the diaphragm is known as the metering suction differential (MSD) and is an indication of the amount of air being consumed by the engine. As the throttle is being opened, the venturi suction increases, and the resulting increase in MSD causes the fuel pressure regulator valve to move open and allow more fuel to enter the metering chamber. As the rate of flow into the regulated pressure chamber increases, the pressure on the fuel diaphragm builds up. The valve will continue to move open until the fuel pressure against the fuel diaphragm balances both the MSD across the air diaphragm and the discharge fuel pressure on the fuel balance diaphragm.

Since the MSD is a relatively small force, the fuel pressure applied on the pressure regulator valve fuel diaphragm is partially balanced out by the fuel at discharge nozzle pressure applied to the fuel balance diaphragm. Any change in discharge nozzle pressure which would cause an abnormal variance of the metering head (pressure differential across the jets) is hydraulically transmitted to this diaphragm and results in a movement of the pressure regulator valve, which will compensate for the disturbance. Analysis will show that the pressure difference between these opposed fuel forces is equal to the metering head; thus, the MSD is required only to balance a force equal to the metering head. The ratio of fuel forces to air forces always remains constant; therefore, any change in airflow will result in a proportionate change in the metering head.

The power output of the engine is determined by the weight of air consumed, but the weight of a given volume of air decreases as altitude and/or temperature increases. To maintain engine power under these conditions, it is necessary to maintain the weight of airflow by increasing its volume. However, an increase in airflow volume will cause an increase in venturi suction which, if communicated to the pressure regulator assembly, would open the pressure regulator valve and cause an undesired enrichment of the mixture. The automatic mixture control is designed to correct this condition and insure satisfactory metering under all conditions of altitude and temperature.

The automatic mixture control consists of a contoured valve, the position of which is controlled by a nitrogen-filled bellows containing some oil to dampen its motion. The altitude valve is placed in series with the boost venturi and acts as a throttle to control the amount of air passing through the boost venturi. Loss of air density caused by either increased altitude or increased temperature will cause the bellows to expand and move the altitude valve farther into its seat thereby restricting the airflow through the boost venturi. The contour of the altitude valve is such that it enables the automatic mixture control to hold the MSD to a predetermined value for a given fixed mass airflow regardless of changes in air density.

The 58-CPB11 carburetor uses six jets and a power enrichment valve to create a constant mixture strength for all conditions of operation. See table 4-1 for listing of jets, bleeds, and their purpose. Control of the B valve is effected by variation of the metering head imposed across the diaphragm. In CRUISE RANGE–RICH or NORMAL (fig. 4-12 (B), shown in CRUISE RANGE–NORMAL), the control spring plus discharge fuel pressure overbalances the reduced regulated fuel pressure from the E bleed (port 4 in RICH), thus closing the B valve. IN POWER RANGE–RICH or NORMAL (fig. 4-12 (A), shown in . POWER RANGE–RICH), the regulated fuel pressure from port 4 (reduced regulated fuel pressure from E bleed in NORMAL), overbalances the spring plus discharge pressure, thus opening the B valve.

During periods of low airflow, such as idling, the desired mixture varies from that which can be obtained from the jet system. The throttle-operated idle valve acts as the metering orifice during this period. As the throttles are moved into the idle range, the idle valve is moved progressively further into the fuel discharge passage and becomes the metering orifice. The position of the valve may be varied in relation to that of the throttle to obtain desired mixtures by means of an adjusting device in the idle adjustment body. The pressure regulator valve position at this time is determined mainly by a system of springs. The desired valve position is obtained by adjusting the force of the opposing springs by means of an adjusting screw.

The flow of the fuel to the different jets is controlled by the manual mixture control which, in turn, controls a disk type selector valve in the mixture control housing. When this disk type valve is set in the CUTOFF position, all fuel is shut off. During MANUAL LEAN and in NORMAL position, the manual mixture control directs fuel to jets A, Y2, E bleed, and B valve. In the RICH position, fuel is directed to jets A, Y2, C, port 4, and B valve. The manual lean position may be varied to any desired point between CUTOFF and NORMAL for greater economy of fuel consumption in the CRUISE RANGE.

The derichment system consists of a spring-loaded diaphragm valve with dual seats. The valve N, allowing the fuel flow from B valve and jet C, is normally held open; and the valve M, allowing flow from jet DE, is normally held closed by the spring and discharge pressure acting on the diaphragm. As the water injection system is actuated, water pressure applied to the diaphragm causes valve N to close the passage

Table 4-1.—Application of jets, bleeds, and B valve

Part	Application
A jet	Meters fuel for minimum combustion requirements.
Y2 jet	In parallel with jet A, supplements jet A fuel flow during NORMAL and RICH operation. When the mixture control valve is moved from the NORMAL position toward CUTOFF position, the valve disk tends to restrict the flow of fuel through port 2 to the Y2 jet.
C jet	C or rich jet supplements NORMAL flow through entire range when mixture control is in RICH and operates in parallel with jets A and Y2 and in series with jet D.
D jet	In series with the B valve and jets C and DE and parallel with jets A and Y2, limits the amount of fuel that can be added for maximum power operation.
DE jet	Operates when the derichment valve is actuated by water injection to maintain the desired fuel flow to jet D when the B valve and jet C are closed off. When valve N closes to block fuel flow through the B valve and jet C to the discharge port, valve M opens to permit flow from the DE jet.
B valve	Diaphragm-actuated B valve (power enrichment valve), in parallel with jets A and Y2 in NORMAL, with A, Y2 and C in RICH, operates from the metering head to enrich the mixture in POWER and TAKEOFF range.
L jet	Limits fuel flow to the solenoid primer valve.
E bleed	Drilled passage located in the mixture control valve seat governs the flow of fuel to the top side of B valve diaphragm during normal operation.
F bleed	Regulates pressure at the B valve diaphragm.
G bleed	Limits flow in line to discharge from the fuel balance diaphragm chamber.
H bleed	Supplies a source of fuel to fuel balance diaphragm chamber to remove trapped air and help fill the chamber when empty.
K bleed	Limits the sudden surging of impact pressure from the main venturi to the low suction side of the air diaphragm.
S bleed	Limits the fuel flow from the solenoid primer valve to the fuel balance diaphragm.

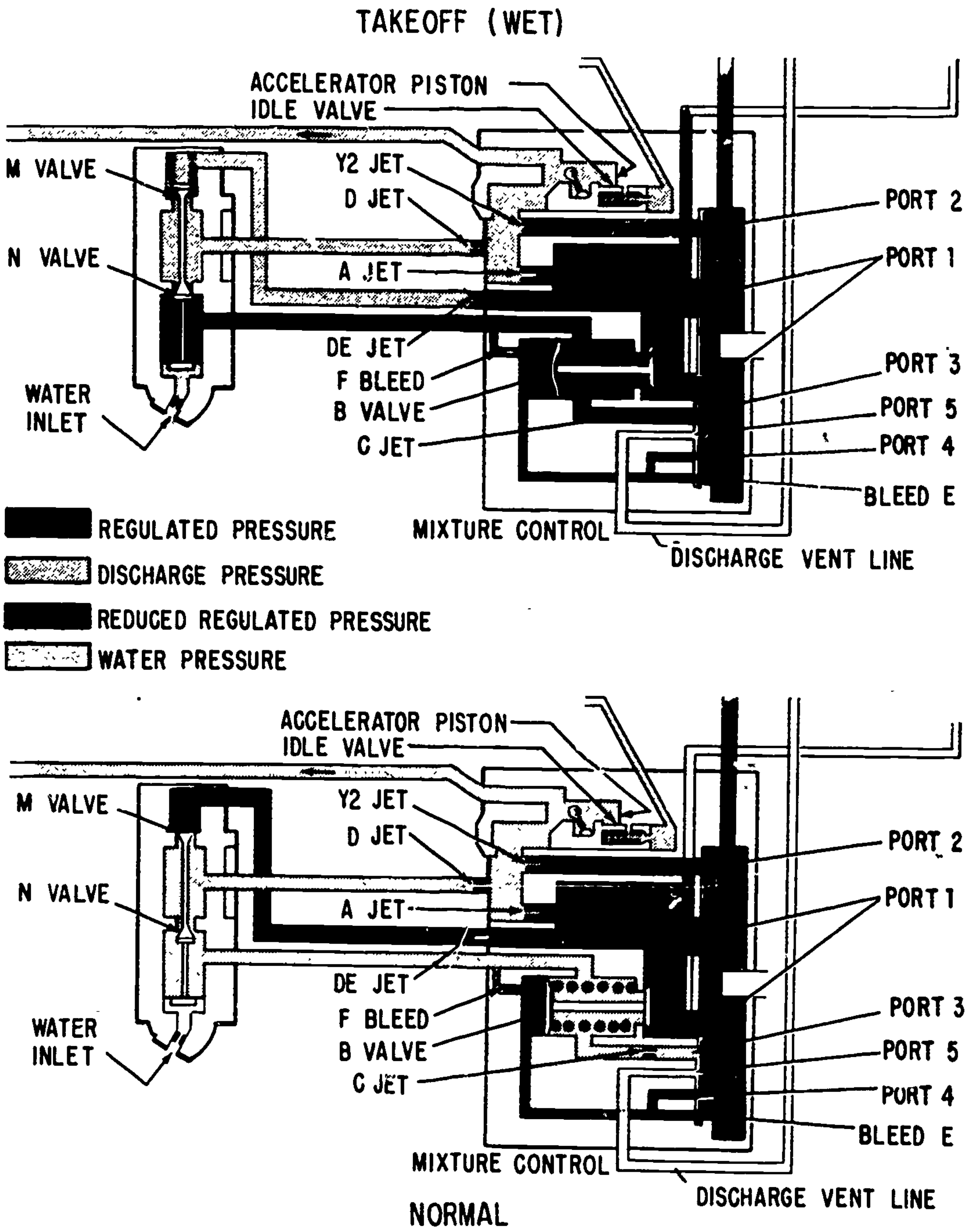

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Figure 4-12.—Power enrichment valve, B valve, schematic diagram.

from the jet C and the B valve and to open the passage from jet DE, thus deriching the mixture to the desired strength.

During rapid acceleration, the reaction of the fuel metering system is slower than the increase of airflow to the engine. If this lag is not corrected, a momentary lean mixture would result. To enrich the mixture, the back of the idle valve is used as a piston, and under sudden throttle opening, forces a fuel charge into the discharge pressure balance chamber. As the outlets of the discharge pressure balance line are restricted at bleeds G and H, the fuel charge from the idle piston momentarily raises the pressure in the discharge pressure fuel balance diaphragm, which in turn opens the fuel regulator valve, providing the additional fuel necessary during acceleration.

For instructions concerning adjusting of the 58-CPB11 model carburetor idle mixture, idle rpm, and troubleshooting procedures, refer to the applicable Maintenance Instructions Manual, Flight Manual, and/or local maintenance instructions.

DIRECT FUEL INJECTION

The model PR-58S2 injection carburetor (master control) is a downdraft unit employing a proven method of metering fuel through fixed jets, proportional to mass airflow. (See fig. 4-13.) This mass airflow is controlled, measured, and converted into a working force to supply fuel. Therefore, any increase in mass airflow provides an automatic increase in fuel.

By sensing changes in air pressure and temperature, automatic adjustment of the metering force provides fuel metering during all conditions of engine operation. Using direct injection pumps to supply metered fuel to the engine, ice formation caused by fuel evaporation within the master control is eliminated and positive fuel metering during all maneuvers and aerobatics is assured. The master control provides a manual means for selecting the fuel requirements of the engine for all operating conditions, regardless of engine speed, propeller load, or throttle position.

Understanding of the construction, inspection, and overhaul of the master control is made easier since it is subdivided into the following basic assemblies, each of which has an individual function:

1. Throttle body assembly.
2. Pressure regulator assembly.
3. Fuel control assembly.
4. Automatic mixture control assembly.
5. Electric primer valve assembly and alternate fuel source solenoid.

Operating Principles

The throttle body assembly controls airflow to the engines by use of throttle valves. Measurement of mass airflow is accomplished by sensing pressure differential. Design features create the differential, while impact tubes and boost venturi tubes sense the pressures. These pressures are applied to either side of the air diaphragm in the regulator assembly to provide air metering force (metering suction). This metering suction is the means of measuring mass airflow to the engine. (Corrections for changes in air pressure and temperature are accomplished by the automatic mixture control assembly.)

The pressure regulator assembly is operated by air and fuel pressure differentials. Regulated impact air pressure and boost venturi suction establish an air pressure differential (metering suction). Unmetered and metered fuel create a fuel pressure differential (metering head). An air diaphragm, fuel diaphragm, and suitable sealing diaphragms, mechanically connected by a single stem to the poppet valve, provide a means for balancing the differential pressures. Thus the pressure regulator assembly automatically supplies fuel to the fuel control assembly in proportion to the mass airflow through the throttle body assembly. To prevent vapor from affecting positive metering, two vapor separators are provided, one each in the top of chambers D and E. Foreign particles that may cause master control malfunction are removed from inlet fuel by the regulator fuel strainer.

The fuel control assembly contains metering jets, power enrichment valve, idle metering valve, and the manual mixture control. The fuel control attaches directly to the regulator assembly, from which it receives unmetered fuel. The idle metering valve is mechanically connected to the throttle shaft and controls fuel metering throughout the lower range of engine

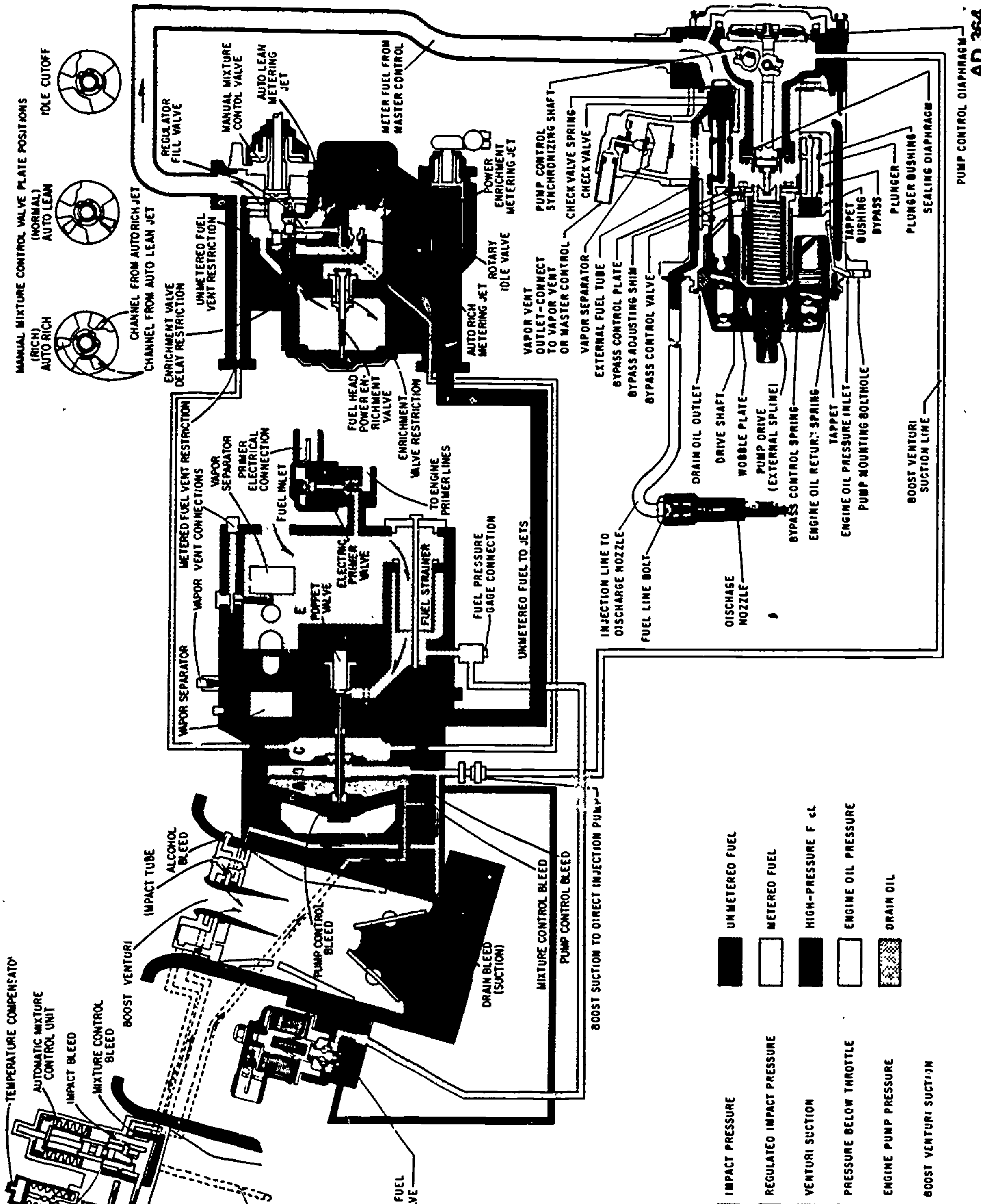

Figure 4-13.—Schematic diagram of the Stromberg PR-58S2 Master Control.

operation. The diaphragm-operated power enrichment valve provides fuel enrichment proportional to mass airflow through the throttled body assembly. A manual means for selecting the proper amount of fuel for various engine operations is provided by the manual mixture control.

The purpose of the automatic mixture control assembly is to correct fuel flow in response to changes in air pressure and temperature. Using two sealed metallic bellows, the automatic control assembly is able to sense air density changes caused by changes in altitude or temperature. Movement of either bellows repositions a contoured needle in its orifice to alter impact air pressure applied to the regulator assembly.

The PR-58S2 master control uses two electric primer valve assemblies. One primer valve assembly introduces fuel at engine pump pressure into the airstream. The second primer valve assembly (alternate fuel source solenoid) provides an alternate fuel source in the event of master control malfunction. The coils permit continuous operation of either unit without excessive temperature rise. Satisfactory positive grounding of the primers can be accomplished only when shielded cables, or grounding straps, are used for direct connection to the aircraft frame.

Injection Pumps

Metered fuel from the master control is directed through a fuel flow divider to the two injection pumps. Each of the pumps receives an equal amount of the fuel from the master control. An adapter which is timed to the engine provides for the mounting of each pump. The splined drive shaft of the pump has a master spline, so that the pump can be mounted on the adapter in only one position. The pump adapters are timed to the engine crankshaft, so that the cylinder receives the fuel charge at the correct moment in relation to piston position and the ignition event.

A simple schematic diagram of the direct fuel injection system is shown in figure 4-14. In the sectional view of the injection pump, note both the wobble plate on the drive shaft and the spring on each hollow plunger that hold the plungers against the wobble plate. As the drive shaft is rotated, the plungers move in and out–forced to the right by the wobble plate and returned by the action of the springs. This is the pumping action which forces the fuel received from the master control into the lines leading to the discharge nozzle mounted in each cylinder of the engine. Each plunger furnishes fuel for one cylinder (nine plungers, nine cylinders to each pump).

Each plunger works inside of a fixed plunger bushing. The bushing has a passage through the side which acts as a relief port to end the effective pumping stroke. The end of the effective pumping stroke occurs at the same position all the time, and the length of plunger travel is the same at all times. It is the beginning of the effective pumping stroke that varies at the different power settings.

Around the outside of each plunger there is a bypass sleeve which determines where the effective pumping stroke begins. The bypass sleeve is attached to a bypass control plate. The effective pumping stroke starts when a lower port in the plunger is covered by the bypass sleeve. When the control plate is moved to the left (fig. 4-14), the effective pumping stroke is lengthened, sending more fuel to the cylinders. When the control plate is moved to the right (fig. 4-14), the effective pumping stroke is shortened, sending less fuel to the cylinders.

On the return stroke of the plunger, fuel is trapped in the line to the discharge nozzle by a check valve. There is an individual check valve for each plunger.

The bypass plate is positioned automatically by metered fuel pressure and boost venturi suction. (See fig. 4-14.) The metered fuel pressure and boost venturi suction, which vary at different power settings, are applied to the pump control diaphragm, which works against the tension of the bypass control spring. (See fig. 4-14.) The metered fuel pressure and boost venturi suction are strongest at the higher power settings. This moves the bypass control plate to the left, lengthening the effective pumping stroke and increasing the fuel flow to the discharge nozzles in the cylinders. At the lower power settings, the bypass control spring, opposed by a weaker metered fuel pressure and venturi suction, moves the control plate to the

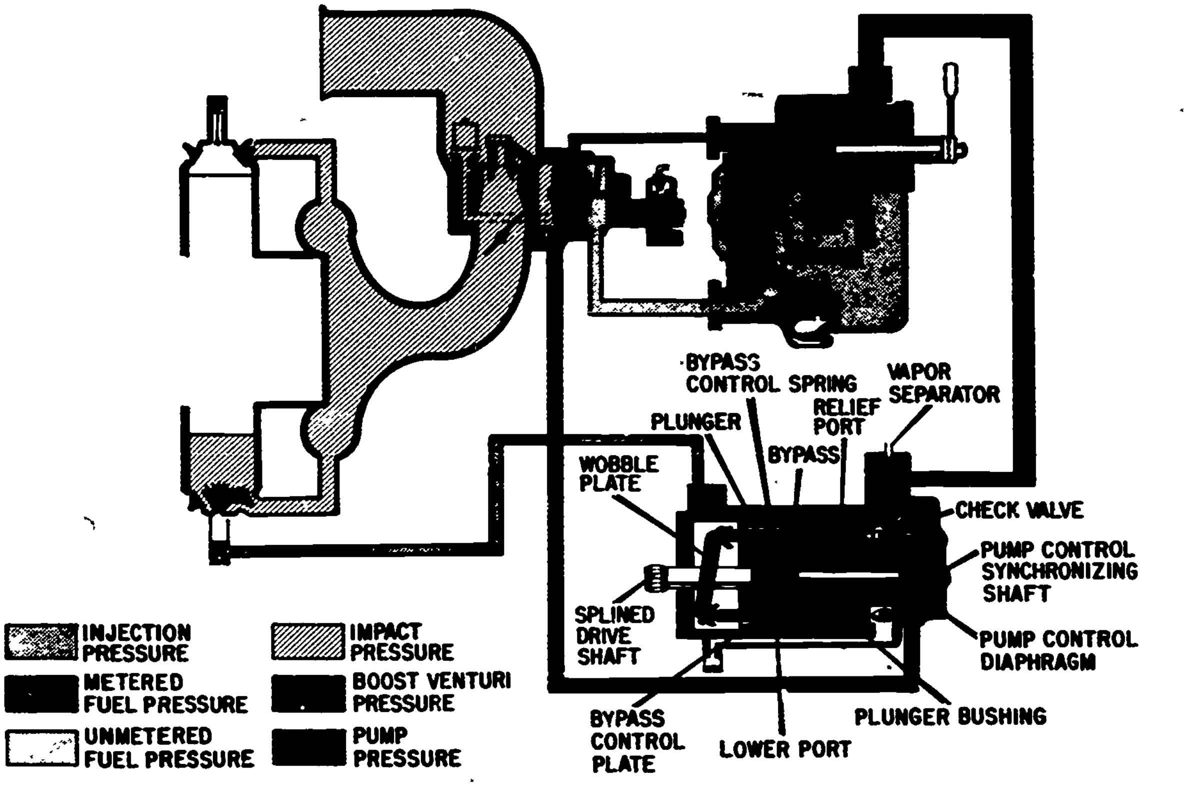

Figure 4-14.—Schematic diagram of the direct fuel injection system.

right. This shortens the effective pumping stroke, sending less fuel to the cylinders.

When the mixture control of the master control is placed in the IDLE CUTOFF position the fuel flow to the injection pumps is stopped. This reduces the fuel pressure on the pump control diaphragm and allows the bypass control spring to move the control plate fully to the right. (See fig. 4-14.) In this position the spill port remains uncovered and the discharge nozzles in the cylinders will remain closed due to insufficient fuel pressure. A similar action will take place if a fuel tank is run dry during flight. The control plate will move to the IDLE CUTOFF position and stop the flow of fuel to the engine. Fuel will remain in the pump body to provide the necessary lubrication of the plunger mechanism as the pumps are rotated by the windmilling of the engine. The wobble plate mechanism is lubricated by engine oil and the plungers are lubricated by the fuel.

Vapor elimination is provided in each pump by vapor separators which are similar to those in the master control. They vent and return vapors to the master control, which in turn return vapors to the service tanks of the aircraft.

Fuel is delivered from the injection pumps to each individual discharge nozzle via the fuel injection lines. Each individual plunger builds up sufficient pressure to overcome the force of the check valve spring, causing the check valve to open, allowing the fuel to enter the injection lines. Further movement of the plunger builds up the pressure sufficiently then to open the discharge nozzle located in the cylinder head and spray the fuel into the cylinder at the proper time in relation to ignition timing and position of the piston in the cylinder. When the spray pattern is poor, combustion in that cylinder will result in engine instability and possible power loss.

STROMBERG INJECTION CARBURETORS

The PR-58T1 Stromberg injection carburetor is identical to the PR-58S2 master control, and the principles of operation are the same except for the following:

A constant effort spring, located in chamber A, tends to open the poppet valve with a constant force and provides a smooth transfer from idle to low power cruise operation. This spring is in operation through the entire fuel flow range and increases the metering head a fixed amount.

All fuel delivered by the power enrichment valve and automatic rich metering jet must pass through the power enrichment jet in parallel with the derichment jet. After the power enrichment valve opens to a predetermined point, the combined jet area of the power enrichment valve and the automatic rich jet becomes greater than the jet area of the power enrichment and derichment jets; at this point the power enrichment and derichment jets take over the metering.

The derichment valve is operated by a diaphragm exposed to water pressure on one side and metered fuel pressure on the other. When the water pressure is applied, the derichment valve closes, stopping the fuel supply through the derichment jet.

The acceleration pump, mounted on the throttle body assembly, is used to compensate for the inherent lag in fuel flow during rapid or sudden acceleration. The throttle-actuated acceleration pump, which unbalances the poppet valve momentarily, consists mainly of a throttle-actuated piston operating in a cylinder. An inlet check valve allows fuel to enter the pump cylinder when the piston is retarded. The piston travels into the cylinder as the throttle is opened, forcing the pump fuel through a channel to the balance chamber in the regulator assembly. This increase in the balance chamber pressure opens the poppet valve momentarily, increasing the fuel flow to the discharge nozzle. The duration of the increased discharge is controlled by the two bleeds located in the channels leading to and from the balance chamber at the front of the pressure regulator assembly.

The metered fuel from the fuel control assembly flows through a fuel transfer tube to the throttle body assembly. From the throttle body assembly the fuel flows to the engine nozzle, which has an opening pressure of approximately 14 pounds.

A thermal expansion vent is provided to C chamber for the purpose of bleeding off static metered fuel pressure when the mixture control lever is placed in IDLE CUT-OFF. This eliminated the possibility of fuel leakage past the nozzle due to thermal expansion of metered fuel after the engine is shut down.

WATER INJECTION SYSTEM

The R3350-32W engine is equipped with a complete water injection system through which antidetonant fluid (usually called water) may be introduced into the engine induction system along with the fuel mixture. With the engine operating at high power and high manifold pressure, such as during takeoff or during combat emergency, water added to the fuel serves to prevent detonation.

The fluid used in the water injection system should be a mixture of 50/50 percent AMS 3006A water injection fluid, type I, above -49° F; 60/40 percent AMS 3006A water injection fluid, type IV, below -49° F. Distilled water should be used, but tap or drinking water is generally suitable for use in the system. Salt water or dirty water must not be used under any circumstances, and water with high mineral concentration should not be used regularly.

NOTE: Water injection fluid is a deadly poison for which there is no antidote. The vapors of the fluid, if inhaled in sufficient quantity, will have the same effect as if the fluid was taken internally.

COMPONENTS

The water injection system used on the R3350-32W engine consists of two water injection discharge valves, a water power control unit, and water injection pressure tubes. The water injection system provides, automatically, combat power in both low and high supercharger ratio for "wet" operation.

OPERATING PRINCIPLES

The water injection system is energized by an electric pump which supplies fluid under pressure up to the control unit. Moving the throttle beyond 40 inches MAP compresses the metering valve bellows in the power control unit and opens the valve, allowing the injection fluid to flow into the injection valves to be discharged just below the carburetor.

During its operation, the fluid cools the burning in the cylinders, allowing a higher MAP and a leaner fuel mixture without detonation or higher cylinder head temperatures.

If the engine is operated until the injection fluid is exhausted, the loss of fluid pressures at the derichment valve will allow the carburetor to enrich the fuel-air mixture automatically. Manifold pressure is manually adjusted.

IGNITION

HIGH-TENSION IGNITION

The high-tension ignition system consists of a magneto, distributors, the ignition harness, and the individual spark plug leads. The distributor may or may not be integral with the magneto. In the high-tension system, the coils, breaker points, and capacitors are located in the magneto housing. Figure 4-15 shows a simple schematic of a high-tension ignition system.

The magnetic circuit consists of a rotating permanent magnet, pole shoes, pole shoe extensions, and coil core. The pole shoes, extensions, and coil core are made of laminated soft iron. The poles of the magnet are arranged so that the direction of flux through the soft iron core reverses as the rotating magnet is turned. On this type of magneto, the number of flux reversals during one completed revolution of the rotating magnet is equal to the number of poles on the rotating magnet.

The primary coil is wound around the soft iron core, one end of the coil being grounded, the other being connected to ground through the breaker points. The changing magnetic field in the coil core induces a current flow in the primary circuit when the breaker points are closed.

When the primary circuit is opened by the breaker points, current flow stops in the primary coil and the magnetic field surrounding it collapses. This action allows the flux of the permanent magnet to reverse very rapidly, producing a very high voltage in the secondary coil. The amount of voltage generated is dependent upon the strength of the magnet, the

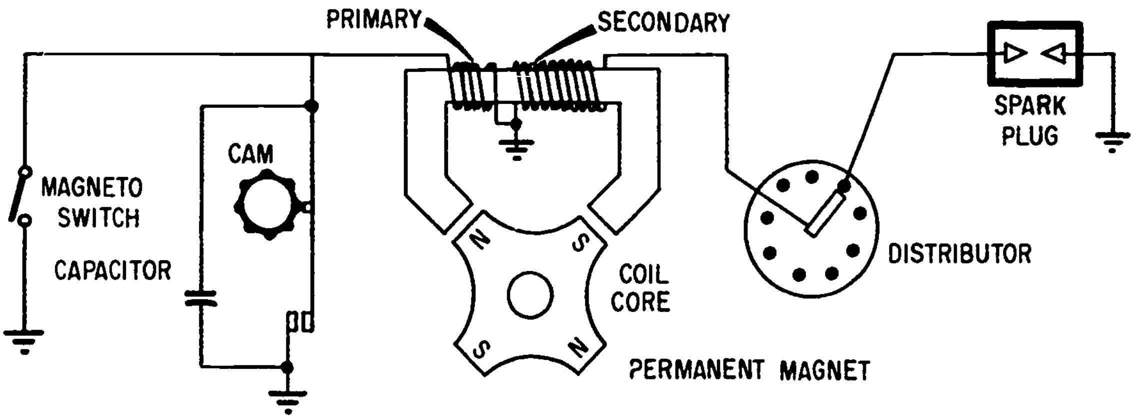

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Figure 4-15.—Simple schematic of a high-tension ignition system.

number of turns in the secondary coil, the speed of the flux reversal, and the resistance of the secondary ignition circuit.

The breaker points are spring loaded to close and are opened by the lobes on the cam when it is rotated. Because of the reversal of flux in the primary coil, the direction of current flow across the breaker points changes, thus minimizing the transfer of metal from one breaker point to the other.

A capacitor connected in parallel with the breaker points absorbs the current flow at the time of breaker point opening. In this way the capacitor aids in the interruption of primary current flow, which results in a higher voltage output from the magneto. In addition, arcing across the breaker points is held to a minimum when they are just opening.

The magneto ground wire is connected to the primary circuit. When the ground wire is grounded by the ignition switch, opening of the breaker points does not interrupt the primary circuit; hence, no high voltage is generated in the secondary. The potential voltage available on currently used magnetos is approximately 15,000 to 20,000 volts.

The distributor is the point where the high voltage generated by the magneto is distributed through the ignition harness and leads to the spark plugs at the proper time and in the firing sequence of the engine. It consists of a rotor which rotates at one-half crankshaft speed and which is connected to the high-tension wire from the secondary coil of the magneto, and electrodes located radially around the distributor finger and spaced the proper number of degrees apart, as required for the engine and the number of cylinders involved, and in the firing order of the engine.

The ignition harness consists of a manifold which contains the wires leading from the individual electrodes in the distributors to the spark plugs. This manifold shields the wires and grounds out the electrical disturbances which would be picked up by the radio equipment in the aircraft. For this reason the metal portion of the ignition harness must be kept in good condition, with no breaks or openings in the harness from the shielded distributor to the point where the electrical spark is transmitted to the insulated core in the spark plug.

LOW-TENSION IGNITION SYSTEM

Electrically, the difference between the low-tension ignition system and the high-tension ignition system is quite pronounced. Compare the schematic of the high-tension system (fig. 4-15) with the schematic of the low-tension ignition system in figure 4-16. The high-tension system generates high voltage at the magneto and then transmits this high voltage through the distributors to the spark plugs. The low-tension system, however, generates only low-voltage current at the magneto. In the low-tension system the electrical energy is maintained at a low voltage until it is transformed to a high voltage by the use of transformer coils located on each cylinder. By transformer action, the magneto generator primary voltage is greatly increased by the secondary coil of the transformer, and builds to a voltage value sufficient to create a current flow at the spark plug gap.

The low-tension system has many advantages over the high-tension system. In principle, this system isolates the secondary winding of the conventional high-tension coil from the magneto and locates it as closely as possible to the spark plug. Thus, the magneto generates a relatively low voltage, thereby reducing the electrical stresses in the wiring and reducing the possibility of flashover at high altitude.

The short high-tension leads also decrease the capacitance in the system, thereby lowering the voltage losses which result in lower peak energy to fire the spark plug. This also greatly reduces the spark plug erosion rate, an item which has become increasingly important because of compression chamber pressures and temperature increase. The confinement of the high voltage to a relatively short lead has sharply decreased the maintenance problems that insulation gives at high altitudes.

Since a separate transformer is used with each spark plug, a carbon brush type distributor can be, and is, used to distribute the primary output voltage of the magneto generator. This eliminates the flashover characteristics of the high-tension distributor. A complete typical low-tension ignition system is illustrated in figure 4-17.

The distributor rotor and breaker cam must both be driven at one-half engine speed, making

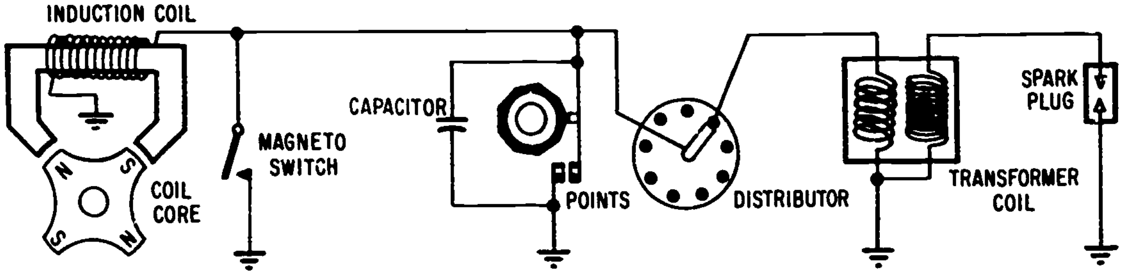

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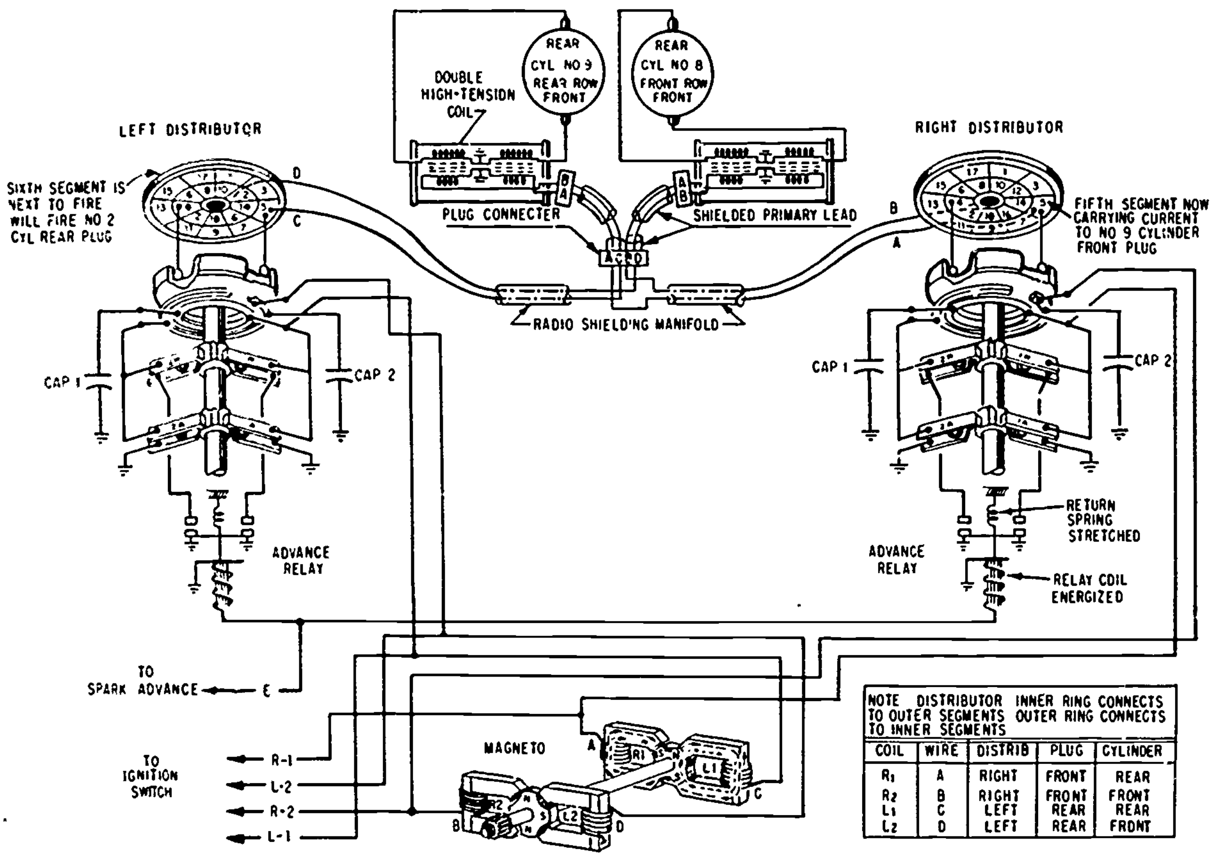
Figure 4-16.—Simple schematic of the low-tension ignition system.



COIL	WIRE	DISTRIB	PLUG	CYLINDER
R_1	A	RIGHT	FRONT	REAR
R_2	B	RIGHT	FRONT	FRONT
L_1	C	LEFT	REAR	REAR
L_2	D	LEFT	REAR	FRONT

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Figure 4-17.—Low-tension ignition system.

it advantageous to put the breaker cam on the distributor shaft. The distributor unit contains the breaker points, capacitors, distributor rotors, and carbon brushes. Low-tension leads carry the current from the distributor to the transformer primary coil. Basically, the coil is a transformer containing two primary and two secondary windings; each unit supplies the high voltage required for the two spark plugs of the cylinder upon which the coil is mounted.

The low-tension system contains at least two of every component except for the magneto generator drive shaft. This provides for two completely identical systems–RIGHT and LEFT. The RIGHT system, or right magneto, includes magneto coils R1 and R2, right distributor, one primary and one secondary coil in each transformer unit, and the front spark plug in each cylinder. The left magneto system duplicates the right magneto system and includes coils L1 and L2 and all of the rear spark plugs, plus one primary and one secondary coil in each transformer unit. The function of the magneto coils can be further isolated, in that L1 and R1 coils fire the spark plugs in all of the odd-numbered cylinders and L2 and R2 coils fire all the spark plugs in all of the even-numbered cylinders.

Spark Advance

The type of spark advance in common usage today is the manually controlled system, which requires selection of the desired spark setting by a switch in the cockpit. Figure 4-18 shows a schematic of the manual spark advance system on the R3350-34 series engine. The ignition timing is advanced by electrically energizing a relay located in the distributor which deactivates the retard points and allows the advance points to interrupt the circuit.

A brief description of the theory of spark advance and the factors that determine ignition timing is as follows. if the fuel/air remains constant, the length of time required for the flame to progress across the cylinder remains

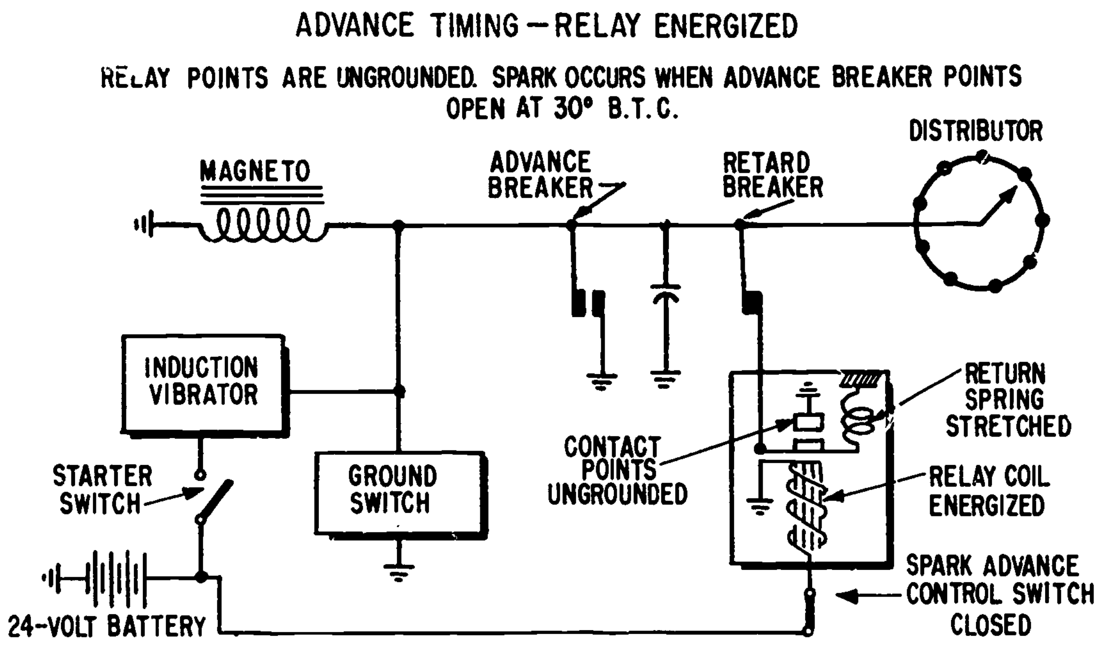

Figure 4-18.–Manual spark advance system.

constant. Therefore, the time at which ignition occurs determines the point where the pressure pattern will peak as measured in degrees of crankshaft angle. This, of course, assumes the rpm remains constant. If the rpm is increased, the flame speed will stay fairly constant and the pressure pattern will peak later in reference to the crankshaft angle. To maintain the optimum pressure pattern, it would be necessary to vary the ignition time with each rpm and fuel/air combination. This is, of course, not practicable. On engines with fixed timing, it is the general practice to select an ignition timing that gives a desirable pressure pattern for takeoff with something close to the optimum pattern for cruise. This will insure low basic specific fuel consumption for the greater percentage of operating time.

If the maximum economy is to be realized on engines that use extremely lean fuel/air ratios for cruise, it is necessary to advance the spark for this regime of operation. The speed of flame propagation is a function of mixture strength, with the flame speed reaching its maximum rate at a BEST POWER fuel/air ratio. The lean fuel/air flame speed is compensated by advancing the spark. Thus, the engine does not respond to a change in ignition timing within the BEST POWER fuel/air ratio range; but versus lean fuel/air ratios the power dropoff is at a faster rate with the relatively retarded spark. When troubleshooting an engine, this effect of fuel/air ratio on engine timing in the lean range is a point to remember.

The effects on engine operating temperatures of using an advanced spark are as follows:

1. Increased cylinder head temperatures for the following two primary reasons: First, there is a higher resultant peak temperature in the cylinder when the mixture is ignited earlier; and second, the burning combustion gases are in contact with the combustion chamber for a longer period of time. A 10° spark advance will increase cylinder head temperatures approximately 17° C.

2. A decrease in exhaust gas temperature results primarily from the combustion temperature reaching its peak earlier in the power stroke. Earlier peak temperatures result in a more efficient heat balance; that is, a greater portion of the total available energy is utilized in moving the pistons. Therefore, if the engine converts a greater portion of its heat into work, there will be a corresponding decrease in the amount of energy or heat lost through the exhaust gases. Each degree of spark advance will lower the exhaust gas temperature by approximately 5 1/2° C.

EXHAUST SYSTEM

The exhaust system of the R3350-32W and the -34 is composed of a system of pipes which collect the exhaust gases from the individual cylinders and deliver them to the three power recovery turbines. From the turbines the gases are then discharged to the atmosphere. The exhaust system arrangement can be seen in figure 4-9. The components of the exhaust must be inspected for serviceability at regular intervals to check for the following:

1. Cracks or holes are not permitted in the pipes, sleeves, and joints.
2. Broken welds are not permitted.
3. The total fore and aft movement of the ball joint ring cannot exceed 0.060 inch.
4. Free movement of the ball joint ring is required.
5. Evidence of overheating, leaking, or chafing which would require further inspection to determine the cause.
6. Wear of the welded-on antichafe rings or bolted-on antichafe clamps should not exceed one-half of the original thickness.

Figure 4-19 shows the exhaust pipes, antichafe clamps, and the inlet pipe ball joints of the power recovery turbine.

LUBRICATION

INTERNAL OIL SYSTEM

The lubrication system of the R3350-32W and -34 engines is a pressure, dry sump type. All moving parts are lubricated by oil under pressure, except the piston rings, piston pins, cylinder walls, intake and exhaust valves, crankshaft main bearings, and propeller shaft thrust and radial bearings, all of which are either lubricated by a splash or jet. For a diagram of

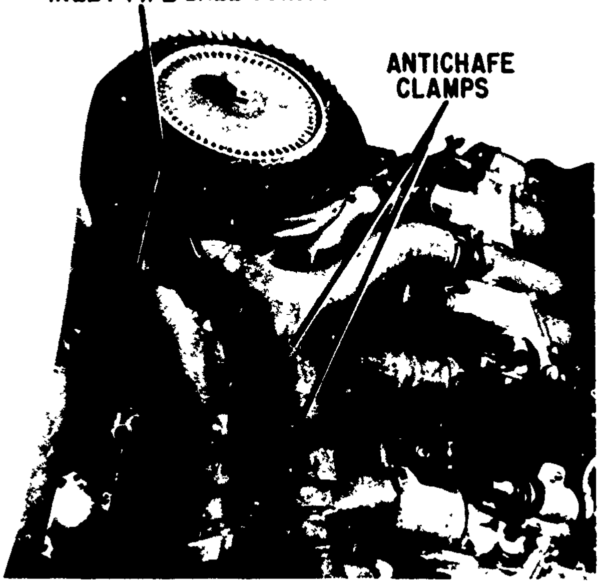

Figure 4-19.--Inlet pipe ball joints.

the flow of pressure and scavenge oil through the engine, refer to the appropriate maintenance instructions.

