DOCUMENT RESUME

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TITLE	Aviation Structural Mechanic, First Class, 2-12. Military Curriculum Materials for Vocational and Technical Education.
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DESCRIPTORS	*Aviation Mechanics; Aviation Vocabulary; Behavioral Objectives; *Construction (Process); Correspondence Study; *Learning Activities; Learning Modules; Mathematical Applications; Military Training; Postsecondary Education; Programed Instructional Materials; Secondary Education; *Sheet Metal Work; Technical Education; *Units of Study; Vocational Education; Workbooks
IDENTIFIERS	Military Curriculum Project

ABSTRACT

This self-paced, individualized course, adapted from military curriculum materials for use in vocational and technical education, teaches students the skills needed to become aviation structural mechanics (first class). The course materials consist of three pamphlets. The first pamphlet covers aircraft maintenance management, records, and reports as required by the standardized maintenance management system. Sheet metal layout and forming, including simple shop mathematics, is the subject of the second pamphlet. Also included are the different forming processes used on aircraft parts. The final pamphlet, aircraft damage repair, is divided into three sections containing the following information: inspection and classification of aircraft damage, types of repairs to be made, and selection of repair materials; general procedures for repairing reinforced plastic and sandwich construction components; and procedures for selecting and using rivets for aircraft repair. Each pamphlet is a student workbook with reading assignments, learning objectives, self-tests, and answers to the tests. Materials are illustrated with line drawings. (KC)

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL

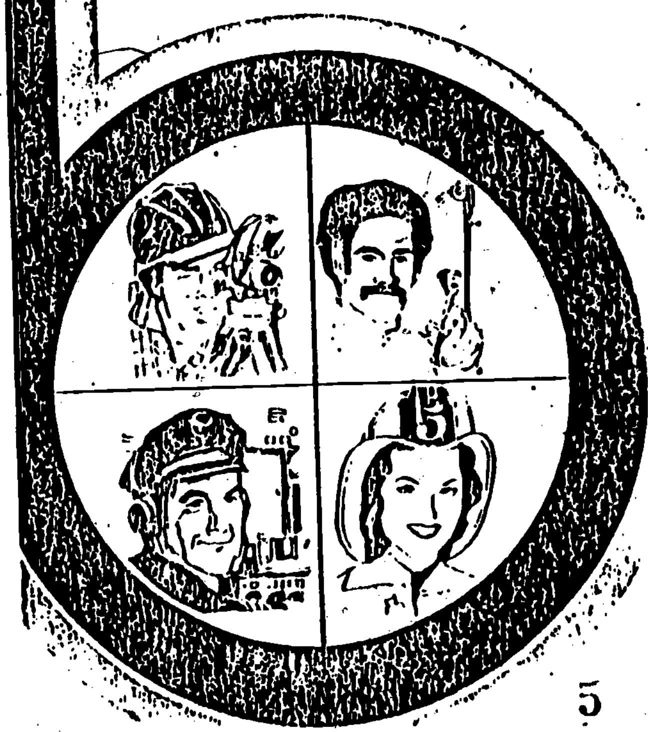
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION

Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education



Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

NORTHWEST
William Daniels
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AVIATION STRUCTURAL MECHANIC, FIRST CLASS 2-12

TABLE OF CONTENTS

Aviation Structural Mechanic, First Class
AMI-0107

Correspondence Course 2-12

Developed by:
United States Coast Guard

Development and Review Dates:
7/81

Occupational Area:
Aviation

Print Pages:
219

Availability: The National Center for Research in Vocational Education; ERIC

Suggested Background:
NONE

Target Audiences:
Grade 11 - Adult

Organization of Materials:
Student workbook with objectives, assignments, tests and answers

Type of Instruction:
Individualized, self-paced

Type of Materials:	No. of Pages:	Average Completion Time:
Aviation Administration	79	Flexible
Sheet Metal Layout and Forming	42	Flexible
Aircraft Damage Repair	63	Flexible

Supplementary Materials Required:
NONE

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Course Description:

This course includes three pamphlets. The information covered is:

Aircraft maintenance management, records and reports. This section concerns the standardized maintenance management system. Its design ensures maximum use of manpower, material, and equipment.

Sheet metal layout and forming covers simple shop mathematics. Also included are the different forming processes used on aircraft parts.

Aircraft damage repair is divided into: Damage Repair Procedures, which discusses the inspection and classification of aircraft damage, types of repairs to be made, and selection of repair materials; Reinforced Plastic and Sandwich Construction Repair, which includes general procedures for repairing reinforced plastic and sandwich construction components; Riveting Procedures, which outlines rules for selecting and using rivets for an aircraft repair.

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AVIATION ADMINISTRATION

DEPARTMENT OF TRANSPORTATION
U.S. Coast Guard (07/81) AMI-0I07

U. S. Coast Guard Institute
PAMPHLET NO. 340

This pamphlet contains original material developed at the Coast Guard Institute and also excerpts from:

Air Operations Manual	M3710.1
Aeronautical Engineering Maintenance Management Manual	M13020.1
Air Force Technical Order System	TO 00-5-1
Aircraft, Drone and Air Launched Missile Inspections, Flight Reports, and Supporting Documents	TO 00-20-5
Configuration Management Systems	TO 00-20-4
Technical Order Distribution System	TO 00-5-2
Introduction to Federal Supply Catalogs and Related Publications	NAVSUP 4000
Aircraft Material Stocking-List	CG-298
Directives, Publications, and Reports Index	COMDTNOTE 5600
Aeronautical Engineering Publications Index	M13005.1
Commandant Instruction 4410.3	
AICPINST 4231.1	
Comptroller Requisitioning Handbook (MILSTRIP/SURF)	M4400.8

IMPORTANT NOTE: In July, 1981, the information contained in this pamphlet was current according to the latest updates of those Directives/Publications listed. This pamphlet was compiled for training **ONLY**. It should **NOT** be used in lieu of official Directives or publications. It is always **YOUR** responsibility to keep abreast of the latest professional information available for your rate.

The personnel responsible for the latest review and update of the material in this component during July 1981 are:

ATCS B. L. Ely	(Subject Matter Specialist)
D. Burns	(Education Specialist)
YN2 D. J. Laase	(Typist/Typographer)

Questions about the text should be addressed to your Subject Matter Specialist.

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INTRODUCTION

This pamphlet outlines the purpose and scope of Coast Guard aircraft maintenance administration. To ensure the readiness of Coast Guard aircraft, all aviation maintenance personnel must be thoroughly familiar with the information that will be presented here.

Four major topics will be discussed in this pamphlet:

(1) Aircraft maintenance management
(2) Aircraft records and reports
(3) Maintenance publications and directives
(4) Aviation supply

First, we will discuss the general purpose and organization of the Coast Guard aircraft maintenance management system. We will not attempt to include all the aircraft inspection information you will need to do your job. More specific details are available in the Aeronautical Engineering Maintenance Management Manual M13020.1.

Following the general discussion of maintenance management, we will describe the records, reports, directives, and publications used in Coast Guard aircraft maintenance. You will learn how to prepare maintenance records and reports, and how to order and use Air Force technical orders and Coast Guard technical orders, directives, and publications. The Air Force Technical Order System will be discussed in detail.

The last section of the pamphlet provides instructions for obtaining materials you will need for aircraft maintenance. We will cover only those aspects of aviation supply that have direct application to maintenance.

This pamphlet is divided into four sections; each section includes a list of objectives, text material, a self-quiz, and an answer key. At the end of the pamphlet is a multiple-choice review quiz. The quiz items are designed to test your mastery of the objectives, which emphasize the most important points of the text.

To get the most from this pamphlet, you should use the study tips provided in the INSTRUCTIONS sheet for this course.

AVIATION ADMINISTRATION

AIRCRAFT MAINTENANCE MANAGEMENT SYSTEM

OBJECTIVES

When you complete this section, you will be able to:

1. Describe the organization of the typical Coast Guard air station Engineering Section; list the duties of each subsection of the Engineering Section.
2. Explain the purpose of the aircraft inspection system and the various types of inspections performed on aircraft.
3. Use maintenance procedure cards (MPC's) and inspection work cards to perform aircraft and engine inspections.
4. Maintain aircraft status boards.
5. State the types and purposes of the various post-maintenance functional checks.
6. State the maintenance levels used in Coast Guard aviation and describe their purpose.
7. Explain the functions of prime units; name the prime units for specific aircraft.

INTRODUCTION

The Coast Guard aircraft maintenance management system was designed to ensure maximum use of manpower, material, and equipment. It also established standard maintenance procedures and organizations to accomplish maintenance on Coast Guard aircraft and associated equipment. The adoption of standard organizations and procedures promotes a high degree of uniformity among all activities in the methods used to manage and use maintenance personnel, material, and facilities. This results in a decrease in the time required to indoctrinate recently assigned personnel.

A new aircraft is expected to fill a specific need and accomplish a certain mission. Enough personnel, material, and equipment must be planned, procured, and assigned to maintain this aircraft in a ready status for a given length of time.

The improvement of aircraft readiness is of utmost importance. Costly, complex systems and spares demand maximum attention to the repair of critical items to enable aircraft to be in a ready status. It is therefore mandatory that all maintenance personnel have a thorough knowledge of the established procedures.

ORGANIZATION

The Coast Guard aircraft maintenance management system is a composite of Air Force and Navy systems, commercial procedures, and Coast Guard developed procedures. The objective of this system is to ensure that assigned material is serviceable, safely operable, and properly configured to meet the mission requirements. This is accomplished by performing maintenance which includes, but is not limited to, inspection, repair, overhaul, modification, preservation, testing, and condition or performance analysis. These tasks should be completed on a preplanned scheduled basis. Proper planning provides supervisory personnel with the workload plans required for timely accomplishment through the efficient use of personnel, facilities, and equipment. Proper planning reduces unscheduled maintenance events and allows for an orderly progression of maintenance actions toward returning material to a safe and operable condition.

The degree of equipment readiness at an operating unit must be directly related to the assigned mission. Failure to recognize equipment readiness requirements may permit excessive equipment deficiencies and maintenance backlog. On the other hand, unrealistically high readiness requirements may cause essential maintenance to be deferred. Either extreme reduces the unit mission capability. Each commanding officer must make equipment available for maintenance when the resources are available. He must ensure that maintenance is completed in an orderly and timely manner to meet the assigned mission requirement. The key to mission success is the sustained ability to provide safe, reliable, and properly configured equipment at the time and place it is required.

The equipment maintenance function has three basic elements: management, technical, and production. The Aeronautical Engineering Division (G-EAE) of Coast Guard Headquarters has the primary responsibility for management; G-EAE is also a focal point for technical and engineering support for systems and equipment. The Aircraft Repair and Supply Center and the "prime units" (to be discussed later) perform most of the technical maintenance engineering under the direction of G-EAE. Operating activities are concerned primarily with maintenance production. They provide the basic data for maintenance engineering decisions. Maintenance production is the performance of equipment maintenance and related functions, such as servicing, repairing, testing, overhaul, modification, calibration, conversion, and inspection. These tasks are carried out at two levels: unit and depot.

As defined by the Coast Guard, unit-level maintenance includes both of the Department of Defense (DOD) levels described as organizational and intermediate. A using organization performs unit-level maintenance on assigned equipment. Unit-level maintenance normally consists of inspecting, servicing, lubricating, adjusting, and replacing parts, minor assemblies, and subassemblies. It also consists of: (1) calibrating, repairing, or replacing damaged or unserviceable parts, components, or assemblies; (2) modification of material and emergency manufacturing of unavailable parts; and (3) providing technical assistance to using organizations.

Depot-level maintenance is the responsibility of, and is performed by, designated maintenance activities to augment stocks of serviceable material and to support unit level maintenance activities. Depot-level maintenance includes more extensive shop facilities and equipment, and personnel of higher technical skill than are normally available at the lower levels of maintenance. It normally consists of: (1) repairing, modifying, overhauling, reclaiming, or rebuilding parts, assemblies, subassemblies, components and end items; (2) emergency manufacturing of unavailable parts; and (3) providing technical assistance to using activities. Depot-level maintenance is normally accomplished at AR&SC and other overhaul activities designated by Commandant (G-EAE).

ENGINEERING SECTION ORGANIZATION

Since the Engineering Section at a Coast Guard air station controls the Coast Guard aircraft maintenance management system, we will describe the organization of a typical Engineering Section.

The Coast Guard Organization Manual (CG-229) describes the manner in which all Coast Guard units fit into the basic pattern of organization and command. The Coast Guard Air Operations Manual (CG-333) sets forth the minimum requirements for organizing, administering, and operating aviation units. The following paragraphs describe the function and duties of the Engineering Section organization components as explained in CG-333.

HEAD, AVIATION ENGINEERING SECTION

The details of the Engineering Section organization at an individual air unit must be tailored to the size and mission of the unit. The adopted organization must retain the emphasis on quality assurance and must comply with the characteristics and principles of organization, functions of management, and concept of staff as set forth in the preface of the Organization Manual, CG-229. The Head, Aviation Engineering Section shall:

Manage the Aviation Engineering Section and be responsible to the commanding officer for the maintenance of aircraft, associated equipment, and facilities including avionics and survival/rescue equipment. He must realize that the primary purpose of his section is to provide properly maintained aircraft to support the unit's operational mission.

Administer the Aviation Engineering Section in accordance with policies, procedures, reports, and applicable technical instructions.

Administer the aircraft maintenance program to provide for necessary maintenance, routine inspection, and servicing of aircraft and associated equipment. This program includes the following: (1) the necessary disassembly, cleaning, repair, modification, test, inspection, assembly, and preservation; (2) special work and compliance with technical directives and local instructions; (3) assurance of high quality of all work; (4) maintenance of records and technical publications; (5) maintenance of tools and other support equipment; (6) timely, effective, and economical material and parts support for maintenance needs; and (7) training of assigned personnel including the Plane Captain Examining Board.

Continuously and progressively analyze the mission of the section under changing circumstances to identify all functions required in support of the mission and assign them for performance, and to initiate timely planning for future requirements.

Coordinate maintenance scheduling with Operations Section requirements, giving proper consideration to priority work, availability of skills and man-hours, availability of materials, tools, and equipment, adequacy and use of facilities.

Establish such programs as fuel and oil contamination prevention, foreign object damage prevention, and corrosion control.

Promulgate and ensure compliance with quality, maintenance, safety, and security procedures.

Plan, budget for, and request the facilities, equipment, and manpower required to accomplish the maintenance program necessary to support the unit's operational requirements. Administer section funds.

Perform the duties of the head of a "department" as specified by Coast Guard Regulations.

The Engineering Section at an air station has five subsections: Quality Assurance, Engineering Administration, Aviation Material, Aircraft Maintenance, and Avionics Maintenance.

QUALITY ASSURANCE SUBSECTION

The duties of the Quality Assurance Subsection are:

Determine the quality of maintenance throughout the unit's aircraft maintenance complex, and give complete, impartial reports and recommendations which will help to eliminate errors in aircraft maintenance. Establish a relationship with the individual maintenance supervisors which will ensure adequate corrective action on all discrepancy reports; frequently check with maintenance supervisors to determine whether inspection coverage is adequate and is assisting maintenance personnel.

Maintain the master library of all technical publications and directives. Review all incoming technical publications and directives to determine their application to quality assurance; assist in preparation of local maintenance instructions; ensure that each maintenance organization segment has available all publications applicable to its work area and that these publications are kept current.

Review work orders, inspection sheets, aircraft maintenance records, and all logs and records pertaining to the aircraft for recurring discrepancies requiring special action.

Ensure that established and adequate procedures are observed for conducting ground tests, routine and special inspections. Perform quality inspections on representative work to ensure that the desired quality level is being attained; ensure that maintenance personnel are observing current standard procedures in the repair and bench test of components.

Ensure all work guides, checkoff lists, work cards, and test flight forms to define or control maintenance are complete and current.

Participate in flight verification checks and test flights; ensure that test pilots and crews are briefed before test flights so that the purpose and objectives of the flights are clearly understood.

Ensure that the configuration of aircraft and aircraft components is such that all essential modifications have been incorporated. Ensure that support equipment meets calibration and safety requirements.

Review Unsatisfactory Reports (UR's) and Aviation Electronics Maintenance Records (CG-4237's) to detect trends with the objective of determining when discrepancies in any area are ascending or exceeding normal limits.

Approve or reject completed work based on appropriate standards.

Spot check equipment received for use, or returned for repair, to assure that its condition, identification, packaging, preservation, and configuration are satisfactory and, when applicable, that shelf life limits have not been exceeded.

Establish qualifications requirements for quality assurance inspectors and collateral duty quality assurance inspectors; review the qualifications of personnel assigned to these positions; maintain a record of all designated inspectors.

ENGINEERING ADMINISTRATION SUBSECTION

The duties of the Engineering Administration subsection are:

Provide administrative and clerical services for the Aviation Engineering Section. Establish and control a system for correspondence receipt, distribution, reply, and filing. Ensure submission of all required reports. Prepare and distribute internal maintenance directives, schedules, and information. Maintain aircraft logbooks and historical records.

Properly distribute all nontechnical information and publications.

Supervise and coordinate engineering administrative responsibilities with other sections as required.

Establish and coordinate aviation engineering section training requirements and obtain necessary school quotas to support these requirements, using available Class "C" and commercial schools; program for and provide adequate on-the-job training; provide for engineering related aircrew training. Coordinate with Operations Section in providing SAR aircrew training.

Control classified material required by the section.

AVIATION MATERIAL SUBSECTION

The duties of the Aviation Material Subsection are:

Forecast changes in the supply requirements of the Aviation Engineering Section and properly present them to the unit's Supply Section; accomplish effective follow-up procedures to assure timely, effective, and economical support for all maintenance needs.

Maintain liaison with the Supply Section, and provide technical advice for procurement and requisitioning of aviation engineering supplies and allowance list spares.

Keep the Head, Aviation Engineering Section advised of the overall supply situation as it affects the aircraft maintenance program.

Compile and analyze maintenance usage data, Not Operationally Ready due to Supply (NORS) and Not Operationally Ready due to Maintenance (NORM) experience; recommend changes to stocking lists when justified.

Inventory aircraft upon receipt and transfer, and ensure that proper inventory log entries are made.

Be responsible for procurement, custody, issue, and condition of all general and special tools required by the Aviation Engineering Section.

Request, receive, identify, classify, store, and issue all special aviation material required by the Aviation Engineering Section.

Assist the Supply Section in maintaining a complete inventory of material required in the operation of the Aviation Engineering Section and initiating immediate replacement of established stocking levels.

Periodically spot-check aviation material in supply to ensure shelf life has not expired.

Assist in estimating budgetary needs and administering funds allotted for procurement of material and services. Establish internal methods and procedures by which maintenance personnel can obtain required material to support the maintenance effort.

Begin action for the survey of material if accountable items are lost, damaged or destroyed.

Recommend and control cannibalization in accordance with applicable directives when such action is advisable and in the best interest of the maintenance operation.

Manage the operation of the Aviation Engineering Section tool room(s).

Ensure that all Class 265 material is carefully screened and a positive determination is made that repair of such material is beyond unit or local repair capability. Ensure that material is properly tagged, packaged, and expeditiously processed.

AIRCRAFT MAINTENANCE SUBSECTION

The duties of the Aircraft Maintenance Subsection are:

Direct preventive and corrective maintenance of airframes, engine accessories, survival/rescue devices, equipment, and the shop facilities associated with the aviation mission.

Plan and schedule assigned aircraft through all phases of maintenance. Perform progress checks on all work assigned; maintain aircraft maintenance status boards and keep the proper personnel informed of aircraft status.

Plan, schedule, and control all maintenance of aircraft and associated equipment, considering:

1. Priority work to be accomplished.
2. Availability of skills and man-hours.
3. Availability of material.
4. Availability of tools and equipment.
5. Availability and adequacy of facilities.

Request required material from the Aviation Material Subsection for the maintenance of aircraft and equipment. Establish a system to ensure delivery of necessary items at the required time and place.

Direct and coordinate all activities of the Aircraft Maintenance Subsection. Receive work requests from other sections and schedule accomplishment of the work.

Ensure that maintenance instructions are prepared when required.

Ensure prompt and safe movement of aircraft to facilitate the maintenance effort. Prepare necessary aircraft parking plans.

Maintain a current status of all ground support equipment including inspection requirements compliance.

Provide aircraft line maintenance including aircraft preflight, aircraft postflight, aircraft servicing, and transient maintenance. Correct all aircraft discrepancies. Carry out an active program guarding against foreign object damage.

Supervise the operation of the aviation fuel storage facility and exercise overall supervision of all fuel handling operations.

Coordinate the training of taxi signalmen and tractor and mobile ground power unit operators with the Engineering Administration Subsection. Provide for aircraft security including tiedowns and checks for assigned aircraft.

Accomplish required aircraft runup, aircraft washing, and aircraft interior cleanup.

Coordinate, supervise, and complete all aircraft scheduled and unscheduled maintenance.

Promptly accomplish all work orders in accordance with established priorities.

Process repairable material to a serviceable status.

Maintain assigned shop equipment and ready-for-issue (RFI) items. Program and budget for economical repairs or replacement of equipment.

Ensure that all material and equipment are properly stored, secured, and accounted for.

Ensure precision measurement equipment is calibrated and certified in accordance with current directives.

Establish the level of maintenance required in accordance with current directives and assure shop facilities are adequate for the needs.

Maintain oxygen and armament (JATO, drop tank jettison, etc.) system components, parachutes, para-drop kits, life rafts, life jackets, droppable SAR equipment, ammunition, pyrotechnics, and parachute flares.

Prepare Unsatisfactory Reports of aeronautical material in the rough and forward them to the Engineering Administration Subsection.

Request shop material required; periodically review shop usage and establish inventory low levels.

AVIONICS MAINTENANCE SUBSECTION

The duties of the Avionics Maintenance Subsection are:

Manage the Avionics Maintenance Subsection and maintain electronic and electrical equipment and shop facilities.

Administer the subsection in accordance with controlling directives of higher authority concerning policies, procedures, reports, and applicable technical instructions.

Plan, schedule, and control the avionics maintenance program to provide for the necessary maintenance, routine inspection, servicing, and calibration of avionics equipment and the associated test equipment. This shall include:

1. Disassembly, cleaning, examination, repair, modification, test, inspection, assembly and preservation of all equipment as necessary.
2. Special work necessary for compliance with technical directives.
3. Maintenance of avionics records and technical publications.
4. Maintenance of tools and other support equipment.
5. Training of subsection personnel including the supervision of the avionicsman aircrew training.

Assign personnel as necessary to the Aircraft Maintenance Subsection to meet scheduled and line maintenance requirements.

Coordinate maintenance scheduling with the Aircraft Maintenance Subsection, giving proper consideration to priority of work, availability of skills and manhours, availability of materials, tools and equipment, adequacy and utilization of facilities.

Promulgate and ensure compliance with maintenance, safety, and security procedures.

AIRCRAFT INSPECTION SYSTEM

At the time of this pamphlet update, all Coast Guard aircraft, except the HU-16, are maintained under the Computerized Maintenance System. The HU-16 aircraft is still maintained under the Workcard System developed by the Coast Guard. This maintenance information is outlined in the Coast Guard Aeronautical Engineering Maintenance Management Manual (CG-452), dated 6 August 1979.

We will not attempt to incorporate in this pamphlet all the aircraft inspection information contained in the Maintenance Management Manual. This training pamphlet provides only general information to acquaint you with the Coast Guard aircraft maintenance systems. You should refer to the Maintenance Management Manual (CG-452) for specific inspection criteria for each type of Coast Guard aircraft. (See figure 1).

DEFINITION OF INSPECTIONS

Maintenance inspections, varying in scope, purpose and frequency, are performed on assigned aircraft to ensure that aircraft are retained in a serviceable condition. Because of the variety of inspection terminology generated by military and commercial maintenance systems, USCG aircraft inspection types and application are herein defined under two categories: Routine and Special.

Routine Inspections

The following inspections are considered routine:

1. Preflight Inspection. The maintenance preflight inspection is to be accomplished prior to the first flight of the day and remains effective for 24 hours provided no subsequent maintenance has been performed. The preflight inspection consists of checking the aircraft for flight preparedness by performing visual examinations and operational tests to discover defects and maladjustments which, if not corrected, could adversely affect safety or mission accomplishment.

2. Thruflight Inspection. The thruflight inspection requirements are accomplished as a turnaround inspection before takeoff on the second and each subsequent flight of the day on selected types of aircraft. Units operating aircraft authorized to use the thruflight system will have satisfied the requirements for preflight certification on the Aircraft Flight Record (Form CG-4377) after completing a thruflight.

3. Basic Postflight Inspection. The basic postflight inspection will be accomplished after the last flight of the flying period. This inspection consists of checking the aircraft to determine if it is suitable for continued flight. Certain components, systems, or areas are visually inspected to assure that no defects exist which would be detrimental to further flight. Additionally, the postflight checking for leaks, chafing, maladjustments, etc., should disclose defects requiring correction before deteriorating into major maintenance items. The postflight inspection frequency ranges from once a day to once per week, depending on the type of aircraft involved.

4. Hourly/Weekly Inspection. These inspections are designed to provide servicing and verification of satisfactory functioning of critical systems/components at frequent intervals, (i.e., HH52A 10 Hour, C-131A Weekly). The frequency of these inspections prohibit use of the computer for scheduling.

5. Intermediate Inspection. (HU-16E only) The intermediate inspection is a limited overall examination of the condition of the aircraft. It includes certain requirements that are also applicable to the preflight/thruflight/postflight inspections plus requirements that must be applied at periods occurring more frequently than major inspection.

6. Major Inspection. (HU16E only) The major inspection is a thorough and searching examination of the aircraft. It includes items that are also applicable to the intermediate inspections.

7. CMS Maintenance Due List (MDL). Those maintenance tasks previously required during periodic/phased inspections will now appear as separate line items on the MDL. Subdivided into three sections; Hourly, Calendar, and Operations, this report ensures a thorough and searching examination of all systems and components on a scheduled basis.

Special Inspections

Special inspections are certain additional inspections, distinct in frequency from those routine inspections described above. They are conditional upon the operational environment, specific incidents, or other circumstances requiring inspections. The myriad number of special inspections required for all aircraft and circumstances are too numerous and changing to list. A few types are given in the following items to illustrate their distinction from ROUTINE:

1. Overtemperature, Overboost, Overspeed, Metal Contamination (etc.), Inspections. These types of special inspections define the specific maintenance actions to be taken based upon the circumstances of the event. These inspections have been documented into existing manuals as the result of actual prior experiences or a high probability of encountering the event.

2. TCTO/ITCTO. A TCTO/ITCTO may be issued to perform a one-time inspection of an aircraft component or system. This action is normally generated by a reported safety of flight incident or failure trend. Normally TCTO's will appear on the MDL for action. In any event, all TCTO/ITCTO compliance shall be reported to the computer center, (via the Blank Update Form), for recording in the Aircraft History Report.

INSPECTION REQUIREMENTS

Inspection Interval

The calendar and flight hour inspection due times listed in the Aircraft Inspection Criteria

(CG-452) and the CMS Maintenance Due Lists are the maximum intervals for completion of one to the start of the next inspection. The inspection schedules are limits based upon average operating experience. Whenever an aircraft or engine accumulates the limiting number of hours before the calendar interval has expired, the inspection becomes due and will be performed, (i.e., C130 Basic Postflight). Commanding Officers are responsible for the adequate maintenance and corrosion control of aircraft in their custody and are to impose such other inspection requirements as necessary to meet differing environmental and operational conditions as may exist.

Extension of Interval

Maintenance Due List items other than Operations may be delayed a maximum of 30 days for calendar items for 10 percent for hourly items at the discretion of the Commanding Officer or his designated representative. Failure to accomplish actions within this time frame shall require grounding of the aircraft. Maintenance requirements grouped under Operations category are intended to be accomplished within the month scheduled. Individual items of the Operation may be extended through the next month when authorized by the Commanding Officer, or his designated representative, due to extended deployment, urgent operational requirements, or environmental factors which preclude accomplishment, (i.e., engine wash at extreme temperatures). The following restrictions apply to performing maintenance actions early:

1. Thirty days/10 percent maximum for scheduled component changes.
2. Operations - early accomplishment to meet operational commitments shall be authorized by G-EAE on an individual basis.
3. There are no restrictions on all other maintenance actions.

Interruption of Interval

The accumulation of calendar time on an aircraft/engine is halted for the period that the aircraft/engine is in storage, extended repair or lengthy modification status. Calendar time accrual is resumed when the aircraft/engine returns to operational status. The Commandant (G-EAE) will determine and authorize on an individual occurrence basis those situations which constitute causes for interval interruption. When anticipated, timely input to the computer center should be provided to adjust maintenance due list requirements.

Inspection Facilities

Aircraft missions are planned, if possible, so that intermediate, major, and CMS inspections are performed at the home station, where adequate personnel, parts, tools, and equipment are available. This ensures a high level of quality control and minimum NOR (Not Operationally Ready) time.

Aircraft Transfer

If it is necessary to transfer aircraft when a routine or special inspection, change, TCTO, or other maintenance requirement has not been completed due to the lack of parts, kits, special tools, or other reasons, the transferring activity must perform the following actions:

1. A detailed logbook entry describing the deficiency.
2. A letter describing the deficiency must be forwarded through channels to the receiving activity with a copy to the Commandant (G-EAE).

NOTE: Submittal of pre-overhaul report required by CG-452, will constitute compliance with this requirement.

Whenever an aircraft, (except C-130 to PDM), is transferred the following shall accompany the aircraft:

(1) Logbook.
(2) Change Kits.
(3) Computerized Aircraft History Reports (current month and final report for each previous year).
(4) Spectrometric Oil Analysis Program (SOAP) records for engines/gearboxes.
(5) Airframe and engine status reports.
(6) Completed CG-4377's (Part III) for previous 3 months.
(7) Completed Maintenance Procedure Cards (MPC's) on file (maximum previous 3 months).
(8) All pending scheduled MPC's.
(9) All other current computerized reports.

NOTE: Items (6) through (9) above shall not accompany all aircraft being transferred into overhaul at AR&SC and may be discarded once the aircraft is inducted. This does not apply to depot level maintenance other than overhaul, i.e., crash damage repair.

Two complete sets of unscheduled MPC's (including binders) shall accompany the aircraft if no replacement aircraft is anticipated.

(6) Completed MPC's on file (maximum previous 3 months).
(7) Two complete decks of unscheduled MPC's, including binders, if no replacement aircraft is anticipated.

NOTE: All other current computerized reports and all pending scheduled MPC's shall be returned to the computer center once the aircraft is inducted into PDM.

1. Basic Inspection Concept - Computerized Maintenance System (CMS)

2. Routine Inspection Cycle

a. Airframe	Interval	Inspection/ Requirements	Remarks
Preflight	Prior to first flight of the day	CMS	Valid for 24 hours. A completed postflight eliminates the requirements for next day's preflight unless maintenance is performed after that postflight. However, fuel sumps and filter drains shall be checked prior to the first flight each day.
Thruflight	Prior to second and subsequent flight of each day	CMS	Completion constitutes authorization for certification of preflight on CG-4377
Postflight	After last flight of the day	CMS	Completion constitutes authorization for certification of preflight on CG-4377
Weekly	Every seven days	CMS	Valid for seven days. May be accomplished early to meet scheduling requirements.
Bi-monthly	60 days	CMS 1-12 Operation	

b. Engine - As scheduled by CMS

c. Special Inspections - As scheduled by CMS

Figure 1. - C-131A INSPECTION CRITERIA.

When a C-130 is transferred to PDM, the following shall accompany the aircraft:

(1) Logbook.
(2) Change Kits.
(3) Computerized Aircraft History Reports (current month and final report for each previous year).
(4) Spectrometic Oil Analysis Program (SOAP) records for engines and gearboxes.
(5) Completed CG-4377's (Part III) for previous 3 months.

Inspection/Discrepancy Records. Completed MPC's, Squawk Reports and FORM CG-5181 (Carry Forward Discrepancies) will be retained by unit for a period of three months; they may then be discarded.

COMPUTERIZED MAINTENANCE SYSTEMS (CMS)

GENERAL

The Computerized Maintenance System developed for Coast Guard Aircraft (except the

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HU-16E), includes all previously applicable inspection requirements; however, the requirements are presented in a different format. Instead of accomplishing a large number of maintenance tasks during an extended periodic down time, tasks are completed and accounted for on an individual basis. This allows more operational and maintenance flexibility and manhours savings. The savings and flexibility are made possible by utilizing a computer system to keep track of the large volume of daily maintenance activities. The periodic/phase inspections previously accomplished are no longer required, once an aircraft is initiated into CMS. The CMS will commence on unit aircraft upon receipt of the computer generated maintenance material. The CMS program employs a computer to maintain status records, schedule maintenance tasks, and report the results of maintenance operations. From updated computer data files, a series of reports and information covering all maintenance tasks is generated. Each report is complete within itself and, with one exception, when new reports are received, the previous ones may be discarded (the last Aircraft History Report of each calendar year shall be retained for permanent record). These reports are submitted to each operating unit at the frequency indicated, and selected reports are submitted to AR&SC and the Commandant (G-EAE).

CMS FORMS

The following is a list of CMS forms and prescribed procedures:

1. Maintenance Requirements List (MRL). The document that initiates an aircraft on the CMS. The MRL contains a listing of significant components of the aircraft with blank areas for recording the present status of each component such as the part number, serial number, date installed, aircraft hours at installation, time since new (TSN) and time since overhaul (TSO) at the time of installation. In addition, the MRL lists all services and inspections required with blank areas for recording the date and aircraft hours when last accomplished. After the computer center maintenance analyst or operating activity records the latest information for each maintenance function being tracked on the MRL, the present status of the aircraft will be known.

2. Aircraft Status Report (ASR). The ASR is printed monthly and supersedes the previous month's report which should be discarded. It details the present overall status of the aircraft (including engine and propeller information on C-131's) as of the report date listed on the upper right-hand corner of each page. The ASR contains such information as part number, serial number, average man-hours for replacement and unit time of components presently installed on the aircraft. It also lists the frequencies for performing the services, inspections and component replacements. In addition, the ASR lists the date and aircraft hours when components were installed, when inspections and services were last complied with and when they will be due again. Each individual task is identified by a six digit number. The first two digits identify the appropriate ATA-100 chapter while the last four digits are used for date retrieval. ATA-100 is the specification published by the Air Transport Association that assigns subject matter pertaining to manufacturers technical data in specific groupings or chapters. The Aircraft Status Report is printed on blue lined paper.

3. Engine and Propeller Status Report: The Engine and Propeller (C-130 only) Status Reports are printed monthly and, as with the Aircraft Status Report, are on blue lined paper. Each separate report details the present status of the engine or propeller currently installed by part number, serial number, and position, as well as those components by part number and serial number that are installed on it or which make up the total or "quick engine change" (QEC) assembly. Service items or inspections pertaining to the engine, propellers or installed components are also listed. In addition, each report indicates the date and hours (both aircraft and engine) when last installed as well as the engine hours remaining until next removal or inspection. Each report will move with the engine or propeller it pertains to as a permanent record or traveler. If a spare engine or propeller from overhaul or from another air-

craft is installed, the reports are moved in the same manner as the engines or propellers. When the next month's reports are received, the engine that was a spare will be shown installed in its proper position on the reported aircraft while the engine that was removed will now be indicated in a spare status at the appropriate operating activity. As new reports are received each month, the old reports are discarded.

4. Aircraft Maintenance Due List (MDL): The Maintenance Due List (MDL), printed on red lined paper, is printed monthly and follows the same general format as the Aircraft Status Report. The report chronologically covers a two (2) month period ahead of any given date and lists all scheduled maintenance requirements (inspection, services and component replacements) that will become due by scanning through the Aircraft Status Report and printing all tasks that fall equal to or below the aircraft hours and/or calendar time for that period of projected aircraft utilization. Each maintenance requirement that appears as due on the Maintenance Due List shall be specifically referenced to the appropriate Maintenance Procedure Card needed to accomplish the task. The MDL is subdivided into three (3) sections with each maintenance requirement listed in order of urgency within that particular requirement section. The three sections are HOURLY, CALENDAR and OPERATIONS.

   a. Hourly Due List: Those maintenance tasks whose compliance is governed by accumulating a required amount of flying hours since they were last complied with.

   b. Calendar Due List: Those maintenance tasks whose compliance is governed by accumulating a required amount of calendar time (in months) since they were last complied with.

   c. Operations Due List: Those maintenance tasks whose compliance is governed by accumulating a required amount of time (usually calendar) since they were last complied with and, because of the repetitive nature or complexity of the tasks, have been grouped with similar tasks into predetermined operation cycles by COMDT (G-EAE).

If any task falls due in more than one MDL section of calendar or hours, a dash (-) will appear next to the card number. All the maintenance requirements previously listed on the Maintenance Due List that have not been reported as complied with since they first appeared will be signified with an "R" next to the code number. The "R" identifies it as a repeat item indicating that a Maintenance Procedure Card has been mailed to the operating activity with previous reports and no further MPC will be sent. Any maintenance task what happens to become due prior to the last actual reported aircraft hours or before the date of the MDL it appears on, will be listed as an overdue item at the top of the page. The word OVERDUE will print under the Next Due column to signify these items. TCTO's, other than those accomplished in PDM, will be listed as PENDING, (vice "OVERDUE"), with a due date as that date it first appears on the MDL. PDM TCTO's will be listed as due on projected date the aircraft enters PMD. Normally, TCTO's involving kits will not be issued until the kits are available at AR&SC. The MDL will continue to list rescinded TCTO's on new or overhauled components if there is no record of compliance. It will be the unit responsibility to verify the TCTO has been complied with, and update the computer accordingly. Each new updated Maintenance Due List supersedes the previous one which should be discarded upon receipt of the updated MDL.

5. Engine and Propeller Maintenance Due List (Does not apply to HC-131): The Engine and Propeller (C-130 only) Due Lists are printed monthly and, as with the Aircraft Maintenance Due List (MDL), are printed on red lined paper. Each separate report follows the same general format as the Engine and Propeller Status Report. The report chronologically covers a two (2) month period

ahead of any given date and lists all scheduled maintenance requirements (inspections, services and component replacements) that will come due by scanning through the Engine or Propeller Status Report and printing all tasks that fall equal to or below the aircraft (or engine) hours or calendar time for that period of projected aircraft utilization. Each maintenance requirement that appears as due on the Engine or Propeller Maintenance Due List shall be specifically referenced to the appropriate Maintenance Procedure Card needed to accomplish the task. Each Maintenance Due List is subdivided into two (2) sections with each maintenance requirement listed in order of urgency within that particular requirement section. The two sections are HOURLY and CALENDAR.

a. Hourly Engine and Propeller Due List: Those maintenance tasks whose compliance is governed by accumulating a required amount of flying hours (engine hours) since they were last complied with.

b. Calendar Engine and Propeller Due List: Those maintenance tasks whose compliance is governed by accumulating a required amount of calendar time (in months) since they were last complied with.

If any task falls due in more than one Maintenance Due List section of calendar or hours a dash (-) will appear next to the card number. All the maintenance requirements previously listed on the Maintenance Due List that have not been reported as complied with since they first appeared will be signified with an "R" next to the code number. The "R" identifies it as a repeat item indicating that a Maintenance Procedure Card has been mailed to the operating activity with previous reports and no further MPC will be sent. Maintenance tasks, other than TCTO's that happen to become due prior to last actual reported aircraft hours or before date of the MDL it appears on, will be listed as an overdue item at the top of the page. The word "OVERDUE" will print under the next due column to signify these items. TCTO's, other than those accomplished in PDM, will be listed as "PENDING", (vice "OVERDUE"), with a due date as that date if first appears on the MDL. PDM TCTO's will be listed as due on projected date the aircraft enters PDM. Normally, TCTO's involving kits will not be issued until the kits are available at AR&SC. The MDL will continue to list rescinded TCTO's on new or overhauled components if there is no record of compliance. It will be the unit's responsibility to verify if the TCTO has been complied with, and update the computer accordingly. Each new updated Maintenance Due List supersedes the previous MDL, which should be discarded upon receipt of the updated MDL.

6. Special Requirements Maintenance Due List: The Special Requirements Due List provides a means of tracking G-EAE generated inspection/servicing requirements for items which are not assigned to a specific aircraft, i.e., Night Sun, Carolina Moon, Hobart power cables, cargo and engine slings. Additionally, the program provides an optional means of tracking a myriad of periodic requirements at an Air Station, such as mobile GSE/survival equipment maintenance, hangar/ramp/fuel farm maintenance and recurrent reports.

a. General. On a monthly basis, a 60 day calendar projection will produce the Special Requirements Due List derived from the Special Requirements Status Report which will follow the same general format as the Aircraft Maintenance Due List (MDL). The report, Figure 10, shall be in three parts:

(1) Mobile Ground Support Equipment. Those maintenance tasks that apply to gasoline, electric or diesel powered servicing equipment, power carts, fuel trucks, crash trucks and tow tractors. An MPC is provided (Figure 11) which lists the quarterly and annual minimum inspection requirements outlined

in Enclosure 14. Space is provided on the MPC to list additional local inspection requirements.

(2) Miscellaneous. Those maintenance tasks that apply to hangar equipment, hoist equipment, emergency generator systems, air compressors, fire extinguishers, etc.

(3) Rescue and Survival Equipment. Those maintenance tasks that apply to parachutes, life jackets, survival kits, oxygen masks, rescue baskets, slings, pumps and so forth.

Maintenance Procedure Cards will be provided to record and update accomplishment of certain items, (mobile GSE, Night Sun, Carolina Moon, etc.), appearing on the Special Requirements Due List. The remainder of items shall be recorded and updated to the computer center via the provided Special Requirements Update Form. Certain restrictions apply for enrollment of optional items. They are:

(1) Minimum Interval. The minimum interval for a requirement shall be three months.

(2) Personnel Information. No personnel information such as recurrent training or flight physicals may be tracked.

(3) Personnel Parachutes and Life Vests. Personnel parachutes and life vests must be tracked in groups.

7. Maintenance Procedure Card (MPC): The Maintenance Procedure Card (MPC) is the primary source document for updating the CMS program. The cards are printed in various colors to identify the different aircraft types on CMS and incorporate carbonless paper tear-offs for updating purposes. Scheduled MPCs (identified by clipped corner) are sent to the operating activity for each maintenance task listed on the Maintenance Due List (MDL). Two complete decks of unscheduled cards (unclipped corner) are supplied for each aircraft on the program. In the event of unscheduled maintenance, these cards are withdrawn from the deck and used in a similar manner as scheduled cards (the information is the same). The computer center maintenance analyst, upon receipt of an unscheduled card will resupply the operating activity with an identical card to keep their supply at two complete decks at all times. The Maintenance Procedure Cards detail and illustrate the necessary steps to perform the particular maintenance task and reference the applicable T.O. from which the procedure is taken. Each card contains an update block with spaces for entering such information as date and hours the task was performed and part number, serial number and reason removed for components removed. Replacement component information such as part number, serial number, TSN and TSO are also available as well as spaces for the mechanic and QA inspector to sign off the task. Additionally, QA inspection may be called for in the text of an MPC by means of an asterisk. This implies that at that particular point during the maintenance task, QA has to check or verify a step being completed. It does not imply that this is the only spot where QA inspection may be needed, or that only those asterisked items need be inspected. Space for recording engine serial number, engine total time and position is provided on engine MPCs. In addition, each MPC has remarks codes where maintenance personnel can record information pertaining to the task being performed for future data retrieval. The remarks codes are as follows:

REMARKS CODE		REASON - COMPONENT REMOVED
1	TIME EXPIRED	The component has reached it's maximum operating life, or is due for overhaul/maintenance which is not possible at unit level.

2	FAILED	The component fails to meet minimum operating criteria, i.e., excessive leakage or excessive wear (prior to 75% TBO is established).
3	PRECAUTION	Continued use may result in failure, or the integrity of the component is questionable, i.e., SOAP indicates high metal.
4	MOD	Removed for modification in compliance with CGTO or TCTO.
5	SERVICE	Component requires removal for scheduled maintenance, which is not practical while installed, i.e., T-58 600 hour inspection.
6	SCHED CONVEN.	Component is removed strictly for convenience, i.e., for installation on a Bravo aircraft, (cannibalization), or to align future inspections to a more convenient time.
7	WORN	Removed for wear which would be considered normal, i.e., tip cap wear/erosion or wear after 75% TBO (if established).
8	ASSEMBLY	Component removed in conjunction with next higher assembly.

REMARKS CODE		INSPECTIONS (CHECK TYPE OF SQUAWKS FOUND)
A	NONE	No Squawks Were Found
B	PREVENT. MAINT.	Preventive Maintenance (minor) Squawks Were Found
C	SAFETY OF FLT.	Safety of Flight (major) Squawks Found
D	CORROSION	Corrosion Was Found During Inspection

REMARKS CODE		SERVICES (CHECK SERVICING FREQUENCY)
A	EXTEND	Extend the Frequency (Do Less Often)
B	OK	Frequency is OK as is
C	REDUCE	Reduce the Frequency (Do More Often)
H	COMPONENT CHG.	Service was Complied With Because of Component Change

All Spaces on the Maintenance Procedure Card must be filled in accurately to ensure that no erroneous information is fed into the computer. To prevent this possibility, space is provided at the bottom of each MPC for a signature indicating that the card has been reviewed and is ready to mail to the computer center for processing. Also the computer program has built in quality control features whereby the operating activity will be alerted to the fact that incorrect information may be present in the reports. (Refer to paragraphs 10 and 11). When the MPC is completely filled out, the top sheet (white) of the carbonless signoff is separated and mailed to the computer center for processing, while the second sheet, (yellow) is retained by the unit.

8. Shop Maintenance Squawks Report. The Shop Maintenance Squawks Report is for recording man hours expended, by individual rate for direct aircraft maintenance performed in the shops. Avionics shops should note that this does not eliminate reporting requirements of the EICAM System. The report incorporates a carbonless tear-off feature. The original is sent to the computer center for processing while the copy is retained at the operating activity.

9. Maintenance Squawks Report. The Maintenance Squawks Report is for reporting action taken and man hours expended, by rate, in correcting all discrepancies generated by MPC's and non-grounding discrepancies generated by Pre/Thru/Postflight inspections, QA spot inspections, etc. The report incorporates a carbonless tear-off feature. The original is sent to the computer center for processing while the copy is retained at the operating activity.

10. Aircraft History Report (Not Applicable to HC-131): The Aircraft History Report (AHR) is printed on green paper and is a cumulative record of all maintenance performed. The report is in ATA-100 chapter order and lists each task completed in chronological order, with the latest complied-with date being last. Each monthly Aircraft History Report supersedes the previous month's report, which should be discarded. The December report however should be retained, since it contains a complete record of component changes during the previous year on CMS. The January report starts a new year's maintenance history listing.

The Aircraft History Report lists what maintenance was performed, when it was performed and, in a coded format, why it was performed. In the case of components, the total time in service at the time of removal is listed to determine performance and reliability. Any man hours expended are also listed.

When an operating activity reports a component change and the serial number reported being removed does not match the serial number previously reported as installed in that position, the record will appear on the Aircraft History Report as a double entry. Whenever this type of error occurs, the operating activity will be advised of the error by the Inconsistency Report (refer to item 11).

11. Insufficient Information Report: The Insufficient Information Report is computer generated as required, to alert the operating activity of possible erroneous information. As the mechanic peforms each job he fills in the blank spaces on the Maintenance Procedure Card to record details pertinent to the particular operation. This information is then key-punched and fed into the computer. If there are blank areas or inaccuracy bits of operator-supplied information, there can be inaccurate information in the following month's reports. On component entries, blank or inaccurate information can cause the particular item to appear on the Insufficient Information Report as well as appear with an arrow in the "Next Due" area on the Aircraft Status Report (ASR) and the Maintenance Due List (MDL). The arrow (>) is merely a symbol used to indicate to the operating activity that a possible error exists on the Aircraft Status Report (ASR). If the operating activity does not provide the computer center with the TSN/TSO values of a component that is time controlled, the computer will make the calculations assuming these values to be zero and list them under the "Next Due" column with an annotation that the calculation is possibly incorrect. To positively draw attention to this condition, the Insufficient Information Report is automatically printed by the computer and supplied to the operating activity who in turn is requested to supply the computer center with the information missing to guarantee the accuracy of the "Next Due" calculations. The report will print each month until the necessary corrections are made.

12. Inconsistent Information Report: The Inconsistent Information Report is sent to the operating activity when a component serial number reported removed on a Maintenance Procedure Card differs from the serial number listed on the Aircraft Status Report being updated. This error appears on the Aircraft History Report as a double entry with the first entry being the information on the previous Aircraft Status Report and the second entry showing the updated removal information. This layout will show the operating activity that there is a missing link within the history record of that particular component change. The operating activity is requested to fill out the missing information on the Inconsistency Report and return the completed report to the computer center to correct the Aircraft History Report. Any inconsistent information that is not corrected will not be used in the calculations when printing the quarterly Performance and Reliability Summary Reports.