Oil from an external tank enters the pressure pump in the left side of the rear oil pump and sump body. The pump discharges the oil through cored passages in the pump and sump body into the inside of the pressure strainer and then through the outside of the strainer into the strainer cavity. A strainer bypass valve provides the engine with lubrication if the oil is too cold, or if the strainer should become clogged. A spring-loaded check valve at the inlet side of the strainer prevents the flow of oil under gravity pressure from the tank when the engine is not operating.

The pressure relief valve in the rear pump regulates oil pressure to 70 plus or minus 5 psi during all cruise and high power settings. The quantity of oil flowing through the valve varies with engine rpm, engine demand, and the oil temperature. A pressure control valve in the front pump and sump housing reduces the oil pressure to 35 plus or minus 5 psi, and another pressure control valve in the supercharger front housing reduces the pressure through it to 50 plus or minus 5 psi.

Three pumps collect and return the scavenge oil to the oil tank. Two of these pumps are located in the front pump housing and one is located in the right side of the rear pump and sump body. There is also a scavenge oil strainer and a drain plug in the front pump housing. There are three drain plugs plus a scavenge strainer through and over which the scavenge oil must pass before it enters the scavenge outlet chamber.

EXTERNAL OIL SYSTEM

Each engine installed on an aircraft has its own complete oil system. The P-2H aircraft will be used here for discussion purposes. The external oil systems of this aircraft contain the following components: A self-sealing tank and hopper assembly, an oil foam tank, oil cooler doors and thermostatic control system, manual shutoff valves, a temperature-controlled diverter valve, a capacitance oil quantity system, an oil dilution system, and all the necessary plumbing.

In operation, each engine oil system automatically maintains normal oil temperatures. Engine oil is supplied through a standpipe in the tank sump; propeller feathering oil is supplied from a point below the engine oil standpipe level. Oil flowing from the tank makes a complete cycle through the engine and returns to the tank. (See fig. 4-20.) The cycle of operation is as follows: The oil flows by gravity feed from the tank to the engine rear oil pump. From there it is routed through the engine and returned by the oil scavenge pumps to the oil temperature regulator valve. The regulator valve is attached to the oil cooler and directs the flow of oil according to its temperature either to bypass the cooler, flow over the cooler, or to flow through the cooling tubes. From the regulator valve the oil then flows through a thermostatic control unit which senses the temperature of the oil and varies the position of the oil cooler doors to control the amount of airflow through the oil cooler. Oil then flows through a manual check valve. The next and last unit the oil goes through on its return to the oil tank is the oil diverter valve.

The oil diverter valve also has a temperature sensitive element in one end to sense the temperature of the oil flowing from hopper to

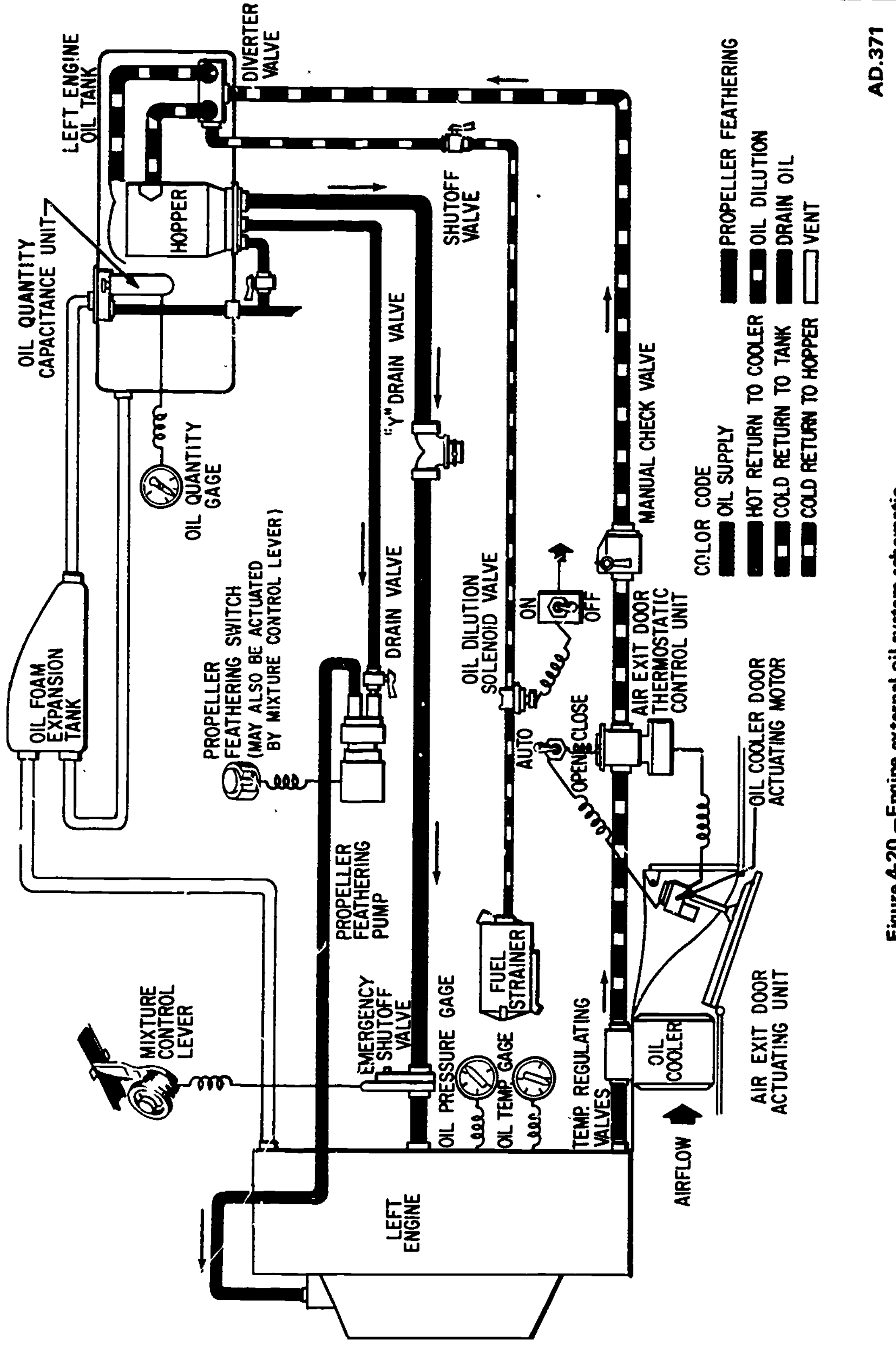

Figure 4-20.—Engine external oil system schematic.

the engine, and this determines whether the oil from the engine is returned to the main part of the tank or to the hopper within the tank. The purpose of the hopper is to circulate a small portion of the oil in the tank for initial warmup of the engine. As the oil gets hotter, the diverter valve begins to close and then diverts the oil into the main portion of the oil tank.

The emergency shutoff valve for the oil is manually operated from the cockpit. It is connected to a motor-driven actuator which opens or closes the oil shutoff valve. The one other unit mounted in the oil supply line to the engine is the Y-drain valve, which is used for draining the oil on periodic inspections or whenever needed.

CHAPTER 5

RECIPROCATING ENGINE TROUBLESHOOTING

Troubleshooting reciprocating aircraft engines may be defined as the systematic and thorough analysis of the symptoms of engine malfunctioning. Proper troubleshooting determines the proper corrective steps to be taken. Generally speaking, when irregular ground or flight operating characteristics are observed in aircraft engines, the cause can be traced to improper maintenance and/or operation, or to the malfunctioning of engine components.

Efficient maintenance of any mechanism invariably depends upon the familiarity which operators and maintenance personnel have with the mechanism. The reciprocating engine offers no exception to this rule.

It is essential that Aviation Machinist's Mates know the engine thoroughly. They should know what it is designed to do and how it fulfills that function. They should be familiar with normal operating details of the engine, such as oil pressures, temperatures, and consumption, and fuel pressures and fuel flow. All of these should be known for at least three engine operating conditions: idle, normal rated, and military. In addition to these items, personnel should have a thorough understanding of the effect of local conditions on the engine; that is, temperature, humidity, field altitude, and wind effect.

If information of the type contained in this chapter is followed, it will be productive of the most efficient maintenance; that is, preventing trouble before it arises, by recognizing abnormalities of the equipment and tracing them to their sources and making corrections before damage is done. Frequently, several seemingly unrelated indications of malfunctioning will eventually be traced to a single source.

It is often unsafe to assume that the engine is completely out of danger when some obvious corrective measure has been taken. Do not be hasty in assuming any conclusions. Do not confuse the significance of cause and effect. For example, low oil pressure, in itself, is not trouble. It is only an indication that some malfunctioning exists, the true cause of which is the trouble.

The preceding point is stressed to emphasize the importance of tracing an abnormal indication to its source, rather than being satisfied that restoration to normal by some obvious adjustment, such as changing the oil pressure relief valve setting, is all that is required. Invariably, there is a reason for abnormal indication. Be sure you know what the reason is and that you have taken the proper corrective measures before signing out the engine for further service. Proper corrective measure means the use of time-proven methods, not makeshift FIXES. For example, if an accessory fails to perform according to its specification and no standard repair or adjustment is established to correct the condition, replace with a new part and turn in the offending part so that it can be properly corrected at overhaul or scrapped.

Defects resulting from careless engine operation often may be observed best during disassembly when the component is covered with oil or carbon (prior to the cleaning process). During disassembly, visually check all components for signs of scoring, galling, or burning. Look for mechanical defects, deposits of carbon, and caked or coagulated oil. Trace the cause of the defects encountered and take the necessary remedial measures.

NATOPS Flight Manuals contain diagrams, drawings, and charts for use in troubleshooting. Diagrams of the various electric circuits, fuel systems, lubrication systems, etc., found in Service Instructions Manuals are very useful in isolating troubles. Cutaway drawings illustrating the internal construction of components, and exploded views showing how the various parts of a component are put together will often save valuable time in troubleshooting.

Engine troubleshooting in the field may be simplified through the use of various types of charts. A typical ground propeller load curve is shown in figure 5-1. These curves may be constructed locally by recording the rpm, manifold absolute pressure, BMEP, and the fuel flow at 100-rpm intervals from the CLOSED THROTTLE position to the field barometric pressure. The propeller should be in full increase rpm (against the low pitch stops) and the runup should be made first in AUTO-RICH and then in AUTO-LEAN. The shape of the curve for the engines run in the field will usually follow the example in figure 5-1. However, the curve may vary in the MAP/RPM relationship due to the differences in field altitude, temperature, humidity, wind effect, low pitch stop setting, and the carburetor or master control metering. Therefore, it can be seen that a number of these propeller curves should be made in order that the troubleshooter can take these variables into consideration.

ENGINE DISCREPANCY REPORTS

The accurate analysis of engine discrepancies and malfunctions and determining what corrective action is to be taken are important functions of the senior ADR's. A knowledge of what may be wrong when trouble comes will provide the best possible clue to the right course

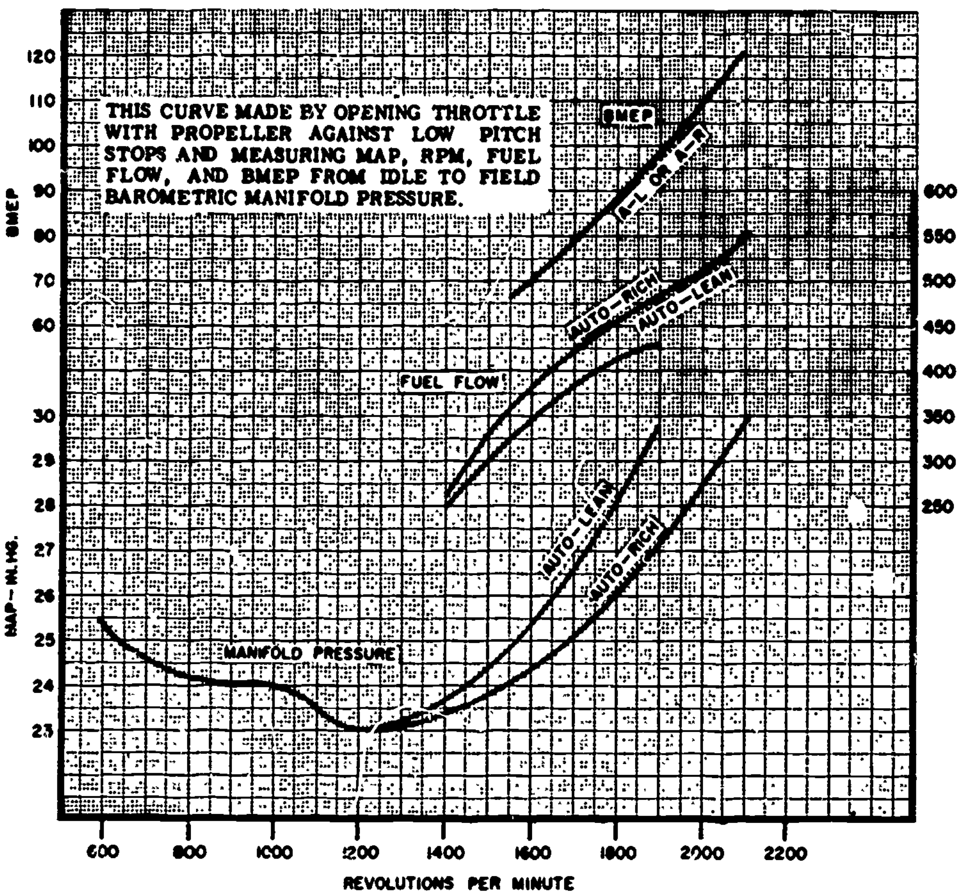

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Figure 5-1.—Typical ground propeller load curve.

of action in each instance. Many situations can be quickly analyzed and timely measures taken if an engine's malfunction symptoms are understood. On the other hand, misinterpretation of apparent abnormal engine operation and subsequent improper corrective action may possibly cause a more serious situation than was present in the first place.

In the event of abnormal engine operation of any kind, consult the pilot's Naval Aircraft Flight Record (yellow sheet), diagrams, charts, and all other available sources for any pertinent information which might give a clue in locating the trouble and effecting a remedy. Whenever possible, the engine instrument readings before and after the malfunction should be noted. Proper research of engine discrepancies will result in more positive malfunction analysis and faster, better corrective maintenance.

GROUND SAFETY PRECAUTIONS

Troubleshooting a reciprocating engine normally requires the engine to be installed in an aircraft and operating. This broadens the danger area for the maintenance man doing the troubleshooting. Safe working conditions must be maintained at all times. Therefore, the ADR must be familiar with and observe all safety precautions. The following paragraphs cover some of the ground safety precautions.

Operational readiness of a maximum number of aircraft is necessary if naval aviation is to successfully perform its mission. Keeping its aircraft in top operating condition is the principal function of naval aviation maintenance personnel, and an essential objective should be to perform maintenance work without injury to personnel and without damage to equipment or aircraft.

Aircraft maintenance is, to some extent, naturally hazardous due to the nature of the work, the equipment and tools involved, and the variety of materials required to perform many repairs and maintenance functions. Factors which can function to increase or decrease these hazards are (1) the experience levels and mental attitudes of assigned personnel and (2) the quality of supervision of the maintenance tasks. Thorough indoctrination of all personnel is the most important single step in maintaining safe working conditions.

The concept of aircraft maintenance safety should extend beyond concern for injury to personnel and damage to equipment and aircraft. Safe work habits go hand-in-hand with flying safety. Tools left in aircraft, improper torquing of fasteners, and poor housekeeping around aircraft can cause conditions which may claim the lives of flying personnel as well as cause strike damage to aircraft. Safety on the ground is equally as important as safety in the air.

A recent type commander letter states in part, "While the increased complexity of our modern aircraft is a factor, it is noted that a large number of maintenance-error-caused accidents and incidents are due, not to complexity of equipment, but to lack of supervision and technical knowledge. Many mistakes are simple ones in routine maintenance."

Safety in aircraft maintenance depends largely upon the supervisory personnel. The standards of quality which they establish are directly reflected in the quality of the aircraft maintenance. The primary duty of the senior petty officers is to supervise and instruct others rather than to become totally engrossed in actual production. Attempts to perform both functions invariably result in inadequate supervision and greater chance of error. Supervisors must exercise mature judgment when assigning personnel to maintenance jobs. Consideration must be given to each man's experience, training, and ability.

Sometimes overlooked in a maintenance program are the considerations generally grouped under the term "human factors." These factors are important in that they determine if an individual is ready and physically able to do work safely and with quality. Supervisory personnel should be constantly aware of conditions such as general health, physical and mental fatigue, unit and individual morale, training and experience levels of personnel, and other conditions which can contribute in varying degrees to unsafe work. Not only is it important that proper tools and protective clothing and equipment be available, but maintenance supervisors must insure that these items are properly used on all occasions requiring their use.

It is a continuing duty of every person connected with aircraft maintenance to try to discover and eliminate unsafe work practices. Accidents caused by such practices may not take place until a later date and their severity cannot be predicted. The following general safety items should be observed to prevent on-the-job accidents.

PROPELLERS

The senior ADR's must continually remind personnel working around propeller-driven aircraft that the first general precaution that must be observed is to BEWARE OF PROPELLERS. Parking areas and runup areas must be kept clean at all times. During high-power turnups the velocity of the propeller slipstream may pick up and blow loose dirt, sizable rocks, sand, debris, and even equipment a distance of several hundred feet. Therefore, due caution should be used in parking an aircraft for runup to avoid personnel injury and property or aircraft damages.

ENGINE NOISES

Reciprocating engines produce noise capable of causing temporary as well as permanent loss of hearing in certain frequency ranges. The senior ADR must continually remind personnel working around operating engines to observe the following precautions:

1. Wear the proper ear protection (earplugs and/or sound attenuators).
2. Do not exceed the time limits on exposure to the various sound intensities.
3. Have periodic checks on hearing ability.

More detailed information on these precautions may be found in Bureau of Medicine and Surgery Instruction 6260.6 (Series).

Engine noise is broadcast from the aircraft in patterns which vary in direction, distance, and intensity with engine speed. Generally, the most intense sound areas are in the shape of two lobes extending out and aft from the engine centerline. However, dangerous intensities are also present to the side and forward of the engine.

Damage to hearing occurs when the ear is exposed to high sound intensities for excessive periods. The higher the sound intensities, the shorter is the period of exposure which will produce damage. Above 140 db sound intensity, any exposure without ear protection can cause damage.

NOTE: Sound intensity is measured in decibels (db). A decibel is a number which relates a given sound intensity to the smallest intensity that the average person can hear.

The wearing of regulation earplugs or sound attenuators will raise the limits of time exposure. All personnel working within danger areas should be familiar with calculated db levels (as specified in the applicable Maintenance Instructions Manual) and should wear the necessary protective equipment.

Another effect of engine noises that is very important to the supervisor is that they cause fatigue. Personnel exposed to high levels of noise for extended periods of time become overly fatigued and cease to think properly. This can cause mistakes that may result in serious accidents or at best increase the time required for maintenance. Every effort should be made to prevent overlong exposure to high noise levels.

At the present there are very few noise abatement devices for reciprocating aircraft engines. Engines equipped with Power Recovery Turbines and those with collector ring exhaust systems are substantially quieter than engines with straight stack exhaust systems. Blast deflectors are of some help to maintenance personnel in that they deflect the engine noises upward.

AIRCRAFT SURFACES

The radically designed naval aircraft is very apt to have painted, waxed, and buffed surfaces. As a result, slippery conditions are likely to exist, especially when wet. This possibility should always be taken into consideration to avoid slips or falls. Cockpit and maintenance ladders or platforms are furnished to facilitate safe servicing.

Movable surfaces such as flight control surfaces, speed brakes, power-operated canopies, and landing gear doors constitute a major hazard to troubleshooting personnel. These units are normally operated during ground operations and maintenance. Therefore, care should be taken to insure that all personnel and equipment are clear of the area before operating any movable surfaces.

FUELS

When working on or around an engine, troubleshooting personnel must guard against breathing hydrocarbon (fuel) vapors as they may cause sickness or may even be fatal. Fumes must not be allowed to accumulate; therefore, always use adequate ventilating measures. Also, avoid getting fuel on clothes, skin, or in the eyes, because of the high lead content.

After an engine has operated with leaded fuel, it may have yellow residue on parts exposed to the exhaust gases. These deposits may cause lead poisoning if inhaled or swallowed. Parts covered with the yellow residue should be handled with caution. Be sure to clean parts showing yellow residue before reworking them; however, protect open cuts, eyes, nose, and mouth against entry of any of the material from these deposits when performing cleaning operations.

LUBRICATING OILS

Lubricating oils may have an irritating effect on the skin, and the same safety precautions as used with fuel should be followed. In the event the clothing becomes saturated with either fuel or oil, the clothing should be removed immediately. However, fuel saturated clothing should be removed in a shower due to the danger of static electricity igniting the fuel vapors.

CLEANLINESS

Efficient operation of a reciprocating engine is largely dependent upon the cleanliness of the various engine components. These components must be kept clean and free from foreign matter. The area in which any adjustment, replacement, or repair is to be done should be kept as clean as possible. All tools and equipment should be free of rust, grease, metal shavings, and other foreign matter.

During assembly, do not remove the wrapping from any part until it is ready to be installed. Do not remove the masking tape, seals, or plastic plugs from any orifice, passage, or port until necessary.

CARBURETION

Some symptoms which are seemingly caused by faulty carburetion are sometimes caused by other malfunctions. Symptoms such as improper idle, poor acceleration, roughness, and lack of power, often do not originate in the fuel system. They may be caused by faulty ignition, induction, valve operation, or propeller operation. When it has been determined that the fuel system is at fault, it is possible to isolate certain parts of the fuel system that may be the trouble source. On the injection carburetor this is done by checking the fuel system for pressure loss as follows:

1. Place the fuel selector in the ON position.
2. Turn the fuel boost pump ON.
3. Move the manual mixture control out of the IDLE CUTOFF position. (This allows the fuel transfer line between the carburetor and the spinner injection nozzle to be pressurized.)
4. Return the manual mixture control to the IDLE CUTOFF position.
5. Simultaneously turn the fuel selector and fuel boost pump OFF. (Fuel is now trapped between the selector valve and the mixture control plates, and between the mixture control plates and the spinner injection nozzle.) The reading on the fuel pressure gage (taken from chamber E as the fuel enters the carburetor) should drop and stabilize at the pressure specified for the particular system. This indicates that there is no pressure loss between the selector valve and the mixture control plates.

If the reading on the fuel pressure gage drops to zero, there is an external leak between the selector valve and the mixture control plates, or leakage at one of the following points is indicated: vapor vents, primer, selector valve, engine fuel pump diaphragm, balance diaphragm (in chamber A), or oil dilution valve.

If the reading on the fuel pressure gage drops to the spinner injection nozzle spring pressure (7 to 10 psi for a 10-pound spring), leakage is indicated at one of the following points: mixture control plates, regulator fill valve, or fuel diaphragm (between chambers C and D).

6. If no pressure loss is indicated in step No. 5, move the manual mixture control out of the IDLE CUTOFF position. The fuel pressure should drop and stabilize at the spinner injection nozzle spring pressure. If the pressure drops below that of the spinner injection nozzle spring, check for the following: leak in the fuel transfer line, injection nozzle stuck open, ruptured diaphragm between chambers B and C or a weak spring in the spinner injection nozzle.

Engine backfiring and high cylinder head temperatures are often indications of a mixture that is too lean. A lean mixture may be caused by the following: low fuel pressure, vapor separator stuck closed, boost venturi loose, clogged impact tubes, ruptured air diaphragm (between chambers A and B), defective spinner injection nozzle, defective or dirty automatic mixture control unit, or a dirty or collapsed strainer in the carburetor.

Afterburning and black exhaust smoke are often indications of a mixture that is too rich. A rich mixture may be caused by the following: excessive inlet fuel pressure, clogged mixture control bleeds, leaking primer, ruptured fuel diaphragm or ruptured balance diaphragm.

DIRECT FUEL INJECTION

When troubleshooting the direct fuel injection system, that part of the fuel system between the fuel selector valve and the mixture control plates of the master control may be checked in the same manner as for an injection type carburetor. Malfunctions of the master control produce the same symptoms as similar malfunctions of the injection carburetor. It is in that portion of the fuel system downstream from the mixture control plates that the master control troubleshooting procedures differ from that of the conventional injection carburetor. In troubleshooting the direct fuel injection system, proper use of the primer, tachometer, manifold pressure gage, fuel flowmeter, cylinder head temperature gage, and BMEP gage are invaluable. The use of charts, particularly the accountability charts which can be used to check engine performance, part throttle cruise performance charts, and the full throttle performance curves can be of great help to the troubleshooter in his work.

FLOW BENCH TESTING

Carburetors and master controls that have been removed from service because of defects must be overhauled or repaired. When the repair or overhaul has been completed, the carburetor or master control must be tested on a flow bench by qualified personnel. The following paragraphs cover some of the flow bench testing procedures.

The carburetor or master control should be set up on a test bench and adjusted to the specifications that the manufacturer furnishes, which will produce the exact conditions under which the unit will operate on the engine. The bleed check will provide a means for calibrating the mixture control bleeds, back vent bleeds, and channels in relation to the complete air circuit. The air circuit test provides a means for calibrating the automatic mixture control unit in relation to the fixed variables previously calibrated by the bleed check.

After the proper checks and adjustments have been made on the flow bench, the carburetor is ready for a test flight. Runs or readings are unnecessary on an engine in a test cell. Before starting the test on the flow bench, you should have at hand the carburetor setting specifications sheet and the flow test limit sheet, both of which contain the information on the correct sizes of the various parts, settings, and flow limits for the carburetor or master control as it is applied to a certain engine.

The flow bench is designed for duplicating the effects of engine operation on the regulator unit and the fuel control unit. The metering pressure across the jets in the fuel control unit are controlled by the regulator unit, which is actuated by the venturi suction and the impact pressure resulting from the airflow through the throttle body.

The airflow and corresponding venturi suction and impact pressure are recorded for each engine operating condition from an actual run on a test engine. These records are placed on a specification sheet for the engine and carburetor. If the venturi suction and the impact pressure corresponding to a given airflow are imposed upon the regulator unit, the volume of fuel flowing from the metering jets would be exactly equal to that which would flow from the metering jets if the carburetor were attached to an engine with the corresponding volume of air flowing through the throttle body.

This means that if the same conditions of suction and pressure can be imposed on the carburetor or master control artificially as when it is in place upon the engine, it can be tested independently of the engine. This is exactly what is done on the flow bench. Instead of having air actually flowing through the throttle body—as would be the case with the carburetor on the engine—the corresponding values of suction and impact pressure, which produce the same effect as the airflow, are employed in the test.

It has been explained that the air section of the regulator unit is divided by a diaphragm into a low-pressure chamber and a high-pressure chamber. The pressure difference between the two chambers acting upon the air diaphragm produces the air metering force. To avoid the necessity of regulating both suction and pressure on the diaphragm during a test on the flow bench, a value of suction alone equal to the difference in pressure between the two chambers is applied to the suction side of the diaphragm. The other side has a vent open to the outside air, so that it is always at atmospheric pressure.

A carburetor test on the flow bench consists of applying a value of suction to the regulator unit corresponding to an airflow for each engine operating condition and of measuring the resulting fuel flow from the metering jets. The fuel/air ratio is the ratio of the number of pounds of air corresponding to the value of the suction applied to the low-pressure chamber of the regulator unit in relation to the number of pounds of air flowing from the metering jets.

The flow bench used for testing carburetors and master controls consists of equipment that will supply a source of regulator suction, a fuel supply that will maintain fuel delivery to the unit being tested at the required pressure, manometers (gages for measuring the pressure of gases and vapors), and gages for measuring the fuel flow through the carburetor. Through use of the flow bench, a simple, definite, and accurate check can be obtained on the performance that the carburetor or master control will give when installed on an engine.

IGNITION SYSTEM

The ignition system on the reciprocating engine, from the standpoint of the ADR performing troubleshooting maintenance, is probably the system with the most discrepancies. A clear understanding of the operation of the ignition system, the use of various pieces of testing equipment, the ability to interpret what the test equipment shows, and the proper maintenance procedures will improve aircraft availability, decrease operating costs, and make easier the job of maintaining the aircraft engine for the mechanic.

In troubleshooting the ignition system on a reciprocating engine, you will find that the use of certain pieces of equipment will become invaluable. In order to obtain the maximum use of test equipment and to thoroughly understand the ignition system, it is necessary for the mechanic to have an understanding of basic electricity. The necessary test equipment for maintaining ignition systems will be briefly discussed here. Refer to the appropriate technical publications for more detailed information concerning these pieces of equipment.

OHMMETER

The ohmmeter is used on the low-tension ignition system to check for continuity, amount of resistance, or for infinity in a circuit, or for part of a circuit. The ohmmeter has its own source of power; therefore, before using, always insure that the circuit being tested is not live. This will prevent damage to the ohmmeter. To use the ohmmeter, first turn the switch on. Then either set the selector switch to the LOW or HIGH position or place the test leads in the proper sockets in the meter to receive the proper reading in ohms. Touch the probes together and adjust the pointer to read "zero" by turning the adjusting knob. For testing, put that part of the circuit to be tested between the two probes. An infinity reading will indicate an open circuit, whereas any reading between zero and infinity will indicate the number of ohms resistance in that circuit.

HIGH-VOLTAGE INSULATION TESTER

There are several types of high-voltage insulation testers in use. One type is shown in figure 5-2. All of these testers are very dangerous if they are used improperly. The ground lead MUST always be connected to a definite ground before the tester is turned on. When testing a lead, the tester must be connected to that lead before the test voltage switch is turned on. A safe procedure is to operate the equipment and secure the leads with one hand only. The positive test voltage lead is connected to the conductor of the part to be tested. The negative test voltage lead is connected to the insulation of the part to be tested. After getting the proper reading, if the lead is good, turn the test voltage rheostat to zero. Allow the voltage to bleed off; then turn the test voltage switch to the OFF position and hook up to the next lead to be tested.

PISTON POSITION INDICATOR

The piston position indicator (the Time-Rite is a common type) is used to accurately determine the position of the piston, in crankshaft degrees, relative to top dead center (TDC). Due to the variations in spark plug position, cylinder size, piston dome shapes, etc., it is necessary to use the proper arm and scale for the engine on which you are working.

TIMING LIGHTS

The timing lights are used with the piston position indicator to determine the exact instant the breaker points open and close. There are several different types of timing lights in use in naval aviation. On some, the light goes out when the points open; on others, the light comes on when the points open. Some timing lights also incorporate a buzzer to aid in determining point opening and closing.

COLD CYLINDER INDICATOR

The cold cylinder indicator is a test instrument used in determining whether individual cylinders are functioning normally. It consists of a millivoltmeter, calibrated from 0° to 350° C. It has a wand connected to it by a two-wire

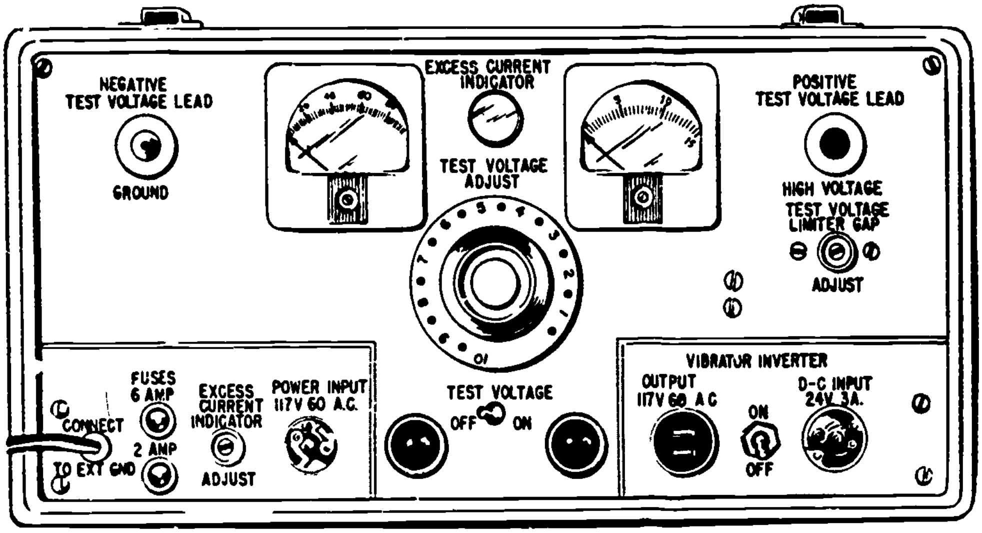

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Figure 5-2.—High-voltage insulation tester.

cable. The wand consists of a contact point, a chuck for holding the contact point, three rod sections, and a contact sleeve assembly (handle) containing a switch. A ground wire is equipped with an alligator clip.

After assembling the wand, check to see that the pointer indicates 0°. Adjust if necessary. The indicator is now ready for use. The procedure for using the indicator is as follows:

1. Head the aircraft into the wind, start the engine, and warm it up in the normal manner with the cowl flaps open until the CHT reaches 150°, or until temperature stabilizes at a lower reading.

2. Then place the ignition switch in the position in which an excessive magneto dropoff has been noted. Operate the engine between 1,200 and 1,600 rpm to allow the cylinders in which the plug or plugs are not firing to cool down.

3. Stop the engine and immediately perform the cold cylinder check. Starting with No. 1 cylinder, proceed in numerical order around the engine. Check and record the temperature reading on each individual cylinder, making sure that a good contact is made at the same relative point on each cylinder head, preferably near the exhaust port.

This check with the cold cylinder indicator should be made within the shortest time possible. The cylinders which have been operating properly will retain their heat and will be much higher in temperature than the cylinder that has not been operating. Do not perform this check with the cowling removed from the engine.

IDENTIFICATION OF METAL PARTICLES

When particles of metal are found in the fuel filter and oil screens, they may be either magnesium, steel cadmium, tin, aluminum, silver, or bronze. In some cases, the type of metal may be determined by the color and the hardness of the pieces. When the particles cannot be positively identified by visual inspection and the knowledge of the type of metal deposits is desired as an aid to troubleshooting, a few simple tests will determine the kind of metal present.

The following equipment and chemicals are required to make the few simple tests: A source of open flame, a permanent magnet, 5 percent solution of chromic acid, an electric soldering iron, and 2 ounces each of concentrated hydrochloric acid and concentrated nitric acid. CAUTION: Use extreme care when handling the acids.

For best results, the following test procedures are recommended for determining the type of unknown metal particles:

1. Magnesium. A simple test for magnesium particles is burning. Magnesium will burn with a bright white flash. CAUTION: Never attempt to burn more than a few particles of metal suspected of being magnesium. Magnesium powder or dust is explosive.

2. Steel. The steel particles can be isolated by using a permanent magnet. Steel or iron is attracted by a magnet.

3. Cadmium. Cadmium particles will dissolve quite rapidly when dropped in a 5 percent solution of chromic acid.

4. Tin. Tin particles can be distinguished by their low melting point. Use a clean soldering iron, heated to 260° C (500° F) and tinned with 50-50 solder (50 percent tin and 50 percent lead). A tin particle dropped on the soldering iron will melt and fuse with the solder.

5. Aluminum. When a particle of aluminum is placed in hydrochloric acid, it will fizz with a rapid emission of gas bubbles and gradually disintegrate, forming a black residue (aluminum chloride). Silver and bronze are not noticeably attacked by hydrochloric acid.

6. Silver. When a silver particle is placed in nitric acid, it reacts rather slowly, producing a whitish fog in the acid.

7. Bronze. When a bronze (or copper) particle is placed in nitric acid, it will react rapidly; a bright bluish green cloud is produced in the acid.

SPECTROMETRIC OIL ANALYSIS

The spectrometric method of analyzing engine oil for its metallic content has become an established program.

To date successes in spectrometric oil analysis have been mainly in analyzing conditions of reciprocating, turboprop, and turbojet engines and helicopter transmissions. By this method, impending failures were predicted before advancing to in-flight failures.

Under certain conditions and within certain limitations, the internal condition of any enclosed mechanical system can be evaluated by the spectrometric analysis of lubricating oil samples from all enclosed, oil-lubricated, aircraft mechanical systems.

Under normal conditions, the rate of wear of moving parts will be constant and quite slow, and the wear metal particles will be microscopic or submicroscopic in size so that the particles will remain in suspension in a recirculating lubrication system. The spectrometric oil analysis method is basically applicable only to those beginning failures which are characterized by an abnormal increase in the wear metal content of the lubricating oil, and which proceed toward total failure at a slow enough rate to permit corrective action to be taken by the operating activity after receipt of adverse reports from the laboratory.

The sampling interval is currently established as 30 operating hours. Samples should represent the oil circulating in the system. Ordinarily, about 5 hours' operation after oil change is needed to allow the circulating oil in an aircraft engine to reach equilibrium in regard to metal wear content. Samples taken after oil is added to the system should be taken only after the aircraft engine has been operated for at least 20 minutes.

Complete details of the spectrometric oil analysis program is contained in NAVMATINST 4731.1; titled Navy Oil Analysis Program (NOAP).

CORROSION

Metal corrosion is the deterioration of the metal by chemical or electrochemical attack. The deterioration can take place internally as well as on the surface. Corrosion can cause eventual structural failure if left unchecked. Therefore, corrosion cannot be overlooked as a possible cause of trouble when troubleshooting aircraft engines.

A thorough comprehension of the dangers of corrosion, the ability to recognize the various forms of corrosion, and the development of the skills necessary to cope with these dangers should be included in the objectives of every powerplants shop training program.

When troubleshooting a reciprocating engine, the entire engine as well as all parts removed should be cleaned and inspected for evidence of corrosion.

The following paragraphs describe some of the different types of corrosion and how to treat, prevent, and control them.

COMMON TYPES

Corrosion has been cataloged and typed in many ways. For descriptive purposes the following general breakdown is used:

1. Direct surface attack.
2. Galvanic or dissimilar metal corrosion.
3. Pitting.
4. Intergranular attack.
5. Crevice attack or concentration cell corrosion.
6. Fretting corrosion.
7. Stress corrosion cracking.
8. Corrosion fatigue.

Direct Surface Attack

The most common type of general surface corrosion results from direct reaction of a metal surface with oxygen in the air. General attack also occurs under marine conditions from exposure of bare aluminum to salt spray or salt-bearing air. The same type of attack results when engine surfaces are exposed to solid particles and gases blown from aircraft carrier stacks or when corrosion occurs downstream from engine exhaust areas.

All such direct surface attack results in general etching of the exposed areas. The entire area becomes anodic and loses electrons directly to the corrosive material dispersed in the air or spilled upon the surface of the metal.

Galvanic or Dissimilar Metal Corrosion

Most corrosion is galvanic in nature, involving an exchange of electrons between two points or areas, with the destruction of the anodic area. The specific type of attack indicated here is that which occurs whenever two metals or two metallic areas of different electrical potential are in contact with each other and also connected by a continuous liquid or gas path, usually salt spray, exhaust gas, or condensate. This is a true chemical cell. Electrons flow, and the anodic area is destroyed. (See fig. 5-3.) When such a condition develops, either from faulty design or from maintenance errors, the most easily oxidized surface becomes the anode (positive pole) of the galvanic cell and corrodes. The less active member of the couple becomes the cathode (negative pole) of the galvanic cell and is protected. The degree of attack depends on the relative activity of the two surfaces; the greater the difference in activity, the more severe the attack.

Pitting attack is a special kind of galvanic reaction, usually localized, with well-defined boundaries. It results from partial protection of an exposed area. Although pitting may occur in any metal system, it is particularly characteristic of the alloys of aluminum, nickel, and chromium, and is usually a localized breakdown of protection. The point of weakness may be a lack of homogeneity in the alloy surface, either from mechanical working or faulty heat treatment. It may result from an inclusion or rough spot in the metal surface or from localized contamination that breaks down the surface protection. (See fig. 5-4.)

True pitting takes place at random with no selective attack along grain boundaries. Isolated areas become anodic to the rest of the surface. Corrosion products formed accentuate the anodic characteristics in the pit area, and deep penetrating attack develops rather than a general surface attack. Aluminum alloy is particularly susceptible to perforation type pitting when in the presence of chlorides which are always present in salt deposits. Maintenance consists chiefly of washing away any concentration of chlorides and avoiding pockets of stagnant water on the engine.

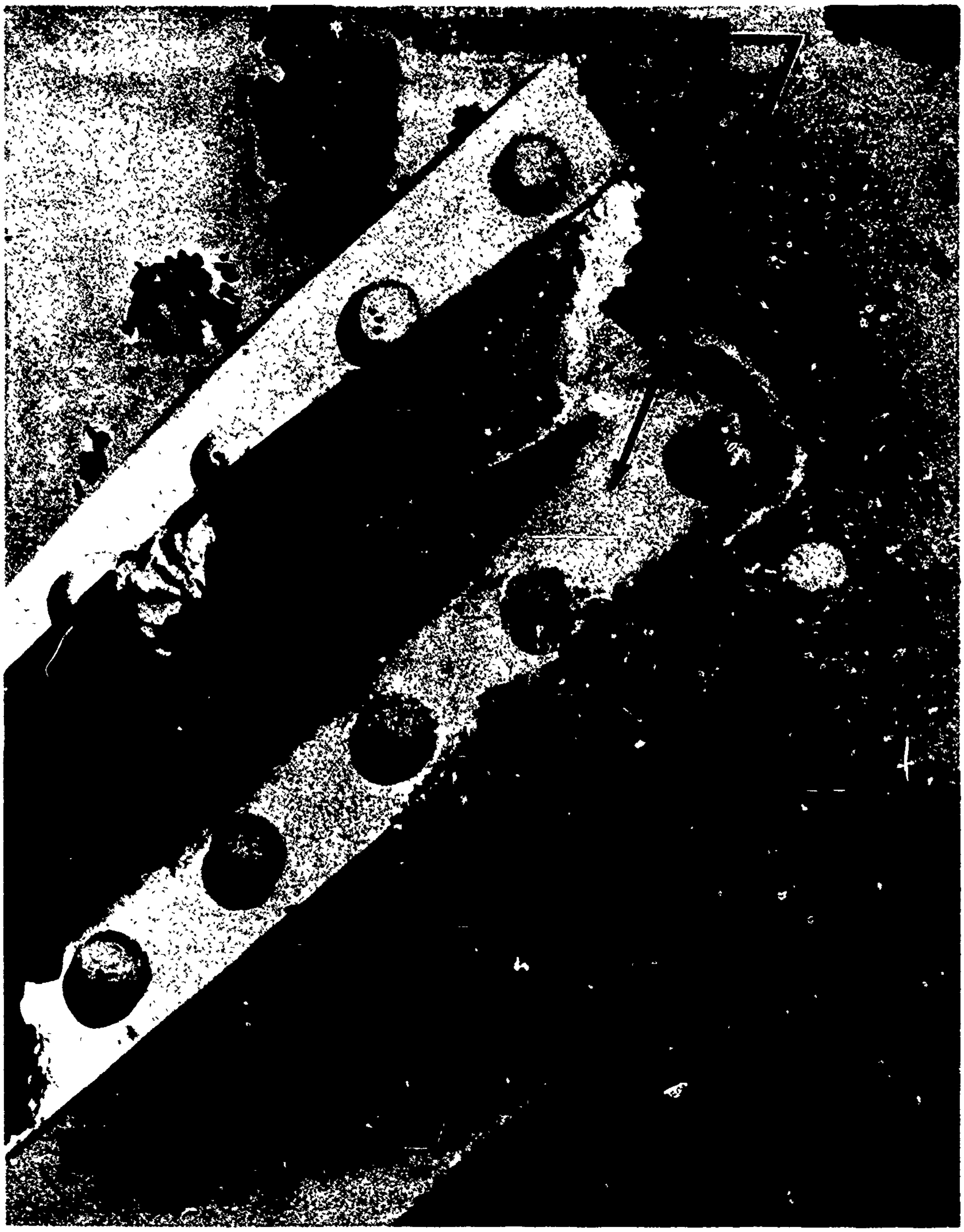
Intergranular Corrosion

Intergranular corrosion is selective attack along the grain boundaries of metal alloys. (See fig. 5-5.) It results from lack of uniformity in the alloy structure. It is particularly characteristic of aluminum alloyed with copper or zinc and some stainless steels. Aluminum extrusions and forgings in general may contain nonuniform areas, which in turn may result in galvanic attack along the grain boundaries. Piano hinges are used extensively in aircraft engine nacelles and are a good example of extrusions which are extremely susceptible to such attack.

Similar differences in structure can also develop from localized overheating, such as from fire damage, in which case the overheated area may become subject to intergranular attack. Stainless steels and chromium containing alloys in general are subject to intergranular attack when overheated.

Intergranular corrosion may exist without visible evidence on exterior surfaces, and serious structural weakening may occur before an appreciable volume of corrosion products accumulate on the surface. Methods are being developed to detect intergranular corrosion by use of ultrasonics and eddy currents. Until these are fully developed, squadron personnel should utilize the services of the nearest NARF materials engineering laboratory when intergranular corrosion is evident or suspected. When attack has gone deep enough, the corrosion may actually delaminate the basic metal layers, because of the increase in volume of the products over the original metal. This condition of layers of metal peeling off a surface is called "exfoliation."

In some cases intergranular corrosion can be controlled and treated if the attack has not penetrated too far, and if sufficient structural strength still remains. All corrosion products, surface pitting, and fissuring must be completely removed to make sure that a true evaluation of remaining structural strength is possible. The cleaned areas require surface treatment and a renewed protective coating.



AD.374

Figure 5-3.—Galvanic or dissimilar metal corrosion.

AD.375
Figure 5-4.—Pitting corrosion of steel.

Crevice Attack or Concentration Cell Corrosion

Concentration cell corrosion is a type of pitting attack which depends on differences in concentration of either the dissolved oxygen or the charged metal particles that may be present in an entrapped solution. If there are concentration differences at two different points in an entrapped pool of water or cleaning solution, anodic and cathodic areas may result, and the anodic area will be attacked. This type of attack is generally associated with crevices, scale, surface deposits, and stagnant water traps.

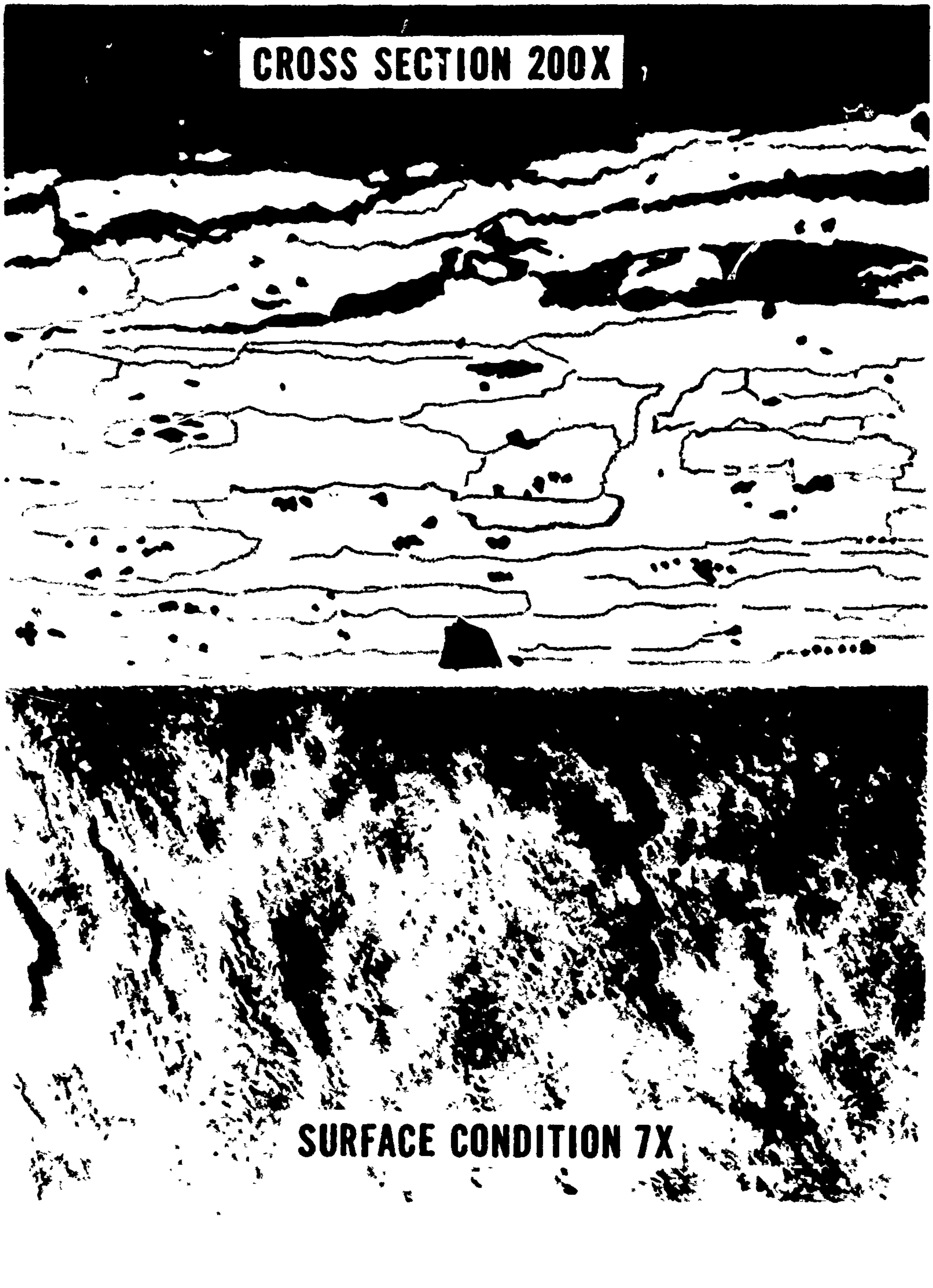
If iron is the corroding metal, it combines directly with oxygen to form insoluble ferric hydroxide, using up the oxygen and depositing red corrosion products at the point of attack. Around the edge of the corroded area, the oxygen is renewed by direct absorption of oxygen from the atmosphere. Underneath the corrosion deposits, a shortage of oxygen develops compared to the rest of the water solution, and the metallic area becomes anodic. Additional metal goes into solution, and a chemical cell results with differences in concentration of charged particles of iron in the solution also supplementing the effect of oxygen concentration differences. As a pit begins to form, the corrosion rate increases, since the bottom of a pit is a perfect spot for an anode to develop. The small area of the anode, compared to that of the cathode, accentuates and concentrates the attack.

Concentration cell corrosion can be controlled and prevented by keeping areas clean, by eliminating stagnant pools of water, by avoiding the creation of crevices during any repair work, and by eliminating existing voids which may become water traps by use of sealants and calking materials.

Fretting Corrosion

Fretting corrosion is a limited type of attack that develops when two heavily loaded surfaces in contact with each other are subject to slight vibratory motion or oscillations. (See fig. 5-6.) At least one of the surfaces must be metallic. The rubbing contact destroys any protective film that may be present on the metallic surface, and additionally removes small particles of virgin metal from the surface. These particles will usually oxidize to form abrasive materials. The continuing motion of the two surfaces prevents the formation of any protective oxide films and exposes fresh active metal to the atmosphere. Supplemented by the abrasive effects of the corrosion products, support areas in general become actively corroded. If the contact areas are small and sharp, deep grooves resembling Brinell markings or pressure indentations may be worn in the rubbing surface. As a result, this type of corrosion has also been called false brinelling when developing on bearing surfaces.

Fretting corrosion is evident at an early stage by surface discoloration and the presence of corrosion products in any lubricant present. It frequently develops when moving heavy equipment by truck or from the rhythmic vibration of a railroad car during long hauls. This type of corrosion is limited in its occurrence, but its presence ruins bearing surfaces, destroys critical



AD.376

Figure 5-5.–Intergranular attack in aluminum alloy.

AD.377
Figure 5-6.—Fretting corrosion of steel.

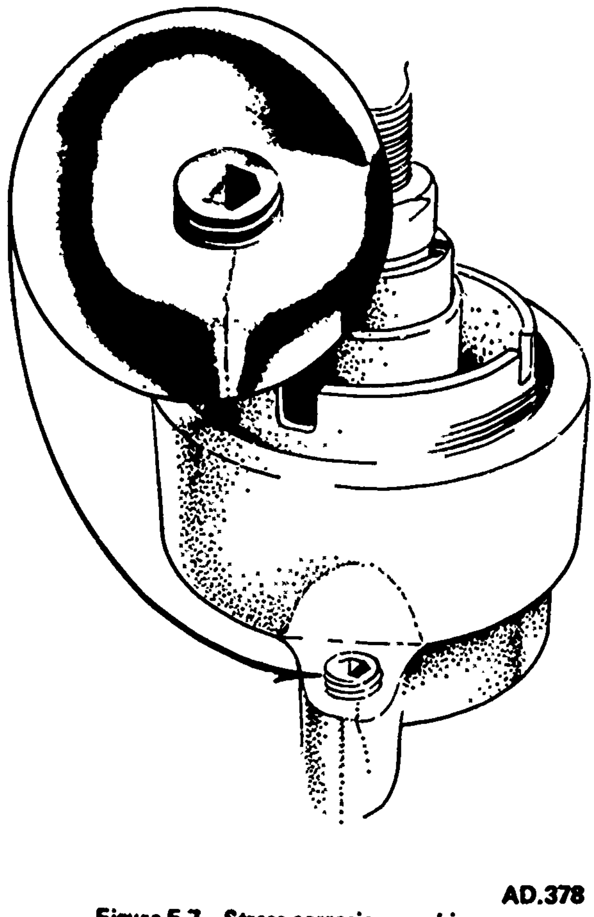
dimensions, and may be serious enough to eventually cause actual cracking and fatigue failure. It can be reduced either by controlling rhythmic vibration or by preventing slippage of two metal surfaces. Contact surfaces may be bonded together or slippage controlled by increasing the contact load. Use of oils, greases, or dry film materials also usually reduces the degree of fretting corrosion by lubricating the oscillating surfaces.

Stress Corrosion Cracking

Stress corrosion is the combined effect of static stresses applied to a surface over a period of time under corrosive conditions. (See fig. 5-7.) Stress corrosion cracking is found in most metal systems; however, it is particularly characteristic of aluminum, copper, certain stainless steels, high strength alloy steels, and magnesium alloys. It usually occurs along lines of cold working and may be transgranular or intergranular in nature. Aluminum alloy bellcranks employing pressed-in taper pins, clevis joints, shrink fits, and exposed or overstressed tubing "B" nuts are examples of parts which are susceptible to stress corrosion cracking. Distorted and stressed metal tends to become anodic when in contact with stress-free material, and the galvanic attack occurs along the lines of stress, which in turn results in rapid failure of the part.

Corrosion Fatigue

Corrosion fatigue is a second type of stress corrosion resulting from cyclic stresses on a metal in corrosive surroundings, rather than the



AD.378
Figure 5-7.—Stress corrosion cracking.

static loads that cause stress corrosion cracking. The resulting corrosion usually starts at the bottom of an existing shallow pit in the stressed area (fig. 5-8). Sharp deep pits form, which in turn become the origin of cracks that may ultimately result in failure of the part. This type of attack is characteristic of any part under regular cyclic stressing. Once attack begins, the continuous flexing prevents the repair of protective surface coatings, and additional corrosion takes place in the area of stress. It is difficult to detect this type of attack in advance except as cracking develops. Frequently, by the time it is noted, the only solution is the replacement of the part.

IDENTIFICATION AND TREATMENT

When active corrosion is visually apparent, a specific and immediate program for identification and treatment is required. In general, any complete treatment involves the cleaning and stripping of the corroded area, the removal of as much of the corrosion products as practicable, the neutralization of any residual materials that may remain in pits and crevices, such restoration of protective surface treatment films as is practicable, and the earliest replacement of permanent protective coatings and paint finishes. Each particular type of corrosion has its own peculiarities and may require special treatment.

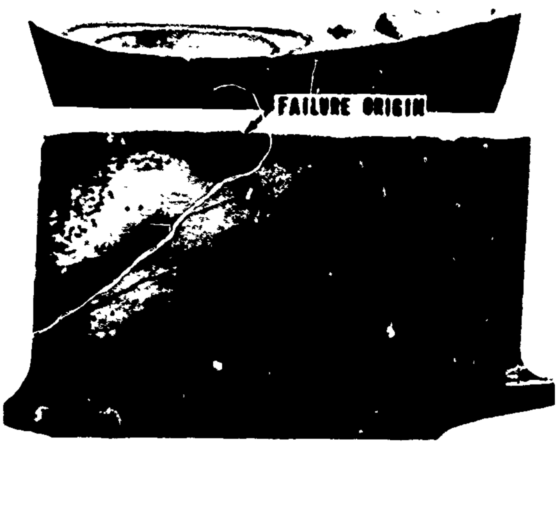


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Figure 5-8.—Corrosion fatigue.

One of the most familiar types of corrosion is red iron rust, generally resulting from atmospheric oxidation of steel surfaces.

Some metal oxides protect the underlying base metal, but red rust is not a protective coating in any sense of the word. Its presence actually promotes additional attack by attracting moisture from the air and acting as a catalyst in causing additional corrosion to take place. As a result, all rust must be removed from steel surfaces if complete control of corrosive attack is to be realized. There is no effective inhibitor for its safe control on aircraft surfaces in the installed condition.

Rust first shows on boltheads, holddown nuts, and other unprotected aircraft hardware. Its presence in these areas is generally not dangerous and has no immediate effect on the structural strength of any major components. However, it is indicative of a general lack of maintenance and possible serious attack in more critical areas. It is also a factor in the general appearance of the equipment. When paint failures occur or mechanical damage exposes highly stressed steel surfaces to the atmosphere, even the smallest amount of rusting is potentially dangerous in these areas and must be removed and controlled.

Magnesium attack is possibly the easiest type of corrosion to detect in its early stages, since magnesium corrosion products occupy several times the volume of the original magnesium metal destroyed. The beginnings of attack show as lifting of paint films and white spots on the magnesium surface, which very rapidly develop into snowlike mounds or even white whiskers. Reprotection involves the maximum removal of corrosion products, the partial restoration of surface coatings by chemical treatment, and a reapplication of protective coatings.

PREVENTIVE MAINTENANCE

Preventive Maintenance is a powerful tool which can be used to effectively correct even the most difficult "built-in" corrosion problem.

Such a program can be adjusted by the operating squadron to meet the severe environment of shipboard operations, and then decreased in scope when the aircraft is returned to the relatively mild conditions of an island shore base. Much has been done to improve the corrosion resistance of military aircraft, including improvements in the selection and combination of materials of construction, in chemical surface treatments, in dissimilar metal insulation, and in protective paint finishes. All of these have been aimed at reducing maintenance effort as well as improving reliability. But in spite of refinements in design and construction, corrosion and its control are a very real problem that requires a continuous maintenance program particularly under marine operating conditions.

Methods

Preventive maintenance, as related to corrosion control, includes the following specific functions:

1. Adequate cleaning program.
2. Periodic lubrication.
3. Detailed inspection for corrosion and failure of protective systems.
4. Emergency treatment of corrosion as it occurs.
5. Early paint touchup of damaged areas.
6. Use of supplementary preservative coatings as necessary.
7. Adequate draining of internal cavities by maintaining drain holes free of obstructions.
8. Daily draining of fuel cell sumps to remove accumulated water and other foreign matter.
9. Daily wipe down of exposed critical surfaces.
10. Sealing of aircraft against water and salt spray during foul weather, and proper ventilation of the same aircraft on warm, sunny days.
11. Using all available protective covers on parked aircraft (wing roots, air intakes, engine covers).

In corrosion control work, the term "clean" means to do the best job possible, using the materials and facilities available. A wipe down with a water- or oil-soaked cloth is better than no cleaning at all. The importance of frequent cleaning cannot be overemphasized. However, any cleaning procedure used should always be the mildest method which will produce the desired results. For example, steam cleaning is a very effective method for removing soils and residual grease, but it also may erode paint and damage electrical insulation. The Aircraft Cleaning and Corrosion Control Manual, NA 01-1A-509, covers procedures to be used in cleaning aircraft. This manual should be referred to for detailed information on materials, methods, and equipment.

In general, aircraft engines should be cleaned as often as necessary to keep surfaces free of salt, soil, and other corrosive deposits. More specifically, a thorough cleaning should always be accomplished as a part of each calendar inspection. Such routine or periodic cleaning should include the removal of all oil, water, and engine exhaust deposits; the replacement of contaminated supplementary preservative coatings; and a thorough cleaning of all external surfaces.

The amount of cleaning necessary between periodic inspections varies with operating conditions, but for ship-based aircraft any period of foul weather should be followed by fresh water to remove salt deposits. If fresh water is not available, waterless cleaner may be used for limited shipboard cleaning. In any type of cleaning, make sure that salt solutions and cleaning compounds are not washed into internal areas and allowed to become trapped. Mask or seal vents and openings necesary to prevent this. Following cleaning, rinse out and drain exposed cavities to assure that residual cleaning materials have all been removed.

Engine frontal areas and cooling air vents are being constantly abraded with airborne dirt and dust, bits of gravel from runways, and rain erosion, which tend to remove the protective finish. In addition, air intake ducts, cooler radiator cores, etc., are not painted. Engine accessory mounting bases usually have small areas of unpainted magnesium or aluminum on the machined mounting surfaces. With moist, salt-laden air constantly flowing over these surfaces, they are prime sources of corrosive attack. Inspection of such areas should also include all sections in the cooling air path, with special attention to obstructions and crevices where salt deposits may build up during marine operations. It is imperative that incipient corrosion be inhibited and that paint touchup and hard film preservative coatings be maintained intact on seaplane and amphibian engine surfaces at all times.

Equipment

In emergencies where regular waterproof canvas covers are not available, suitable covering and shrouding may be accomplished by using polyethylene sheet, polyethylene-coated cloth or metal foil barrier material. These covers should be held in place with specification tapes designed specifically for severe outdoor applications. All covers and shrouds should be installed in such a manner that free drainage is assured. Do not create a bathtub which will trap and hold salt water. Shrouds or covers may also act as a greenhouse in warm weather and cause collection and condensation of moisture underneath. They should be loosened or removed and the aircraft ventilated on warm, sunny days. Where protection from salt spray is required aboard carriers, leave covers in place and ventilate only in good weather. Fresh water condensate will do far less damage than entrapped salt spray.

CHAPTER 6

ENGINE ANALYZERS

As naval aviation progressed new equipment was developed to assist maintenance personnel in maintaining and operating the new aircraft. An example of the new equipment developed is the engine analyzer. The engine analyzer provides continuous visual analysis of the complete aircraft powerplant. It not only detects, but also locates and identifies all of the common ignition malfunctions and imminent failures that may occur during engine operation. The Sperry and Bendix engine analyzers are covered in this chapter.

FUNCTIONS

The function of the engine analyzer is to provide the operator with a means for quick detection, location, and identification of engine malfunctions in flight or on the ground by maintenance personnel, and for checking out engines after overhaul or repairs. In flight, it provides a means for the flight engineer to keep the engines of the aircraft under constant surveillance. Should an engine malfunction develop, he can evaluate its severity and make the adjustments as required. Further, with the identity and location of the malfunction definitely established while the aircraft is still airborne, the ground crew can concentrate on remedying the malfunction immediately on landing without the need of time and effort to locate and identify it. A further important fact is that the engine analyzer can detect troubles peculiar to high altitudes which could not normally be discovered during ground checks.

IGNITION ANALYSIS

During ignition analysis the engine analyzer records the voltage of the primary coil. In a sense the analyzer is a recording voltmeter, showing every change in voltage that occurs in the primary coil as the magneto completes a full cycle (two crankshaft revolutions). By sensing every change in the voltage of the primary coil, the analyzer shows how the magneto is operating. It shows breaker point operation and measures the length of time they are open. It indicates an improperly operating primary condenser and shows the condition of the secondary circuit. To some extent the condition of the spark plugs will reveal to the experienced operator the condition of the cylinders.

VIBRATION ANALYSIS

Vibration analysis is accomplished by installing vibration pickup units on the cylinders and connecting the units to the analyzer. These units convert vibrations into voltages which can be seen on the indicator of the analyzer. The use of vibration analysis can minimize the more costly engine repairs, such as cylinder changes and engine changes. By inspection of valve action and combustion characteristics the mechanic can see evidence of malfunctions before serious damage is done. Early detection of such things as improper valve clearance, valve bounce or wobble, and detonation may greatly increase the lifespan of the engine.

PORTABLE ANALYZERS

SPERRY PORTABLE ENGINE ANALYZERS

The Sperry Portable Engine Analyzer can be used to analyze only one engine at a time. It is universal in that it can be used with any type engine. It can be used with engines having any number of cylinders. The portable analyzer consists of an indicator, cycle switch, condition switch, power switch, signal switch for pattern attenuation, sweep switch, generator rotation switch, power supply amplifier, inverter, and isolating resistor, mounted in a single cabinet. A synchronizing generator, a vibration pickup unit, and connecting wires and cables complete the portable engine analyzer. A Sperry Portable Engine Analyzer is shown in figure 6-1.

Components

CATHODE RAY TUBES.–The cathode ray tube has a phosphorescent screen upon which voltages of the ignition primary circuit or of the vibration pickup units are displayed as patterns, which the operator interprets. An electron gun in the cathode ray tube generates an electron beam and directs it against the screen. Two sets of deflection plates in the cathode ray tube cause this beam to move on the face of the screen. Voltages in the primary circuit of the magneto (or vibration pickup units during vibration analysis) control the vertical deflection or movement. Changes in these voltages cause the position, shape, or size of the pattern to vary. Voltages from the synchronizing generator control the horizontal deflection of the beam, according to crankshaft position.

CYCLE SWITCH. The cycle switch (fig. 6-2) enables the operator to select the pattern of a certain position of the crankshaft (the pattern of a certain cylinder). Three removable faceplates, with the firing order of 9- and 18-, 7- and 14-, and 28-cylinder engines, are furnished with the Sperry engine analyzer. (See fig. 6-3.) A red dot at the base of the pointer of the cycle switch is used as an index mark for vibration analysis. When the red dot is alined with a selected cylinder number, the exhaust valve closing of that cylinder will appear on the left of the viewing screen.

CONDITION SWITCH.–A condition switch permits the operator to select the type of analysis desired. One is shown in figure 6-4. The condition switch has one index mark which may be lined up with one of five positions:

- L - The pattern of the left magneto is shown on the indicator.

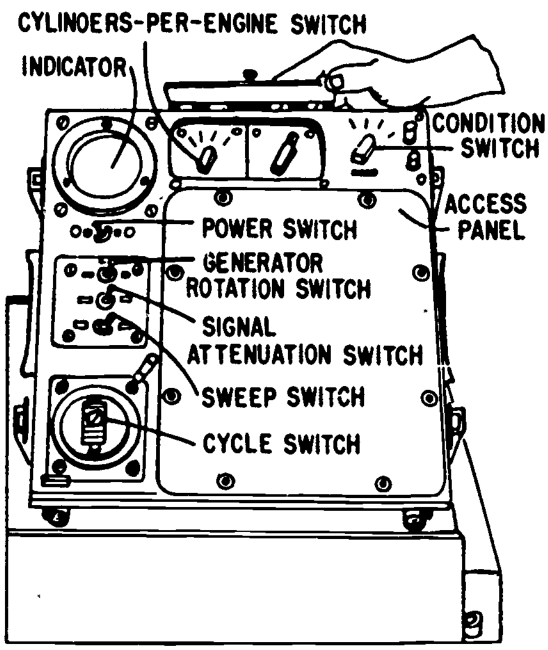

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Figure 6-1.–Sperry Portable Engine Analyzer.

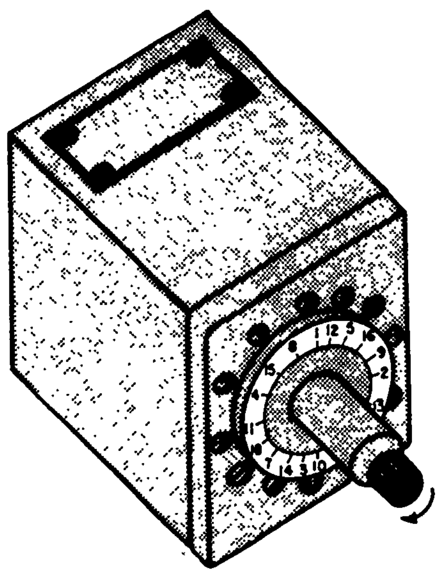

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Figure 6-2.–Cycle switch (with 18-cylinder faceplate installed).

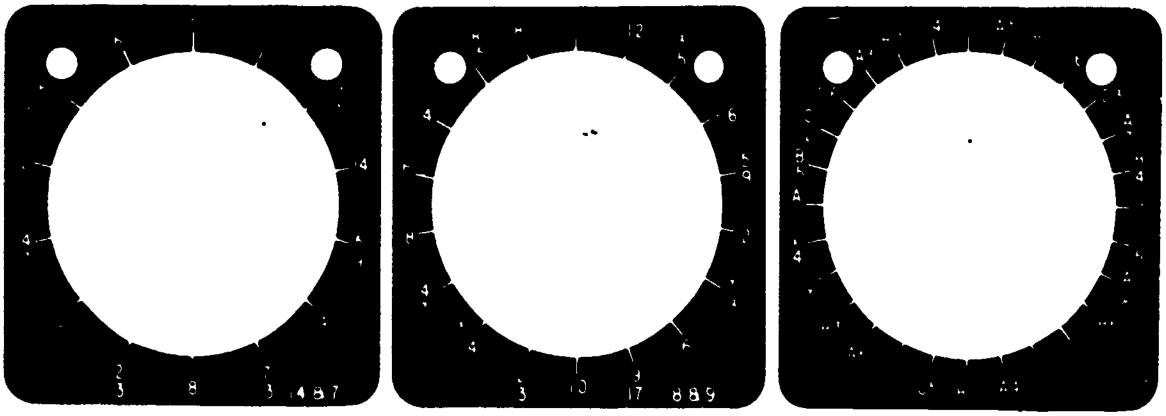

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Figure 6-3.—Cycle switch faceplates.

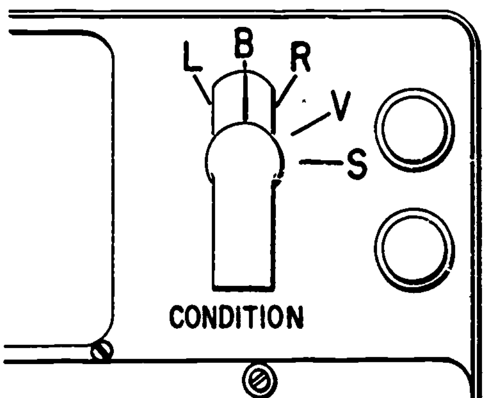

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Figure 6-4.—Condition switch.

B - The pattern of both magnetos is shown on the indicator.

R - The pattern of the right magneto is shown on the indicator.

V - The vibration pattern is shown on the indicator.

S - This position establishes the circuit for analysis of any other chosen source of signal voltage delivered to the analyzer by means of the two posts adjacent to the condition switch.

POWER SWITCH.—The power switch is a two-position, ON-OFF toggle switch which controls the power to the analyzer.

GENERATOR ROTATION SWITCH.—The generator rotation switch is a two-position switch, clockwise and counterclockwise, which is provided to reverse the phasing sequence of the synchronizing generator. This feature permits the use of one cable for generators of either clockwise or counterclockwise rotation.

NOTE: The generator rotation switch must be placed in the position which will cause the patterns to move from right to left when the cycle switch is rotated in a clockwise direction. The check for this condition is called the phasing check.

SIGNAL SWITCH.—The signal switch is a two-position switch, attenuated and normal. When this switch is in the NORMAL position, the patterns are of a normal size. In the

ATTENUATED position, the signal voltages are reduced to a lower amplitude, and the patterns appear much smaller.

SWEEP SWITCH.–The sweep switch is a two-position toggle switch, slow and fast. In the SLOW SWEEP position, the patterns for 720° of crankshaft travel (18 patterns on 18-cylinder engines) appear on the screen. In the FAST SWEEP position, the patterns for 80° of crankshaft travel (2 patterns on 18-cylinder engines) appear on the screen.

CYLINDERS PER ENGINE SWITCH.–The cyls-per-engine switch is a four-position switch labeled 18 HT or less, 18 LT, 28 HT, and 28 LT. This switch selects the number of isolating resistors to be used. It must be set to the position corresponding to the number of cylinders and type ignition system being analyzed.

POWER SUPPLY AMPLIFIER.–The power supply amplifier contains the various circuits, capacitors, transformers, and resistors necessary to provide the voltage required for the proper operation of the engine analyzer. It provides the means of making the proper pattern adjustments. These are screwdriver adjustments. (See fig. 6-5.)

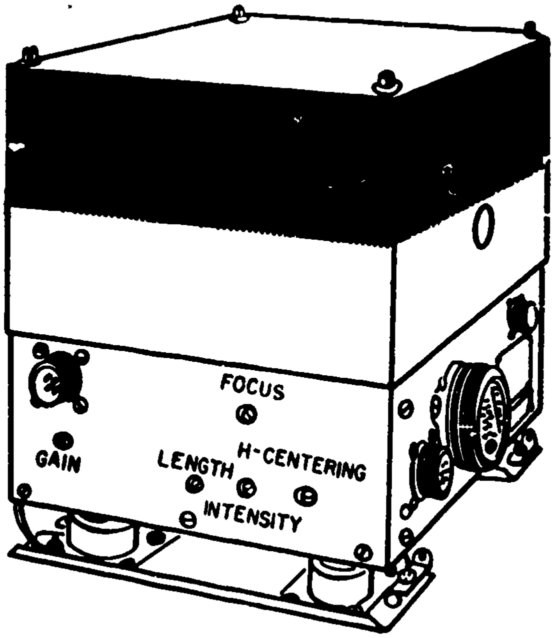

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Figure 6-5. Power supply amplifier showing screwdriver adjustments.

1. The intensity adjustment screw regulates the brightness of the pattern. The adjustment screw is turned in one direction or the other until the brilliance desired by the operator is obtained.

2. The focus adjustment screw controls the sharpness of the picture. The desired sharpness is obtained by turning the screw in one direction or the other.

3. The H-centering (horizontal centering) adjustment controls the start ot the trace line from the left side of the cathode ray tube. (The trace line, seen on the indicator, is caused by the electron beam being deflected across the cathode ray tube by the horizontal deflection plates.) The trace line is adjusted to begin one-eighth inch from the left side of the cathode ray tube. Before making the adjustment, the sweep switch must be in the SLOW SWEEP position, showing the patterns of all the cylinders.

4. The length adjustment controls the length of the trace line. It should be adjusted to give a trace line 2½ inches long. This will normally extend the right end of the tracc line to one-eighth inch from the right edge of the cathode ray tube. The sweep switch must be in the SLOW SWEEP position for this adjustment also.

NOTE: Engine must be at cruise for all trace line adjustments.

5. The gain adjustment is used only for vibration and special analysis. It adjusts the background hash or trace line. The amplitude of the vibration pattern is dependent upon the shock forces applied to the cylinder.

ISOLATING RESISTOR BOX.–Isolating resistors are in the circuit between the aircraft engine and the engine analyzer. They prevent the engine magnetos from grounding out in the event that the engine analyzer develops an unintentional ground. They also reduce the voltage that is applied to the CRT.

INVERTER.–An inverter is used to convert the 24- to 28-volt, d-c input power to the required 115-volt, a-c (400-Hz) supply for the engine analyzer.

SYNCHRONIZING GENERATOR.–The synchronizing generator is mounted on the auxiliary tachometer drive of the aircraft engine. This is the unit that permits timing of the analyzer to the aircraft engine. It furnishes the voltages needed for control of the horizontal trace line. Two types are available to fit either of two standard types of mounts with which aircraft engines are equipped. Each of these two types may be fitted with either a straight or an offset electrical receptacle. Figure 6-6 shows a flange-mounted generator with an offset receptacle.

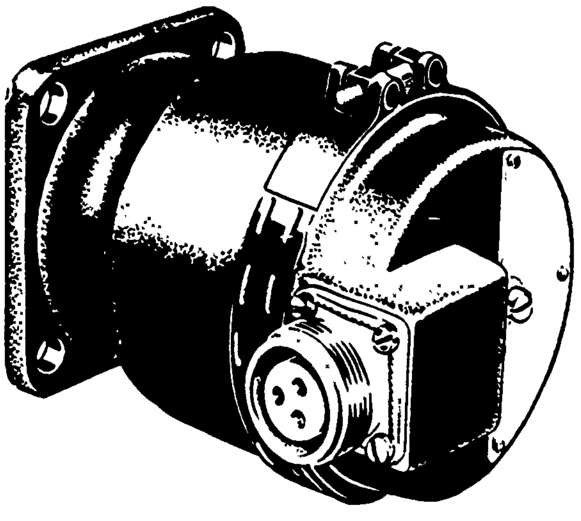

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Figure 6-6.–Flange-mounted synchronizing generator with an offset receptacle.

Figure 6-7 shows a synchronizing generator, mounted by internal threads of the generator housing and having a straight electrical receptacle. Flexible drive shafts are provided for some installations. However, when a flexible shaft is used, it is possible for undesirable whip action of the shaft to have an adverse effect upon the timing.

VIBRATION PICKUP UNIT.–The vibration pickup unit, containing a coil and a magnet, is mounted on the aircraft engine cylinder head to be analyzed. The unit is installed either directly

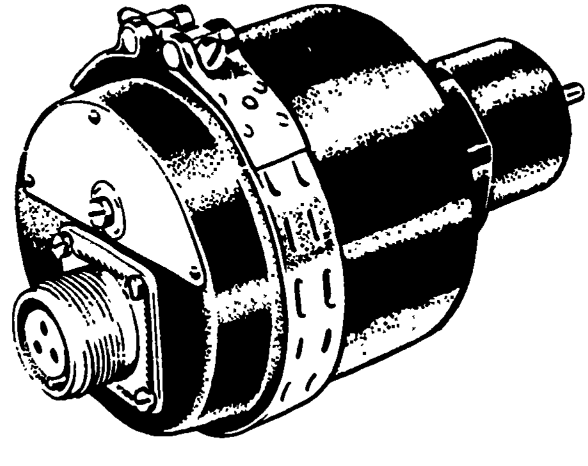

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Figure 6-7.–Thread-mounted synchronizing generator with a straight receptacle.

in a tapped hole provided in the cylinder head or in an adapter mounted in the tapped hole, depending on the particular engine. Since the portable engine analyzer is not equipped with a vibration selector switch and harness, it is possible to analyze, for vibration, only one cylinder of an engine. Any vibrations (impact forces) in the cylinder are transmitted to the magnet in the pickup, causing the magnetic field to strengthen or weaken, producing voltage. The value of this voltage depends upon the impact forces in the cylinder. A vibration pickup unit is shown in figure 6-8.

Connecting the Portable Analyzer to the Engine

The portable engine analyzer is usually mounted in a portable cart assembly, equipped with a power panel and various cables for connecting the analyzer to the engine. If it is impracticable to use the cart assembly at any time, the engine analyzer may be removed from it, and power from the aircraft inverter or other source supplying the required 115-volt, a-c power may be used. The inverter which normally converts the 28-volt input to 115 volts would remain with the cart assembly and so is

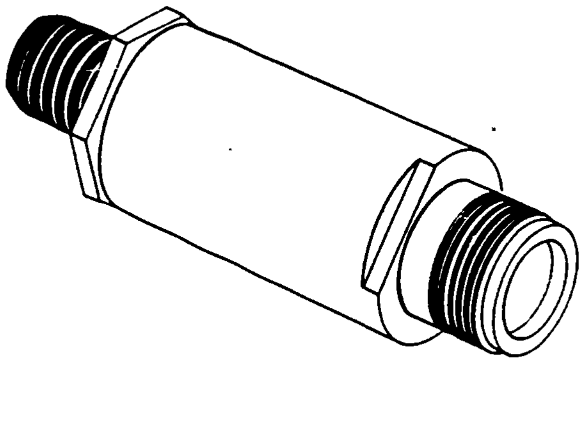

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Figure 6-8.—Vibration pickup unit.

not used when the analyzer is removed from the cart assembly.

A general coverage of the procedure for connecting the analyzer to the engine is given here. The appropriate technical publication must be consulted for specific instructions. The general procedure is as follows:

1. Install the synchronizing generator on the auxiliary tachometer mounting pad, using the proper adapter, if necessary, and the appropriate generator type.

2. Install the vibration pickup unit on the cylinder head, if vibration analysis is desired.

3. Make the cable connections to the analyzer, as shown in figure 6-9.

BENDIX ENGINE ANALYZER

The Bendix analyzer is similar in many respects to the Sperry portable; however, the controls are labeled differently, and there are some additional controls. The following paragraphs explain the functions of the Bendix analyzer controls and their use. Figure 6-10 shows the front panel of the Bendix analyzer.

SPARE - Contains a spare 0.75 amp fuse.

PILOT LIGHT - Indicates when power is applied to the analyzer circuity.

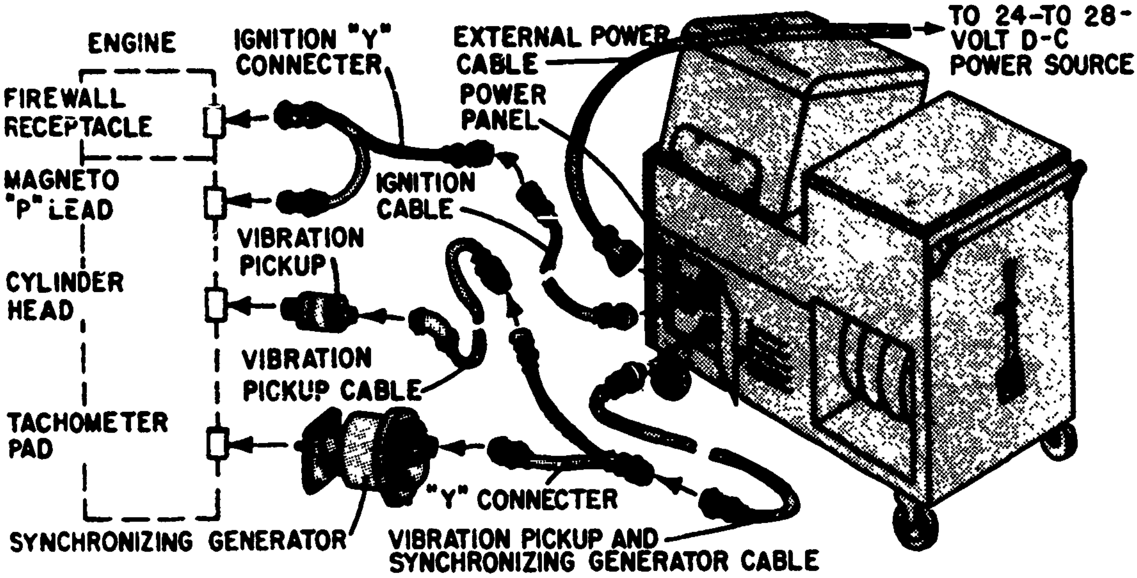

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Figure 6-9.—Portable engine analyzer installation diagram.

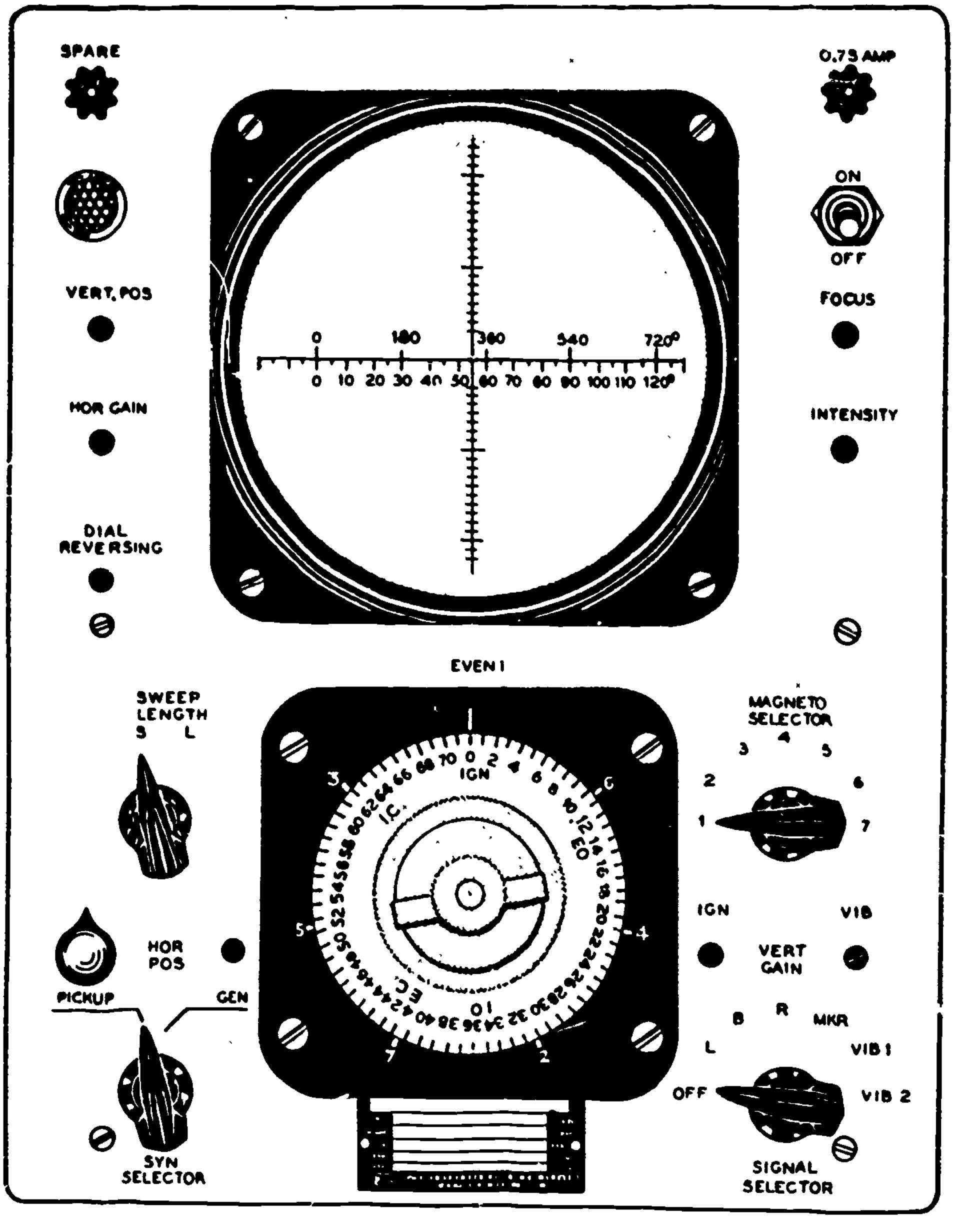

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Figure 6-10.—Bendix analyzer front panel.

VERTICAL POSITION - Used to either raise or lower the trace on the cathode ray tube.

HOR GAIN - Horizontal Gain Control, increases or decreases the width of the patterns.

DIAL REVERSING - Enables the operator to parade the patterns across the scope in the same direction that the EVENT control is rotated. (Same as the Sperry generator rotation switch.)

SWEEP LENGTH S L - Sweep Length Short or Long control. In the S (short) position all the ignition patterns for one magneto circuit appear on the analyzer scope. In the L (long) position the patterns are spread out enabling them to be observed one at a time. (Same as the Sperry sweep switch; short is the same as slow sweep and long is the same as fast sweep.)

HOR POS - Horizontal Position Controls. One is a knob control that is used when synchronizing with a capacitive type pickup in the long sweep position of the sweep length control. The other is a screwdriver control that is used when a synchronizing generator is installed. It functions in both short and long sweep, and is also used with capacitive pickup synchronization in the short sweep position. While one control is in use the other is inoperative. The screwdriver control used with the synchronizing generator enables the horizontal beam to be positioned on short sweep and normally does not need readjustment. (Same as the Sperry H centering adjustment.) The patterns are moved across the scope by the EVENT control. Since the EVENT control is not used with capacitive pickup synchronization the patterns are moved across the scope by use of the HOR POS PICK-UP Knob control.

SYN SELECTOR, PICKUP and GEN - Selects the desired type of synchronization. (Either capacitive pickup or three-phase generator.)

0.75 AMP - The main line AC power input fuse.

ON-OFF - The analyzer power control switch.

FOCUS - This control varies the sharpness of the electron beam in the cathode ray tube. (Same as the Sperry focus adjustment.)

INTENSITY - This control varies the briliancy of the electron beam in the cathode ray tube. (Same as the Sperry intensity adjustment.)

MAGNETO SELECTOR - Provides selection of up to seven dual magneto primary circuits for analysis.

VERT GAIN IGN and VIB - Vertical gain controls for Ignition and Vibration. Used to vary the vertical height of the patterns appearing on the scope.

SIGNAL SELECTOR - Selects the desired signal source for analysis. In the "L" position the left primary of the magneto previously selected by the MAGNETO SELECTOR switch will be observed. "B" position brings both magneto primaries (left and right) to the vertical deflection circuits. "R" position is for analyzing the right magneto primary. "MKR" (marker) uses a signal from the capacitive pickup as a timing reference when using a synchronizing generator, the capacitive pickup being installed in a known location, normally the number 1 cylinder. VIB 1 and VIB 2 (vibration) positions select the desired vibration pickup for analysis. (Same as the Sperry condition switch.)

NOTE: In order to obtain complete ignition analysis of an engine with more than two magneto primary circuits it will be necessary to use both the MAGNETO SELECTOR and SIGNAL SELECTOR switches. For example, an R3350 engine with low tension ignition would be analyzed in the following manner: MAGNETO SELECTOR to the number 1 position, SIGNAL SELECTOR to the "R" position; this will allow the operator to analyze R-1 primary circuit. By placing the SIGNAL SELECTOR to the "L" position the L-1 primary circuit may be analyzed. To analyze R-2 and L-2 primary circuits the MAGNETO SELECTOR must be positioned to the number 2 position, and the SIGNAL SELECTOR positioned to "R" for the R-2 primary circuit and then to "L" for the L-2 primary circuit.

EVENT - This control varies the point of synchronization (sweep initiation) thru a full 720 degrees of crankshaft rotation or two engine revolutions. This means that a pattern disappearing on one side of the analyzer scope will reappear on the opposite side thru continued rotation of the EVENT control; or, in other words the sweep may be started at any point during the engine cycle. Three reciprocating engine firing order sequence plates are secured to the analyzer. These three plates cover the 6, 7, 9, 14, 18, and 28 cylinder engines. The plates are easily changed by removing the four 1/4 turn fasteners. The desired plate is then placed in front and the plates resecured. The degree indicator is marked in engine degrees and is read by placing a zero after each indication, for example 4 is 40, 10 is 100, 36 is 360, and 0 is either 0 or 720. The dial indicator may be repositioned or set without moving the particular pattern on the analyzer scope. This is accomplished by holding the dial with one hand while using the other to loosen the keyed knob 1/4 turn. Rotate the dial keeping it out on its shaft. When positioned, retighten the keyed knob. (The EVENT control performs the same function as the Sperry cycle switch.)

PATTERN INTERPRETATION

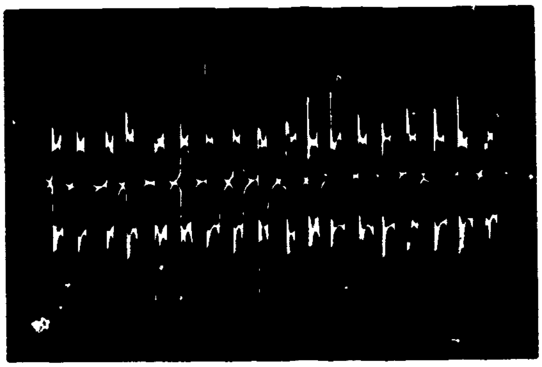
Cylinders free from malfunctions form patterns on the cathode ray tube that are characteristic of a specific engine type and of a specific engine ignition system. Malfunctions of the ignition system, improper combustion, and mechanical malfunctions in the cylinder will cause deviations from the normal patterns. The deviations may be irregularities in shape, or in the relative size or position of the patterns. Each type of malfunction forms a pattern peculiar to the malfunction. For example, on two engines of the same type, with the same type ignition systems, shorted high-tension leads would form similar patterns on the cathode ray tube.

There are several types of ignition systems, each of which produce groups of patterns peculiar to a certain type ignition system. The type of spark plugs installed may cause the patterns to vary slightly. For all of the previously mentioned reasons it is extremely important that the analyzer operator have a thorough knowledge of the ignition system and engine prior to attempting analysis or recommending any corrective action. The patterns of the low-tension ignition system used on the R3350 engine are discussed here. Other engines with low-tension ignition systems will produce patterns somewhat similiar to the patterns pictured in this chapter.

LOW-TENSION IGNITION SYSTEM PATTERNS

On the R3350 engine, the magneto arrangement is that of two 9-cylinder engines. Each primary coil of the magneto fires nine (an odd number) spark plugs; thus the successive firing of the same spark plugs are of alternate positive and negative polarity. For example, the first time that the front spark plug of No. 1 cylinder fires, the spark will travel from the center electrode of the spark plug to one of the outer electrodes; the next time this same spark plug fires, the spark will travel from one of the outer electrodes to the center electrode. This polarity change causes a double pattern to appear on the cathode ray tube. Normal patterns, slow sweep, 18-cylinder engine, low-tension ignition system, are shown in figure 6-11. With the sweep switch in the SLOW SWEEP position, crankshaft travel of 720° (all cylinders) appears on the cathode ray tube. The pattern at the left side of the cathode ray tube is the pattern for the cylinder selected by the cycle switch. The pattern second from the left is the pattern of the next cylinder to fire, and so on in the firing order of the engine.