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13. Maintenance Management Report: The Maintenance Management report contains a summary of the total monthly and annual cumulative man hours for scheduled maintenance, unscheduled maintenance, percent of scheduled maintenance and percent of unscheduled maintenance. The man hours are presented by mechanic types performing the maintenance tasks. The information is taken from the completed Maintenance Procedure Cards, Shop Maintenance and Scheduled Maintenance Squawk Reports filled out by the operating activities. The report also lists the man hours used for Pre-flight, Thru-flight and Post-flight. In addition, it lists total man hours used to correct scheduled and shop maintenance squawks and man hours used for unscheduled CG-4377 Part III items.

    A report is completed for each individual operating unit and also servicwide. It is submitted each month to the Commandant (G-EAE/63) only.

14. Composite Aircraft History Report (Not Applicable to HC-131): This report is compiled by combining the individual aircraft history reports of all the same type aircraft participating in the CMS program. The report presents all items with the same code numbers and identifies the aircraft number for each line. The Composite Aircraft History Report is submitted, on microfiche, each quarter to COMMANDANT (G-EAE) only.

15. Performance and Reliability Report (Not Applicable to HC-131): This report is compiled from the voluminous data contained in the Aircraft History Report (AHR) and Aircraft Status Reports (ASR) of all the specific type model aircraft participating in the program. The report is a summarized analysis of all component removals contained in the Composite Aircraft History Report. It contains such information as total hours by part number, total number of removals by reason, mean time to unscheduled removal, mean time between unscheduled removal, removal rate per 1000 flight hours, mean time between failures and recommended replacement times in hours and months for components removed during a given period of time. The report is presented in two (2) ways: Alpha-Numeric Listing by Part Number within ATA chapter and Numeric Listing by Code Number.

    The report is sent to COMMANDANT (G-EAE) and each operating activity each quarter.

16. Inspection and Services Summary (Not Applicable to HC-131): The Inspection and Services Summary is an analysis of all inspections and services that have been reported in the Composite Aircraft History Report as complied with. It summarizes the total number of times any given inspection or service has been performed. The total figure is then broken down under coded columns to indicate the number of times given conditions were found.

PROCEDURES

Operations. Aircraft, (other than HH-52A), participating in CMS will undergo a predetermined Operations cycle culminating with each aircraft undergoing overhaul or induction into Programmed Depot Maintenance (HC-130) only). The intervals for Operation are as follows:

HC-130: Twelve Operations. One Operation is due each month and must be accomplished within that month. Operations will repeat consecutively until suspended for the Programmed Depot Maintenance (PDM) period which is normally scheduled between 24 and 36 months.

HH-3F. Twelve Operations. One Operation is due every third month and must be accomplished within that month. Overhaul will be scheduled every 36 months with Operations again commencing with number one regardless of last one completed prior to overhaul.

HC-131. Discontinued. Previous Operations items have been integrated into the calendar and hourly sections of the Maintenance Due List.

HH-52A. Discontinued. Previous Operations items have been integrated into the calendar section of the Maintenance Due List.

Programmed Depot Maintenance (HC-130 Only). The scheduled period of time (normally 75 to 90 days) when Programmed Depot Level Maintenance is performed causes the suspension of the normal CMS operations. Upon receipt of TWX notification of Programmed Depot Level Maintenance (PDM) induction, the computer center will suspend the normal OPERATIONS due requirements for that month. Suspension of the calendar and hourly requirements will be based on the actual date of arrival at the PDM site.

1. Prior to Transfer. Prior to transfer of aircraft to PDM the unit shall ensure all calendar and hourly items not routinely accomplished during PDM are completed, up to and including the induction date. Completion of the OPERATION due during the month the aircraft is to be inducted is not required.

NOTE: All items which are routinely accomplished in PDM have been coded as such on the Aircraft Status and Maintenance Due List. These items need not be accomplished prior to induction provided extension of interval criteria, paragraph 8-E-2, has not been exceeded as of induction date.

2. Transfer. For transfer of aircraft to PDM refer to paragraph 8-E-5.

3. Maintenance Continuity. Two PDM Due Lists pertaining to specific contract maintenance will be at the PDM site to ensure maintenance continuity throughout the PDM work period. Periodic updating of maintenance during the time the aircraft is undergoing PDM will be in the form of MPC's and annotated Aircraft Status Reports. Additionally, carbonless blank update forms will be provided to the Coast Guard representative on site to be used only in the absence of an MPC. Not later than eight days prior to the completion of PDM, the Coast Guard representative on site will furnish the completed PDM Due List to the computer center, which in turn will generate an "interim" MDL. This "interim" MDL and associated scheduled MPC's will be sent to the aircraft's home station to coincide with the aircraft arrival.

4. Post PDM Maintenance Procedure Cards. The acceptance crew will comply with a special Post PDM Maintenance Procedure Card which will detail an expanded post-flight or daily inspection. Hourly and calendar requirements will again commence the day of PDM completion and the OPERATIONS cycle will begin the first full month following acceptance of the aircraft.

NOTE: Since all OPERATIONS tasks are routinely performed during PDM, OPERATION 1 or OPERATION 7, whichever is closest in sequence to the last OPERATION completed prior to PDM), will begin the new cycle.

Man Hour Accounting. On a monthly basis, reports pertaining to man hour accounting are generated that compile information by individual operating unit as well as servicewide. Man hour figures are retrieved in the following manner:

1. Maintenance Procedure Cards. Total man hours by rate for both scheduled and unscheduled component changes, services and inspections are extracted for those items covered by an MPC.
2. Shop Maintenance Squawks Report. Man hours expended correcting squawks discovered while an aircraft, engine or component is in the shop are extracted from the shop Maintenance Squawks Report. The report will separate these hours by operating activity, aircraft type and individual mechanic rate.
3. Maintenance Squawks Report. (Replaces Scheduled Maintenance Squawks Report). Pertains to man hours expended correcting squawks discovered during scheduled/unscheduled maintenance. The report separates hours individually by mechanic type, aircraft type and operating activity.
4. CG-4377 Part III. Man hours correcting flight squawks entered on CG-4377 Part III are recorded on a special MPC whereby on a daily basis (up to a month) these hours are documented. At a prescribed time each month, the

hours are totaled and transferred to another MPC for reporting to the computer center.

5. Preflight, Thruflight and Postflight. Man hours expended on Preflight, Thruflight and Postflight inspections are reported in the same manner as CG-4377 Part III.

Data Input Cut-Off Dates: Completed data should be submitted to the computer center for processing on a regular basis of at least once per week. Input for the month shall be submitted prior to the third day of the subsequent month to insure the Maintenance Due List and Aircraft Status Reports are as current as possible. Cut-off for accepting data for processing will be the eighth day of the month. Any scheduled maintenance accomplished where input data was received after the cut-off date will be reflected on the following month's due list as a repeat item.

Aircraft Enrollment: The computer center shall supply the necessary forms and reports to the units for each new aircraft being enrolled in CMS. The forms require information pertaining to last compliance of those maintenance tasks that required periodic calendar or hourly accomplishment plus part number and serial number data on those components that require retirement or overhaul. Most information will be available from the aircraft or engine logs as well as AFTO 95 forms maintained at each air station. Certain components may require a visual check on the aircraft to determine the serial number of the currently installed but if this is impractical, the serial number can be determined upon eventual replacement of the component. The completed data is then sent to the Computer Center to establish a file for each aircraft. Any maintenance performed after the completed forms are returned to the Computer Center for processing will be updated using MPCs. Aircraft completing overhaul will be restarted in CMS using the overhaul completion day as the last complied with date for those inspections, services or component changes that were performed in conjunction with the overhaul. Operations will commence with the first operation beginning with the first day of the month following acceptance from overhaul. The overhauling activity will be responsible for component replacement information pertaining to part number and serial number changes by the normal means of updating using MPCs.

Engine/Propeller Enrollment (Not Applicable to HC-131A): The Computer Center shall supply the necessary forms and reports to the units for each new engine or propeller (C-130 only) being enrolled in CMS. They require the same type of data pertaining to last compliance, similar to the aircraft, but in engine hours (or prop hours) instead of airframe hours. Units returning engines (or propellers) to an overhaul or depot level facility (non-Coast Guard activity) will ensure that all reports and MPCs pertaining to the engine are forwarded to the CMS Computer Center. Additionally, the "Engine Off" and "Components Off" pages of the engine change MPC must be immediately returned to the Computer Center with "Engine Off" and "Component Off" information filled out in order that the engine may continue to be tracked prior to its installation on another aircraft. The Computer Center will then suspend the mailing of reports pertaining to that engine to the unit. The unit must retain the "Engine On" page to record the replacement engine data on the engine position vacated by the engine going to overhaul. Upon installing a replacement engine in that position, the "Engine On" page is returned to the Computer Center in order that the Aircraft and Engine Status Reports can be updated. If the replacement engine being installed is missing components (previously removed), an individual component MPC must be filled out with the words "None Installed" in the Serial Number Off area and the newly installed component serial number written in the Serial Number On area. Units transferring engines or propellers within the Coast Guard (unit to unit) shall include all logs, reports and due MPCs with the engine.

Upon receipt of an overhauled engine from a non-Coast Guard activity, the receiving unit shall complete Part I of the QA Acceptance MPC and forward to the Computer Center immediately which, when received, will restart the cycles of mailing reports and due MPC to that unit. Part II (reverse side) shall be retained at the unit until the engine is built up to a QEC condition. At that time the unit shall send Part II to the Computer Center for processing BEFORE THE ENGINE IS INSTALLED ON AN AIRCRAFT. Any components removed, replaced or installed on a QEC engine after Part II has been sent for processing must be recorded on the appropriate MPC in order to maintain accurate engine information. Upon receipt of an overhauled propeller from a non-Coast Guard activity, the receiving unit must complete the "Receipt of Overhauled or New Propeller/Buildup" MPC and forward it to the CMS Computer Center after the prop is in an RFI status and before it is installed on an aircraft. Upon receipt of this MPC, the Computer Center will send reports to the receiving unit and track the propeller as a spare similar to the engine.

Special Requirements Enrollment: The Computer Center shall supply the necessary blank forms to each air station to account for the type and quantity of support equipment to be controlled on the Special Requirements Status Report. Last compliance information on each serialized piece of equipment must be provided along with the frequency of the periodic or life cycle maintenance to be performed. Upon receipt of a new piece of equipment not currently controlled, the Computer Center must be notified to include it on the applicable status report for that particular air station. Each item controlled will be separate and individually coded by serial number. Updating will be by special MPCs provided by the CMS contractor and the routine of operation will be similar to the aircraft CMS in all respects.

Discrepancies: Discrepancies generated by operational flying or through the use of MPC's shall be documented and corrected in the following manner:

Non-Grounding Discrepancies:

1. Scheduled Maintenance Discrepancies. Scheduled Maintenance Discrepancies, (generated by scheduled MPC's), will be documented and signed off on the Maintenance Squawks Report. The applicable ATA Code shall be entered in the block provided.

2. Unscheduled Maintenance Discrepancies. Unscheduled Maintenance Discrepancies, (generated by Pre/Thru/Post-flight inspections, QA spot inspections, etc.), will also be documented and signed off on the Maintenance Squawks Report. If applicable, the associated unscheduled MPC will be completed and the "Action Taken" entry on the Maintenance Squawks Report should be "Complied with MPC #_____." Otherwise, the following ATA code number will be inserted in the block provided; first two digits will reflect the ATA Chapter of the system effected, followed by four zeros.

Grounding Discrepancies: All grounding discrepancies shall be entered on CG-4377, Part III, and thereafter handled in the same manner as Flight Discrepancies. Grounding discrepancies generated by scheduled MPC's shall also be entered on the Maintenance Squawks Report.

Flight Discrepancies: Flight discrepancies Originating on CG-4377 shall be corrected utilizing an MPC if applicable. Sign off in the corrective action block on Part III shall include notation of the MPC number. Where there is no applicable MPC, corrective action shall be in accordance with applicable technical orders.

Special Inspections: Special inspections are to be performed using the applicable MPC provided. Where no MPC exists for a particular inspection, it will be carried out in accordance with the appropriate technical orders or directives.

Technical Order Compliance: Applicable T.C.T.O.s will be listed on the maintenance Due List (MDL) and Aircraft Status Report (ASR). Report compliance utilizing a precoded update card supplied by the Computer Center.

CMS OPERATING CYCLE

Unit Responsibility: Each month every operating activity receives an updated Aircraft Status Report (ASR), Maintenance Due List (MDL), Aircraft History Report (AHR) and scheduled Maintenance Procedure Cards (cut corner) for each task listed on the Maintenance Due List. The computer reports should immediately be incorporated into the supplied binders and the previous month's reports should be discarded. Maintenance Procedure Cards (MPC) should then be compared against the new Maintenance Due List and assembled into the order of how they will be accomplished based on the aircraft's availability. The Maintenance Due List for each aircraft may be extracted from the report binder and openly displayed in the maintenance shop to be used as a working checklist of what has been accomplished thereby providing a running summary of upcoming maintenance at a glance.

As the scheduled MPCs are complied with, they will be reviewed for completeness by the unit engineering office and noted as such at the "card reviewed by" space on the bottom of each MPC. The white tear-off copy should then be returned for processing immediately and not held to accumulate a larger mailing. The yellow unit copy may be retained until the transaction appears on the next status and history, then be discarded.

Contractor Responsibility: Upon receipt of the completed MPCs, the contractor maintenance analyst reviews each card for possible errors or omissions before releasing it to be key-verified. If the maintenance analyst feels that information is lacking which might cause erroneous data being shown on the reports, he will return the card to the unit or, more than likely, establish telephone contact in order to expedite processing of the card in question. Once data has been punched and verified, it goes to the computer for processing where, after the eighth day of each month, updated status, due and history reports are run. The new reports are then separated by unit and individual aircraft or engine number for mailing to the various air stations. Prior to mailing, scheduled MPCs are pulled and checked for each new task appearing on the aircraft or engine due list plus any new unscheduled MPCs that have to be returned in order to replace any used during the previous month. The reports and cards are then mailed as a package and the cycle is repeated.

Miscellaneous: Accuracy of reports can be assured if the reporting units take the time to correctly record part numbers and serial numbers of components. Reporting a different serial number component being removed from what is currently shown as being installed on the Aircraft Status Report will generate an Inconsistent Information Report the following month. The problem usually occurs because the component was previously replaced and a Maintenance Procedure Card was not filled out updating the current Aircraft Status Report with the serial number that is now being removed. To correct the situation, two MPCs must be filled out; one for the component serial numbers previously removed and installed with the date and hours of replacement and another card to update the latest component change. Also TSN or TSO information must be supplied for components having overhaul or scrap requirements otherwise an Insufficient Information Report will be generated the following month. Time Since New (TSN) of installed components, if unknown, should be reported as UNK. Time Since Overhaul (TSO) of installed components that have been zero timed can only be reported as 0 (zero) in the TSO area. It cannot be 0 (zero) in both TSN and TSO at the same time, i.e., new components must be reported as 0 in TSN only.

Any errors or recommendations may be brought to the attention of the contractor aircraft maintenance analyst, however, all changes must be approved by Headquarters (G-EAE).

HU16E INSPECTION REQUIREMENTS

Definition of Inspections

Maintenance inspections, varying in scope, purpose and frequency, are performed on assigned aircraft to ensure that aircraft are retained in a serviceable condition. Because of the variety of inspection terminology generated by military and commercial maintenance systems, USCG aircraft inspection types and application are herein defined under two categories: Routine and Special.

1. Routine Inspections

The basic concept of USCG HU16E maintenance inspection is isochronal (controlling routine inspections by calendar time with flight hours a secondary limiting consideration). The calendar interval concept schedules inspections at the expiration of a specified number of days rather than at the expiration of a specified number of flying hours. To facilitate maintenance planning, extensive inspections are prescribed at intervals in multiples of seven-day periods. The following inspections are considered routine:

a. Preflight Inspection The Maintenance Preflight Inspection (workcards) is to be accomplished prior to the next flight of the day and remains effective for 24 hours, provided no subsequent maintenance has been performed. The preflight inspection consists of checking the aircraft for flight prepareness by performing visual examinations and operational tests to discover defects and maladjustments which, if not corrected, could adversely affect safety or mission accomplishment.

b. Thruflight Inspection. The Thruflight requirements are to be accomplished as a turnaround inspection prior to take-off on the second and each subsequent flight of the day. Completion constitutes authorization for certification of pre-flight on Form CG-4377.

c. Postflight Inspection. The Postflight Inspection will be accomplished after the last flight of the day. This inspection consists of checking the aircraft to determine if it is suitable for continued flight by performing a visual inspection of certain components, systems or areas to assure that no defects exist which would be detrimental to further flight. Additionally, the postflight, checking for leaks, chafing, maladjustments, etc., should disclose defects requiring correction before deteriorating into major maintenance items.

d. Intermediate Inspection. This is a limited over-all examination of the condition of the aircraft. It includes certain requirements that are also applicable to the preflight/thruflight, postflight inspections plus requirements that must be applied at periods occurring more frequently than major inspection.

e. Major Inspection. This is a thorough and searching examination of the aircraft. It includes items that are also applicable to the intermediate inspections.

2. Special Inspections

Special inspections are certain additional inspections, distinct in frequency from those Routine inspections described above, which are conditonal upon operational environment, specific incidents or other circumstances requiring inspections. Special inspections are categorized as follows:

a. Hourly Special. These inspections are designed to provide verification of satisfactory functioning at frequencies between routine inspections, for those systems vulnerable to malfunctions through normal wear.

b. Overtemperature Overboost, Overspeed, Overtorque, Metal Contamination. (etc.). Inspections. These types of special insections define the specific maintenance actions to be taken based upon the circumstances of the event. Inspections of this nature have been documented into existing manuals as the result of actual prior experiences or a high probability of encountering the event.

3. Requirements

a. Inspection Interval

The calendar and flight hour inspection times listed in Table 1, are the maximum intervals for completion of one to the start of the next inspection. The inspection schedules outlined herein are limits based upon average operating experience. Whenever an aircraft or engine accumulates the limiting number of hours before the calendar interval has expired, the inspection becomes due and will be performed. Commanding Officers are responsible for the adequate maintenance and corrosion control of aircraft in their custody and are to impose such other inspection requirements as necessary to meet differing environmental and operational conditions as may exist. This would include reduction of the periods specified in the enclosures if appropriate.

b. Extension of Interval

The Commanding Officer, or his designated representative may extend routine intermediate and major inspections up to ten days in calendar time and/or 10% in flight hours in order to meet workload, scheduling or operational requirements. Aircraft components with specified replacement intervals may be extended up to 10% by the unit Engineering Officer so as to schedule replacement coincident with the next routine intermediate or major inspection. Commanding Officers may authorize a further extension of the aircraft inspection interval to fulfill an urgent search and rescue requirement. In this latter instance, a letter of justification for exceeding authorized inspection interval shall be submitted to the Commandant, (G-EAE).

c. Reduction of Interval

Commands that accumulate flight hours more rapidly than average should consider reducing their calendar time intervals for more effective maintenance and operational scheduling.

d. Interruption of Interval

The accumulation of calendar time on an aircraft/engine is halted for the period that the aircraft engine is in storage, extended repair or lengthy modification status. Calendar time accrual is resumed when the aircraft/engine returns to operational status. The Commandant (G-EAE) will determine and authorize an individual occurrance basis those situations which constitute causes for interval interruption.

e. Inspection Facilities

The aircraft missions should be planned, if possible, so that intermediate and major inspections are performed at the home station where adequate personnel, parts, tools and equipment are available. This will insure a high level of quality control and minimum NOR (Not Operationally Ready) time.

f. Aircraft Transfer

If it is necessary to transfer aircraft when a routine or special inspection, change, bulletin, or other maintenance requirements has not been completed due to lack of parts, kits, special tools, or other reasons, the following actions are required by the transferring activity:

(1) A detailed logbook entry describing the deficiency.

(2) A letter describing the deficiency shall be forwarded through channels to the receiving activity with copy to the Commandant (G-EAE).

NOTE

Submittal of pre-overhaul report as required by existing instructions will constitute compliance with this requirement.

g. Inspection/Discrepancy Records

Maintenance inspection records and test flight reports will be retained by the engineering section until the second subsequent inspection has been completed (or six months); they may then be discarded.

1. Basic Inspection Concept—USCG Developed System
2. Routine Inspection Cycle

a. Airframe	Interval	Inspection Requirements	Remarks
Preflight	Prior 1st flight each day	USCG Workcards	Valid for 24 Hours. A completed postflight eliminates the requirements for next day's preflight unless maintenance is performed after that postflight. However, fuel sump and filter drains shall be checked prior to the first flight each day.
Thruflight	Prior to 2nd and subsequent flight each day	USCG Workcards	Completion constitutes authorization for certification of preflight on Form CG-4377.
Postflight	After last flight of the day	USCG Workcards	Completion constitutes authorization for certification of preflight on Form CG-4377.

Figure 1A. - HU-16E Inspection Criteria

INSPECTION CRITERIA FOR HU 16E AIRCRAFT - Continued

		Airframe	Interval	Inspection Requirements	Remarks
		Intermediate	77 days or 200 flight hours	USCG Workcards	Two (2) intermediates between each major.
		Major	77 days or 200 flight hours after 2nd intermediate	USCG Workcards	
	b.	Engine			
		In conjunction with airframe		USCG Workcards	
3.	Special Inspections				
	a.	Airframe			
		Hourly Special	75 flight hours since last inspection	USCG Workcards	Accomplished at first shutdown after aircraft has accumulated 75 flight hours. Commanding Officers may extend this interval a maximum of ten flight hours to fulfill operational requirements Justification need not be submitted.
	b.	Propeller	600 flight hours since last inspection	USCG Workcards	Extensions may be authorized IAW paragraph 4. b.
	c.	Other Special Inspections	On occurrence	USCG Workcards	Refer to paragraph 3.b. and CGTO-1U-16E-6WC-6.

Figure 1B. — HU-16E Inspection Criteria.

AIRCRAFT STATUS BOARD

This board provides a visual presentation of current status information on all aircraft assigned to an activity. The aircraft status board, such as the one depicted in figure 2, should be of suitable size and material to display such information so that personnel can quickly ascertain the essential facts.

Size and location of the board will vary with the employment and operating conditions of the particular activity. The board must be maintained in a current and up-to-date status. Additional columns and subcolumns for rapid reference may be used to indicate the status of selected components and functional systems, as well as replacement times or dates on selected items. When items having established replacement intervals are selected for the status board, the time at which replacement is required can be effectively displayed by entering in the component column the replacement interval (or the time remaining on the item) plus the aircraft or engine time when the item was installed. Thus, replacement is required when the aircraft or engine time equals the time entered in the component column. For a more effective display, the figure in the component column may be entered in red as the replacement time or date approaches. A sample helicopter status board is also depicted in figure 2.

AIRCRAFT

MODEL	A/C No.	UP or DOWN	STATUS CODE	ENGINE HOURS (since overhaul)	ENGINE HOURS (since check)	A/C HOURS (since check)	NEXT PERIODIC INSPECTION		MONTHS IN SERVICE	REMARKS
							TYPE INSPECTION	DUE DATE		

HELICOPTER

	Gear Box				Rotor Blades					Main Servos															
ENGINE	MAIN	Intermediate	Tail Rotor	ROTOR HUB	RED	YELLOW	BLUE	BLACK	TAIL ROTOR	FORE & AFT	RT LATERAL	LFT LATERAL	CLUTCH	FAN	TIME THIS TOUR	Plane Captain	A/C No.	MONTHS IN TOUR	OUT COMM	IN COMM	TIME SINCE CHECK	NEXT CHECK DUE (TYPE)	TIME THIS MONTH	STATUS	Next Inspection Due (DATE AND TYPE)
[illegible]	480	720	[illegible]	480	840	840	840	840	840	840	840	840	480	[illegible]											

NOTES: (1) Width of columns are not necessarily in ratio to the space required.

(2) Times shown on the sample Helicopter Status Board indicate replacement intervals of the engine and components. Hours inserted under these column headings may be entered in RED when approaching the terminal time.

Figure 2. — Aircraft status boards.

FUNCTIONAL CHECKS OF AERONAUTICAL EQUIPMENT

General. The depth of maintenance performed on an aircraft prior to flight and its relevance towards flight safety determine the depth to which components are functionally checked prior to maintenance release. Functional checks are divided into ground checks, flight verification checks and test flights; and are defined as follows:

1. Ground Checks. Visual inspection and/or functional checks performed on the ground utilizing auxiliary power units, ground power (electrical or hydraulic) units, ground test equipment, and/or the aircraft engines as necessary to provide system power.

2. Flight Verification Checks. Airborne functional checks, conducted during a scheduled operational or training mission, of components or systems whose failure would not adversely affect flight safety nor seriously affect mission accomplishment.

3. Test Flights. Airborne functional checks to establish if an airframe or equipment, while subjected to design environment, is operating properly. Generally, areas checked on test flights are equipments or systems requiring flight verification and whose failure would adversely affect flight safety.

Requirements. Specific functional check requirements are delineated herein and are minimum standards. The prerogative for more stringent minimums is reserved for Commanding Officers as local conditions or events dictate. The following requirements shall be adhered to:

Ground Checks

1. General. The performance of all aeronautical equipment is normally ground checked as the final step of maintenance action. Ground checks will be performed in accordance with applicable work cards, T.O.'s or maintenance instructions, and as dictated by good judgement. Certain specific main-

tenance actions such as the replacement of landing gear actuators are clearly detailed in maintenance instructions. The required ground checks for system cycling and landing gear drop checking are included in these instructions. Other maintenance actions not specifically addressed by the applicable publications require application of sound engineering practice and enlightened supervision to ensure minimum adequate ground checks. An example of this latter situation would be maintenance on landing gear hydraulic lines or fittings where replacing a line or tightening loose fittings may only require a system precheck whereas replacement of a selector valve would require aircraft jacking and complete landing gear drop checking. Adequate ground checks are essential to safe execution of flight verification checks and test flights.

2. Flight Controls. Disassembly or replacement of any portion of a flight control system (for example: elevators, rudders, ailerons, blade unfolding, trim tabs, rotor head and blades, tail rotor gear box and blades, control cables, fairleads, pulleys, rods, servo system, etc.) requires a ground check to ensure synchronization of pilot's and copilot's controls and the proper movement of the control surfaces. This ground check shall be performed by all of the following:

   (a) The mechanic performing maintenance.
   (b) A quality assurance inspector.
   (c) Any officer or petty officer qualified to sign a maintenance release.
   (d) The pilot designated to conduct the ensuing required test flight.

Flight Verification Checks. Any component or system not specifically requiring a test flight may receive a flight verification check at the discretion of the maintenance officer. Flight verification checks may be conducted on C-130 aircraft in lieu of test flights at the discretion of the Commanding Officer when maintenance, refer to page 24, has been performed on no more than one of the power packages. For example, a C-130 flight verification check is permissible after an engine or propeller change providing the maintenance listed below has not been performed on additional airframe components.

Test Flights.

1. Full-Scale Test Flights. A full-scale test flight is required in accordance with applicable test flight sheets after the following:

   (a) Completion of routine inspections (Intermediate, Major, Phase, Progressive).
   (b) Completion of major structural rework.
   (c) For those ACFT on CMS, CMS cards will indicate when a test flight is required.

2. Selective Test Flights. Upon completion of critical unscheduled maintenance a selective test flight is required to functionally check those components or systems which may have been affected by the maintenance action. Selective test flights are required after the following:

   (a) QEC Assembly Change.
   (b) Propeller or L.O.C. Change.
   (c) Flight control maintenance as described previously (exception - 1. HH-52A blade fold/unfold evolution requires only ground check, with rotor engagement. - 2. Replacement of the copilot's cyclic stick requires ground check and flight verification.)
   (d) Power plant fuel system maintenance.
   (e) As required by work cards, maintenance instructions or applicable T.O.'s.

Preflight Briefing. Pilots in command of flight verification checks or test flights shall be briefed on procedures and systems to be checked by a Quality Assurance Inspector prior to aircraft departure. Additonally, such inspector should be assigned as a part of the flight crew when practical. Form CG-4789, Maintenance Flight Safety Warning, certifies completion of this briefing.

Records. Form CG-4789, Maintenance Flight Safety Warning, shall be initiated and affixed to the pilot's yoke or cyclic stick whenever maintenance has been performed requiring a ground check or airborne functional check (flight verification or test flight). This form shall be removed, completed by the assigned pilot and turned over to the quality assurance subsection prior to aircraft departure. In the case of flight control maintenance, signatures on this form also indicate signees have themselves conducted a ground check. Form CG-4789 shall be retained with the file of Form CG-4377, Flight Record, Part III.

Supply Data. Form CG-4789 is stocked at Supply Center, Brooklyn, N.Y.

COAST GUARD MAINTENANCE LEVELS

Each Coast Guard aviation unit is assigned a classification or maintenance level. The assigned classification reflects the "minimum required" level of maintenance capability of the unit. It does not restrict the unit's initiative or expansion to greater capability, when economical and practical, considering the capabilities of the personnel assigned, local operating conditions, and efficiency of operations and costs.

CG-452 prescribes the minimum required level of maintenance capability of each aviation field unit. So that all levels of command will understand the maintenance capability expected at aviation field units and the consequent support required in terms of equipment, personnel, and funds, each aviation field unit is classified by prescribing its minimum required level of maintenance capability. CG-452 lists the specific functions required to attain these levels or classifications. This provides a basic standard for use in determining the best allocation of resources - men, material, and funds - by permitting a cost versus benefit comparison to be made. This standard provides unit and district personnel, who have responsibility for support of operations, with an effective tool to use in evaluating such things as the following items:

1. Requests for changes in allowance lists.
2. Requests for new/replacement equipment.
3. Requirements for additional aircraft maintenance funds.

Each aviation unit is assigned two classifications. The first is the required level of maintenance using local and commercial facilities and services to the fullest extent practical. The distance/time elements of the word "local" is up to the commanding officer of each unit and is dependent on such things as:

1. Urgency of need for function.
2. Frequency of need for function.
3. Transportation availability and frequency.
4. Inherent delays in obtaining the services or use of the facility versus time available.

The second classification is the minimum "in house" or on-board capability required. This level will be maintained regardless of the availability of local facilities. It represents the minimum readiness posture of the unit from an aircraft maintenance standpoint.

Major changes in the availability of local facilities and services to the Coast Guard, or changes in assigned aircraft or support equipment, may require changes in the on-board equipment or funds necessary to maintain the required level of capability.

The classification or levels assigned to the Coast Guard aviation units are defined in the following paragraphs.

CLASS C (Component Repairs)

Class C-level maintenance is one phase of the Department of Defense "intermediate maintenance" and is devoted to the repair (not overhaul), test, and return to Ready for Issue (RFI) status of unserviceable aeronautical components and equipment. Items repaired by C-level maintenance have been removed from locally operating aircraft or equipment and, due to the nature of the discrepancies involved, have usually been replaced by serviceable items drawn from stock. (Component repair maintenance involves preservation, inspection, examination, specified bench test, correction of discrepancies, calibration, repair or replacement, and emergency manufacture of parts requiring light installed equipment.) Class C-level maintenance includes all the requirements of lower Class D-level maintenance.

CLASS D (Shop Maintenance)

Class D-level of maintenance is also a part of DOD "intermediate maintenance." The work performed consists of the routine day-to-day upkeep required of shop facilities and includes minor repair, check test, and adjustment of aeronautical items that have been removed and which are normally reinstalled after completion of such work. (Shop maintenance includes preservation, inspection, examination, specified bench test, correction of discrepancies, adjustment, minor repair and/or replacement, and emergency manufacture of parts requiring only portable hand and machine tools and semiportable or bench mounted equipment.)

All Coast Guard aviation units are expected to perform their own aircraft inspections and minor repairs.

You should refer to CG-452 for classification of specific maintenance operations. For example, machine shop "milling" operations are Class C maintenance.

PRIME UNIT RESPONSIBILITIES

The "prime unit" concept draws upon the knowledge and experience of a particular unit to provide information and assistance which can be used in the preparation of directives, manuals, work cards, etc., that are accurate and up to date. It also provides for and centralizes a point for technical investigation for each type aircraft. These prime units supplement the existing responsibilities in aircraft maintenance by completing the tasks outlined in the paragraphs below.

The following air stations are designated prime units for the indicated aircraft and their engines:

AIRCRAFT	AIR STATION
U-16	Cape Cod
C-130	Elizabeth City
H-52, H-3, C-131	Aviation Training Center, Mobile
C-4, C-11	Washington

Prime units provide information in the following areas:

WORK CARDS

Prime units develop and/or revise inspection work cards as needed so that the cards will be tailored to Coast Guard usage and can be used with optimum efficiency. Operating units forward recommendations for work card changes to the prime unit using AFTO form 22. The Commandant (G-EAE) issues interim changes to work cards. Prime units maintain a record of interim and recommended changes and periodically, as needed, submit proposed revised work cards to the Commandant for approval.

MANUALS

Primary HH-3F and HH-52A handbooks are the only manuals written specifically for Coast Guard aircraft. HC-130B, HC-130E, and HC-130H manuals have additional Coast Guard Supplementary Maintenance Publications (SMP) issued which spell out the differences between Coast Guard and Air Force aircraft. All other manuals, while applicable to Coast Guard aircraft, do not outline the differences and are updated by the controlling service with little or no input from the Coast Guard. Prime units will not normally be asked to submit aircraft manual changes: HH-52A and HH-3F prime units, however, will be asked to review proposed revisions for completeness and accuracy. Operating units forward recommended manual revisions using AFTO Form 847 to the prime unit with a copy to the Commandant.

PROTOTYPE AND VERIFICATION OF CHANGES AND TECHNICAL ORDERS

Prime units make trial installations of change directives prepared by AR&SC or other activities to verify kit contents and installation instructions before general distribution of the directive. Occasionally prime units may be asked to prototype a change and prepare the directive. This should occur only when accessibility of an airframe to AR&SC is a problem. Such directives are then forwarded to the Commandant for review and distribution.

AIRCRAFT LOGS

The prime unit reviews aircraft logs, including the aircraft inventory log, and submits proposed changes to the Commandant (G-EAE) when required. When approved, changes are distributed to units by AR&SC; greater standardization of forms should result.

BENEFICIAL SUGGESTIONS

Beneficial suggestions which deal with a specific aircraft type may be forwarded by the Commandant to the prime unit for evaluation. If the suggestion merits servicewide adoption, the Commandant will direct or suggest its use by all applicable units. In some instances, a prime unit may be asked to prototype a change and prepare a directive based on the suggestion.

UNSATISFACTORY REPORTS

The preparing unit for the aircraft involved forwards two copies of Unsatisfactory Reports (UR's) to the prime unit. Prime units are also included as information addressees on all safety of flight messages involving material failure or maintenance procedures. The Commandant and AR&SC monitor UR's to detect failure trends. In general, AR&SC is responsible for followup action, where indicated, on items which have been overhauled by AR&SC or under a contract administered by AR&SC. The Commandant follows up on components that have not been overhauled. Prime units will occasionally be asked to comment on or recommend corrective action for reported failures and malfunctions. Since Class .265 components are returned to AR&SC, prime units work closely with AR&SC when investigating component failures.

CONFERENCES AND MEETINGS

Prime units send representatives to attend selected meetings which involve the prime aircraft or its engines.

MISCELLANEOUS TECHNICAL AND SUPPLY PROBLEMS

Prime units evaluate proposals, develop configuration standards, submit data, etc., on their prime aircraft type for issues not associated with any of the above categories.

SUMMARY

In this section we have introduced you to Coast Guard aviation's aircraft maintenance management system. The Engineering Section at an air station controls this system. A typical Engineering Section has five subsections, whose duties have been outlined in this pamphlet.

All Coast Guard aircraft except the HU-16E are maintained by use of the Computerized Maintenance System (CMS). A computer is utilized with this system to schedule and keep tract of the day to day maintenance activities. A Maintenance Procedure Card is used in performing the various maintenance tasks as scheduled by the computer.

The HU-16E is maintained with the Coast Guard developed Workcard System. Inspection Workcards are used in performing routine and special aircraft inspections.

An aircraft status board shows current information on all aircraft assigned to an air station.

Coast Guard aircraft require three types of post-maintenance functional checks; ground checks, flight verification checks, and test flights.

Some Coast Guard air stations are assigned as "prime units" for specific aircraft. The prime units are assigned tasks to supplement existing responsibilities in aircraft maintenance.

See how well you can do, now, on the following review questions. They will test you on your mastery of the objectives of this section:

LESSON QUIZ

INSTRUCTIONS

Cover the answers to the questions with the Answer Key Mask. Carefully answer the questions; then remove the mask to check with the printed answer. If you answered any question incorrectly, refer to the text material.

1. TECHNICAL and ENGINEERING support fc aircraft systems and equipment is provided t ________________.

2. As defined by the Coast Guard, unit leve maintenance includes Department of Defense levels __________ and __________.

3. In the engineering section at an air station, who must ensure the establishment of a corrosion control program for the unit's aircraft?

IN QUESTIONS 4 - 7 MATCH THE TASK WITH THE SUBSECTION RESPONSIBLE FOR PERFORMING THE TASK.

TASK

4. Which subsection must ensure that current applicable publications are available to each maintenance shop?

5. Which subsection is responsible for the custody and condition of all special tools?

6. Which subsection is responsible for aircraft flight engineering training?

7. Which subsection is directly responsible for maintaining a current status of engineering ground support equipment?

SUBSECTION

A. Aviation Material

B. Aircraft Maintenance

C. Quality Assurance

D. Engineering Administration

1. Coast Guard Headquarters Aeronautical Engineering Division (G-EAE) (Page 2)

2. Organizational and Intermediate (Page 2)

3. Head, Engineering Section (Page 3)

4. C(Page 3)

5. A(Page 4)

6. D(Page 4)

7. B(Page 5)

8. Which routine inspection is performed after the first flight of the day and satisfies the requirements for a preflight on the Aircraft Flight Record?

8. Thruflight (Page 7)

9. Does the calendar time accumulated while an aircraft is stored count as part of the total accumulated time between inspections?

9. No (Page 21)

10. As replacement time approaches for an aircraft component, the status board time entry should be entered in ________.

10. Red (Page 23)

11. A quality assurance inspector certifies that he has briefed the pilot on systems to check on a test flight by signing the ________.

11. Maintenance Flight Safety Warning (CG-4789) (Pages 25 & 26)

12. A flight verification check may be performed instead of a complete test flight after an engine change on a ________ type aircraft.

12. C-130 (Page 25)

13. An air unit is authorized to perform component repairs in a Class ________ maintenance activity.

13. C (Page 26)

14. The prime unit for C-130 aircraft is ________.

14. Elizabeth City Air Station, N.C. (Page 27)

AIRCRAFT RECORDS AND REPORTS

OBJECTIVES

When you complete this section, you will be able to:

1. Recognize standard aircraft record forms and make proper entries in these forms (aircraft logs).
2. Annotate mechanized reports.
3. Make entries in standard maintenance forms including aircraft reports.
4. Requisition standard forms used in aircraft maintenance record keeping.
5. Make entries in aircraft inventory records.

AIRCRAFT LOGBOOKS (Records)

All activities having custody of Coast Guard aircraft are required to maintain the aircraft logbooks and associated records for aircraft in a proper and up-to-date status. Aircraft logbooks are an essential element of aeronautical technical discipline. They provide a history of maintenance, as well as aircraft operational information and configuration control of the aircraft. They also provide for control of maintenance schedules for time replacement of components and accessories.

Coast Guard aircraft maintenance is increasingly allied with Air Force procedures. Several of our aircraft types and most sources of aircraft and engine overhaul outside the Coast Guard use Air Force logs, records, and reports. Our aircraft maintenance officers and aerospace engineers are given training in Air Force procedures. This preponderence of Air Force influence, the inefficiencies of using two logbook systems, and the waning impact of Navy procedures have resulted in the decision to standardize on Air Force logs (records) and reports.

Use of Air Force instructions must be tempered with good judgment in the specific applications. In cases of conflict between Air Force and Coast Guard directives, the Coast Guard directives have priority.

USAF Logbooks (Records) will be used for all USCG aircraft in accordance with USAF directives. Table 1 lists the Air Force forms used in the Coast Guard logbooks and the directive that prescribes their use. Specific forms required in each logbook for each aircraft type, except the VC-4A and the VC-11A, are listed in Table 2.

LOGBOOK FORMS

The aircraft logbook forms are principally of two types. The first type, AFTO Form 781 series, collectively provides a maintenance, inspection, service, configuration, status and flight record. The second type of forms are the historical documents. These are AFTO Forms 95, 44, 71 A-2, and 34.

AFTO 781 Series

Due to the specific needs of the Coast Guard, only certain of the AFTO 781 series forms are used.

Aerospace Vehicle Flight Status Report and Maintenance Document (AFTO Form 781F)

The AFTO Form 781F (figure 3) is the identification for the binder for a particular aircraft and is a source document for obtaining billing information for fuel and oil issues if desired. This form is inserted in the front cover of the binder and becomes the first page of the logbook.

TABLE 1. — Air Force Forms Used in Coast Guard Logbooks.

Form	Title		Prescribing Directive
AFTO 34	Cylinder Compression History	T.O.	00-20-5
AFTO 44	Turbine Wheel Historical Record		00-20-5
AFTO 71A-2	Shop and Historical Record of Battery Service		8D2-3-1
	Field/Depot Aircraft Change Status Report		Para 7-C-1.h CG-452
AFTO 95	Significant Historical Data		00-20-4/5
AFTO 100 Series (Optional)	Visible Card File System		00-20-5
AFTO 781D	Calendar and Hourly Item Inspection Document		00-20-5
AFTO 781E	Accessory Replacement Document		00-20-5
AFTO 781F	Aerospace Vehicle Flight Report and Maintenance Document		00-20-5
AFTO 781J	Aerospace Vehicle-Engine Flight Document		00-20-5
AF 510	Aerospace Vehicle Delivery Receipt		N/A
DD 780	Aircraft Inventory Record		00-35D-780
DD 780-1	Aircraft Inventory Record Equipment List		00-35D-780
DD 780-2	Aircraft Inventory Record Shortages		00-35D-780
DD 780-3	Aircraft Inventory Record Certification and Record of Transfers		00-35D-780
RCS: LOG - MMO(W) 7138	ECMS Overhaul Report		00-20-4
SF 368	Quality Deficiency Report		00-35D-54

Table 2. - Contents of Aircraft Logbooks.

Components	C-131	C-130	HH-3F	HH-52	HU-16E
Airframe					
AFTO 781F	X	X	X	X	X
AFTO 781J	X	X	X	X	X
AFTO 781D					X
AFTO 781E	X				X
AFTO 95	X	X	X	X	X
DD 780 Series	X	X	X	X	X
AF 510 (Latest Copy)	X	X	X	X	X
W&B AN 1-1B-40	X	X	X	X	X
Engine					
AFTO 781E	X	---	---	---	X
AFTO 34	X	---	---	---	X
AFTO 44 (Each Turbine Wheel)	---	X (4 Stages)	X (3 Stages)	X (3 Stages)	---
AFTO 95 (Engine)	X	X	X	X	X
AFTO 95 (Compressor Rotor)	---	---	X	X	---
APU					
AFTO 95	---	X	X	---	X
Propeller					
AFTO 95	X	X	---	---	X

*Items 1 through 8 of Table 4-1 list more component forms associated with each USCG aircraft:

1. Component AFTO 95 - HU-16E
   Aircraft
   Engine
   Propellor
   Carburetor
   Main Wheels
   Nose Wheels
   APU

2. Component AFTO 781E - HU-16E
   Accessories listed on AFTO 781E are limited to those items included in the current HU-16E Bulletin 114 Series.

3. Component AFTO 95 - C-130
   Reduction Gear Box
   Power Package Assembly
   Torquemeter

Table 2. - Contents of Aircraft Logbooks (continued).

3. Component AFTO 95 - C-130 (cont'd)
   QEC Nacelle Assembly
   GTC
   Propellor
   Propellor Pump Housing
   Propellor Valve Housing
   Turbine Rotor Assembly

4. Component AFTO 95-C-131A
   Aircraft
   Engine
   Propeller
   Governor-Propeller
   Carburetor

5. Component AFTO 95-HH-52A and HH-3F Helicopters
   Main Rotor Blades
   Main Rotor Head
   Dampers
   Main Gearbox and Gimbal Ring
   Primary Servos
   Rear Engine Support
   Main Drive Shaft and 'T' Bolts
   Rotor Brake Disc
   Int. Gearbox
   Tail Gearbox
   Tail Rotor Head
   Tail Rotor Blades
   Rescue Hoist
   Auxiliary Servo
   Front Frame Accessory Drive Assembly
   Fuel Control
   Fuel Pump-Engine Driven
   Engine Accessory Drive Gear Box
   Main Lube Pump (Engine)
   Compressor Rotor
   Pilot Valve
   Flow Divider
   Right Angle Drive

6. HH-52A Only
   Primary Servo Input Rods
   Speed Sensitive Switch
   MRH Base Nut

7. HH-3F Only
   MRH Spindle Assy.
   MRH Sleeve Assy.
   Flexible Coupling, Tail Take-off
   Tail Rotor Pitch Change Beam
   Bifilar
   APU Clutch
   Upper Link, Rotating Swashplate
   Lower Link, Rotating Swashplate
   Eyebolt, Horn

8. On-Condition Aircraft Accessories to be Listed on AFTO 781E (HU-16E and C-131A Only)
   Generators
   Starters
   Hydraulic Pumps

1. STANDARD REPORTING DESIGNATOR

2. ID NUMBER

AEROSPACE VEHICLE FLIGHT REPORT AND MAINTENANCE DOCUMENT

HOUR AND MINUTES TO HOUR AND TENTH CONVERSION TABLE

1 or 2 minutes	-	.0 hour
3 thru 8 minutes	-	.1 hour
9 thru 14 minutes	-	.2 hour
15 thru 20 minutes	-	.3 hour
21 thru 26 minutes	-	.4 hour
27 thru 33 minutes	-	.5 hour
34 thru 39 minutes	-	.6 hour
40 thru 45 minutes	-	.7 hour
46 thru 51 minutes	-	.8 hour
52 thru 57 minutes	-	.9 hour
58 thru 60 minutes		Next whole hour

3. DOD ACTIVITY ADDRESS CODE		4. CUSTOMER ID CODE	
5. MISSION DESIGN SERIES		6. SERIAL NUMBER	
7. ORGANIZATION		8. LOCATION	9. STATION CODE

10. SERVICE CAP	INTERNAL	EXTERNAL	TOTAL	11. INV DATA	COMMAND	CODE
A FUEL CAPACITY POUNDS GALLONS				A ASSIGNMENT		
B OIL CAPACITY PINTS, QUARTS, GALLONS	EACH ENGINE		AUXILIARY TANKS	B POSSESSION		

AFTO FORM MAY 73 781F PREVIOUS EDITION WILL BE USED

Figure 3. — AFTO Form 781F, Aerospace Vehicle Flight Report and Maintenance Document.

Aerospace Vehicle - Engine Flight Document (AFTO Form 781J)

The AFTO Form 781J (figure 4) is used to document aircraft and engine data including operating time. Some of the entries on this form are self-explanatory. The entries listed below are those which may cause some misunderstanding.

1. DATE: Enter in the FROM block the date by day, month, and year on which the form was initiated. When the form is closed out, enter the date by day, month, and year in the TO block.

2. MDS (Mission Design and Series): Enter the aircraft type (HH-3F, etc.)

3. AIRFRAME TIME: In the "Previous" block, enter the time reflected in the last entry on the previous AFTO Form 781J. Each day the flight time accrued for that day is entered on the line opposite the specific date entry identifying that day's operation. This entry is added to the previously recorded time to provide new totals. If desired, the entries on this form may be posted for each flight in lieu of each day.

4. OIL CHANGE: Enter the engine time at the last oil change. To facilitate completion of an AFTO Form 119, Oil Analysis Request, circle, under the appropriate column, the engine operating time in red when an oil change is made.

DATE	FROM / /	TO / /	CREW CHIEF	ORGANIZATION	LOCATION	MDS	SERIAL NUMBER

AIRFRAME AND ENGINE OPERATING TIME AND CYCLE DOCUMENTATION

DATE	AIRFRAME TIME	OIL CHANGE	OVER TEMP	OIL CHANGE	OVER TEMP	OIL CHANGE	OVER TEMP	OIL CHANGE	OVER TEMP	OIL CHANGE	OVER TEMP	OIL CHANGE	OVER TEMP	OIL CHANGE	OVER TEMP	OIL CHANGE	OVER TEMP
		NO 1 ENG		NO 2 ENG		NO 3 ENG		NO 4 ENG		NO 5 ENG		NO 6 ENG		NO 7 ENG		NO 8 ENG	
		TIME	CYCLES	TIME	CYCLES	TIME	CYCLES	TIME	CYCLES	TIME	CYCLES	TIME	CYCLES	TIME	CYCLES	TIME	CYCLES
PREVIOUS																	
/ /																	
TOTAL																	
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TOTAL																	
/ / CARRIED FORWARD																	

AFTO FORM MAY 781J — AEROSPACE VEHICLE - ENGINE FLIGHT DOCUMENT — PREVIOUS EDITION IS OBSOLETE

Figure 4. — AFTO Form 781J, Aerospace Vehicle-Engine Flight Document.

5. OVER TEMP: If the applicable inspection requirements require inspection or replacement of the engine or engine components based on a specified number of overtemperatures, maintain a cumulative total of the overtemperatures. Each time an overtemperature occurs, increase the entry in the OVER TEMP block by one.

6. ENGINE TIME AND CYCLES: Engine time entries are documented in the same manner as aircraft time. When an engine change occurs, make a brief entry in the next open date line. Entries for the new engine, together with the active entries of the other columns, will be reopened in the "total" block. Engine operating times are cumulative; therefore, the 781J engine time entry must be adjusted accordingly at engine change. (Example: If an engine had accumulated 700 hours on another aircraft, the "previous" time would begin with 700.0).

7. CARRIED FORWARD: When all columns have been completely filled in or when columns have been used to the extent that a new AFTO Form 781J must be initiated, total the individual times and enter them in the CARRIED FORWARD block. Carry these totals forward to the new AFTO Form 781J.

Calendar and Hourly Item Inspection Document (AFTO Form 781D)

HU-16E ONLY

AFTO Form 781D (figure 5) is a required form in CG HU-16E aircraft logbooks. Short term and long term calendar and/or hourly inspections are listed on AFTO From 781D. You may type or preprint the calendar inspection item listing on the form.

The required entries for the AFTO Form 781D are as follows:

1. Enter those items to be inspected or tested at specified hourly or calendar periods derived from the applicable inspection work cards or phase cards.

2. Use a two line entry for those items requiring inspection at either an hourly interval or a calendar period.

3. Enter additional items which may be required due to the type of mission, geographical location, or at the direction of higher command or local command policy.

NOTE: This form is for special inspection items that have a frequency different from the routine periodic or phased inspection.

4. Use the "Next Due" block to enter the aircraft hours, engine hours, or calendar date the next inspection is due. Upon completion of the prescribed inspection, line out the date or hours reflected in the old NEXT DUE column and enter the new date or hours in the new NEXT DUE column.

Accessory Replacement Document (AFTO FORM 781E)

HU-16E and HC-131A ONLY

AFTO Form 781E (figure 6) lists all accessories requiring replacement at specified intervals. Also listed are those "on condition" items listed in the Aeronautical Engineering Maintenance Management Manual (CG-452) as required entries for the type of aircraft at your unit. One AFTO Form 781E is maintained for aircraft accessories and one for the engine-mounted accessories of each engine or APU. The accessories that must be listed on the AFTO Form 781E for either an engine or an APU are found in either T.O. 2J-1-24 or T.O. 2R-1-16.

AFTO Form 781E provides data to facilitate compliance with replacement or inspection requirements. The form is also useful in providing failure dates and operating hours for UR's.

Many of the entries on the AFTO Form 781E are self-explanatory. Those entries which may cause some confusion are discussed here.

1. NOMENCLATURE AND TYPE: Use a two-line entry for those items requiring replacement at either the aircraft or equipment time, specified cycles, rounds, or calendar period. Ditto marks may be used in columns A, B, and C for the second line of such entries. Additional items required due to the type of mission, geographical location, or by direction of higher authority are listed after the CG-452 standard listing.

PAGE

DATE FROM	TO	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NUMBER

INSPECTION ITEM	FREQUENCY	NEXT DUE	NEXT DUE	NEXT DUE	NEXT DUE	NEXT DUE	NEXT DUE

AFTO FORM MAY 73 781D CALENDAR AND HOURLY ITEM INSPECTION DOCUMENT PREVIOUS EDITION WILL BE USED

Figure 5. – AFTO Form 781D, Calendar and Hourly Item Inspection Document.

PAGE OF PAGES

DATE	FROM / /	TO / /	CREW CHIEF	ORGANIZATION	LOCATION	MDS	SERIAL NUMBER

NOMENCLATURE AND TYPE A	SERIAL NO B	LOCATION C	REPLACE EVERY D	PREVIOUS OPERATING TIME E	INSTALLED AT F	REPLACEMENT DUE AT G	REMOVED H	TIME ACCUMULATED I	TOTAL OPERATING TIME J

AFTO FORM 781E ACCESSORY REPLACEMENT DOCUMENT PREVIOUS EDITION WILL BE USED.

Figure 6. — AFTO Form 781E, Accessory Replacement Document.

2. LOCATION: Record the actual location of the accessory. (EXAMPLE: #2 Eng, FLTDK, AFTCGO Compt, etc.) This entry may be omitted if the location is obvious.

3. REPLACE EVERY: Enter the replacement cycle for the accessory, i.e., 600 hrs., 1,200 hrs., etc.

4. PREVIOUS OPERATING TIME: Enter the previous operating time or usage of the accessory. If the item is new, enter O.O.

5. INSTALLED AT: Enter the aircraft or engine hours at the time the accessory was installed.

6. REPLACEMENT DUE AT: The figure for this entry can be arrived at by subtracting the "previous operating time" from the "replace every" time and adding the "installed at" time.

7. TIME ACCUMULATED: Subtract the "installed at" time from the "removed" time to arrive at this figure.

8. TOTAL OPERATING TIME: Add the previous operating time and the time accumulated. For example, if an item having 250 hours previous operating time is installed at 550 hours and removed at 1,050 hours, the total operating time will be 750 hours. Entries for items having only a calendar replacement interval will reflect the calendar period of installation as computed from the date of installation to the date of removal.

Historical Documents

Significant Historical Data (AFTO Form 95)

AFTO Form 95 (figure 7) is used to maintain a permanent history of significant maintenance actions on end items of equipment including aircraft, engines, components, etc., and shall be used to record the status of TCTO's, CG AMC/AMB's, etc., when a mechanized report (SCMS or ECMS) is not available. The AFTO Form 95 replaces DD FORM 829-1 for recording TCTO compliance; however, all C-130 airframe and engine TCTO information logged prior to 1 January 1970 should be retained on the latter form. A separate AFTO 95 should be used for each component listed in Table 2(pages 33 & 34).

Procedures for filling out AFTO Form 95 are for the most part self-explanatory, with the exception of column B (REMARKS). Use as many lines as necessary to enter the applicable information. All operating units are required to enter, in column B, information concerning the following:

1. Removal and replacement of aircraft fixed wings and stabilizers.

2. Special service test equipment installed or removed.

3. Severe corrosion, its location, extent, and treatment accomplished or required.

4. Accidents or incidents, the extent of damage and repairs made.

5. Weather damage.

6. Emergency depot level maintenance.

7. TCTO's and any modifications to the aircraft. (TCTO entries are not required if a mechanized report is used.)

8. Overstresses and hard landings.

9. Airframe painting.

10. Airframe preservation, depreservation, and storage.

Some additional requirements for engine AFTO Form 95 entries are:

1. Engine requirements for preservation, depreservation, receipt inspection, and 180-day storage inspections.

2. Test cell run time, date, and facility.

3. Engine one-point tuning adjustments.

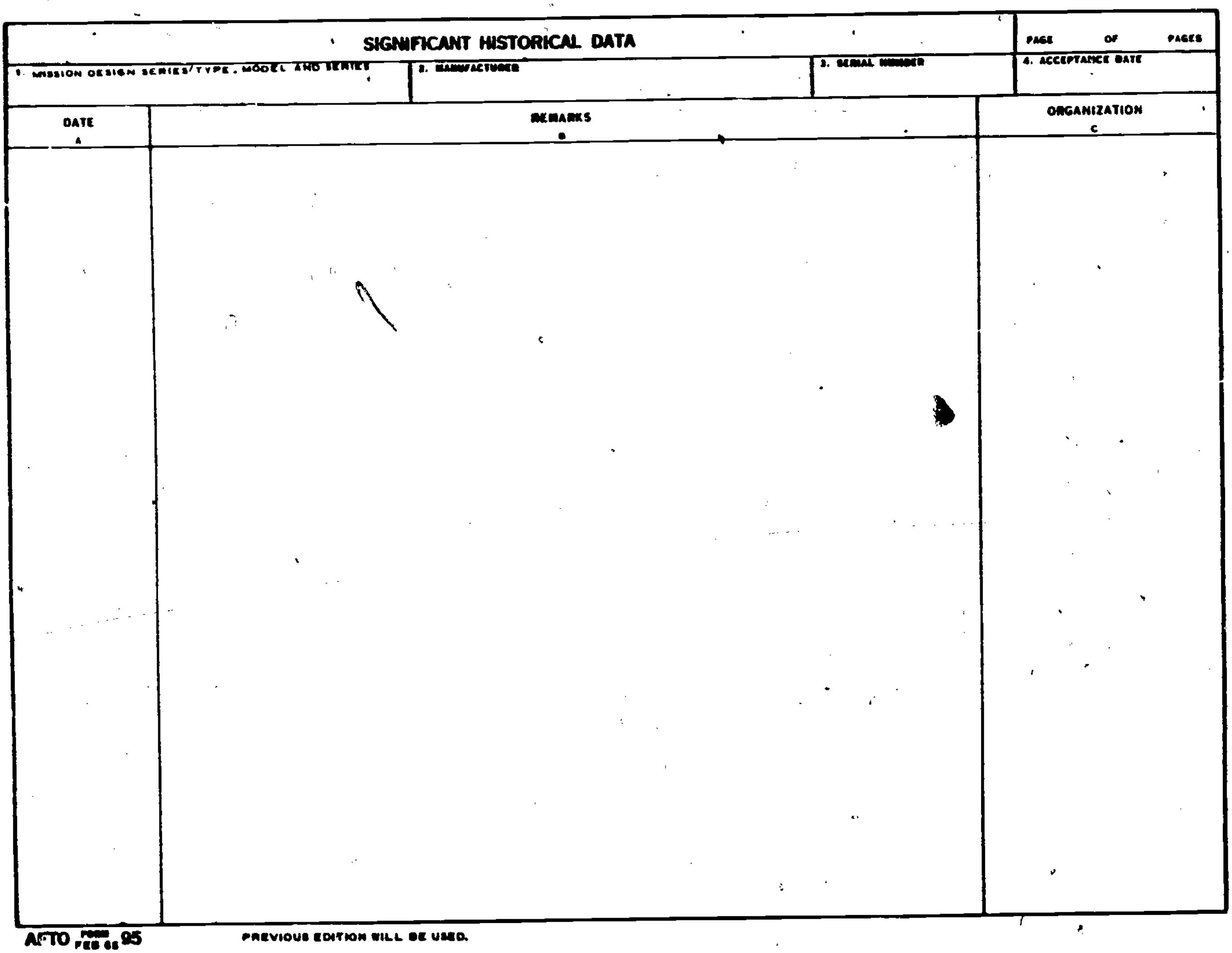
4. Throttle valve adjustments.

Refer to T.O. 00-20-4/5 for additional information concerning AFTO Form 95 entries.

Turbine Wheel Historical Record (AFTO Form 44)

AFTO Form 44 (Figures 8 and 9) is used to document accumulated cycles, operating time, and maintenance history, as well as pertinent manufacturing data for jet engine turbine wheels. AFTO Form 44 is initiated and maintained for all turbine wheels assigned to a unit. Many of the blocks are completed by the manufacturer or overhaul activity. The blocks that you will be primarily concerned with are:

1. ABNORMAL TEMPERATURE AND/OR OVERSPEED DATA: This section of the form provides a record of all abnormal temperature and/or overspeed operation of gas turbine engines. The entries are self-explanatory.



SIGNIFICANT HISTORICAL DATA

PAGE OF PAGES

1. MISSION DESIGN SERIES/TYPE, MODEL AND SERIES	2. MANUFACTURER	3. SERIAL NUMBER	4. ACCEPTANCE DATE

DATE A	REMARKS B	ORGANIZATION C

AFTO FORM FEB 65 95 PREVIOUS EDITION WILL BE USED.

Figure 7. — AFTO Form 95, Significant Historical Data.

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TURBINE WHEEL HISTORICAL RECORD			OMB NO. 21-R0184 EXPIRES 30 APRIL 1975
1. AF PART NUMBER	2. MANUFACTURER'S NUMBER	3. AF SERIAL NUMBER	4. TURBINE STAGE NUMBER

5. WHEELBLANK DIAMETRICAL MEASUREMENT	6. ABNORMAL TEMPERATURE AND/OR OVERSPEED DATA					
	DATE A	ENGINE TIME B	WHEEL TIME C	TEMPERATURE OR SPEED D	TIME OVER LIMIT E	NATURE AND POSSIBLE CAUSE F
NEW						
1ST OVERHAUL						
2ND OVERHAUL						
3RD OVERHAUL						
4TH OVERHAUL						
5TH OVERHAUL						
6TH OVERHAUL						
7TH OVERHAUL						
8TH OVERHAUL						

7. INSTALLATION DATA								
ACTIVITY A	ENGINE MODEL AND SERIAL NO B	INSTALLED		REMOVED		WHEEL TIME SINCE NEW G	WHEEL TIME SINCE OVHL H	REASON FOR REMOVAL I
		DATE C	ENG TIME D	DATE E	ENG TIME F			

AFTO FORM APR 72 44 PREVIOUS EDITION WILL BE USED

Figure 8.— AFTO FORM 44, "Turbine Wheel Historical Record."

8. TURBINE WHEEL BLADE DATA							9. TURBINE WHEEL PART NUMBER
DATE A	ACTIVITY B	WHEEL TIME C	BLADE PART NUMBER			BLADE POSITION G	REMARKS H
			REMOVED D	REPLACED E	NEW/USED F		

Figure 9.— AFTO FORM 44, "Turbine Wheel Historical Record" (Reverse).

AIRCRAFT MISSION DESIGN SERIES	SERIAL NUMBER	ORGANIZATION	LOCATION

AIRCRAFT DATA RECORD

DATE	NEXT HPO MINOR, PH. MAJ. OR PE DUE AT	DATE	NEXT HPO MINOR, PH. MAJ. OR PE DUE AT	DATE	NEXT HPO MINOR, PH. MAJ. OR PE DUE AT	DATE	NEXT HPO MINOR, PH. MAJ. OR PE DUE AT	DATE	NEXT HPO MINOR, PH. MAJ. OR PE DUE AT

AFTO FORM MAY 72 100 PREVIOUS EDITION WILL BE USED.

DATE SIGNAL	FOR AIRCRAFT, INDEX BY TYPE, MODEL, SERIES & SERIAL NO. FOR ACCESSORIES, INDEX BY NOMENCLATURE AND TYPE.	FOR AIRCRAFT, SET SIGNAL TO HOURS NEAREST ACCUMULATED TIME. FOR ACCESSORIES, SET SIGNAL TO HOURS NEAREST TO REPLACEMENT DUE TIME.

Figure 11. - AFTO FORM 100, "Aircraft Data Record."

NOMENCLATURE AND TYPE	LOCATION	REPLACEMENT INTERVAL	AIRCRAFT TYPE	AIRCRAFT SERIAL NO.

ACCESSORY REPLACEMENT RECORD

LINE NO.	DATE	SERIAL NO.	PREVIOUS OPERATING TIME	INSTALLED AT	REPLACEMENT DUE AT	REMOVED AT	TIME ACCUMULATED	[illegible] TIME
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								

AFTO FORM NOV 72 100A PREVIOUS EDITION WILL BE USED.

DATE SIGNAL	FOR AIRCRAFT, INDEX BY TYPE, MODEL, SERIES & SERIAL NO. FOR ACCESSORIES, INDEX BY NOMENCLATURE AND TYPE.	FOR AIRCRAFT, SET SIGNAL TO HOURS NEAREST ACCUMULATED TIME. FOR ACCESSORIES, SET SIGNAL TO HOURS NEAREST TO REPLACEMENT DUE TIME

USAF REMINGTON OFFICE SYSTEMS

Figure 12. — AFTO FORM 100A, "Accessory Replacement Record."

DEPARTMENT OF TRANSPORTATION U. S. COAST GUARD CG-5181 (11-78)	CARRY FORWARD DISCREPANCIES	A/C MODEL A/C NUMBER

SYMBOL	DISCREPANCY	DOC# (PP ONLY)	DATE ENTERED	DATE COMP.	TRANSFERRED BY/ COMP VERIFIED

CANNIBALIZATION RECORD (PP ENTRY REQUIRED ABOVE)

DATE	PART REMOVED	INSTALLED ON A/C#	AUTHORIZED BY

SPECIAL INSPECTIONS/SERVICES RECORD

DESCRIPTION	FREQUENCY	NEXT DUE	NEXT DUE	NEXT DUE	NEXT DUE	NEXT DUE

SN-7530-01-GF2-0690

Figure 13. - Sample Carry Forward Discrepancies Form

OIL ANALYSIS REQUEST	KEYPUNCH CODE
TO: OIL ANALYSIS LAB	
FROM: MAJOR COMMAND	
FROM: OPERATING ACTIVITY *(Include ZIP Code/APO)*	
EQUIPMENT MODEL/APL	
EQUIPMENT SER. NO.	
END ITEM MODEL/HULL NO.	
END ITEM SER. NO./EIC	
DATE SAMPLE TAKEN *(Day, Mo., Yr.)* / LOCAL TIME SAMPLE TAKEN	
HOURS/MILES SINCE OVERHAUL	
HOURS/MILES SINCE OIL CHANGE	
REASON FOR SAMPLE ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER *(Specify)*	
OIL ADDED SINCE LAST SAMPLE *(Pts, Qts, Gals)*	
ACTION TAKEN	
DISCREPANT ITEM	
HOW MALFUNCTIONED	
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW	
HOW TAKEN ☐ DRAIN ☐ TUBE ☐ HOT SAMPLE ☐ COLD SAMPLE	
REMARKS	

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						
FE	AG	AL	CR	CU	MG	NI
PB	SI	SN	TI	MO		
LAB RECOMMENDATION						
SAMPLE NO.				COMPONENT CONTROL NO. *(CCN)*		

DD FORM 2026, 1 AUG 73 — REPLACES AFTO FORM 119, APR 73, DA FORM 3253, NOV 72, AND NAVMAT FORM 4731/1, JUL 72 WHICH ARE OBSOLETE

Figure 14. - DD Form 2026, Oil Analysis Request

Shop and Aircraft Historical Record of Battery Service (AFTO Form 71A-2)

This form is used as a record of battery service relative to a particular battery for both the battery shop and the aircraft. Installation of the adhesive backed copy on the battery is optional by the unit. The hard back copy will be maintained in the battery shop. Instructions for completing AFTO Form 71A-2 are found in T.O. 8D2-3-1.

Carry Forward Discrepancies FORM CG-5181 (Replaces AFTO FORM 781K). (See Page 46).

This form is used to track aircraft discrepancies upon which action must be delayed for more than one (1) day.

Additionally, space is provided to log incidents of cannibalization and to track Special Inspection requirements, i.e., HH-52A 10 Hour Inspection, HH-3F MRH Spindle Inspection, Propeller retorque. This form should be maintained in the aircraft maintenance book, adjacent to the completed CG-4377's (Part III), as ready referene for the Maintenance Officer/Pilot. Completed CG-5181's should be retained for a period of three months and may then be discarded. See Figure 13 for sample form.

AIRCRAFT REPORTS

Coast Guard aviation units are required to submit several different reports using Coast

Guard and Air Force forms. These reports are prepared and distributed in accordance with the prescribing Coast Guard or Air Force directive.

Unsatisfactory Report Of Aeronautical Equipment. (Form CG-4010SM)

All Coast Guard Aviation units and cutters use this form (figure 16) when aircraft are deployed on board for extended periods. It is the routine means of reporting failures or unsatisfactory conditions of aeronautical equipment. Aeronautical equipment includes all items associated with flight and the aircraft's mission. Also included are all special support equipment, test equipment, and tools which support the aircraft and its mission equipment.

Maintenance personnel are expected to use good judgement regarding submission of UR's. Experience has indicated that UR's are not good indicators of the total number of items which have failed during a given period of time, (i.e. It is not necessary to report every clock failure by UR. AR&SC can provide information on the number of clocks issued if this information is desired.)

The UR program was established to provide information on premature failures (prior to 75% of time between overhaul if established), inadequate procedures, poor workmanship, etc. Routine failure of an item after a reasonable service period need not be reported. DD Form 1577-2, which should accompany every item returned to AR&SC will suffice.

Unit procedures should insure that; (1) UR's are submitted when appropriate, and (2) UR's are not submitted when no reasonable need exists for their submission.

Failure or unsatisfactory conditions of aeronautical material affecting SAFETY OF FLIGHT are reported by message (figure 15). The Commandant routes messages to other agencies if deemed appropriate. The message is an interim Unsatisfactory Report (UR) and must be followed up with a completed Form CG-4010SM.

Special considerations for reporting failed or unsatisfactory avionics material are necessary. Although all avionic equipment failures are reported under the EICAM system, an Unsatisfactory Report for avionic material, is a necessary supplement. The avionics Unsatisfactory Report should report conditions such as inadequate equipment design, improper or poor installation designs, deficiencies involving safety, human factor or display inadequacies, etc. Essentially, UR's are expected on avionics failures more extensive than random failures of bits and pieces. The Unsatisfactory Report not only notifies the Commandant of a problem, and/or a solution to a problem, but can alert other aviation units to something they may be unaware of.

Both AR&SC and G-EAE review all avionics Unsatisfactory Reports. Many are acted upon on receipt; the remainder are filed by category, and the frequency of recurrence is monitored. Units must make full use of the Unsatisfactory Report system for avionics failures, and supervisors must constantly reemphasize its importance.

The Unsatisfactory Report should be based on a reasonably thorough evaluation of the circumstances. To expedite submission, Unsatisfactory Reports may be legibly printed or written in script. A typed report is preferred, however, if there is a possibility that the report will be disseminated outside the Coast Guard.

The Unsatisfactory Report form will also be used for reporting deficiencies noted on aircraft overhauled at AR&SC. This report should include only those discrepancies encountered during the first 14 days of operational availability at the reporting unit; but in no case shall the report be submitted later than 30 calendar days after acceptance. Only discrepancies that can be directly related to overhaul deficiencies shall be reported on the aircraft overhaul report. The report is designed to provide AR&SC with information which can be used to correct deficiencies in their overhaul or quality control procedures. A general entry such as "Numerous lines chafing in transmission area" does not provide enough detail to enable AR&SC to take corrective action. Photographs can be very helpful in documenting problems. A good guide in writing a discrepancy is to ask yourself if the discrepancy write-up contains enough information for you to take the necessary corrective action to prevent that discrepancy from occurring again. Discrepancies should be reported as either Major or Minor. A Major discrepancy is one which affects safety of flight or grounds the aircraft. A Minor discrepancy is any other discrepancy noted which, by reporting to AR&SC, will allow them to improve their overhaul efforts. Figure 17 outlines the format to be used for this report.

Reports should not be delayed past the submittal date on the basis of "something else will show up." Discrepancies discovered after the 14 day period that can be attributed directly to the aircraft overhaul will be submitted via a supplementary Unsatisfactory Report.

All discrepancies reported in the aircraft overhaul report are investigated by AR&SC and findings and action taken on major discrepancies will be reported to the receiving activity via rapid draft letter. Similarly, AR&SC will document and report to the unit concerned, unusual problem areas discovered on aircraft inducted into overhaul. This documentation should be useful to field units, highlighting areas of their aircraft maintenance program where greater emphasis is required.

Instructions For Completing Form CG-4010SM (See figure 16).

Fill in the blocks of Form CG-4010SM as follows:

1. REPORT SERIAL NUMBER: Assign numbers consecutively, starting at the beginning of each calendar year. For example, UR 2-75 would be the second Unsatisfactory Report prepared at the unit in 1975.

2. AIRCRAFT SERIAL NUMBER: Self-explanatory.

3. MODEL AND SERIAL NUMBER OF AFFECTED COMPONENT: The component on which the unsatisfactory item is installed. For example, an unsatisfactory starter might be installed on a GE-T58-8B engine, S/N 271542.

4. NAME OF UNSATISFACTORY ITEM: Self-explanatory.

5. MANUFACTURER: Manufacturer of unsatisfactory item.

6. MODEL OR TYPE NUMBER: Model or type number of unsatisfactory item.

7. SERIAL NUMBER: Serial number of unsatisfactory item.

8. PART OR STOCK NUMBER: Part number and NSN (if available) of unsatisfactory item.

9. CONTRACT NUMBER OF ORIGINAL MANUFACTURER: If the namplate data of the unsatisfactory item shows the contract number, list it here. Disregard the word "(Electronics)" and use the block for all items if available.

10. PRIOR FAILURE: List the number of prior failures for which records are reasonably available and the date of the oldest known failure. For example, if it can be easily determined that eight prior failures occurred at your unit since July 1968, show "8: 7-68." Do not include the number of defective items reported by the current UR as prior failures. Cutters show prior failures for their current deployment only.

11. LAST OVERHAUL AND DATE: List the last overhaul activity and the date of the last overhaul. Be sure to list both if known. If it is a new item, insert "NEW."

12. TOTAL TIME SINCE OVERHAUL: Show the time since last overhaul or if it is a new item, show the time since new.

13. NUMBER DEFECTIVE: List the number of failed items reported for the first time by current UR. Do not include items listed in the "prior failure" block.

14. DATE OF FAILURE: Self-explanatory.

15. DD-787 REPORT NUMBER (Electronics): Leave Blank.

16. EXHIBIT DISPOSITION: Report action taken in accordance with the following guidelines:

a. Do not turn failed items over to a contractor's representative without the approval of the Commandant.

b. When you are turning a failed item over to a supply or overhaul activity, place a copy of the UR in a suitable envelope marked "UR" in large red letters, and attach it to the failed item. On Air Force equipment, mark "UR EXHIBIT" in red on the envelope containing the UR's.

c. Retain a failed item for 60 days before scrapping.

17. DETAILS

a. References: List the publications or documents referenced.

b. Description: Describe the failure in clear, concise terms. If photos or sketches are attached, mark them with the UR number and station for identification in case they become detached. Include the following information if appropriate:

(1) Include pertinent changes, bulletins, and technical orders and date incorporated in the detailed data.

(2) Give the gross weight, maneuvers, thunderstorms, hard landings, etc., in reports concerning structural failures.

(3) For engine failure, give the operating parameters, the know elements failed, and the sequence of events. Analyze foreign material and/or metal particles. Specify engine bulletins not installed if pertinent. Enclose one copy of the engine UR in the engine logbook. Include any recent SOAP data analysis.

(4) Report excessively corroded engines, installed or spare.

(5) On UR's concerning tires and tubes, give the location, number of plies, fabric, new or recapped, name and date of manufacture and recap, estimated percentage of wear, reason, and date of removal, and photo.

(6) Operating activities do not disassemble instruments or instrument components to determine the cause of internal failures. Units are also discouraged from disassembling other items due to the possibility of introducing problems which-would distort subsequent investigation as to the cause of failure or malfunction.

c. Cause: Give the cause of the unsatisfactory conditions if known; otherwise, omit this subheading.

d. Action Taken: Give a concise statement of the action taken.

e. Recommendations: Give recommendations if they are considered pertinent; otherwise, omit this subheading.

f. Distribution: Show "standard" plus the additional distribution above standard. If the distribution is standard, omit this subheading.

18. DATE FORWARDED: Self-explanatory.

19. INVESTIGATING OFFICER: The engineering officer may designate a qualified commissioned officer, warrant officer, or petty officer as investigating officer. The investigating officer will sign the report.

20. COMMANDING OFFICER: The commanding officer or his designated representative will also sign the report. Designation of "BY DIRECTION" authority to the engineering officer is encouraged.

UR's are distributed in accordance with the following standard and elective lists:

1. All UR's

(1) Commandant (G-EAE)	3 copies
(2) AR&SC	5 copies
(3) Prime unit	2 copies
(4) AVTECHTRACEN	1 copy

2. An additional distribution of UR's is required on selected aircraft and engine equipment such as C-130, C-131A, HH-3F, all Air Force type UR's, T58 and R2800 engines. These requirements are listed in CG-452.

3. Elective distribution: Copies may also be sent to each unit operating the same type of aircraft or equipment if deemed useful.

4. Safety of Flight failures or unsatisfactory conditions are reported by message.

UR forms are requisitioned in accordance with the Catalog of Forms (CG-218).

AIRCRAFT/TYPE I MATERIAL REPORT (CG-2897)

This report (figure 18) is used to gather information on a continuing basis on certain high value or critical items in the aeronautical support inventory (generally Type I or Type II items). All units that have aircraft attached submit the report monthly, and they indicate the inventory of items as of 2400 on the last day of each month. Parts I (original) and II are mailed so as to arrive at their intended destination not later than the 10th day of the following month. Part I is sent to AR&SC and Part II to Commandant (G-EAE). Copies, other than the original (including the unit's copy) are disposed of after 1 year.

Entries are self-explanatory except as described below:

1. Use a separate page for each type of aircraft assigned.

2. Entries must be typewritten or legibly printed with a ballpoint pen.

SECURITY CLASSIFICATION -

[illegible] TRANSPORTATION U. S. COAST GUARD CG-2655 (Rev. 3-67)	U. S. COAST GUARD - OFFICIAL MESSAGE
UNIT	DATE

FM COGARD AIRSTA ____________

TO COMDT COGARD
COGARD AIRREPSUPCEN ECITY, N. C.

INFO CCGD ____________

COGARD AIRSTA ____________ (Prime Unit for A/C Type)

UNCLAS

TO G-EAE

URGENT INTERIM UR NO. ________ (Unit's UR Serial Number)

IN TEXT GIVE NECESSARY INFORMATION. USE ATTACHMENT 4-1 AS A GUIDE TO ENSURE THAT NO ESSENTIAL INFORMATION IS OMITTED. CONFIRM WITH WRITTEN UR CITING MESSAGE INTERIM UR.

DATE - TIME GROUP	PRECEDENCE	ACTION / INFO
DRAFTED BY:		RELEASED BY:

SECURITY CLASSIFICATION -
PREVIOUS EDITIONS MAY BE USED
GPO

Figure 15. — Message UR.

DEPARTMENT OF TRANSPORTATION
U. S. COAST GUARD
CG-4010SM (Rev. 9-69)

UNSATISFACTORY REPORT OF AERONAUTICAL EQUIPMENT

REPORTS CONTROL SYMBOL
EAE-3006

REPORTING ACTIVITY

REPORT SERIAL NUMBER	REPORTING ACTIVITY	MAILING ADDRESS

IDENTIFICATION OF UNSATISFACTORY ITEM

AIRCRAFT MODEL	AIRCRAFT SERIAL NUMBER	MODEL AND SERIAL NUMBER OF AFFECTED COMPONENT	
NAME OF UNSATISFACTORY ITEM		MANUFACTURER	MODEL OR TYPE NUMBER
SERIAL NUMBER	PART OR STOCK NUMBER	CONTRACT NUMBER OF ORIGINAL MANUFACTURER (Electronics)	
PRIOR FAILURES	LAST OVERHAUL AND DATE	TOTAL TIME SINCE OVERHAUL	NUMBER DEFECTIVE
DATE OF FAILURE	DD-787 REPORT NUMBER (Electronics)	EXHIBIT DISPOSITION	

DETAILS (Description, Cause, Action Taken, Recommendations)

DATE FORWARDED	SIGNATURE OF INVESTIGATING OFFICER	SIGNATURE OF COMMANDING OFFICER

PREVIOUS EDITIONS MAY BE USED

Figure 16.– Form CG-4010SM, Unsatisfactory Report of Aeronautical Equipment.

DEPARTMENT OF TRANSPORTATION U. S. COAST GUARD CG-4810SM (Rev. 9-69)	UNSATISFACTORY REPORT OF AERONAUTICAL EQUIPMENT	REPORTS CONTROL SYMBOL EAE-3006

REPORTING ACTIVITY

REPORT SERIAL NUMBER	REPORTING ACTIVITY	MAILING ADDRESS
109-76	CGAS Cape Cod	

IDENTIFICATION OF UNSATISFACTORY ITEM

AIRCRAFT MODEL	AIRCRAFT SERIAL NUMBER	MODEL AND SERIAL NUMBER OF AFFECTED COMPONENT	
HH-52A	1386	NA	
NAME OF UNSATISFACTORY ITEM		MANUFACTURER	MODEL OR TYPE NUMBER
Aircraft		Sikorsky	NA
SERIAL NUMBER	PART OR STOCK NUMBER	CONTRACT NUMBER OF ORIGINAL MANUFACTURER (Electronics)	
NA	NA	NA	
PRIOR FAILURES	LAST OVERHAUL AND DATE	TOTAL TIME SINCE OVERHAUL	NUMBER DEFECTIVE
NA	10 Jan 76	40	NA
DATE OF FAILURE	[illegible] REPORT NUMBER (Electronics)	EXHIBIT DISPOSITION	
31 Jan 1976	NA	NA	

DETAILS (Description, Cause, Action Taken, Recommendations)

AIRCRAFT OVERHAUL REPORT

Discrepancies	Corrective Action
MAJOR	
1. NONE	
MINOR	
1. Slight hydraulic leak at primary panel package.	1. Installed new "O" ring and tightened "B" nut at pressure outlet (2MH)
2. Paint peeling from Station 25 to Station 35 bottom hull (see photo).	2. Touched-up paint (4MH).

DATE FORWARDED	SIGNATURE OF INVESTIGATING OFFICER	SIGNATURE OF COMMANDING OFFICER

PREVIOUS EDITIONS MAY BE USED

Figure 17. – Overhaul Deficiencies Report.

3. All hours shall be rounded off to nearest whole number. The total flight hours accumulated per aircraft type assigned for the month shall be included.

4. Use the TYPE column for identification of the basic engine component in sectionalized engines such as the T56. Use the following codes:

P - Power Section

R - Reduction Gear

T - Torquemeter

For the sectionalized engines, list the serial numbers and time for each component.

5. Use the REMARKS column for the following information:

a. Monthly NORM/NORS rate - record the average NORM/NORS rate which is calculated as follows:

Total the number of hours that all aircraft of a certain type were not operationally ready due to maintenance work that had to be performed. Divide this total by the total number of hours the aircraft have been assigned for the month. (Example: NORM total for three H-52 aircraft = 540 hours. Three aircraft assigned for a full month (30 days). Total hours assigned = 2,160 hours. NORM Rate = $\frac{540}{2100}$ = 25%. The NORS rate is computed in a similar manner. (See figure 20 for the display format.)

b. The REMARKS column is also used for other significant information concerning either an aircraft or aircraft engine. Date of gain or loss of an aircraft is a required entry in this column. Criteria for the date to be used in gains or losses appear in the Air Operations Manual (CG-333). This entry is made only in the report covering the period during which the gain or loss occurred. Use appropriate abbreviations in all entries. Here is a list of required entries and the proper abbreviations:

Item	Entry
(Aircraft transferred 5-14)	"DL-14"
(Aircraft received 5-20)	"DG-20"
Grounded for Corrosion Control	"Grnd-Corsn"
Accident Repairs	"Crash Rpr"
Engine Change	"Eng Chg"
Temporary Storage	"T"
Spare	"S"

6. Engine serial numbers need not be prefaced with letter designations, such as EL, W, KF, AE, etc.

7. Use the STATUS column for RFI engines to describe engine status if it is other than "in the can, ready to ship." The usual entries are:

Condition	"Status Entry"
In can, RFI	No Entry
Built-up as QEC	QEC
In Shop for Inspection (Rotational Spare)	SHOP

Periodically AR&SC may request, by message or letter, certain information on selected Type 2 high value or critical items (main gear boxes, main rotor heads, power packages, etc.) to be included on this end-of-month report. When reporting such special items, head the listing with the applicable material (i.e., H-3 tail rotor gear box) in the applicable section (installed, RFI, or Class 265), and then list the part number and/or serial number plus time since overhaul (TSO). Comply also with any additional AR&SC requests for data on the material.

STANDARD FORM 368

Quality Deficiency Report (see figure 19). DOD has adopted this form as a standard form for use in reporting quality deficiencies on all DOD owned material (i.e. components, engines and aircraft). This form replaces the AFTO 64 form previously utilized for this purpose. Regulations applicable to the use of SF 368 require that each service establish a central screening point for all SF 368 submissions. The following action will be taken by Coast Guard units when reporting quantity deficiencies:

PAGE 1 OF 1	G. E. KRIETEMEYER	PERIOD ENDING 6-30-75	UNIT CGAS Elizabeth City, NC

AIRCRAFT MODEL	CGNO	HOURS THIS MONTH	HOURS TOTAL	REMARKS	TYPE	INSTALLED TYPE I MATERIAL SERIAL NUMBER AND TIME SINCE OVERHAUL (ENGINES) 1	TSO	2	TSO	3	TSO	4	TSO
HH-52A	1407	98	2955			271350	971			H-52 MGB			
HH-52A	1450	60	2311			271502	1324			A-7-5-69	214		
HH-52A	1457	20	2289			271571	1356			A-7-151	891		
		178								A-7-221	163		
				NORM-25%									
				NORS- 5%									
AVAIL	2160												
NORM	540												
NORS	108												

RFI TYPE I MATERIAL MODEL	SERIAL NO. ENGINES	TSO	STATUS	RFI TYPE I MATERIAL (Continued) MODEL	SERIAL NO. ENGINES	TSO	STATUS	265 TYPE I MATERIAL MODEL	SERIAL NO. ENGINES	TSO
T-58-GE-8B	270793	0	SHOP	H-52MGB	A-7-162	0				
T-58-GE-8B	271127	600	QEC							

PREVIOUS EDITIONS ARE OBSOLETE — PART 1 - TO ARSC

DEPT. OF TRANSP. U.S. COAST GUARD CG-2897 (Rev. 1-71)

Figure 18.— Form CG-2897, Aircraft/Type I Material Report.

Deficiency reports concerning components and engines, regardless of the overhaul/repair activity involved, shall be submitted to AR&SC, ATT: Tech Services, via an unsatisfactory report. AR&SC will function as the screening activity and will prepare and submit SF368s as required.

Deficiency reports resulting from C-130 PDM shall be prepared in message format by the receiving activity not later than twenty days after receipt of the aircraft in accordance with T.O. 00-35D-54. Commandant (G-EAE/63) shall be an information addressee.

Deficiency reports pertaining to GSA procured tools shall be submitted to (G-EAE/63), utilizing SF 368. Commandant (G-EAE/63) will act as the screening activity for these reports and will provide followup action when required. Deficiency reports concerning aircraft overhauled at AR&SC shall be submitted on an unsatisfactory report.

AFTO FORM 103 - AIRCRAFT MISSILE CONDITION REPORT.

Reporting custodians will submit AFTO Form 103 for aircraft scheduled for programmed depot maintenance at any military or commercial activity including AR&SC. Prepare the form in accordance with T.O. 00-25-4 and route so as to arrive no later than 45 days prior to the scheduled input date.

1. C-130 Reporting Custodians. Submit AFTO Form 103 as directed in the preinduction notice.

2. H-3, HU-16E, and H-52 Reporting Custodians. Submit AFTO Form 103 in triplicate to AR&SC with a copy to Commandant (G-EAE/63). The following additional information will be included on the AFTO Form 103.
   - (a) Any unusual work which will be required during programmed depot maintenance, such as repair of extensive corrosion, rework of temporary structural repairs, or incorporation of Changes, Bulletins, or TCTO's which are applicable and due for the aircraft involved.
   - (b) The uninstalled change kits which will accompany the aircraft. Note: A list of components with their accumulated time is not longer required.

3. All PDM requirements for te HC-131A have been deleted by the Air Force and incorporated into the phase inspections. With the Coast Guard maintaining the aircraft on CMS, these former PDM requirements are being put into a special overhaul package due at 45 months.

QUALITY DEFICIENCY REPORT
(Category II)

SECTION I

1a. From (Originating point)	2a. To (Screening point)
1b. Typed Name, Duty Phone and Signature	2b. Typed Name, Duty Phone and Signature

3. Report Control No.	4. Date Deficiency Discovered	5. National Stock No. (NSN)	6. Nomenclature
7. Manufacturer/Mfg. Code/Shipper	8. Mfg. Part No.	9. Serial/Lot/Batch No.	10. Contract/PO/Document No.

11. Item ☐ New ☐ Repaired/Overhauled	12. Date Manufactured/Repaired/Overhauled	13. Operating Time at Failure	14. Government Furnished Material ☐ Yes ☐ No
15. Quantity — a. Received	b. Inspected	c. Deficient	d. In Stock

16. Deficient Item Works On/With	a. End Item (Aircraft, tank, ship, howitzer, etc.)	(1) Type/Model/Series		(2) Serial No.
	b. Next Higher Assembly	(1) National Stock No. (NSN)	(2) Nomenclature	(3) Part No. / (4) Serial No./Lot No.

17. Dollar Value	18. Est. Correction Cost	19. Item Under Warranty ☐ Yes ☐ No ☐ Unknown	20. Work Unit Code/EIC (Navy and Air Force only)

21. Action/Disposition
☐ Holding Exhibit for ___ days ☐ Released for Investigation ☐ Returned to Stock/Disposed of ☐ Repaired ☐ Other (Explain in Item 22)

22. Details (Describe, to best ability, what is wrong, how and why, circumstances prior to difficulty, description of difficulty, cause, action taken including disposition, recommendations. Identify with related item number. Include and list supporting documents. Continue on separate sheet if necessary.)

SECTION II

23a. To (Action Point)	24a. To (Support Point) (Use Items 25 and 26 if more than one)
23b. Typed Name, Duty Phone and Signature	24b. Typed Name, Duty Phone and Signature
25a. To (Support Point)	26a. To (Support Point)
25b. Typed Name, Duty Phone and Signature	26b. Typed Name, Duty Phone and Signature

368-101

STANDARD FORM 368, April 1974
General Services Administration (FPMR 101-26-7)

Figure 19. — Standard Form (SF) 368, Quality Deficiency Report.

AIRCRAFT/MISSILE CONDITION REPORT

DATE	PAGE OF PAGES	REPORTS CONTROL SYMBOL

TO:	FROM: (Name, Orgnl Code, and Telephone)

AIRCRAFT/MISSILE MDS	SERIAL NO.	SUBSTITUTE SER NO.	EST DEL DATE	FLYING HRS/CAL MON SINCE DEPOT MAINT	TOTAL FLYING HRS/ CALENDAR MONTHS

PART I - SPECIAL CONDITIONS

List specific areas of hidden corrosion, fuel tank leaks, temporary repairs, etc., which might not be detected and corrected during accomplishment of the work package. List only those discrepancies which require depot level maintenance. Do not list items included in the basic work package.

	ENGINE SER NO.	HRS SINCE NEW OR OVHL
1		
2		
3		
4		
5		
6		
7		
8		

PART II - SPECIAL INSTRUCTIONS (For SSM Use)

List maintenance requirement identified in Part I which the Specialized Repair Activity is authorized to accomplish.

SSM ACTION (Name, Orgnl Code, and Telephone)

AFTO FORM APR 66 103 PREVIOUS EDITIONS WILL BE USED. AFLC-WPAFB-APR 66 80M

Figure 20.— AFTO Form 103, Aircraft/Missile Condition Report.

DEPARTMENT OF TRANSPORTATION
U.S. COAST GUARD
AIRCRAFT FLIGHT RECORD

A/C MODEL	A/C NUMBER	UNIT	DATE

PART III – MAINTENANCE RECORD

TOTAL FLIGHT TIME	NO. OF LANDINGS	AIRCRAFT CONDITION	TOTAL NOR		MPC/LOG ENTRIES COMPLETE
ENG START CYCLES: 1 / 2 / 3 / 4			NORM	HRS / TENS	AIRCRAFT
					ENGINES
PILOT			NORS	HRS / TENS	ACCESS'S

1.	X IF GROUNDED	TIME	DATE	MAINTENANCE RELEASE IF GROUNDED	TIME	DATE
DISCREPANCY			NF	* / CORRECTIVE ACTION	MECH SIGNATURE	
					RATE	MAN HRS *
					QA RELEASE	

2.	X IF GROUNDED	TIME	DATE	MAINTENANCE RELEASE IF GROUNDED	TIME	DATE
DISCREPANCY			NF	* / CORRECTIVE ACTION	MECH SIGNATURE	
					RATE	MAN HRS *
					QA RELEASE	

3.	X IF GROUND	TIME	DATE	MAINTENANCE RELEASE IF GROUNDED	TIME	DATE
DISCREPANCY			NF	* / CORRECTIVE ACTION	MECH SIGNATURE	
					RATE	MAN HRS *
					QA RELEASE	

4.	X IF GROUNDED	TIME	DATE	MAINTENANCE RELEASE IF GROUNDED	TIME	DATE
DISCREPANCY			NF	* / CORRECTIVE ACTION	MECH SIGNATURE	
					RATE	MAN HRS *
					QA RELEASE,	

ENG/PROP OIL ADDED					LUBE OIL ADDED		HYD FLUID ADDED				TOTAL A/C TIME	
	1	2	3	4	MGB		PRI	AUX	UTIL	BOOST	PREVIOUS TOTAL	
ENG					IGB						TIME THIS FLIGHT	
PROP					TGB						NEW TOTAL	

CG-4377 (Rev. 2-69)

Figure 21. – Aircraft Flight Record, Part III.

65

AIRCRAFT FLIGHT RECORD

The Aircraft Flight Record form (CG-4377) is used by all aviation units to record flight and maintenance data. The Air Operations Manual (CG-333) contains specific information for the proper use of Parts I and II of the Aircraft Flight Record form. In this pamphlet we will discuss only Part III of the form. See figure 21.

Maintenance personnel are required to make the following entries in Part III (Maintenance Record) of the Aircraft Flight Record:

1. LOG ENTRIES: The person transcribing Part III data to the appropriate aircraft, engine, or accessories logs should initial this block.

2. CORRECTIVE ACTION: The mechanic should use explicit, concise terms to describe the action taken to correct the discrepancy noted. Entries such as "ground checks OK" should not be used. The mechanic responsible for the corrective action taken must legibly sign (not initial) in the appropriate space. The man-hours expended must be entered. A quality assurance inspection and release signature is mandatory for any grounding discrepancy or flight control work, including trim tabs, rigging work, engine change, propeller or governor work, and landing gear system work. Part numbers or stock numbers should be entered if components have been removed, replaced, or installed.

If corrective maintenance action is delayed beyond one day, the asterisked box immediately preceding the corrective action block must carry one of the following symbols:

CK - Indicates carried forward to check (HU-16E only)

CF - Indicates carried forward

PP - Indicates pending parts

In this case, NO OTHER ENTRY SHALL BE MADE in the corrective action block. Any delayed corrective action symbol MUST be initialled by an Aircraft Maintenance Officer or his designated representative prior to release of the aircraft for flight. All carry forward discrepancies shall be transferred to FORM CG-5181. To clear FORM CG-5181, entries (delayed discrepancies), must be re-entered on CG-4377), Part III and signed off with the corrective action.

3. REMARKS: Record special information that may be required from time to time. The log yeoman should check this block for possible AFTO Form 95 (Significant Historical Data) entries.

4. TOTAL FLIGHT TIME: Many times the flight time entries on Parts II and III do not agree. The pilot will occasionally make a correction to the flight time block on Part II after he gets to operations, without reflecting this change on Part III. It is therefore a good practice for the log yeoman to take flight times from the Part II instead of Part III.