Now place the sweep switch in the FAST SWEEP position. In this position crankshaft travel of only 80° (patterns of two cylinders)



AD.390

Figure 6-11.—Normal pattern—slow sweep, 18-cylinder engine, low-tension ignition system.

appears on the tube. The pattern on the left is the pattern of the cylinder selected by the cycle switch. The right-hand pattern is the pattern of the next cylinder to be fired by the same magneto. Figure 6-12 shows a normal low-tension pattern in the FAST SWEEP position. Both patterns appear above and below the trace line, as successive firings of the same spark plug are alternately positive and negative (positive above the trace line, negative below). The normal pattern has the following characteristics as shown in figure 6-12.

AD.391

Figure 6-12.—Normal low-tension pattern—fast sweep.

1. Breaker point opening. The instant of breaker point opening, shown by the departure of the beam from the horizontal trace line.
2. First excursion. The initial rise and the return toward the trace line, indicating the high initial peak voltage necessary to overcome the resistance in the secondary circuit.
3. Second excursion. Indication of the discharge of the condenser.
4. Saddle. Several low frequency waves representing ionization of the spark plug gap.
5. Hook. A slight, though distinct, increase in amplitude before the beam falls to the trace line, indicating combustion.
6. Breaker point closing. The point at which the pattern returns to the trace line.

An engine is analyzed by comparing the characteristics of abnormal patterns to the characteristics of a normal pattern. In general a malfunction that causes a higher than normal resistance in the ignition circuit (e.g., a disconnected spark plug lead) will produce a pattern that has a higher than normal amplitude and a shorter duration of the active portion of the pattern giving a high narrow appearance. A malfunction causing lower than normal resistance (e.g., a shorted spark plug lead) will produce a pattern with lower than normal amplitude and a longer duration of the active portion of the pattern giving a long, low appearance.

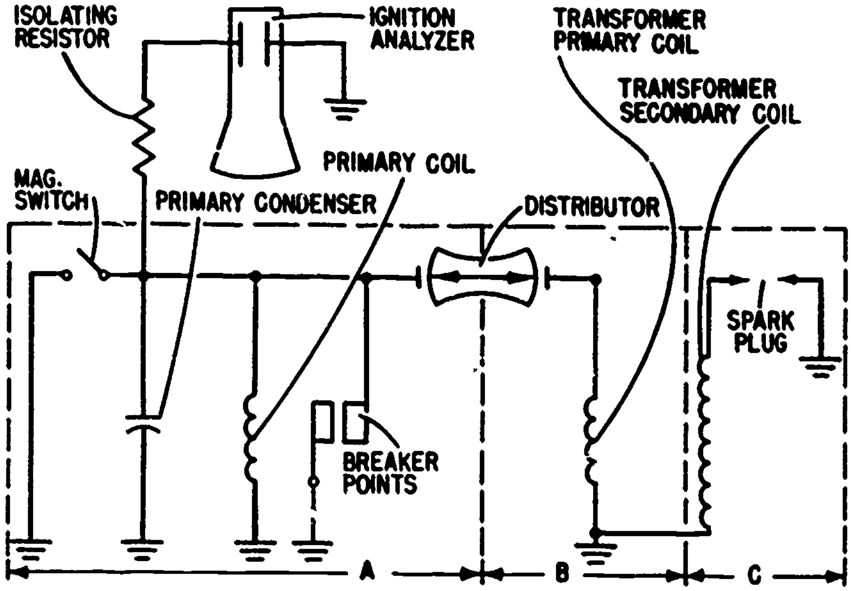
A schematic drawing of a low-tension ignition system is shown in figure 6-13. For the purpose of this discussion of abnormal patterns, the schematic drawing is divided into three sections: A, B, and C. The abnormal patterns are also divided into three groups. For example, a shorted secondary pattern will indicate trouble with one of the components in section C of the schematic drawing; it is listed with group C abnormal patterns.

In the following abnormal pattern illustrations in which the two patterns appear, the abnormal pattern appears on the left and a normal pattern is shown on the right for a comparison.

Group A Patterns

Groups A patterns are caused by arcing breaker points, breaker point bounce, breaker points out of synchronization, a shorted primary coil, an open primary coil, or an open connection somewhere between these components.

An arcing breaker points pattern is shown in figure 6-14. An early stage of arcing breaker points appears as a bright spot just after the breaker point opening. Severe arcing is illustrated. The arc is maintained until the points have opened sufficiently to extinguish the arc, at which time primary coil current flow ceases, inducing a surge of energy into the high-tension coil. The activity in this high-tension coil then becomes visible on the tube. Since a large percentage of the primary coil energy was dissipated during the arcing, the amplitude of the pattern is not as large as normal. The oscillation in the saddle portion of the pattern indicates that the spark plug is firing. All spark



AD.392

Figure 6-13.—Low-tension ignition system—schematic drawing.

AD.393

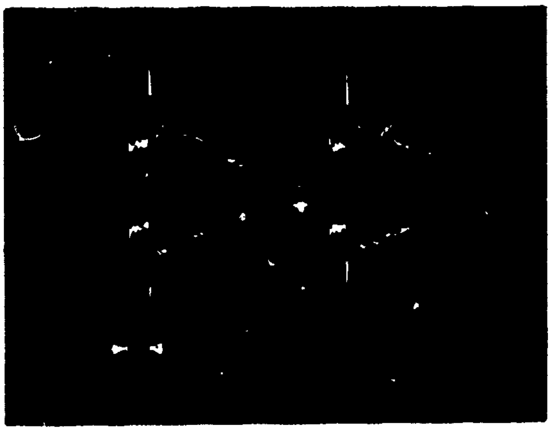
Figure 6-14.—Arcing breaker points pattern—low-tension ignition system.

plugs fired by the affected magneto display this pattern. Probable causes are oil on the breaker points or a defective (open) or disconnected primary condenser.

A breaker point bounce pattern is shown in figure 6-15. The pattern shown in figure 6-15 resembles that for breaker point nonsynchronization (fig. 6-16). The marked difference, however, is the short trace line separating the two initial high-amplitude oscillations. Breaker point bounce may occur before the normal breaker point opening and after the normal breaker point closing. Probable causes are a weak breaker point spring or damaged cam with rough spots on it. A weak spring should cause bounce on all spark plug positions of the affected magneto; for a damaged cam the bounce should occur on only one spark plug position.

A breaker point nonsynchronization pattern is shown in figure 6-16. The breaker point

AD.394
Figure 6-15.–Breaker point bounce pattern–low-tension ignition system.

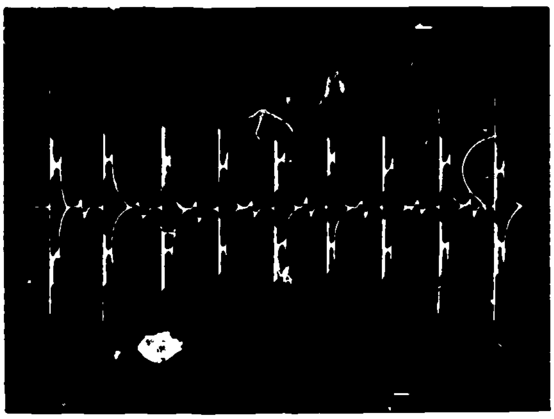


AD.395
Figure 6-16.–Breaker point nonsynchronization pattern–low-tension system (condition switch set to "B" position).

synchronization check is made to determine that both spark plugs in each cylinder are fired simultaneously. The condition switch is set to "B" (both magnetos) to display on the cathode ray tube the patterns from both left and right magnetos superimposed on each other. If the breaker points are not synchronized, the breaker points associated with the patterns appearing to the left are opening before those associated with the patterns on the right. By measuring the distance on the cathode ray tube between the breaker point openings and allowing 1/32 of an inch to equal 1° of crankshaft rotation, the amount of synchronization error may be determined. The breaker point nonsynchronization check should be made on the cylinder to which the magnetos are timed.

The foregoing check indicates that one set of breaker points is opening before the other set, but it does not indicate which breaker points are opening first. By switching the condition switch from "B" to "L," then to "R," it can then be determined which set of points is opening first but it cannot be determined by this check which set of points is timed properly.

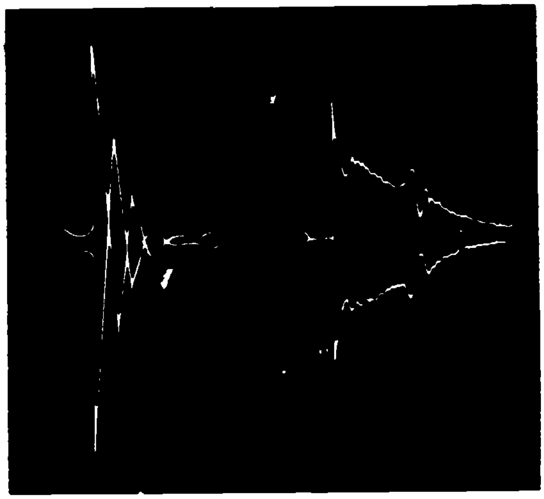
A shorted primary circuit (magneto to distributor) pattern is shown in figure 6-17. A completely shorted primary circuit in the grounding system or between the magneto and distributor produces no pattern; only the horizontal trace line is seen. Nine very small pips, which are inductive pickups from the other magneto, are sometimes visible. All spark plugs fired by the



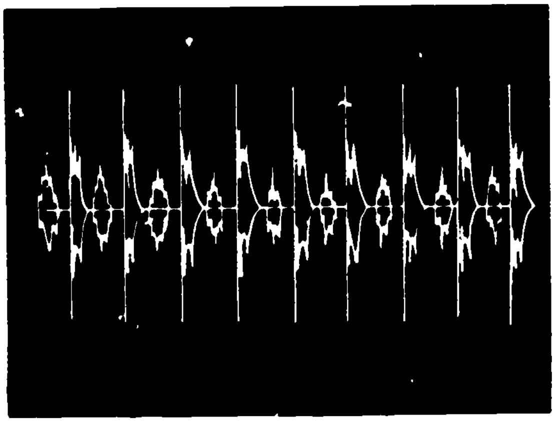
AD.396
Figure 6-17.–Shorted primary circuit (magneto to distributor) pattern–low-tension ignition system, slow sweep.

affected magneto will display this pattern. The nine additional patterns are from the other magneto. Probable causes are faulty magneto switch or grounding system, the breaker points not opening, a grounded primary coil or condenser, or a ground between the magneto and distributor.

An open primary circuit (magneto to distributor) pattern is shown in figure 6-18. The nine small distorted patterns are caused by the faulty circuit. The nine normal patterns are from the unaffected magneto, but are usually distorted slightly because of the malfunction present on the one magneto. Probable causes are the breaker points not closing either mechanically or electrically because of excessive point clearance or a foreign substance insulating electrical contact between the points. The pattern can also be caused by an open in the distributor.



AD.398
Figure 6-19.—Open primary circuit (distributor to coil) pattern—low-tension ignition system.



AD.397
Figure 6-18.—Open primary circuit (magneto to distributor) pattern—low-tension ignition system, slow sweep.

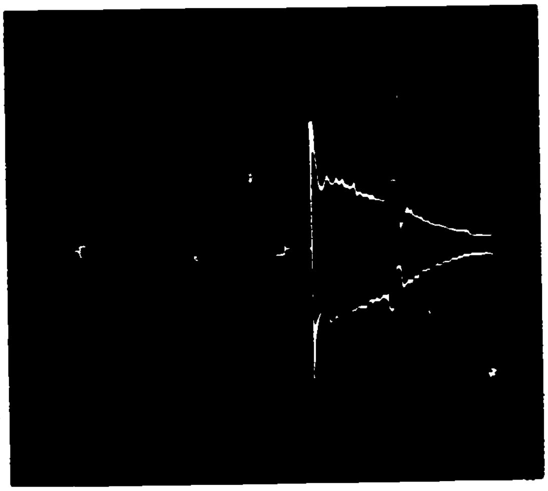
Group B Patterns

Patterns in group B are caused by trouble in the component shown in section B of figure 6-13.

An open primary circuit (distributor to coil) pattern is shown in figure 6-19. This pattern has a very high initial voltage and what appears to be a series of loops. Probable causes are an open in the lead from the distributor to the cylinder-mounted coil or an open in the primary winding of this coil.

A shorted primary circuit (distributor to coil) pattern is shown in figure 6-20. No pattern will appear for the selected spark plug (only a split trace line will be seen), but the pattern for the next spark plug fired by the selected magneto is distorted because of the reaction of this malfunction on the system. Probable causes are a ground in the primary lead from the distributor to the cylinder-mounted coil or a short in the primary winding of this coil.

An arcing distributor brush pattern is shown in figure 6-21. This pattern appears normal except for the unusual amount of activity in the sloping tail of the pattern between the hook and breaker point closing. Early stages of arcing appear on isolated cylinders. As the malfunction progresses, more cylinders are affected. The oscillations become larger and cover a greater portion of the pattern. Severe arcing may cause excessive activity throughout the entire length of the pattern. Probable causes are burned or dirty distributor segments, concaved segment surfaces causing the brushes to jump, weak brush springs, feathered segment edges, or excessive distributor vibration.



AD.399

Figure 6-20.—Shorted primary circuit (distributor to coil) pattern—low-tension ignition system.

AD.400

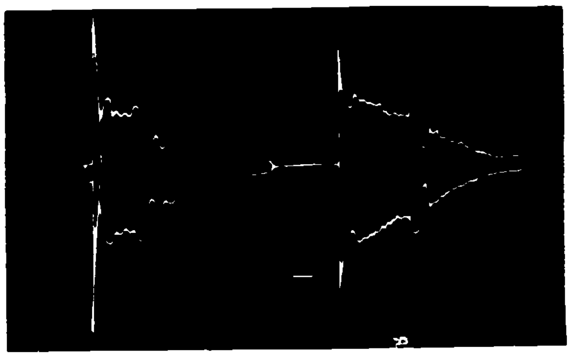
Figure 6-21.—Arcing distributor brush pattern—low-tension ignition system.

Group C Patterns

These patterns indicate a malfunction in the secondary coil of the transformer coil unit, the high-tension lead, or the spark plug itself. (See fig. 6-13.)

These are three different patterns caused by high resistance in the secondary circuit. The difference in these three patterns depends on the amount of that resistance. The resistance varies from first-stage resistance, which permits SOME spark across the spark plug gap, to an open circuit, which permits NO spark across the spark plug gap. It is sometimes hard to distinguish between the patterns of first-stage resistance and second-stage resistance, but since the causes are the same in both cases, the corrective action is the same. Second-stage resistance usually begins as first-stage resistance and becomes progressively worse.

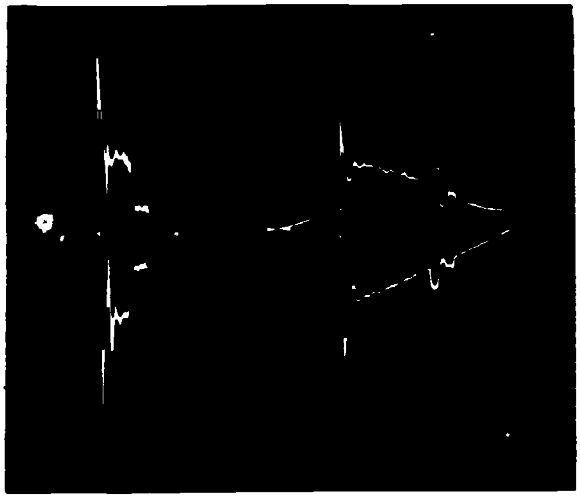
A first-stage high resistance secondary pattern is shown in figure 6-22. The initial high peak voltage is higher than normal, and this first excursion returns to a point nearer the zero trace line. Following this the saddle portion is shorter than normal. Probable causes are large spark plug gap, high resistance within the spark plug, dirty spark plug contact button or cylinder-mounted coil contact button, damaged cigarette spring at the spark plug or at the cylinder-mounted coil, or any abnormal gap in the secondary circuit.



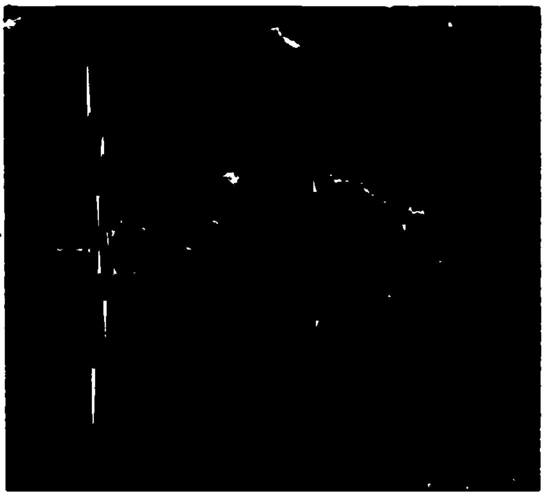
AD.401

Figure 6-22.—First stage high resistance secondary pattern—low-tension ignition system.

A second-stage high resistance pattern is shown in figure 6-23. The initial high peak voltage is higher than normal, and this first excursion returns to a point very near the zero



AD.402
Figure 6-23.—Second stage high resistance secondary pattern—low-tension ignition system.



AD.403
Figure 6-24.—Open secondary pattern—low-tension ignition system.

trace line. Following this, the saddle portion is much shorter than normal. The hook following the saddle and the sharp return toward the zero trace line are not pronounced. The probable causes are the same as those for first-stage high resistance patterns.

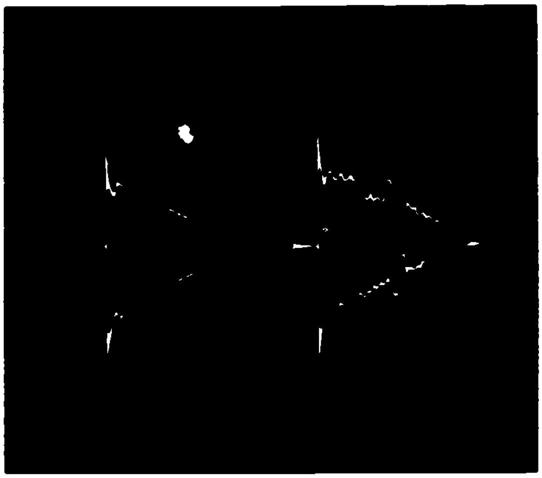
An open secondary pattern is shown in figure 6-24. The initial high peak voltage is higher than normal, and this excursion returns to a point below the zero trace line. This is followed by three or four excursions with decreasing amplitude and a low frequency tail. Since the high-tension circuit is open, the plug is not fired and the high frequency oscillation normally associated with the energy flow in the high-tension circuit is not present. This pattern may occur on only one or on scattered cylinders. Probable causes are an open within the spark plug, a disconnected lead, or any open in the high-tension circuit.

An initial fouling of a spark plug pattern is shown in figure 6-25. The height of the initial high amplitude oscillation is less than normal and does not return as close to the zero trace line as normal. There is less oscillation in the saddle portion of the pattern, and the sharp slope following the saddle is not as pronounced as normal. Some combustion is indicated by the oscillation in the saddle portion of the pattern. Probable causes are early stages of spark plug fouling due to a foreign substance (lead or carbon) on the spark plug electrodes. This condition can generally be cleared up by the recommended plug defouling procedure.

AD.404
Figure 6-25.—Initial fouling of spark plug pattern—low-tension ignition system.

A fouled spark plug pattern is shown in figure 6-26. This pattern is similar to the shorted secondary pattern. However, in contrast to the

AD.405
Figure 6-26.–Fouled spark plug pattern–low-tension ignition system.



AD.406
Figure 6-27.–Shorted secondary pattern–low-tension ignition system.

steady appearance of the shorted secondary pattern, it represents a changing, dancing appearance. Probable causes are spark plug fouling due to a foreign substance (lead or carbon) on the electrodes. This condition can sometimes be cleared up by using the recommended defouling procedure.

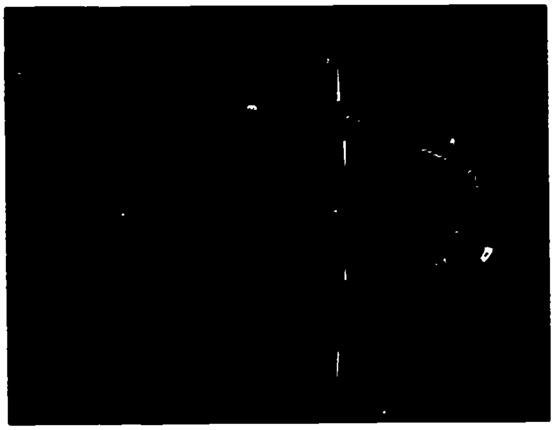
A shorted secondary pattern is shown in figure 6-27. The initial peak voltage amplitude is less than normal. The pattern tail appears as a steady curved line. Probable causes are a badly fouled spark plug, a short circuit within the spark plug, a short in the high-tension lead or coil, or a spark plug lead off and shorted to ground. If the pattern appears on both spark plugs of the same cylinder, it usually indicates cylinder failure where metal particles have peened over the spark plug electrodes. In this case the engine should be secured as soon as possible to prevent further damage.

Miscellaneous Patterns

Two patterns not caused by faulty ignition are in this group. They are open "P" lead pattern and the no combustion pattern.

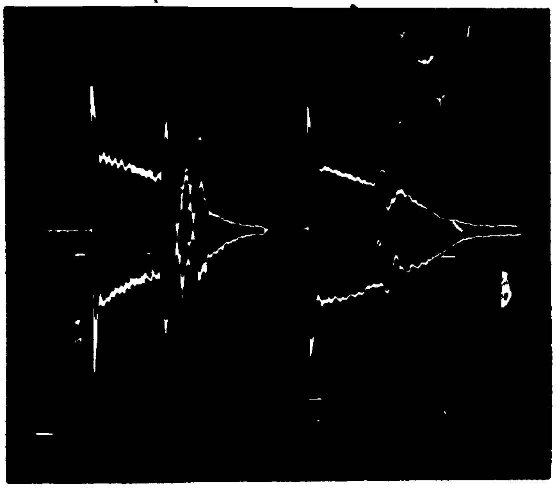
An open "P" lead pattern is shown in figure 6-28. This pattern can be best described as nine small pips and nine normal patterns. The normal patterns are usually slightly distorted because of the malfunction. Probable causes are an open in the magneto primary lead either in the magneto or at the AN connecter on the magneto, an open between the magneto and grounding switch, or an open in the ignition cable to the analyzer. This pattern is identical to the shorted primary pattern (fig. 6-17). It does not affect engine operation; however, it indicates a "hot mag" (cannot be shut off) and is a very hazardous situation. It must be tagged and repaired immediately.

A no combustion pattern is shown in figure 6-29. High-amplitude oscillations continue throughout the pattern. This pattern will appear for both spark plugs of a cylinder. It indicates normal ignition without combustion. Probable causes are poor carburetion, faulty fuel nozzle, faulty injection pump, leaking fuel line, induction system leaks, sticking valves, or any malfunction causing abnormally lean mixtures resulting in no combustion. Ignition and compression must be normal for this pattern to appear.



AD.407

Figure 6-28.—Open "P" lead pattern—low-tension ignition system.



AD.408

Figure 6-29.—No combustion pattern.

VIBRATION ANALYSIS

With the portable analyzer, provisions are made for the vibration analysis of only one cylinder. With the vibration pickup installed in the cylinder to be analyzed, and the cable connection made from the pickup to the Y-lead of the synchronizing generator (fig. 6-13), the vibration signal is carried to the analyzer by the five-strand cable that also carries the synchronizing generator signals to the analyzer. The vibration leads are shielded to prevent distortion of the pattern by ignition or other outside sources of voltage.

The analyzer measures the shock stresses on the cylinder head as the piston in that cylinder completes the four strokes of its cycle (720° of crankshaft travel). These shocks, or impact forces, which appear as voltages on the cathode ray tube, are the results of exhaust and intake valve closing, combustion, and scavenging. Any additional patterns seen are indicative of engine malfunction and should be thoroughly investigated.

The normal sequence of events taking place inside the cylinder as the piston completes the four strokes of a cycle are as follows:

1. Starting with the piston at top center on the intake stroke, the first event taking place as the piston travels downward is the exhaust valve closing.
2. Then, slightly after bottom center, the intake valve closes as the piston travels upward on the compression stroke.
3. Before the piston reaches top center on this stroke, ignition occurs, starting the combustion of the mixture.
4. As the piston travels downward on the power stroke, the gases expand until the exhaust valve opens.
5. The piston passes bottom center and starts upward on the scavenge stroke. Shortly before top center the intake valve opens, and the events are repeated.

The vibration patterns, as seen on the scope of the analyzer, are portrayed in vertical pips. Normally only four pips are seen on the analyzer scope, representing exhaust valve closing, intake valve closing, combustion, and scavenge. There are two important factors governing accurate interpretation of these patterns: the time position and the amplitudes of these pips.

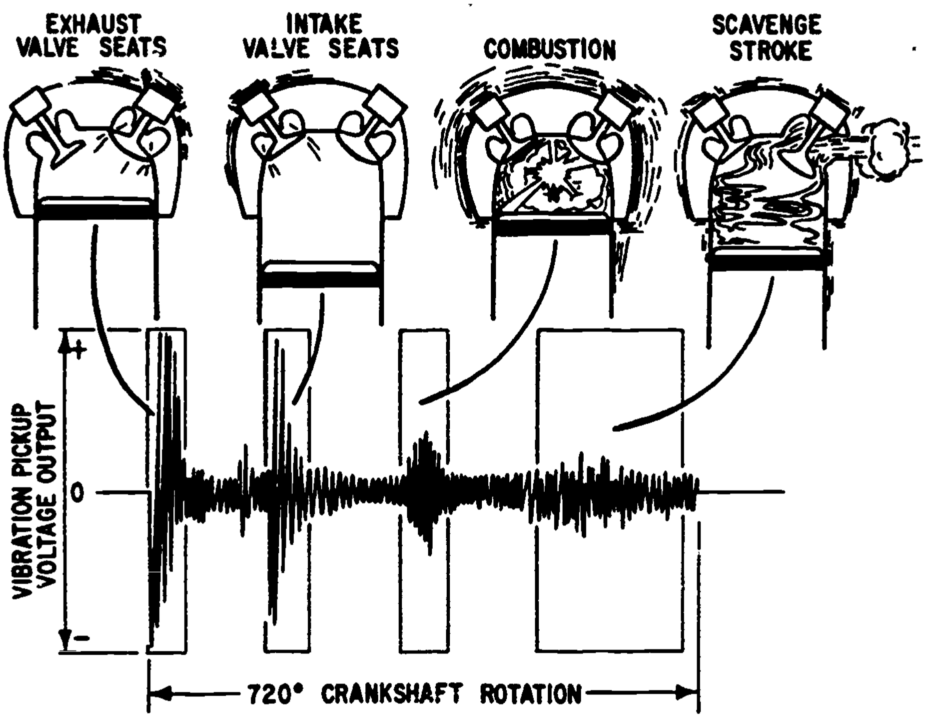
Time Position

The time position, or location of the pips along the horizontal trace line, depends on when, or at what crankshaft position, these events causing impact forces occur. The time position of the pips indicating exhaust valve and intake valve closing is affected by valve timing, valve clearances, and valve operation. Some allowance must be made for normal variations in time position caused by normal differences in valve clearances, cylinder temperatures, and wear.

Amplitude

The amplitude of the pips representing an event in the cylinder depends upon the intensity of the impact forces in the cylinder. On engines having exhaust and intake valves of the same size and weight, such as the R3350, the pips for exhaust closing and intake closing will have about the same amplitude. On engines having exhaust valves which are larger and heavier than the intake valve, such as the R2800, the pips for the exhaust valve closing will be higher in amplitude than the pips for the intake closing, because the impact forces created when the heavier valve seats are greater. Exhaust and intake valve opening may or may not cause very small pips to appear on the cathode ray tube. The pips representing combustion will vary in amplitude according to the pressures in the cylinder. At high brake mean effective pressures the pip will become higher. When detonation occurs, the amplitude of the pip will be very high. The pips representing scavenge are caused by the vibrations accompanying the discharge of turbulent gases through the exhaust port. Figure 6-30 illustrates the association of engine events with the vibration pattern.

In order to obtain a vibration pattern on the portable engine analyzer, place the condition switch in the VIBRATION position, place the sweep switch in the SLOW position, and index the red dot on the cycle switch to the number of the cylinder on which the pickup is mounted. A vibration pattern for 720° of crankshaft rotation



AD.409

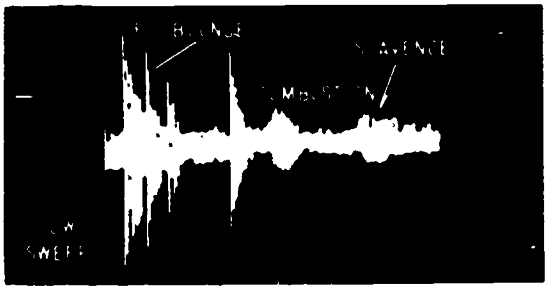
Figure 6-30.—Association of the engine events with the vibration pattern.

will appear on the cathode ray tube. The background hash (the low-amplitude part of the pattern between the events) should be adjusted to about one-fourth inch in height. This is done with the gain control adjustment on the power supply amplifier.

A normal vibration pattern is shown in figure 6-31. The pip at P_1 indicates the exhaust valve opening; the pip at P_2 indicates the intake valve opening. These pips may or may not appear on a normal pattern. A normal pattern for an engine having the same size valves would have the EC (exhaust close) pip or IC (intake close) pip of equal amplitude.

AD.411
Figure 6-32.—Sticking exhaust valve pattern.

AD.410
Figure 6-31.—Normal vibration pattern.



AD.412
Figure 6-33.—Bouncing exhaust valve pattern.

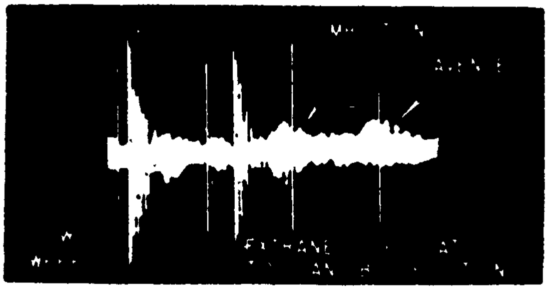
A sticking exhaust valve will produce a pattern such as that shown in figure 6-32. The EC appears to shift back and forth, intermittently moving to the right, which indicates the valve is sticking and closing late. Probable causes are weak valve spring, warped valve stem, carbon deposits on the valve stem, or worn or damaged valve guide.

A bouncing exhaust valve pattern is shown in figure 6-33. Notice the multiple EC pips. This is usually caused by a weak valve spring.

An improperly seating exhaust valve pattern is shown in figure 6-34. The EC pip will either be missing or be very small in amplitude. The combustion and scavenge pips generally do not appear when this condition exists. The probable causes are a damaged valve stem or guide, broken valve spring, broken cam follower, swallowed valve, or a foreign substance under the valve head.

AD.413
Figure 6-34.—Improperly seating exhaust valve pattern.

The pattern illustrated in figure 6-35 is a normal pattern with foreign pips appearing throughout the pattern. The four foreign pips illustrated are evenly spaced, occurring at the travel limits of the piston, two at the top center position of the piston, and two at bottom center. This pattern is considered normal when the foreign pips are of smaller amplitude than the valve closing pips. This pattern is caused by badly worn piston pins, piston slap, or possible bearing wear.



AD.414

Figure 6-35.—Foreign vibrations throughout pattern.

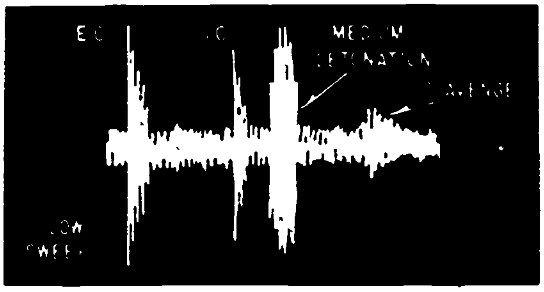
A no combustion vibration pattern is shown in figure 6-36. The valve closing pips are normal, but the combustion pip is missing. Since combustion does not occur, the turbulent gases are not present to cause the scavenge pip. This pattern is usually due to lack of fuel because of a bad leak or an obstruction in the induction system. In the case of an engine equipped with fuel injection it may be caused by a faulty fuel injection nozzle, or a broken or disconnected fuel line.

A medium detonation pattern is shown in figure 6-37. Detonation vibrations occur at the same time position as normal combustion vibrations, but detonation vibrations are higher in amplitude and may be spasmodic. The amplitude varies with the extent of the detonation. A lean mixture is a common cause of detonation.

If any part of a vibration pattern exceeds the EC event in amplitude, it indicates serious trouble in the engine.

AD.415

Figure 6-36.—No combustion vibration pattern.



AD.416

Figure 6-37.—Medium detonation pattern.

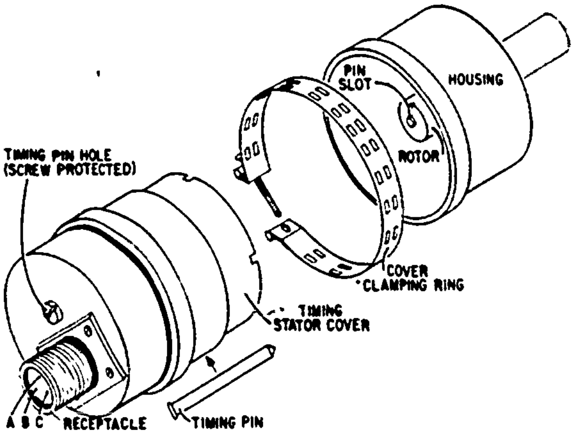
TIMING OF THE SYNCHRONIZING GENERATOR

TIMING OF THE PORTABLE ANALYZER

The synchronizing generator (fig. 6-38) must be properly timed to the engine in order for the horizontal trace line to represent the proper crankshaft angle. Four methods of timing are discussed here.

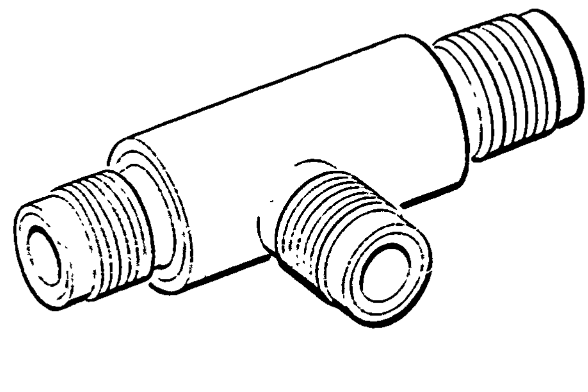
Ignition Pulse Method of Timing

Install an ignition pulse pickup unit between any convenient spark plug and spark plug lead.



AD.417
Figure 6-38.—Synchronizing generator.

An ignition pulse pickup unit is shown in figure 6-39. Connect the vibration lead to the ignition pulse pickup lead and to the analyzer lead. Connect the analyzer to the proper power source. Start the aircraft engine. Turn the analyzer power switch to the ON position. Check for proper phasing (patterns should move from right to left across the face of the cathode ray tube when the cycle switch is turned in a clockwise direction). If the patterns move from the left to the right, change the position of the two-position generator rotation switch.



AD.418
Figure 6-39.—Ignition pulse pickup unit.

Check for proper magneto grounding. This is accomplished by placing the sweep switch on FAST, the condition switch to LEFT, and the magneto switch to RIGHT, grounding out the left magneto. A shorted primary pattern (described previously in pattern interpretation) should appear on the cathode ray tube. Leave the sweep switch on FAST, place the condition switch to RIGHT, and the magneto switch to LEFT, grounding out the right magneto. Again, a shorted primary pattern should appear. Place the sweep switch in SLOW SWEEP. This gives a view on the tube of all cylinders. Adjust the gain control to give a distinctively high pip on the tube.

Now place the sweep switch in the FAST SWEEP position. Index the cycle switch to the cylinder number on which the ignition pulse pickup unit is installed. Hold the cycle switch firmly in this position, and with a screwdriver, rotate the screw in the center of the knob of the cycle switch until the distinctively high pip is approximately one-half inch from the left end of the trace line. The analyzer is now timed to the engine ignition system.

Known-Trouble Method Timing

Disconnect the lead from any convenient spark plug and cap the lead or tie it back where it cannot make ground contact with the engine or cowling at any place. Start the aircraft engine, connect power to the analyzer, and turn on the power switch. Check for proper phasing and magneto grounding. With the condition switch, select the proper magneto (the magneto which fires the spark plug from which the lead was removed). Set the sweep switch to the FAST SWEEP position. Index the cycle switch to the cylinder number on which the spark plug lead was removed. Hold the cycle switch knob firmly in this position and, with a screwdriver, rotate the screw in the center of the knob until the open secondary pattern (described previously in this chapter) is approximately one-half inch from the left end of the trace line. The analyzer is now timed to the engine. Shut down the engine and replace the spark plug lead before continuing with analysis. When using the known-trouble method of timing, you should be sure that there is not another trouble in the system which would cause a similar pattern to the one which you have intentionally introduced.

The disadvantage of the ignition pulse and known-trouble methods results from the analyzer being timed to the ignition system instead of the engine crankshaft. Too, there is the possibility that the magneto being used may not be timed properly.

Pin Timing Method

Install the synchronizing generator on the auxiliary tachometer mounting pad as with the portable analyzer if it is not already installed. Using a piston position indicator, locate the proper crankshaft position. The appropriate technical instructions must be consulted for this information. (For example: Position the crankshaft at 36° BTC, compression stroke, No. 1 cylinder for R3350-24 engines.) Loosen the cover clamping ring of the synchronizing generator (fig. 6-38). Remove the screw from the timing pin hole. Insert the timing pin in the timing pin hole. Rotate the housing, keeping a light pressure on the timing pin. When the timing pin falls into the slot of the rotor, the generator is timed to the engine. Tighten the cover clamping ring, remove the timing pin, and replace the screw in the timing pin hole. Connect the cable to the receptacle on the generator.

Electrical Timing Method

As with the pin method, locate the proper crankshaft position, install the synchronizing generator, and loosen the cover clamping ring. Connect a milliammeter to the receptacle on the generator as follows: (1) Negative side of the ammeter to "A" pin of the receptacle; (2) positive side of the ammeter to "B" and "C" pins of the receptacle (fig. 6-39). Rotate the stator housing in short jerky movements. Stop the rotation at the exact position where the deflection on the ammeter changes from negative to positive. The synchronizing generator is now timed to the engine. Secure the cover clamping ring, disconnect the ammeter, and connect the cable to the receptacle on the generator.

CHAPTER 7

RECIPROCATING ENGINE REMOVAL AND INSTALLATION

This chapter deals primarily with the general procedures involved in reciprocating engine removal and installation. The step-by-step procedures for removal and installation of a specific engine can be found in the applicable technical instructions, which should be used as a guide in the actual removal and installation procedure.

The first part of this chapter deals with ordering, inventorying, and disposal procedures. The second portion covers the removal and installation procedures of a powerplant which encompasses almost all the accessories that will be encountered by an ADR. Powerplant preservation and depreservation are covered in the last part of the chapter.

ORDERING, INVENTORYING, AND ACCOUNTING FOR THE QEC

The ADRC must know the procedures for ordering, inventorying, and accounting for quick engine change kits (QECK) and spare engines.

Quick engine change kit (QECK) is a kit containing all items required for a quick engine change assembly, less government furnished accessories, engine, and propeller. Quick engine change assembly (QECA) is a quick engine change kit completely assembled on a quick engine change stand with the engine and all the accessories, less the propeller for reciprocating engine.

The initial requirement for the QECK is determined by the Naval Air Systems Command. When such a requirement is established, the QECK is procured from the airframes contractor and allocated in sufficient quantities to meet initial outfitting requirements. The Aviation Supply Office can fill supplement section BRAVO requirements for newly formed squadrons where complements of existing squadrons have been reduced.

Accounting for the QECK is the responsibility of the supply department, but in some cases the ADR is responsible for the inventory of the kit. Reports of quick-change kits, of which the QECK is considered one, are required monthly from all reporting activities. If a supervisor has custody of a QECK he must make his reports to the local supply activity on time to insure timely preparation of the consolidated report to the Naval Air Systems Command.

A QECK should not be uncrated for replacement of overage components or incorporation of applicable changes. Outstanding changes beyond a using activity's capabilities are installed prior to issue.

NOTE: The powerplants supervisor must take necessary steps to insure that the QECK in his custody is not used for a ready source of spare parts. He can accomplish this by proper indoctrination of his workers and proper security measures.

ENGINE DISPOSAL PROCEDURES

It is the responsibility of the ADR to know the procedures for the disposition of aircraft engines removed from service. To know this he must be familiar with the system used by the Naval Air Systems Command. Each model of aircraft engine is assigned to one of the following classifications, and by this classification the disposition of the engine is determined.

CLASSES

Class I and II

These engines are installed in currently operating naval aircraft or scheduled for installation in new aircraft.

Classes IIIA and IIIB

These engines are installed in current operating naval aircraft, aircraft held in reserve stock or contingency reserve, and aircraft on bailment, loan, or lease.

Class IV

Class IV engines are obsolete. These engines are no longer required to support aircraft in the current naval operating program, but are being retained for training purposes, special projects, cannibalization, or conversion to an acceptable configuration.

Class V

These engines are obsolete and excess to the requirements of naval aviation.

DISPOSITION

Serviceable class I, II, IIIA, and IIIB engines are Navy required and should be reported on the aircraft engine accountability report form.

Unserviceable class I and II engines located within the continental limits of the United States are disposed of as follows:

1. Engines removed from aircraft due to engine failure or high time, and damaged spare engines should be shipped to the designated overhaul activity.

2. Engines installed in aircraft stricken in categories 1, 2, and 4 are to be recovered and shipped to the designated overhaul activity unless the Naval Air Systems Command specifically authorizes disposal simultaneously with the aircraft.

3. All engines referred to must be reported on form NavAir 13700/2 under the applicable codes.

4. The overhaul and repair departments must determine the feasibility of overhauling damaged engines or recommend disposal by strike in accordance with current instructions.

Unserviceable class IIIA engines located within the continental limits of the United States are retained at the present location or point of generation pending disposal instructions. Engines in this classification located at a designated overhaul activity can be utilized for support of limited overhaul requirements as necessary.

Unserviceable class IIIB engines and all class V engines, both serviceable and unserviceable, located within the continental limits of the United States are disposed of as follows:

1. If in reportable condition, engines in these categories must be retained at the present location or point of generation, and reported to the supply department. The supply department furnishes the holding activity an automatic release date after which the engine may be disposed of without further authorization.

2. Engines installed in aircraft stricken may be retained with the aircraft and reported in the applicable status code. Upon final disposition of the aircraft, the engines may be disposed of simultaneously without further authorization.

Unserviceable class II, IIIA, and IIIB engines and all class V engines, both serviceable and unserviceable, located outside the continental limits of the United States must be disposed of as excess in accordance with instructions set forth by Navy Property Redistribution and Disposal Regulation No. 1, as amended.

Serviceable and unserviceable class IV engines, both installed and spares, should be retained at the present location pending disposal instructions from the Naval Air Systems Command.

When an aircraft is stricken because it is lost or missing, or suffers complete destruction, the engines which were installed are expended with the striking of the aircraft.

Spare engines damaged to the extent of complete destruction are the subject of local survey action and subsequently are stricken.

Engines determined as excess in accordance with current instructions and reported to the proper authority are retained, pending disposal by transfer or donations. No accessory or part shortage is filled or rework accomplished on such engines. Engines classified as excess by the Naval Air Systems Command and awaiting disposition by scrap or salvage do not require further preservation or protection.

ENGINE BUILDUP AND ENGINE CHANGE

Reciprocating engine removal and installation or "engine change" includes the following requirements: cowling removal, engine removal, engine installation (including proper hookup and rigging), systems adjustments, and complete system checkout for flight.

A Chief or First Class Aviation Machinist's Mate R is likely to be assigned the responsibility of supervising the powerplants work center at either the Intermediate or Organizational maintenance level. At the Intermediate maintenance level the powerplants work center is primarily concerned with engine buildup, and at the Organizational maintenance level the powerplants work center is normally concerned with the engine change. Therefore, the senior ADR must be capable of supervising and directing both engine buildup and engine changes.

REASONS FOR REMOVAL

The reasons for engine removal are as follows:

1. High time. The current issue of General Reciprocating Engine Bulletin (GREB) 86 lists all reciprocating engines and the maximum allowable operating time for each. It also authorizes, under certain conditions, two 10-percent extensions of the maximum allowable operating time.

2. Mechanical failures. These include three categories: internal, external, and unsatisfactory performance.

a. External failure. This includes cracks in the main engine sections, broken studs which cannot be replaced, and/or damage to a part that cannot be repaired in the field.

b. Internal failure. This is further broken down into two groups: determined causes and undetermined causes. Determined causes are known failures of parts; for instance, a supercharger clutch stuck in high blower, no low blower action, hydraulic lock, or an impeller that has been damaged beyond limits. Undetermined causes are not readily apparent. Examples of these are engine seizures, unusual noises, and metal particles in the sump or strainers. Whenever metal particles are found in the sump and strainers, see the current issue of GREB 165 which covers metal contamination of engines and provides operating activities with comprehensive procedures for the identification of foreign material, serviceability determination, test, and cleaning of contaminated engines and oil systems. Further, it serves to eliminate unnecessary removals and overhauls of engines with suspected internal failure.

c. Unsatisfactory performance. Examples of unsatisfactory performance are high oil consumption; low compression (covered by the current issue of GREB 207) caused by broken or worn rings and burned or warped valves; worn, scuffed, or damaged pistons; and internal oil leaks which will cause malfunction of systems or bearing failure.

3. Accidents. Possible engine damage may occur whenever the propeller comes into contact with a foreign object or the ground upon landing. Whenever this happens, the following procedures must be followed to determine the extent of the damage, if any, to the engine.

a. If engine is not operating at impact.

(1) Always inspect the propeller shaft for runout in accordance with the applicable GREB. NOTE: If the propeller has been subjected to extensive damage indicating that a large amount of work will need to be performed to determine the extent of the damage to the engine, the engine should be removed and returned to the designated overhaul activity for major inspection and repair.

b. If the engine is rotating at impact.

(1) If the propeller strikes a foreign object or the ground which results in the complete stalling of the engine and the blades are bent or twisted beyond allowable limits, the engine must be removed and sent to the designated overhaul activity for inspection and repair. Whenever blade bending or twisting is not apparent to the naked eye, the propeller track will be determined by tracking with the use of the correct equipment and the proper procedures.

(2) Whenever the propeller strikes a foreign object or the ground and does not result in the complete stalling of the engine and does not twist or bend the blades, but cuts, pits, or gouges are present so that the propeller needs to be removed, the following procedures must be followed:

(a) The sumps and strainers must be inspected for metal contamination in accordance with GREB 165 and its latest revision.

(b) Propeller shaft runout must be checked thoroughly.

(c) Timing of the magneto must be checked to determine if the engine has been subjected to gear or shaft damage in the rear section.

c. All information concerning the rejecting of or continuing in service propellers, rotors, or helicopter gearboxes is included in the applicable publications pertaining to these components.

4. Overspeed. A current GREB covers maximum overspeed and lists engines and the maximum rpm allowed, the rpm at which an inspection is required, and the rpm that requires an engine change.