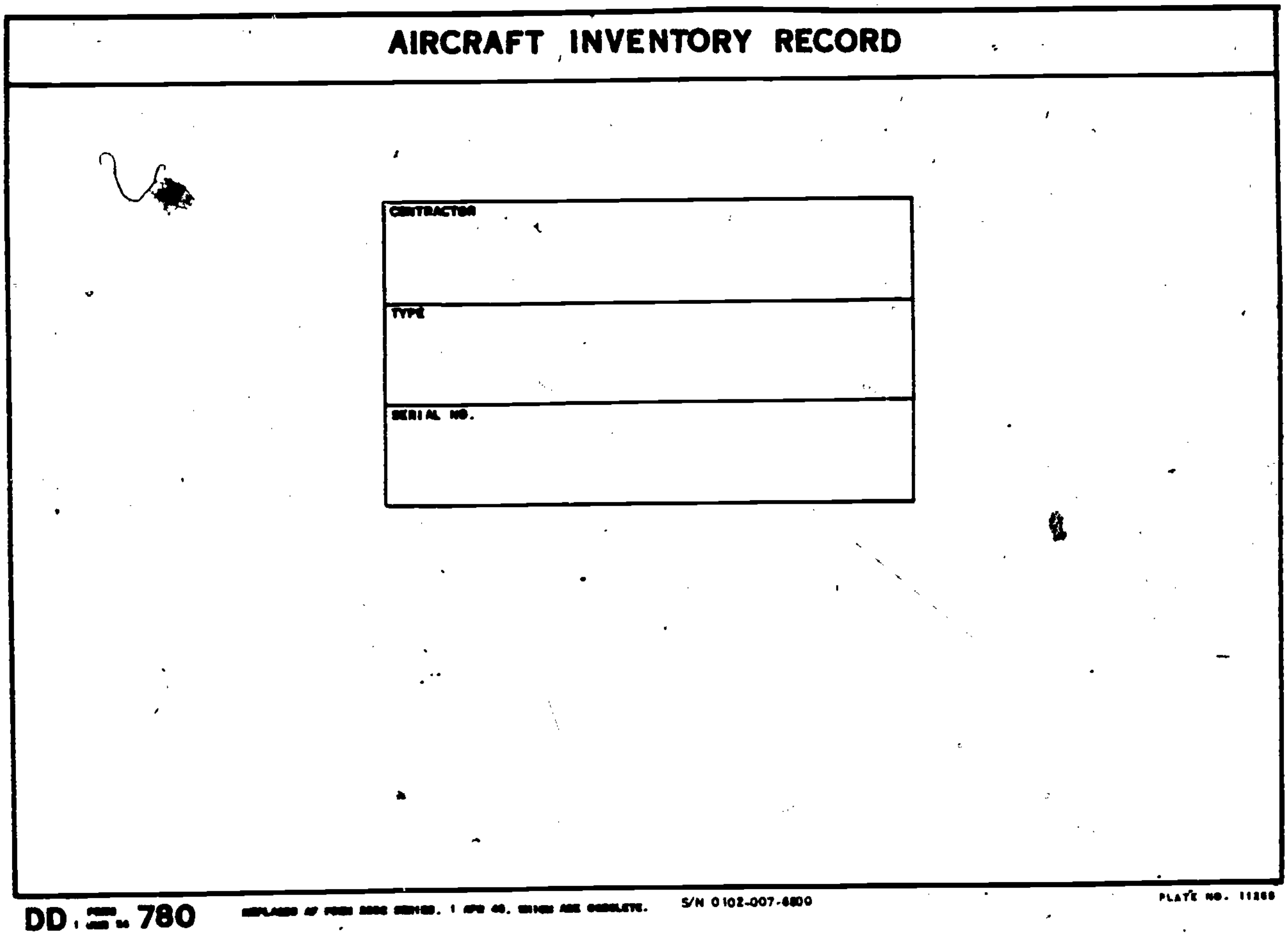
5. ENGINE HOURS: Record engine time if for some reason it is different from the total flight time.

The engineering section retains the completed Part III forms for a period of 12 months. The forms may then be discarded.

AIRCRAFT INVENTORY RECORD

To maintain an unbroken chain of custodial responsibility incident to the transfer and acceptance of military aircraft, the Aircraft Inventory Record (DD Form 780) was developed as an instrument of transfer. (See figure 22). The Department of Defense designed the Aircraft Inventory Record in the interest of standardization among the armed services. These standard inventories have been purged of all items which would be noticeably missing during a thorough preflight and acceptance test flight. As an example, all communications and navigation components have been deleted to reduce the man-hours required to inventory aircraft.

The Aircraft Inventory Record normally will not be carried aboard the aircraft but will be filed in the maintenance office. Permanent entries will be made in ink or typed. Temporary entries, such as remarks indicating temporary removal of equipment for storage, may be made in pencil.


AIRCRAFT INVENTORY RECORD

CONTRACTOR

TYPE

SERIAL NO.

DD FORM 780

S/N 0102-007-6800

Figure 22. — DD Form 780, Aircraft Inventory Record.

If an aircraft is dropped from Coast Guard inventory, the records will be retained 3 months. After that time, they may be destroyed. Inventory records accompany the aircraft throughout its service life. Inventory changes that change the aircraft weight and balance should be reflected on the DD-365 Weight and Balance forms series.

The Aircraft Inventory Record is made up of four forms: (1) Aircraft Inventory Record cover page and the Section Breakdown Diagram (DD-780, front and back), (2) Aircraft Inventory Record - Equipment List (DD-780-1), (3) Aircraft Inventory Record - Shortages (DD-780-2), and (4) Aircraft Inventory Record - Certification and Record of Transfer (DD-780-3). Procedures for completing these forms are given in the following paragraphs.

AIRCRAFT INVENTORY RECORD WITH SECTION BREAKDOWN DIAGRAM (DD-780, Back)

The entries on this form (figure 23) are self-explanatory with the following exceptions:

1. The EXPLANATION block is used to explain the sectional breakdown diagram if necessary.

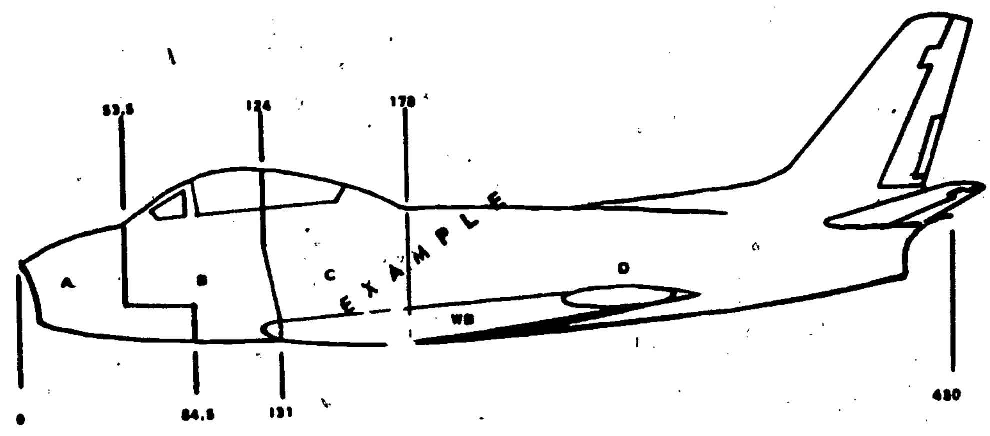
2. The MISCELLANEOUS DATA block may be used to enter any special notes about items listed on DD Form 780-1.

The sections of the sectional breakdown diagram are identified by letters to facilitate inventorying. The letter A is assigned to the foremost section. The letter B is assigned to the next section, and so on, generally to the rear of the aircraft. The letter R, as part of the item number, denotes items mounted on

AIRCRAFT TYPE | SERIAL NO. | CONTRACT NO. | PRIME CONTRACTOR | ACCEPTANCE DATE

EXPLANATION

SECTIONAL BREAKDOWN DIAGRAM



MISCELLANEOUS DATA

PLATE NO. 11263 (BACK)

Figure 23. — DD Form 780 (Reverse) Aircraft Inventory Record.

AIRCRAFT INVENTORY RECORD EQUIPMENT LIST	SECTION	GOVERNMENT SERIAL NO.	AIRCRAFT TYPE	PAGE OF PAGES

ITEM NO. A	NOMENCLATURE, TYPE AND MODEL B	REQUIRED HERE C	EQUIPMENT CHECKS[1] D: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	LOCATION OR REMARKS E

CHECK 1 BY	CHECK 7 BY	CHECK 13 BY	CHECK 19 BY
CHECK 2 BY	CHECK 8 BY	CHECK 14 BY	CHECK 20 BY
CHECK 3 BY	CHECK 9 BY	CHECK 15 BY	CHECK 21 BY
CHECK 4 BY	CHECK 10 BY	CHECK 16 BY	CHECK 22 BY
CHECK 5 BY	CHECK 11 BY	CHECK 17 BY	CHECK 23 BY
CHECK 6 BY	CHECK 12 BY	CHECK 18 BY	CHECK 24 BY

[1] Verify each equipment check by entering the signature of the person performing the inventory.

DD FORM 1 JUN 54 780-1 REPLACES AF FORM 203C SERIES, 1 APR 45, WHICH ARE OBSOLETE. 0102 007 7000

C20489

Figure 24. — DD Form 780-1, Equipment List

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.

AIRCRAFT INVENTORY RECORD - EQUIPMENT LIST (DD-780-1)

The equipment list portion of the Aircraft Inventory Record (figure 24) 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.

The heading entries for DD-780-1 are self-explanatory. The REQUIRED HERE column indicates the number of this item required in this compartment in accordance with existing instructions.

The EQUIPMENT CHECKS column indicates that required items are present. Enter a check mark in the appropriate column. If shortages exist, indicate the quantity actually aboard or "0" in red as appropriate. When all equipment check columns are used, a new DD-780-1 must be initiated. The old form is retained until the next inventory, after which the form may be destroyed. The individual making the check certifies that each check is complete by signing the appropriate block at the bottom of the page.

The LOCATION OR REMARKS column indicates the authority for removal and location.

AIRCRAFT INVENTORY RECORD - SHORTAGES (DD-780-2)

This form (figure 25) is used to record the shortages found during the inventory. The transferring activity makes every effort to locate missing items or to withdraw from stock the replacement items necessary to complete the inventory.

The heading entries for DD-780-2 are self-explanatory. The item number in column A must correspond with the item number as shown on form DD-780-1. The authority or reason for the shortage should be placed in column D. Whenever an existing shortage is made up by an activity, note in the REMARKS column that the item has been installed or replaced. This notation should include the name of the organization. Additional pages of the DD-780-2 are added as necessary. Only those showing current shortages will be retained. All others may be destroyed.

AIRCRAFT INVENTORY RECORD - CERTIFICATION AND RECORD OF TRANSFERS (DD-780-3)

This form (figure 26) provides a place for both the transferring activity and the receiving activity to certify the completion of their inventories. A signature on this form certifies that the aircraft was equipped at the time of delivery or receipt with the items listed on the Equipment List, with the exception of any shortages noted on the Shortages form.

Retain completed DD-780-3 forms showing entries less than 1 year old. Destroy all others.

Aerospace Vehicle Delivery Receipt (AF Form 510)

This form (figure 27) is used by the transferring and the receiving activity to acknowledge receipt of an aircraft and its logs and records. There is no prescribing directive for this form. The instructions for filling out the form are printed on the form.

REQUISITIONING OF FORMS

The USAF-type forms listed herein may be requisitioned from CG Supply Center, Brooklyn, utilizing DD Form 1348 in accordance with Catalog of Forms (CG-218). Requests to utilize other USAF-type forms shall be forwarded to Commadant (G-EAE/63), indicating estimated usage data. When additional USAF-type forms are approved for Coast Guard use, they will be listed in the Catalog of Forms (CG-218) and stocked at CGSC Brooklyn.

The Numerical Index of Departmental Forms (AF Regulation 0-9) contains the prescribing directives for the USAF, AFTO, and DD type forms.

AIRCRAFT INVENTORY RECORD SHORTAGES		GOVERNMENT SERIAL NO.	AIRCRAFT TYPE	PAGE OF PAGES
ITEM NO. A	NOMENCLATURE, TYPE AND MODEL B	QUANTITY SHORT C	AUTHORITY OR REASON FOR SHORTAGE D	REMARKS E

DD FORM 1 JUN 54 780-2 REPLACES AF FORM 283C SERIES, 1 APR 45, WHICH ARE OBSOLETE. 0102 007 7100

Figure 25. - DD Form 780-2, Aircraft Inventory Record, Shortages.

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AIRCRAFT INVENTORY RECORD
CERTIFICATION AND RECORD OF TRANSFERS

PAGE ____ OF ____ PAGES

NAME OF PRIME CONTRACTOR	GOVERNMENT SERIAL NO.	CONTRACT NO.	AIRCRAFT TYPE

I CERTIFY THAT THIS AIRCRAFT, AT TIME OF DELIVERY, WAS EQUIPPED WITH THE ITEMS LISTED IN PRECEDING PAGES OF THE AIRCRAFT INVENTORY RECORD WITH THE EXCEPTIONS OF THOSE NOTED ON DD FORM 780-2, "SHORTAGES".

CERTIFICATE NO.	TRANSFERRED FROM	DATE TRANSFERRED	SIGNATURE OF GOVERNMENT REPRESENTATIVE OR AUTHORIZED AGENT OFFICIAL DESIGNATION AND ORGANIZATION

I CERTIFY THAT THIS AIRCRAFT, AT TIME OF RECEIPT, WAS EQUIPPED WITH THE ITEMS LISTED IN PRECEDING PAGES OF THE AIRCRAFT INVENTORY RECORD WITH THE EXCEPTIONS OF THOSE NOTED ON DD FORM 780-2, "SHORTAGES".

CERTIFICATE NO.	RECEIVED BY	DATE CERTIFIED	SIGNATURE OF GOVERNMENT REPRESENTATIVE OR AUTHORIZED AGENT OFFICIAL DESIGNATION AND ORGANIZATION

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CERTIFICATE NO.	TRANSFERRED FROM	DATE TRANSFERRED	SIGNATURE OF GOVERNMENT REPRESENTATIVE OR AUTHORIZED AGENT OFFICIAL DESIGNATION AND ORGANIZATION

I CERTIFY THAT THIS AIRCRAFT, AT TIME OF RECEIPT, WAS EQUIPPED WITH THE ITEMS LISTED IN PRECEDING PAGES OF THE AIRCRAFT INVENTORY RECORD WITH THE EXCEPTIONS OF THOSE NOTED ON DD FORM 780-2, "SHORTAGES".

CERTIFICATE NO.	RECEIVED BY	DATE CERTIFIED	SIGNATURE OF GOVERNMENT REPRESENTATIVE OR AUTHORIZED AGENT OFFICIAL DESIGNATION AND ORGANIZATION

DD FORM 1 JUN 54 780-3 REPLACES AF FORM 263C SERIES, 1 APR 45, WHICH ARE OBSOLETE.

Figure 26. — DD Form 780-3, Certification and Record of Transfers.

AEROSPACE VEHICLE DELIVERY RECEIPT

DATE

INSTRUCTIONS

1. All items shown below must be present before delivery commences, except:

a. AN 1-1B-40 (*Weight and Balance Handbook*) which is necessary for only Class 1B and Class 2 aircraft. (*See T.O. 1-1B-43. Class 1A includes all Basic Trainer, Primary Trainer, and Liaison type aircraft, as well as a few Cargo and Advanced Trainer types.*)

b. Load Adjuster is necessary for all Class 2 aircraft. (*See T.O.1-1B-43.*)

2. Ferry pilot/transporter receiving aircraft/missile will personally check all forms and sign receipt provided.

3. Recipient organization will check all aircraft/missile forms upon delivery of the aircraft/missile and enter quantity of each item in column "J" below.

4. DISTRIBUTION OF THIS FORM: Copy 1 to home station; copy 2 for pilot/transporter; copy 3 for recipient; copy 4 for releasing organization; copy 5 to contract facility property administrator.

5. Indicate remarks on reverse.

AIRCRAFT/MISSILE MODEL	SERIAL NUMBER	ACCOUNT/CONTRACT NO	PROJECT AND/OR PRIORITY	FLT/TRANSPORTATION ORDER NO. (*When known*)

CLASSIFIED MATERIAL INSTALLED ON AIRCRAFT/MISSILE

RECEIVING ORGANIZATION	DELIVERY POINT
RELEASED BY (*Unit, Base and Command*)	PICK-UP POINT AND DATE

PAPERWORK CHECKLIST (*For aircraft/missile shown above*) A	PLACED ON AIRCRAFT/MISSILE BY RELEASING ORGAN B	RECEIVED BY PILOT/TRANSPORTER C	CHECK APPROPRIATE COLUMNS IN D	OUT E	IN F	OUT G	IN H	OUT I	RECEIVED BY RECIPIENT ORGAN J
DD FORMS 780 SERIES—AIRCRAFT/MISSILE									
AFTO FORMS 781, 781A, 781D, 781H, 781J AND 781K—AIRCRAFT									
AFTO FORM 781E OR AFTO FORMS 100 SERIES—AIRCRAFT									
AFTO FORMS 2E, 207, 208, 209 AND 281—MISSILES									
AFTO FORM 95—AIRCRAFT/MISSILE									
DD FORM 829-1, RCS 9LOG-K75 OR RCS LOG-K245—AIRCRAFT/MISSILE									
DD FORM 829-1 OR RCS 26-LOG-K75—AIRCRAFT ENGINES									
AFTO FORM 95 AND AFTO FORM 781E—AIRCRAFT ENGINES									
AFTO FORM 44—TURBO JET ENGINES									
AN 1-1B-40 WEIGHT AND BALANCE HANDBOOK—AIRCRAFT									
LOAD ADJUSTER—AIRCRAFT									
AFTO FORM 359—AIRCRAFT									
AFTO FORM 95 FOR COMPONENTS LISTED IN T.O. 00-20-4, SECTION II									
(*Enumerate applicable components below*)									

TRANSPORTING/FERRYING ORGANIZATION RECEIPT

I ACKNOWLEDGE RECEIPT OF AIRCRAFT/MISSILE WITH CONTENTS, AS NOTED ABOVE, AND WITH AIRCRAFT/MISSILE PAPERWORK LISTED IN COLUMN "B"

FERRYING/TRANSPORTING ORGANIZATION	TYPED NAME OF AUTHORIZED PERSON	SIGNATURE	DATE

RECIPIENT ORGANIZATION RECEIPT

I ACKNOWLEDGE RECEIPT OF AIRCRAFT/MISSILE WITH CONTENTS, AS NOTED ABOVE, AND WITH AIRCRAFT/MISSILE PAPERWORK LISTED IN COLUMN "B"

RECIPIENT ORGANIZATION	TYPED NAME OF AUTHORIZED PERSON	SIGNATURE	DATE

GPO 1971 OF—415-011

AF FORM FEB 71 510 PREVIOUS EDITIONS ARE OBSOLETE

Figure 27. - AF Form 510, Aerospace Vehicle Delivery Receipt.

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SUMMARY

In this section we have discussed the aircraft records and reports used in Coast Guard aircraft maintenance. Also discussed were instructions for completing the forms used for these records and reports.

Two types of forms are used in maintaining aircraft logbooks: (1) AFTO Form 781 series (781F, 781J, 781D, 781E), and (2) historical documents (AFTO Forms 95, 44, and 34). Computerized (mechanized) reports are used to keep track of aircraft and engine configuration. Operating units annotate these reports and forward them to appropriate offices. Miscellaneous and optional forms are authorized for use in maintaining records of aircraft accessory time.

Several reports are used in aircraft maintenance. These include the Unsatisfactory Report (UR), Aircraft/Type I Material Report, Aircraft Missle Condition Report and the Quality Deficiency Report.

Maintenance personnel use the Aircraft Flight Record, Part III, to record aircraft maintenance data.

The Aircraft Inventory Record provides a list of equipment items on an aircraft. The record is made up of four types of forms: (1) Cover page and the Section Breakdown Diagram, (2) Equipment Lists, (3) Shortages, and (4) Certification and Record of Transfer.

The Air Force forms discussed in this section may be requisitioned from the Coast Guard Supply Center, Brooklyn.

Answer the following review questions to see if you have achieved the objectives for this section. If you have any problem answering the questions, go back and review the text.

LESSON QUIZ

INSTRUCTIONS

Cover the answers to the questions with the Answer Key Mask. Carefully answer the questions; then remove the mask to check with the printed answer. If you answered any question incorrectly, refer to the text material.

1. If there is a conflict between Air Force and Coast Guard directives, the ________ directives have priority.	1. Coast Guard (Page 31)
2. Which AFTO form is the identification page for the logbook binder?	2. AFTO Form 781F (Page 31)
3. How is an engine change indicated on AFTO Form 781J?	3. An "engine change" entry is made on the next open date line (Page 37)
4. AFTO Form 781D is a required form in the ________ aircraft logbook ONLY.	4. HU-16E (Page 37)
5. An item requiring inspection or testing at a specified hourly or calendar period is listed on AFTO Form ________.	5. 781D (Page 37)
6. By subtracting the "previous operating time" from the "replace every" time and adding the "installed at" time on AFTO Form 781E, you will arrive at the ________ time.	6. "replacement due at" (Page 40)
7. When an aircraft is painted, an entry is made on AFTO Form ________.	7. 95 (Page 40)
8. What is one required entry on the AFTO Form 44?	8. Turbine wheel blade replacement (Page 44)
9. What form is used to track aircraft discrepancies upon which action must be delayed for more than one day?	9. Carry Forward Discrepancies FORM CG-5181. (Page 47)
DELETED	10. DELETED
11. The optional AFTO 100 series forms contain the same information as AFTO Form ________.	11. 781E (Page 44)

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12. Assume that five HH-3F primary hydraulic pumps have failed at your unit since September 1972. If you are writing a UR for the sixth pump, what entry should go in the "prior failures" block?

12. 5: 9-72 (Page 49)

13. Which aircraft components should NOT be disassembled to determine the cause of internal failures for UR information?

13. Instruments (Page 50)

14. The unit's copy (III and IV) of the Aircraft/Type I Material Report must be retained on file for ________ months.

14. 12 (Page 50)

15. Any unusual work to be performed by depot level maintenance during aircraft overhaul is reported by operating units on AFTO Form ________.

15. 103 (Page 54)

16. Who must initial the release box on Part III of the Aircraft Flight Record (CG-4377) if a delayed corrective action symbol is used?

16. Maintenance officer (Page 58)

17. After an aircraft has been dropped from the Coast Guard inventory, how long are aircraft inventory records maintained?

17. 3 months (Page 58)

18. If an inventory item is removed from an aircraft, the authority for removal should be indicated in the ________ block of DD-780-1.

18. "Location or Remarks" (Page 62)

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PAMPHLET REVIEW QUIZ

PAMPHLET REVIEW QUIZ

INSTRUCTIONS

Cover the answers to the questions with the Answer Key Mask. Carefully answer the questions; then remove the mask to check with the printed answer. If you answered any question incorrectly, refer to the text material.

1. In the Aircraft Maintenance Management System, the technical element of maintenance enginnering is performed by ________.

   A. AR&SC and Commandant (G-EAE)
   B. Commandant (G-EAE) and field units
   C. AR&SC and prime units
   D. Field units and AR&SC

1. C - AR&SC and the prime units work under the direction of Commandant (G-EAE) to provide field units with the technical element of maintenance engineering. (Page 2)

2. Which publication describes the standard organization of an air station's engineering section?

   A. Mission of U.S. Coast Guard Aviation Units (CG-112)
   B. Operating Facilities of the Coast Guard (CG-244)
   C. U.S. Coast Guard Organization Manual (CG-299)
   D. Air Operations Manual (CG-333)

2. D - The standard organization of ALL sections of an air unit is contained in Appendix B, Air Operations Manual (CG-333). (Page 2)

3. Which subsection maintains the master library of all technical publications and directives?

   A. Engineering administration
   B. Quality assurance
   C. Aircraft maintenance
   D. Avionics maintenance

3. B - Maintaining the master library is one of the functions of the Quality Assurance subsection. (Page 3)

4. Who supervises the examination board for plane captain qualification?

   A. Engineering officer
   B. Quality assurance officer
   C. Aircraft maintenance officer
   D. Engineering administration officer

4. A - The engineering officer designates the members of the Plane Captain Examining Board and supervises the board. (Page 3)

5. Which subsection manages the operation of an engineering section's tool room?

   A. Aircraft maintenance
   B. Quality assurance
   C. Aviation material
   D. Avionics maintenance

5. C - One of the functions of the aviation material subsection is to ensure that the unit's tool room is operated properly. (Page 5)

6. What are the two MAJOR categories of aircraft inspections?

A. Routine and Special
B. Intermediate and Major
C. Major and Phased
D. Intermediate and Special

6. A - All the various types of aircraft inspections are included in the two major categories. (Page 6)

7. An HH52A 10 Hour is an example of a ______________ inspection.

A. Preflight
B. Thruflight
C. Basic Postflight
D. Hourly/Weekly

7. D - These inspections are designed to provide servicing and verification of satisfactory functioning of critical systems components at frequent intervals. (Page 7)

8. Completed CG-4377's, Part III, should be retained at the unit for ______ months, then may be discarded.

A. 3
B. 6
C. 12
D. 24

8. C - Completed MPC's and Squawk Reports should be retained for three months. (Page 52)

9. Which maintenance operation requires a complete test flight?

A. C-130 engine change
B. Routine inspection
C. Hydraulic pump change
D. Fuselage skin patch

9. B - A complete test flight is necessary after a routine inspection, but a flight verification of functional check is sufficien after some maintenance. (Page 25)

10. How long should an engineering section retain HU-16E maintenance inspection/discrepancy records and test flight reports?

A. Until the aircraft goes to overhaul
B. 18 months
C. 1 year
D. Until the second subsequent periodic inspection or six months

10. D - After the second subsequent periodic inspection, these forms may be disposed of. (Page 22)

11. A Coast Guard air station that is NOT authorized to perform component repairs is a Class __________ maintenance activity.

A. A
B. B
C. C
D. D

11. D - Making component repairs is a function of a Class C maintenance activity. (Page 26)

12. The prime unit for the H-3 type helicopter is ___________.

A. CGAS, St. Petersburg
B. CGAS, New Orleans
C. CGAS, San Diego
D. ATC, Mobile

12. D - Aviation Training Center, Mobile, is the prime unit for HH-52A and HH-3F helicopters and the C-131 aircraft (Page 27)

13. A permanent history of significant aircraft maintenance action is maintained on AFTO Form ________.

A. 34
B. 44
C. 95
D. 119

13. C - AFTP Form 95, Significant Historical Data (Page 40)

14. Aircraft operating hours and accessory operating times needed for filling out UR's can be found on AFTO Form 781 ________. (HU-16E & C-131 ONLY)

A. D
B. E
C. F
D. J

14. B - AFTO Form 781E, Accessory Replacement Record, has spaces for entering operating hours accumulated on accessories. This information is needed for filling out a U.R. (Page 37)

15. Aircraft and engine time is recorded on AFTO Form 781 ________.

A. D
B. E
C. J
D. K

15. C - Aircraft and engine hours are recorded on AFTO Form 781J after each flight or at the close of each flying day (Page 36)

16. Which entry on AFTO Form 781J is circled in red?

A. Engine operating time at oil change
B. Airframe time at phase inspection
C. Airframe time at engine change
D. Engine operating time at last inspection

16. A - Engine operating time at oil change is circled in red on AFTO Form 781J. This aids in time keeping for oil changes and oil sample taking (Page 36)

17. If depot-level maintenance is not performed by AR&SC, who designates the other activity?

A. AR&SC
B. COMDT (G-EAE)
C. Prime Unit
D. USAF

17. B - (Page 2)

18. Which aircraft inspection is classified as a special inspection?

A. Preflight
B. Hourly
C. Intermediate
D. TCTO

18. D - (Page 7)

19. Who is responsible for the management and technical elements of equipment maintenance?

A. AR&SC
B. Prime Unit
C. COMDT (G-EAE)
D. Field Units

19. C - (Page 2)

20. AFTO Form 44 is used to document an operating history of ____________.

A. an aircraft
B. a reciprocating engine
C. a turbine engine
D. turbine wheels

20. D - A complete service life history of a turbine wheel is maintained on AFTO Form 44 (Page 40)

21. Maintenance Due List items may be delayed for a maximum of _________ days for calender items.

A. 10
B. 20
C. 30
D. 60

21. C - (Page 8)

22. Reporting activities identify Unsatisfactory Reports by assigning ____________.

A. consecutive fiscal year serial numbers
B. consecutive calendar year serial numbers
C. continuous consecutive serial numbers
D. alphabetical/numerical serial numbers according to category and fiscal year

22. B - Each January 1st the serial number sequence begins again (Page 49)

23. A unit has completed a UR for a failed aircraft component. The unit may turn the component over to the contractor's representative, providing prior approval was obtained from the ___________.

A. engineering officer
B. commanding officer
C. Commandant
D. Commanding Officer, AR&SC

23. C - The Commandant must approve of turning over government materials to a contractor (Page 49)

24. Part I of the Aircraft/Type I Material Report (CG-2897) for the month of July must arrive at AR&SC on or before ____________.

A. 10 July
B. 31 July
C. 10 August
D. 31 August

24. C - The parts of the report being mailed must reach their destination by the 10th of the month following the month for which the report is made (Page 50)

25. Which of the following must be entered in the REMARKS column of a unit's Aircraft/Type I Material Report for an aircraft received on board 5 August?

A. DG - 05
B. AR - 05/8
C. R-A/C - 5/08
D. DL - 05/08

25. A - Gains or losses of aircraft are reported in the "Remarks" block of the Aircraft/Type 1 Material Report 9CG-2897) (Page 53)

26. Deficency reports concerning Aircraft overhauled at AR&SC shall be submitted on a/an ________.

A. AFTO Form 103
B. UR Form 4010 (SM)
C. Standard Form 368
D. CG Form 4377

26. B - This is a new CG policy. SF-368 is used to report quality deficiencies of DOD overhauled aircraft and engines (Page 48)

27. The Aircraft/Missile Condition Report (AFTO Form 103) must arrive at its destination at least ________ days before the scheduled aircraft overhaul date.

A. 10
B. 15
C. 30
D. 45

27. D - Forty-five days permits the overhaul activity to adequately plan for the overhaul of the aircraft (Page 54)

28. On the MDL, an extension of interval for calender and hourly items can be made only by the ________ officer or designated represenative.

A. Operations
B. Engineering
C. Maintenance
D. Commanding

28. D - (Page 8)

29. What letter in an Aircraft Inventory Record identifies an inventory item located in the foremost section of an aircraft?

A. A
B. E
C. F
D. R

29. A - Using letters to identify the sections of an aircraft helps you to locate items of equipment during an inventory (Page 58)

30. Which CMS Report provides a detailed overall status of the aircraft and is printed on blue line paper?

A. Aircraft Maintenance Due List
B. Aircraft Status Report
C. Maintenance Requirements List
D. Maintenance Procedure Card

30. A - (Page 10)

MODIFICATIONS

Pages 69 - 136 of this publication has been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted materials involve extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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USCG GUARD INSTITUTE OKLAHOMA CITY

SHEET METAL LAYOUT AND FORMING

DEPARTMENT OF TRANSPORTATION
U. S. Coast Guard (11/81) AMI-0107

U. S. Coast Guard Institute
PAMPHLET NO. 345

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IMPORTANT
NOTICE TO THE STUDENT

A pamphlet review quiz appears in the back of this pamphlet. Correct answers and page references follow the questions. Do not send any answer sheets to the Coast Guard Institute. If you have any question about the course or any part of it write to the instructor for your rating.

This pamphlet contains original material developed at the Coast Guard Institute and also excerpts from:

Introduction to Metal/U.S. Air Force Manual 5331A 01 1061 0764

Airframe Maintenance and Repair/U.S. Air Force Manual . 52-11

IMPORTANT NOTE: In November, 1981, the information contained in this pamphlet was current according to the latest updates of those Directives/Publications listed. This pamphlet was compiled for training **ONLY**. It should **NOT** be used in lieu of official Directives or publications. It is always **YOUR** responsibility to keep abreast of the latest professional information available for your rate.

The personnel responsible for the latest review and update of the material in this component during November 1981 are:

AMCM H. F. Schoettle .... (Subject Matter Specialist)

Darla Burns .... (Education Specialist)

YN1 P. J. Schneider .... (Typographer)

YN1 P. J. Schneider .... (Typist)

Questions about the text should be addressed to your Subject Matter Specialist.

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SHEET METAL LAYOUT AND FORMING

TABLE OF CONTENTS

Shop Mathematics

This section is written for a number of people with varying degrees of mathematical knowledge. We have prepared the material on the assumption that the average student knows very little mathematics. The problems with their explanations and discussions are strictly problems in fabrication of sheet metal objects and sheet metalworking.

A portion of the material has to do with a thorough discussion and explanation of the various geometric figures with which you, in all likelihood, may have to deal in your work with sheet metal. Each figure is accompanied by the formula for figuring the area and/or volume of the figure. It is suggested that, for practice, you should work as many of these problems as you possibly can. Later on in the course, you will be called upon to work out some problems in connections with layout and fabrication.

Improper Fractions

A fraction in which the numerator is smaller than the denominator is called a proper fraction. Examples of proper fractions are 3/4, 2/3, 8/9, and 21/37.

Improper fractions are those with a numerator larger than the denominator: for example. 4/3 and 13/7. The fraction 4/3 may be considered to be the sum of 3/3 plus 1/3; and since 3/3 equals 1 or the whole, we can say 4/3 = 1 1/3. It is customary to change improper fractions to mixed numbers by dividing the numerator by the denominator. The quotient (or result) is expressed as a whole number followed by a fraction in which the remainder is the numerator, and the denominator is the same as before. For example, 52/15 = 3 7/15, since 15 is contained in 52 three times, leaving a remainder of 7.

Sometimes, as in multiplication, it is desirable to convert a mixed number to an improper fraction. This can be done by reversing the above process. To accomplish this conversion, we multiply the whole number by the denominator of the accompanying fraction and add the numerator. We then use this number as the new numerator, and the denominator remains the same as in the mixed number. Thus, to change 2 5/7 to an improper fraction, we multiply 2 × 7 and get 14; 14 + 5 equals 19: putting this over the original denominator, 7, we now have 19/7. Similarly, 4 3/5 = 23/5.

When both the numerator and denominator of a fraction contain a common factor, the fraction should be reduced by this factor. That is, the numerator and the denominator are divided by the common factor. For example, the fraction 9/15 can be reduced by dividing the 9 and the 15 by 3. The answer we get is 3/5, which has the same value as 9/15. This is called reducing a fraction to its lowest terms. If both the numerator and denominator of a fraction are either multiplied or divided by the same number, the value of the fraction is not changed.

Multiplication of Improper Fractions. Perhaps the simplest operation with fractions is multiplication. When mixed numbers are to be multiplied, change each to an improper fraction and then proceed as follows:

a. $1\ 2/3 \times 3\ 1/2 = 5/3 \times 7/2 = 35/6 = 5\ 5/6$
b. $1\ 1/4 \times 2\ 1/2 = 5/4 \times 5/2 = 25/8 = 3\ 1/8$

Canceling. Frequently we can simplify the multiplication and division of fractions by performing certain divisions of numerators and denominators before proceeding with the indicated multiplication. For instance, we could multiply 3/10 by 4/9 in the following way:

$$3/10 \times 4/9 = 12/90 = 2/15$$

In this case we reduced the 12/90 to its simplest form by dividing the 12 and the 90 by the common factor 6. But an easier way to do the problem would be:

$$\overset{1}{\cancel{3}}/\underset{5}{\cancel{10}} \times \overset{2}{\cancel{4}}/\underset{3}{\cancel{9}} = 2/15$$

Here we divided (commonly called canceling) before performing the indicated multiplication. We divided the numerator 3 and the denominator 9 by the common factor 3, and divided the numerator 4 and the denominator 10 by the common factor 2. Then, with the numerators 1 and 2 and the denominators 5 and 3, we easily arrived at the answer 2/15.

Adding Mixed Numbers. In adding mixed numbers we first add the whole numbers just as in ordinary addition, and then we add the fractions after changing all of the fractions to a common denominator. If the sum of the fractions is an improper fraction, we change it to a mixed number or a whole number, add the whole numbers, and keep the remaining fraction as part of the answer. A few examples will aid you in making this process clear.

Examples:

a.
$$\begin{aligned} 12\ 1/6 &= 12\ 3/18 \\ 14\ 2/3 &= 14\ 12/18 \\ 5\ 1/9 &= 5\ 2/18 \\ \hline & \quad 31\ 17/18 \end{aligned}$$

b.
$$\begin{aligned} 120\ 3/4 &= 120\ 6/8 \\ 52\ 3/8 &= 52\ 3/8 \\ 23\ 1/2 &= 23\ 4/8 \\ \hline &= 195\ 13/8 \\ 13/8 &= 1\ 5/8 \\ 195 + 1\ 5/8 &= 196\ 5/8 \end{aligned}$$

Subtraction of Mixed Numbers. When the fraction in the top number (minuend) is greater than the fraction in the lower number (subtrahend), we subtract the whole part from the whole part and the fraction from the fraction, arriving at our answer directly.

Examples:

a.
$$\begin{aligned} &22\ 4/5 \\ -&12\ 3/5 \\ \hline &10\ 1/5 \end{aligned}$$

b.
$$\begin{aligned} 22\ 3/4 &= 22\ 3/4 \\ -12\ 1/2 &= -12\ 2/4 \\ \hline & \quad 10\ 1/4 \end{aligned}$$

If the upper fraction is the smaller of the two, we must first borrow one whole unit from the top whole number, converting it into the fractional equivalent of a whole number and add this and the fraction we already have. Then we proceed with the subtraction.

Example:

$$\begin{aligned} 29\ 1/4 &= 28\ 5/4 \\ -15\ 3/4 &= -15\ 3/4 \\ \hline & \quad 13\ 2/4 = 13\ 1/2 \end{aligned}$$

Percentage

The term "percent" comes from the Latin term "per centum," which means "by the hundred" or "out of the hundred." One percent of a dollar is the same as one hundredth of a dollar or one cent. One percent can be expressed as 1/100, .01, or 1%. Similarly, 5% or .05 means "five out of every one hundred."

To change from percent to a decimal, you divide the number of percent by 100, which is the same as omitting the percent sign and moving the decimal point two places to the left.

Examples:

a. 5% = 5 hundredths = .05
b. 15% = 15 hundredths = .15
c. 320% = 3 and 20 hundredths = 3.20
d. 14.6% = 146 thousandths = .146

To change from a decimal to percent, we multiply the decimal fraction by 100, which is the same as moving the decimal point two places to the right and annexing the percent sign.

Examples:

a. $.45 = .45 \times 100 = 45\%$
b. $1.46 = 1.46 \times 100 = 146\%$
c. $.033 = .033 \times 100 = 3.3\%$

When solving problems involving percent, change the percent to a decimal and multiply as in decimals.

Examples:

a. 12.5% of 96.4 = $.125 \times 96.4 = 12.05$
b. 33 1/3% of 990 = $.33\ 1/3 \times 990 = 330.00$

In case the digits to the right of the decimal point are zeros, as in example *b*, the answer is a whole number. If there are digits other than zero, the answer will be a whole number and a decimal fraction.

To find what percent a quantity is of a larger quantity, we divide the smaller number by the larger number. The decimal or mixed number resulting shows the fractional part. Multiplying by 100 or moving the decimal point two places to the right, we state the figure as a percent.

Example:

```
                    .5757 = .58
a.  6600  /3800.0000
           3300 0
            500 00
            462 00
             38 000
             33 000
              5 0000
              4 6200
```

Thus, 3800 is 58/100 or 58% of 6600.

Powers and Roots

When two or more numbers are to be multiplied, each number is called a factor of the product. Thus, in the product $3 \times 4 = 12$, 3 and 4 are factors of 12. When the same number is used as a factor a given number of times, the product, or answer, is called a power. Since $4 \times 4 \times 4 = 64$, and 4 is used as a common factor, the product 64 is called a power. The factor 4 is used three times; therefore, the product 64 is the third power of 4. In the same manner, the fourth power of 2 is the product obtained by multiplying $2 \times 2 \times 2 \times 2$ which is 16. The second power of 8 is 64; the third power of 5 is 125, etc. The number which is to be raised to a power is called a *base*. Thus, the third power of 2 is 8. In this example, 2 is the number used as a factor which is to be raised to the third power; therefore, 2 is called the base.

If the base is a common fraction or a decimal fraction, the power is found in a similar manner. Thus, the third power of 2/3 is found by multiplying $2/3 \times 2/3 \times 2/3$ which equals 8/27. The second power of 2.1 is 2.1×2.1 which equals 4.41.

Examples:

a. Raise 8 to the third power.
$8 \times 8 \times 8 = 512$
b. Find the fourth power of 5.
$5 \times 5 \times 5 \times 5 = 625$
c. Find the third power of 3.2.
$3.2 \times 3.2 \times 3.2 = 32.768$
d. Find the second power of 12/13.
$12/13 \times 12/13 = 144/169$

Exponents. An exponent is a small number written to the right and a little above the base number to indicate the number of times the base is to be used as a factor or to indicate to what power the base is to be raised. Thus 3^2 means 3×3. Since 3 is the number used as a factor, it is the base. The 2 is the exponent and shows that 3 is to be used as a factor twice. Likewise, 4^3 means 4 is to be used as a factor three times; and 6^4 means that 6 is to be used as a factor four times or, in other words, 6 is to be multiplied by itself four times $(6 \times 6 \times 6 \times 6)$. If the exponent is 2, it is called the square; for example, 4^2 is read four squared. If the exponent is 3, it is called a cube. Thus 4^3 is read four cubed. If the exponent is 4, it means that the base is raised to the fourth power. All other exponents are read in a similar manner. When no exponent is indicated, it is understood to be 1. For example, 4 used as a base with no exponent is understood to mean 4^1 or 4.

When using addition, subtraction, multiplication, and division of numbers involving exponents, remember that the exponent is only a method of compactly writing an indicated multiplication. When the four fundamental processes of arithmetic are used in the same problem, we perform the multiplication and division first, then addition and subtraction. In the example $4^2 + 4^2$ we have, when written out, $4 \times 4 + 4 \times 4$, which gives us $16 + 16$, which equals 32. This might also be written 2×16, since 16 is equal to 4×4 or 4^2.

When adding and subtracting numbers, remember that only numbers of the same unit can be added or subtracted. This is also true of numbers containing exponents. This is similar to adding 2 square inches + 2 square inches, the sum being 4 square inches. The square represents the exponent and the inches represent the base. It is impossible to add 2 square inches and 2 cubic inches because the exponents (square and cubic) differ. Neither can you add 2 inches and 4 gallons because the bases (inches and gallons) differ.

In multiplication of terms having the same base, the product has the same base with an exponent equal to the sum of the exponents of the factor. *Example:* $3^2 \times 3^4 = 3^6$. The common base is 3; the exponents of the factors are 2 and 4. Therefore the product is the same base 3 with an exponent equal to the sum of 2 + 4, or 6.

The multiplication of common fractions and decimal fractions is performed in a similar manner; that is, $(4/9)^2 \times (4/9)^3 = (4/9)^5$. The base is 4/9 and the sum of the exponsnts is 5. In the use of decimals, $(4.6)^3 \times (4.6)^4 = (4.6)^7$. The base is 4.6 and the sum of the expohents is 7.

In the cases where the bases are not alike, perform the indicated operations and proceed by using the order of operation in arithmetic. Thus: $3^2 \times 4^3$ means $(3 \times 3) \times (4 \times 4 \times 4)$ or 9×64 which equals 576. It is impossible to combine unlike bases in any manner, whatsoever and indicate the answer by the use of exponents.

If a base number is to be raised to a power and then that quantity raised to another power, the answer is the base number with an exponent equal to the product of the exponents. *Example:* $(4^2)^3 = 4{,}096$. This means that the quantity 4^2 is to be used as a factor three times, or $4^2 \times 4^2 \times 4^2$, which is equal to 4,096, the base number 4 with an exponent equal to the product of the exponents 2×3 in the original example. In a like manner, $(3^4)^5 = (3^{20})$; $(2/3^2)^4 = (2/3^8)$; $(2.2^2)^3 = (2.2^6)$.

When terms having the same base are to be divided, the product is the common base with an exponent equal to the difference between the exponents in the dividend and the divisor. *Example:* $6^3 \div 6^2 = 6^1$. The base is 6 and the exponent in the answer is found by subtracting the exponent of the divisor, in this case 2, from the exponent of the dividend 3. The difference is 1, making the final answer 6^1 or 6. This may also be shown by cancellation. 6^3 is equal to $6 \times 6 \times 6$, and 6^2 is equal to 6×6. Therefore,

$$\frac{\not{6} \times \not{6} \times 6}{\not{6} \times \not{6}} = 6$$

If the bases are different, perform the indicated operations similar to multiplication. *Example:* $4^3 \div 3^2$ equals $64 \div 9 = 7\ 1/9$. It is impossible to combine the bases in any manner whatsoever and indicate the answer by use of the exponent if the bases are unlike.

Examples:

a. Find the value of 4^4.
$4^4 = 4 \times 4 \times 4 \times 4 = 256$

b. Find the value of $3^2 \times 3^4$.
$3^2 \times 3^4 = 3^{(2+4)} = 3^6$ or 729

c. Find the value of $5^2 \times 4^3$.
$5^2 \times 4^3 = 5 \times 5 \times 4 \times 4 \times 4 = 25 \times 64 = 1600$

d. Find the value of $(4.1)^2 \times (4.1)$.
$(4.1)^2 \times (4.1) = 4.1^3$ or 68.921

e. Find the value of $(3/4)^2 \times (3/4)^3$.
$(3/4)^2 \times (3/4)^3 = (3/4)^5$ or 243/1024

f. Find the value of $(6^2)^3$.
$(6^2)^3 = (6 \times 6)^3 = (6 \times 6)(6 \times 6)(6 \times 6) = 6^6$ or 46.656

g. Find the value of $7^4 \div 7^2$
$7^4 \div 7^2 = 7^{(4-2)} = 7^2$ or 49

Roots of Numbers. The square root of a number is that number which, when multiplied by itself, will give you an answer (product) equal to the original number. Thus, the square root of 9 is 3, because 3 multiplied by itself gives 9. The square root of 4 is 2 or of 49 is 7, etc. A radical sign is a symbol used to indicate roots. Whenever a root of a number is to be found, the radical sign is placed over the number, thus:

$\sqrt{9} = 3$ (the square root of 9 equals 3)

$\sqrt{25} = 5$ (the square root of 25 equals 5)

A little number written above the radical sign is called the index figure of the root; it indicates into how many equal factors the number is to be divided. The number beneath the radical sign is the radicand, which represents the number to be divided into equal factors. If there is no number above the radical sign, the index figure of the root is understood to be 2.

In solving such shop problems as finding the volume of a frustum of a pyramid, it is necessary to find the square root of numbers. Ordinarily these values can be found in all engineering handbooks, such as the *Machinist's Handbook*. These tables will save you much time and insure accurate results. However, you should understand the method of extracting the roots of numbers.

Extracting is the operation of finding the square root of a given number. Assume that we need to extract the square root of 186,624.

Beginning at the decimal point (the last figure at the right of a whole number), separate the numbers under the radical sign into groups of two digits each, moving toward the left: thus 18–66–24. If there is an uneven number of digits to the left of the last unit, it will of course have only one figure. Find the largest whole number that multiplied by itself will not exceed the value of the first set of numbers in the left-hand unit and write this number as the first figure of the answer. Then subtract the square of this number from the first group, 18, leaving a remainder of 2. This forms the new dividend (266).

Multiply the 4 × 2 = 8; add a zero (80). This is the first trial divider. Divide the dividend (266) by the trial divisor (80) to get the next figure in your answer. This gives you 3.

Add this figure (3) to the trial divisor for the final divisor (80 + 3 = 83).

Multiply the final divisor (83) by 3 and subtract this result (249) from the dividend (266). The remainder is 17, and you bring down the next unit (24).

Multiply your partial answer (43) by 20 to get the next trial divisor (860).

Divide the dividend (1724) by the trial divisor (860) for the third figure in your answer, which is 2.

Add this figure (2) to the trial divisor for the final divisor (862).

Multiply the final divisor (862) by 2 and subtract. There is no remainder, and the answer is 432, the exact square root of 186,624. The complete operation is as follows:

	4 3 2
	4√18–66–24
4 × 4 =	16
20 × 4 = 80	2 66
80 + 3 = 83	
83 × 3 =	2 49
20 × 43 = 860	17 24
860 + 2 = 862	
862 × 2 =	17 24

If any additional decimal places are required in the answer, annex zeros in groups of two to the given number and continue as before until a sufficient number of decimal places have been attained to make the answer as accurate as desired. For example, find the square root of 1.25 and carry to the nearest thousandths.

	1. 1 1 8
	1√1.25–00–00
1 × 1 =	1
20 × 1 = 20	25
20 + 1 = 21	
21 × 1 =	21
20 × 11 = 220	4 00
220 + 1 = 221	
221 × 1 =	2 21
20 × 111 = 2220	1 79 00
2220 + 8 = 2228	
2228 × 8 =	1 78 24
	76

Also, remember that at any time the trial divisor does not go into the dividend, you must place a zero in the answer. Then bring down the next group of figures and proceed as before.

Example:

	3 0 6
	$3\sqrt{9\text{-}36\text{-}36}$
3 × 3 =	9
20 × 3 = 60	36 36
600 + 6 = 606	
606 × 6 =	36 36

Square root of decimals. To determine the square root of a decimal fraction or a whole number and a decimal, always separate the whole number and the decimal in groups of two digits each, beginning at the decimal point.

Example:

2–18–46.65–87–5

If there is an uneven number of digits to the left of the decimal point or whole number, the extreme left group, 2, will contain only one digit instead of two. On the other hand, if we go to the right of the decimal point and the last group contains one digit, we can complete the last figure by adding a zero without changing the value of the number.

Example:

2–18–46.65–87–50

Remember that in each square root problem, the first step is that of separating the numbers into groups of two digits each. Beginning at the decimal point, work to the left on whole numbers, and to the right on the decimals.

Correctly grouped:	0.43–62–9	2–51.57–4
Incorrectly grouped:	0.4–36–29	25–1.5–74

In order to save confusion, always place the decimal in the answer as soon as the first group of decimals is moved down.

Example:

	1. 7 0
	$\sqrt{2.91\text{-}60}$
1 × 1 =	1
20 × 1 = 20	1 91
20 + 7 = 27	
27 × 7 =	1 89
20 × 17 = 340	2 60
340 + 0 = 340	
340 × 0 =	0 00
	2 60

Square root of common fractions. There are two methods which may be used in finding the square root of a common fraction. One is to change the common fraction to a decimal fraction. For example, find the square root of 144/169.

$$\frac{144}{169} = .8520$$

	. 9 2
	$\sqrt{.85\text{-}20}$
9 × 9	81
	4 20
18 × 20 + 2	3 64
	56

The other way is to extract the square root of both the numerator and the denominator.

Example:

	1 2		1 3
	$1\sqrt{1\text{-}44}$		$1\sqrt{1\text{-}69}$
1 × 1 =	1	1 × 1 =	1
20 × 1 = 20	44	20 × 1 = 20	69
20 + 2 = 22		20 + 3 = 23	
22 × 2	44	23 × 3 =	69

Therefore $\sqrt{\frac{144}{169}} = \frac{12}{13}$

Proof of square root. To prove a problem in square root, multiply the answer by itself and, if there is a remainder, add it to the product. This should give the original number from which the square root was to be extracted. To prove the above problem, proceed as follows:

```
     .92
   × .92
   -----
     184
    828
   -----
   .8464
  +.0056 remainder
   -----
   .8520
```

Equations and Formulas

In this section, we are entering into one of the most important relations between mathematics and the sheet metal man. Do not treat it lightly, for your complete understanding of this phase and successful use of formulas will eliminate difficulties and wasted time. The use of the formula in the shop is not difficult because it deals primarily with the fundamentals of arithmetic and simple algebra.

Equations. An equation is a mathematical statement which expresses the equality of two or more quantities. For example, the statement $5 + 4 = 9$ is an equation. It expresses in an abbreviated form the fact that $5 + 4$ is equal to 9. Furthermore, if three unknowns such as a, b, and c were given and it was assumed that the whole equaled the sum of the parts, the equation $a + b + c = x$ could be formed. This is the abbreviated or short form of the above statement.

An equation is always divided into two parts by the sign of equality (=). These two parts of the equation are called members of the equation or the two sides of the equation.

It is necessary that the equation be balanced at *all times*. If two unequal weights are placed in the pans of a common scale, the scale will not balance. In like manner if we say $2 + 2 = 2 + 3$, our equation does not balance. It should read $2 + 2 = 2 + 2$, or 4. In an equation, however, any change may be made provided the equality is maintained.

Formulas. A formula is a special type of an equation which expresses a certain fact, law, or relation by means of symbols or letters. There are several reasons why a formula is used in solving many shop problems. First of all, a formula is more compact, making it easier for the eye to distinguish the whole meaning of the law or rule at a glance. Secondly, it is easier for an individual to memorize a few symbols rather than a paragraph of explanations. For example, the law for determining the area of a circle is usually stated as follows: *The area of a circle is equal to the square of the radius times pi (3.1416).* This law, however, can be simplified by the equation $A = r^2\pi$. Any equation that is expressed by the use of algebraic symbols is called a formula. In this formula you are given a full picture of how to attain the area of a plane, in this case the circle. If you will notice, this formula eliminates using long terms that are difficult to interpret. In short, we have a simplified expression of the same law or rule.

For example, if the speed of a driving pulley and its diameter are known, the speed of the driven pulley may be determined by the following rule:

Multiply the speed of the driving pulley, in revolutions per minute, by its diameter and divide the product by the diameter of the driven pulley to obtain the speed of the driven pulley.

Now, if S is the speed of the driving pulley, D is the diameter of the driving pulley, I is the diameter of the driven pulley, and s is the speed of the driven pulley, then we can set up the following formula which represents the rule previously given:

$$s = \frac{S \times D}{I}$$

This formula merely shows that to obtain the speed (s) of the driven pulley, the speed (S) of the driving pulley must be multiplied by its diameter (D) and the product divided by the diameter (I) of the driven pulley. It is evident, then, that the formula is practically a picture of the rule. It enables the individual to see at a glance that to obtain the value of s, it is simply necessary to multiply the values of S and D and divide the product by I.

In some formulas, two letters represent one quantity or numerical value. For instance, HP is used to represent horsepower; BHP is used to represent brake horsepower of a fan motor; VP is used to represent velocity pressure which is used in designing air ducts.

Transformation of formulas. As shown by the preceding examples, the common method of writing a formula is to place the known value on one side of the equal sign and the unknown value on the opposite side. As an example, the formula $A = L \times W$ states that the area of any rectangle (A) may be found if the length (L) is multiplied by the width (W). Now, if the area (A) and the length (L) are known, the problem is to find the width (W). This formula can be changed or transposed to read:

$$W = \frac{A}{L}$$

Here we have the same law but a different arrangement for the purpose of finding the width

(W) if the area (A) and length (L) are given. It is necessary to know how a formula can be changed or transposed to determine the values represented by different letters of the formula. Changing a formula in this way is known as transposition. The four general rules that apply to transposition are as follows:

a. A single term preceded by a plus sign (+) can be transferred to the other side of the equal sign (=) if the plus sign is changed to a minus sign (–).

b. A single term preceded by a minus sign (–) can be transferred to the other side of the equal sign (=) if the minus sign is changed to a plus sign (+).

As an illustration, suppose in the equation $X = M - Y$ we want to find the value of Y. To do this, we must apply the rules previously given. Transpose or change $-Y$ from one side of the equation to the other merely by changing the sign, for example:

$$X = M - Y$$
$$Y + X = M$$
$$+Y = M - X$$

All we have done here is to move the $-Y$ to the other side of the equal sign and make it a $+Y$. We also must move X to the right of the equal sign, changing its value to a $-X$. So our equation now reads $Y = M - X$. Perhaps this can be seen better if arithmetic values are used in the equation. If $X = 12$ and $M = 16$, what is the value of Y?

Example:

$$12 = 16 - Y$$
$$Y + 12 = 16$$
$$Y = 16 - 12$$
$$+Y = 4$$

c. Any member which multiplies all the other members on one side of the equal sign can be transposed to the other side of the equal sign *if* it is made to divide all the members on that side.

As an illustration, suppose we use the formula $A = LW$. Remember, if we have two terms given, we can find the third term by using rule *c*. Assuming that A is 24 inches and L is 4 inches, what is W? In order to change or transpose L from one side of the equation to the other, we must divide the terms to the left and right of the equal sign by L and proceed as in ordinary arithmetic, thus:

$$A = LW \text{ or } \frac{A}{L} = \frac{\not{L} \times W}{\not{L}}$$

$$\frac{A}{L} = W$$

If we substitute our arithmetical terms for these symbols, we have something like this:

$A = 24$ inches

$L = 4$ inches

$W = ?$

$$\frac{A}{L} = W$$

$$\frac{24}{4} = W = 6$$

d. Any member which divides all the other members on one side of the equal sign can be transposed or changed to the other side of the equal sign if it is made to multiply all the members on both sides of the equal sign.

As an illustration for this rule, we can use the formula for finding the area of a rectangle. If this formula reads $\frac{A}{L} = W$ and we want to find the value of A, we proceed as follows: Assume that L is 4 inches and W is 6 inches; L must be brought to the other side of the equation, which means that we must multiply both sides of our formula by L. Our formula will now look like this: $A = LW$ or $L \times W$. If we substitute numerical numbers for our symbols, our answer will be:

$$\frac{A}{L} = W$$

$$\not{L} \times \frac{A}{\not{L}} = \times W$$

If $L = 4$ inches

$W = 6$ inches

$A = ?$

$A = LW$ (or $L \times W$)

$A = 4 \times 6$

$A = 24$ inches

Mensuration

Mensuration sounds like a big word, and yet it is just the term used for the process of measuring. To use Webster's definition, mensuration is the act, art, or process of measuring. Mensuration can be explained in the following

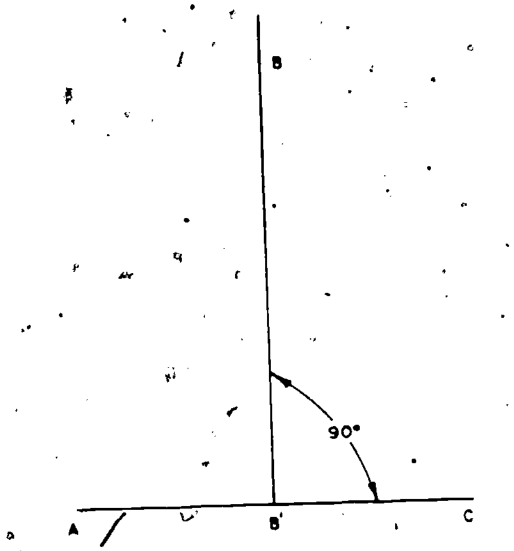

Figure 1. *Perpendicular lines.*

example. Assume that you are planning to construct a building. Angles, solids, lengths of lines, surfaces, areas, and volumes must be determined before the construction begins. Measurements must be taken; this is called mensuration. When measurements are taken, certain principles or laws must be strictly followed. Therefore the following information is presented in the form of definitions to aid you in the process of mensuration.

Lines. A *straight line* is the shortest line that can be drawn between two points. When the term "line" is used, it is understood to mean a straight line. A *curved line* is a line no part of which is straight; and a *broken line* is made up of a series of straight lines. *Parallel lines* are lines in the same plane which will never meet, regardless of how far they are extended. All lines are measured in linear units and have only one dimension, length.

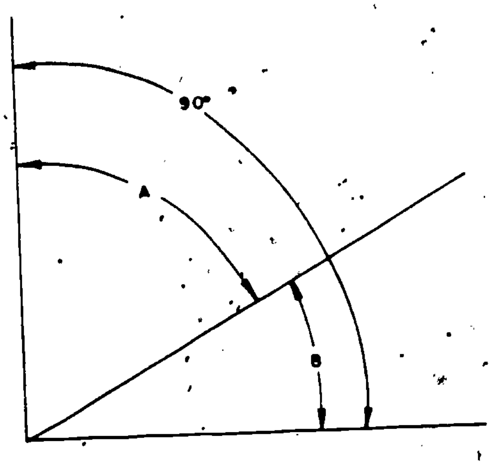

Figure 2. *Complementary angles.*

Angles: An angle is the amount of opening between two intersecting straight lines. The point of intersection of the two sides (lines) is known as the *vertex*. Angles are measured in degrees (°), which are further divisible into minutes, which in turn are divisible into seconds.

Example:

60 seconds (″) = 1 minute (′)
60 minutes (′) = 1 degree (°)
90 degrees (°) = 1 right angle
180 degrees = 1 straight line

A line is *perpendicular* to another line if it forms an angle of 90° with the other line (see figure 1). BB' is perpendicular to AC.

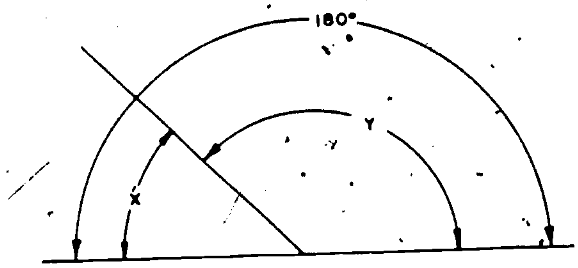

Figure 3. *Supplementary angles.*

Complementary angles are angles whose sum equals a right angle or 90° (see figure 2). Angle A + angle B = 90°.

Supplementary angles are angles whose sum equals 180° (see figure 3). Angle X + angle Y = 180°.

Geometric Figures. A *figure* is a point, a straight or curved line, a surface, a solid, or any combination of these (see figure 4).

Similar figures are those having the same shape.

Equivalent figures are those having the same size.

Congruent (or equal) figures are those having the same shape and size; therefore, they can be made to occupy the same space.

A rectilinear figure is one composed only of straight lines.

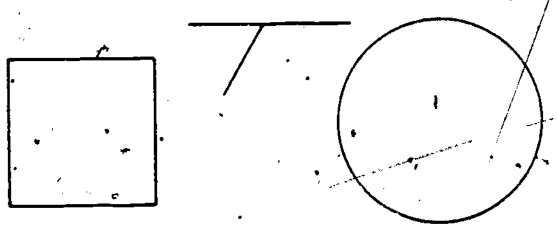

Figure 4. *Geometric figures.*

A curvilinear figure is one composed only of curved lines.

Polygons. A figure containing many sides and angles, usually more than four, is called a polygon.

A *quadrilateral* polygon has four sides.

An *equilateral* polygon is one in which all the sides are equal.

Polygons of more than four sides are named by the use of a Greek prefix: penta meaning five, hexa meaning six, octa meaning eight, etc. Thus, pentagon means a five-sided polygon.

Triangles. A triangle is a three-sided figure. The sides of a triangle are the lines which bound or inclose it. Therefore, angles of a triangle are those angles formed by the sides. In any triangle the sum of the angles is 180°. The base of a triangle is the side upon which it is supposed to stand. Therefore, any side may be the base. The angle opposite the base is called the vertex angle, the point opposite to and farthest from the base. The altitude of a triangle is the perpendicular distance from the vertex to the base (see figure 5). DAC is a triangle; angle A is the vertex angle. Point *A* is the vertex of the vertex angle, and *DC* is the base of the triangle. *BA* is the altitude of the triangle *DAC*.

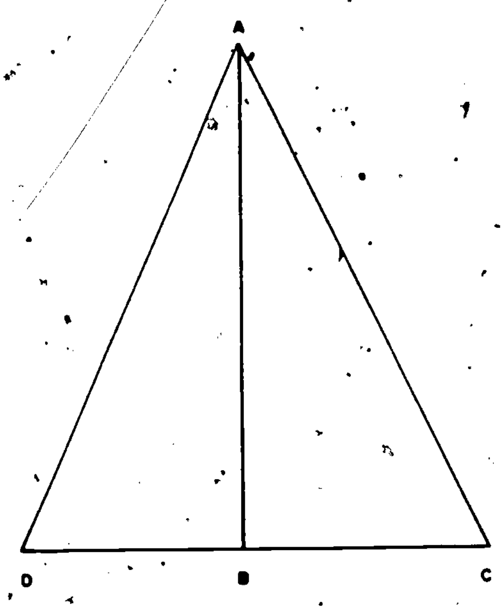

Figure 5. *Vertex of a triangle.*

An *isosceles triangle* is a triangle in which two sides are equal, as shown in figure 6. Side BA is equal to side *AC*. Therefore, side *BC*, or the unequal side of an isosceles triangle, is always called the base. The point where the two equal sides intersect is always called the vertex.

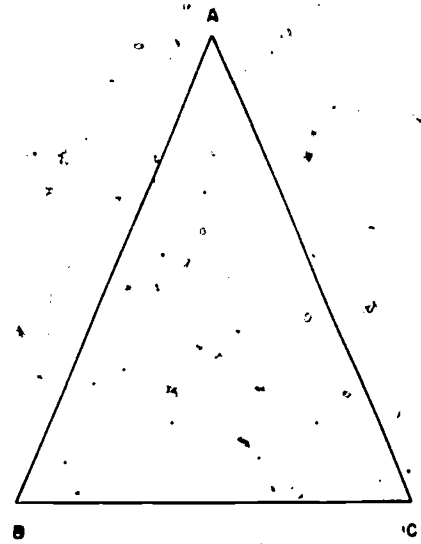

Figure 6. *Isosceles traingle.*

An *equilateral triangle* is one having *all sides* equal, as shown in figure 7.

An *equiangular triangle* is one having *all angles* equal. Therefore, an equilateral triangle is equiangular, and an equiangular triangle is equilateral (see figure 8). AB is equal to BC, which in turn is equal to *AC*. Each angle (*A*, *B*, and *C*) contains 60°, with a total of 180°.

A *right triangle* is a triangle in which one of the angles is 90°. The side opposite the 90° angle is known as the *hypotenuse*, and the other two sides are called legs.

An *acute triangle* is one in which each angle of the triangle is less than 90°.

An *obtuse triangle* is a triangle in which one

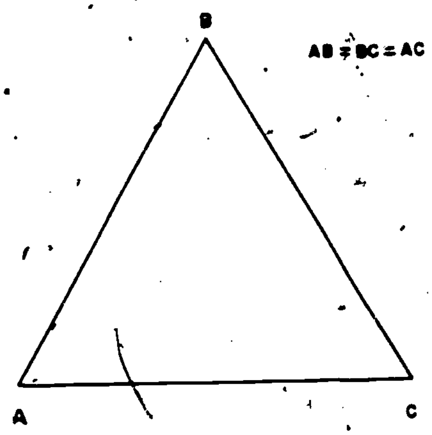

Figure 7. *Equilateral traingle.*

of the angles is more than 90°. A sample of each of these three triangles is shown in figure 9.

Circles. A circle is a closed curved line all points of which lie in the same plane and are equidistant from a point called the center. This center is generally labeled with a capital letter to identify or name the circle. To successfully perform pattern development, it is necessary to know the lines and line parts of a circle. These are shown in figure 10 and are defined as follows.

The *circumference* of a circle is the length of the curved line which forms the circle; it is often referred to as the perimeter of a circle. Generally speaking, the letter "*C*" is used to designate circumference in a formula. A circle contains 360°; this means that the circumference of any circle is divided into 360 equal units of measurement. In sheet metalwork we must find the linear measurement (inches, feet, etc.) of the circumference of a circle. This is done by multiplying the diameter by a predetermined number. This predetermined number is called pi (π). Pi is a numerical value (3.1416) indicating the ratio of the distance around the perimeter of the circle to the diameter of the circle.

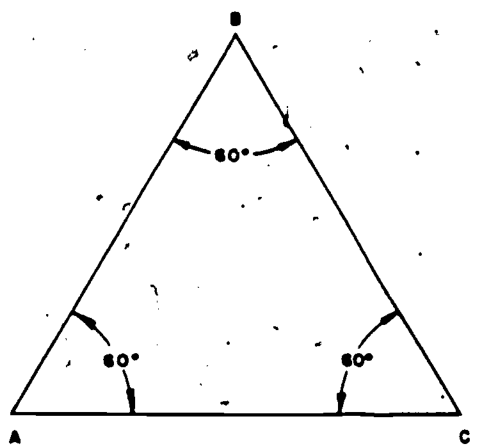

Figure 8. *Equiangular traingle.*

The *diameter* of a circle is a line drawn through the center and ended by the circumference. The letter "*D*" is always used to identify this part of the circle.

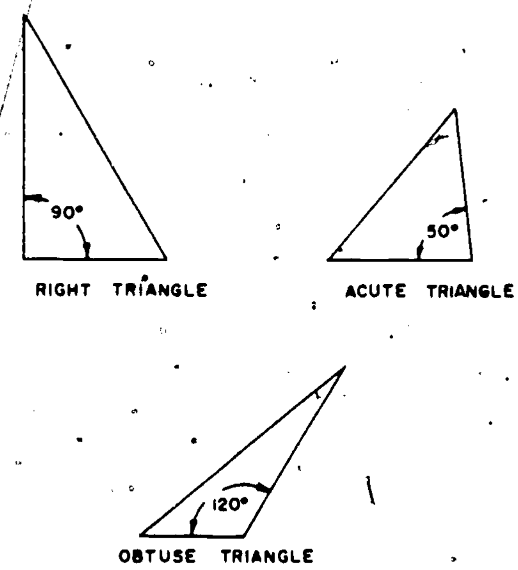

Figure 9. *Types of triangles.*

The *radius* of a circle is one-half the diameter or the distance from the center to a point on the circumference. The letter "*R*" is always used to name this part.

An *arc* is any part of a circle, such as *AB*. If the arc should bisect the circle, it is known as a semicircle. Letters or numbers may be used to identify various arcs.

A *chord* is a straight line joining the ends of an arc, as shown by line *AB*. Whenever one chord is drawn within a given circle, we have two arcs. A *minor* arc is less than a semicircle and a *major* arc is larger than a semicircle.

A *tangent* is a straight line drawn in such a

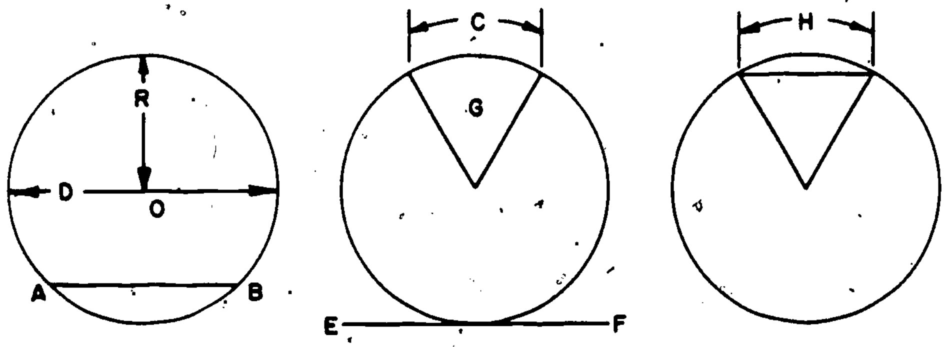

Figure 10. *Parts of a circle.*

manner that it touches, never crosses, only a single point of the circumference of a circle. Line EF is tangent with the circle shown in figure 10.

A *sector* of a circle is that part bounded by two radii and an arc. In the illustration we have used the letter "*G*" to identify the sector of a circle bounded by the arc *C*.

A *segment* of a circle is that part which is bounded by an arc and a chord connecting the ends of the arc. The letter "*H*" is the segment of the circle in figure 10.

Solids. A solid is any surface or a series of surfaces which will inclose a section of space. The illustration in figure 11 represents a cube. It has six surfaces or faces which inclose a section of space. All solids have length, thickness, and width.

A *prism* is a solid figure which has bases or ends that are similar, equal, and parallel polygons, the faces or surfaces of which are parallelograms (see figure 12).

A *pyramid* is a solid figure whose base may be a plane triangle, rectangle, or other polygon.

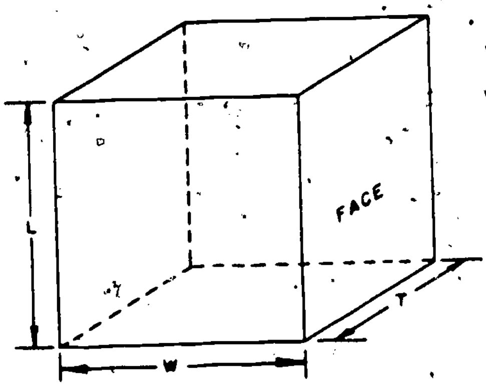

Figure 11. *A cube.*

Its sides form several triangles with a common vertex with their bases forming the sides of the pyramid base (see figure 13).

A *cylinder* is a solid figure bounded by a lateral curved surface with ends or bases round and equal in size (see figure 14). The axis

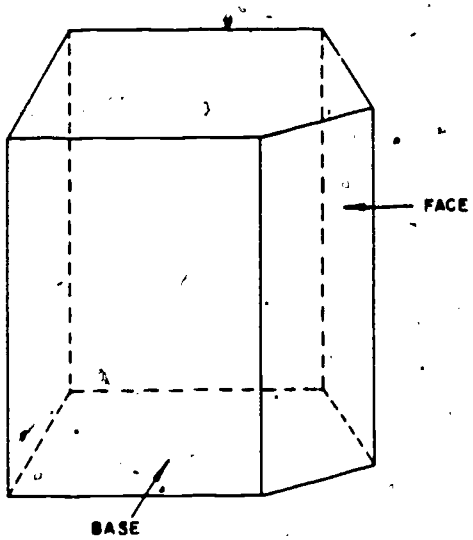

Figure 12. *A prism.*

of a cylinder is the lengthwise center line about which the cylinder turns.

A *sphere* is a solid figure bounded by one surface, all points of which are equidistant from a point within called the center (see figure 15). The *axis of a sphere* is the fixed center line about which the sphere revolves. The *diameter of a sphere* is any straight line that passes through the center of the axis and ends when it touches the surface of the sphere.

A *cone* is a solid figure attained when a

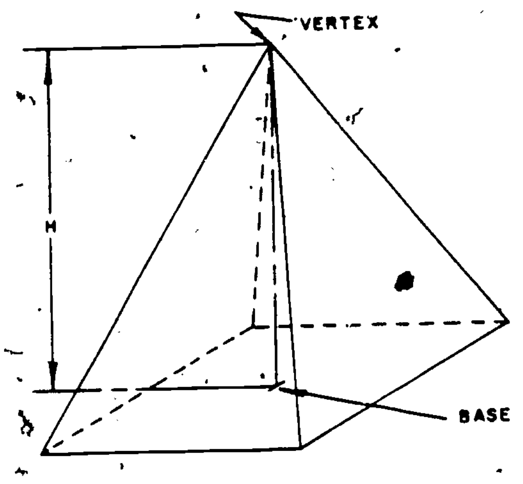

Figure 13. *A pyramid.*

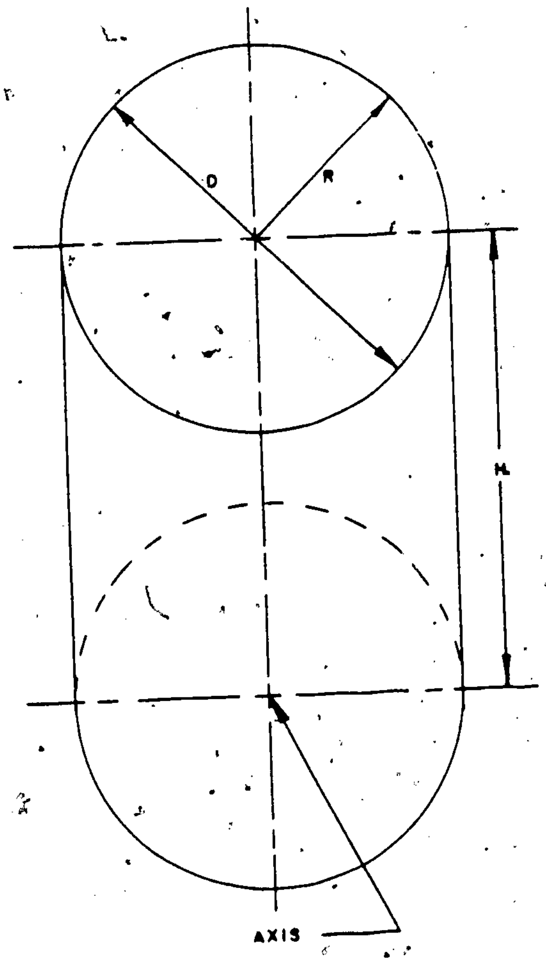

Figure 14. *A cylinder.*

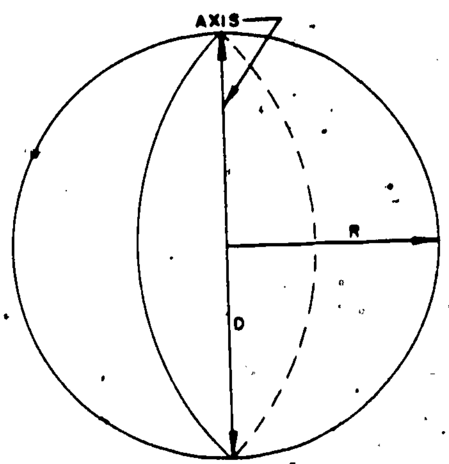

Figure 15. *A sphere.*

right triangle is rotated about one of its legs. This leg is commonly referred to as the axis. The base of the cone is the circle formed when the horizontal leg is rotated completely around the axis (see figure 16).

Area of Plane Surfaces. What is area? Webster defines area as the superficial surface included within any given line. This means that any figure or object that has a plane or flat surface bounded by sides but which has no thickness is considered an area. Examples of areas are tabletops, the top surface of floors in a room, or the walls of a room. However, remember that area does not merely mean a large flat surface; it is a form of measurement. Therefore, it is capable of being measured.

Area, unlike other forms of measurement, is measured by a unit of surface. Each unit has two dimensions, length and width (see fig. 17). Then the area of a surface is the number of square units that are contained in a given surface. For example, in figure 18 we have an illustration of a rectangle whose sides are 4 inches long and 3 inches wide. Each square in the rectangle is 1 by 1 inch, which makes each of them a unit of measurement. If you count the number of squares in the rectangle, you will find that we have twelve 1-inch squares or 12 square inches.

We have just covered the most elementary method of finding the area of a given surface or figure. Although it works, it is clumsy and

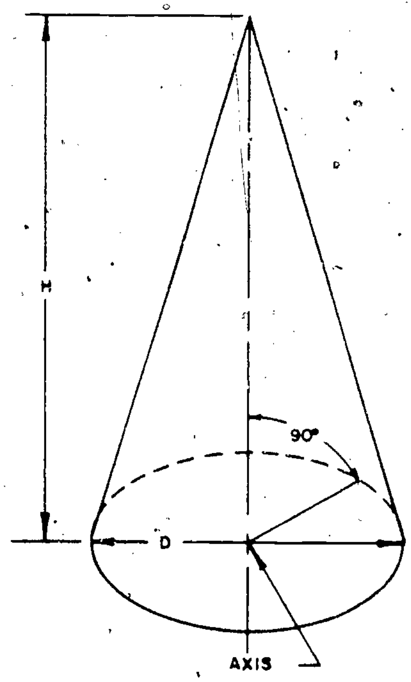

Figure 16. *A cone.*

impractical. Below is a list of formulas that will aid you in determining the area of surfaces.

Square. The square, as shown in figure 19, has four sides which are of equal length and four 90° angles between the sides. To determine the area of a square, we must multiply the length of one side by itself. If the side of a square is 15 inches, then to find the area we must multiply 15 × 15, which equals 225 square inches. Then the formula for finding the area of a square is $A = S^2$.

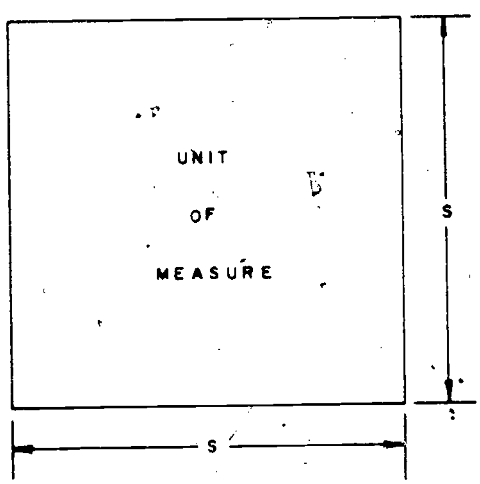

Figure 17. *Measurement of area.*

Rectangle. The rectangle, shown in figure 20, has four sides, the opposite sides of which are equal in length and parallel. The remaining sides, or ends, are perpendicular to the first two sides.

We can find the area of a rectangle by multiplying the height by the length or base. Assume that the height is 6 inches and the base is 8 inches; then the area equals 6 × 8 or 48 square inches. Then the area of a rectangle can be determined by the formula $A = L \times W$.

If the area and one side of a rectangle is known, the other side can be found by dividing the area by the length of the known side.

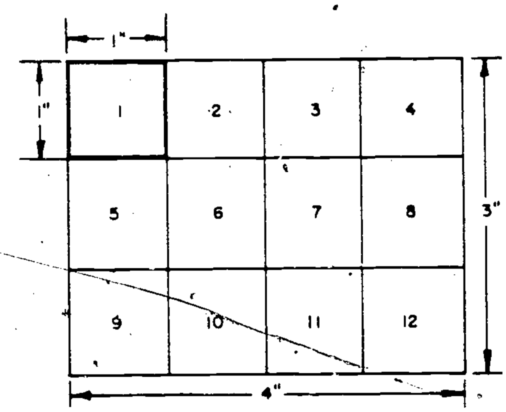

Figure 18. *Area of a rectangle.*

If the area of a rectangle equals 144 square inches and the length of one side is 12 inches, then the height of the other side is 144 ÷ 12 = 12 inches.

Parallelogram. Figure 21 illustrates a four-sided figure commonly known as a parallelogram. The opposite sides are equal and parallel to each other. Therefore, the opposite angles are equal. According to previous information, a rectangle is a special type of parallelogram. The height or altitude of a parallelogram is determined by drawing a perpendicular line from the base to the opposite side. Dimension *a* is the elevation, and *b* is the base.

To determine the area of a parallelogram, multiply the base by the height. If *a* is 16 inches and *b* is 16 inches, then the area is 16 × 16, or 256 square inches. If the area and height are

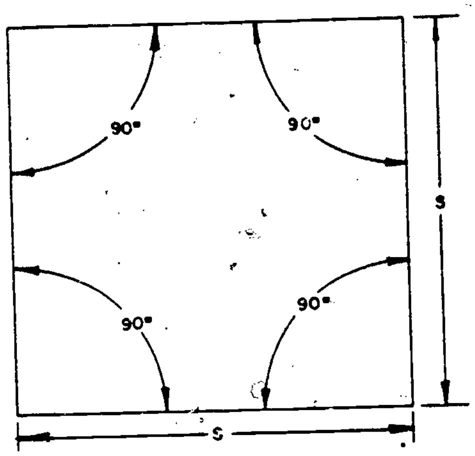

Figure 19. *A square.*

known, you can find the length of the base by dividing the height into the area.

Example: Find the base when the area is 256 square inches and the height is 16.

$$A = a \times b$$

$$\frac{A}{a} = \frac{a \times b}{a} \quad \text{Transpose}$$

$$\frac{A}{a} = b = \frac{256}{16}$$

$$b = 16 \text{ inches}$$

Trapezoid. A trapezoid, as shown in figure 22, is a quadrilateral with only the top and base parallel. The height of a trapezoid is the perpendicular distance between the two parallel sides, a and b. To find the area of a trapezoid, we must take one-half the sum of the length of the parallel sides and multiply by the height.

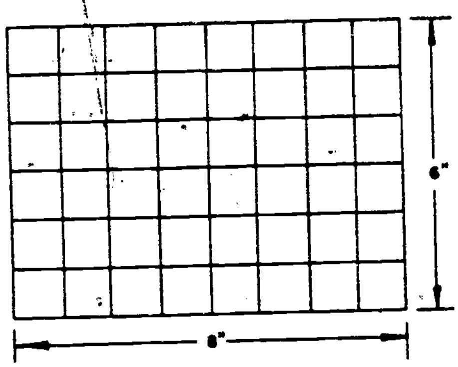

Figure 20. *A rectangle.*

To illustrate, assume that a equals 4 feet, b equals 6 feet, and h equals 2 feet. Then the area will equal 1/2 (4 + 6) × 2, or 10 square feet.

For example, assume side a = 23 feet, side b = 30 feet, and height = 12 feet. Find the area.

$$A = \frac{(a + b)}{2} \times h$$

$$A = \frac{(23 + 30)}{2} \times 12$$

$$A = \frac{53 \times 12}{2}$$

$$A = 318 \text{ square feet}$$

Triangles. A triangle, shown in figure 23, is any figure bounded by three straight lines. Any one of the three sides can be called the base. The altitude or height of a triangle is established by drawing a perpendicular line from the base to the vertex. To find the area of any triangle, multiply the base times the height and divide by 2. If b is the base and is equal to 16 inches, and h is the height and is equal to 8 inches, then the area (A) would equal 16 × 8 ÷ 2, or 64 square inches.

For example, find the area of a triangle which has a base of 24 inches and an altitude or height of 12 inches.

$$A = \frac{bh}{2}$$

$$A = \frac{24 \times 12}{2}$$

$$A = \frac{288}{2}$$

$$A = 144 \text{ square inches}$$

Circles. If we know the diameter of a circle, the circumference can be found by multiplying the diameter by the fixed number 3.1416. ($C = \pi D$.)

If we know the circumference of the circle, the diameter can be found by dividing 3.1416 into it. Instead of using the number 3.1416 in a formula, the term pi (π) is generally used; for example, $4\pi = 4 \times 3.1416$.

To determine the area of a circle, you can use two methods: square the radius and multiply it

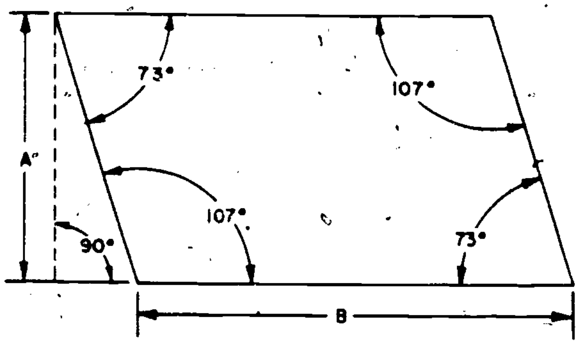

Figure 21. *A parallelogram.*

by π or square the diameter, and multiply it by 0.7854. Either rule is correct.

If we know the area of a circle, we can find the radius by taking the square root of the area divided by 3.1416. For example, the area of a circle is 12.5664 square inches; find the radius. Let D equal the diameter, A equal the area, and R equal the radius, then:

$$R = \sqrt{\frac{A}{\pi}} \qquad R = \sqrt{\frac{12.5664}{3.1416}}$$

Now divide the area, 12.5664 square inches, by pi to get the radius squared, which is 4. Then extract the square root of 4 and we arrive at the radius, which is 2 inches, as shown below.

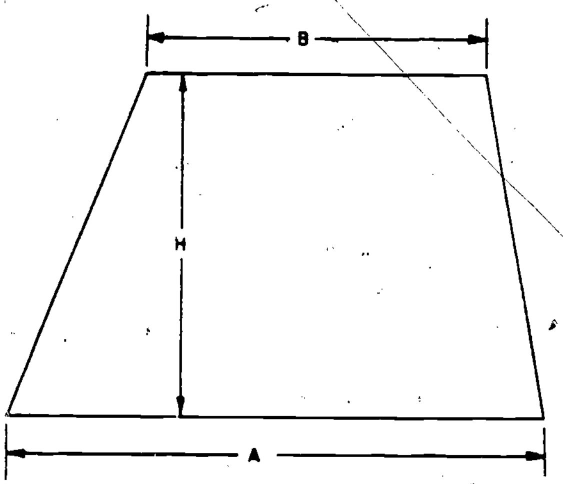

Figure 22. *A trapezoid.*

$$R = \sqrt{4}$$
$$R = 2 \text{ inches}$$

Circular ring. A circular ring, as shown in figure 24, is a circle which has had the center removed. Therefore, the area of the inner circle must be determined and subtracted from the area of the original circle in order to find the area of the circular ring which remains.

The following formula is used to find the area of any circular ring, $A = (R^2 - r^2) \times 3.1416$. For example, assume that the radius of the larger circle is 6 inches (R) and the radius of the inner circle is 4 inches (r). If we substitute numbers for letters in the formula, it now reads: area equals 3.1416 $(6^2 - 4^2)$, or $A = 3.1416 \times (36 - 16)$; or $A = 3.1416 \times 20$; or $A = 62.83$ square inches.

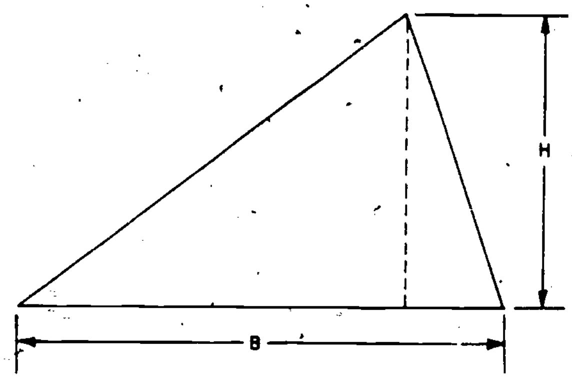

Figure 23. *A triangle.*

Volume. The volume of an object is the space occupied by that object. Volume is measured by length, width, and thickness; and the measurement is expressed in cubic inches, cubic feet, etc. In sheet metalwork the measurement of volume is used extensively to determine the capacities of different objects. For instance, if we know the dimensions of a given cylindrical tank and the number of cubic feet in a gallon of a specific liquid, we can determine how many gallons of that particular liquid the tank will hold.

Cube. The cube, as shown in figure 25, is the basic measurement used in determining the volume of solid or hollow objects. Therefore, it is extremely important that you understand its basic characteristics. For all practical purposes, a cube is a solid object with all sides equal. If

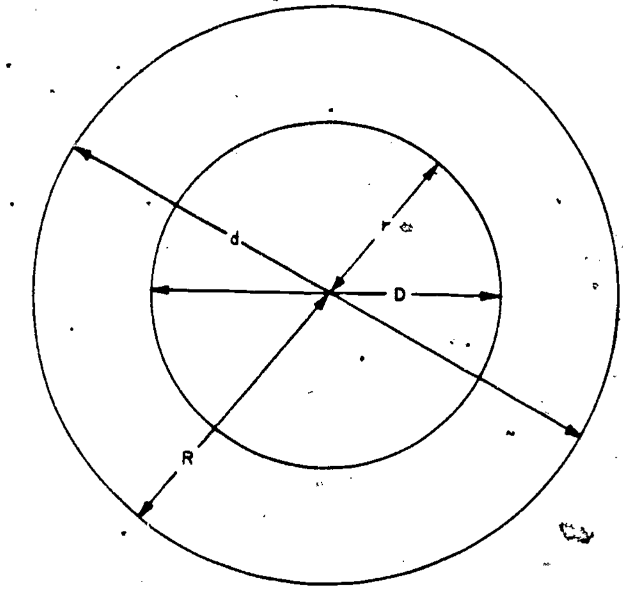

Figure 24. *Circular ring.*

one side of a cube equals S, then the volume equals $S \times S \times S$, or the length times the width times the height. Since all sides of a cube are equal, the rule can be written $V = S^3$. Let us assume that the length of one side of a cube is 4 inches; then the volume would be $4 \times 4 \times 4$, which equals 64 cubic inches. In other words, a 4-inch square contains sixty-four 1-inch cubes.

Square prism. A square prism, shown in figure 26, is a solid object, the sides of which are

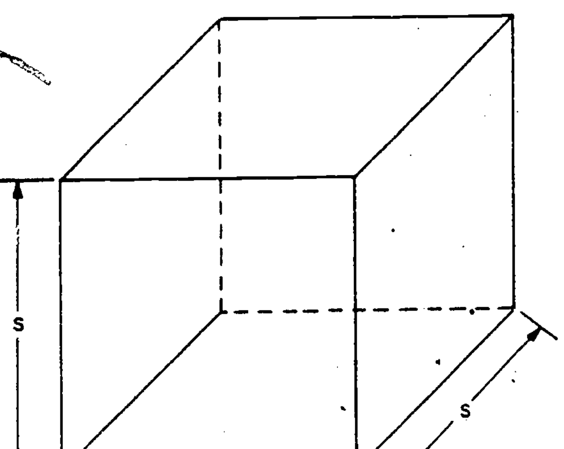

Figure 25. *A cube.*

rectangular and the ends of which can be square or rectangular in shape. All angles are right angles, and the opposite surfaces are parallel. To determine the volume of a square prism, simply multiply the length times the height times the width ($V = L \times W \times H$). Assume that $L = 10$ inches, $W = 6$ inches, and $H = 8$ inches; then the volume would be $10 \times 6 \times 8$, or 480 cubic inches.

Pyramid. To determine the volume of a pyramid, shown in figure 13, multiply the area of the base by one-third its height ($V = 1/3\ H \times$ area of base). The height of a pyramid is a line drawn from the vertex, perpendicular to the base. Assume we have a pyramid 18 inches in height and a base 12 inches square. The volume of the pyramid equals $1/3\ (18 \times 12 \times 12)$ or 864 cubic inches.

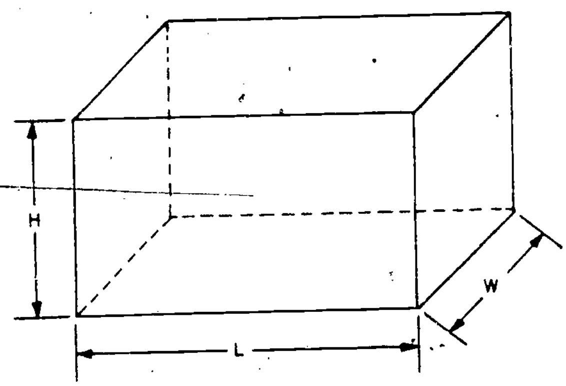

Figure 26. *Square prism.*

Circular cylinder. The volume of a cylinder (see figure 14) equals the area of the base multiplied by the height ($V = .7854\ d^2h$). Assume we have a cylinder with a diameter of 5 inches and a height of 40 inches; find the volume.

$$V = .7854 d^2 h$$
$$V = .7854 \times 5^2 \times 40$$
$$V = .7854 \times 25 \times 40$$
$$V = 785.4 \text{ cubic inches}$$

In order to find the volume of part of a cylinder (see figure 27), we must multiply the sum of two vertical heights (H, h) by the fixed number, .3927 (1/8 of π). So our formula now reads:

$$V \doteq .3927\ d^2\ (H + h)$$

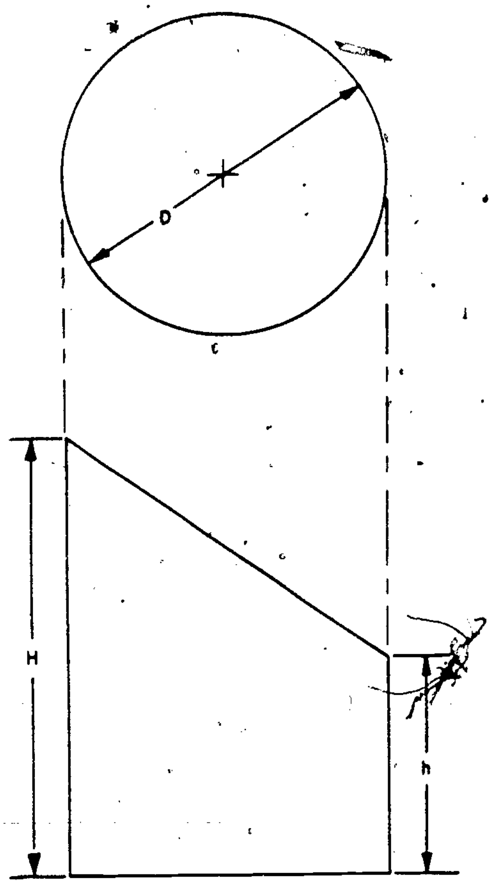

Figure 27. *Irregular frustum of a cylinder.*

Assume we have a cylinder 6 inches in diameter and it is cut off at an angle, as shown in the illustration. $H = 12$ and $h = 6$ inches; find the volume of the figure.

$V = .3927\ d^2\ (H + h)$
$V = .3927 \times 6^2 \times (12 + 6)$
$V = .3927 \times 36 \times 18$
$V = 254.470$ cubic inches

Cone. In order to find the volume of a cone, shown in figure 16, it is again necessary to find the area of its base. The volume can be found by multiplying one-third of the height by the area of the base. If D equals the diameter of the base and H equals the height, then the area equals $.7854D^2$ multiplied by one-third of the height.
Example:

Volume $= .7854 \times D^2 \times 1/3 \times H$, or
$1/3 \times .7854 \times D^2 \times H$, which equals
$.2618 \times D^2 \times H$

The number .2618 can be used as a constant. So our formula now reads:

Volume $= .2618D^2H$

Assume the diameter of a cone is 6 inches and the height is 9 inches; what is the volume?
Example:

$V = .2618d^2h$
$V = 2618 \times 6^2 \times 9$
$V = .2618 \times 36 \times 9$
$V = 84.8$ cubic inches

A *frustum* of a cone is a cone, shown in figure 28, with its top cut off, which leaves the top circle or surface parallel with the base. The height of a frustum of a cone is the distance of a line drawn from the top surface perpendicular to the base. The volume of a frustum of a cone can be found when the diameter of the parallel surfaces and the height are known. For example, let V equal the volume of the frustum, H equal the height, D the diameter of the bottom surface, and d the diameter of the top surface.