Engines that have been operated in the inspection-required range must be properly inspected to determine the status of the engine as follows:

a. Remove the main oil screen and inspect.

b. Check the valve clearances to determine whether valve stretching has occurred.

c. Check the compression of all cylinders; replace any cylinders that show a compression loss greater than 35 percent.

d. Visually inspect the cylinders for cracks and the tops of the pistons for indications of twisted articulating rods.

e. Check all valve adjusting screws for the correct torque.

f. Check all spark plugs for the correct torque.

g. Inspect cylinder holddown capscrews for the correct torque.

h. Functionally check the propeller governor and other suspected components.

i. Ground check the engine.

j. Inspect the strainers and magnetic sump plugs.

k. Conduct postflight inspection of the strainers and the magnetic sump plugs after the next three flights following abnormal operation.

5. Excessive corrosion. If this is of a sufficient nature, it requires an engine change. When propeller shaft corrosion is present, the area affected and the depth of the corrosion are the criteria for an engine change. The propeller shaft should be checked for corrosion as prescribed by the current applicable GREB and whenever the propeller is removed for maintenance checks, rework, etc.

Engine modifications are normally accomplished at engine overhauls. Specific engine bulletins may require an engine to be changed and sent to overhaul for incorporation of modifications, but usually is completed at the next routine overhaul if not done by the operating activity.

SAFETY PRECAUTIONS

Prior to removal and installation of a reciprocating engine the aircraft should be in a clean workspace, free from foul weather disturbances. Adequately secure the aircraft with wheel chocks or with tiedown provisions. Turn off all electrical power to the aircraft. Install protective plugs and caps on all openings, lines, and electrical connectors when disconnected or removed.

Care must be taken when maneuvering workstands, engine stands, cranes, etc., around the aircraft to prevent damage to the engine and aircraft. Prior to using a hoist or crane to raise or lower an engine, the cable should be checked for frayed, worn, or broken strands. Check for proper routing of the cable on the drum to prevent cable slippage or jamming during engine removal and installation. Never leave an engine unattended while it is being supported by a hoist. When lowering an engine, constantly observe the engine clearance with the aircraft nacelle to prevent damage to the engine or nacelle.

Cleaning of the engine air inlet and the aircraft nacelle cannot be overemphasized in order to protect the engine from entry of foreign materials which will cause serious damage to the engine. Account for each nut, bolt, washer, safetywire, etc., used or replaced during engine maintenance. When transporting engines on trailers or trucks, make certain that all openings of the engine are covered. If the engine is not to be installed in the aircraft in the immediate future, install engine closures and cover the engine with a clean, light canvas or wrapping paper.

Do not start an engine before accounting for every tool and all equipment used in the vicinity, and thoroughly inspect the inlet duct area and cowling for loose objects. Make certain all personnel and equipment are clear of the propellers and aircraft control surfaces prior to starting the engine. Use care when operating an engine on the ground or deck. Use no more power than necessary.

FOREIGN OBJECT DAMAGE (FOD) AND QUALITY CONTROL

The object of aircraft maintenance is to insure the highest state of readiness and reliability at the lowest cost in men, money, and material. Two of the controlling factors in achieving this goal are FOD prevention and quality control.

Due to the large area and different work centers involved in a reciprocating engine removal and installation, FOD potential is great. Therefore, the need for good quality control is greater.

There should be little doubt as to what constitutes foreign objects. Actually a foreign object may be anything that can pass through an intake or find its way into a sump, a fuel tank, or a lube tank with the potentiality of causing damage to the engine or its components.

Toolboxes are a great source of foreign objects. Every time something is taken from a toolbox and not returnedimmediately after use, FOD potentialities climb sky high. Engine after engine has been damaged with stray wrenches, screwdrivers, and flashlights.

Toolboxes must be checked and rechecked. All parts, nuts, bolts, washers, and safetywire must be kept off the floor, the deck, the turnup areas, and any other place where there is the slightest possibility that they might get into an engine.

Personal belongings must be carefully guarded, even to the extend of emptying pockets before approaching an engine. Nothing must be placed near inlets of engines which could be forgotten.

The quality control concept is fundamentally the prevention of the occurrence of defects. This concept embraces all events from the start of the maintenance operation to its completion.

Prior to the engine installation, a thorough inspection of the aircraft and engine should be conducted. If any maintenance has been done in the nacelles which required removal of sealants, insure that all affected areas are resealed prior to the engine installation.

Inspect the nacelle area, including small openings, niches and indentation, for foreign materials. Inspect the engine mount wells and mounting brackets. Check all electrical boxes and conduits, fire detector elements, and clips.

Check all lines, hoses, cables, and electrical wiring for correct installation and security. They should be secured with clamps at proper intervals to prevent vibration and chafing.

TYPES OF ENGINE CHANGES

Two methods of engine replacement are employed with reciprocating engine aircraft. They are the QEC (quick engine change) and the six-point method. The QEC method is the more widely used and is the one discussed in this chapter. The six-point method, although acceptable, has the disadvantage of consuming too much time. The prime requisite in naval aviation is the availability of aircraft or how soon the aircraft can be returned to a flying status. Therefore, the QEC method is the one that is used the most often.

Under some conditions, it is necessary to change only the engine (six-point method) and transfer the necessary parts and accessories to the new engine. The lack of replacement parts and accessories is the reason for using this method and involves either installing the parts and accessories on the engine while it is mounted on an engine stand or after it has been installed on the aircraft.

QEC

The QEC unit consists of the powerplant complete with accessories, cowling, the oil cooler and scoop, etc. The assembly may be detached at the firewall and removed intact if further disassembly is unnecessary. If the powerplant is being removed for disassembly, it may be more convenient to first remove the propeller, oil scoop, and the cowling panels. Figures 7-1, 7-2, and 7-3 show three different conditions in which the engine may be removed. In some

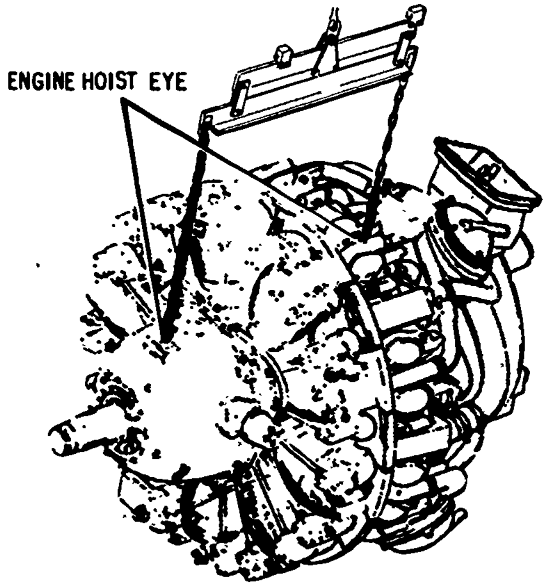


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Figure 7-1.—Bare engine removal.

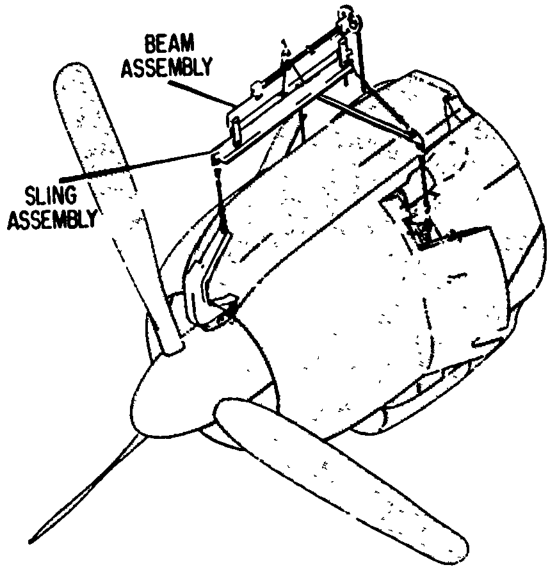

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Figure 7-3.—Complete powerplant removal from the firewall (QEC).

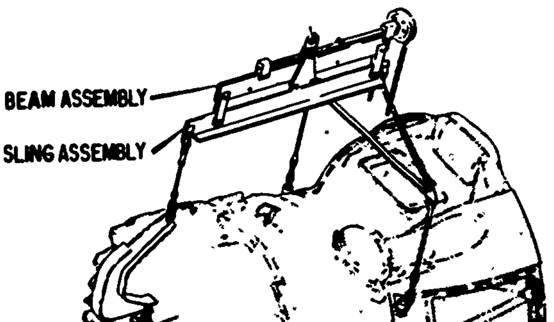

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Figure 7-2.—Powerplant and engine mount removal.

cases where a propeller is not immediately available for the QEC buildup or the propeller still has a considerable number of hours left before it would ordinarily be changed, it is removed and reinstalled on the replacement engine. See the current propeller bulletin for the allowable times between overhauls for propellers and propeller system components.

Removal of the Powerplant from the Aircraft

Prior to removal, perform an engine preservation run in accordance with NavAir 15-02-500.

When the powerplant is to be removed from the airframe to accomplish other work and be remounted after this work is accomplished, it will not be necessary to drain the oil. If the removal is for the purpose of an engine change, certain flushing procedures must be performed in accordance with the latest issue of GREB 165 and Accessory Bulletin 42, Series 1964.

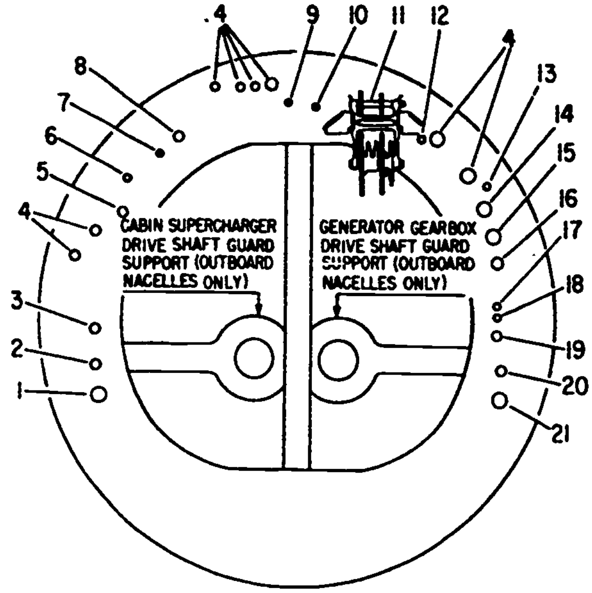
If the propeller has been feathered because of internal failure of the engine, it must be ascertained that there are no metal or foreign particles present in the propeller feathering system. All feathering lines must be flushed. The governor and the feathering pump should be removed and sent to overhaul. The propeller dome and barrel should be thoroughly flushed and cleaned, and checked for metal contamination.

For removal of a typical powerplant from a multiengine aircraft, the following steps are to be taken:

1. Support the tail of the aircraft with a tail stand.
2. Remove the propeller.
3. Drain the engine oil tank, if required; then close the hydraulic, fuel, oil, and the blast tube shutoff, utilizing the firewall shutoff lever (emerg.) in the cockpit.
4. Drain the engine oil sumps and the oil cooler and replace the plugs.
5. Disconnect the battery or pull and tag all the circuit breakers in the powerplant circuit to the engine being removed.
6. Disconnect the magneto cannon plug at the firewall recptacle and connect to the grounding receptacle.
7. Disconnect all fluid lines at the firewall. (See fig. 7-4.)

NOTE: Cap all lines and fittings as soon as they are disconnected in order to prevent entry of foreign materials into the various systems.

8. Disconnect all electrical connections at the firewall.
9. Disconnect the throttle and mixture control rods at the master control and at the firewall pulleys. Keep these rods with the aircraft.
10. Disconnect the engine supercharger control rod at the engine rod.
11. Disconnect the cabin supercharger drive shaft disconnect cable at the disconnect lever (outboard engines only).
12. Remove the cabin supercharger drive shaft and disconnect unit (outboard engines only).
13. Remove the generator gearbox drive shaft and disconnect unit (outboard engines only).
14. Disconnect the accessory blast tube actuating rod at the valve and at the firewall. Keep it with the aircraft.



1. Engine oil-in (engines Nos. 1, 2, and 4).
2. Engine oil-out (engines Nos. 1, 2, and 4).
3. Propeller feathering oil.
4. Electrical connecter.
5. Hydraulic pump suction.
6. Oil tank vent.
7. Hydraulic case drain return.
8. Hydraulic pump pressure.
9. Cabin supercharger drive shaft disconnect cable (outboard nacelles only).
10. Engine supercharger control cable.
11. Throttle and mixture control pulleys.
12. Fuel vapor return.
13. Oil separator return.
14. Deicer suction.
15. Deicer pressure.
16. Fire extinguisher supply.
17. Master control anti-icer.
18. Propeller anti-icer.
19. Fuel supply.
20. Engine oil-out (engine No. 3 only).
21. Engine oil-in (engine No. 3 only).

Figure 7-4.—Disconnect points at the firewall (view looking aft).

15. Attach the powerplant hoist sling and the variable center of gravity beam to the powerplant as shown in figure 7-3.
16. Apply just enough lift to the hoist to relieve the engine attaching bolts of weight.

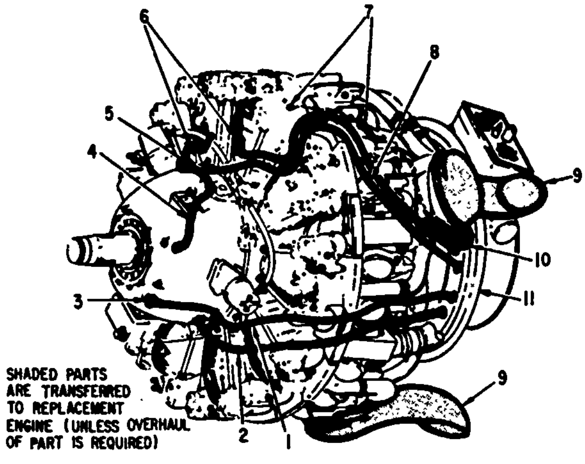
17. Make a final check to insure that all disconnections have been made at the firewall.

18. Remove the powerplant attaching nuts, washers, and bolts. Note the combination of bolts and washers at each point of attachment for correct reassembly.

19. Move the powerplant straight forward until clear of the nacelle.

NOTE: The assembly should be kept balanced to maintain a horizontal attitude in order to prevent damage to the control brackets and pulleys at the firewall.

20. Mount the powerplant on a workstand.



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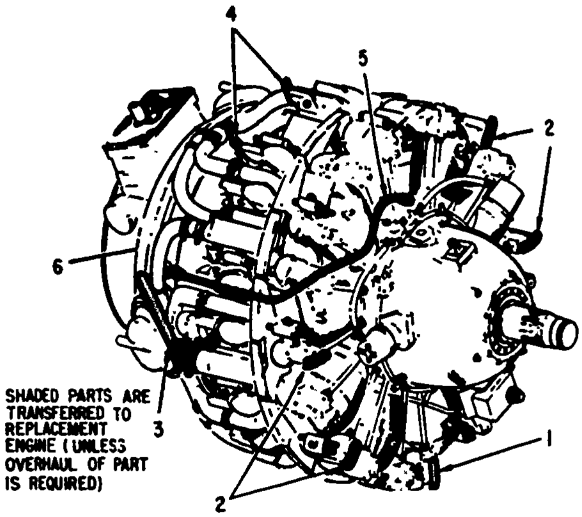
1. Propeller anti-icing fluid line and clips.
2. Torquemeter pressure line and clips.
3. Propeller anti-icer flow regulator.
4. Propeller junction box to brush housing conduit.
5. Propeller junction box.
6. Propeller governor control wiring.
7. Cylinder head temperature bulb and wiring.
8. Propeller reversing blade switch wiring.
9. Power recovery turbine hood (three).
10. Engine mount cooling blast tube.
11. Fireseal installation.

Figure 7-6.—Left side view of the powerplant.



AD.423

1. Lower cowl panel support cable hook.
2. Side cowl panel support rod bracket.
3. Engine mount cooling blast tube.
4. Upper cowl panel support rod bracket.
5. Propeller feathering oil line and clips.
6. Fireseal installation.

Figure 7-5.—Right side view of the powerplant.

Removal of the Engine From the Mount

With the powerplant mounted on a workstand, proceed with the following steps:

1. Remove the oil cooler scoop and all cowling.

2. Remove the shroud access panels.

3. Remove the three power recovery turbine hood and tail pipe assemblies and place protective covers over the turbines. (See fig. 7-5.)

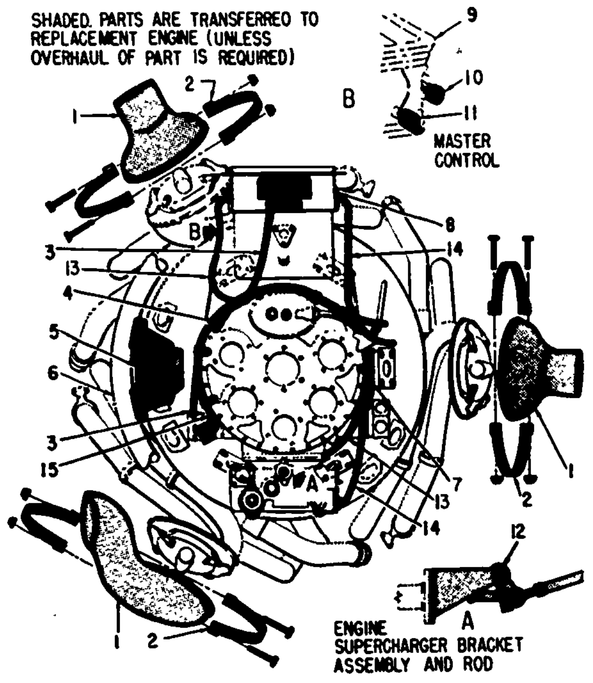
4. Disconnect and cap the propeller anti-icing lines at the fireseal fitting.

NOTE: Figures 7-5, 7-6, and 7-7 are three views of the engine showing transferable parts and the parts locations.

5. Disconnect the propeller governor wiring harness at the engine left junction box.

6. Disconnect the propeller reversing harness at the engine left junction box.

7. Remove the governor and the reversing harness feed-through fitting screws at the fireseal



AD.425

1. Power recovery turbine hood (three).
2. Power recovery turbine hood clamp assembly (three sets).
3. Fuel pump balance line and clips.
4. Manifold pressure line and clips.
5. Engine dynafocal mounts (six).
6. Engine mount ring.
7. Cabin supercharger disconnect bearing temperature indicator wires.
8. Master control adapter and seal assembly.
9. Master control seal assembly.
10. Mixture control valve lever.
11. Throttle shaft lever.
12. Engine supercharger bracket assembly and rod.
13. Master control deicer oil-out line.
14. Master control deicer oil-in line.
15. Torquemeter pressure gage line and clips.

Figure 7-7.—Accessory section of the powerplant (looking forward).

and pull the harnesses forward for removal with the engine.

8. Disconnect the temperature indicator bulb wires for cylinders No. 1 and No. 2, and pull the wires back to remain with the mount.

9. Disconnect the propeller feathering oil line at the fireseal.

10. Remove both fuel injection pumps.

11. Remove the master control and place a protective cover over the mounting pad.

12. Disconnect the oil tank breather line, engine breather lines, oil-in and oil-out lines, and the engine oil pressure line at the engine.

13. Disconnect the oil-out temperature bulb wires.

14. Disconnect the inlet, outlet, and pressure balance lines from the engine-driven fuel pump and remove the pump.

15. Disconnect the seal drain lines at the engine-driven accessories, and disconnect the blower case drain at the engine.

16. Disconnect the air lines at the air pump.

17. Disconnect the lines at the hydraulic pump.

18. Disconnect the manifold pressure line at the engine.

19. Disconnect the electrical terminals at the magneto, generator, primer solenoid, starter, analyzer signal generator, and tachometer. Disconnect the starter ground cable.

20. Disconnect the accessory blast tubes.

21. Remove all plumbing support clips from the engine.

22. Make a final check to insure that all disconnections are made.

23. Install the hoist sling and variable center-of-gravity beam as shown in figure 7-1 and apply just enough lift to support the engine.

24. Remove the engine mount-to-mount ring bolts and bonding links.

25. Move the engine forward and up so that the engine rear oil sump will clear the mount ring.

Installation of the Engine in the Mount

After an engine has been depreserved and prepared for installation in accordance with current technical publications, the following steps are to be taken for installation of the engine:

1. Transfer the engine-driven accessories which are to be returned to service from the removed engine to the replacement, or install the replacement accessories and parts.

NOTE: Each aircraft engine has an inventory list of those parts and accessories which should remain with the engine. If this inventory list is not available, the current GREB should be consulted to determine which parts and accessories are to remain with the old engine and the ones which are to be removed and installed on the replacement engine.

2. Transfer the propeller governor harness and propeller reversing harness to the replacement engine.

3. Transfer the propeller feathering line to the replacement engine.

4. Transfer the propeller fairing assembly.

5. Transfer the propeller electrical junction box.

6. Transfer the cowling support rod brackets and lower cowl panel support cable hook.

7. Install a new or reconditioned set of engine mounts as follows:

a. Clean the parting surfaces of the engine mounting pads and the mount pedestals.

b. Place new insulating pads over the engine mounts.

c. Install the six mounts on the engine, using a washer under each nut. Tighten to the specified torque.

8. Apply a thin coat of specified lubricant to the mating surfaces of horns, mount ring eyes, and the bolt shanks only. Do NOT lubricate the bolt threads.

9. Move the engine aft to aline mounts with the mount ring and insert the bolts with the heads forward, using a washer under each bolthead. Maintain the engine at an attitude that will bring the fireseal rings into alinement.

10. Mate the fireseal rings; then continue the aft movement until the engine mounts contact the mount ring.

11. Install the washers and nuts and tighten to the specified torque.

NOTE: If the entire chamfer on the end of the bolt does not extend through the locking portion of the nut, remove the washer from under the nut. Do NOT remove the washer from under the bolthead. When installing the engine, apply a coating of the approved thread seal to all slip joint surfaces of the asbestos sheet seal, engine fireseal segment assemblies, fireseal retaining ring assembly, engine fireseal flange assembly, and engine fireseal retainer segment. Do NOT aline fireseal rings with fingers. Start the engagement with the proper tool.

The remaining steps of installation are in the reverse order of those given for the removal of the engine.

Installation of the Powerplant on the Aircraft

When the replacement powerplant is ready for installation on the aircraft, proceed with the following steps:

1. Magnetically inspect the powerplant attaching bolts.

2. Inspect all the firewall fittings and electrical connectors for condition. Make the necessary replacements before mating the power plant to the firewall.

3. Inspect the shroud-to-firewall seal assembly and replace it if damaged.

4. Apply a thin coat of approved lubricant to the mating surfaces of the nacelle and the engine mount aft fittings; to the exposed outer surfaces of the alining bushings; and to the exposed surface of the shearpins. Do NOT lubricate threads.

5. Hoist the powerplant package with the variable center of gravity adjusted to suspend the package in a horizontal position.

6. Move the assembly straight aft and engage the shearpins and alining bushings.

7. Install the attachment bolts with the heads forward. Make certain that the washers with the chamfered bores are placed under the heads of the bolts.

8. Tighten all bolts evenly; then tighten the two upper bolts to the specified torque.

9. Remove the hoisting equipment; then tighten the remaining bolts to the specified torque.

The remainder of the connections can now be made in the reverse order of removal.

SIX-POINT METHOD

The six-point method of engine change is the type used to remove the engine from the mount without removing the mount from the aircraft. The engine can also be removed with the mount from the aircraft, but this will depend on the availability of equipment such as L stands and engine stands to support the old and the new engines while the necessary work is performed.

This type of engine change is usually a slow process; and when speed of operation is needed, it is not recommended unless the support equipment is available.

The procedure involved in changing an aircraft engine by the six-point method will follow along the same lines as the QEC. All the necessary disconnections and removal of parts will be the same except that all of this work will take a longer period of time and usually within the same workspace in the hangar and in the vicinity of the aircraft. The length of time that hangar, dock, and shop space will be tied up while changing an aircraft engine by the six-point method is an item that will have to be considered. Also, the new engine and accessories that need to be changed should be ordered far enough in advance in order that the minimum amount of time will be consumed once the engine change has been started.

RIGGING AND ADJUSTING

This section covers some of the basic inspections and procedures to be used in the rigging and adjusting of throttles, mixture controls, fuel selectors, and firewall shutoff valves. These procedures are given only to acquaint the ADR with the rigging and adjusting procedures and should not be used for actually rigging the controls on the aircraft.

Inspect all bellcranks, cables, and rod bearings for looseness, cracks, and corrosion. Particular attention should be given the rod and bellcranks where the bearing is staked. This area is subject to stress cracking and corrosion. The adjustable rod ends should be inspected for damaged threads and the number of threads remaining after final adjustment. The drums should be inspected for wear, and the cable guards should be checked for proper position. If the cables have been loosened, the tension must be set.

THROTTLE

The throttles are actuated by cable systems which extend from the flight station to the firewall in each nacelle. Levers for each throttle system are located on the pilot's control stand and the flight engineer's control stand. The controls that are forward of the firewall consist of a pulley mounted in a swing bracket supported by the nacelle structure, and two parallel rods extending from the pulley to a double-armed bellcrank on the master control throttle shaft. The swinging bracket will compensate for engine vibration and movement so that the throttle settings will not be affected. To rig the throttle control proceed as follows:

1. Install a rigging pin in the firewall pulley and its bracket.
2. Adjust the push-pull rods between the firewall pulley and the master control so that the throttle shaft is resting firmly against the closed stops and the pulley shaft center on the swinging bracket is the correct number of inches from the firewall.
3. Then adjust the cable tension in the system to the proper tension so that the pilot's throttle lever has the correct amount of cushion in the closed position.
4. While maintaining the position of the pilot's lever, adjust the turnbuckles at the flight engineer's control stand so that the flight engineer's lever will have the correct amount of cushion.
5. Recheck the cable tension, the throttle shaft position, and the position of both throttle levers in the cockpit.
6. Then remove the rigging pin and check the throttle lever from both positions in the cockpit several times to ascertain that there is a full freedom of movement.

MIXTURE CONTROL LINKAGE

The mixture control on the master control is cable operated from the flight engineer's control stand to a pulley mounted on a swinging bracket on the overhead of the nacelle structure forward of the firewall. The bellcrank on the mixture control rod is connected to this pulley by a push-pull rod. The swinging bracket performs the same function here as the swinging bracket assembly performs for the throttle.

The rigging of the mixture control is as follows:

1. Install a rigging pin in the firewall pulley and bracket.
2. The mixture control lever on the master control is to be placed in the IDLE CUTOFF position.

3. The push-pull rod between the master control and the swinging bracket on the firewall should be adjusted until the swinging bracket is the proper distance from the firewall. When this is done, slip the bellcrank onto the mixture control and then tighten it down against the serrations.

NOTE: Observe the precautions of adjusting the rod end assembly so that it has sufficient thread engagement.

4. Adjust the cable portion of the linkage so that the control lever in the cockpit is in the IDLE CUTOFF position. Then tighten the cables to the proper tension.

5. Remove the rigging pin and then operate the system through the full range of travel several times to insure that the mixture control plates are in the proper position in relation to the lever at the flight engineer's panel.

FUEL SELECTOR

The fuel tank selector and shutoff valves are cable operated from the flight engineer's control stand. To rig them, proceed as follows:

1. Place the flight engineer's control levers in the CLOSED position for the valves to Nos. 1, 4, and 5. The three-way selector valve control levers are to be placed in the midtravel position, or in the No. 2 and No. 3 positions, respectively.

2. Adjust the cable tension to the proper amount so that the control levers to Nos. 1, 4, and 5 have the proper amount of cushion in the CLOSED position. Remove the rigging pin and check for the proper amount of cushion when the levers are moved to the OPEN position. While the three-way selector valve control levers are in the MID position, check for the proper amount of tension on the cables.

NOTE: All cable tension adjustments should be made in relation to temperature.

3. Recheck all cable tensions, position of the control levers, and the position of the valve actuating levers. Also check for smoothness of operation throughout the operating range.

FIREWALL SHUTOFF VALVES

The four emergency fuel shutoff valves are located upstream from the engines. These are manually operated two-way valves and operate in conjunction with the blast air, oil, and hydraulic emergency shutoff valves. They are controlled from the overhead control panel in the flight station. The rigging procedure is as follows:

1. Insert pin in the pulley rigging hole.
2. Place valve lever in the OPEN position.
3. Place the flight station emergency shutoff lever in the OPEN position.
4. Adjust the push-pull rod to the proper length and install on the valve lever. Make final adjustment as necessary to the rod for the proper alinement of the levers.
5. Operate the flight station lever to the OPEN and the CLOSED position to check the proper operation of the valve.

ENGINE RUN-IN

A carefully controlled run-in of new or newly overhauled engines before they are operated at high power for prolonged periods of use will add greatly to the service life of the engine. Preoiling is required for model R3350 engines when starting a new or newly overhauled engine for the first time, when depreserving an engine, when an engine is started after having been idle for longer than 72 hours, and when an oil change or other operations have been performed which would permit air to enter the inlet oil line between the supply tank and the pressure pump.

The procedures for preoiling, ground run-in, and flight testing of a newly installed engine are discussed in the following paragraphs.

PROCEDURE

The procedure for engine run-in is as follows:

1. After insuring that the engine has been completely depreserved, it is necessary to pre-oil the engine. The pre-oiling should be accomplished just before the engine is ready to run. The primary purpose for pre-oiling the engine is to insure that EVERY bearing surface in the engine has an oil cushion on it prior to the initial starting of the engine. A typical pre-oiling procedure is as follows:

a. The oil tank is to be filled to a safe operating level.

b. Remove the engine sump plugs and the engine oil strainers and drain all excess corrosion preventive compound. Clean the oil strainers with Stoddard Solvent and reinstall. Provide containers to catch oil at these points.

c. Remove the rear oil pump and sump pre-oiling vent plug.

d. Open the oil tank shutoff valve and allow approximately 2 gallons of oil to drain from the vent to make sure that there are no air pockets in the oil tank supply line. Then replace the vent plug.

e. Connect the pre-oiling line to the pre-oil connection in the rear pump and sump housing.

f. Remove a rocker box cover from one of the uppermost cylinders.

g. Remove the front spark plug from each cylinder. This will reduce the load on the starter as the engine is pulled through during the pre-oiling procedure.

h. Use the correct grade of engine oil that is normally used. The oil used in pre-oiling should be heated in the range of 71°C to 104°C and supplied to the engine at 30- to 50-psi oil pressure by the pre-oiling equipment while the engine is being pulled through with the starter. Do not exceed 50 psi at any time during pre-oiling.

i. Operate the starter and the pre-oiling unit until oil is visible in the rocker box from which the cover has been removed. Do not allow the starter to become overheated.

j. Secure pre-oiling, install the rocker box cover, and install all of the spark plugs except those of the bottom cylinders. Install the engine depreservation plugs in those cylinders for the initial run of the engine. CAUTION: Insure that spark plug leads are properly capped to prevent the ignition of the oil and fuel expelled through the blowout plugs. The initial run of the engine should be approximately 30 seconds.

NOTE: Prior to starting the engine, and to prevent loading the manifold absolute pressure transmitter with preservative mixture and/or oil during depreservation of model R3350 engines, remove and cap off the MAP line to the transmitter at the engine rear cover location. Leave this line capped off during the depreservation run, being careful not to exceed 2,200 rpm and to maintain propeller control in full increase rpm settling. Following the depreservation run, remove the cap, blow out the manifold absolute pressure line from the rear case forward, and reconnect the line.

After insuring that the engine will operate, remove the depreservation plugs (blowout plugs) from the lower cylinders and install the spark plugs. Then proceed with the normal run-in in accordance with existing instructions. At all times during the run-in there should be adequate firefighting equipment standing by with sufficient checked-out personnel to use if necessary.

2. Ground run. After the initial depreservation run and during the subsequent ground operating time, the engine is to be operated with the propeller in the full low pitch position, the aircraft must be headed into the wind in a dust-free area, and the engine instruments must be under the close scrutiny of a qualified mechanic at all times. Personnel standing by with firefighting equipment should also be on the lookout for fuel and oil leaks.

After it has been determined that the installation is performing properly, the cowling is to be installed to obtain the maximum cooling of the engine for all subsequent ground operation. Upon completion of the depreservation run and the inspections that are outlined in section 5 of NavAir 15-02-500, any additional ground operating time can be limited to that required for the final adjustments of the oil and fuel pressures and the propeller governor, and any other adjustments that may be required to insure that the engine performs properly.

3. Test flight. When the above requirements have been satisfactorily completed, the aircraft may be released for a 1-hour minimum test flight. The gross weight of the aircraft should be kept to an absolute minimum practicable for the flight (minimum fuel, crew, etc.). The aircraft should also be flown within gliding distance of the field from which the takeoff was made, if operationally feasible. Full power should be used for the takeoff, but the power and the rpm should be reduced to climb power as soon as possible to hold the time at maximum power to a minimum. It is also important to hold climb power to a minimum and to avoid reaching the service ceiling of the engine. All climbs and higher power settings must be made in the auto-rich position, and the climb attitude should be such that the maximum cooling of the engine can be maintained at all times. It is also necessary to insure that the specified temperatures, manifold pressure, and the BMEP limits are not exceeded at any time.

The engine controls should not be moved rapidly at any time during the test flight, but should be moved with moderation, keeping watch on the instruments for any unusual indications. When increasing the power settings above minimum cruise, it should be done gradually at 100-rpm increments with a duration of 1 minute at each increment and returning to low cruise power and remaining there for a sufficient period of time to allow the engine to cool.

The engine may be operated in the auto-lean range during cruising after at least one-half hour has elapsed after takeoff. However, all climbs and descents will be made with the mixture control(s) in the auto-rich position.

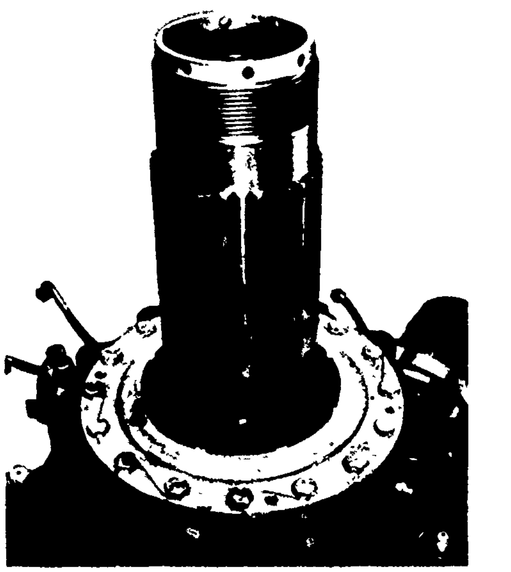
4. Ground check after test flight. When the test flight has been satisfactorily completed and upon return to the line, a high-power runup is made for approximately 1 minute. When this has been done and the engine secured, the strainers are checked and the engine given a thorough visual inspection for evidence of fuel and oil leaks, and the security of all hoses, connections, and accessories is checked.

When this procedure has been satisfactorily completed, the engine may be released for unrestricted flight.

The procedures that have been listed above are the minimum requirements that have been established to insure that the engine has been satisfactorily installed prior to the release of the engine for normal flight operations. Whenever any abnormal discrepancies or conditions exist during the ground run or the test flight, the cause of the malfunction must be determined in a sufficiently extended ground run and/or test flight before the engine can be released for normal flight operations.

PRESERVATION AND DEPRESERVATION

The Chief and First Class Aviation Machinist's Mate R must know the procedures for preserving and depreserving reciprocating engines and their accessories. Corrosion is the result of chemical or electrochemical action upon metals. (See fig. 7-8.) It is greatly accelerated when dissimilar metals such as magnesium and steel are coupled or when dirt, salt, exhaust gases, etc., are in contact with metal surfaces. Rust on iron or steel and the white powder on aluminum or magnesium are the products of corrosion. These products, along with dirt and salt, pick up moisture from the air and hold it in contact with the metal, thereby speeding up the corrosive action. When moisture and dirt are permanently removed from metal surfaces, the tendency of such surfaces to corrode is usually eliminated. Therefore, the major problem facing the ADR is to prevent the accumulation of moisture on the surfaces of the engine and its accessories.



AD.426

Figure 7-8.—Example of corrosion.

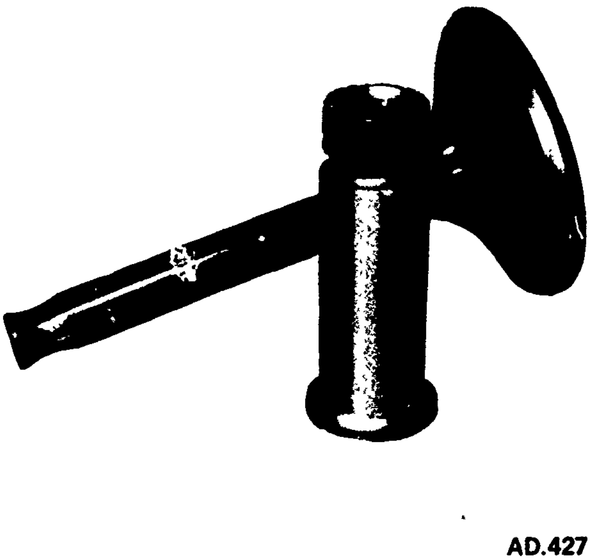
To achieve suitable protection against corrosion, a continuous barrier must be placed between the metal surface and any possible source of moisture. This can be accomplished by one or both of the following procedures:

1. As a direct barrier, all the surfaces whose operation will not be impaired thereby are protected against the accumulation of moisture by a coating of a protective surface film. Where practicable, this film is an electro-plate, a paint, or a chemical treatment. Examples of these are: cadmium plating on studs and nuts, paint on the engine exteriors, and a permanent resin coating on the articulating and master rods and many other nonbearing internal engine surfaces. Surfaces which cannot be so treated are covered with temporary coatings containing special corrosion-preventive ingredients. These compounds are as heavy as it is practicable to apply without

adversely affecting the operating characteristics of the engine. The protective film is ineffective against moisture that is trapped between the surface to be protected and the film at the time of application. It is essential, therefore, that the surface to be protected be both dry and clean when the protective film is applied. The coating material, the air used to apply it, and the atmosphere where the work is being accomplished must be as moisture free as possible. For results of good and poor preservation, see figures 7-9 and 7-10, respectively.

2. Additional protection against corrosion is provided by completely enclosing uninstalled engines and some of the accessories in a moistureproof barrier. The moisture content of the barrier is reduced by adding dehydrating agents. The amount of the dehydrating agent used is sufficient to reduce the relative humidity within the barrier to 30 percent or below at all temperatures normally encountered. It has been established that corrosion will not take place if the relative humidity is maintained below 30 percent.

NOTE: To be effective, either of these procedures must be applied to an engine before there has been an opportunity for corrosion to start. These procedures are not nearly so effective in retarding existing corrosion as they are in preventing it in the first place. Corrosion should be removed before preservation is attempted.



AD.427
Figure 7-9.—Results of good preservation.

AD.428
Figure 7-10.—Results of poor preservation.

The primary determining factor in selecting the proper type of preservation is the disposition of the engine or the accessories after they have been preserved. For example, in the preservation of an engine to be reinstalled, longtime storage shutdown procedure should be used to cover any changes in the anticipated installation date. Another factor to be considered is the time that will elapse between preservation and reuse or overhaul. The status of the equipment and the method by which the equipment will be transported may present still other problems. Prior to applying a protective coating to a reciprocating engine refer to the latest amendment to GREB 213.

TYPES OF PRESERVATION

Methods used for preserving aircraft engines vary, depending upon the length of storage time anticipated, the conditions under which the engine is stored, and the internal preservative material used. There are five basic preservation types in use for aircraft engines. Maintenance procedures and depreservation requirements also vary, depending on the original preservation applied.

Type I

This type of preservation is used for all engines where the length of the storage period is not known to the activity preparing the engine. Its primary application is for the protection of new or newly overhauled engines and for operable engines being returned for overhaul or minor repair. It may also be used for low-time engines which are being removed from one aircraft for installation in a second, when the period between removal and subsequent ground runup is unknown or is to exceed the period of time an uninstalled engine may remain outside a container. This type of preservation must not be applied sooner than 10 days prior to removal of the engine from the aircraft.

Type II

Type II preservation is intended primarily for operable engines which are stored under cover (indoors or on the hangar deck) for periods within the storage limits permitted outside dehydrated containers. It is used primarily for:

a. Engines which have failed the test stand check and must be returned to shops for minor repair and adjustment.

b. Low-time engines being removed from an aircraft and scheduled for installation in a second aircraft within the permissible storage limitations for an engine outside a container.

c. An operable low-time engine turned in for overhaul or minor repair when the activity preparing the engine knows that the overhaul or minor repair will be undertaken within the storage limitations for engines outside of containers.

Type III

Type III preservation is intended primarily for operable engines that are to be stored under cover (indoors or on the hangar deck) for periods not longer than 14 days. This period includes the entire elapsed time from the original preservation runup or exercising run to the ground runup of the engine after it is installed on the aircraft. While Type III usage is limited compared to other types of preservation, it can be used by squadrons and maintenance activities changing an engine from one aircraft to another, or by Depot maintenance activities for protection of engines during progressive aircraft rework or modification. This type preservation for uninstalled engines may not be renewed.

Type IV

Type IV preservation is used for the protection of inoperable engines being prepared for storage and shipment, with the exception of those inoperable engines which have been subjected to water immersion. An inoperable engine is considered to be an engine that cannot be given a complete preservation run even when installed on a test stand or in an aircraft. Examples of engines in this category are reciprocating engines with sudden stoppage damage, stuck superchargers, cracked housings, or broken accessory holddown studs. This type of protection may also be used by activities which do not have runup facilities, or at times when improperly preserved or corroded engines are found in storage, and it is known that the disposition of the engine is overhaul or minor repair.

Type V

All aircraft engines which have been immersed in water (either salt or fresh), or which have been involved in fires or aircraft accidents, where the engine has been exposed to Foamite, or other firefighting chemicals must be preserved with Type V preservation.

PREPARATION FOR PRESERVATION

To accomplish satisfactory preservation, the surfaces must be thoroughly cleaned wherever practicable before application of the preservation compound. Not only is any surface contamination capable of picking up moisture from the surrounding air, but also it may be of such a composition as to result in direct chemical attack. New or newly overhauled engines may usually be externally cleaned by removing grease and oil from the surfaces. Particular care must be taken to clean the protruding portion of a propeller shaft. For cleaning of this nature, usually accomplished between the preservation run and final preservation, an approved drycleaning solvent is recommended. If it is not available, kerosene may be used. However, kerosene is not considered as useful as drycleaning solvent because of the evaporation time. Surfaces must be both clean and dry prior to application of the preservative compounds.

For engines being returned for overhaul or minor repair, a proper balance should be maintained between cleaning and leaving satisfactory preservative compounds in place. No general rule can be made except that corrosion-preventive compounds allowed to remain should be free of dirt. Steam cleaning with the proper steam cleaning compound usually removes most soils. If the engine is excessively oily, greasy, or coated with old preservative compounds, a presoak for approximately 15 minutes with a spray-applied mixture of six parts of kerosene and one part of grease cleaning compound, should provide sufficient softening to permit steam cleaning to function. If the engine is not excessively coated with foreign matter, the use of kerosene alone may give satisfactory results. Again, great care must be used to insure proper cleaning.

PRESERVATION OF RECIPROCATING ENGINES

The preservation of a reciprocating engine is accomplished after the engine lubricating system has been filled with the required preservative.

During the preservation run, the engine is operated for the minimum period of 15 minutes with the specified corrosion-preventive mixture in the lubrication system, which varies with the particular type of preservation that is being accomplished. The engine must be operated so that the oil inlet temperature of the engine is maintained within a temperature range of 95°C to 120°C for the entire preservation run of the engine. The oil cooler inlets may be blanked off if the desired temperature of the oil cannot be reached. During the preservation run of the engine, care should be taken not to exceed the cylinder head temperature limits.

At the completion of the preservation run inject the atomized corrosion-preventive mixture into the induction system. The mixture should be applied at a rate of approximately 40 to 50 gallons per hour so that full coverage of the complete induction system will be attained. Injection of the mixture is made at the base of the carburetor instead of the top so that the impact tubes of the carburetor will not become clogged.

Four basic factors control the quantity of the mixture as it is injected:

1. The size and the number of the outlet orifices in the injection nozzle.
2. The pressure of the compound at the time of injection.
3. The engine rpm.
4. The temperature of the compound at the injection nozzle.

NOTE: Preservation of Aircraft Engines, NavAir 15-02-500, illustrates a typical corrosion-preventive compound injection nozzle.

Actual injection of the preservative mixture into the induction system is accomplished in the following manner:

1. Adjust the engine rpm so that it is operating in the range of 1,200 to 1,600 rpm.
2. Begin injecting the compound.
3. As soon as steady smoking is observed from all the exhausts of the engine, move the mixture control to the IDLE CUTOFF position. Do not close the throttle.
4. When the engine stops rotating, shut off the ignition.
5. Cut off the supply of injection compound to the engine.
6. When the engine has come to a complete stop and the ignition is turned off, turn on the fuel boost pump and open the mixture control to the AUTO-RICH position and allow the fuel to drain from the supercharger drain valve. When preservative-free fuel is observed running from the supercharger drain valve, close the throttle and mixture control, and shut off the fuel boost pump.

Immediately upon shutdown of the engine and while it is still hot, place the propeller or test club blades in the proper position so that removal can be accomplished without rotating the engine.

As soon as possible after the preservation run and while the engine is still hot, drain the excessive corrosion-preventive compound from the oil tank, engine sumps, crankcase, and oil screen or filter chambers. Check for metal contamination. If none is found, clean the oil screens or filters, coat them with the compound, and reinstall them in the engine. Install dehydrator plugs in all sump plug openings, and secure the sump plugs to the engine structure with lock wire.

During or after the draining of the corrosion-preventive compound from the engine and as soon as practicable, remove the air intake ducts, exhaust stacks, and other equipment that will not be shipped with the engine. Also remove the accessory drive covers that are not pressure lubricated.

Depending upon the type of preservation being used, an even coating of hot compound must be sprayed into and over all internal surfaces of each cylinder through the spark plug openings. DO NOT ROTATE THE CRANKSHAFT DURING OR AFTER THIS OPERATION.

NOTE: Do not apply excessive amounts of preservative. All that is necessary is a uniform thin coating on all surfaces. Excessive amounts of preservative do not contribute to the effectiveness of the preservation; but they do cause difficulty whenever the engine is depreserved and increase the possibility of hydraulic lock. The personnel whom you designate to do the cylinder spraying should be thoroughly trained in the proper procedure of applying the compound to the inside of the individual cylinders.

The general procedure for spraying the internal area of the cylinder is as follows:

1. Place the cylinder preservation mixture in the reservoir, heat the mixture to the correct temperature, and mix thoroughly. Premixing and preheating the compound prior to placing it in the reservoir will be a timesaver.

2. Close the vessel and connect the gun and lines.

3. Discharge the gun into a clean container until a fine uniform spray is produced at the nozzle. This mixture discharged from the gun can be retained for future use.