The volume of a frustum can be determined in the following manner:

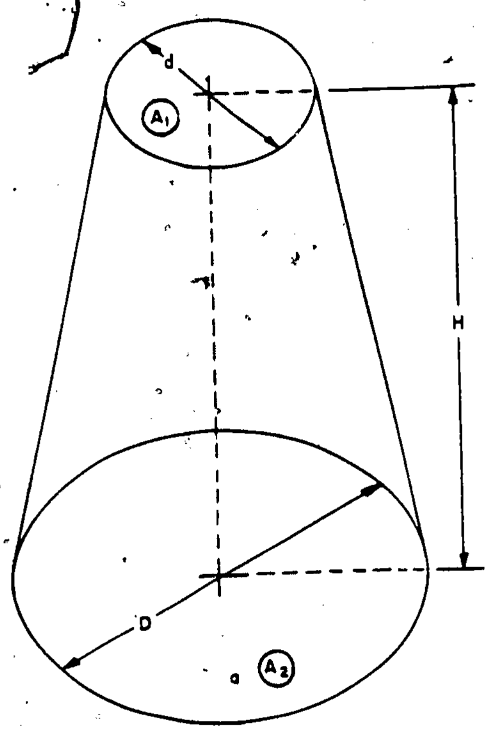

Figure 28. *Frustum of a cone.*

a. Find the area of the upper surface $A_1 = \pi r^2$
b. Find the area of the lower surface $A_2 = \pi R^2$
c. Multiply $A_1 \times A_2$ and take the square root of the product $\sqrt{A_1 \times A_2}$
d. The volume of the frustum is equal to 1/3 of the height times the sum of $(A_1 + A_2 + \sqrt{A_1 \times A_2})$ The formula is:

$$\text{Volume} = 1/3\ H\ (A_1 + A_2 + \sqrt{A_1 \times A_2})$$

Now suppose that we want to make a grain hopper, and its upper portion is a frustum of a cone. The height of the frustum is 6 feet, the base is 8 feet in diameter, and the top diameter is 6 feet. How much grain will it hold? If we substitute figures in the formula above, we have:

$$V = 1/3\ H\ (A_1 + A_2 + \sqrt{A_1 \times A_2})$$
$$V \doteq 2\ (28.274 + 50.265 + 3769)$$
$$V = 2\ (116.23)$$
$$V = 232.46 \text{ cubic feet}$$

Summary

As a sheet metalworker, you should remember that mathematics plays a very important part in the construction trade. Regardless of the articles to be manufactured, they must be measured accurately. For example, let us make a 2-gallon measure that has the following dimensions: top 6 3/4 inches, bottom 8 3/4 inches, and a height of 9 3/4 inches. These fractions may have to be added, subtracted, multiplied, or divided in order to arrive at the amount of metal needed to make one container. Once the amount of metal needed for one container is determined, it is possible to calculate the area of metal needed for a given number of containers. However, circumstances may arise when only the size of an object is given; then, it will be up to you to determine the amount of oil, grain, etc., the object will hold.

This section has been devoted to the discussion of mathematics and geometrical forms; the information may have been confusing at times. However, you should thoroughly understand this information in order to comprehend pattern devlopment.

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Forming Processes

Before a part is attached to the aircraft during either manufacture or repair, it has to be shaped to fit into place. This shaping process is called forming. Forming may be a very simple process, such as making one or two holes for attaching, or it may be exceedingly complex, requiring shapes with complex curvature.

Parts are formed at the factory on large presses or by drop hammers equipped with dies of the correct shape. Every part is planned by factory engineers who set up such specifications for the materials to be used that the finished part will have the correct temper when it leaves the machines. A layout for each part is prepared by factory draftsmen.

Forming processes used on the flight line and those practiced in the maintenance shop or repair depot are almost directly opposite in method of procedure. They have much in common, however, and many of the facts and techniques learned in the one process can be applied to the other.

Forming is of major concern to the airframe repairman and requires the best of his knowledge and skill. This is especially true since forming usually involves the use of extremely light-gage alloys of a delicate nature which can be readily made useless by coarse and careless workmanship. A formed part may seem outwardly perfect, yet a wrong step in the forming procedure may leave the part in a strained condition. Such a defect may hasten fatigue or may cause sudden structural failure.

Of all the aircraft metals, pure aluminum is the most easily formed. In the other alloys, ease of forming varies with the temper condition. Since modern aircraft are constructed chiefly of aluminum and aluminum alloys, this section deals with the procedures for forming those types of metals. Most parts can be formed without annealing the metal, but if extensive forming operations such as deep draws (large folds) and complex curves are planned, the metal should be in the dead soft or annealed condition. During the forming of some complex parts, operations may have to be stopped and the metal annealed before the process can be continued or completed. Alloy 2024 in the "O" condition can be formed into almost any shape by the common forming operations, but it must be heat-treated afterward.

In forming, use hammers and mallets as sparingly as practicable, and make straight bends on bar folders and cornice brakes. Use rotary machines whenever possible. If a part fits poorly or not at all, do not straighten a bend or a curve and try to re-form it. Discard the piece of metal and start with a new one.

In making layouts, be careful not to scratch aluminum or aluminum alloys. A pencil, if kept sharp, will be satisfactory for marking. Scribers make scratches which induce fatigue failure, but they may be used if the marking lines fall outside the finished part—that is, if the scribed line will be in the waste material. Keep bench tops covered with material hard enough to prevent chips and other foreign material from becoming imbedded in them. Be sure also to keep bench tops clean and free from chips, filings, and the like. For the protection of the metals being worked, keep vise jaws covered with soft metal jaw caps.

Stainless steel can be formed by any of the usual methods but requires considerably more skill than aluminum or aluminum alloys. Since stainless steel work-hardens very readily, it requires frequent annealing during the forming operations. Always try to press out stainless steel parts in one operation. Use dies, if possible.

FORMING OPERATIONS AND TERMS

The methods you will use in forming operations include such sheet metalwork processes as shrinking, stretching, bumping, crimping, and folding.

Bumping

Shaping or forming malleable metal by hammering or pounding it to form a bump is called bumping. During this process, the metal is supported by a dolly, a sandbag, or a die. Each contains a depression into which hammered portions of the metal can sink. Bumping can be done by hand or by machine.

Crimping

Whenever you fold, pleat, or corrugate a piece of sheet metal in a way that shortens it, you are crimping it. Crimping is often used to make one end of a piece of stovepipe slightly smaller so that one section may be slipped into another. Turning down a flange on a seam is also called crimping. Crimping one side of a straight piece of angle with crimping pliers will cause it to curve, as is shown in figure 54.

Stretching

If you should hammer a flat piece of metal in an area such as is indicated in figure 54, the material in that area will become thinner. However, since the amount of metal will not have been decreased, it will cover a greater area. You will therefore have caused stretching at this spot.

Stretching one portion of a piece of metal affects the surrounding material, especially in the case of formed and extruded angles. For example, if you should hammer the metal in the horizontal flange of the angle strip over a metal block (as shown in figure 54), its length would be increased (stretched) and, therefore, that section would become longer than the section near the bend. To allow for this difference in length the vertical flange, which tends to keep the material near the bend from stretching, would be forced to curve away from the greater length.

Shrinking

During the shrinking process, material is forced or compressed into a smaller area. The shrinking process is used when the length of a piece of metal, especially on the inside of a bend, is to be reduced. The shrinking of sheet metal can be accomplished in two ways: by hammering on a V-block (figure 55), or by crimping and then shrinking on a shrinking block.

To curve the formed angle by the V-block method, place the angle on the V-block and gently hammer downward against the upper edge directly over the V (figure 55). Move the angle back and forth across the V-block, while hammering, to compress the material along the upper edge. Compression of the material along the up-

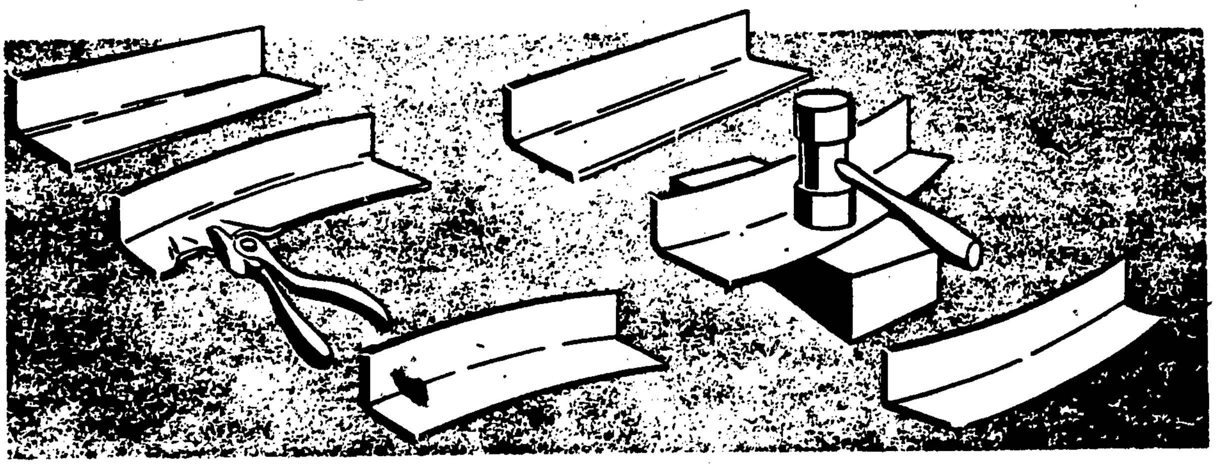

Figure 54. *Crimping and Stretching*

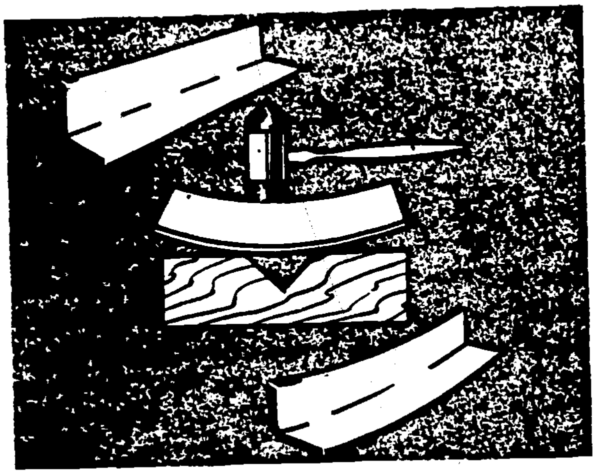

Figure 55. *Shrinking on a V, Block*

per edge of the vertical flange will cause the formed angle to take on a curved shape. The material in the horizontal flange will merely bend down at the center and the length of that flange will remain the same. This method is very effective if the curve (or the bend) is not to be too sharp.

To make a sharp curve or a sharply-bent flanged angle, you would probably utilize crimping and a shrinking block. In this process, you would place crimps in the one flange, then apply a shrinking block and, by hammering, drive out (shrink out) the crimps one at a time.

Folding

Making bends in sheets, plates, or leaves is called folding. Folds are usually thought of as sharp, angular bends. They are generally made on folding machines.

Making Straight Line Bends

When forming straight bends, you must consider the thickness of the material, its alloy composition, and its temper condition. Generally speaking, the thinner the material, the sharper it can be bent (the smaller the radius of bend), and the softer the material, the sharper the bend.

The sharpest bend that can be placed in a piece of metal without critically weakening the part is called the minimum radius of bend. Other factors that must be considered when making straight line bends are bend allowance, set-back, and brake or sight line.

Formulas and tables to be applied under the varying conditions have been established for your use. Application of the formulas usually consists merely of substituting measurements, such as sheet stock thicknesses and degree of bends. All these tables and formulas are based on the decimal system. If sheet stock thicknesses are given in gage numbers, you must convert them to their decimal equivalent before you can proceed with your calculations.

RADIUS OF BEND. The radius of bend of a sheet of material is the radius of the bend as measured on the inside of the curved material. The minimum radius of bend of a sheet of material is the sharpest curve, or bend, to which the sheet can be bent without critically weakening the portion at the bend. If the radius of bend is too small, stresses and strains will weaken the metal and may result in cracking.

A minimum radius of bend is specified for each type of aircraft sheet metal: The kind of material, thickness, and temper condition of the sheet are factors affecting it. You may bend annealed sheet to a radius approximately equal to its thickness. Stainless steel and 2024–T aluminum alloy require a fairly large bend radius.

BEND ALLOWANCE. Suppose you were confronted with the problem of making a formed angle or a stringer to fit into a corner. The corner measures 1 inch on each side, but you realize that you cannot make a square bend in the metal and that it will not fit squarely into the corner because it will have a curve. You know, also, that the curved distance will be shorter than the distance into the corner and out. When making a bend or fold in a sheet of metal, you must calculate bend allowance—the length of material required for the bend.

Bend allowance depends on four factors: the degree of bend, the radius of the bend, the thickness of the metal, and the type of metal used. The radius of the bend is generally proportional to the thickness of the material. Furthermore, the sharper the radius of bend can be made, the shorter will be the material needed for the bend. The type of material is also important, for if the material is soft it can be bent very sharply, but if it is hard the radius of bend will be greater, and bend allowance will be greater. The degree of bend will affect the overall length of the metal, whereas the thickness influences the radius of bend.

Bending the strip would compress the material on the inside of the curve and stretch the material on the outside of it. However, at some distance between these two extremes lies a space which is not affected by either force. This is known as the neutral line or neutral axis. It occurs at a distance approximately 0.445 of the metal thickness (0.455 × T) from the inside of the radius of bend. (See figure 56.)

When bending metal to exact dimensions, the length of the neutral line must be determined in order that sufficient material can be allowed for the bend. To save you time in calculation of the bend allowance, formulas and charts for various angles, radii of bends, material thicknesses, and other factors have been established for your use. The bend allowance formula for a 90° bend can be derived as follows.

To the radius of bend, R, add one-half the thickness of the metal, ½ T. This gives R + ½ T, or the radius of the circle of approximately the neutral axis.

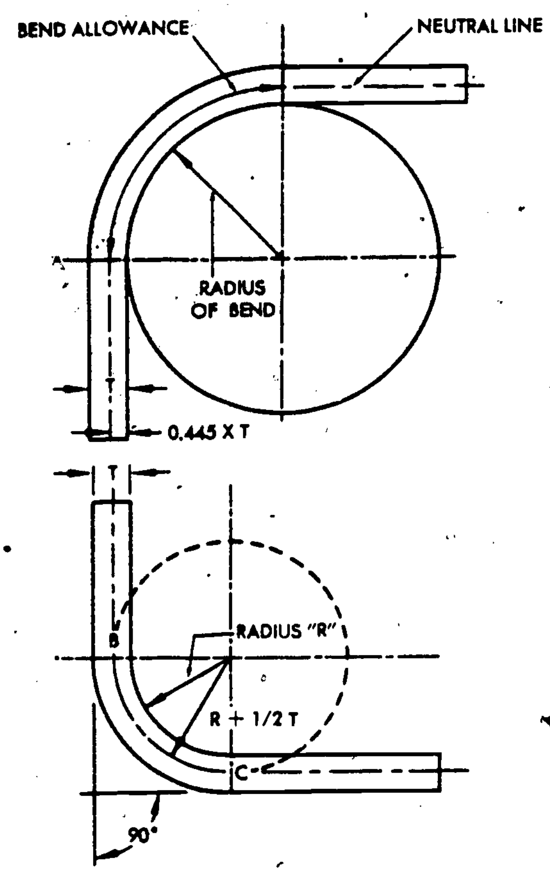

Figure 56. *Bend Allowance, 90° Bend*

Compute the circumference of this circle by multiplying the radius of curvature of the neutral line (R + ½ T in the illustration) by 2π. This gives the circumference as

$$2\pi(R + \tfrac{1}{2}T)$$

Since a 90° bend (AB in figure 56) is a quarter of the circle, divide the circumference by 4. This gives

$$\frac{2\pi(R + \tfrac{1}{2}T)}{4}$$

Therefore, bend allowance for a 90° bend is

$$\frac{2\pi(R + \tfrac{1}{2}T)}{4}$$

To use the formula in finding the bend allowance for a 90° bend having a radius of ¼-inch for material 0.051-inch thick, substitute in the formula as follows:

Bend allowance

$$= \frac{2 \times 3.1416[.250 + \tfrac{1}{2}(.051)]}{4}$$

$$= \frac{6.2832(.250 + .0255)}{4}$$

$$= \frac{6.2832(.2755)}{4}$$

$$= .4323$$

So, the necessary bend allowance or the length of material required for the bend is 0.4323- or 7/16-inch.

The formula is slightly in error because actually the neutral line is not exactly in the center of the sheet being bent (see figure 56). However, the amount of error incurred in any given problem is so slight that, for most work, since the material used is thin, the formula is satisfactory.

This formula may be used in the absence of a bend allowance chart. To determine bend allowance for any degree of bend by use of the chart (figure 57), find the allowance per degree for the thickness of the material and the radius of bend in question, and then multiply by the number of degrees in the bend.

Radius of bend is given as a decimal fraction on the top line of the chart. Bend allowance is given directly below the radius figures. The top number in each case is the bend allowance for a 90° angle, while the lower placed number is for a

RADIUS GAGE	.031	.063	.094	.125	.156	.188	.219	.250	.281	.313	.344	.375	.438	.500
.020	.062 .000693	.113 .001251	.161 .001792	.210 .002333	.259 .002874	.309 .003433	.358 .003974	.406 .004515	.455 .005056	.505 .005614	.554 .006155	.603 .006695	.702 .007795	.799 .008877
.025	.066 .000736	.116 .001294	.165 .001835	.214 .002376	.263 .002917	.313 .003476	.362 .004017	.410 .004558	.459 .005098	.509 .005657	.558 .006198	.607 .006739	.705 .007838	.803 .008920
.028	.068 .000759	.119 .001318	.167 .001859	.216 .002400	.265 .002941	.315 .003499	.364 .004040	.412 .004581	.461 .005122	.511 .005680	.560 .006221	.609 .006762	.708 .007862	.805 .007862
.032	.071 .000787	.121 .001345	.170 .001886	.218 .002427	.267 .002968	.317 .003526	.366 .004067	.415 .004608	.463 .005149	.514 .005708	.562 .006249	.611 .006789	.710 .007889	.807 .008971
.038	.075 .000837	.126 .001396	.174 .001937	.223 .002478	.272 .003019	.322 .003577	.371 .004118	.419 .004659	.468 .005200	.518 .005758	.567 .006299	.616 .006840	.715 .007940	.812 .009021
.040	.077 .000853	.127 .001411	.176 .001952	.224 .002493	.273 .003034	.323 .003593	.372 .004134	.421 .004675	.469 .005215	.520 .005774	.568 .006315	.617 .006856	.716 .007955	.813 .009037
.051		.134 .001413	.183 .002034	.232 .002575	.280 .003116	.331 .003675	.379 .004215	.428 .004756	.477 .005297	.527 .005855	.576 .006397	.624 .006934	.723 .008037	.821 .009119
.064		.144 .001595	.192 .002136	.241 .002676	.290 .003218	.340 .003776	.389 .004317	.437 .004858	.486 .005399	.536 .005957	.585 .006498	.634 .007039	.732 .008138	.830 .009220
.072			.198 .002202	.247 .002743	.296 .003284	.436 .003842	.394 .004283	.443 .004924	.492 .005465	.542 .006023	.591 .006564	.639 .007105	.738 .008205	.838 .009287
.078			.202 .002249	.251 .002790	.300 .003331	.350 .003889	.399 .004430	.447 .004963	.496 .005512	.546 .006070	.595 .006611	.644 .007152	.745 .008252	.840 .009333
.081			.204 .002272	.253 .002813	.302 .003354	.352 .003912	.401 .004453	.449 .004969	.498 .005535	.548 .006094	.598 .006635	.646 .007176	.745 .008275	.842 .009357
.091			.212 .002350	.260 .002891	.309 .003432	.359 .003990	.408 .004531	.456 .005072	.505 .005613	.555 .006172	.604 .006713	.653 .007254	.752 .008353	.849 .009435
.094			.214 .002374	.262 .002914	.311 .003455	.361 .004014	.410 .004555	.459 .005096	.507 .005637	.558 .006195	.606 .006736	.655 .007277	.754 .008376	.851 .009458
.102				.268 .002977	.317 .003518	.367 .004076	.416 .004617	.464 .005158	.513 .005699	.563 .006257	.612 .006798	.661 .007339	.760 .008439	.857 .009521
.109				.273 .003031	.321 .003572	.372 .004131	.420 .004672	.489 .005213	.518 .005754	.568 .006312	.617 .006853	.665 .008394	.764 .008493	.862 .009575
.125				.284 .003156	.333 .003697	.383 .004256	.432 .004797	.480 .005338	.529 .005678	.579 .006437	.628 .006978	.677 .007519	.776 .008618	.873 .009700
.156					.355 .003939	.405 .004497	.453 .005038	.502 .005579	.551 .006120	.601 .006679	.650 .007220	.698 .007761	.797 .008860	.895 .009942
.188						.417 .004747	.476 .005288	.525 .005829	.573 .006370	.624 .006928	.672 .007469	.721 .008010	.820 .009109	.917 .010191
.250								.568 .006313	.617 .006853	.667 .007412	.716 .007953	.764 .008494	.863 .009593	.961 .010675

Figure 57. *Bend Allowance Chart*

1° angle. Material thickness is given in the left column of the chart.

To find the bend allowance when the sheet thickness is .051-inch, the radius of bend is ¼-inch (.250-inch), and the bend is to be 90°, look at the bend allowance chart (figure 57). Reading across the top of the chart find the column for a radius of bend of .250-inch. Now find the block in this column that is opposite the gage of .051 in the column at left. The upper number in the block is .428, the correct bend allowance in inches for a 90° bend.

If the bend is to be other than 90° you must use the lower number in the block (the bend allowance for 1°) and compute the bend allowance. The lower number in this case is .004756. Therefore, if the bend is to be, say, 120°, your total bend allowance in inches will be 120 × .004756, or .5707-inch.

SET-BACK. When bending a piece of sheet stock, it is necessary to know the starting and ending points of the bend so that the length of the "flat" of the stock can be determined. Two factors are important in determining this—the radius of bend and the thickness of the material.

In figure 58, note that set-back is the distance from the bend tangent line to the mold point. The mold point is the point of intersection of the lines extending from the outside surfaces, while the bend tangent lines are the starting and end points of the bend. Also note that set-back is the same for the vertical flat and the horizontal flat.

To calculate the set-back for a 90° bend, merely add the inside radius of the bend to the

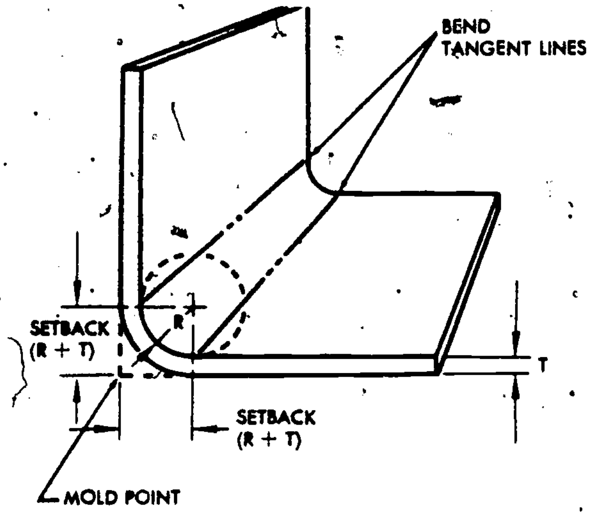

Figure 58. *Setback, 90° Bend*

thickness of the sheet stock. In formula form this would read SB = R + T.

To calculate set-back for angles larger or smaller than 90°, you have to consult set-back charts (figure 59), or K chart, for a value called K, and then substitute this value in the formula SB = K(R + T). The value for K varies with the number of degrees in the bend.

For a 90° bend, if the material is .051-inch thick and the radius of bend is specified to be ⅛-inch (.125), substitute in the formula SB = R + T and solve as follows:

SB = .125 + .051 = .176-inch set-back

For a 120° bend with a radius of bend of .125-inch in a sheet .032-inch thick, obtain the value of K from the set-back chart (K for 120° bend = 1.732), substitute in the formula SB = K(R + T) and solve as follows:

SB = 1.732(.032 + .125) = .272-inch

Brake or Sight Line. The brake or sight line is the mark on a flat sheet which is set even with the nose of the radius bar of the cornice brake. It serves as a guide in bending. You can locate the brake line by measuring out one radius from the bend tangent line which is to be inserted under the nose of the brake or against the radius form block. (See figure 60.)

MAKING LAYOUTS

It is wise to make a layout or pattern of the part before forming it to prevent any waste of

A	K	A	K	A	K
1°	.00873	61°	.58904	121°	1.7675
2°	.01745	62°	.60086	122°	1.8040
3°	.02618	63°	.61280	123°	1.8418
4°	.03492	64°	.62487	124°	1.8807
5°	.04366	65°	.63707	125°	1.9210
6°	.05241	66°	.64941	126°	1.9626
7°	.06116	67°	.66188	127°	2.0057
8°	.06993	68°	.67451	128°	2.0503
9°	.07870	69°	.68728	129°	2.0965
10°	.08749	70°	.70021	130°	2.1445
11°	.09629	71°	.71329	131°	2.1943
12°	.10510	72°	.72654	132°	2.2460
13°	.11393	73°	.73996	133°	2.2998
14°	.12278	74°	.75355	134°	2.3558
15°	.13165	75°	.76733	135°	2.4142
16°	.14054	76°	.78128	136°	2.4751
17°	.14945	77°	.79543	137°	2.5386
18°	.15838	78°	.80978	138°	2.6051
19°	.16734	79°	.82434	139°	2.6746
20°	.17633	80°	.83910	140°	2.7475
21°	.18534	81°	.85408	141°	2.8239
22°	.19438	82°	.86929	142°	2.9042
23°	.20345	83°	.88472	143°	2.9887
24°	.21256	84°	.90040	144°	3.0777
25°	.22169	85°	.91633	145°	3.1716
26°	.23087	86°	.93251	146°	3.2708
27°	.24008	87°	.80978	147°	3.3759
28°	.24933	88°	.96569	148°	3.4874
29°	.25862	89°	.98270	149°	3.6059
30°	.26795	90°	1.0000C	150°	3.7320
31°	.27732	91°	1.0176	151°	3.8667
32°	.28674	92°	1.0355	152°	4.0108
33°	.29621	93°	1.0538	153°	4.1653
34°	.30573	94°	1.0724	154°	4.3315
35°	.31530	95°	1.0913	155°	4.5107
36°	.32492	96°	1.1106	156°	4.7046
37°	.33459	97°	1.1303	157°	4.9151
38°	.34433	98°	1.1504	158°	5.1455
39°	.35412	99°	1.1708	159°	5.3995
40°	.36397	100°	1.1917	160°	5.6713
41°	.37388	101°	1.2131	161°	5.9758
42°	.38386	102°	1.2349	162°	6.3137
43°	.39391	103°	1.2572	163°	6.6911
44°	.40403	104°	1.2799	164°	7.1154
45°	.41421	105°	1.3032	165°	7.5957
46°	.42447	106°	1.3270	166°	8.1443
47°	.43481	107°	1.3514	167°	8.7769
48°	.44523	108°	1.3764	168°	9.5144
49°	.45573	109°	1.4019	169°	10.385
50°	.46631	110°	1.4281	170°	11.430
51°	.47697	111°	1.4550	171°	12.706
52°	.48773	112°	1.4826	172°	14.301
53°	.49858	113°	1.5108	173°	16.350
54°	.50952	114°	1.5399	174°	19.081
55°	.52057	115°	1.5697	175°	22.904
56°	.53171	116°	1.6003	176°	26.636
57°	.54295	117°	1.6318	177°	38.188
58°	.55431	118°	1.6643	178°	57.290
59°	.56577	119°	1.6977	179°	114.590
60°	.57735	120°	1.7320	180°	Infinite

Figure 59. *Setback (K) Chart*

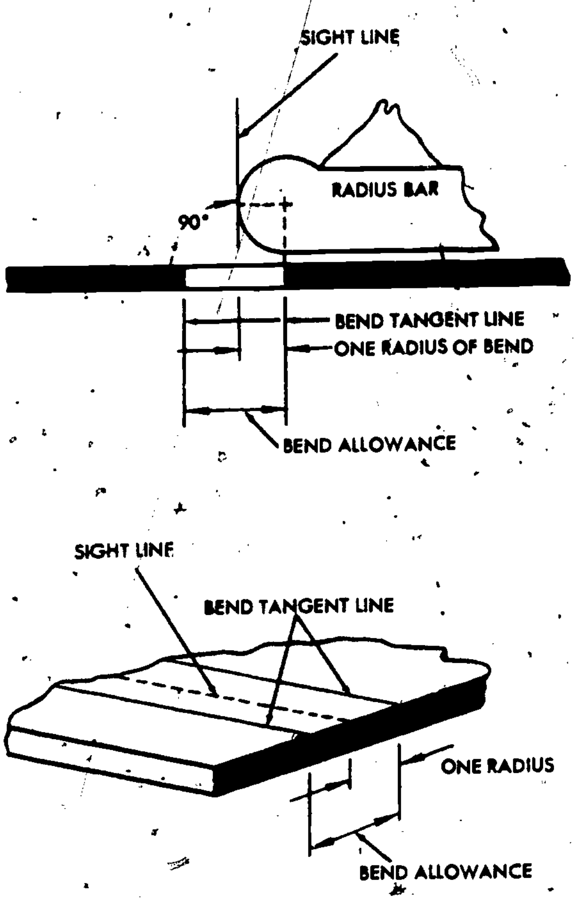

Figure 60. *Brake or Sight Line*

material and to get a greater degree of accuracy in the finished part. Where straight angle bends are concerned, correct allowances must be made for set-back and bend allowance. If the shrinking or stretching processes are to be applied, an accurate estimate of where the metal sheet is to be stretched or shrunk must be made so that the part can be turned out with a minimum amount of forming.

The layout procedures can be put into three general groups: flat layout, duplication of pattern, and projection through a set of points. All three processes require a good working knowledge of arithmetic and geometry. Only two processes, flat layout and duplication of pattern, will be discussed here.

Flat Layout

Assume that you are to lay out a flat pattern of a channel (figure 61) in which the left-hand flat, A, is to be 1 inch high, the right-hand flat, C, is to be 1¼ inches high, and the distance between the outside surface of the two flats, B, is to be 2 inches. The material is .051-inch thick and the radius of bend is to be 3/16-inch (.188). The angles are to be 90°. Proceed as follows.

First, determine the set-back in order to establish the distance of the flats.

- The set-back for the first bend is R + T, or .188 + .051 = .239.
- The first flat A is equal to the overall dimension less the set-back, or 1.000 − .239 = .761 inch.

Next, calculate the bend allowance for the first bend by using the bend allowance table. (BA = .3307 or .331)

Now lay off these measurements so you know where to begin and end each bend (see figure 61).

Now lay off the second flat, B. This is equal to the overall dimension less the set-back at each end, or B-two set-back, or 2.000 − (.239 + .239) .4781 = 1.522 (see figure 6–8).

The bend allowance for the second bend is the same as that for the first bend (.331). Mark off this distance (See figure 61.)

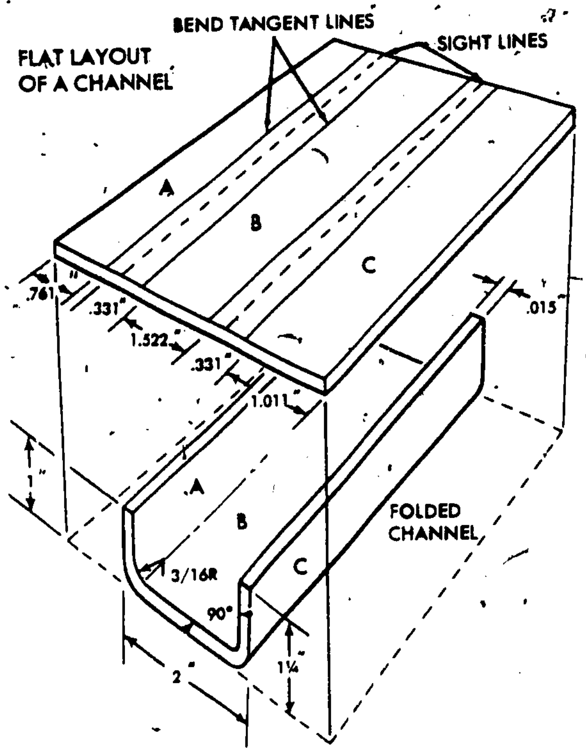

Figure 61. *Flat Layout of a Channel*

The third flat, C, is equal to the overall dimension less the set-back, or 1.25 − .239 = 1.011. Lay off this distance. (See figure 61.)

Adding the measurements of flats A, B, and C, and both bend allowances, (.761 + .331 + 1.522 + .331 + 1.011), the sum is 3.956, or approximately 4.00 inches. Totaling the three flats, A, B, and C, 1 inch, 2 inches, and 1¼ inches, respectively, the sum is 4.250 inches of material length. You can see how set-back and bend allowance affect material lengths in forming straight line bends. In this case the reduction is approximately ¼-inch. If the angles were not right angles, you would take the set-back values from set-back or K charts.

After all measurements are calculated, cut the material and mark off the brake or sight lines as shown in figure 61. You are ready to use the brake to form the channel.

Duplication of Pattern

When it is necessary to duplicate an aircraft part and blueprints are not available, you may take measurements directly from the original or from a duplicate part. In studying the following steps for laying out a part to be duplicated, refer to the illustrations in figure 62.

Draw a reference (datum) line, AB, on the sample part and a corresponding line on the template material (example 1, figure 62).

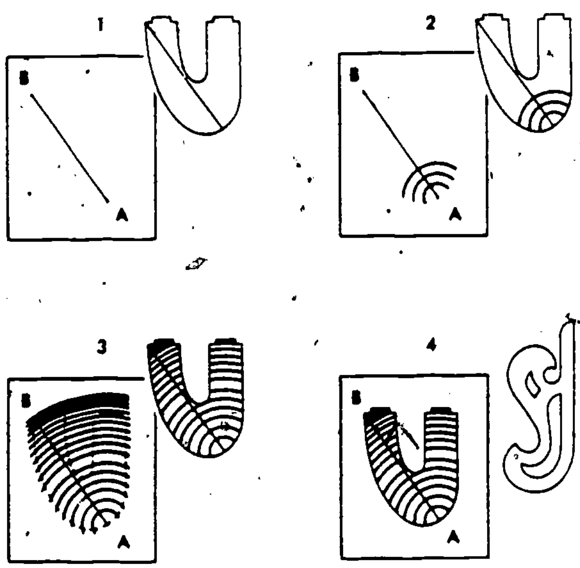

Figure 62. *Duplicating a Pattern*

Next, with point A on the sample part as a center, draw an arc having a radius of approximately ½-inch and extending to the flanges. Number the arc as it passes through the reference line (example 2, figure 62).

Draw similar arcs each with a radius ½-inch greater than the previous one until you have marked the entire part. In case there is an extremely sharp curve in the object, decrease the distance between the arcs to increase the number of arcs. This procedure will increase the accuracy of the layout. An arc must pass through every corner of the part; one arc may pass through more than one corner (example 3, figure 62).

Locate the coordinate point on the layout by measuring on the part with dividers. Always measure the distance from the reference point to the beginning of the bend line on the flange of the part.

After you have similarly located all points, draw a line through them, using a French curve to insure a smooth pattern (example 4, figure 62).

Allow for additional material for forming the flange and locate the inside bend tangent line by measuring, inside of the sight line, a distance equal to the radius of bend of the part.

Using the intersection of the lines as a center, locate the required relief holes. Then cut out and form as necessary.

Relief Holes

Wherever two bends intersect, material must be removed to make room for the material contained in the flanges. Holes are therefore drilled at the intersection. These holes, called relief holes, prevent strains from being set up at the intersection of the inside bend tangent lines. Such strains may cause the metal to crack. Relief holes also provide a neatly trimmed corner where the excess material is trimmed away.

The size of relief holes varies with thickness of the material. They should not be less than ⅛-inch in diameter for aluminum alloy sheet stock up to and including .064-inch thick, or 3/16-inch for stock ranging in thickness from .072-inch to .128-inch. The most common method of determining the diameter of a relief hole is to use the radius of bend for this dimension, provided it is not less than the minimum allowance (⅛-inch).

Relief holes must touch the intersection of the inside bend tangent lines. To allow for possible error in bending, make relief holes extend $\frac{1}{32}$ to $\frac{1}{16}$ of an inch behind the inside bend tangent lines. It is good practice to use the intersection of these lines as center for the holes (see figure 63). The line on the inside of the curve is cut at an angle toward the relief holes to allow for the stretching of the inside flange.

Lightening Holes

Occasionally, holes are cut in rib sections, fuselage frames, and other structural parts to decrease weight. Such holes are known as lightening holes. To keep from weakening the member (by removal of the material), flanges are often pressed around the holes to strengthen the area from which the material was removed.

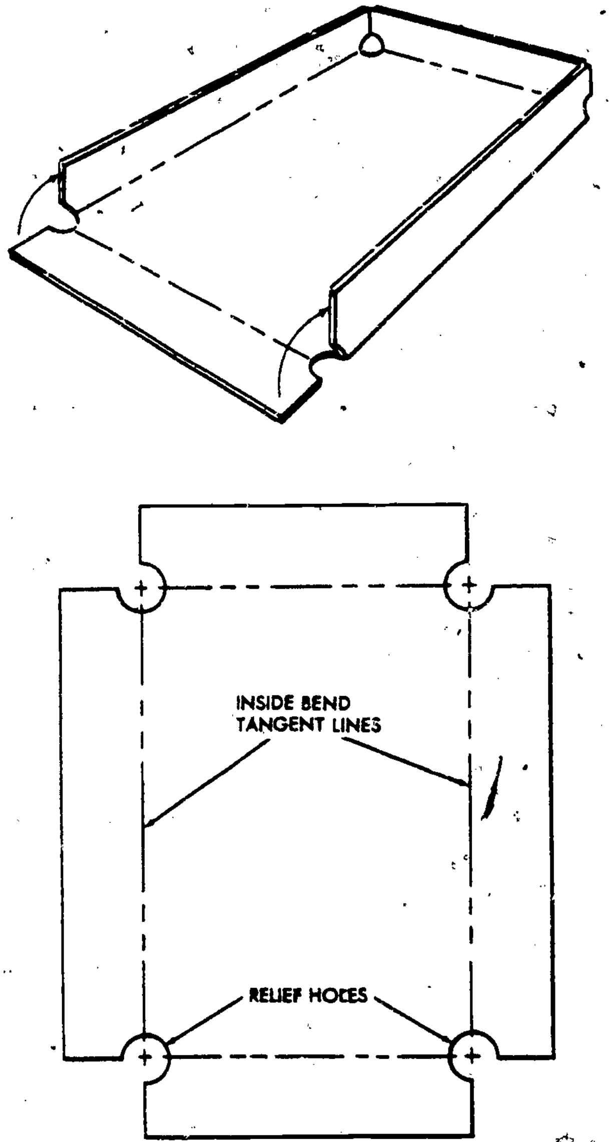

Figure 63. *Locating Relief Holes*

These holes should never be cut in any structural part unless authorized. The size of the lightening hole and the width of the flange formed around the hole are determined by design specifications. Margins of safety are considered in the specifications so that the weight of the part can be decreased and still retain the necessary strength. You may cut out lightening holes by any one of the following methods:

- Punching out, if the correct size punch die is available.
- Cutting out with a fly-cutter mounted on a drill.
- Scribing circumference of a hole with dividers and drilling around the entire circumference with a small drill, allowing enough clearance to file smooth.
- Scribing the circumference of the hole with dividers, drilling the hole inside the circumference large enough to insert aviation snips, cutting out excess metal, and filing smooth.

Form the flange by using a flanging die, or hardwood or metal form blocks. Flanging dies consist of two matching parts, a female and a male die. For flanging soft metal, dies can be of hardwood, such as maple. For hard metal or for more permanent use, they should be made of steel. The pilot guide should be the same size as the hole to be flanged, and the shoulder should be the same width and angle as the desired flange.

When flanging lightening holes, place the material between the mating parts of the die and form it by hammering or squeezing the dies together in a vise or in an arbor press. The dies will work more smoothly if they are coated with light machine oil.

Note that in the two form blocks shown on the left side of figure 64, the hole in the upper block is the same size as the hole to be flanged and is chamfered to the width of the flange and the angle desired, while in the lower block, the hole is the same diameter as that of the flange. You may use either type. When using the upper block, center the material to be flanged and hammer it with a stretching mallet, around and around, until the flange conforms to the chamfer.

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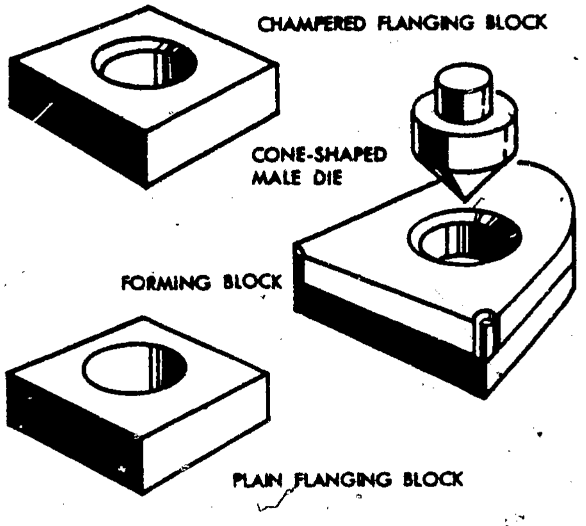

Figure 64. *Flanging Form Blocks*

When using the lower block, center the lightening hole over the hole in the block, then stretch the edges, hammering the material into the hole, around and around, until the desired flange is obtained.

Occasionally, the chamfer is formed with a cone-shaped male die used in conjunction with the form block with which the part was formed. (See figure 64.)

Methods of Pattern Development

Occasionally in your work you may have to design ducts and pipes which meet other ducts or pipes at various angles, such as a round air duct joining a square one. By mathematical calculations and drafting methods, you will have to determine the size, shape, and curve of the cuts, which when laid out on a flat pattern or blank piece of sheet stock, formed, and put together, will give the correct shape of the object. The edge of the round duct that attaches to the square duct is not a straight line when drawn on a flat sheet, but is a flowing curve. It ascends gradually to a peak, and then descends gradually on the opposite side. Should the blank be cut out along this curved line and rolled up, it would fit snugly against the elliptical hole in the square duct. The repairman should make such sketches on paper first—that is make the layouts or patterns—then cut them out and fit them together before trying them on sheet stock.

The process by which the repairman projects and drafts lines and curves into layouts is called development. Such airframe drafting is based on those principles of geometry which relate to the surface of solids. Sheet metal articles are hollow and, in airframe drafting, they are considered as if they were coverings for solids of the same shapes.

The three commonly used methods of development are parallel line development, radial line development, and triangulation. These three methods can be used to develop objects with single curvatures only. Articles such as wing fillets and cowling parts have compound curvatures—that is, bulges which curve in at least two directions at the same time and require stretching and shrinking. They are undevelopable. Their size and form must be determined by trial and error or by slitting the old part open and flattening it out.

PARALLEL LINE DEVELOPMENT. Parallel line development is applicable to forms such as pipes, ducts, T-joints, and the like, which have opposite sides parallel. Whenever laying out patterns for a cylindrical object, consider the object as a form having an infinite number of sides, each of the same length as the form but very narrow.

During this process of development, first draw an elevation view to show the true length of the sides of the object; next, draw a plan view or a half plan view to show the true size and shape of the end of the object. (In figure 65, a half plan view is shown.) Strike off equal distances along the curved line of the half plan dividing the area around the cylinder into equal parts. The greater the numbers of parts, the more nearly accurate the layout.

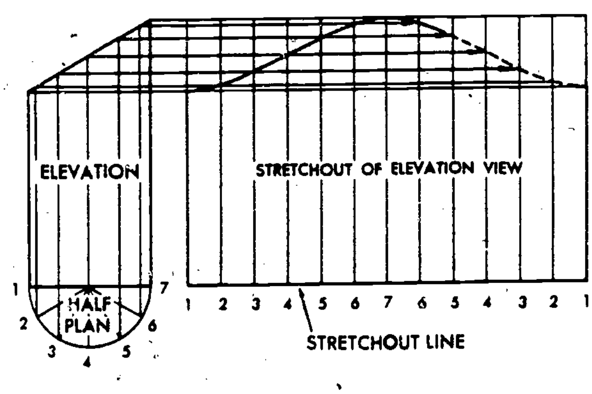

Figure 65. *Parallel Line Development*

Now draw a stretchout line. This is drawn from the base of the elevation view (see figure 65). On this line, locate and number the equal spaces laid out on the half plan view. You will have the other half of the cylinder to form too, so locate and number the spaces in the pattern from one up to seven then back to one again (see figure 65). Through these points, draw measuring lines at right angles to the stretchout line. Also, from the points 2 to 6 laid out in the half plan, draw lines to the top line in the elevation view. Draw all these lines perpendicular to the base line.

Next, draw projection lines parallel to the stretchout line and through the points where the vertical lines from the half plan view intersect the top line of the elevation view. Mark the points where these projection lines intersect the correspondingly numbered measuring lines; then connect all these points with an easy-flowing curved line. This curve forms the top angular edge of the pattern; the stretchout line forms the base of the object.

Radial Line Development. Several objects have shapes which will not permit the use of parallel line development because their sides are not parallel. Such forms require other methods of development. Radial line development is one such method; and, as in parallel line development, the objects to be developed must have certain characteristics. Only forms which have a circle for their bases, or a base that can be inscribed in a circle, and sides that slant to a common center, can be developed by this method. The center must be located directly over the center of the base. This base, however, may be projected or imaginary rather than the actual base of the object.

When the base is round, the object has a conical shape (see example A in figure 66). When the object has a square base, it has the shape of a pyramid (see example B, figure 66). Any part or section of these cones or pyramids can be developed by radial line development.

A cone with the top cut off parallel with the base is called a regular frustum. One with the top cut off on an angle with the base is called an irregular frustum (see figure 67). Objects which have these characteristics can be developed by the radial line method.

When drawing a frustum, the apex is located by extending the sides until they intersect. This point of intersection of imaginary lines is the apex. The apex must be located, regardless of the shape, in order to obtain the slant height.

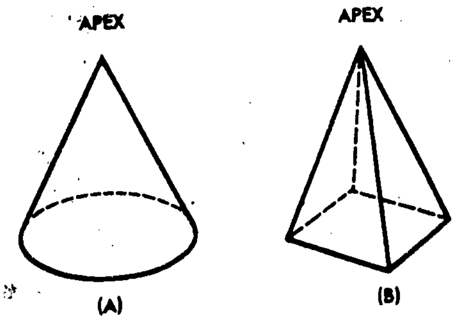

Figure 66. *Objects Developed by Radial Line Method*

Generally, the pattern of these objects is fan-shaped. When the object is unrolled, the stretchout pivots around the apex or the pattern radiates from the apex. (See figure 68.)

The pattern for a cone is found by using the elevation view and plan view. In this type of line development the elevation has two heights, the actual and the slant. The actual height is used only to draw the elevation view, and the slant height is used as the radius for the stretchout arc.

The length of the stretchout arc is equal to the distance around the base or plan view. The slant height is the distance from the apex to the base down the visible slant. Note in figure 69 the pattern of an object whose base is not round. However, the radius and the length of the stretch-

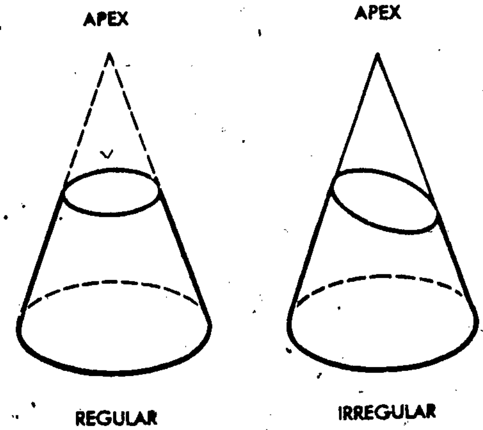

Figure 67. *Truncated Cones*

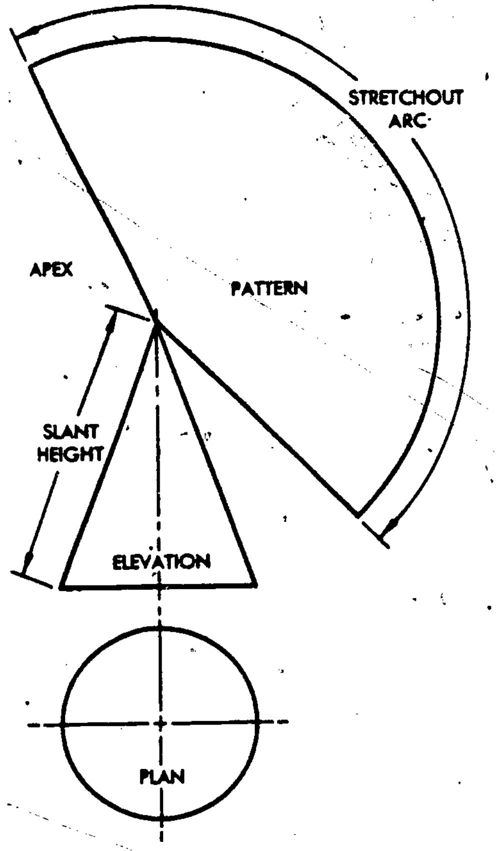

Figure 68. *Cone Stretchout*

out arc are found in the same manner as if the base of the object were round.

An irregular frustum presents a slightly different situation, the difference being that the pattern line A—B (in figure 70), could not be shown as an arc. Therefore, to pinpoint it on the pattern, surface element lines must be constructed on the elevation view. The plan, or half plan, is divided into equal spaces and then extended up perpendicular to the base line. From there all surface element lines converge to one point, the apex (figure 70).

In parallel line development, the surface element lines are perpendicular to the base; but, in radial line development, they are not perpendicular to the base line. These lines are on a slant and therefore are shortened. The only lines that are in their true length are the slant height lines.

In order to find the true length of all surface lines, simply project them from line A—B (miter line) to the slant height, as shown in figure 70. All true lengths are taken along the slant height side.

To develop the pattern shown in figure 70, swing the stretchout arc, using the slant height as the radius. After you find the length of the arc by measuring the distance around the base of the object, divide the arc into surface element lines corresponding to those in the elevation view and transfer the measurement to the lines having the same number as in the pattern. After locating all points, connect them with a curved line to form the outline of the pattern.

The steps in developing a pattern using the radial line method are:

Layout of half plan view:

- Swing half circle equal to the diameter of the base.
- Divide half plan view into equal parts with dividers.
- Extend surface element lines upward to base line.

Layout of elevation view:

- Draw elevation view.
- Extend sides up to center line to obtain the apex.
- Extend all surface element lines from the base line to the apex (top). Construct true lengths if the object is an irregular frustum. (If the object is a regular frustum or cone, no true lengths are

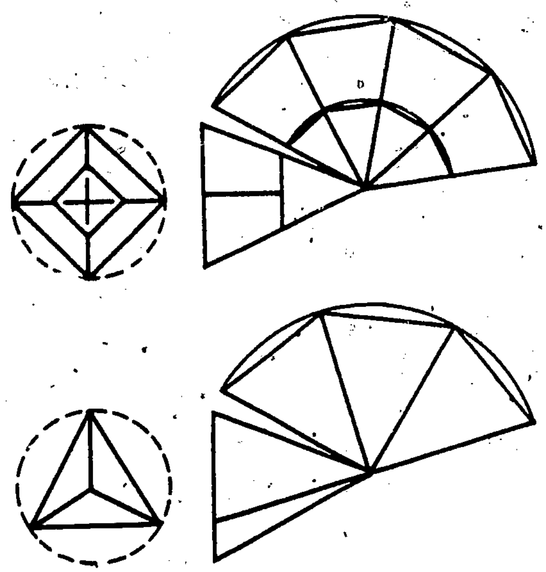

Figure 69. *Patterns for Objects Without Round Bottoms*

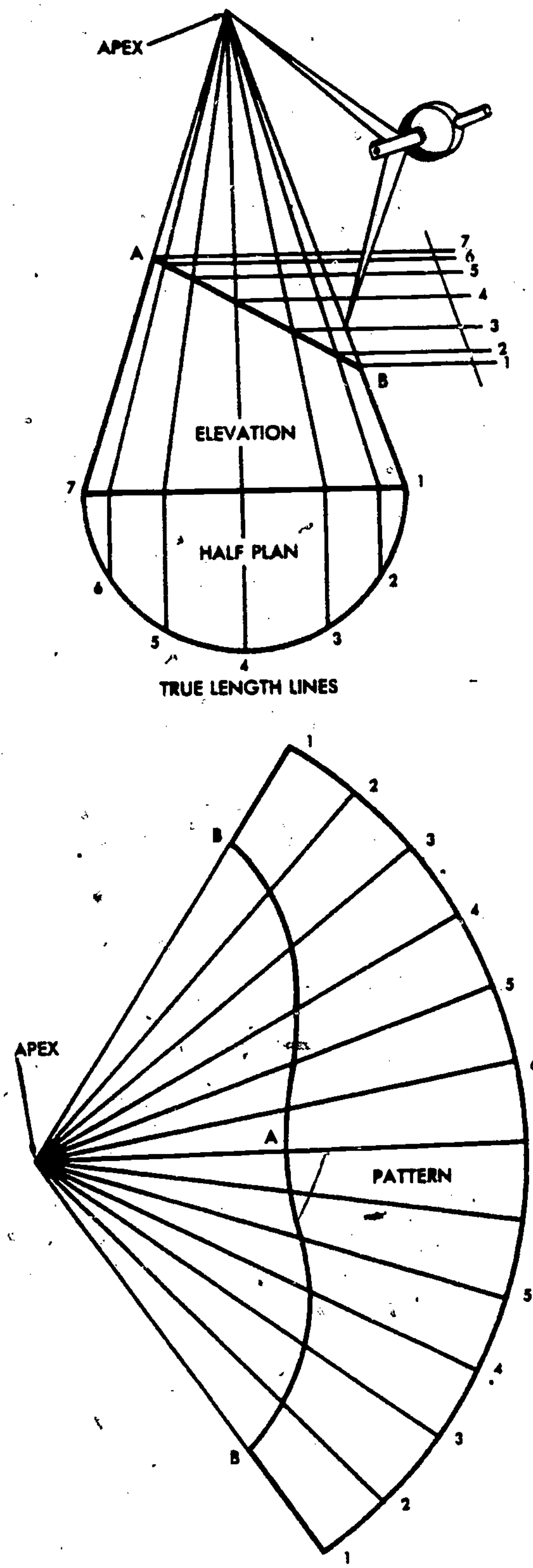

Figure 70. *Irregular Frustum Development*

necessary; the slant height is then used.) The true lengths are constructed by projecting lines parallel to base line from the points of intersection of the surface element lines and the miter line over to the slant height.

• Letter and number all points of importance on the layout.

Layout of pattern:

• Take the distance along the slant height from the apex to the base line and swing the stretchout arc. Set dividers to the equal space between surface element lines on circumference of half plan view. Mark off equal spaces on the length of the stretchout arc. Extend the surface element lines from the stretchout arc to the apex.

• Transfer the true lengths of the surface element lines from the elevation view to the pattern, measuring from the apex down the slant height to the numbered true length lines drawn out from the miter line. (If the object is a regular frustum or cone, no true lengths are needed.) Draw curve and add seam allowance to the ends of pattern.

TRIANGULATION. The process of triangulation is used for the layout of irregular forms having sides which are not parallel and which, if extended, would not meet at a common point. Forms of this type cannot be developed by methods other than triangulation. Triangulation is applicable to a wide range of layout problems and, though more detailed than other methods, it is very simple and easy to use when the underlying principles are understood.

Step-by-step procedures for the development of a pattern by triangulation are explained below. Follow figure 71 in studying these procedures.

• Draw the elevation view of the object.

• Draw the plan view of the object.

• Divide the circle in the plan view into a convenient number of parts. Number each point.

• Draw lines to each of the corners A, B, C, and D.

NOTE: Since lines A–1, A–2, A–3, and so on are foreshortened lines, it is necessary to determine their true lengths before they can be used in the layout of the pattern. This can be accomplished by the use of a true length chart.

• Construct a true length chart by first drawing line AO perpendicular to a base line OY. Transfer the distances A–1, A–2, A–3, and A–4 in the

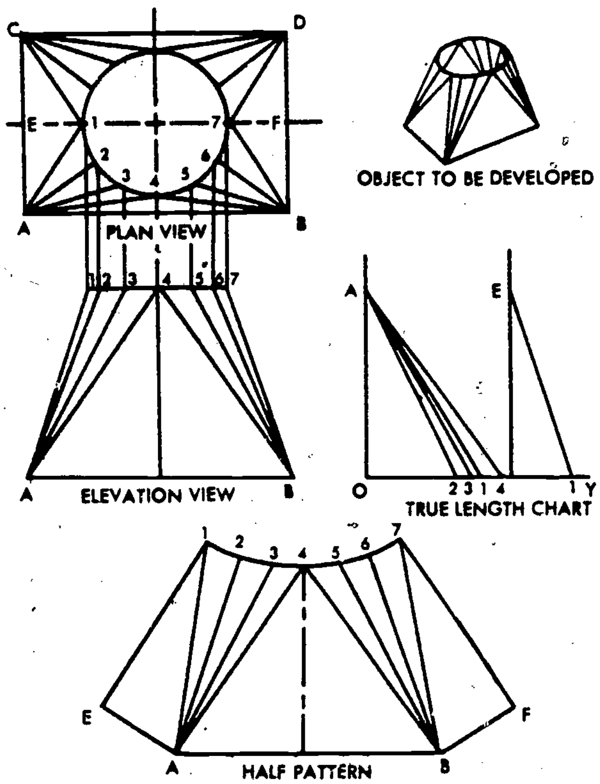

Figure 71. *Development by Triangulation*

plan view to the base line OY. Each distance must begin at point O. Now draw lines to these points from point A, thus producing the true lengths of the lines. (Since this object is symmetrical, the following combinations of lines are the same length: A–4 and B–4, A–3 and B–5, A–2 and B–6, A–1 and B–7.)

• Lay out the half pattern (refer to figure 6–18) as follows:

1. Lay out base line AB.

2. Locate point 4 by scribing arcs using radii equal to the true length of lines A–4 and B–4. Draw lines A–4 and B–4 on the pattern.

3. Set your dividers to length 3–4 on the plan view. Using this measurement, scribe arcs to the right and left of point 4 on the pattern.

4. From pattern points A and B, respectively, scribe arcs having radii equal to the true length of lines A–3 and B–5 to intersect the previously made arcs. Draw lines A–3 and B–5.

5. Continue laying out the pattern, locating points 2, 1, 6, and 7 by using the same procedures as were used to locate points 3, 4, and 5.

6. Construct triangles A–E–1 and B–F–7 of the pattern by scribing arcs from points A and B using a radius equal to the true length of line AE, and scribing arcs from points 1 and 7 using a radius equal to the true length of line E–1. Draw lines through the points of intersection for these arcs.

• These procedures will develop only one half pattern for the object. The other half pattern can be developed by repeating these procedures or by reversing this pattern when cutting the sheet stock for manufacture of the object. Extra material must be added for the seam to be used. Where the object is unsymmetrical (not uniform), the remaining sides also have to be laid out, using a separate true length chart.

HAND FORMING

All forming revolves around the process of shrinking and stretching, and hand forming processes are no exception. If a formed or extruded angle is to be curved, you either stretch one leg or shrink the other, whichever will make the part fit the job at hand. In bumping, you stretch the material in the bulge to make it "balloon," and in joggling, you stretch the material between the joggles. Material in the edge of lightening holes is often stretched to form a beveled reinforcing ridge around them.

Straight Line Bends

The cornice brake and bar folder are ordinarily used to make straight bends. Whenever such machines are not available, you can bend comparatively short sections by hand with the aid of wooden or metal bending blocks by proceeding as explained in the following paragraphs.

After you have laid out and cut the blank to size, clamp it rigidly along the bending line between two wooden blocks held in a vise. The wooden forming block should have one edge rounded for the desired radius of bend. It should also be curved slightly beyond the 90° point to allow for springback.

By tapping lightly with a rubber, plastic, or rawhide mallet, bend the metal protruding beyond the bending blocks to the desired angle. Start tapping at one end and work back and forth along the edge, making the bend gradually and evenly.

Continue this process until the protruding metal is forced down to the desired angle against the forming block. Allow for springback by driving the material slightly farther than the actual bend. If a large amount of metal extends beyond the bending blocks, maintain hand pressure against the protruding sheet to prevent "bouncing."

Remove any irregularities by holding a straight block of hardwood edgewise against the bend and striking it with heavy blows of a mallet or hammer. If the amount of metal protruding beyond the bending blocks is small, make the entire bend by using the hardwood block and hammer.

Formed or Extruded Angles

Both formed and extruded types of angles can be curved (not bent sharply) by stretching or shrinking either of the flanges. Curving by stretching the one flange is usually preferred since this process requires only a V–block and a mallet and is very easily accomplished.

STRETCHING ONE FLANGE. In the stretching process, place the flange to be stretched in the groove of the V-block. Using a stretching mallet, strike the flange directly over the V portion with light, even blows and gradually force it downward into the V. Too heavy a blow will buckle the angle strip. Keep moving the angle strip across the V-block but always strike the spot directly above the V. Form the curve gradually and evenly by moving the strip slowly back and forth, distributing the hammer blows at equal spaces on the flange.

Lay out a full-sized accurate pattern on a sheet of paper or plywood and periodically check the accuracy of the curve. By comparing the angle with the pattern you can tell exactly how the curve is progressing and just where it needs to be increased or decreased. It is better to get the curve to conform roughly to the desired shape before attempting to finish any one portion, because the finishing or smoothing of the angle may cause some other portion of the angle to change shape. If any part of the angle strip is curved too much, reduce the curve by reversing the angle strip on the V-block, placing the bottom flange up, and striking it light blows with the mallet.

Try to form the curve with a minimum amount of hammering, for excessive hammering will work-harden the metal. Work-hardening can be recognized by a lack of bending response or by springiness in the metal. It can be recognized very readily by an experienced worker. In some cases you may have to anneal the part during the curving operation. If you do, be sure to heat-treat the part again before installing it on the aircraft.

SHRINKING ONE FLANGE. Curving an extruded or formed angle strip by shrinking may be accomplished by either of two methods, the V-block method or the shrinking block method. Of the two, the V-block is, in general, more satisfactory because it is faster, easier, and affects the metal less. However, very good results can be obtained by the shrinking block method.

In the V-block method, place one flange of the angle strip flat on the V-block with the other flange extending upward, as shown in figure 72. Hold it firmly so that it does not bounce when hammered, and strike the edge of the upper flange with light blows of a round, soft-faced mallet. Begin at one end of the angle strip and, working back and forth, strike light blows directly over the V-portion of the block. Strike the edge of the flange at a slight angle as this tends to keep the vertical flange from bending outward.

Occasionally, check the curve for accuracy with the pattern. If a sharp curve is made, the angle (cross section of the formed angle) will close slightly. To avoid such closing of the angle, clamp the angle strip to a hardwood board with the hammered flange facing upward. Use small C clamps on which the jaws have been covered with masking tape. If the angle has already closed, you can bring the flange back to the correct angle with a

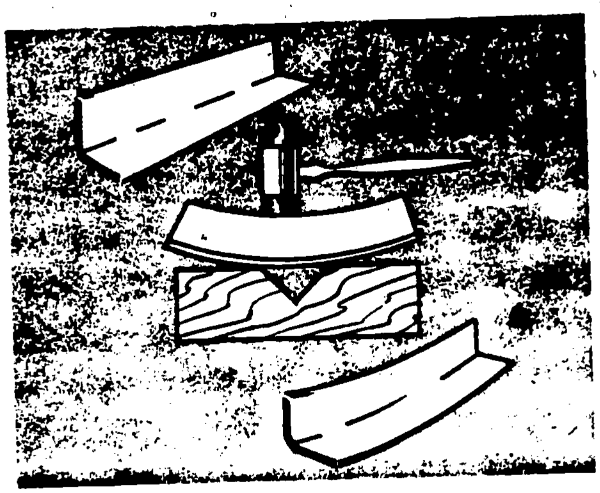

Figure 72. *V-Blocks*

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few blows of a mallet or with the aid of a small hardwood block. If any portion of the angle strip is curved too much, reduce it by reversing the angle on the V-block and hammering with a suitable mallet, as explained in the previous paragraph on stretching. When you have obtained the proper curve, smooth the entire angle by planishing with a soft-faced mallet.

If the curve in a formed angle is to be quite sharp or if the flanges of the angle are rather broad, the shrinking block method must be used. In this process, crimp the flange which is to form the inside of the curve.

When making a crimp, hold the crimping pliers so that the jaws are about ⅛-inch apart. By rotating the wrist back and forth, bring the upper jaw of the pliers into contact with the flange, first on one side and then on the other side of the lower jaw. Complete the crimp by working a raised portion into the flange, gradually increasing the twisting motion of the pliers. Do not make the crimp too large as it will be difficult to work out. The size of the crimp depends upon the thickness and softness of the material. But usually about ¼-inch is sufficient. Place several crimps spaced evenly along the desired curve with enough space left between each crimp so that jaws of the shrinking block can easily be attached.

After completing the crimping, place the crimped flange in the shrinking block so that one crimp at a time is located between the jaws. Flatten each crimp with light blows of soft-faced mallet, starting at the apex (the closed end) of the crimp and gradually working toward the edge of the flange. Check the curve of the angle with the pattern periodically during the forming process and again after all the crimps have been worked out. If it is necessary to increase the curve, add more crimps and repeat the process. Space the additional crimps between the original ones so that the metal will not become unduly work-hardened at any one point. If the curve needs to be increased or decreased slightly at any point, use the V-block.

After obtaining the desired curve, you may planish the angle strip over a stake or a wooden form.

Flanged Angles

The forming process for the following two flanged angles is slightly more complicated than that just discussed in that the bend is shorter (not gradually curved) and necessitates shrinking or stretching in a small or concentrated area. If the flange is to point toward the inside of the bend, the material must be shrunk. If it is to point toward the outside, it must be stretched.

FORMING BY SHRINKING. In forming a flanged angle by shrinking, use wooden forming blocks similar to those shown in figure 73 and proceed as follows.

Cut the metal to size, allowing for trimming after forming. Determine bend allowance for a 90° bend and round the edge of the forming block accordingly.

Clamp the material in the form blocks as shown in figure 73, and bend the exposed flange against the block. After bending, tap the blocks slightly. This induces a setting process in the bend.

Using a soft-faced shrinking mallet, start hammering near the center and work the flange down gradually toward both ends. The flange will tend to buckle at the bend because the material is made to occupy less space. Work the material into several small buckles instead of one large one, and work each bucklet out gradually by hammering lightly and gradually compressing the material in each buckle. The use of a small hardwood wedge block (as shown in figure 73) will aid in working out the buckles.

Planish the flange after it is flattened against the form block, and remove small irregularities. If the form blocks are made of hardwood, use a metal planishing hammer; if the forms are made of metal, use a soft-faced mallet. Trim the excess material away and file and polish.

FORMING BY STRETCHING. To form a flanged angle by stretching, use the same forming blocks, wooden wedge block, and mallet as in the shrinking process. Proceed as follows.

Cut the material to size (allowing for trim), determine bend allowance for a 90° bend, and round off the edge of the block to conform to the desired radius of bend.

Clamp the material in the form blocks as shown in figure 73.

Using a soft-faced stretching mallet, start hammering near the ends and work the flange down smoothly and gradually to prevent cracking and splitting. Planish the flange and angle, as in the

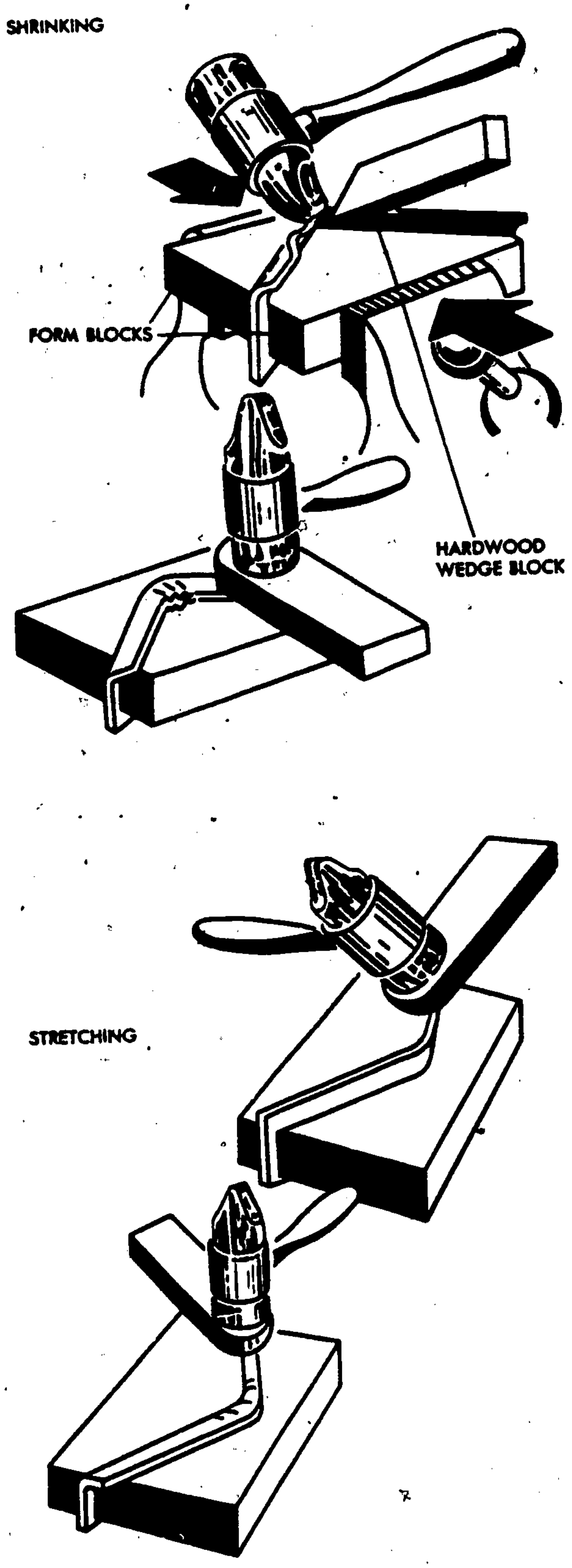


Figure 73. *Forming a Flanged Angle*

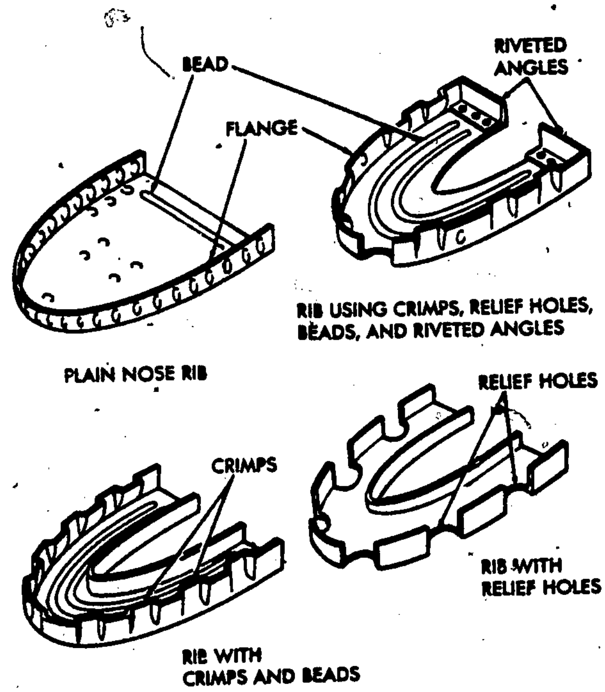


Figure 74. *Nose Ribs*

previous procedure, and trim and smooth the edges, if necessary.

Curved Flanged Parts

Curved flanged parts are usually hand formed. Of the types shown in figure 74, the one with relief holes is probably the simplest to form. It has a concave flange (the inside flange) and a convex flange (the outside flange).

The concave flange is formed by stretching; the convex flange by shrinking. Such parts may be formed with the aid of hardwood or metal forming blocks. These blocks are made in pairs similar to those used for straight angle bends and are identified in the same manner. They differ in that they are made specifically for the particular part to be formed, they fit each other exactly, and they conform to the actual dimensions and contour of the finished article.

The mating parts may be equipped with aligning pins to aid in lining up the blocks and holding the metal in place. The blocks may be held together by C clamps or a vise. They also may be held together with bolts by drilling through both forms and the metal, provided the holes do not affect the strength of the finished part. The edges of the forming block are rounded to give the correct radius of bend to the part, and are undercut to allow for springback of the metal. The undercut is especially necessary if the material is hard or if the bend must be highly accurate.

Note the various types of forming represented in figure 74. In the plain nose rib, only one large convex flange is used; but, because of the great distance around the part and the likelihood of buckles in forming, it is rather difficult to form. The flange and the beaded portion of this rib provide sufficient strength to make this a very good type to use. In the type with relief holes, the concave flange gives difficulty in forming; however, the outside flange is broken up into smaller sections by relief holes (notches inserted to prevent strains in a bend). In the type with crimps and beads, note that crimps are inserted at equally spaced intervals. The crimps are placed to absorb material and cause curving, while also giving strength to the part.

In the fourth nose rib illustrated, note that a combination of the four common forming methods

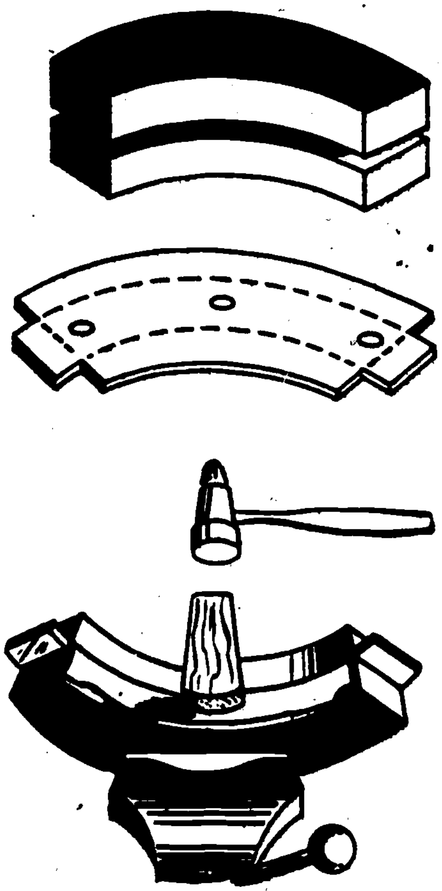


Figure 75. *Forming a Concave Curve*

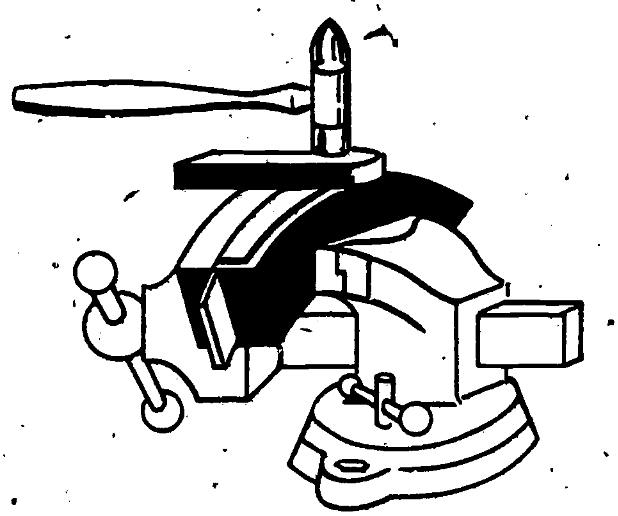


Figure 76. *Forming a Convex Curve*

are applied. They are crimping, bending, putting in relief holes, and using a formed angle riveted on at each end. The beads and the formed angles supply strength for the part.

In forming a curved flange part, the major steps are as explained in the following paragraphs.

Cut the material to size (allowing for trim), locate and drill holes for alignment pins, and remove all burrs (jagged edges). Place the material between the wooden blocks. Clamp blocks tightly in a vise so that the material will not move or shift. Clamp the work as closely as possible to the particular area being hammered to prevent strain on the form blocks and to keep the metal from slipping. (See figure 75.)

Bend the flange on the concave curve first. This practice may keep the flange from splitting open or cracking when the metal is stretched. (Should this occur, a new piece will have to be made.) Using a soft mallet or wooden wedge block, start hammering at a point a short distance away from the beginning of the concave bend and continue toward the center of the bend. This procedure permits some of the excess metal along the tapered portion of the flange to be worked into the curve where it will be needed. Continue hammering until the metal is gradually worked down over the entire flange, flush with the form block.

Starting at the center of the curve and working toward both ends, hammer the convex flange down over the form. (See figure 76.) Strike the metal with glancing blows, at an angle of approximately

30° off perpendicular, and with a motion that will tend to pull the part away from the block.

Stretch the metal around the radius bend and remove the buckles gradually by hammering on a wedge block.

While working the metal down over the form, keep the edges of the flange as nearly perpendicular to the block as possible. The wedge block helps keep the edge of the metal perpendicular to the block, lessens the possibility of buckles and of splitting or cracking the metal, and aids in removing buckles.

Finally, trim the flanges of excess metal, planish, remove burrs, round the corners (if any), and check the part for accuracy.

Bumping

Bumping on a form block or female die and bumping on a sandbag are the two common types practiced. In either method only one form is required — a wooden block, lead die, or sandbag. A good example of a part made by the block or die type of bumping is the "blister" or streamlined cover plate. Wing fillets constitute a good example of parts that are usually formed by bumping on a sandbag.

FORM BLOCK OR DIE BUMPING. The lead die or the wooden block designed for bumping must have the same dimensions and contour as the outside of the blister. To provide sufficient bucking weight, and to give sufficient bearing surface for fastening the metal, the block or die should be at least 1 inch larger in all dimensions than the form requires.

When forming the wooden block, hollow it out with saws, chisels, gouges, files, and rasps. Smooth and finish it with sandpaper. Make the inside of the form as smooth as possible, because any slight irregularity will show up on the finished part. Prepare several templates (patterns of the cross-section), such as those shown with the form block for the blister in figure 77, so that the form can be checked for accuracy.

Shape the contour of the form at points 2, 3, and 4. Shape the areas between the template check points to conform to the remaining contour and to template 4. Shaping of the form block requires particular care because the more nearly accurate it is in all details, the less time it will take to produce a smooth, finished part.

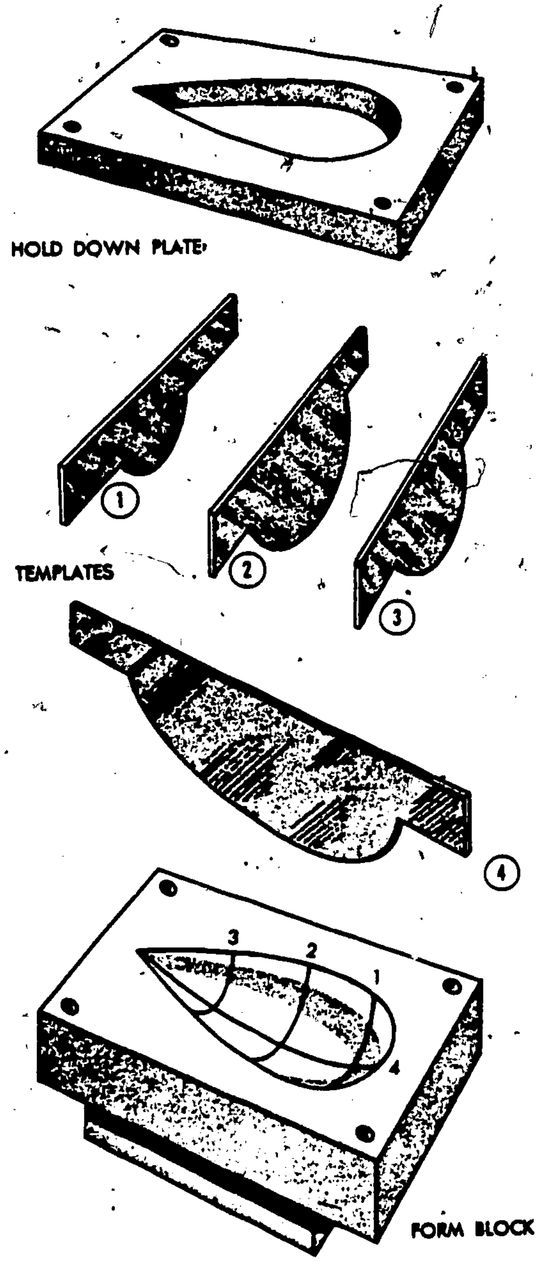


Figure 77. *Form Blocks and Templates*

Correct clamping of the material to the form block is an important part of the block forming operation. Several methods are possible. For parts such as the blister, one of the best means of clamping the material is to use a full metal cutout or steel holddown plate as shown in figure 77.

In this process, place the holddown plate directly over the material to be formed and clamp it in position with bolts or C clamps. Tighten the C clamps or bolts just tight enough to hold the material flat against the face of the form block, but not so tight that the metal cannot be drawn into the form. If the material is not held flat against the face of the form, it will bend up or buckle away from the block. If it is not permitted to slip into the concave depression a little, the blister portion will become very thin in places.

Holddown plates should be of heavy steel, ⅛-inch for small forms and ¼-inch or heavier for large forms.

If the material for making a full metal holddown plate is not available, use a hardwood cutout. Make the cutout and use it in the same manner as the steel plate, but take greater precautions to make sure that the material is held as desired.

You may use pieced form-clamps if a full metal holddown plate or hardwood cutout is not available or if a full cutout cannot be used. Be careful to clamp them properly and locate them so that they line up with the edge of the form. If they are not lined up accurately, the material will bulge.

After preparing and checking the form, perform the bumping process according to the following general steps.

- Cut a metal blank to size, allowing an extra ½ to 1 inch to permit "drawing."
- Apply a thin coat of light oil to the block and to the aluminum to prevent galling (scraping on rough spots).
- Clamp the material between the block and steel plate, as previously described, so that it will be firmly supported yet able to slip a little toward the inside of the form.
- Clamp the bumping block in a bench vise. With a soft-faced mallet or with a hardwood drive block and suitable mallet, start the bumping near the edges of the form.
- With light blows of the mallet, work the material down gradually from the edges. Remember that the object of the bumping process is to work the material into shape by stretching it, rather than by forcing it into the form with heavy blows. Always start bumping near the edge of the form; never start near the center of the blister.
- Smooth the work as much as possible before removing it from the form. You can do this by rubbing the work with the rounded end of a maple block or with the round end of a stretching mallet.
- Remove the blister from the bumping block and trim it, leaving a ½-inch flange.
- Finally, drill the rivet holes, chamfer the edges 45°, and clean and polish the part.

SANDBAG BUMPING. Bumping on a sandbag is one of the most difficult types of sheet metal hand forming, as there is no exact form block to serve as a guide. During this type of forming operation, you force a depression into a sandbag to take the shape of the hammered portion of the metal. The depression or pit has a tendency to more or less shift from the hammering. This necessitates readjusting from time to time during the bumping process. The degree of shifting depends largely on the contour or shape of the piece being formed, and whether glancing blows must be struck in order to stretch, draw, or shrink the metal.

When forming by this method, prepare a contour template or some sort of a pattern to serve as a working guide and to insure accuracy of the finished part. Make the pattern from ordinary kraft or similar paper, folding it over the part to be duplicated. Cut the paper cover at the points where it would have to be stretched to fit, and attach additional pieces of paper with masking tape to cover the exposed portions. After completely covering the part, trim the pattern to exact size.

Open the pattern and spread it out on the metal from which the part is to be formed. Although the pattern will not lie flat, it will give you a fairly accurate idea of the approximate shape of the metal to be cut, and the pieced-in sections will indicate where the metal is to be stretched. When the pattern has been placed on the material, mark the outline of the part and the portions to be stretched with pencil. Add at least 1 inch of excess metal when cutting the material to size. You can trim off this excess metal after bumping the part into shape.

If the part to be formed is radially symmetrical, it will be fairly easy to shape since a simple contour template can be used as a working guide, making a pattern to indicate the portions of unequal stretching unnecessary. However, the procedure for bumping sheet metal parts on a sandbag follows certain basic rules which can be applied to any part, regardless of its contour or shape.

- Lay out and cut the contour template. (This can be made of sheet metal, medium-heavy cardboard, or thin plywood.)

• Determine the amount of metal needed, lay it out, and cut it to size, allowing at least ½-inch excess.

• Place a sandbag on a solid foundation capable of supporting heavy blows and, with the aid of a smooth-faced mallet, make a pit in the bag. Analyze the part to determine the correct radius of the pit for the forming operation. The pit will change with the hammering it receives and must be readjusted occasionally.

• Select a soft round-faced or bell-shaped mallet having a contour slightly smaller than the contour desired on the sheet metal part. Holding one edge of the metal in the left hand, place the portion to be bumpted near the edge of the pit on the sandbag. Strike the metal with light glancing blows, about ½ to 1 inch from the edge.

• Continue bumping toward the center, revolving the metal and working gradually inward until the desired shape is obtained. Shape the entire part as a unit. If you shape one portion completely and continue hammering on some other portion, the completed portion will be thrown out of shape.

• At frequent intervals during the bumping process, check the part for accuracy of shape by applying the template. If wrinkles are formed, work them out before they become too large.

• Finally, with a suitable stake and planishing hammer, or with a hand dolly and planishing hammer, remove small dents and hammer marks.

• With a pair of dividers, mark around the outside of the object. Trim the edge and file smooth. Clean and polish the part.

Joggling

A joggle is an offset formed on an angle strip to allow clearance for a sheet or an extrusion. Joggles are often found at the intersection of stringers and formers. One of these members, usually the former, has the flange joggled to fit flush over the flange of the stringer. The amount of offset is usually small; therefore, the depth of the joggle is generally specified in thousandths of an inch. The thickness of the material to be cleared governs the depth of the joggle. In determining the length of the joggle necessary, it is common practice to allow an extra $\frac{1}{16}$-inch to give enough added clearance to assure a fit between the joggled, overlapped part.

There are a number of different methods by which you can form joggles. If the joggle is to be made on a straight flange or flat piece of metal, form it on a cornice brake by inserting and bending up along the line of the joggle. Hold a piece of metal of the correct thickness to give the desired offset under the bent-up portion, and pound the flange down while the metal is still in the same position in the brake.

Where a joggle is necessary on a curved flange, forming blocks or dies made of hardwood, steel, or aluminum alloy may be used. If the die is to be used only a few times, hardwood is satisfactory as it is easily worked. If a number of similar joggles are to be produced, then use steel or aluminum alloy dies. Dies of aluminum alloy are preferred, since they are easier to fabricate than those of steel and will wear about as long. They are sufficiently soft and resilient to permit forming aluminum alloy parts on them without marring, and nicks and scratches are easily removed from their surfaces.

When using joggling dies for the first time, test them for accuracy on a piece of waste stock. In this way you will avoid the possibility of ruining already fabricated parts. Always keep the surfaces of the blocks free from dirt, filings, and the like, so that the work will not be marred.

Working Stainless Steel

When working with stainless steel make sure that the metal does not get unduly scratched or marred. Also take special precautions when shearing, punching, and drilling this metal. It takes about twice as much pressure to shear or punch stainless steel as it does to cut mild steel. Keep the shear or punch and die adjusted very closely. Too much clearance will permit the metal to be drawn over the edge of the die and cause it to become work-hardened, resulting in excessive strain on the machine.

In drilling stainless steel, use a high-speed drill ground to an included angle of 140°. Some special drills have an offset point while others have a chip curler in the flutes. When using an ordinary twist drill, grind its point to a stubbier angle than the standard drill point. Keep the drill speed about one half that required for drilling mild steel, but never exceed 750 rpm. Keep a uniform pressure on the drill so the feed is constant at all times. Drill the material on a backing plate, such as cast iron, which is hard enough to permit the drill to cut all the way through the stock without pushing the metal away from the drill point. Spot the drill before turning on the power and also make sure that when the power is turned on, pressure is being exerted.

To avoid overheating, dip the drill in water after drilling each hole. When it is necessary to drill several deep holes in stainless steel, use a liquid coolant. A compound made up of 1 pound of sulfur added to 1 gallon of lard oil will serve for this purpose. Apply the coolant to the material immediately upon starting the drill. High-speed portable hand drills have a tendency to burn the drill points and excessively work-harden the material at the point of contact. Because of the temperatures developed by high-speed drill rotation, they should not be used. A drill press, adjustable to speeds under 750 rpm, is recommended.

Working Magnesium

Magnesium, in the pure state, does not have sufficient strength to be used for structural purposes; but, as an alloy, it has a high strength-to-weight ratio. Its strength is not affected by subzero temperatures, and this increases its adaptability to aircraft use. Its nonmagnetic property makes it valuable for instrument cases and parts.

While magnesium alloys can usually be fabricated by methods similar to those used on other metals, it must be remembered that many of the details of shop practice cannot be applied. Magnesium alloys are difficult to fabricate at room temperature; therefore, operations other than the most simple ones must be performed at high temperatures. This requires preheating of the metal or dies or both.

Magnesium alloy sheets may be cut by blade shears, blanking dies, routers, or saws. Hand or circular saws are usually used for cutting extrusions to length. Conventional shears and nibblers should never be used for cutting magnesium alloy sheet because they produce a rough, cracked edge.

Shearing and blanking require close tool tolerances. A maximum clearance of 3 to 5 percent of the sheet thickness is recommended. The top blade of the shears should be ground with an included angle of 45° to 60°. The shear angle on a punch should be 2° to 3°, with a 1° clearance angle on the die. For blanking, the shear angle on the die should be 2° to 3° with a 1° clearance angle on the punch. Holddown pressures should be used when possible. Cold shearing should not be accomplished on hard-rolled sheet thicker than .064-inch or annealed sheet thicker than 1/8-inch. Shaving is used to improve the characteristic rough, flaky edges of magnesium sheet which has been sheared. This operation consists of removing approximately 1/32-inch by a second shearing.

Hot shearing is sometimes used to obtain an improved sheared edge. This is necessary for heavy sheet and plate stock. Annealed sheet may be heated to 600° F, but hard-rolled sheet must be held under 400° F, depending on the alloy used. Thermal expansion makes it necessary to allow for shrinkage after cooling, which entails adding a small amount to the cold metal dimensions before fabrication.

Sawing is the only method used in cutting plate stock more than 1/2-inch thick. Bandsaw raker-set blades of 4- to 6-tooth pitch are recommended for cutting plate stock or heavy extrusions. Small and medium extrusions are more easily cut on a circular cutoff saw having 6 teeth per inch. Sheet stock can be cut on bandsaws having raker-set or straight-set teeth with a pitch of 8 teeth per inch. Bandsaws should be equipped with nonsparking blade guides to eliminate the danger of sparks igniting the filings.

Cold-working most magnesium alloys at room temperature is very limited because they work-harden very rapidly and do not lend themselves to any severe cold-forming. Some simple bending operations may be performed on sheet material, but the radius of bend must be at least 7 times the thickness of the sheet for soft material and 12 times the thickness of the sheet for hard material. A radius of 2 or 3 times the thickness of the sheet can be used if the material is heated for the forming operation.

Wrought magnesium alloys tend to crack after they are cold-worked. Therefore, the best results are obtained if the metal is heated to 450° F before any forming operations are attempted. Parts formed at the lower temperature range are stronger because the higher temperature range has an annealing effect on the metal.

There are some disadvantages to hot-working. First, heating dies and heating the material is expensive and troublesome. Secondly, there are problems in lubricating and handling materials at these temperatures. However, there are some advantages to hot-working magnesium in that it is more easily formed when hot than are other metals and spring-back is reduced, resulting in greater dimensional accuracy.

When heating magnesium and its alloys, watch the temperature carefully as this metal is easily burned. Overheating also causes small molten pools to form within the metal. In either case, the metal is ruined. To prevent burning, magnesium must be protected with a sulfur dioxide atmosphere while being heated.

Proper bending around a short radius requires the removal of sharp corners and burrs near the bend line. Layouts should be made with a carpenter's soft pencil because any marring of the surface may result in fatigue cracks.

It is permissible to heat small pieces of magnesium with a blow torch provided proper precautions are exercised. It must be remembered that magnesium will ignite when it is heated to a temperature near its boiling point in the presence of oxygen.

Press or leaf brakes can be used for making bends with short radii. Die and rubber methods should be used where bends are to be made at right angles, which complicate the use of a brake. Roll forming may be accomplished cold on equipment designed for aluminum. The most common method of forming and shallow drawing magnesium is an operation in which a rubber pad is used as the female die. This rubber pad is held in an inverted steel pan which is lowered by a hydraulic press ram. The press exerts pressure on the metal and bends it to the shape of the male die.

The machining characteristics of magnesium alloys are excellent, making possible the use of maximum speeds of the machine tools with heavy cuts and high feed rates. Power requirements for machining magnesium alloys are about one-sixth of those for mild steel.

Filings, shavings, and chips from machining operations should be kept in covered metal containers because of the danger of combustion. To repeat a previous reminder—in case of a magnesium fire, do not try to extinguish it with water. The oxygen in the water supports the combustion and increases the intensity of the fire. Dry powder is the recommended extinguisher for magnesium fires.

LESSON QUESTIONS

SHEET METAL LAYOUT AND FORMING

Answers and page references for these questions appear on page 71.

1. What is the product of 7/20 x 10/49?

A. 1/14
B. 7/49
C. 17/69
D. 1-18/25

2. What is the sum of 3 1/7 + 5 3/4 + 2 1/14 + 7 1/2?

A. 17 13/28
B. 17 25/56
C. 18 13/28
D. 18 25/56

3. What is the value of 37 1/4 minus 12 3/8?

A. 24 3/8
B. 24 7/8
C. 25 3/4
D. 25 7/8

4. Forty percent changed to a common fraction is ________.

A. 3/8
B. 2/5
C. 3/5
D. 4/5

5. An aircraft repair requires 50 hours to accomplish, and you have used 12 hours for layout and forming. What percent of the total time have you used?

A. 16
B. 20
C. 24
D. 28

6. A search aircraft's fuel load is sufficient for 12 hours of flight time. Of the total fuel, 15% must be used enroute to the search scene, and 25% must be reserved for the return flight. Approximately how long may the aircraft remain on scene?

A. 4 hrs. 48 min.
B. 6 hrs. 17 min.
C. 7 hrs. 12 min.
D. 8 hrs. 18 min.

7. What is the product of $7^2 \times 7^5$?

A. 749,449
B. 823,543
C. 971,949
D. 1,123,443

8. What is the product of $(3^2)^3 \times (5^3)^2$?

A. 7,462,525
B. 9,309,745
C. 10,671,315
D. 11,390,625

9. What is the value of $12^3 \div 16^2$?

A. 1.33
B. 4.25
C. 6.75
D. 9.42

10. What is the square root of 26,569?

A. 159
B. 163
C. 510
D. 563

11. What is the square root of 5.429 to the nearest hundredth?

A. 0.73
B. 1.43
C. 1.97
D. 2.33

12. What is the square root of 3/4 to the nearest thousandth?

A. .279
B. .488
C. .797
D. .866

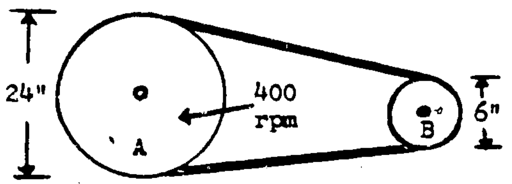
13. What is the area of a 10-inch circle?

A. 78.54 inches
B. 82.14 inches
C. 87.30 inches
D. 91.00 inches

14. What would be the speed of a blower fan having a 10-inch pulley if the fan were powered by a 1250 rpm motor with a 2-inch pulley?

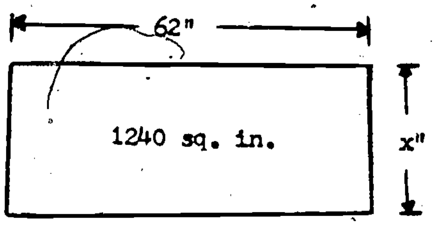
A. 125 rpm
B. 250 rpm
C. 625 rpm
D. 1250 rpm

15. In the illustration below, what is the speed of the pulley B when driven by pulley A?



A. 400 rpm
B. 1250 rpm
C. 1600 rpm
D. 2250 rpm

16. What is the width of the rectangle illustrated below?



A. 20 inches
B. 22.5 inches
C. 24 inches
D. 25.5 inches

17. Given the formula $w = \frac{x - A}{2z}$. What does x equal?

A. $\frac{w - A}{2z}$

B. $w - \frac{A}{2z}$

C. $(w - A)2z$
D. $A + 2zw$

18. Given the formula $2BN = \frac{Bpx}{4N}$. What does x equal?

A. $\frac{B^2p}{2}$

B. $\frac{(2BN - 4N)}{Bp}$

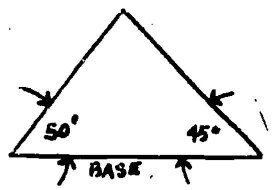
C. $\frac{2N(B + 2)}{Bp}$

D. $\frac{8N^2}{p}$

SECOND ASSIGNMENT

In Pamphlet No. 345 read from MENSURATION on page 8 through page 19 and answer questions 19 through 29.