4. Insert the discharge tube of the gun into the cylinder and determine the position of the piston. Use the free hand to mark the distance the gun will travel into the cylinder to a point just short of the piston. Withdraw the gun until the nozzle is at the spark plug opening.

5. Start spraying. As soon as the trigger is depressed and the mixture begins to discharge into the cylinder, move the gun slowly into the cylinder. Do not touch the piston. Then move the gun back to the spark plug opening and cease spraying.

6. Proceed at once to spray each cylinder in the same manner. Do not allow the gun to become idle for more than 1 minute; otherwise, the mixture will thicken and an even spray will not develop.

The thickness of the coating can be determined by spraying the mixture into a glass jar and experimenting to obtain the minimum coating. Do not rotate the crankshaft during or after the internal spraying of the cylinders.

After completion of the cylinder spraying, all the spark plugs or solid plugs must be installed in the engine. If the engine is going to be placed in a metal container for shipment or storage, the spark plug openings must be sealed with the proper type dehydrator plugs.

The spark plug leads should be cleaned with an approved drycleaning compound, and dried with a lint-free cloth. Insert the insulating and sealing compound in the terminal lead protector and install the protector on the terminal sleeve. Then snap it on the dehydrator plug nipple.

The fuel feed valve cover plate and the fuel feed valve are removed. Coat the fuel feed valve with the preservative compound and reinstall. Be sure there is no fuel remaining in the fuel feed valve recess.

The exhaust ports must be sealed with a bag of desiccant properly anchored within each one. All external openings of the engine are to be sealed in accordance with the existing preservation instructions. When bags of desiccant are placed in the blower throat, a tag indicating the number of bags of the desiccant used should be attached to the cover plate. The accessory drives also should be sprayed with the mixture that was used for the engine runup. Reinstall the cover plates; or if the accessory is to be shipped installed on the engine, install the accessory, using all related attaching parts.

Close the breather openings. For engines that are to be placed in metal containers, use screened plugs or one thickness of a moisture-proof and vaporproof barrier material secured in place with tape. Seal the oil inlet and outlet with oil and moisture resistant blank caps. Use gaskets under all metal blank-off plates. Remove the thrust bearing cover plate, and coat the thrust bearing thoroughly with the engine runup preservative compound.

The propeller shaft should be thoroughly cleaned and then coated with a soft-film corrosion-preventive compound. After it has set, the surface of the shaft should be wrapped with the proper type paper and secured with tape. Installation of the shipping cap for the propeller shaft should be delayed until after the engine has been installed in the shipping container.

NOTE: A durable type tag should be attached to the propeller shaft with the following information on it:

TYPE (indicate type) PRESERVATION
NAME OF ACTIVITY
DATE OF PRESERVATION

The preceding section of this chapter contains some of the general procedures for preserving the aircraft reciprocating engine. For additional information refer to the appropriate technical publication listing reference material concerning the preservation of reciprocating engines.

The supervision of the preservation process of aircraft engines and their associated accessories cannot be stressed too much due to the high cost of repairing or replacing all or part of them when corrosion has set in because of inadequate preservation or the failure to follow the proper procedures.

Aircraft engines are also preserved and left mounted on the airframe. Under these circumstances the engine is preserved in accordance with the type of preservation used on the aircraft.

Type A preservation is applied to aircraft that fall within the following categories: awaiting overhaul (AOH), awaiting modification (AMO), completed service life (CSL). Only overhaul activities perform type A preservation.

Type B preservation is generally applied to serviceable and modernized aircraft that are essentially sound and in flight condition at the time of preservation. Such aircraft may be stored under maintained type B preservation for periods of 6 months duration. Type B preservation is applied only by Depot maintenance activities.

Type C preservation is mandatory for all aircraft that are to be shipped by a surface vessel that does not have the facilities or the personnel available for en route maintenance of type D preservation.

Type D preservation must be applied to any aircraft that is not flown at least once in every 14 days. Aircraft in this category may be maintained in a type D preserved status indefinitely, provided all discrepancies are corrected immediately after a test flight which is made once every 30 days and the preservation is completely renewed at this time.

Type E preservation procedures must be followed for all aircraft that have crashed in salt water or have been subjected to the application of firefighting foam or chemicals. These preservation procedures must be started immediately upon the removal of the aircraft from the water or as soon as the fire is extinguished, depending on the release of the aircraft from the board of inquiry.

For definite information pertaining to the preservation of aircraft and engines, the ADR should consult Preservation of Aircraft Engines, NA 15-02-500.

Preservation of uninstalled engines must be maintained throughout the storage period. It will be necessary to maintain the air within the storage container at the recommended 30 percent relative humidity or below. The corrosion-preventive mixture which was applied during preservation prevents corrosion for only a short period of time whenever high humidity conditions are permitted to enter the container. Corrosion will sometimes be encountered when the relative humidity of the container is below the required 30 percent, but this will be due to the improper removal of corrosion that was present before the engine was placed in the container, or delaying too long in the replacement of dehydrating agents. Carefully following the specified maintenance procedures is equally as important as the initial preservation treatment. When both of these are adhered to throughout, there can be assurance that the engine will be protected throughout its storage period.

Engines that are placed in metal shipping containers are pressurized when they are placed within the container, and this pressure is checked upon receipt of the container. It is also checked before shipment and at least once every 30 days after the initial preservation. Pressure may be checked with a pressure gage or a manometer. If the pressure within the container is too low to measure, the condition of the internal indicator should be determined. If a safe condition is indicated, the container should be repressurized with dry air. If the indicator does not indicate a dry condition, the container will have to be opened and the engine checked for evidence of corrosion.

DEPRESERVATION OF RECIPROCATING ENGINES

The procedures that are followed when depreserving an engine vary in accordance with the type of preservation with which the engine was preserved and whether the engine is installed or uninstalled. The general depreservation procedures are discussed here.

The pressure of the metal container must be relieved before the holddown bolts are taken out. After the top portion of the container has been removed, take all bags of desiccant and the humidity indicator from the engine. Remove all the protective paper, if any, from around the engine. Remove any accessories and their mounting board and hold them for future installation when the engine is ready for them. Remove the engine from the bottom half of the container and install it in a suitable engine stand. Accessories that were attached to the engine should not be depreserved until less than 10 days before the initial runup. The shipping container will be disposed of in accordance with local directives.

When the engine has been mounted in the stand, remove the sump plugs and dehydrator or screen plugs and allow the excess preservative material to drain from the engine. If the job is being performed in cold weather, it may be best to use a preheater and heat the engine so that the maximum amount of preservative can be drained from the engine. While the engine is in a nosedown position, rotate the crankshaft so that the pistons will force the excess preservative out of the spark plug holes. Inspect each cylinder internally for evidence of corrosion and excess preservative material. If excess preservative material is present, pump it out with a suction pump. Replace all drain plugs, but do not lockwire at this time.

Inspect the engine exterior for evidence of corrosion. After the drainage of the excess preservation material has been accomplished (assuming that the engine will be installed on an airframe as soon as it is ready), install the spark plugs in the cylinders. Continue with the normal engine buildup procedure. Do not disturb any breather seals, seals, or anything that is not necessary to be disturbed. Do not depreserve the propeller shaft until immediately prior to the installation of the propeller.

After the engine has been built up and the accessories depreserved and installed, mount the engine on the airframe and complete the necessary connections. Remove the preservative compound from the propeller shaft, using a drycleaning solvent, and dry with a lint-free cloth. Install the propeller, complying with all existing instructions to prevent corrosion of the propeller shaft.

As soon as the engine is ready to operate for the first time, all inspections have been complied with in regard to depreservation, and the installation of the accessories and the engine in the mount has been accomplished, prepare the engine for pre-oiling prior to initial start. Preoiling procedures have been discussed previously in this chapter.

The procedures for depreserving an installed engine are not discussed here, as the procedure is essentially the same as for an uninstalled engine. The procedures, of course, vary somewhat with the type of preservation that has been applied to the engine. Consult the appropriate technical publications, including all local publications and directives, for the proper procedures to follow at all times when preserving and depreserving aircraft reciprocating engines and associated accessories.

CHAPTER 8

FUEL SYSTEM MAINTENANCE

The aircraft fuel system begins with the tanks and ends at the carburetor inlet. The only control required between these points is fuel pressure. It must be capable of delivering fuel to the carburetor at the required pressure and in sufficient volume to meet the demand of the engine(s). The senior ADR must maintain and service the aircraft fuel system. Therefore, he must be familiar with fuel transfer and pressure fueling. construction of fuel cells, and procedures for removal and installation of bladder and self-sealing fuel cells. (The repair of bladder and self-sealing fuel cells is performed by personnel of the AM rating.)

The first part of this chapter is devoted to components and operation of typical fuel transfer and pressure fueling systems. This is followed by a section on the removal and installation procedures for bladder and self-sealing fuel cells. It should be emphasized that this is general information and should not be used for actual fuel cell removal and installation. Identification of foreign matter found in fuel systems is covered at the end of the chapter.

FUEL TRANSFER AND PRESSURE FUELING

Fuel transfer and pressure fueling systems provide a controlled means of receiving fuel from external sources and supplying the fuel from tanks and cells within the aircraft to the engine(s).

NOTE: Since the fuel system of the P-2H encompasses the components used in most reciprocating engine aircraft, it is used in discussing the components and operation of fuel transfer systems.

The P-2H fuel system includes six outer wing panel cells and eight center section cells. Also included are two bomb bay and two wingtip tanks which are optional loading. Control of the fuel system is accomplished by two engine-driven fuel pumps, a maximum of seven electric auxiliary booster and transfer pumps, fuel quantity gages, and all necessary plumbing and controls.

Under normal conditions, fuel in the wingtip tanks, bomb bay tanks, and center section tanks is transferred to the main tanks (outer wing panel tanks) before being supplied to the engines. Fuel in the bomb bay tanks is first transferred to the center section tanks before being transferred to the main tanks. Float valves in the center section and main tanks, together with the transfer boost pumps, automatically accomplish fuel transfer, provided the fuel control panel is placed in normal.

COMPONENT DESCRIPTION

Fuel Cells and Tanks (P-2H)

The aircraft fuel system consists of the following fuel cells and tanks: Outer wing tanks, center section tanks, wingtip tanks, and bomb bay tanks.

The outer wing tanks include three fuel tanks installed in each outer wing panel between wing stations 204 and 420. (Each tank is composed of two interlaced cells.) The cells are constructed of lightweight, bladder type, nonself-sealing, or semirigid, self-sealing cells, depending on the manufacture date of the aircraft.

The center section fuel cells are lightweight bladder type cells and are not of self-sealing construction. They consist of eight cells installed in line in the wing center section, four on each side of the centerline of the fuselage. The four cells on the left are interconnected and act as a single tank, and the four on the right are similarly interconnected.

The wingtip tanks are an integral part of the center mounted, circular nacelles installed at each wingtip. Each tip tank is a self-contained unit; the filler neck, drain valve, and transfer pump are all easily accessible, and do not require removal of any other structure. Quick-release plumbing and electrical fittings make it possible to jettison the tanks if desired.

Provisions are incorporated in the bomb bay for two lightweight self-sealing cells. The cells occupy the full length of the bomb bay and are mounted side by side. When both cells are used, they are plumbed together to act as one bomb bay tank. The cells may be jettisoned, if desired, as all connections are of the quick-release type.

Fuel Transfer (P-2H)

Control of the fuel system is accomplished from the pilot's overhead control panel. Control knobs on the panel actuate electric motors, accessible within the fuselage, which in turn are cable-connected to the individual fuel selector and crossfeed valves, located aft of each engine nacelle. The individual actuators, which position the fuel valves, can also be positioned manually in case of electrical failure.

In normal use, fuel is supplied to the engines from the outer wing tanks. As the outer wing tank fuel level drops, float valves automatically allow transfer of fuel in sequence from the wingtip tanks, the center section tank, and the bomb bay tank. In case of an emergency, fuel can be transferred from the center section tanks to the engines.

OPERATION

Fuel Transfer

Normal fuel transfer is accomplished in the following sequence:

1. When the fuel level in the main tank drops to 3,600 pounds (600 gallons) the float valve in the number 3 cell opens, allowing fuel in the wingtip tank to be transferred to the main tank.
2. When the fuel level in the main tank drops to 2,880 pounds (480 gallons) the float valve in the number 1 cell opens, allowing fuel in the center section tank to be transferred to the main tank.
3. When the fuel level in the center section tank drops to 3,600 pounds (600 gallons) the float valve in the number 1 cell opens, allowing fuel in the bomb bay tank to be transferred to the center section tank.

NOTE: The fuel control panel incorporates a fuel flow diagram. By positioning the tank selector valve controls and fuel flow valve controls to obtain unbroken lines, the course of the fuel flow obtained under various selector valve settings is clearly indicated.

Auxiliary Fuel Transfer

In the event that fuel fails to transfer from the center section tanks to the main tanks, fuel remaining in the center section tanks can be obtained by selecting the center section tanks as the engine feed tanks.

Fuel in tanks on one side of the aircraft can be transferred through the crossfeed line to tanks on the opposite side, according to the settings of the fuel tanks selector valves. The transfer-boost pump in the tank receiving fuel must be OFF, the transfer-boost pump in the tank yielding fuel ON, and the boost pump high-low selector switch in the HIGH position.

Engine Supply

Fuel from either outer wing tank or center section tank can feed directly to one or both engines. In normal use, however, fuel is supplied only through the outer wing tanks. The transfer boost pumps in either the center section tanks or the outer wing panel tanks are capable of maintaining fuel pressure to an engine in case the engine-driven fuel pump fails (provided the jet engines are not operating). Fuel crossfeed is available in the P-2H and is used when an engine failure occurs or when necessary to equalize fuel levels in the left and right wing tanks.

Refueling

Normal refueling of most models of the P-2H aircraft is by gravity fueling through the filler units located in each tank. The aircraft should be fueled in the following sequence; main tanks, center section tanks, wingtip tanks, and the bomb bay tanks.

NOTE: Although the aircraft is normally equipped with circular 200 U.S. gallon wingtip tanks, the elliptical 350 U.S. gallon wingtip tanks are interchangeable. If the aircraft is equipped with the elliptical tanks, fuel loading must be limited to 180 U.S. gallons in each tank.

Some naval aircraft are equipped with features that allow pressure (single-point) refueling. Pressure fueling is accomplished by connecting an outside fuel supply to the pressure fueling connector. The flow of fuel to all tanks or any combination of tanks is controlled by electrically operated pressure fueling valves. These valves are controlled by switches on the pressure fueling control panel.

The primary fuel level control valve (float type) in each tank will act to shut off the fuel inlet at the tank when it becomes full. If a primary valve fails to close when the fuel quantity reaches the proper level, a float-operated secondary shutoff switch (one at each tank) will actuate. The secondary shutoff switch will cause the corresponding tank fueling valve to close and a corresponding indicator light, on the pressure fueling control panel, to go on. This light indicates that the primary fueling float valve has failed and that the fuel quantity for the corresponding tank is above the normal fuel level.

The d-c power must be connected and all appropriate circuit breakers IN to energize the secondary fuel shutoff system at all times during fueling operations.

NOTE: Because of escaping fumes around fuel tank vents and the pressure fueling compartment, operation of lights and electrical equipment nonessential to refueling must be avoided. Always have power off when disconnecting or reconnecting electrical plugs from remotely operated fuel valves when manually overriding the valves.

Defueling

The P-2H is defueled through the defuel valves (fuel drain valves). The valves are mounted over the landing gear trunnion, just forward of the bulkhead, below the rear beam on the inboard side of the nacelles, and at the aft end of the lower electronic compartment. The defuel valves are two-position valves which can be operated only at the valves. When the valves are opened, fuel drains from the system through the drain port in the valve.

Defueling aircraft with pressure refueling capabilities is accomplished through the pressure fueling manifold. Defueling consists of defueling any or all tanks by connecting a fuel line from the fuel manifold connector, through a suction pump to an outside storage tank or suitable receptacle. Selection of the tank or tanks to be defueled is accomplished at the pressure fueling control panel.

FUEL CELLS

Included among the various types of internal fuel cells used in naval aircraft are bladder-type cells, self-sealing cells, and integral cells. Bladder type cells and self-sealing type cells are constructed of rubber and fabric and are removable from the aircraft. Integral cells form a part of the aircraft structure and are therefore not removable. If trouble develops within an integral cell itself, AMS personnel will handle the repairs.

Since the ADR is concerned with removal, installation, and handling of bladder and self-sealing fuel cells, it is imperative that he be familiar with the construction features of these cells and have a clear understanding of the removal, installation, and handling procedures for each type.

During the process of removal and installation of a fuel cell, the fuel cell and aircraft will be open to tools, parts, and foreign objects. Check the cell and aircraft structure before installing a new or repaired fuel cell and, before completing an installation, account for all tools and spare parts. It would take only a small inexpensive part or tool left in a fuel cell to cause millions of dollars in damage and possible loss of life.

SELF-SEALING FUEL CELLS

A self-sealing cell is a fuel container which automatically seals holes or injuries caused during combat operations. A self-sealing cell is not bulletproof, but is merely puncture sealing. As the bullet passes through the cell wall into the cell, the sealant springs together quickly and closes the hole. At this time some of the fuel in the tank comes in contact with the sealant and makes it swell, completing the seal. In this application, science has used the natural stickiness of rubber and the basic conflict of rubber and petroleum to seal the hole. This sealing action reduces the fire hazard brought about by leaking fuel or oil and keeps the aircraft's fuel or oil intact so that the aircraft may continue operating and return to its base. (See fig. 8-1.)

There are several different types of self-sealing cells currently used in naval aircraft. The most commonly used types are the standard six-ply cell, the combination bladder and self-sealing cell, and the non-metallic plioform cell.

The bladder and self-sealing cell is the most common type.

The combination bladder and self-sealing cell is made up of two parts. One part is made of bladder type rubber, and the other part is made of six-ply self-sealing construction. This type cell is also semiflexible.

The nonmetallic plioform cell is of six-ply construction with additional supporting layers. The addition of the supporting layers makes this type cell nonflexible.

AD.429

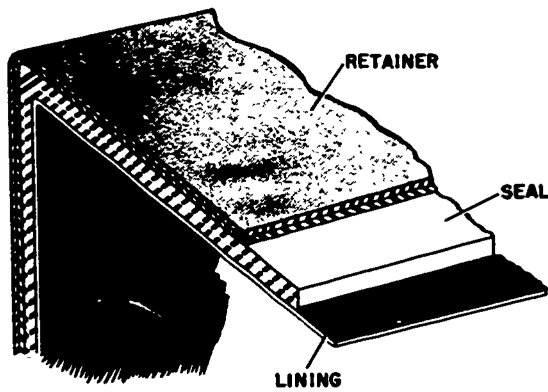
Figure 8-1.—Bullet sealing action.

BLADDER TYPE FUEL CELLS

Bladder type cells are used when self-sealing properties are not required. These cells are usually made of very thin gage material in order to give minimum possible weight. They require complete support from a smooth cavity.

Bladder type cells are fabricated in the same manner as self-sealing cells in that they have a liner, nylon barrier, and a retainer ply. The sealant layers are omitted. All three plies are placed on the building form as one material in this order—liner, barrier, and retainer.

The liner is made of Buna N rubber, the barrier is nylon, and the retainer is a special fabric impregnated with Buna N rubber. The outside is finished with colored Buna Vinylite lacquer. (See fig. 8-2.)



AD.430

Figure 8-2.—Primary fuel cell materials.

The major fittings are similar to those used in self-sealing fuel cells except that they have only one flange on the inside (liner side). The cell is made slightly larger than the cavity of the aircraft so the weight of internal pressure of the fuel is borne by the aircraft structure.

REMOVAL AND INSTALLATION

Most fuel cell damage occurs during the removal and installation process. The correct procedure to be used varies for each type of aircraft; therefore, reference should always be made to the Maintenance Instructions Manual for the aircraft concerned. There are, however, some general removal and installation procedures, as described in the paragraphs following.

Removal Procedure

The steps outlined below are generally followed when removing a fuel cell from an aircraft.

Defueling of the fuel cell is the first step and should be conducted in a designated area. Check to make certain that all the aircraft's electrical switches are in the OFF position. Ground the aircraft and container by approved methods. If no means of grounding is available attach a copper wire to the aircraft structure and secure the other end to a metal stake or pipe driven into the earth approximately 4 feet.

Make certain that firefighting equipment is on hand in the proper working order with qualified personnel for its operation. Completely drain the fuel from the cell.

Purge the fuel cell to remove residual fuel, and explosive and toxic fumes. The use of air for purging is the most efficient and effective means of removing the explosive and toxic fumes present in empty fuel cells. Carbon dioxide may also be used for temporary displacement of explosive mixtures from the interior of fuel cells.

CAUTION: Water is never used on rubber type cells as a purging agent, as it may cause failure of cell stiffeners and baffles.

The cell must be purged until all odors of fuel are removed, or tested with the explosion meter to a nonexplosive mixture content. The most thorough job of purging can be accomplished after the cell has n removed from the aircraft.

Remove any necessary parts of the structure or accessories to gain access to cells. When necessary to remove special equipment, such as radio or radar equipment, it should be removed by a technician from the shop concerned, whenever possible. The removal of stressed skin panels may make it necessary on some aircraft to jack or hoist certain sections to relieve strain and prevent possible structural damage.

Disconnect all fittings and lines leading to the cells as required. Failure to do this may result in damaged fittings. The type of fittings to be disconnected from the cell depends upon the design of the fuel system in the aircraft. Access fittings on some types of cells may have to be removed. This is essential because other fittings may have to be removed from inside the fuel cell.

Tape or protect sharp edges and corners of all cavity openings to eliminate chafing.

If necessary, collapse the cell and strap it in a folded position, being careful that the bends do not occur at any of the fittings. Cells which require collapsing should never be removed by any other method.

Carefully remove the cell, observing the following precautions:

1. Do not pull the cell by its fittings.
2. Carefully guide the protruding fittings past all obstructions.
3. If the cell binds while removing it, do not force it. Stop to determine the cause of the trouble and remedy it before continuing. Sprinkle the cell with talc or other suitable powder if it becomes necessary to squeeze the cell around or between structural members.
4. Do not pry on rubber fittings or on the cell with sharp instruments; use large wooden paddles.

Handling Precautions

Always carry or haul fuel cells. The purpose of carrying or hauling fuel cells is to protect the outside (retainer ply) wall, which serves to support the shape of the cell and protect the self-sealing (sealant) layer underneath it from gasoline spillage; therefore, its cord construction and lacquer coating must be cautiously safeguarded.

Never jostle or carry cells around by their fittings. Such handling may distort or break the metallic ring around the fitting, causing complete failure of the fuel cell. Do not flex cold cells since this will crack the stiffened synthetic rubber. Cells exposed to cold temperature (below 65°F) should be warmed to room temperature before being handled excessively.

Remove cells from shipping containers carefully. Before removing, be sure to detach all carrier straps and hanger fittings. Sufficient manpower should be available to carefully remove the cell from its container.

Never leave a semicollapsible cell without its stiffeners or internal braces for a period beyond 30 minutes. A longer time under such treatment will cause the cell to assume a permanent set or remain partially collapsed.

NOTE: Bladder type fuel and oil cells and nylon pliocels are much more delicate than self-sealing cells and require extremely careful handling; otherwise the handling precautions are the same as for self-sealing cells.

Installation Procedure

The steps outlined below are generally followed when installing a fuel cell in an aircraft.

Check the cells to make certain that it is the proper one for the cavity. Tape all cell openings. Inspect the fuel cell cavity for cleanliness, and loose bolts, nuts, etc., and make certain there are no sharp metal or protruding edges which may damage the cell during or after the installation of the fuel cell. Tape or otherwise protect the edges of the fuel cell if necessary.

Apply talc or other suitable powder to the outer surface of the cell and the cell cavity, as desired, to make it easier to move the cell into position.

If necessary, collapse or fold the cell as required and secure it with webbed straps. The cell should be warmed to room temperature; and when applying straps, place them and the buckles so they are easily accessible after the cell is installed.

Guide the fuel cell into the cavity, making sure it is installed in the right direction. Wooden paddles with rounded edges may be used to guide the cell into the cavity; never use tools with sharp edges or points. If any binding occurs, determine the trouble and remedy it before damage is caused to the fuel cell. Be very careful that protruding fittings are not damaged.

Remove straps if cell was collapsed; then check the interior of the cell to make certain that no tools or foreign materials were left inside.

Install and torque all fittings as required. Tighten and torque bolts in such a sequence that no undue stress will be placed at any one particular point. Lockwire all bolts and screws as necessary and attach all bonding wires.

NOTE: The use of any sealing compounds on rubber fuel cell fittings is prohibited. Sealing compounds may be used only on connections when the adjoining surfaces are metal.

Check the entire system for leaks. The air pressure method is recommended. Cells may be checked by filling with fuel; however, leaks may not occur for 24 hours when using this method.

Torque Requirements

One of the main causes of fuel leaks can be attributed to improper torquing of bolts used to secure fittings, door cover plates, and attachments. Overtorquing causes excessive rubber cold flow, warps fitting plates, and in some cases, breaks the metal inserts in fittings. Improper torquing sequence results in fuel leaks; therefore, it is important that a set sequence be followed. Prior to installation, check the proper technical instructions for torque sequences and techniques.

TESTING

When a new or repaired fuel cell is installed in an aircraft, it should be tested for possible leaks before it is filled with fuel. The air pressure test is the best method of determining if any leaks exist. This test consists of applying air pressure to a sealed cell and checking for the existence of leaks with a mercury manometer.

IDENTIFICATION OF FOREIGN MATTER IN FUEL SYSTEMS

The identification of foreign matter in the fuel system of an aircraft is important in that the carburetor can perform properly only when uncontaminated fuel is delivered to it. For this reason, a system of filters, sumps, drains, and screens are installed in the fuel system to insure that only uncontaminated fuel is delivered to the carburetor. Every precaution must be taken to keep the fuel from being contaminated: from the gas farm, to the gas truck or pit, and through to the final delivery to the aircraft.

The proper daily and preflight inspection procedures and maintenance checks should be rigidly adhered to. The sumps and strainers should be drained after every fueling operation, after allowing time for foreign matter or water to settle to the bottom of the system. The strainers should be taken apart and visually checked at every inspection period and whenever a malfunction is suspected within the system. Pieces of the lining in the tanks or hose lines may be found occasionally in the strainers, and the necessary steps should be taken to locate the source and to repair or replace the item immediately. Material such as dust and dirt may be introduced into the system through the filler necks of the tanks or whenever repairs are made to the system. Cleanliness is of prime importance in all aircraft fuel systems, and any foreign material found anywhere in the system must be identified and its source located as soon as possible.

CHAPTER 9

PROPELLER OPERATiON AND MAINTENANCE

The Chief and First Class Aviation Machinist's Ma'e R are required to troubleshoot and correct propeller system malfunctions and to rig and adjust propeller control mechanisms. In order to accomplish this, they must know the operating procedures for constant-speed propellers, including procedures for propeller disassembly and assembly. In addition, the Chief Aviation Machinist's Mate R must know the procedures for balancing propeller assemblies.

The purpose of this chapter is to provide a generalized picture of the maintenance and troubleshooting of the constant-speed propeller system. The 43E60 and 24260 propellers are used as typical propellers. When actually troubleshooting a system or performing actual maintenance, reference must be made to the appropriate technical publications.

OPERATING PRINCIPLES (43E60 AND 24260)

The Hamilton Standard Reversing Hydromatic propeller permits constant-speed operation within the limits of the pitch changing mechanism, feathering of the propeller in flight, and reverse pitch operation which greatly improves the ground handling characteristics of multiengine aircraft. The two types of propellers discussed in this chapter are the 43E60 and 24260 models, and the model 5U18 double-acting constant-speed control, which is the same for both propellers except for minor modifications. (See fig. 9-1.)

Instead of the two-slope cams used in the nonreversing type, three-slope cams are used in the reversing model, the third slope being utilized for reverse-pitch operation. A reverse-pitch stop ring limits the blade angle in reverse pitch on the 43E60 and 24260. The low blade angle is limited by a low-pitch stop lever assembly. (An oil transfer housing is used to direct oil to and from the propeller.) Oil from the constant-speed control is directed to either the inboard or outboard side of the piston through the oil transfer housing.

A cam assembly on the No. 1 blade shank actuates a blade control switch on the barrel during unreversing and unfeather operation. A similar cam on the No. 2 blade on three-bladed propellers and on the No. 3 blade on four-bladed propellers actuates another blade control switch on the barrel during feathering and reversing operations.

A slipring assembly, which provides a means of current transmission from a brush block assembly mounted on the nose section of the engine to the blade control switch on the 43E60 propeller, is mounted on the inboard end of the propeller barrel. The slinger ring is used to distribute anti-icing fluid to the blades and is attached to the slipring assembly. Nozzles direct the fluid to the propeller blades. The 24260 propeller utilizes both face and drum type sliprings for deicing and control of the propeller. Deicing on this model propeller is done electrically, using heaters in the leading edge of each blade.

BARREL ASSEMBLY

The barrel assembly of the 24260 propeller is machined from a one-piece steel forging incorporating a cylindrical central bore and four cylindrical blade arms. The blades are retained by four races of ball bearings. The inner race for these bearings is on the blades, the outer race is in the barrel. Each blade is free to turn about its axis under control of the dome assembly.

The barrel assembly of the 43E60 propeller is made in two pieces, and they are machined and balanced as a pair and kept together for the life of the propeller. The barrel halves are held

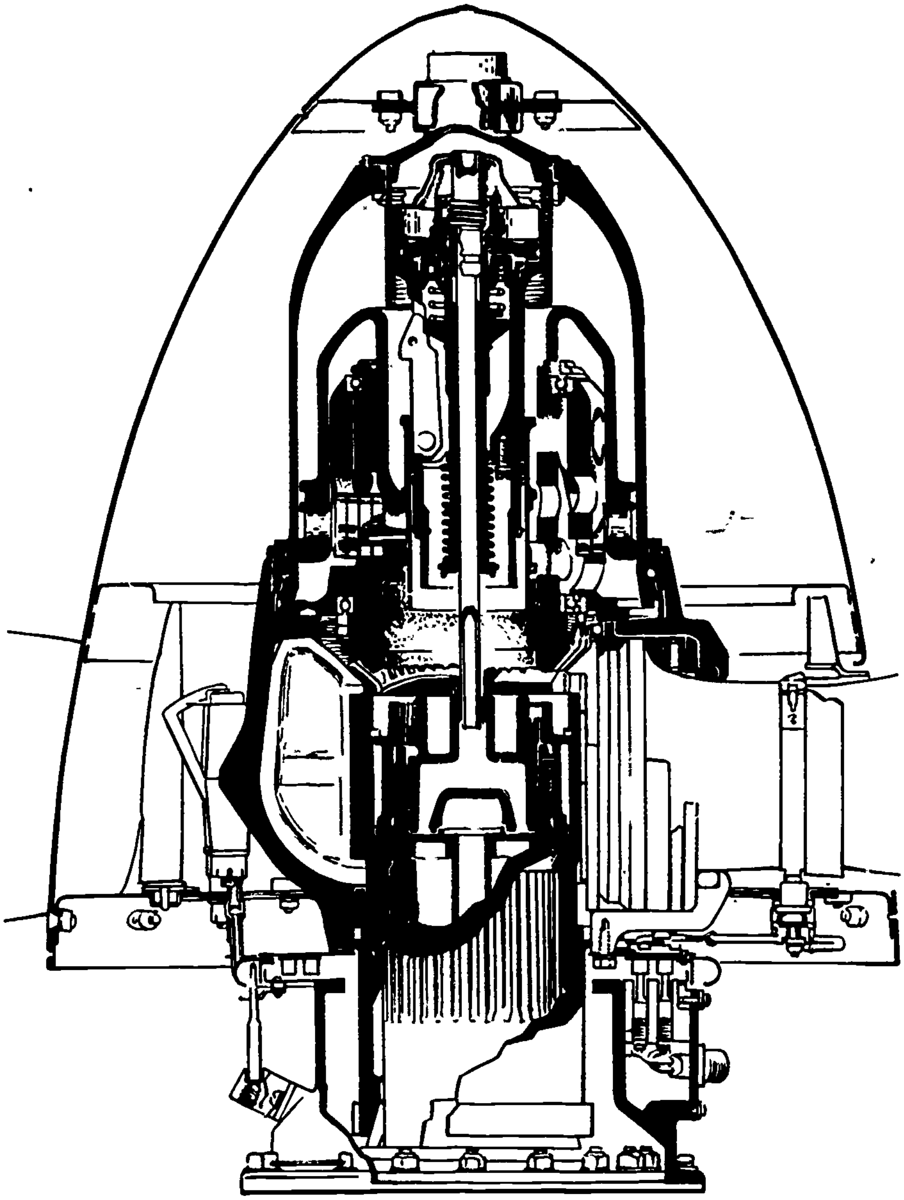


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Figure 9-1.—Cutaway view of the 43E60 propeller.

together by the barrel bolts and nuts. The bolts are hollow and may be filled with lead wool as required to achieve final propeller balance.

CONSTANT-SPEED CONTROL

The double-acting constant-speed control directs oil to either the inboard or the outboard side of the piston in the dome, changing the blade angle in order to maintain the selected engine rpm. It is mounted on the nose section of the engine. The control is made up of three assemblies: head, body, and base. The 5U18 control utilizes a stepmotor electric head to adjust the position of the speeder rack, which in turn changes the compression on the speeder spring. This sets the control to maintain any selected rpm within the operating range of the constant-speed control. The stepmotor electric head may be controlled through a synchronizer system or by a manually operated toggle switch in the cockpit. The electric head eliminates mechanical linkage between the cockpit and the constant-speed control. The constant-speed control also includes flyweights, a gear type pump which produces oil pressure for the operation of the propeller, and various valves which control and direct the flow of oil to the propeller.

An electrically driven auxiliary pump is used as a source of high-pressure oil during the four auxiliary operations. These are the feathering, unfeathering, unreversing, and reversing cycles. The output of the auxiliary pump is led to the constant-speed control and is automatically directed to the proper side of the propeller piston to produce the desired blade angle change.

PROPELLER OPERATION

The most significant natural force affecting the angle of the propeller blades is the centrifugal twisting moment, which tends to move the blades to a flat or a zero blade angle. This force is always present when a propeller is rotating. Oil pressure from the constant-speed control must overcome the centrifugal twisting moment in order to move the blades to a higher blade angle when desired. Therefore, higher oil pressure is required to increase blade angle.

Oil pressure directed to the outboard side of the propeller piston causes the blades to move toward a higher pitch. The constant-speed control permits oil drainage from the inboard side of the piston when the blade angle is increased. When the blade angle is decreased, the constant-speed control directs oil to the inboard side of the piston and allows drainage from the outboard side of the propeller piston back to the inlet side of the pump in the constant-speed control. Both the pressure oil and the drain oil flow through separate passages in the oil transfer housing, which is screwed into the propeller shaft. The propeller piston may move outboard until a steel sleeve in the piston rests against the levers of the low-pitch stop lever assembly. These levers are held outward by a wedge so that they will engage the sleeve in the piston as the propeller blades reach the low-pitch setting.

When reversing operation is desired, oil pressure from the governor aided by oil pressure from the auxiliary pump actuates the servo unit of the low pitch stop lever allowing the piston sleeve to cam the stop levers down and move forward to the reverse position. This allows the levers to move inward so that the sleeve in the piston may pass by the levers, allowing the blades to go past the low-pitch limit and into reverse pitch. The limit of reverse is reached when lugs of the reverse-pitch stop ring on the rotating cam come up against lugs on the stationary cam. The No. 2 blade switch, which is actuated by a cam attached to the blade shank of either No. 2 or No. 3 blade, shuts off the auxiliary pump a few degrees before full reverse. Constant-speed control oil pressure then moves the blades into the full reverse position. In the reverse position, slotted ports in the piston sleeve are opened to act as a dump valve, permitting the high oil pressure on the inboard side of the piston to dump through the ports to the outboard side of the piston.

During unreversing, the auxiliary pump furnishes high-pressure oil to the constant-speed control, which directs the oil to the outboard side of the piston and allows oil to drain from the inboard side of the piston. When the piston has moved to a point where the forward end of the piston sleeve is well past the levers of the low-pitch stop lever assembly, the levers are forced outward by spring tension on the wedge and the auxiliary pump is cut off by the No. 1 blade switch. The piston then moves back until the sleeve rests against the levers of the low-pitch stop lever assembly.

During feathering, the auxiliary pump furnishes high-pressure oil to the constant-speed control, where it is combined with governor oil pressure and is directed to the outboard side of the piston and allows drainage from the inboard side of the piston. This moves the piston inboard and the blades to the feather position. Lugs on the high-pitch stop ring (located on the rotating cam) contact lugs on the stationary cam to stop the blades in the feather position.

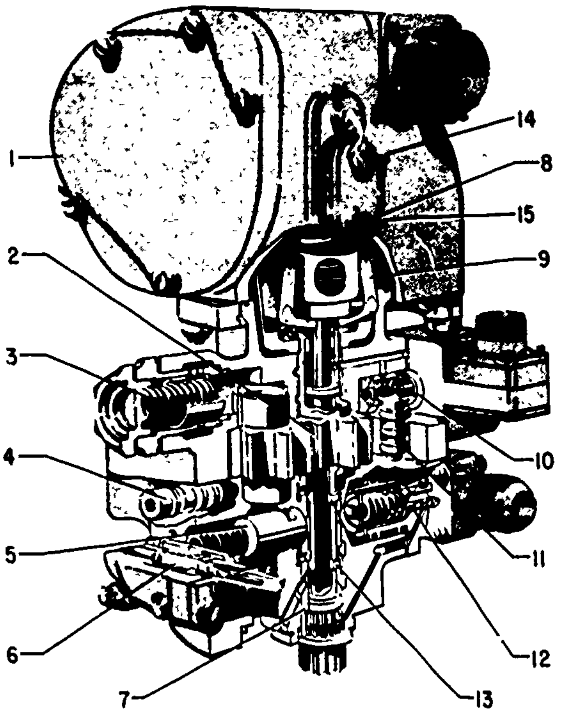
For unfeathering, high-pressure oil from the auxiliary pump is supplied to the constant-speed control which directs it to the inboard side of the piston, moving the piston outboard and the blades to a lower angle. As the propeller begins to windmill, the governor boost pump starts to operate and will aid the auxiliary pump to move the blades out of feather. The auxiliary pump is shut off by releasing the feather button when a low rpm is reached. This terminates the unfeathering cycle and allows the constant-speed control to maintain full decrease rpm, which is selected prior to unfeathering.

CONSTANT-SPEED CONTROL OPERATION

A cutaway view of the constant-speed control is shown in figure 9-2.

The stepmotor electric head provides a means of controlling the compression of the speeder spring (8). This compression determines the rpm necessary to hold the flyweights (9) in a balanced or onspeed condition. If compression on the speeder spring is increased, more rpm is required to cause the flyweights to move outward to attain the onspeed condition. If compression is decreased, less rpm is needed.

Whenever the flyweights move in, the pilot valve (13) moves down. When the flyweights move out, the pilot valves moves up. The position of the pilot valve determines whether oil is directed to the inboard side of the piston or to the outboard side of the piston. During constant-speed operation, the pilot valve (13) is positioned by the forces of the flyweights and the speeder spring. During the four auxiliary



1. Electric head.
2. Pump.
3. High-pressure and relief valve.
4. Shuttle valve.
5. Low-pressure relief valve.
6. Pressure cutout switch.
7. Drive gear shaft.
8. Speeder spring.
9. Flyweight.
10. Solenoid valve.
11. Selector valve.
12. Auxiliary pressure check valve.
13. Pilot valve.
14. Low rpm adjustment.
15. High rpm adjustment.

Figure 9-2.—Cutaway view of the 5U18 constant-speed control.

conditions, it is positioned by oil pressure in the upper or lower positioning chamber. If the greater force is on the top of the positioning land, the pilot valve will move down. If the greater force is on the bottom of the positioning land, the pilot valve will move up.

The pump (2) boosts engine oil pressure to the pressure required to operate the propeller during constant-speed operation. This does not include the four auxiliary conditions mentioned previously.

The high-pressure relief valve (3) limits the maximum oil pressure for operation of the propeller except when correcting for a normal underspeed condition.

The selector valve directs high-pressure oil to back up the spring side of the low-pressure relief valve during the feathering, unfeathering, reversing, unreversing, and normal overspeed operations. The low-pressure relief valve prevents pressure from building up sufficiently to actuate the servo unit of the low pitch stop lever during ground operation.

During all conditions except normal underspeed, high-pressure oil is directed to the spring side of the low-pressure relief valve by the selector valve, increasing the amount of pressure necessary to open the low-pressure relief valve. and allowing pressure to build up until it is relieved by the high-pressure relief valve. By controlling the pressure during a normal underspeed condition, the low-pressure relief valve prevents an inadvertent reversal during ground operation.

The shuttle valve (4) is used to direct high-pressure oil to the plunger side of the pressure cutout switch (16) and return oil to the spring side of the pressure cutout switch. The pressure cutout switch is used on some models to release the feather button after the blades reach the full feather position.

The auxiliary pressure check valve (12) permits the entry of high-pressure auxiliary pump oil into the constant-speed control during the four auxiliary conditions and allows for positive positioning of the pilot valve. It also directs oil to the following places whenever it is in operation: The pressure chamber of the pilot valve, the solenoid valve, and the lower positioning chamber of the pilot valve to create an artificial overspeed for feather and unreverse. It prevents oil from the pump of the constant-speed control from pressurizing the auxiliary pump line during constant-speed operation. It also has a small bleed hole for winterization, which allows a slight amount of control oil to enter the auxiliary line during constant-speed operation. This will prevent oil congealing in this line during cold weather.

The solenoid valve (10), is energized during unfeathering and reversing. It directs oil pressure to the upper positioning chamber causing the pilot valve to move downward, thus creating an artificial underspeed condition.

The low rpm adjustment (14) provides a means of setting the minimum governing rpm by limiting the upward travel of the speeder spring rack.

The high rpm adjustment (15) provides a means of setting the maximum governing rpm by limiting the downward travel of the speeder spring rack.

CONSTANT-SPEED OPERATION

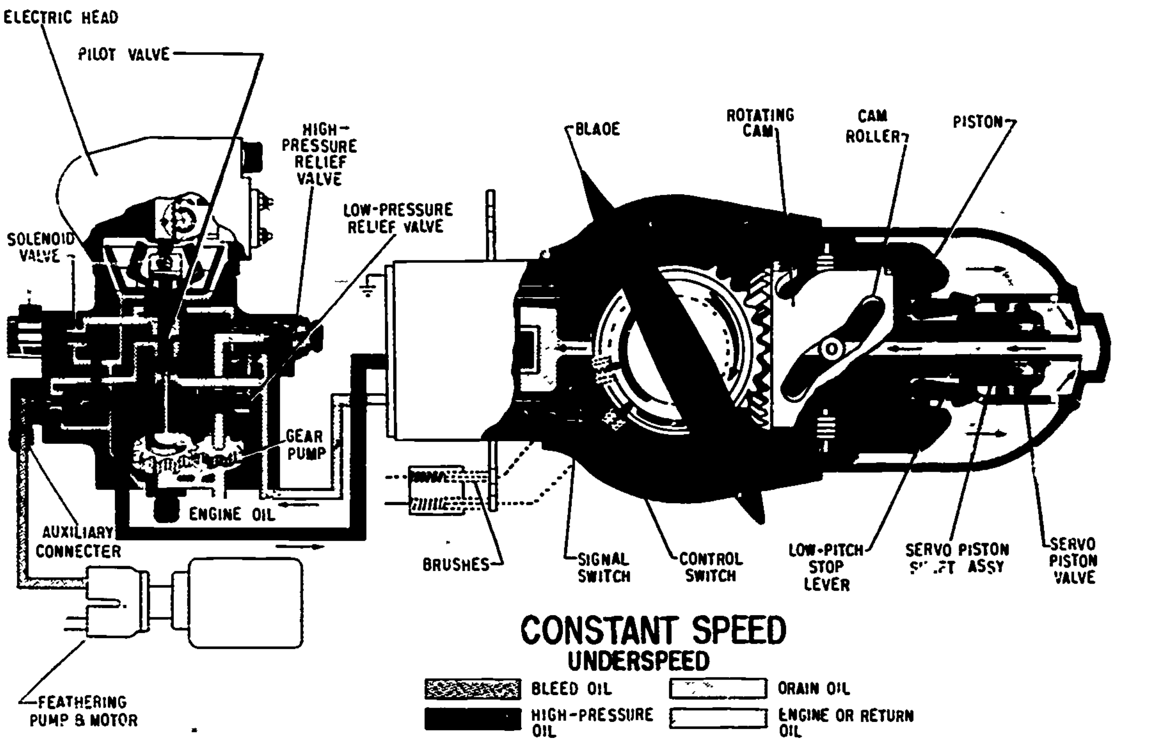
During constant-speed operation the gear pump of the constant-speed control boosts engine oil pressure to that required for the operation of the propeller.

Underspeed

An underspeed condition is shown in figure 9-3. The force on the speeder spring has overcome the centrifugal force of the flyweights and the pilot valve has moved down. The pilot valve in this position directs oil pressure to the inboard side of the propeller piston and allows oil to drain from the outboard side of the piston. The oil pressure on the inboard side of the piston moves the piston outboard, moving the blades to a lower angle. As the blades move to the lower angle, engine rpm increases. The increased centrifugal force on the flyweights causes the flyweights to move outward, raising the pilot valve. When the force of the speeder spring becomes balanced by the centrifugal force on the flyweights, the pilot valve will be in position to restrict the pressure and drain ports, and the pitch will stop changing. This is the onspeed condition.

Overspeed

When the engine rpm exceeds that selected by the pilot, the centrifugal force of the flyweights will overcome the force of the speeder spring and the flyweights will move outward. This raises the pilot valve, directing oil pressure to the outboard side of the piston, allowing drainage from the inboard side of the piston and moving the blades to a higher blade angle. As the blade angle is increased, the rpm is decreased, which lessens the centrifugal force exerted by the flyweights. The flyweights move inward. When the selected rpm is attained, the flyweights balance the force of the speeder spring. The



AD.433

Figure 9-3.—Propeller system operating diagram—constant speed.

pilot valve restricts oil flow to and from the piston, and the onspeed condition is again reached.

During all conditions of constant-speed operation, the wedge is forcing the levers of the low-pitch stop lever assembly outward, holding the levers in position to engage the sleeve of the piston, thus limiting the low blade angle. With the auxiliary pump off and no pressure in the line from the auxiliary pump to the constant-speed control, the auxiliary pressure check valve prevents oil from the pump in the constant-speed control from pressurizing the auxiliary pump line. Except during normal underspeed, the selector valve is in the position which allows outboard oil pressure to reach the spring side of the low-pressure relief valve. This allows the high-pressure relief valve to control the pressure going to the propeller piston except during a normal underspeed condition.

OPERATION DURING AUXILIARY CONDITIONS

Reversing

The operation of the propeller during reversing is shown in figure 9-4. For reversing, an artificial underspeed condition is set up in the constant-speed control. (Notice that the flyweights are inward, in the same position as for a normal underspeed condition.)

The artificial underspeed condition is accomplished in the following manner. An electrical circuit is completed when the throttles are moved back onto the reverse position. A switch on the landing gear prevents this circuit from being completed unless the weight of the aircraft is on the ground. This also prevents accidental reversing during flight. The completion of the circuit turns on the auxiliary pump, which

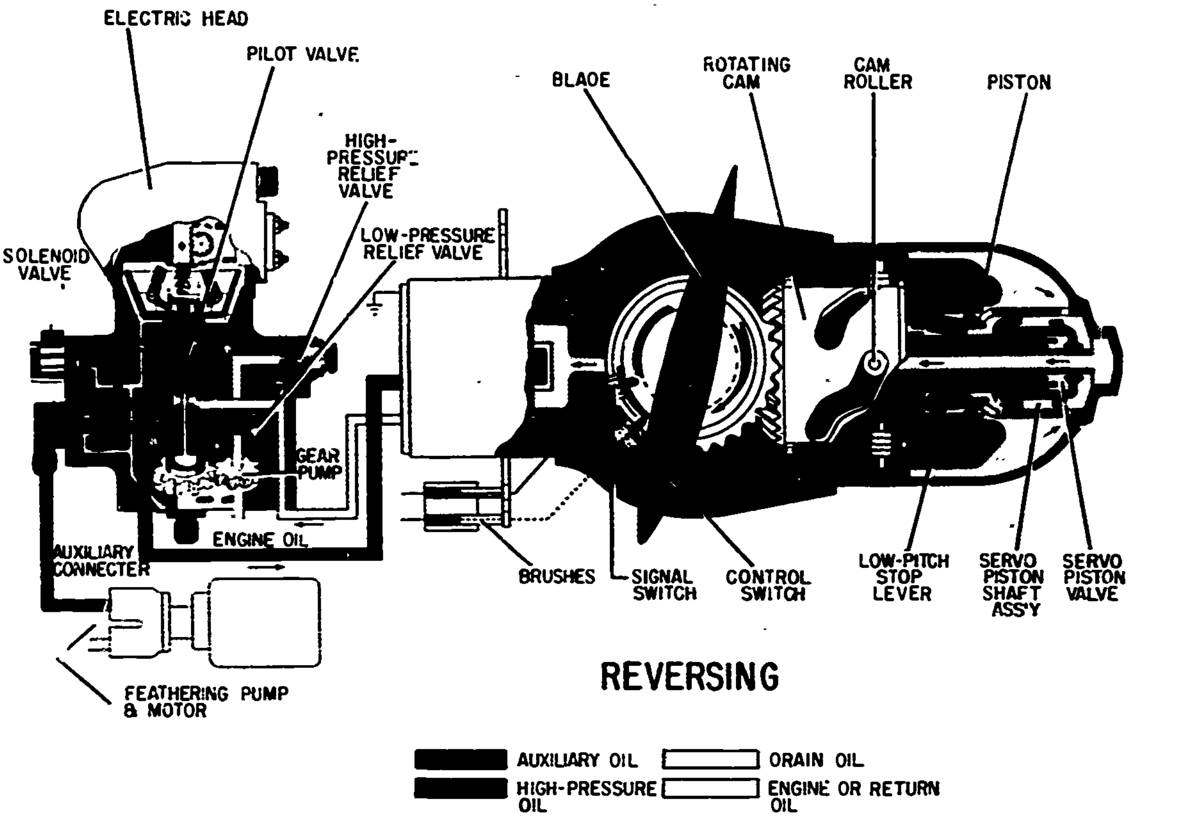


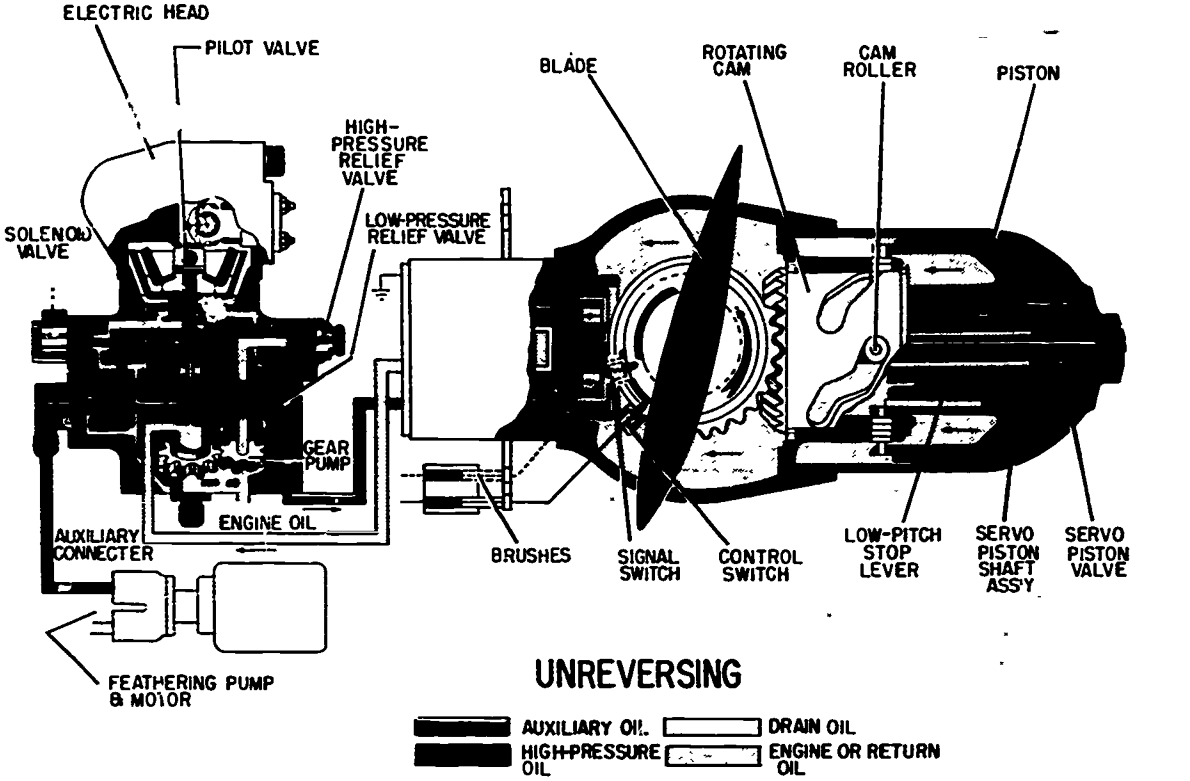
Figure 9-4.—Propeller system operating diagram—reversing.

furnishes high-pressure oil to the governor to assist in reversing the propeller. This high-pressure oil is delivered through the auxiliary pressure check valve to the solenoid valve, which is energized by the completion of the circuit so that the high-pressure oil may enter the upper positioning chamber to the top of the pilot valve. The force of this oil moves the pilot valve down into the underspeed condition. The selector valve allows the oil from the solenoid valve to back up the spring side of the low-pressure relief valve, thus raising the pressure permitted in the system. The underspeed position of the pilot valve directs oil pressure to the inboard side of the piston, moving the piston forward and the blades to reverse pitch.

Since the sleeve of the piston is stopped by the levers of the low-pitch stop lever assembly, sufficient pressure builds up at this point to actuate the servo unit of the low-pitch stop lever to r ove the wedge from underneath the levers. The levers are moved inward by the camming action of the piston sleeve releasing the piston and allowing the blades to move into reverse pitch. Before the blades reach the full reverse position, the cam on the No. 2 or the No. 3 blade actuates the switch that cuts off the auxiliary pump. The blades are then held in reverse pitch by pressure from the pump of the constant-speed control. The reverse stop ring limits the angle of the blades while in full reverse.

Unreversing

The operation of the propeller during unreversing is shown in figure 9-5. To accomplish unreversing, an artificial overspeed condition is set up in the constant-speed control.



AD.435

Figure 9-5.—Propeller system operating diagram—unreversing.

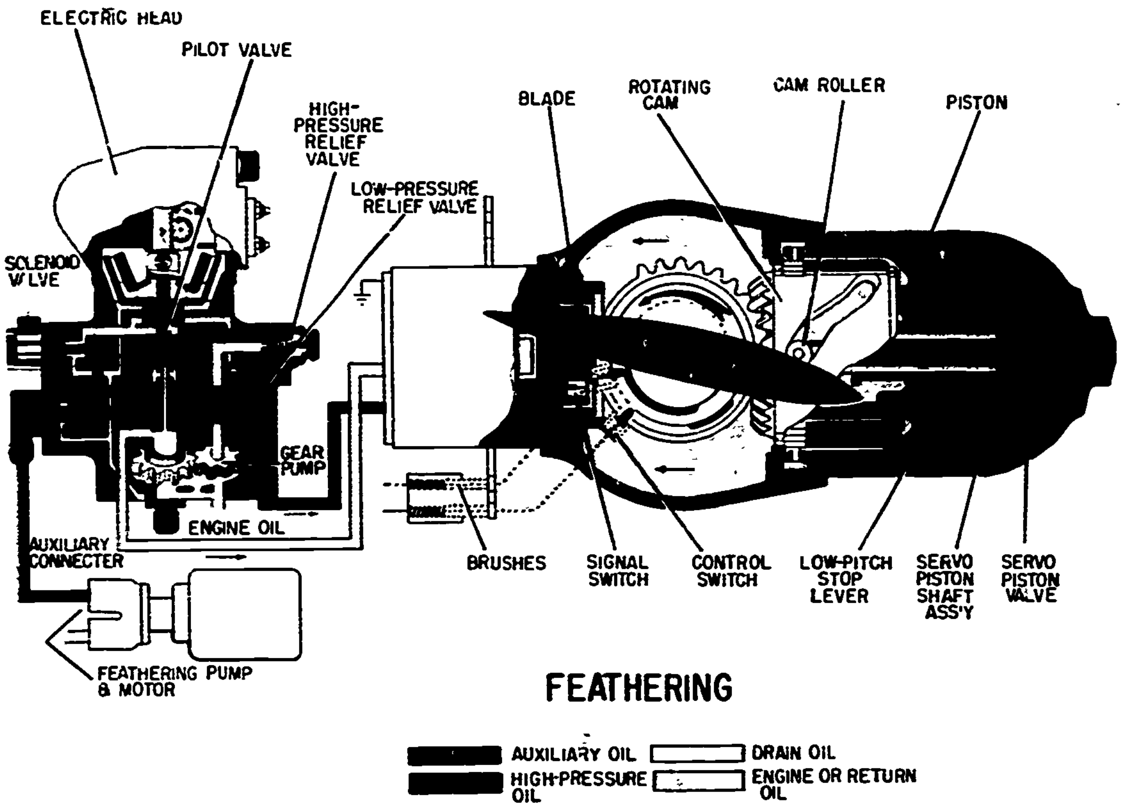
When the throttle is moved forward (out of the reverse position), the unreversing circuit is energized, thus turning on the auxiliary pump. The solenoid valve, when deenergized, shuts off the pressure to the upper positioning chamber, which had been maintaining the artificial underspeed condition, and allows it to drain. The auxiliary connector check valve directs oil pressure that moves the pilot valve up and into the overspeed condition. Oil pressure is again directed by the selector valve to back up the spring of the low-pressure relief valve, thus allowing high oil pressure into the system. Oil is directed by the pilot valve to the outboard side of the piston, which moves the blades toward a high angle.

Because of the reduced oil pressure on the inboard side of the piston, the wedge moves under the levers of the low-pitch stop lever assembly after the piston sleeve clears them. This forces the levers outward. When the sleeve of the piston passes the levers, the levers return to their normal constant-speed position. When the blades reach an angle well above the low-pitch position, the cam mounted on the No. 1 blade actuates a switch that turns off the auxiliary pump and the propeller returns to a low blade angle.

Feathering

The operation of the propeller during feathering is shown in figure 9-6. For feathering, an artificial overspeed condition is set up in the constant-speed control.

When the feather button is pushed in, the auxiliary pump is started. High-pressure oil is directed by the auxiliary connector check valve to raise the pilot valve to the overspeed condition. High-pressure oil again backs up the spring



AD.436

Figure 9-6.—Propeller system operating diagram—feathering.

of the low-pressure relief valve and permits the high pressure necessary for moving the blades to the feather position. Oil is directed by the pilot valve to the outboard side of the propeller piston, moving the blades to the feather angle. When the lugs of the feather stop ring on the rotating cam contact the lugs of the stationary cam, the blades are in the feather position. The feathering operation is terminated by pulling out the feather button and breaking the circuit, or by a pressure cutout switch or timer which automatically releases the feather button, depending on the installation used.

Unfeathering

The operation of the propeller during unfeathering is shown in figure 9-7. To accomplish unfeathering, an artificial underspeed condition is set up in the constant-speed control.

To unfeather, the feather button is momentarily held out manually. This turns on the auxiliary pump and positions the solenoid valve to direct auxiliary oil pressure to the upper positioning chamber to position the pilot valve in an artificial underspeed condition. At the same time this high-pressure oil from the solenoid valve is directed through the selector to back up the low-pressure relief valve, allowing a high pressure in the system. With the pilot valve in the underspeed condition, oil is directed to the inboard side of the piston. This forces the piston forward and moves the blades out of the feather position to a lower blade angle.

Unfeathering is terminated when the feather button is released. If the feather button is held out too long, the cam on the No. 1 blade actuates the switch which cuts out the auxiliary

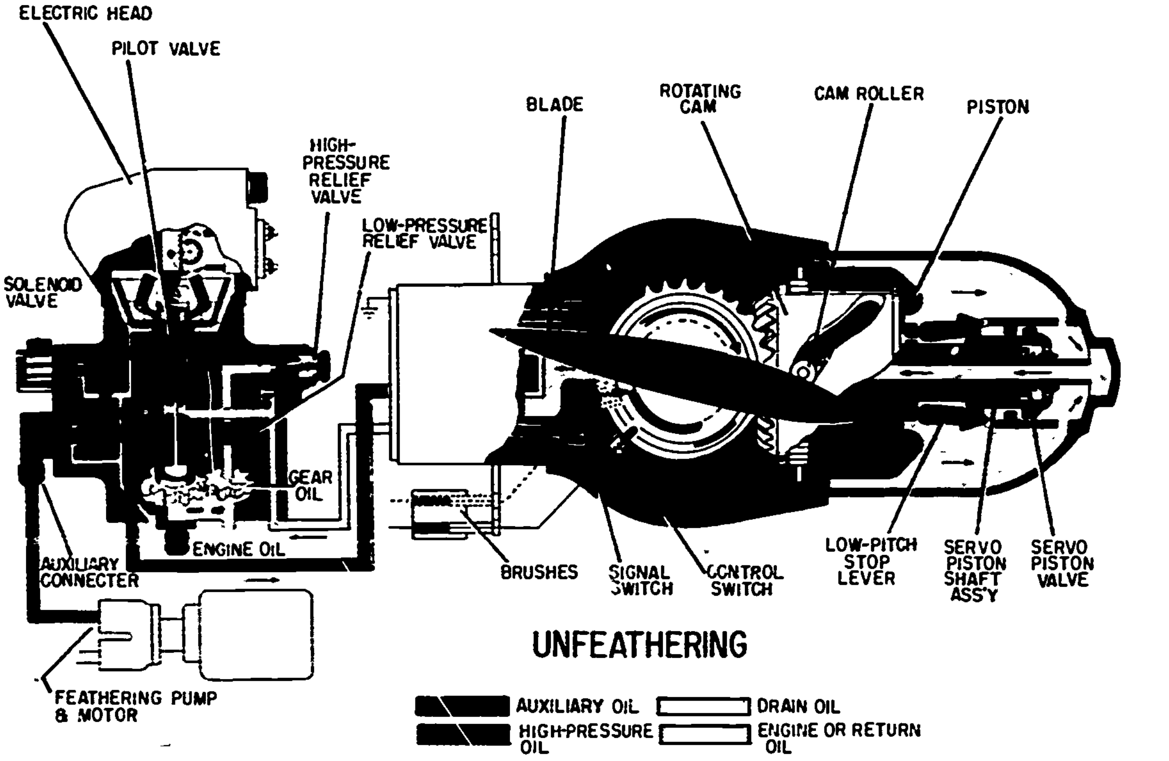


Figure 9-7.—Propeller system operating diagram—unfeathering.

pump and deenergizes the solenoid valve. This happens just before the sleeve in the piston reaches the low-pitch stop lever and prevents accidental reverse pitch, since an artificial underspeed condition is required to actuate the low-pitch stop lever.

CONSTANT-SPEED CONTROL INSTALLATION AND REMOVAL

INSTALLATION

A general discussion of installation procedure is given here. The appropriate technical publications should be consulted for specific instructions.

If the constant-speed control is to be installed on a new or overhauled engine, remove the mounting pad cover from the engine nose. Make sure that the shipping gasket between this cover and the engine pad is also removed. Failure to remove this gasket would affect the flow of engine oil to the control and would cause malfunction of the control. Clean the surface of the mounting pad and base of the control. Install a new gasket on the mounting pad with the raised portion of the metal screen of the gasket facing up. Install the control on the studs of the mounting pad. The one proper position of the control on the mounting pad is indicated by the shape of the joining surfaces. Make sure that the splines of the control shaft are properly alined with the internal splines in the engine pad and that the circular boss in the base of the control fits properly into the circular recess in the engine pad. Install the washers and nuts and tighten evenly to the proper torque. Lockwire the nuts in pairs.

Connect the auxiliary high-pressure oil line from the auxiliary pump to the auxiliary connector on the control. Make the electrical connections to the solenoid valve, etc. After tune-up, if necessary, make the low-rpm and high-rpm adjustments by first toggling the speeder spring rack off the stop and then loosening the self-locking nuts on the adjusting screws. Remove the lockwire from the screws and adjust to give the desired rpm settings. Tighten the nuts and lockwire the adjusting screws to each other.

REMOVAL

The removal of the constant-speed control is the reverse of the installation procedure. If another control is not installed immediately, install a gasket and cover on the mounting pad.

PROPELLER INSTALLATION AND REMOVAL

INSTALLATION

Clean the propeller shaft and engine thrust nut thoroughly. Put a light coat of clean engine oil on the propeller shaft. Install the split rear cone on the propeller shaft, making sure that the surfaces of the cone are dry and clean. Install the spider shaft spacer on the shaft next to the rear cone. Install the O-ring seal on the shaft next to the spacer. Make pencil marks on the forward end of the propeller shaft to indicate the locations of the locking holes of the shaft. This will facilitate the alinement of one of the slots in the retaining nut with a hole in the propeller shaft.

Place the front cone, propeller retaining nut, and snapring in position in the propeller hub, turning the blades in the hub enough to allow these parts to be inserted past the blade gear segments. As with the rear cone, the surfaces of the front cone should be clean and dry. Apply a thin coat of thread lubricant to the threads of the propeller shaft.

Using a power wrench and sling assembly, lift the propeller onto the shaft. If the propeller shaft has an index spline or an index screw, aline the blank spline of the propeller hub with it and slide the propeller back on the shaft. As the propeller is pushed fully into position, tighten the retaining nut by hand to insure that there is not binding or cross threading. Tighten the retaining nut with a short bar until it is snug. Using the power wrench, tighten the retaining nut to the proper torque, and aline one of the locking slots in the retaining nut with one of the locking holes in the propeller shaft.

Place the oil transfer housing gasket against the plate inside the propeller shaft. Clean the threads of the oil transfer housing and the internal threads of the propeller shaft and apply a light coat of thread lubricant or engine oil to them. Carefully screw the oil transfer housing into the shaft by hand. Tighten the oil transfer housing to the proper torque, alining the splines on the housing with the splines on the inside of the retaining nut to receive the lock segment. Install the lock segment and secure with the lock segment lockwire.

NOTE: Never back off the retaining nut to aline a slot with a hole. If necessary, back the retaining nut all the way off and retighten to the proper torque. Insert the propeller retaining nut lock through the hole in the shaft and into the slot in the retaining nut.

Prior to installing the dome, each blade should be turned in the barrel to the specified feathering setting and the rotating cam in the dome should be set at the high angle.

NOTE: The dome may be installed with the blades at the low pitch setting with the same results; however, it is recommednded that the method of setting the units at the feather angle be used. Therefore, this method is described in the following paragraphs.

Assuming that all correct settings and adjustments have been made during assembly of the dome, set each blade of the propeller in the feathered angle specified. Refer to the blade butt index and, using the blade turning bar, turn all blades in a manner that will aline the index line on the barrel with the feathering angle specified on the butt blade. Using the correct tool on the rotating cam gear, turn the cam until the feather stop ring lugs contact the lugs on the base of the fixed cam. This stop ring should, of course, be checked to assure that it is accurately located.

Install the required number of preload shims over the fixed cam locating dowels. The total thickness of shims required is etched on the barrel shelf. The dash number following the shim number indicates the thickness of the shim in thousandths of an inch. Do not install the dome-barrel seal at this time.

With the dome lifting handle installed in the dome, lift the dome and aline it with the locating dowels on the barrel shelf. Because of the dowel arrangement, the dome will fit in only one position. Just before installing the dome, check that the rotating cam is tightly against the stop lug. After the dome is positioned correctly, tighten the dome retaining nut until it is firmly seated on the barrel shelf. Aline the hole in one of the retaining nut lugs with one of the crescent slots in the outboard edge of the barrel. Carefully mark this location of the retaining nut, and remove the dome.

Install the dome-barrel seal, and again place the dome in position using the same care as before. Tighten it until the previously marked holes are lined up.

NOTE: With the dome assembly properly seated in the barrel, the front face of the dome retaining nut will be approximately flush with the outboard edge of the barrel. Failure to tighten the dome unit securely in the hub will result in elongation or failure of the dome shell retaining screws, and oil leakage around the dome retaining nut.

Check the feather angle at the reference station with a protractor and blade template.

Remove the dome lifting handle and, with the aid of a blade turning device, manually turn the blades to low pitch. Again check the setting with the protractor. At both feather and low pitch, the blade angles should be within 0.5 degrees of the specified settings. Insert the dome retaining nut lock screw and safety it with a cotter pin. Install the dome cap, and lock the cap in place with a cotter pin or a lock screw and a cotter pin on later assemblies.

NOTE: If for any reason the oil transfer tube is removed from the dome or the setting of the low-pitch stop lever assembly is disturbed, these must be reset according to current propeller overhaul instructions. This also applies to the reverse- and high-pitch stop rings. Care must be taken not to damage the oil transfer tube during dome installation and removal.

REMOVAL

The removal procedures are the reverse of the installation procedures. While the dome or the propeller is removed, special care must be taken that no electrical circuits are energized from the cockpit. If the auxiliary pump were turned on, a stream of oil (often hot) under pressure would be sent out the propeller shaft, causing possibly serious injury to anyone in front of the propeller.

After removal, if another propeller is not to be installed immediately, clean, oil, and cover the propeller shaft. If the propeller is to be stored for any length of time, preserve the propeller in accordance with current instructions.

ASSEMBLY AND DISASSEMBLY

The installation and removal of propellers are usually performed in Organizational maintenance activities. The supporting AIMD provides replacement propellers to the Organizational activity in a ready-for-installation condition and receives the replaced propellers in the condition they were removed from aircraft. Therefore, the preparation of new or overhauled propellers for Organizational activities is the responsibility of the AIMD. Thereby, propellers received from Organizational activities are either repaired or are prepared for shipment to Depot maintenance by the AIMD. This requires the assembly and disassembly of the propellers, as appropriate, which, of course, must be accomplished by the ADR's assigned to the AIMD.

NOTE: It must be emphasized that the procedures discussed in the following paragraphs are representative of those required for the assembly and disassembly of different models of propellers. Therefore, applicable technical manuals must be utilized for the assembly and disassembly of specific models. Current technical manuals are especially important for obtaining such information as the part numbers of required special tools, military specifications of cleaning materials and lubricants, correct torque values and tolerances, etc.

Assembly

The following procedures are those required to assemble a new or overhauled propeller as received from supply and to test it prior to installation on an aircraft. As received, the disassembled components are coated with preservative and packed in a shipping box.

Remove the barrel from the shipping box and clean it thoroughly with an approved solvent. Place the barrel on the assembly and balancing bushing installed on the post of the assembly table. Attach the bushing in place with the front cone and propeller retaining nut. Remove the barrel bolts and separate the barrel halves using the specified puller. Make certain not to let the bottom half of the barrel drop on the table.

Remove the blades from the shipping box and clean with an approved solvent. Do not allow the cleaning solvent to contact any rubber parts. All plated steel parts should be given a light coat of oil after cleaning.

Remove the various components from their packing containers and remove the preservation. It should be noted that the components are numbered to indicate their location in the propeller. It is imperative that these parts be installed in their correct positions to obtain proper fit and balance of the propeller.

Install the blade packing rings by opening the split and sliding onto the blade shank. Make certain the side with the pins is outboard. Apply a light coat of the recommended lubricant to the packings and spider arm bearing surfaces, and stretch the packings over the blade butts. Apply a light coating of the recommended lubricant on the shim and shim plate and install them onto their respective blade butts. After making certain that the barrel supports are in their proper position, install the blades on the spider arms in accordance with the proper numbers. Before pressing the blades against the spider, make sure that the spider shim plates are correctly fitted over the drive pins.

Line the zero on the beveled washer with the zero on the blade butt. Apply a light coat of lubricant to the thrust bearing retainers and install the retainers between the flat surfaces on the beveled and flat thrust washers on the blade shank.

While holding the thrust bearing retainers in place on each shank, and, with the blade packing in place against the thrust washer, raise the inboard barrel half into position so that the arm-identifying numbers on the spider and barrel half coincide. With the barrel half properly alined, carefully drive it into place with a rawhide or rubber mallet. Lubricate the barrel half seals and install them into the groove of the rear barrel half.

Match the position numbers of the outboard barrel half with the inboard half and drive the outboard half down with a rawhide or rubber mallet until it seats on the barrel supports. When driving the barrel halves together, drive them into place evenly. Do not hammer continuously on one side.

The barrel bolt bosses are numbered so that they progress in a counterclockwise direction with numbers 1, 2, 3, and 4 between barrel blade bores 1 and 2, and so number 1 and number 12 are at opposite sides of number 1 barrel blade bore. The barrel bolts are numbered correspondingly. Install the bolts in their respective positions. One washer should be placed on the heads of bolt numbers 2, 6, and 10, and one washer under the head and one washer under the nut of bolt numbers 3, 7, and 11. One washer is required under the head and one under the spinner mounting bolt of bolt numbers 4, 8, and 12. No washers are required on bolt numbers 1, 5, and 9. Install the nuts on the bolts handtight. Torque in the manner and to the value specified in the applicable technical manual.

After it has been assembled thus far, remove the propeller from the assembly table and install it on the post of a test rig. Install the front cone and propeller retaining nut, then install the oil transfer housing.

Remove the dome from the shipping box and clean the exterior surface with an approved solvent. Install the dome, following the procedures similar to those required for installation on the aircraft, discussed previously. Install the dome cap and tighten securely, but do not install the lock screw and cotter pin.

An operational and leakage test is performed at this phase of the assembly. To accomplish this test, open both the pressure and back pressure valves and start the test rig. Check the propeller operation to low pitch by opening the inboard pressure valve, closing the outboard pressure valve, and gradually closing the inboard back pressure valve until a pressure sufficient to unlatch the feather latch is obtained and the blades move to the low pitch position. Manually move each blade simultaneously toward low pitch to remove backlash. Using a protractor and blade template, measure the blade angle. The measured angle should be within 0.5 degree of the specified setting.

To reverse the propeller blades, increase the pressure on the inboard side by closing the inboard back pressure valve until the pressure is sufficient to move the propeller blades to full reverse position. Manually move each blade simultaneously toward full reverse to remove backlash. Measure the blade angle with a protractor and blade template. The measured angle should be within 0.5 degree of the specified setting.

Feather the propeller by opening the outboard pressure valve and gradually closing the outboard back pressure valve until the propeller moves to the full feather position. Manually move each blade simultaneously toward the full feather position to remove backlash. With a protractor and blade template, measure the blade angle. The measured angle should be within 0.5 degree of the specified setting.

Gradually close both the back pressure valves until a pressure of 90 psi is obtained on both inboard and outboard pressure gages and hold this pressure for one minute. There should be no external leakage. Repeat this test with 400 psi applied to both sides of the dome and hold for one minute. There should be no external leakage.

Remove the dome cap, flyweight, and oil transfer tube and then remove the dome assembly. Remove the oil transfer housing, the propeller retaining nut, and the front cone from the test post.

Attach the required deicing components to the propeller in accordance with the applicable technical manual. After these components are properly installed, the propeller is mounted on a propeller stand ready for installation on an aircraft.

Disassembly

When a propeller is removed from an aircraft for shipment to overhaul or to be stored, it must be preserved. The following procedures are required for disassembling the propeller, preserving it for shipment or storage, and placing it in shipping boxes.

Immerse the dome assembly less the flyweight assembly and oil transfer tube in a vat of the approved preservative and let drain on a stand. Remove the lockwire from the drive bolts attaching the slip ring to the barrel. Remove the control switch connectors and then remove the drive bolts and slip ring assembly.

Remove the propeller retaining nut snap ring, the retaining nut, and the front cone. Place the propeller on the assembly post and remove the spinner rear bulkhead attaching nuts, then remove the rear bulkhead. If desired, this may be done while the propeller is suspended by a hoist. Remove the barrel bolts and the bracket and nozzles. The control may be removed or left on the rear bulkhead, as desired. Place all small parts as they are removed in one group so they will not be lost and can be packed separately for shipment.

Install the barrel puller and lift the outboard barrel half from the spider. Using a rubber or rawhide mallet, drive the inboard barrel half down far enough to remove the blades from the spider arms.

With the blades removed, reinstall the barrel halves over the spider and install the barrel bolts. Tighten the bolts to a snug position. Immerse the barrel in the preservative and let it drain on a stand.

Place the dome in a shipping carton lined with oiled paper and seal tightly. Then, place the barrel in a shipping carton and seal tightly with oiled paper. The cartons should be marked in such a way they will not become separated or mixed with other cartons of the same form. Place oiled paper between each blade shank and thrust washer. Cover the thrust washers with an approved preservative and wrap the washers and blade shank with oiled paper. Place the blades and the cartons containing the dome and barrel in the shipping box.

Lubricate all small parts except the slip ring assembly and the spinner rear bulkhead, bracket, and nozzle assemblies. Pack the small parts in containers and place in the shipping box on top of the dome and barrel cartons. Pack so there will be no shifting in handling and then seal the shipping box.

TROUBLESHOOTING

Table 9-1 contains a list of troubles, probable causes, and remedies. The extent to which components may be disassembled for parts replacement or repair is governed by one or more of the following: General or local policy; availability of parts, tools, and equipment; and experience of personnel. In any case when correcting discrepancies, the applicable operation, service, or overhaul instructions should be consulted. The faulty parts listed in table 9-1 may be located by referring to the illustrations indicated in the table. Refer to figures 9-8, 9-9, 9-10, 9-11, 9-12, and 9-13.

RIGGING AND ADJUSTING

Rigging and adjusting of the 43E60 and 24260 propellers are primarily concerned with adjusting, as there is little rigging to be done with these propellers. Adjusting of the low-pitch stop lever assembly and indexing procedures of the dome assembly can be accomplished by referring to the Overhaul Instruction Manuals for each type propeller.

BALANCING

Since a propeller rotates at a very high rate of speed, balance is very critical. A propeller out of balance could cause serious damage or possible loss of life. Therefore, it is of great importance for the Chief and First Class Aviation Machinist's Mate R to understand propeller balancing in order to recognize this dangerous condition and take the proper remedial steps.

Three classifications are used when referring to a propeller out of balance. These are static, dynamic and aerodynamic.

STATIC BALANCE

When a propeller's center of gravity does not coincide with its axis of rotation it is referred to as being out of balance statically. This condition must be checked and corrected by the manufacturer, a Depot maintenance activity, or overhaul activity.

DYNAMIC BALANCE

When similar propeller elements (blades, spinners, cuffs, etc.) do not follow the same plane of rotation the propeller is said to be out of balance dynamically. This condition must be corrected at an overhaul or Depot maintenance activity.

AERODYNAMIC BALANCE

When the amount of thrust per blade is unequal the propeller is out of balance aerodynamically. This condition usually occurs when the improper angle is set on one or more blades of a propeller. This condition usually happens on installation of a propeller or when the dome assembly has been removed for maintenance and reinstalled. Correction of this condition is accomplished locally by removing the propeller dome and indexing the blades to the proper angle.

Table 9-1.—Propeller troubleshooting chart.

Trouble	Probable Cause	Remedy
PROPELLER LEAKAGE		
At dome cap..........	Damaged seal (7), fig. 9-8	Replace seal.
	Loose cap (3), fig. 9-13.......	Tighten cap.
At dome retaining nut	Damaged dome-barrel seal (2), fig. 9-8.	Replace seal.
At barrel blade bore...	Damaged blade packing (21), fig. 9-9.	Replace packing.
	Improper blade packing........	Replace packing.
	Foreign material under blade packing.	Wipe packing and sealing surfaces clean.
In rear cone vicinity...	Damaged spider-shaft seal (2), fig. 9-9.	Replace seal.
	Damaged spider-shaft seal spacer (3), fig. 9-9.	Replace spacer.
	Engine thrust plate seal	Consult engine manual.
CONTROL LEAKAGE		
Between head and body	Damaged head-body seal (14), fig. 9-11.	Replace seal.
	Loose head-body nuts........	Tighten nuts.
At high-pressure connector.	Damaged connector gasket....	Replace gasket.
	Loose attaching nuts.........	Tighten nuts.
Between relief valve housing and body.	Damaged relief valve gasket (26), fig. 9-11.	Replace gasket.

Table 9-1.–Propeller troubleshooting chart–Continued.

Trouble	Probable Cause	Remedy
CONTROL LEAKAGE–CONTINUED		
	Loose relief valve housing (27), fig. 9-11.	Tighten housing.
Between relief valve housing and relief valve plug.	Damaged relief valve plug gasket (31), fig. 9-11.	Replace gasket.
	Loose relief valve plug (32), fig. 9-11.	Tighten plug.
Between body and base.	Damaged body-base seal (9), fig. 9-12.	Replace seal.
	Loose body-base nuts	Tighten nuts.
Between base and engine mounting pad.	Damaged mounting gasket (35), fig. 9-12.	Replace gasket.
	Loose attaching nuts	Tighten nuts.
	Warped base (36), fig. 9-12 ..	Lap base.
	Warped engine mounting pad ..	Consult engine manual.
ROUGHNESS	Ignition or carburetion	Consult engine manual.
	Engine part failure...........	Feather propeller (in flight).
	Ice on propeller	Turn on anti-icing system.
	Blade angles vary among blades	Adjust all blades to the proper angle, using protractor or index lines.
	Blade out of track............	If limit is exceeded, replace propeller.
	Propeller unbalance	Remove and balance propeller.
HUNTING OR SURGING PROPELLER	Ignition....................	Check ignition system.
	Poor carburetion	Check induction system and carburetor.
	Excessive internal leakage in control.	Check control on test stand.
	Excessive leakage in engine nose section.	Consult engine manual.
	Sticky control pilot valve (11), fig. 9-11.	Remove and clean, or replace pilot valve.
	Sticky low-pressure relief valve (30), fig. 9-12.	Remove and clean, or replace valve.
	Sticky selector valve (22), fig. 9-11.	Remove and clean, or replace selector valve.

Table 9-1.—Propeller troubleshooting chart—Continued.

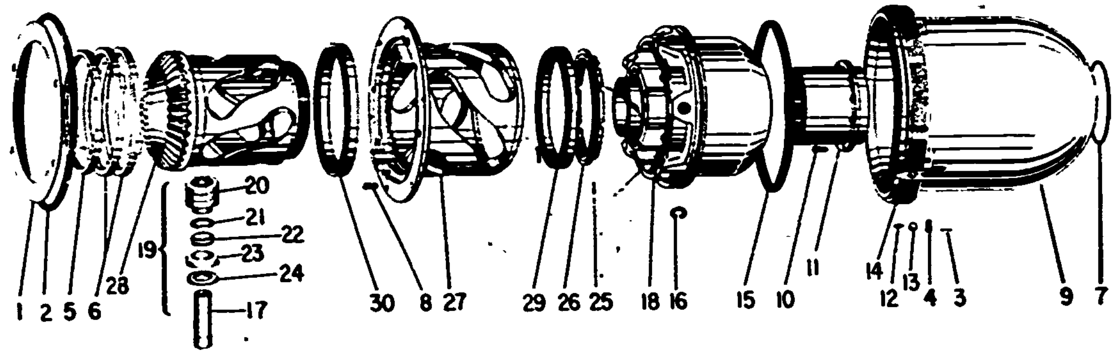
Trouble	Probable Cause	Remedy
HUNTING OR SURGING PROPELLER—CONTINUED		
	Faulty tachometer...........	Calibrate or replace tachometer.
	Air in propeller system......	Operate controls 2 or 3 times between high and low rpm during engine runup.
IMPROPER SYNCHRONIZATION.	Faulty synchronizer	Consult synchronizer manual.
INABILITY TO ATTAIN MAXIMUM RPM AT THE CHOCKS.	Incorrect high rpm setting.....	Adjust high rpm setting on control head.
	Low engine power	Consult engine manual.
	Faulty tachometer	Calibrate or replace tachometer.
	Sticky pilot valve (11), fig. 9-11.	Remove and clean, or replace pilot valve.
	Faulty circuits to stepmotor electric head.	Check circuits.
	Improper installation of low-pitch stop lever assembly ...	Reset stop lever assembly in dome to establish low blade angle specified for the aircraft.
OVERSPEEDING ON TAKEOFF.	Incorrect high rpm setting on control head.	Adjust high rpm setting.
	To rapid opening of throttle....	Open throttle slowly and evenly.
	Damaged or incorrect mounting gasket (35), fig. 9-12.	Install correct new gasket.
	Sticky pilot valve (11), fig. 9-11.	Remove and clean, or replace pilot valve.
	Sticky low-pressure relief valve (30), fig. 9-12.	Remove and clean, or replace relief valve.
	Faulty tachometer	Calibrate or replace tachometer.
	Insufficient exercise of propeller mechanism.	Move control several times through constant-speed range with engine running.
	Damaged shaft gasket (10), fig. 9-13.	Replace gasket.
INABILITY TO FEATHER	*Aircraft batteries low	Charge or replace batteries and check generator system.
	* Faulty electrical system......	Check auxiliary pump circuits.

*Items also apply to INABILITY TO UNFEATHER.

Table 9-1.—Propeller troubleshooting chart—Continued.

Trouble	Probable Cause	Remedy
INABILITY TO FEATHER—CONTINUED.		
	*Sheared coupling in auxiliary pump.	Replace coupling.
	*Restricted oil supply to auxiliary pump.	Check auxiliary pump inlet lines for obstruction.
	*Damaged oil line from auxiliary pump to constant-speed control.	Replace line.
	High-pressure relief valve (28)	Reset or replace valve.
	*Stuck high- or low-pressure relief valve, selector valve, or pilot valve.	Clean or replace valve.
	Windmilling of propeller at feather caused by incorrect setting of high-pitch stop ring.	Reset high-pitch stop ring.
INABILITY TO UNFEATHER	Faulty solenoid valve (20), fig. 9-11.	Repair circuit or replace solenoid valve.
(NOTE: See asterisked items under INABILITY TO FEATHER.)	Faulty No. 1 blade switch circuit	Check and repair circuit.
INABILITY TO REVERSE	Faulty solenoid valve (20), fig. 9-11.	Repair circuit or replace solenoid valve.
	Improver reverse setting.....	Reset reverse stop ring.
	Low-pitch stop levers do not allow piston to pass.	Replace low-pitch stop lever assembly.
	Aircraft batteries low........	Charge or replace batteries and check generator system.
	Stuck selector valve, pilot valve, or high- or low-pressure relief valve.	Clean or replace faulty valve.
INABILITY TO UNREVERSE.	Faulty selector valve or solenoid valve.	Repair or replace faulty valve.
	Faulty No. 1 blade switch circuit.	Check and repair circuit.
	Faulty auxiliary pump or circuit.	Check and repair circuit or pump.

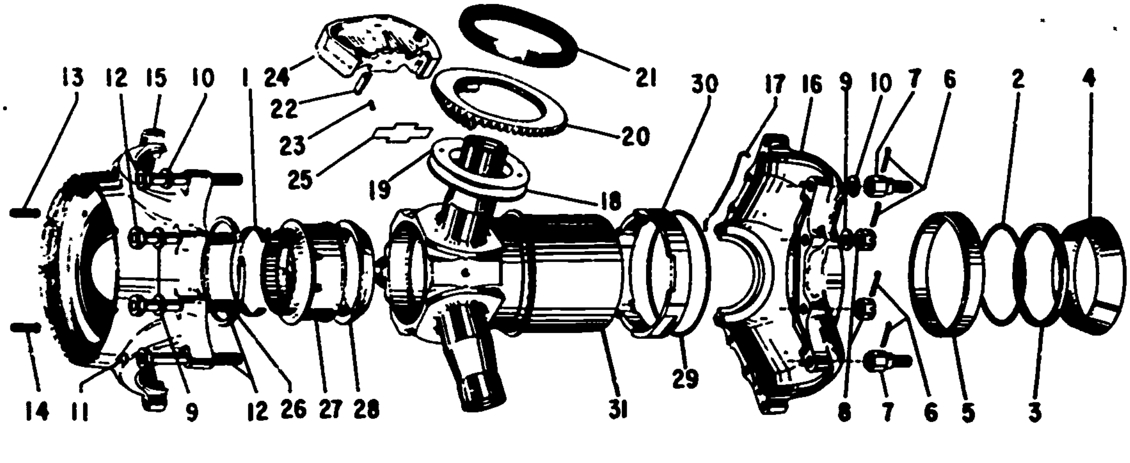
*Items also apply to INABILITY TO UNFEATHER.



AD.438

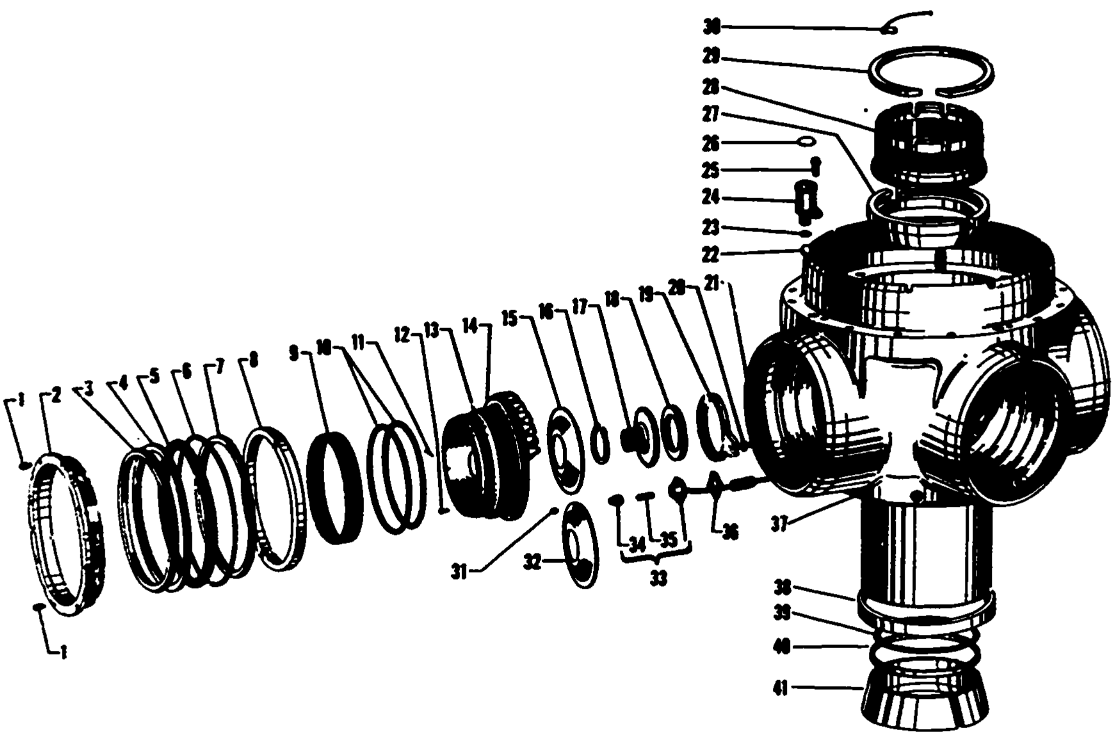
1. Gear preload shim.
2. Dome-barrel seal.
3. Cotter pin.
4. Dome retaining nut lock screw.
5. Stop ring spacer.
6. High- and reverse-pitch stop rings.
7. Dome cap seal.
8. Screw.
9. Dome shell.
10. Screw.
11. Lever sleeve bushing.
12. Welch plug.
13. Ball.
14. Dome retaining nut.
15. Piston seal.
16. Internal retaining ring.
17. Cam roller shaft.
18. Piston assembly.
19. Cam roller assembly.
20. Cam roller sleeve.
21. Cam roller needle bearing spacer.
22. Cam roller needle bearing.
23. Cam roller.
24. Cam roller thrust washer.
25. Colter pin.
26. Cam bearing nut.
27. Fixed cam.
28. Rotating cam.
29. Cam outboard bearing.
30. Cam inboard bearing.

Figure 9-8.—Dome assembly.



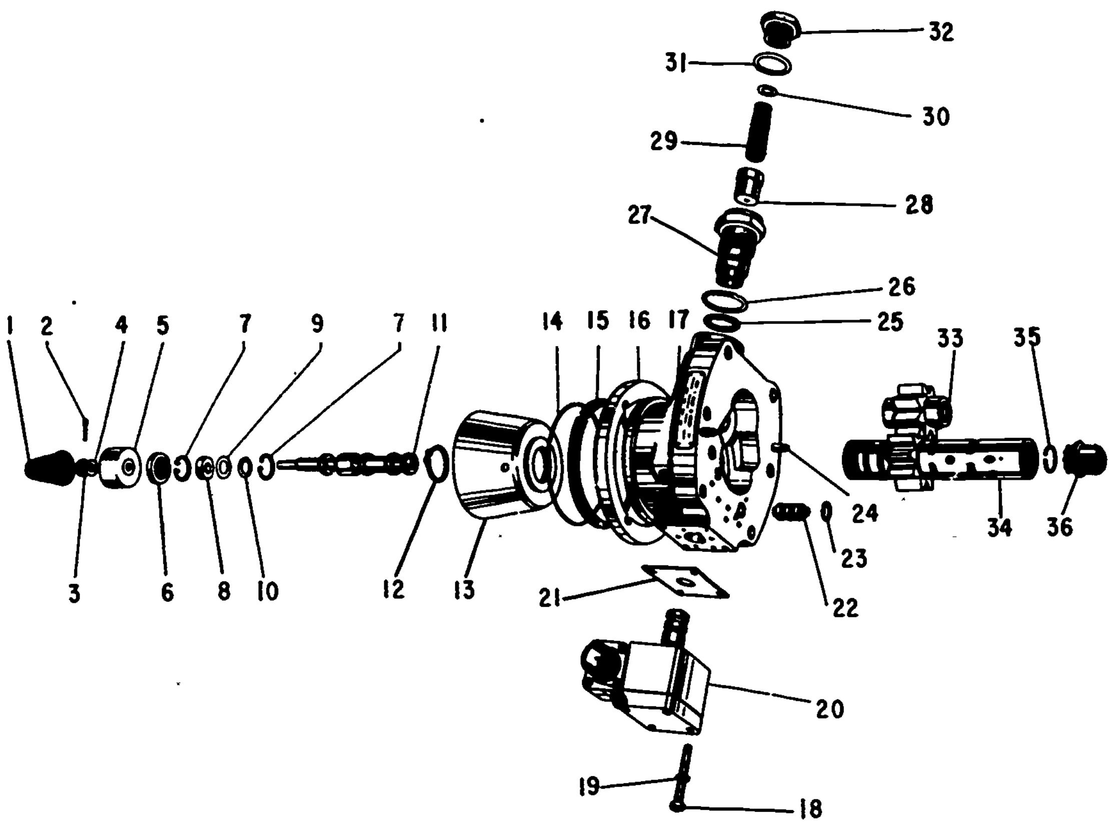
1. Retaining nut lock assembly.
2. Spider-shaft O-ring seal.
3. Spider and shaft seal spacer.
4. Rear cone.
5. Reinforcement sleeve.
6. Cotter pin.
7. Barrel bolt extension.
8. Castellated nut.
9. Washer.
10. Washer.
11. Welch plug.
12. Barrel bolt.
13. Locating dowel.
14. Locating dowel.
15. Barrel (front half).
16. Barrel (rear half).
17. Barrel half seal.
18. Spider shim plate.
19. Spider shim.
20. Blade gear segment.
21. Blade packing.
22. Barrel support insert.
23. Insert pin.
24. Barrel support.
25. Barrel support shim.
26. Hub snapring.
27. Propeller retaining nut.
28. Front cone.
29. O-ring seal.
30. Spider ring.
31. Spider.

Figure 9-9.—Barrel assembly (43E60).



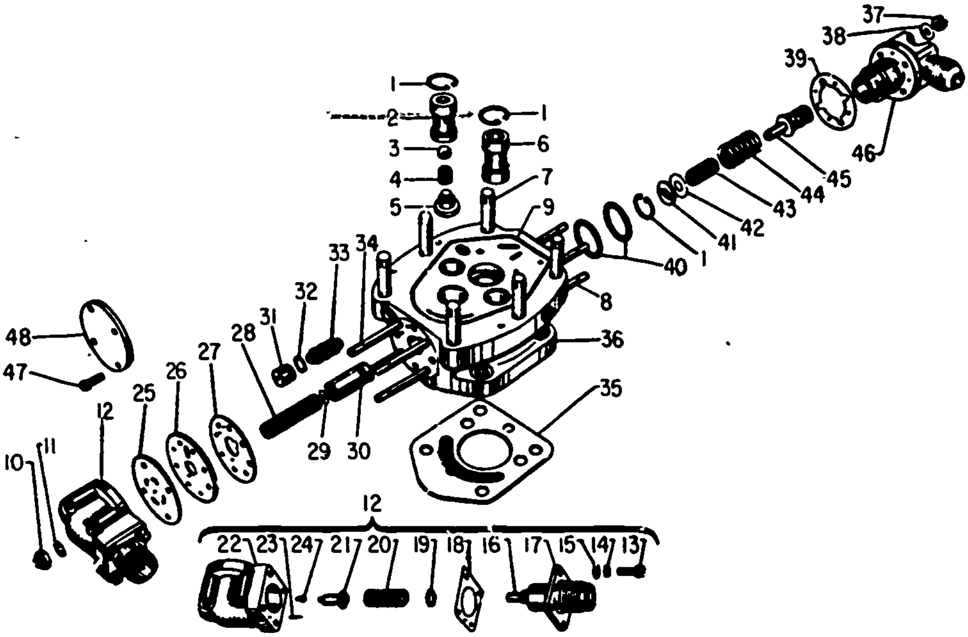
1. Setscrew.
2. Blade packing nut.
3. Blade packing retaining segment.
4. Blade packing backup rings.
5. Blade packing.
6. O-ring seal.
7. Seal retaining segment.
8. Blade support ring.
9. Micro adjusting rings.
10. O-ring seal.
11. Cotter pin.
12. Stop pin.
13. Blade segmental gear.
14. Shim.
15. Unreversing control spacer.
16. Snapring.
17. Preloading screw.
18. Preloading screw thrust ring.
19. Lock wrench.
20. Washer.
21. Lock wrench retaining screw.
22. Blade to barrel arm ball.
23. O-ring seal.
24. Barrel balancing plug.
25. Barrel balancing plug lock screw.
26. Welch plug.
27. Front cone.
28. Propeller retaining nut.
29. Hub snapring.
30. Propeller retaining nut lockwire assembly.
31. Adjusting pin.
32. Unreversing control plate.
33. Brush and connector assembly.
34. Brush.
35. Spring.
36. Tab lock washer.
37. Barrel.
38. Reinforcement sleeve.
39. Barrel-shaft O-ring seal.
40. Barrel-shaft seal spacer.
41. Rear cone.

Figure 9-10.—Barrel assembly (24260).



1. Speeder spring.
2. Cotter pin.
3. Slotted pilot valve nut.
4. Lockwasher.
5. Speeder spring collar.
6. Pilot valve ball bearing.
7. Internal snapring.
8. Drive gear shaft bushing.
9. Drive gear shaft spring washer.
10. Driver gear shaft washer.
11. Pilot valve.
12. External snapring.
13. Flyweight assembly.
14. Head-body seal.
15. Clamp insert.
16. Clamp ring.
17. Body.
18. Solenoid valve attaching screw.
19. Washer.
20. Solenoid valve.
21. Solenoid valve gasket.
22. Selector valve.
23. Internal snapring.
24. Dowel.
25. High-pressure relief valve O-ring seal.
26. High-pressure relief valve gasket.
27. High-pressure relief valve housing.
28. High-pressure relief valve.
29. High-pressure relief valve spring.
30. High-pressure relief valve shim.
31. High-pressure relief valve plug gasket.
32. High-pressure relief valve plug.
33. Idler gear.
34. Drive gear shaft.
35. Coupling snapring.
36. Drive coupling.

Figure 9-11.—Control body assembly.



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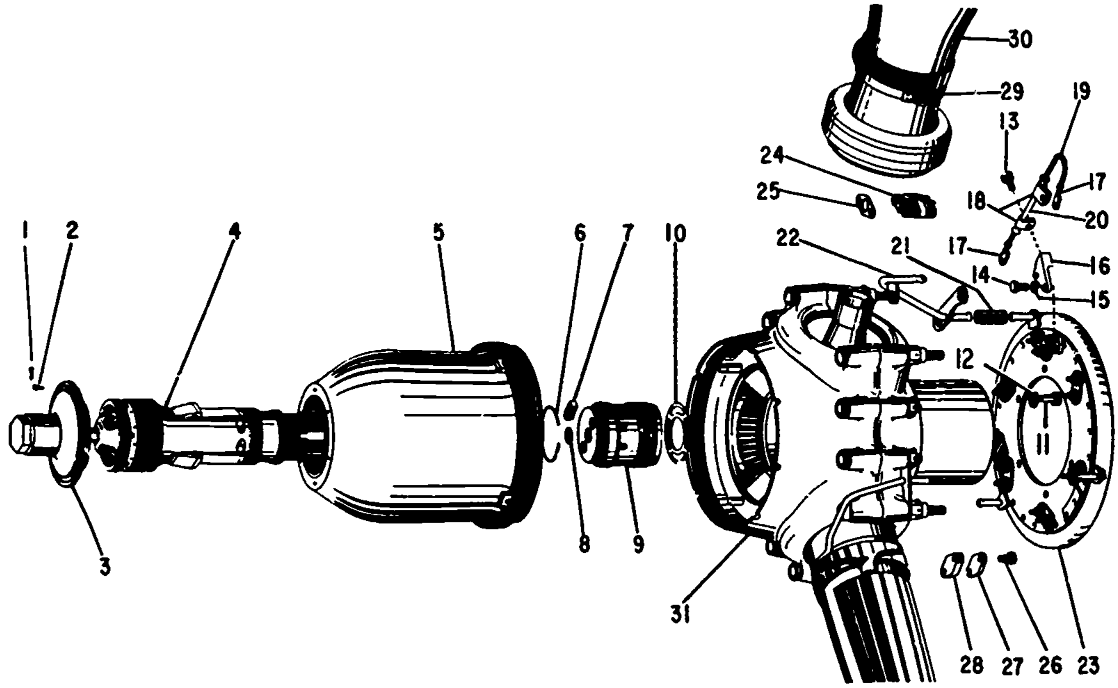
1. Internal snapring.
2. Output check valve housing.
3. Check valve ball.
4. Check valve spring.
5. Check valve stop.
6. Input passage sleeve.
7. Body-base stud.
8. Auxiliary pressure check valve stud.
9. Body-base seal.
10. Castellated nut.
11. Washer.
12. Pressure cutout switch.
13. Receptacle attaching screw.
14. Lockwasher.
15. Plain washer.
16. Receptacle assembly.
17. Receptacle flange.
18. Receptacle gasket.
19. Spring adjustment shim.
20. Spring.
21. Piston.
22. Switch body.
23. Dowel.
24. Contact.
25. Cutout switch gasket.
26. Cutout switch gasket.
27. Cutout switch plate gasket.
28. Low-pressure relief valve spring.
29. Shim.
30. Low-pressure relief valve.
31. Cutout switch shuttle valve plug.
32. Shuttle valve plug base O-ring seal.
33. Cutout switch shuttle valve.
34. Cutout switch attaching stud.
35. Mounting gasket.
36. Base.
37. Castellated nut.
38. Washer.
39. Auxiliary pressure check valve gasket.
40. Valve-base O-ring seal.
41. Spring seat.
42. Shim.
43. Auxiliary pressure check valve inner spring.
44. Auxiliary pressure check valve outer spring.
45. Auxiliary pressure check valve.
46. Elbow.
47. Fillister head screw.
48. Cover plate.

Figure 9-12.—Control base assembly.



AD.443

1. Cotter pin.
2. Screw.
3. Dome cap.
4. Low-pitch stop lever assembly.
5. Dome assembly.
6. Segment lockwire.
7. Lock segment.
8. O-ring seal.
9. Oil transfer housing.
10. Shaft gasket.
11. Drive bolt.
12. Washer.
13. Bolt.
14. Bolt.
15. Washer.
16. Connector support.
17. Terminal.
18. Clamp.
19. Insulated wire.
20. Tube.
21. Coupling.
22. Bracket and nozzle assembly.
23. Control slip ring assembly.
24. Control switch assembly.
25. Shim.
26. Bolt.
27. Counterweight (inner).
28. Counterweight (outer).
29. Blade cam assembly.
30. Blade assembly.
31. Barrel.

Figure 9-13.—Propeller assembly (43E60).

CHAPTER 10

HELICOPTER MAINTENANCE

This chapter covers the SH-3A as a typical helicopter for the description of helicopter maintenance. Although all the helicopters in active service are powered by jet engines, ADR'S are still being assigned to helicopter squadrons and should be familiar with transmission and rotor systems. The engines will normally be maintained by ADJ personnel, but ADR'S may be required to assist them at times. Because of this possibility it is recommended that ADR personnel read the chapter on turboshaft helicopter maintenance contained in the ADJ 1 & C Rate Training Manual.

SH-3A HELICOPTER

The SH-3A is a twin engine, antisubmarine warfare (ASW) helicopter, designed for land and carrier-based operations. It is also capable of water landing and takeoff.

The SH-3A has a hull shaped fuselage and outrigger sponsons into which the main landing gear retracts. A fixed horizontal stabilizer is installed on the upper right side of the pylon and two T58-GE-8B gas turbine engines are mounted side by side above the fuselage forward of the rotary wing head.

Flight configuration is a five-blade main lifting rotary wing head and a five-bladed rotary rudder. Forward, aft, lateral, and vertical flight are accomplished through the rotary wing head, while the rotary rudder counteracts torque from the rotary wing head and provides directional control.

Power to drive the rotary wing head is supplied through the main gearbox. The rotary rudder is driven through shafting which extends aft from the main gearbox, through the disconnect coupling and intermediate gearbox, and terminates at the tail gearbox. The main gearbox also incorporates a rotor lockout system which permits the use of No. 1 engine to operate the generators and hydraulic pumps for ground handling purposes.

Three separate hydraulic systems are used in the SH-3A. The primary and auxiliary hydraulic systems are used in conjunction with the mechanical linkage of the flight controls. The auxiliary hydraulic system is also used in conjunction with the automatic stabilization equipment (ASE).

The utility hydraulic system provides power for the retractable main landing gear, automatic blade fold system, windshield wiper system, and rescue and sonar hoist systems. It also supplies fluid to the rotor brake system. Figure 10-1 shows the SH-3A helicopter.

POWER TRANSMISSION SYSTEM

The transmission system of the SH-3A consists basically of the main gearbox, tail drive shaft, oil cooler and blower, and the pylon installation. The latter includes the intermediate and tail gearboxes.

The main gearbox drives the rotary wing head, tail drive shaft, and accessory components. The accessory components, including the main gearbox oil pump, generators, and the hydraulic pumps, are driven whenever the left engine is operating. The rotor lockout system prevents the rotary wing head and the rotary rudder from rotating during ground runup. The tail drive shaft transmits torque to the intermediate gearbox where the drive angle is changed, and on to the tail gearbox where the drive angle is again changed and the rpm reduced to drive the rotary rudder.

The tail drive shaft also drives the transmission oil cooler and blower. Oil from the main gearbox is fed to the oil cooler and blower and returned to the gearbox for lubrication and

AD.314

Figure 10-1.—Model SH-3A helicopter.

cooling purposes. The main gearbox also includes freewheel units that balance the input from the engines, assist in rotor lockout, and permit freewheeling of the rotary wing head during autorotation.

MAIN DRIVE SHAFT

The main drive shaft is a dynamically balanced shaft that transmits torque from the engine to the main gearbox. It consists of a high-speed shaft, Thomas coupling, engine adapter, match-marked nuts for engine attachment, and match-marked bolts and nuts for attachment to the main gearbox coupling. The Thomas coupling and engine adapter are secured to the shaft by special bolts and Hi-Lok collars to prevent disassembly. The shaft is made of tubular steel. It is flanged at both ends for connection to the Thomas coupling, adapter, and power turbine cooling flange, and to the main gearbox coupling flange. The drive shaft is housed within and protected by the aft engine support. Direction of rotation is clockwise when viewed from the aft end of the engine. To remove the main drive shaft, the affected powerplant must be removed. Figure 10-2 shows a detailed view of the main drive shaft.

MAIN GEARBOX

The main gearbox is located on the transmission deck aft of the engines. It drives the accessories, supports and drives the rotary wing

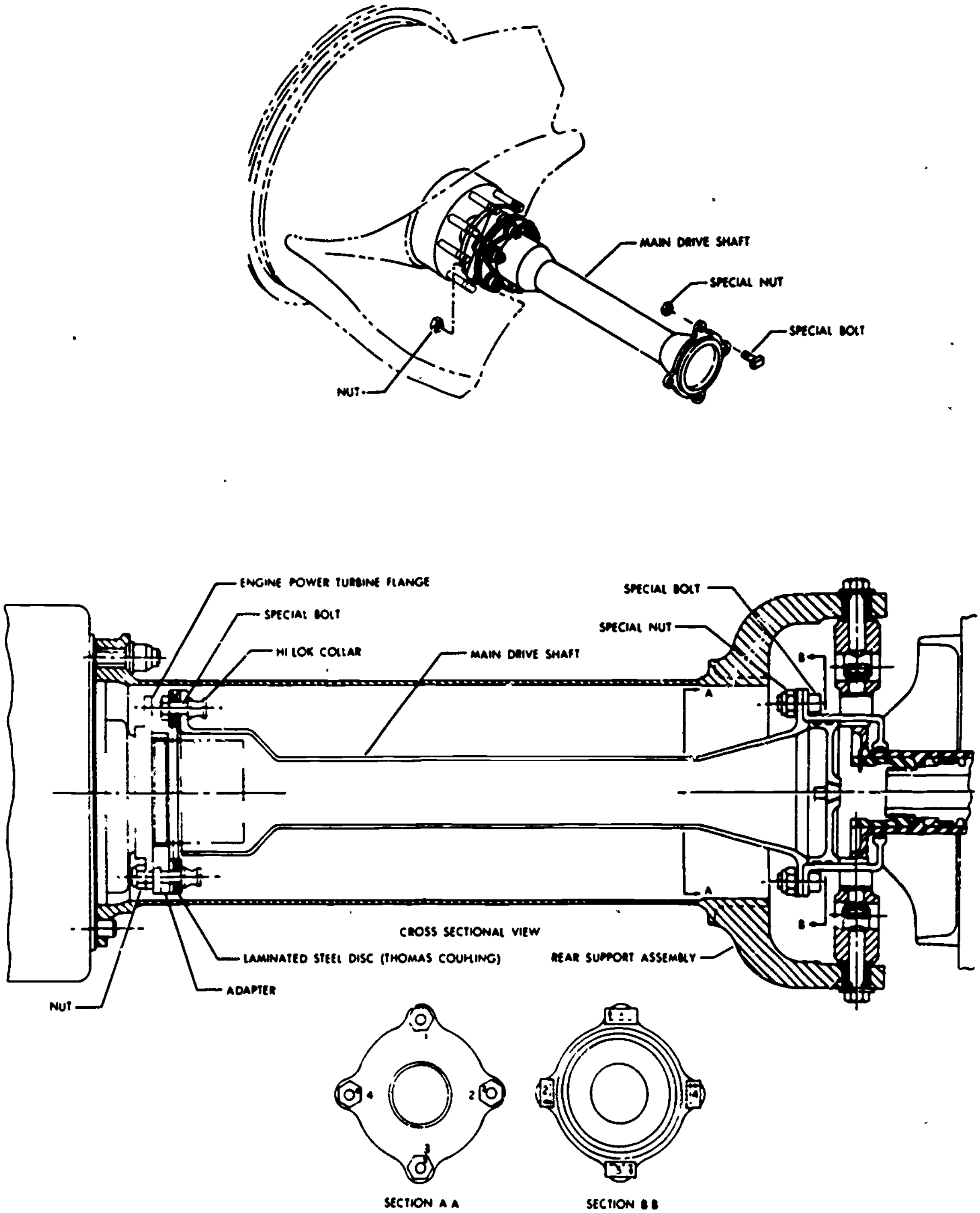


Figure 10-2.—Main drive shaft.

head, and provides the power takeoff to drive the rotary rudder. The accessories, which include two generators, two transmission oil pumps, three hydraulic pumps, and a rotor tachometer-generator, are driven through freewheel units. When the rotary wing head is disengaged, the accessories are driven by a through shaft geared to the No. 1 engine.

Torque sensors, incorporated in the input section, sense engine input torque indications which are transmitted to the engine torque indicators, mounted on the instrument panels. Lubrication of the main gearbox is accomplished by a self-priming wet sump system. The No. 1 oil pump is mounted on the lower left side of the rear cover and supplies oil to the oil cooler and lubricating jets. The No. 2 oil pump is mounted on the upper right side of the rear cover. Each oil pump acts as a backup for the other in case of failure. Oil lines from the two pumps are connected by a tee fitting, from which oil is routed to the oil cooler and the lubricating jets. An oil level sight gage is located on the lower left side of the main gearbox housing. The oil filler tube is located above the sight gage. A transmitter sends oil pressure readings to the transmission oil pressure gage in the cockpit. A temperature bulb located in the main gearbox housing transmits oil temperature readings to an indicator in the cockpit. A chip detector plug in the strainer allows inspection of the main gearbox for metal contamination. The chip detector plug is also connected in series with the intermediate and tail gearbox plugs to a warning light in the cockpit. The actuated freewheel unit in the main gearbox provides the means of disengaging the rotary wing head while providing power to operate the accessories section of the main gearbox. In addition, the unit functions as a freewheel unit during autorotation. Basically, the unit consists of a cam, rollers, a cage, and a housing. In normal flight, the unit is not actuated and the No. 1 engine drives the cam which forces the rollers against the housing. The housing is then mechanically connected to the cam and drives the rotary wing head. Should the housing rotate faster than the cam, as in autorotation, the rollers ride free of the cam and permit the housing and cam to rotate independently. In accessory drive, the actuator shaft lugs rotate the cage, holding the rollers free of contact between the cam and housing. Power is then transmitted to the accessory section by the through shaft. Figure 10-3 shows a schematic view of the main transmission including the freewheel units. Figure 10-4 shows the component location of the SH-3A transmission system.

Removal

For removal and installation, the main gearbox is handled as a quick change unit, either by itself or with the rotary head installed. Accessory components are removed, if necessary, after the main gearbox has been removed from the helicopter.

To facilitate removal of the linear actuator, place the accessory drive switch in the flight position before removal of the main gearbox. Hinge down the engine and transmission service platforms and remove the engine aft cowling and the rotary wing fairing halves.

After opening all access doors, remove the access panel from the aft rotary wing fairing. Turn off all electrical power, disconnect the electrical plug at the chip detector, and install a drain fitting. Drain the oil in a suitable container. After draining the oil, replace the chip detector. For the step-by-step procedure for disconnecting the main gearbox, the operation and service instructions manual should be followed. When all lines and connections are disconnected, install the engine supports. Disconnect the input flange from each engine main drive shaft flange. (Refer to fig. 10-2.)

After disconnecting the engine aft supports from the gimbal rings, remove the first section of the tail drive shaft with the flexible steel couplings. To prevent damage to the main gearbox, accessory components, or the helicopter during removal, check to insure that all electrical wiring and lubrication lines have been disconnected. Using a sling and a suitable hoist with a rated capacity of at least 3,500 pounds, remove the main gearbox and lower it onto a cart.

Installation

For installation, the reverse procedures are used. When the installation is complete, service

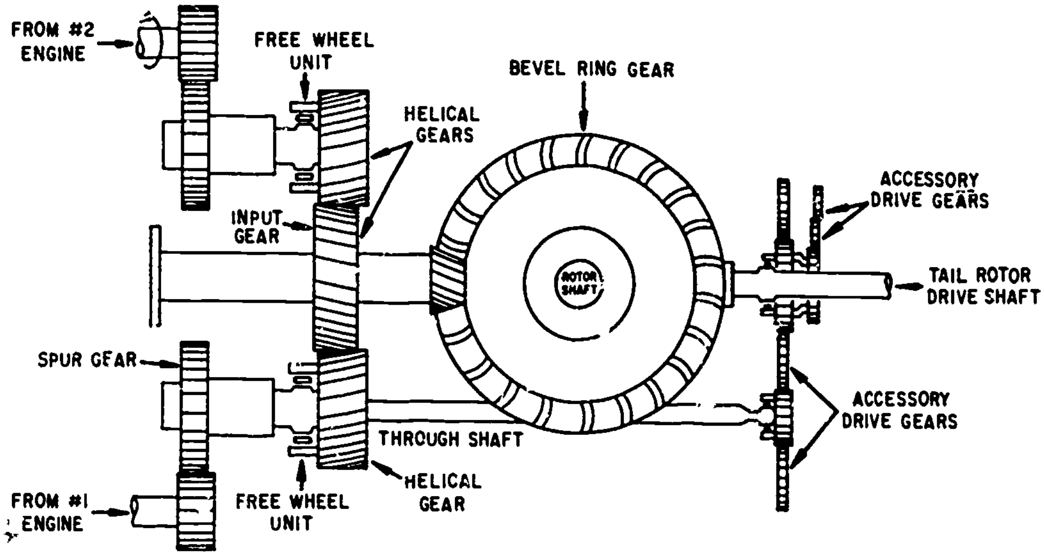


Figure 10-3.—SH-3A main transmission schematic.

the hydraulic tanks and check for leaks. Tighten all lubrication lines and service the main gearbox with oil. Install the engine aft cowlings, rotary wing fairing halves, and the access panel on the aft rotary wing fairing and check for security. After the required flight time, retorque the gearbox mounting bolts in accordance with current instructions.

Troubleshooting

Table 10-1 contains some of the troubles encountered with the main gearbox. It also lists the probable cause and remedy for each trouble.

MAIN GEARBOX OIL COOLER AND BLOWER

The main gearbox oil cooler and blower unit (fig. 10-4) is located in the aft rotary wing fairing. It consists of a cooler (radiator), blower, and duct. The blower is belt driven by the tail drive shaft and forces air through the cooler. Hot oil from the main gearbox is pumped into the cooler. If the temperature of the oil is less than 70°C the oil is bypassed to the return line by a thermostatic regulator. Oil returning from the cooler is forced through the lubricating jets in the main gearbox.

Removal

For removal of the oil cooler and blower, hinge down the transmission service platforms and remove the rotary wing fairing access panels. Drain the oil from the main gearbox and with all electrical power off disconnect the wiring from the fire extinguisher and remove the clips from the blower. Remove the belts from the driven pulley by lowering the oil cooler and blower. (Do not remove the belts from the drive pulley on the tail drive shaft.) Disconnect the hoses and remove the clamps. Separate the

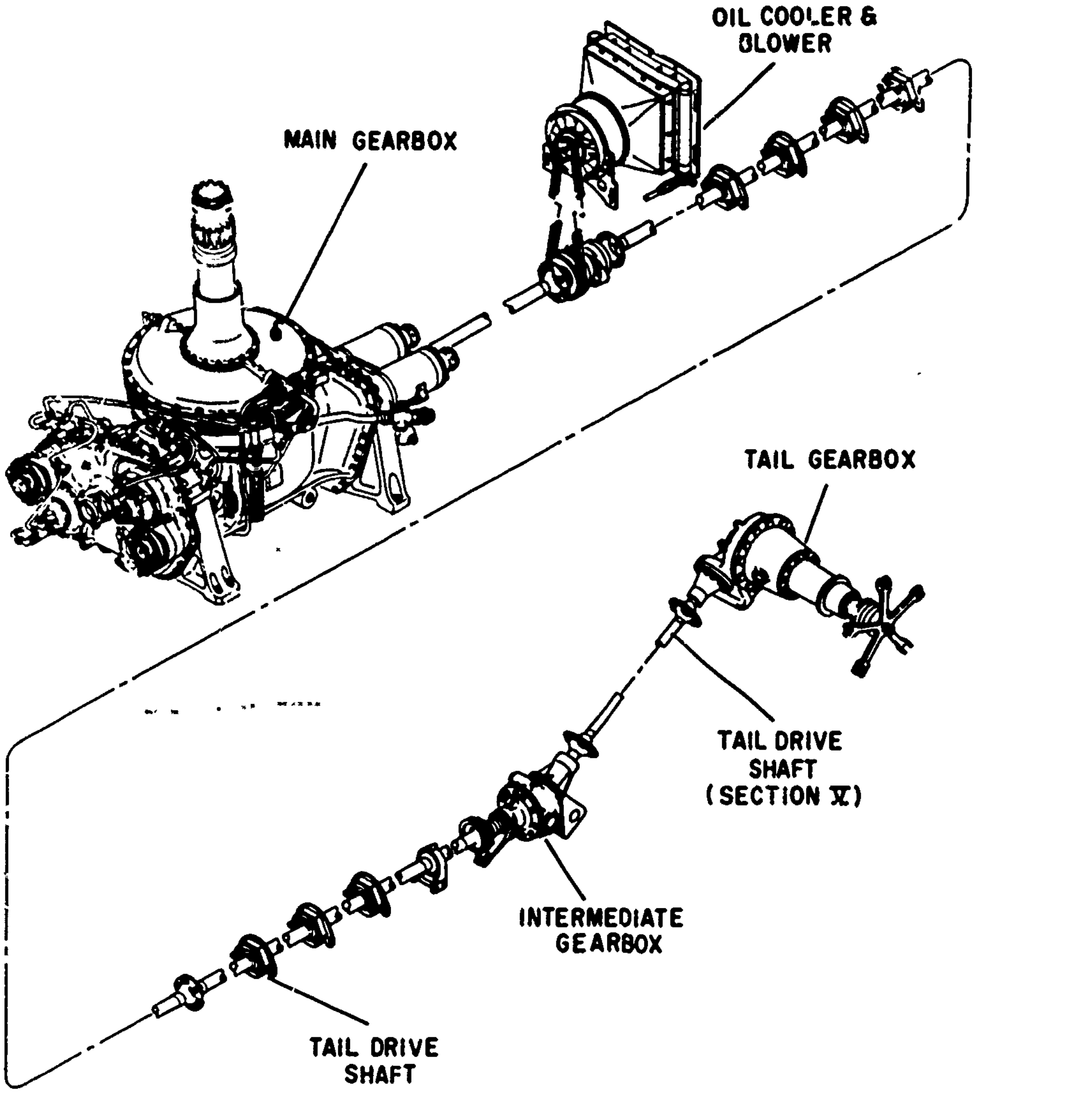


Figure 10-4.—SH-3A transmission system component location.

blower from the cooler and remove the blower, then remove the cooler.

Installation

For installation, position the cooler and support on the bulkhead with the bolts, but do not tighten the bolts. Attach the blower to the cooler and position the oil cooler and blower on the forward support. Install the bolts, but do not tighten. Install the oil hoses and clamps. Install the pulley belts on the driven pulley and the driving pulley on the tail drive shaft. Position the oil cooler and blower, using the special jack. Adjust and align the pulley belts and tighten the holddown bolts. Connect the wiring for the fire extinguishers. Service the main gearbox with oil. If the oil cooler has been

Table 10-1.—Main gearbox troubleshooting chart

Trouble	Probable cause	Remedy
Low oil pressure	Low oil level in sump	Service the gearbox
	Improper oil	Service gearbox with proper oil.
	Oil cooler valve stuck open	Replace cooler.
	Clogged strainer	Clean strainer.
	Relief valve stuck open	Repair or replace valve.
	Excessive leakage in the main gearbox	Replace gearbox.
	Clogging of oil cooler	Clean or replace oil cooler.
	Failure of oil pump	Replace gearbox.
	Leakage in oil cooler	Replace oil cooler.
Gradual dropoff of oil pressure during flight.	Bearing in gearbox running hot . . .	Replace main gearbox.
Fluctuating low oil pressure and excessive oil loss through breather.	Low oil level	Service gearbox.
	Improper oil	Service gearbox.
	Faulty regulator	Replace regulator.
Increase in oil temperature.	Internal leakage of main gearbox . .	Replace main gearbox
	Loose belts on blower drive	Adjust belts.
High oil pressure .	Cold oil in system	Allow sufficient time for oil to warm up.
	Relief valve jammed closed	Repair or replace relief valve.
Excessive chips in strainer, or on magnetic plug.	Internal failure of gearbox	Replace gearbox.
Excessive external oil leakage of the main gearbox.	Leakage around rear accessory seals, main shaft seal, or lower housing bottom seals.	Replace leaking seals.

drained, an additional gallon of oil will be required for the gearbox. Install the rotary wing fairing access panels and hinge up the transmission service platforms.

Troubleshooting

For troubleshooting the main gearbox oil cooler and blower, refer to table 10-2.

ROTOR BRAKE

The rotor brake system permits application of the main rotor brake manually or automatically. It incorporates a master brake cylinder, pressure gage, panel package, rotor brake, accumulator, check valves, and pressure switches. Operation of the system is closely associated with the operation of the blade fold system.

The rotor brake is located on the input cover of the main gearbox and is hydraulically actuated to stop the rotation of the rotary wing head. Actuation is accomplished manually by means of the rotor brake master cylinder in the cockpit, or automatically during blade folding by the blade positioner control valve. In manual operation, the rotor brake is capable of stopping the rotary wing head in 14 seconds from 157 rpm. The rotor brake consists of a rotor brake disc and housings containing four pistons and four brake linings.

Removal

To remove the rotor brake, hinge down the engine and transmission service platforms and remove the engine aft cowlings. Disconnect the hydraulic lines and remove the elbows, nuts, gaskets, and rings. Remove the rotor brake from the main gearbox by removing the nuts and washers; the rotor brake disc may now be removed by removing the six bolts that secure it to the drive.

Installation

Prior to installation check the thickness of the brake disc. If it is not within the specified limits it must be replaced.

Table 10-2.–Main gearbox oil cooler and blower troubleshooting chart

Trouble	Probable cause	Remedy
High gearbox oil temperature with drop in oil pressure.	Loose belts on blower drive......	Adjust belts to obtain proper deflection and tension
	Improper operation of radiator temperature regulator.	Replace radiator.
	Clogged radiator	Clean and flush or replace radiator.
	Leakage in radiator	Replace radiator.
Unusual vibration and noise from oil cooler fan.	Bad bearing in fan	Replace fan.
	Loose belts................	Tighten or replace belts.
	Improper alignment	Align pulleys.

Loosen all the adjusting pin nuts and push the pistons as far into the housing as possible. Now position the rotor brake disc and shims on the input bevel gear flange and secure with the bolts. Before installing the brake assembly, check the runout of the disc. If it is within limits, install it on the main gearbox. Adjust the thickness of the shims to center the rotor brake disc in the brake housings to within 1/32 inch. With the rotor brake disc secured on the main gearbox, check the distance between the edge of the blade positioner drive unit gear and the edge of the rotor disc. If the dimension is not within limits, reshim the positioner drive unit. After obtaining the proper clearance, install the elbows, nuts, gaskets, and rings. Install the hydraulic lines and bleed the brake system to remove the air. Actuate the rotor brake master cylinder several times and then check the clearance of all brake lining pucks. If the proper clearance cannot be obtained, replace the rotor brake.

Troubleshooting

Refer to table 10-3 for troubleshooting the rotor brake system.

TAIL DRIVE SHAFT

The tail drive shaft extends from the tail takeoff coupling flange at the rear cover of the main gearbox to the disconnect jaw of the intermediate gearbox. The primary purpose of the shaft is to transmit engine power to drive the rotary rudder. It also provides the drive for the main gearbox oil cooler blower fan. The tail drive shaft is composed of five sections.

Section I consists of a shaft and two Thomas couplings. Section II consists of a flanged shaft, pulley, bearing support housing, and a flange. Section III consists of a shaft, four bearing supports, and two flexible steel couplings. Section IV consists of a shaft, four bearing supports, and a disconnect coupling jaw.

Sections I and II are enclosed in the aft main rotor fairing. Section III is enclosed in the aft main rotor fairing and in the tail drive shaft access fairings. Section IV is enclosed in the tail drive shaft access fairings. Section V is mounted in the pylon and consists of a shaft and two flexible steel couplings.

Removal

To remove the tail drive shafts, fold the pylon and remove the main rotor fairing screen, hinge down the transmission service platforms and open the tail drive access fairings. For the step by step procedures refer to the applicable technical manual. The following paragraph gives a brief removal procedure.

To remove section IV, remove the bolts and nuts from the bearing rings and remove the rings. Remove the bolts on the right side of the bearing support plates. Remove the lower bolts on the left side of the bearing support and loosen the others. Swing the bearing support plates up and out of the way. Do not remove the bearing support plates, because installation in any position except the original will result in misalignment and excessive runout. The same procedures may be followed for removal of the other shafts except section II. The oil cooler and blower drive belts must be removed from the driving pulley to remove section II.

Installation

For installation, the reverse procedure is used, but upon completion a shaft runout check is required. Any excessive misalignment will cause vibrations and damage to the drive shafts. Refer to the applicable technical manual for the correct procedures and limitations.

Troubleshooting

Refer to table 10-4 for tail drive shaft troubles, probable causes, and remedies.

INTERMEDIATE GEARBOX

The intermediate gearbox (fig. 10-4) is located forward on the pylon where it joins the aft fuselage. The intermediate gearbox transmits torque and changes the angle of drive from the main gearbox to the tail gearbox. It consists of an input housing and gear assembly, with a spring-loaded disconnect jaw, a center housing, and an output housing and gear assembly. The spring-loaded disconnect jaw provides a means of folding and unfolding the pylon without manually disconnecting the transmission. When

Table 10-3.–Rotor brake system troubleshooting chart

Trouble	Probable cause	Remedy
Brake does not hold.	Low hydraulic fluid level........	Service utility fluid tank with hydraulic fluid.
	Leakage in hydraulic lines.......	Check lines for leakage.
	Internal or external leakage in master brake cylinder.	Replace master brake cylinder.
	Internal or external leakage in brake.	Replace brake.
	Worn brake lining pucks	Replace lining pucks.
Spongy brake.	Air in system	Bleed system.
Brake disc scored.	Uneven brake wear............	Replace brake disc.
Evidence of brake contact with rotor brake off.	Brake not disengaging..........	Replace brake assembly.
	Insufficient clearance between brake pucks and disc.	Check clearance.

the pylon is folded, the pylon transmission components are locked to prevent the rotary wing from windmilling. When unfolded, the lock automatically disengages. The input and output housings contain bevel gears to change the angle of drive up along the pylon. The center housing incorporates an oil level sight gage on the left side, a magnetic drain plug on the bottom, and a filler plug at the top. The gearbox is splash lubricated and air cooled.

Removal

To remove the intermediate gearbox, drain the oil and remove the fairing from the pylon, and fold the pylon. Insure that all electrical power is off; then disconnect the electrical wiring at the pylon terminal block and chip detector plug. Remove the grommet and clamp that secures the wiring and pull the wiring upward through the bracket. Support the tail drive shaft and disconnect it at the flange of the output housing. Support the intermediate gearbox, remove the bolts securing it to the bracket, and remove the gearbox. Unbolt and remove the bracket.

Installation

To install the intermediate gearbox, install the bracket and install the gearbox after insuring that the correct shims are on the studs. Check the alignment of the gearbox and position the flexible steel coupling of the tail drive shaft on the output housing of the gearbox. Position the convex seat of each coupling washer against the coupling. Install the shims equally at each ear of the flange. Place the unused shims under the boltheads and washers. Secure this stackup to the output housing of the intermediate gearbox. Shims should be installed equally at each end of the drive shaft sections. Insert the electrical wiring through the bracket and connect it to the chip detector and pylon terminal block. Install the grommet, secure the clamps, and safety wire the chip detector plug. Remove the support

Table 10-4.—Tail drive shaft troubleshooting chart

Trouble	Probable cause	Remedy
High frequency vibrations in helicopter caused by the tail drive shaft.	Loose bolts and nuts at attaching flanges.	Tighten nuts to specified torque.
	Drive shaft installed with incorrect shims.	Install drive shaft correctly.
	Bolts loose, sheared, or with improper torque.	Tighten bolts to required torque. Replace bolts if necessary.
	Damaged bearing support bracket.	Replace bracket.
	Drive shaft not bonded to shaft.	Replace drive shaft section.
	Rough bearing	Replace drive shaft section.
	Damaged coupling disc	Replace damaged part.
	Damaged flange	Replace drive shaft section.
	Damaged drive shaft.	Replace drive shaft section.
Failure of drive shaft.	Fatigue failure	Replace drive shaft section.
	Improperly aligned drive shaft.	Realign drive shaft.
	Scratch or dent on drive shaft	Replace drive shaft section.

from the tail drive shaft and unfold the pylon. Service the gearbox with oil and replace all fairing.

Troubleshooting

Refer to table 10-5 for intermediate gearbox troubles, probable causes, and remedies.

TAIL GEARBOX

The tail gearbox (fig. 10-4), mounted at the top of the pylon, serves as the attachment for the rotary rudder, changes direction of drive 90 degrees, and reduces the shaft speed. An actuator shaft, controlled by the rotary rudder flight controls, operates the pitch control beam. The pitch control beam is connected to the sleeve of each rotary blade to change the pitch of the blades. The gearbox is splash lubricated. A magnetic drain plug is installed in the bottom of the input housing. Access to the tail gearbox is gained by removing the fairing at the top of the pylon.

Removal

To remove the tail gearbox, first remove the rotary rudder, but leave the pitch control beam with the tail gearbox. Insure that all electrical power is off; disconnect the fairing and rotary beacon anticollision light. Disconnect the electri-

Table 10-5.–Intermediate gearbox troubleshooting chart

Trouble	Probable cause	Remedy
Excessive oil leakage at seals or parting flange.	Deterioration of seals.	Replace seals or intermediate gearbox.
Gearbox running too hot.	Insufficient lubrication	Service gearbox.
	Improper gear tooth clearance	Replace gearbox.
	Defective bearings	Replace gearbox.
High frequency vibration in helicopter structure caused by intermediate gearbox.	Gearbox mounting nuts loose	Tighten nuts to required torque.
	Defective gearbox bearings	Replace gearbox.
	Gear teeth damaged.	Replace gearbox.

cal wiring from the chip detector plug and drain the oil. Disconnect and remove the bellcrank and control rod. Support the upper end of the tail drive shaft and disconnect it at the input flange. Retain the nuts, bolts, and shims. Install the lifting eye on the tail gearbox. With tension on the hoist, remove the bolts, washers, barrel nuts, and shims securing the tail gearbox to the support. Now remove the bolts securing the tail gearbox, hoist the tail gearbox from the helicopter, and place in a stand. Retain all washers and shims for installation.

Installation

After repairs have been completed, lift the gearbox into position and align it in accordance with the applicable technical manual. Install and secure the bolts, washers, barrel nuts, retainers, and shims to the support. Remove the lifting eye and torque the bolts to the required torque. Connect the tail gearbox to the flexible steel coupling. Install the coupling shims equally at each ear. Connect the control rod to the bellcrank and secure it. Install all fairing and the rotating beacon anticollision light. Insure that all electrical power is off; then connect the wiring to the anticollision light and magnetic chip detector. Install the rotary rudder fairing and service the gearbox with oil.

Troubleshooting

Refer to table 10-6 for troubleshooting the tail gearbox.

ROTOR HEAD ASSEMBLY

The rotary wing head (fig. 10-5) of the SH-3A helicopter is a fully articulated head, splined to and supported by the rotary wing shaft of the main gearbox. The head supports the five rotary wing blades, is rotated by torque from the main gearbox, and provides the means of transmitting the movement of the flight controls to the blades. Its design permits automatic folding of the blades.

The principal components of the head are the hub and swashplate. The hub consists primarily of a hub plate and lower plate, hinge assemblies (located between each arm of the plates),

Table 10-6.—Tail gearbox troubleshooting chart

Trouble	Probable cause	Remedy
Seal leakage.	Clogged breather	Clean breather.
	Defective seal	Replace seal.
High frequency vibration in helicopter structure caused by tail gearbox.	Tail gearbox mounting bolts loose.	Tighten bolts to required torque.
	Improper number of shims at the mountings.	Check the alignment and install the correct number of shims.
	Defective bearings in tail gearbox.	Replace the tail gearbox.
	Gear teeth damaged	Replace the tail gearbox.
Tail gearbox overheating.	Insufficient lubrication.	Replace the tail gearbox.
	Excessive lubrication	Replace the tail gearbox.
	Defective bearings	Replace the tail gearbox.
	Internal oil system clogged	Replace the tail gearbox.
	Improper gear tooth clearances or bearings preloaded.	Replace the tail gearbox.
Excessive oil leakage at packing seals or parting flanges.	Deterioration of packing or seals.	Replace the input or output seal, and if leakage still exists, replace the tail gearbox.

sleeve-spindle assemblies (which are attached to the hinge assemblies), and five damper-positioners. The swashplate consists of a rotating and a stationary swashplate.

Other components of the head are the five anti-flapping restrainers, five droop restrainers, five adjustable pitch control rods, and the rotating and stationary scissors. The swashplate and pitch control rods allow movement of the flight controls to be transmitted to the rotary wing blades. The hinge allows each blade to lead, lag, and flap. The damper-positioners restrict lead and lag motion and position the blades in preparation for folding. Sleeve-spindles allow each blade to be rotated on its span-wise axis to change blade pitch. The antiflapping restrainers and the droop restrainers restrict flapping motion when the rotary wing head is slowing or stopped. The control lock cylinder is unlocked to permit the sleeve to rotate about the sleeve-spindle axis. The stationary scissors are connected to the stationary swashplate and the main gearbox upper housing; the rotating scissors are connected to the rotating swashplate and the lower plate of the hub.

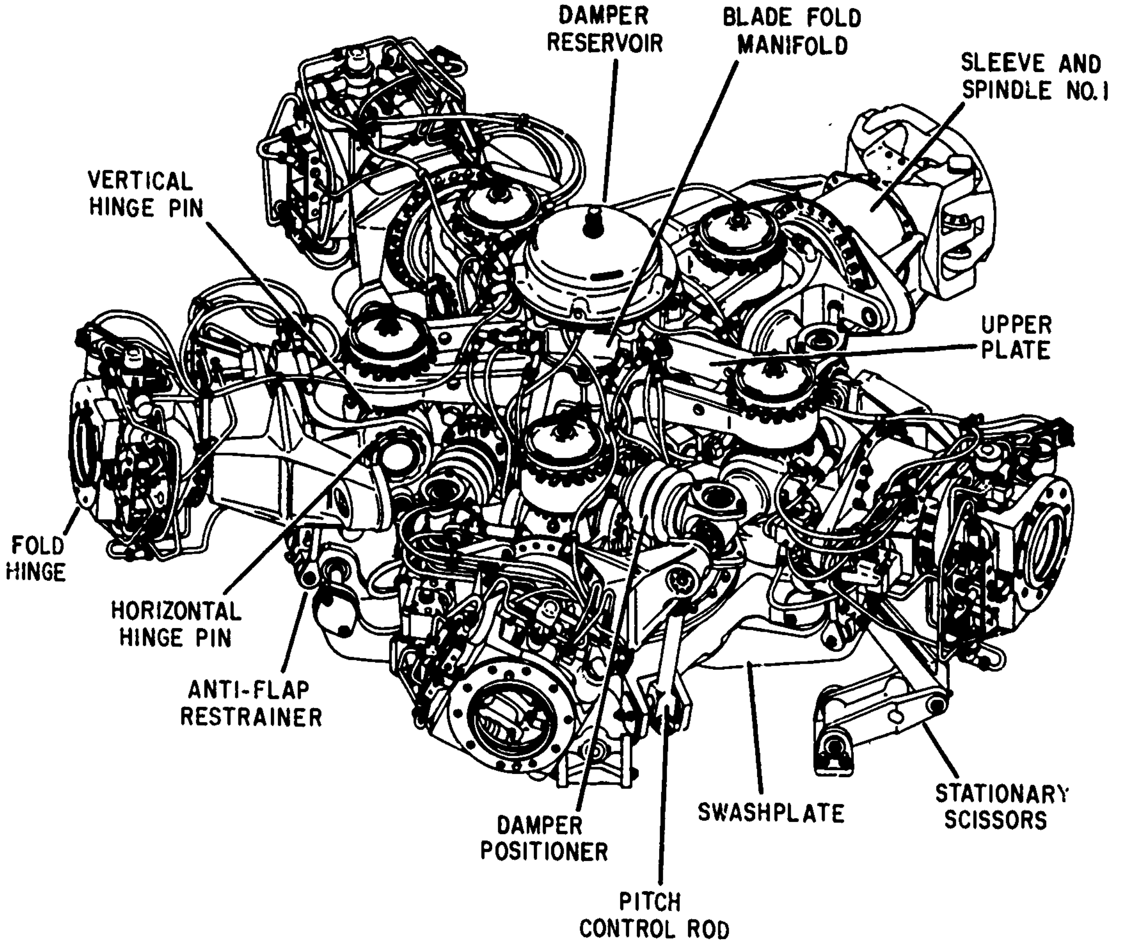


Figure 10-5.—Rotor head assembly.

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