19. What angle is formed at the vertex of the triangle illustrated below?

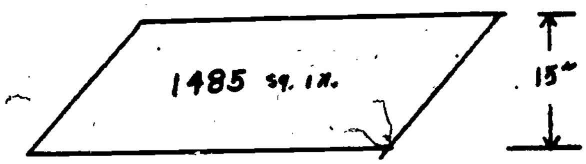


A. 73 degrees
B. 79 degrees
C. 85 degrees
D. 90 degrees

20. The circumference of a circle whose diameter is 8 1/2 inches is ____________ inches.

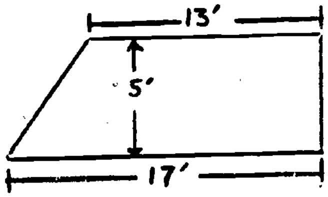
A. 23.907
B. 24.642
C. 26.704
D. 28.603

21. What is the length of the base in the parallelogram illustrated below?



A. 65 inches
B. 74 inches
C. 81 inches
D. 99 inches

22. What is the area in square feet of the trapezoid illustrated below?



A. 35
B. 50
C. 60
D. 75

23. What is the formula for finding the area of a triangle?

A. $A = \frac{bh}{2}$

B. $A = \frac{DR^2}{1/2}$

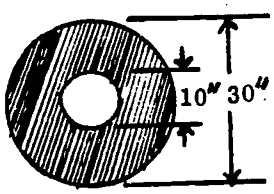
C. $A = \frac{bh}{1/3}$

D. $A = \frac{bac}{2}$

24. The radius of a circle whose area is 78.54 square inches is ____________ inches.

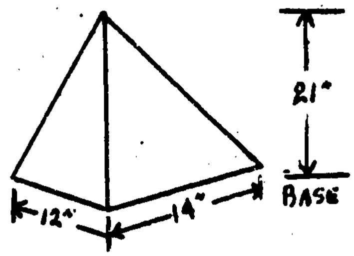
A. 5.00
B. 16.72
C. 25.00
D. 39.27

25. What is the area of the circular ring illustrated below?



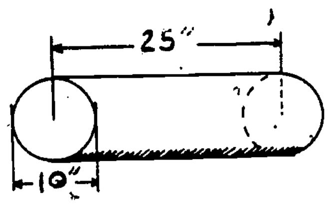
A. 579.65 sq. in.
B. 628.32 sq. in.
C. 643.21 sq. in.
D. 701.00 sq. in.

26. What is the volume in cubic inches of the pyramid illustrated below?



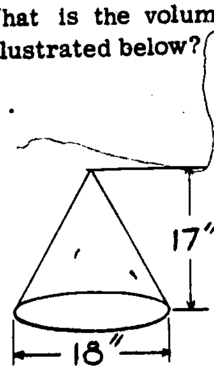
A. 1176
B. 1233
C. 1297
D. 1342

27. What is the volume in cubic inches of the cylinder illustrated below?



A. 196.35
B. 784.50
C. 1367.31
D. 1963.50

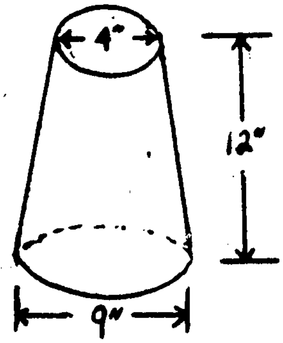
28. What is the volume in cubic inches of the cone illustrated below?



A. 1236.43
B. 1388.21
C. 1441.99
D. 1501.07

151

29. What is the approximate volume of the frustrum of the cone illustrated below?



A. 418 cu. inches
B. 487 cu. inches
C. 513 cu. inches
D. 573 cu. inches

30. Which line on a drawing is used as a basis to determine the weight of the other lines on that drawing?

A. Center line
B. Cutting plane
C. Visible outline
D. Invisible outline

31. In the screw thread size 10-32 NF-2, what does the -2 indicate?

A. Thread fit
B. Thread series
C. Length of screw
D. Threads per inch

32. What is the MINIMUM number of views required on a drawing to completely describe a regular cone?

A. One
B. Two
C. Three
D. Four

33. Which type drawing will show all features of an object in their true shape?

A. Pictorial
B. Projection
C. Perspective
D. Photographic

34. Which type drawing is used to describe the interior construction of complex objects?

A. Assembly
B. Pictorial
C. Auxiliary
D. Sectional

35. What type of view is used to show the true cross-sectional shape of an object at a particular point?

A. Offset section
B. Revolved section
C. Crosshatch detail
D. Broken line detail

36. Where on a blueprint is specific information on heat treatment normally located?

A. Title block
B. Usage block
C. Upper left corner
D. Upper right corner

37. Since stainless steel work hardens very readily, you should use ____________ for forming operations.

A. forming blocks only
B. plastic mallets only
C. dies whenever possible
D. bench stakes whenever possible

38. In sheet metal forming operations, what term is used to describe the sharpest bend that may be used without overstressing the metal?

A. Maximum bend angle
B. Minimum shear angle
C. Maximum radius of bend
D. Minimum radius of bend

39. You must bend a sheet of .125-inch thick annealed aluminum alloy. Normally, the sharpest bend radius that may be used is ______ inch.

A. 3/32
B. 1/8
C. 3/16
D. 1/4

40. You must put a 60 degree bend in a sheet of .072-inch thick aluminum alloy. What is the bend allowance for a bend radius of .375-inch?

A. .4263
B. .6390
C. .6444
D. .8252

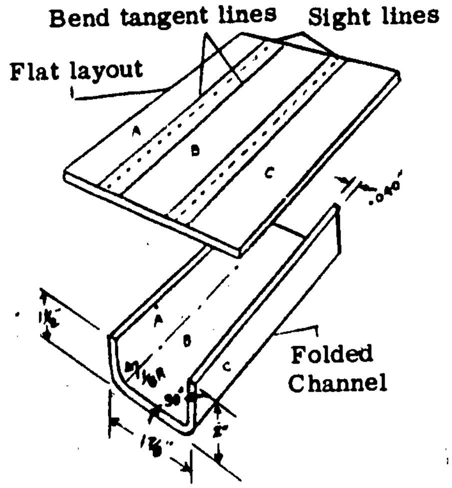
41. When bending sheet metal, measure the set back from the mold point to the ______ line.

A. brake
B. sight
C. bend tangent
D. neutral axis

42. A 111 degree bend must be formed on a sheet of .049-inch thick metal. Using a bend radius of .081-inch, you must allow ______-inch for setback.

A. 0.189
B. 0.257
C. 0.342
D. 1.455

TO ANSWER QUESTIONS 43 THROUGH 47, REFER TO THE ILLUSTRATION BELOW. ASSUME THAT YOU MUST MAKE THE FLAT LAYOUT TO PRODUCE THE FOLDED CHANNEL TO THE SPECIFIED DIMENSIONS.



43. What is the set-back for the bends?

A. .137
B. .149
C. .165
D. .182

44. What is the width in inches of Flat A?

A. 1.229
B. 1.335
C. 1.475
D. 1.500

45. The bend allowance for each fold of the layout is ______ inch.

A. .176
B. .183
C. .218
D. .224

46. What is the width in inches of Flat B?

A. 1.375
B. 1.545
C. 1.710
D. 1.875

47. The width of Flat C is ______ inches.

A. 1.670
B. 1.750
C. 1.835
D. 1.875

48. The size of relief holes at the intersection of bend tangent lines depends on the ______ of the metal to be bent.

A. hardness
B. thickness
C. ductility
D. malleability

49. What process is used to project and draft lines and curves into a layout?

A. Stretchout
B. Development
C. Duplication
D. Patternmaking

50. Which layout method should you use to develop the pattern for a cone shaped object?

A. Radial line
B. Triangulation
C. Parallel line
D. Slanted projection

51. In the pattern for a regular cone, the radius of the stretchout arc is equal to the ___________.

A. radius of the plan view
B. diameter of the plan view
C. slant height of the elevation view
D. actual height of the elevation view

52. All sheet metal forming operations revolve around the process of ___________.

A. stretching and bending
B. beveling and shrinking
C. extruding and stretching
D. shrinking and stretching

53. Which procedure/s should be followed in order to hand form a flanged angle using the shrink forming process?

A. Start hammering near the center and work toward both ends
B. Alternately hammer at both ends and work toward the center
C. Start hammering at one end and work toward the opposite end
D. Any of the above procedures are correct

54. The wooden form block designed for bumping must be of the same size and contour as the ___________ surface of the object that is to be formed.

A. shrunken inside
B. stretched inside
C. shrunken outside
D. stretched outside

55. To reduce the tendency of the metal to crack, wrought magnesium alloys should be ___________ prior to any forming operation.

A. heated
B. annealed
C. normalized
D. cold worked

ANSWER KEY

ITEM	ANS.	REF PAGE	ITEM	ANS.	REF PAGE	ITEM	ANS.	REF PAGE
1	A	2	2	C	2	3	B	2
4	B	2	5	C	3	6	C	3
7	B	4	8	D	4	9	C	4
10	B	5	11	D	5	12	D	6
13	A	6	14	B	7	15	C	7
16	A	8	17	D	8	18	D	8
19	C	10	20	C	11	21	D	14
22	D	15	23	A	15	24	A	16
25	D	16	26	A	17	27	D	17
28	C	18	29	A	19	30	C	22
31	A	24	32	A	26	33	B	28
34	D	32	35	B	33	36	A	37
37	C	41	38	D	43	39	B	43
40	A	45	41	C	45	42	A	46
43	C	47	44	B	47	45	D	47
46	B	48	47	C	48	48	B	48
49	B	50	50	A	51	51	C	51
52	D	54	53	A	56	54	D	59
55	A	62						

COAST GUARD INSTITUTE

OKLAHOMA CITY

AIRCRAFT DAMAGE REPAIR

DEPARTMENT OF TRANSPORTATION
U. S. Coast Guard (01/82) AMT-0107

U. S. Coast Guard Institute
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Airframe Repair Specialist .... Air Force CDC 53450

Aviation Structural Mechanic AMS 3 & 2 .... NAVTRA 10308-C

Structural Hardware .... T.O. 1-1A-8

IMPORTANT NOTE: In January, 1982, the information contained in this pamphlet was current according to the latest updates of those Directives/Publications listed. This pamphlet was compiled for training **ONLY**. It should **NOT** be used in lieu of official Directives or publications. It is always **YOUR** responsibility to keep abreast of the latest professional information available for your rate.

The personnel responsible for the latest review and update of the material in this component during January 1982 are:

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Questions about the text should be addressed to your Subject Matter Specialist.

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AIRCRAFT DAMAGE REPAIR

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AIRCRAFT DAMAGE REPAIR

INTRODUCTION

The purpose of this pamphlet is to outline the procedures for inspecting and repairing damage to Coast Guard aircraft. To ensure the readiness of Coast Guard aircraft, the AM must be familiar with the information presented here.

This pamphlet is divided into three major sections:

(1) Damage repair procedures
(2) Reinforced plastic and sandwich construction repair
(3) Riveting procedures

Section 1 discusses the inspection and classification of aircraft damage, types of repairs to be made, and selection of repair materials. In section 2, general procedures are given for repairing reinforced plastic and sandwich construction components. Section 3 outlines rules for selecting and using rivets for an aircraft repair. Also included are the procedures you should follow for drilling and countersinking rivet holes.

Each section of this pamphlet includes a list of objectives, text material, and a review quiz. At the end of the pamphlet is a multiple-choice review quiz. The quiz items are designed to test your mastery of the objectives, which emphasize the most important points of the text.

NOTE: Correct answers and text references are provided on the back of each page containing quiz items. If you answer any of the quiz items incorrectly, refer to the text for further study.

To get the most from this pamphlet, you should use the study tips provided on the INSTRUCTIONS sheet for this course.

SECTION 1

DAMAGE REPAIR PROCEDURES

OBJECTIVES

When you have completed this assignment, you should be able to:

1. List and describe the methods of inspecting aircraft structural damage.
2. Describe the classifications of aircraft structural damage.
3. Explain the considerations for selecting aircraft repair materials.
4. Explain the considerations in determining whether a repair should be temporary or permanent.
5. Describe the various repairs that may be made to internal structural components.
6. Describe the types of external skin repairs.

In the modern age of high-speed aircraft, the AM must be familiar with the principle of streamlining and fairing. Also, the AM must be aware of the behavior of various metals in high-velocity air currents and torsional stresses encountered during high-speed flying and maneuvering. One of the most important jobs the AM will encounter is the repair of damaged skin. All repairs must be of the highest quality and must conform to certain requirements and specifications.

Methods of repairing the structure of a damaged aircraft are given in the Structural Repair Manual for the specific aircraft. No one set of repair rules will apply to all aircraft. The problem of repairing a damaged section is usually solved by duplicating the original part in strength, using the materials and procedures specified in the aircraft Structural Repair Manual.

PREINSPECTION OF DAMAGED AREAS

When any part of the airframe has been damaged, the first step is to clean off all grease, dirt, and paint in the vicinity of the damage so that the extent of the damage may be determined. The damaged area and adjacent structures must be thoroughly inspected. Basically, there are three methods of inspection that can be used to ensure that a thorough investigation has been made. The three methods are visual inspection, hardness testing, and nondestructive inspection for cracks.

VISUAL INSPECTION

A thorough inspection of the structure should be made for dents, scratches, abrasions, punctures, cracks, distortion, loose joints, breaks, and buckled and wrinkled skin. All riveted and bolted joints in the vicinity of the damaged area should be checked for elongated holes, and loose, sheared, or damaged rivets or bolts. If any doubt should exist about the failure of a rivet or bolt, the fastener should be removed for a more thorough inspection. All access panels, hatches, and doors should be opened for the inspection of the internal structure.

A Borescope (precision optical instrument) can be used to great advantage for the inspection of the internal structure. Structures may be examined with this instrument without being disassembled by removing fasteners, inserting the Borescope, and viewing the area through the eye piece. The fasteners should be removed in a regular pattern to be sure that a complete inspection has been made.

The adjacent structure should be inspected to determine if secondary damage has resulted from the transmission of shock of the load that caused the primary damage. A shock at one end of a structural member may be transmitted to the opposite end of the member, causing sheared rivets or other damage at a considerable distance from the primary damage. In estimating the extent of damage, be sure that no secondary damage remains unnoticed.

Every precaution must be taken during the inspection to ensure that all corrosion is detected, especially in places where it will not be visible after repair. Past experience has proven that corrosion occurs more often in parts of the structure that are poorly ventilated and inaccessible corners of internal joints that prevent proper water drainage.

HARDNESS TESTING

When fire has damaged the airframe, the paint will be blistered or scorched and the metal will be discolored. When these conditions exist, the affected area should first be cleaned and the paint removed. Following this, a hardness test should be made to determine if the metal has lost any of its strength characteristics. This test can be performed with the Barcol or Riehle portable hardness tester. If the material to be tested is to be removed from the airframe, then a more reliable test can be made by the use of a standard bench type tester. If the alloy to be tested is either clad or anodized, the surface coating must be removed to the bare metal at the point of penetrator contact. This is necessary because clad surfaces are softer, and anodized surfaces are harder, than the base alloy.

INSPECTION FOR CRACKS

The existence of suspected cracks or the full extent of apparent cracks in structural members cannot be accurately determined by visual inspection. In cases where it is necessary for cracks to be accurately defined, a penetrant inspection is usually performed.

Fittings should receive a special investigation if they are cracked, since cracks can cause an entire component to fail. Fittings are used to attach sections of wings together and wings to fuselage, as well as attachment of stabilizers, control surfaes, landing gear, engine mounts, etc. The penetrant method of inspection can be used to detect surface cracks in fittings, and the magnetic particle method is used to detect subsurface cracks in ferrous fittings.

CLEANUP OF DAMAGE

Simultaneously with the investigation of damage, clean out all jagged holes, tears, or damaged material. The cleaned out sections must include all the area in which minute cracks are present. The affected area must be cutout and rounded to form a smooth regular outline. If a rectangular-or square-shaped cutout is made, the radii for the corners should be a minimum of one-fourth inch, unless otherwise specified. All burrs should be removed from the edges of the cutout.

All dented plates should be restored to their original shape if possible. Shallow abrasions or scratches should be burnished with a burnishing tool which will compress the projecting metal along the edges down into the scratch. Burnishing has no cutting action and removes no metal. When surface irregularities are smoothed out by burnishing, the stress concentration will be lessened by uniform distribution of the stresses.

CAUTION

Deep scratches and abrasions must be treated as complete breaks.

CLASSIFICATION OF DAMAGES

The Structural Repair Manual normally specifies the type of repair to be made to a damaged structure. Damages can normally be classified under one of the following classifications: negligible damage, damage repairable by patching, damage repairable by insertion, and damage necessitating replacement. (See Figure 1-1) After preinspection of the damaged area, the AM must decide on one of the four classifications.

NEGLIGIBLE DAMAGE

Negligible damage is damage or distortion that can be permitted to exist or can be corrected by a simple procedure. Frequently, negligible damage can be repaired by stop drilling cracks, removing dents, and fabricating temporary fabric patches without placing any restrictions on the aircraft.

DAMAGE REPAIRABLE BY PATCHING

Damage which exceeds negligible damage limits should be investigated to determine the possibility of using a patch repair. A patch repair is made by adding material around the damaged area to enable the damaged structure to carry its designed load.

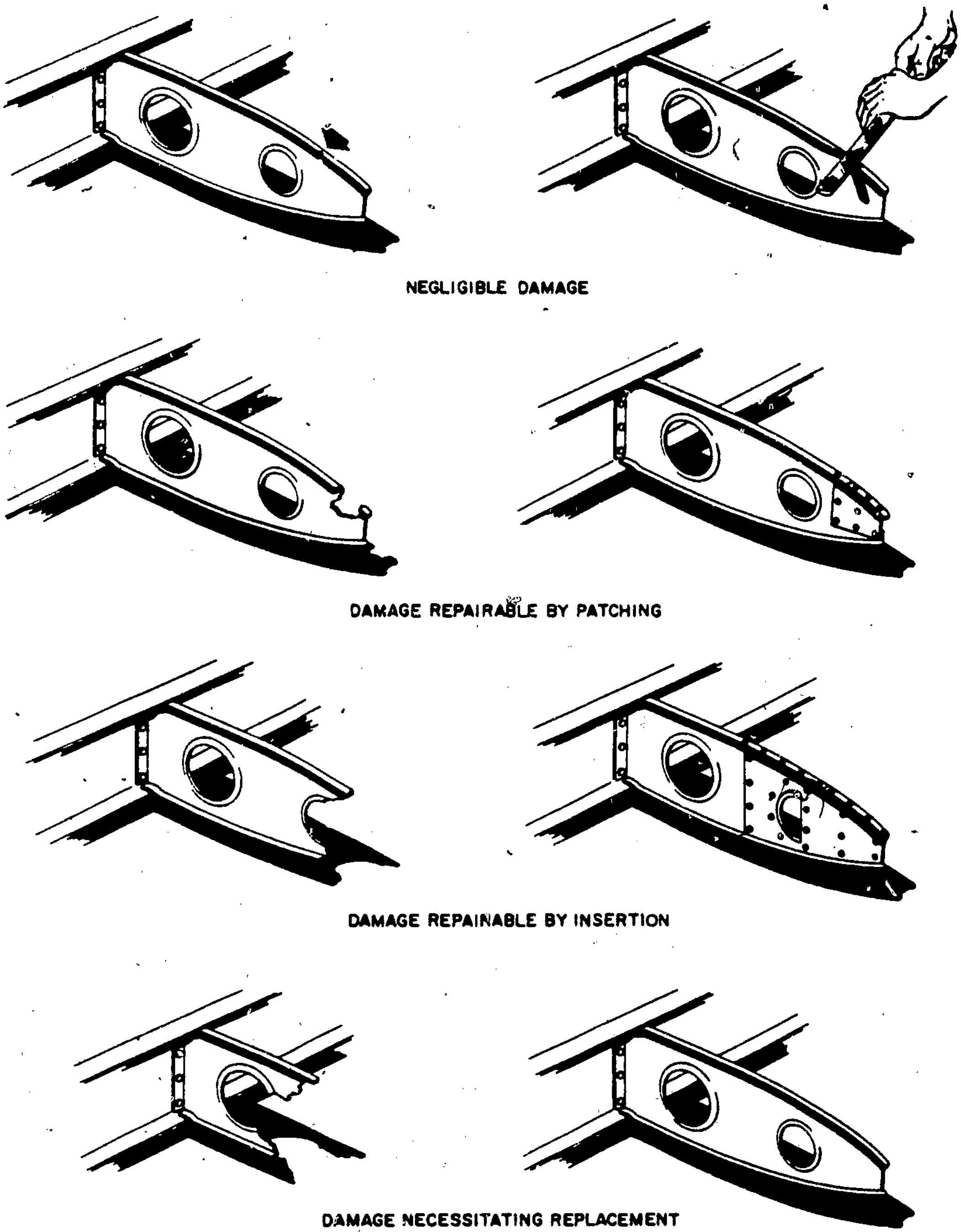


Figure 1-1 -Classification of damages.

DAMAGE REPAIRABLE BY INSERTION

This repair involves the removal of the damaged portion of a member and replacing this portion with materials identical in shape and strength to the damaged member. A backup plate (doubler) is used with this type of repair to reinforce the damaged area and provide a surface to fasten the filler. This repair is used where a flat surface is required.

DAMAGE NECESSITATING REPLACEMENT

Damage which cannot be repaired by any practical means is classified as damage necessitating replacement.

TYPES OF REPAIR

The type of repair to be made will depend on the materials, tools, amount of time available, and the maintenance level. The types of repair are permanent, temporary, and one-time flight (ferry). Repairs are also classified as either internal or external.

A permanent repair is one which restores the strength of the repaired structure equal to or greater than its original strength, and at the same time satisfies aerodynamic, thermal, and interchangeability requirements. This is neccessary to ensure the designed capabilities of the aircraft.

The temporary repair restores the load carrying ability of the structure but is not aerodynamically smooth or able to satisfy interchangeability requirements. This repair should be replaced by a permanent type as soon as possible, in order for the aircraft to be restored to its normal condition.

The one-time flight repair restores a limited load-carrying ability to the damaged structure so that the aircraft can be flown to a Depot maintenance activity for a permanent repair. When this type of repair is made, the aircraft cockpit should be placarded to limit the performance of the aircraft.

INTERNAL STRUCTURAL REPAIR

The repair of internal structures concerns the repair or replacement of extruded parts used as stringers, webs used as bulkheads, and formed parts such as ribs and formers.

After the damage has been inspected and classified, the next consideration is to plan the repair so that it can be done in the proper sequence. Before the removal, repair, or replacement of a structural member is undertaken, the adjacent structural members of the aircraft must be supported so that proper alignment is maintained throughout the operation. Also, proper materials must be selected for the repair or fabrication of structural members.

Selection of Repair Material

The major requirement in making a repair is the duplication of strength of the original structure. The Structural Repair Manual for the aircraft concerned must be consulted for alloy thickness and temper designation of the repair material to be used. This manual will also designate the type and spacing of rivets or fasteners to be used in the repair.

In some instances, substitution of materials is allowed. For example, the Structural Repair Manual may specify that 2024-T42 clad material may be substituted for 2024-T3 clad materials in fuselage areas having sharp or double curvatures. If conflicting information exists concerning the substitution of materials, you should use the Structural Repair Manual for the aircraft being repaired.

When using the Structural Repair Manual, you normally have several steps to take in finding the correct repair materials and procedures. Figure 1-2 illustrates each of the steps listed in the procedures to follow.

NOTE: The C-130 Structural Repair Manual was selected as a typical manual. The procedures that follow are typical but are not standard. Various manufacturers use different methods to indicate the types of materials used and special instructions for using their particular manual.

Step 1. The extent of the damage to the aircraft is determined by the preinspection of the damaged area as previously explained.

Step 2. Using a master index diagram, identify the major assembly that has the damaged structural component. From the table shown on the figure, determine the section of the handbook in which the major assembly is covered. From the right-hand column of the table, determine the figure number of the exploded view of the assembly.

Step 3. Turn to the figure showing the exploded view of the major assembly. Obtain the figure number of the applicable structural or skin illustration of the damaged component.

Step 4. Turn to the applicable structural or skin illustration, and obtain the reference key number for the damaged member of the component.

Step 5. Find the reference key number of the damaged member on the key to the structural or skin illustration. The key to the illustration has the same figure number and title as the illustration itself. This key gives the description, gage, material, Lockheed extrusion, specification, and repair figure number of the damaged member. If the word 'replace' is in the repair figure column instead of a regular repair figure number, replace the damaged member with a spare member or with one of like material having equivalent cross-sectional properties.

Step 6. Turn to the repair illustration for the required repair data. To make the repair, use the repair illustration along with the Structural Repair Code, which is located in the introduction, and the applicable section and general text. Study the repair illustration and read all notes. In every case, the views on the repair illustration show repair of the maximum allowable damage to the cross section of the structural member.

Fabrication of Parts

Information needed to fabricate replacement parts is usually found on blueprints. The aircraft Structural Repair Manual contains information on extrusions and the necessary data for the fabrication of various sheet metal equivalents.

As stated previously, the aircraft Structural Repair Manual will indicate the type of material to be used in each repair. If the manual does not indicate a substitute for unavailable material, you should refer to the General Manual for Structural Repair (NA 01-1A-1) for an acceptable substitute.

The fabrication of sheet metal parts for internal structural repair requires careful adherence to the accepted standards of aircraft sheet metal work. This includes accurate calculation of bend allowance and careful layout of all dimensions.

Layout

Layout means the interpreting and transcribing of information from blueprints, drawings, or written instructions to the metal that will be made into a part for an aircraft.

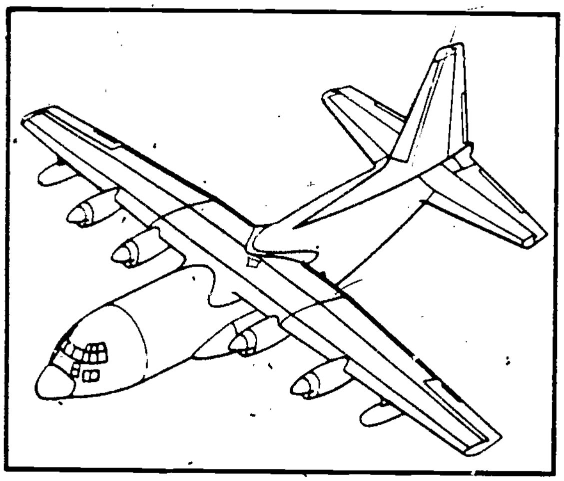
If several parts are to be fabricated, the dimensions may be transferred to a template. Working from a template ensures a higher degree of uniformity and speeds production.

The procedure for making a layout either for a template or for the actual part is essentially the same. Layout of a part or a template consists principally of marking the flat sheet so that all drilling, cutting, bending, and forming operations are indicated on the sheet. It is a working drawing in the strictest sense, because each detail in the fabrication of the part has been clearly indicated by lines and marks.

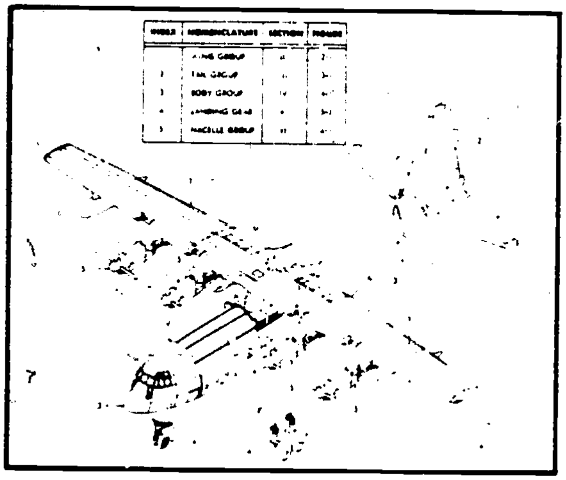
The sheet metal layout may be made from printed instructions, as previously mentioned, but is more often made directly from the blueprint. Accuracy in all details is essential. Care should be taken not to transfer dimensions directly from the blueprint to the layout since the print material may have stretched or shrunk, causing minor distortion of the dimensions. Measurements indicated on the blueprint are made on the layout.

Details are often left out and must be developed in the shop. You may, for example, find that you must add several dimensions and then figure the bend allowance for the material consumed in each bend before you are able to lay out the overall length or width of a part.

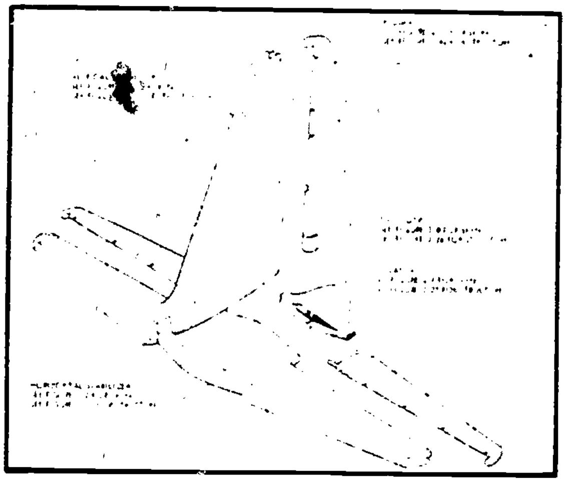
On very accurate layouts, a magnifying glass is frequently used as an aid to permit precision work. A magnifying glass enlarges the graduations on a scale, rendering them easier to read. It helps locate center punchmarks, and it facilitates a close inspection of the accuracy of the completed layout.



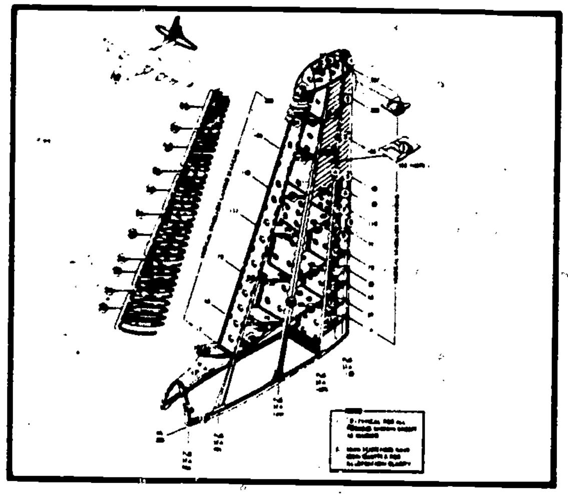
STEP 1.



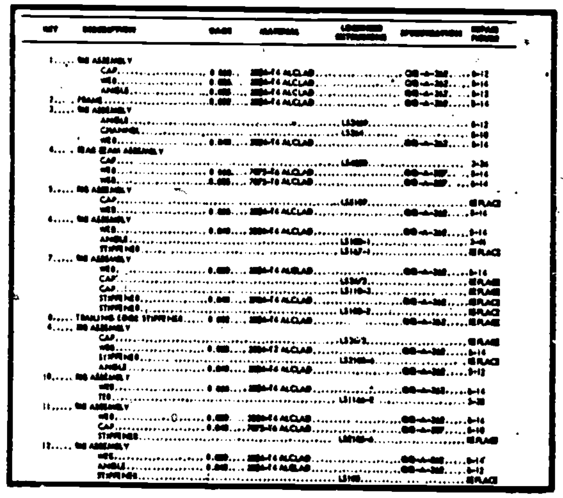
STEP 2.



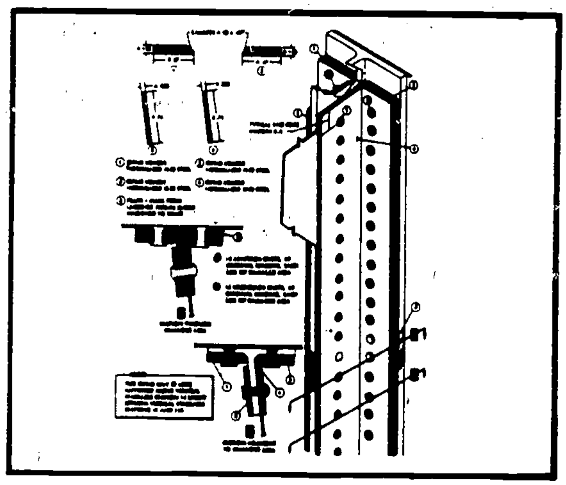
STEP 3.



STEP 4.



STEP 5.



STEP 6.

Figure 1-2 - How to use a Structural Repair Manual.

To begin the layout, make sure one edge of the metal is straight. All measurements can then be based on this edge of the sheet. Lines at a known angle or parallel to the straight edge can be made by marking off points from a combination square held firmly against this edge of the sheet.

If it is impossible to obtain a straight edge on a sheet to start a layout, or if the distance from the edge is too great, a reference line may be used. The reference line may be made by connecting any two points with a straight line. Perpendiculars to the reference line may be geometrically erected by using compasses or dividers to form a cross. This cross, accurately constructed, may be used as the basis for almost any type layout.

A scriber must NEVER be used for drawing lines on aluminum or magnesium except to indicate where the metal is to be cut or drilled. All other lines must be drawn with a pencil. The pencil mark should be removed from aluminum and magnesium to prevent an electrolytic action that will eventually cause corrosion. The mark can be removed with isopropyl alcohol or MEK. Even a shallow line that is cut in the surface of the metal may cause cracking and eventual failure.

In the layout of a part, plan the bending and forming operations so that each step is made in the proper sequence. If the steps are not made in the proper sequence, the part may become too bulky to be inserted in the brake for the final bending.

Bend Allowance

Bend allowance information in this section is limited to illustrating the minimum bend radii table and the bend allowance table for some of the commonly used metal thicknesses and bend radii. The use of the empirical bend allowance formula is also shown.

Figure 1-3 shows the minimum bend radii generally accepted by the aircraft industry.

Figure 1-4 shows the bend allowance per degree of bend for some of the commonly used thicknesses and bend radii. This table is based on the empirical formula for bend allowance illustrated in figure 1-5.

Stringers and Their Repair

A stringer is a spanwise structural member designed to stiffen the skin and aid in maintaining the contour of the structure. Stringers also transfer stresses from the skin to bulkheads and ribs to which the stringers are attached. Stringers are not continuous throughout the structure as are longerons, and are not subject to as much stress. Stringers are made from both extruded and rolled sections and are usually in the form of C channels, angles, or hat sections.

Figure 1-6 illustrates one method used in repairing a damaged stringer by patching. The repair consists of a reinforced splice and a filler splice. The reinforcement splice should be long enough to extend a minimum of four times the width of the leg of the stringer on each side of the damaged area. The cross-sectional area of the reinforcement splice must be equal to or greater than the stringer itself. The damage is cleaned out to a smooth contour with corner radii, and a filler of the proper thickness is prepared to fit in the cleaned out area. If possible, always make both ends of the cutout midway between two rivets, so that the existing rivet pattern can be maintained in the repair. Cut the filler splice 1/32-inch shorter in length than the cutout section. This will allow a 1/64-inch clearance between each end of the filler splice and the stub ends of the stringer, thus eliminating any possibility of stress developing from contact between the two parts.

> **NOTE:** The above repair is permissible when the damage does not exceed two-thirds of the width of one leg of the stringer and is not over 12 inches in length. When the damage is of such length that a single reinforcement splice would involve an excessive amount of material and work, a repair

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by insertion should be made. (See figure 1-7.)

Ribs and Their Repair

Ribs are the principal chordwise structural members in the wings, stabilizers, and other airfoils. Ribs serve as formers for the airfoil, giving it shape and rigidity, and also serve to transmit stresses from the skin to the spars. Ribs are designed to resist both compression and shear loads.

There are three general types of rib construction, as shown in figure 1-8. The reinforced rib and the truss rib are both relatively heavy, as compared to the former rib, and are located only at points where the greatest stresses are imposed. Former ribs are located at frequent intervals throughout the airfoil.

The reinforced rib, which is similar in construction to that of spars, consists of upper and lower capstrips joined by a web plate.

Designation	Gage							
	0.020	0.025	0.032	0.040	0.050	0.063	0.071	0.080
2024-O	1/32	1/16	1/16	1/16	1/16	3/32	1/8	1/8
2024-T4	1/16	1/16	3/32	3/32	1/8	5/32	7/32	1/4
5052-O	1/32	1/32	1/16	1/16	1/16	1/16	1/8	1/8
5052-H34	1/32	1/16	1/16	1/16	3/32	3/32	1/8	1/8
6061-O	1/32	1/32	1/32	1/16	1/16	1/16	3/32	3/32
6061-T4	1/32	1/32	1/32	1/16	1/16	3/32	5/32	5/32
6061-T6	1/16	1/16	1/16	3/32	3/32	1/8	3/16	3/16
7075-O	1/16	1/16	1/16	1/16	3/32	3/32	5/32	3/16
7075-W	3/32	1/32	1/8	5/32	3/16	1/4	9/32	5/16
7075-T6	1/8	1/8	1/8	3/16	1/4	5/16	3/8	7/16

Figure 1-3 - Minimum bend radii for aluminum alloys.

R \ T	0.020	0.025	0.032	0.040	0.050	0.063
1/32	.00070	.00074	.00079			
1/16	.00125	.00129	.00135	.00140	.00148	.00158
3/32	.00179	.00183	.00188	.00195	.00202	.00212
1/8	.00234	.00238	.00243	.00249	.00257	.00267
5/32	.00288	.00292	.00297	.00304	.00311	.00321
3/16	.00342	.00347	.00552	.00358	.00366	.00376
7/32	.00397	.00401	.00406	.00412	.00420	.00430
1/4	.00451	.00455	.00461	.00467	.00475	.00485

Figure 1-4 -Allowance per degree of bend for aluminum alloy.

The web is reinforced between the capstrips by vertical and diagonal angles. The reinforced rib is much more widely used than the truss rib.

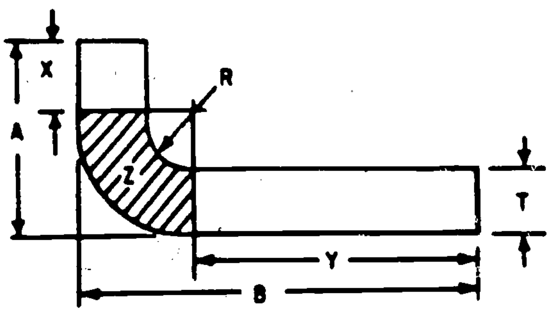
The truss rib consists of capstrips reinforced solely by vertical and diagonal cross-members. It is used in the wings of some Coast Guard aircraft.

Former ribs are made of formed sheet metal and are very light in weight. The bent-up portion of a former rib is correctly referred to as the flange, and the vertical portion is called the web. The web is generally constructed with lightening holes, with beads formed between the holes. The lightening holes lessen the weight of the rib without decreasing the strength. Rigidity of lightening hole areas is accomplished by flanging the edges of the lightening holes. The beads stiffen the web portion of the rib. Rib repair by patching is illustrated in figure 1-9.

Spars and Their Repair

Spars (also called beams) are the main spanwise members of the wing, stabilizers, and other airfoils. They may run the entire length of the airfoil, or only part of the length. Spars are designed primarily to take bending loads imposed on the wing or other airfoil.

The most common type of spar construction consists of extruded capstrips, a sheet metal web or plate, and vertical angle stiffeners. Since spars are very highly stressed members, their repair may not be permitted. If permitted, the repair must be made in strict accordance with instructions given in the Structural Repair Manual, using the best possible workmanship. Figure 1-10 illustrates a spar web repair by insertion.



Bend allowance (Z) = (0.01743R + 0.0078T) x (No. of degrees of bend)

T = thickness of metal

R = radius of bend

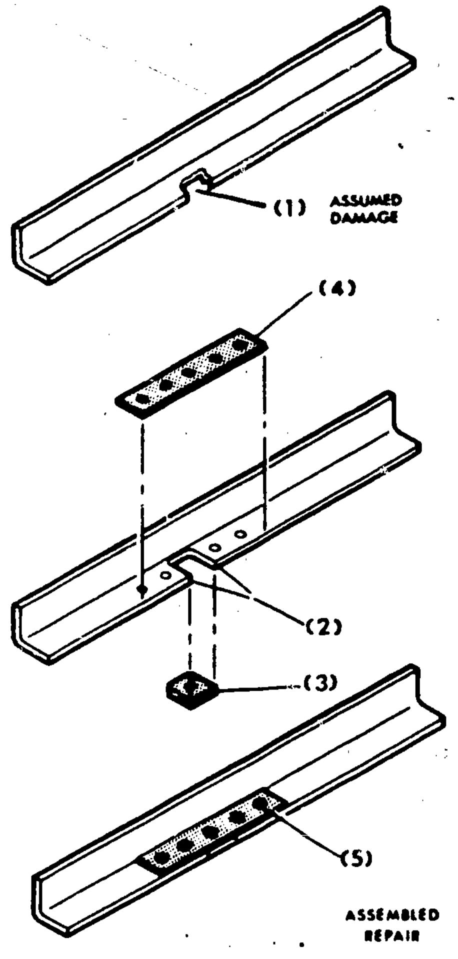
Z = bend allowance

X = A - (R + T)

Y = B - (R + T)

Total developed length = X + Y + Z

Figure 1-5 - Computing bend allowance.



1. Assumed damage.
2. Damage cut out smooth with corner radii.
3. Filler.
4. Reinforcement.
5. Assembled repair.

Figure 1-6 - Stringer repair by patching

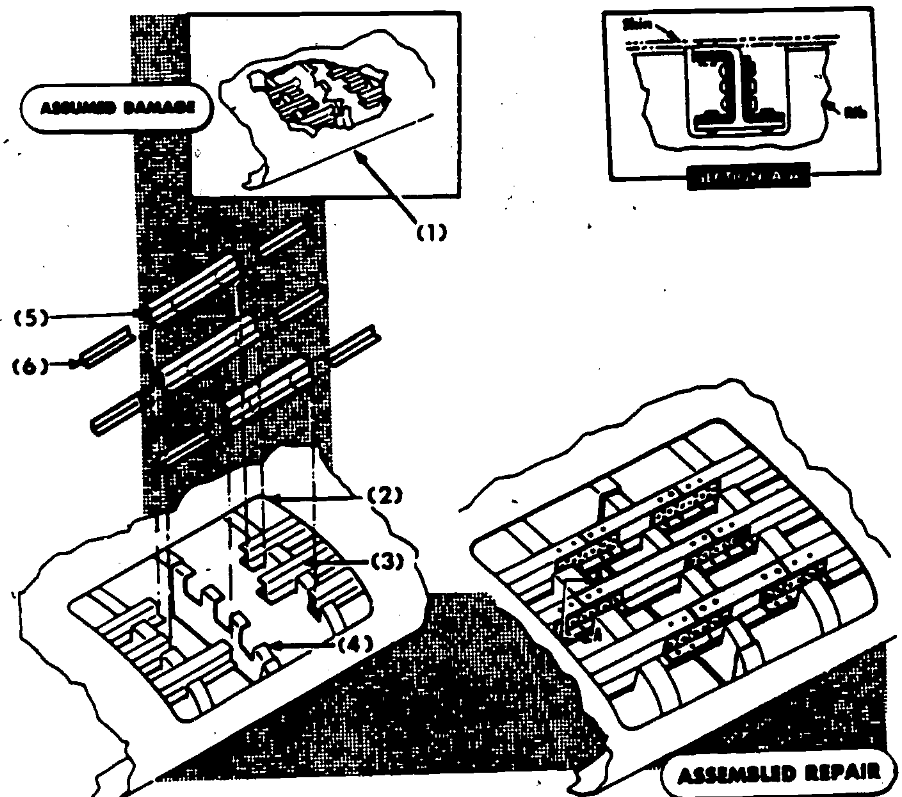
Bulkheads and Their Repair

Any major vertical structural member of a semimonocoque fuselage, hull, or float may be considered a bulkhead. Bulkheads serve to maintain the required external contour at the station where they are located, and they give rigidity and strength to the structure.

Bulkhead construction, which is similar to that used for wing ribs, consists of a web reinforced by angle stiffeners. The web is attached to the skin by formed flanges or extruded angles, which serve as capstrips. Non-watertight bulkheads may have lightening holes, and most bulkheads are cut out to give clearance for stringers. The stringers are usually attached to the bulkhead by means of angle clips.

The repair of the web and formed flange of a bulkhead is similar to the rib web and flange repair shown in figure 1-9; however, the Structural Repair Manual must be consulted for specific information on the repair of a particular bulkhead.

When damage to the web is a crack, dent, or small hole, it may be repaired in the same manner as fully stressed skin. Buckled webs may be repaired by riveting an angle reinforcement over the buckled area, provided the bulkhead is not otherwise distorted. Sheet metal used for repairs near a flanged lightening hole should be formed



1. Assumed damage.
2. Damaged skin cut back to smooth contour with corner radii.
3. Damaged area of stringers cut back in such a way that the joints will be staggered.
4. Repaired rib as shown in figure 6.
5. Stringer insertions.
6. Splice angles or reinforcements.
7. Assembled repair.

Figure 1-7 - Stringer repair by insertion with a 90-degree flange to provide additional stiffening effect.

Longerons and Their Repair

Most aircraft fuselages are constructed in sections and are of the semimonocoque design. A longeron is a fore-and-aft member of the fuselage or nacelle, usually continuous across a number of points of support, such as frames and bulkheads. The longerons along with the stringers are the major load carrying members and stiffeners. Figure 1-11 illustrates the location of the major members of a semimonocoque design forward fuselage. In case it becomes necessary to repair a longeron, review the section on stringer repair, and follow the same procedure.

EXTERNAL REPAIR

After the damage has been inspected and classified on external surfaces, the Structural Repair Manual for the specific aircraft should be consulted for the critical areas where aerodynamic smoothness must be maintained. An aerodynamic filler is available for negligible damage, steps, and gaps. In many sections the skin is Chem-Milled or machined. Chem-Mill is a process whereby the proper shape and size are obtained by a chemical acting on the metal; the proper shape and thickness of machined skin are obtained with the use of a shaper or milling machine. Some skin is manufactured with lands on the metal, which is a thicker portion of the skin where bulkheads and frames are attached.

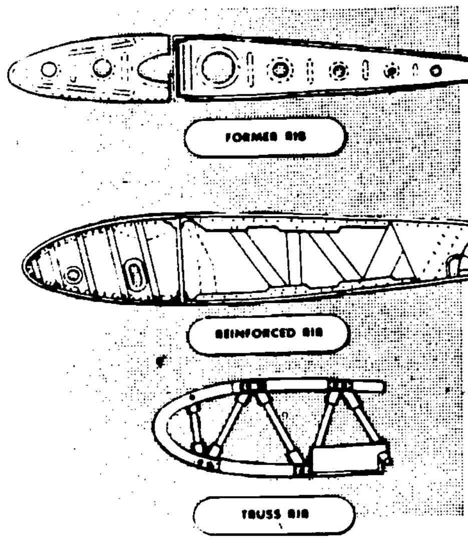
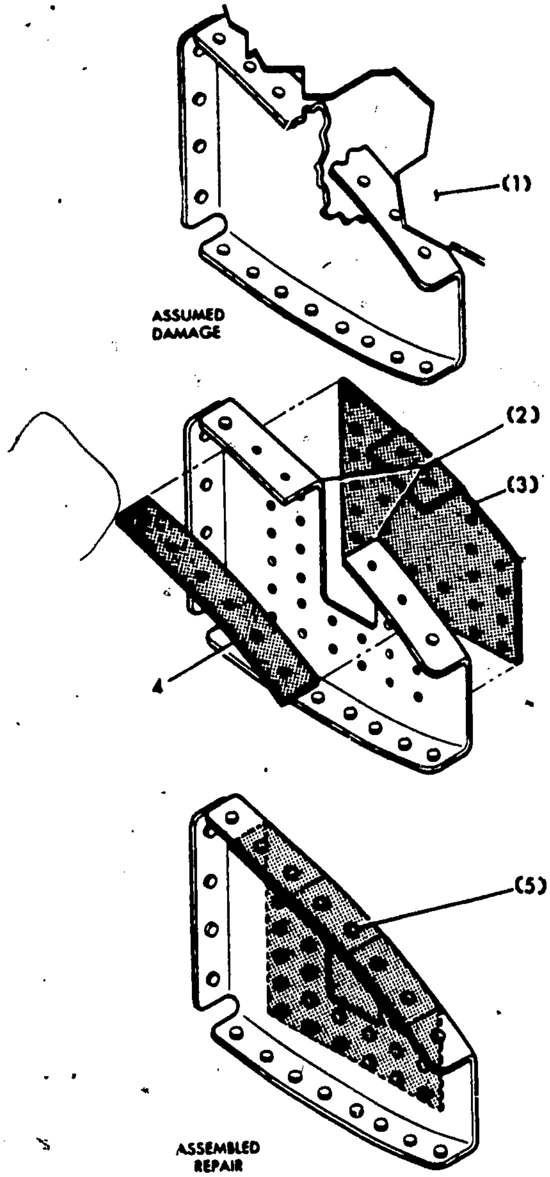


Figure 1-8 - Types of ribs.

Fuselage

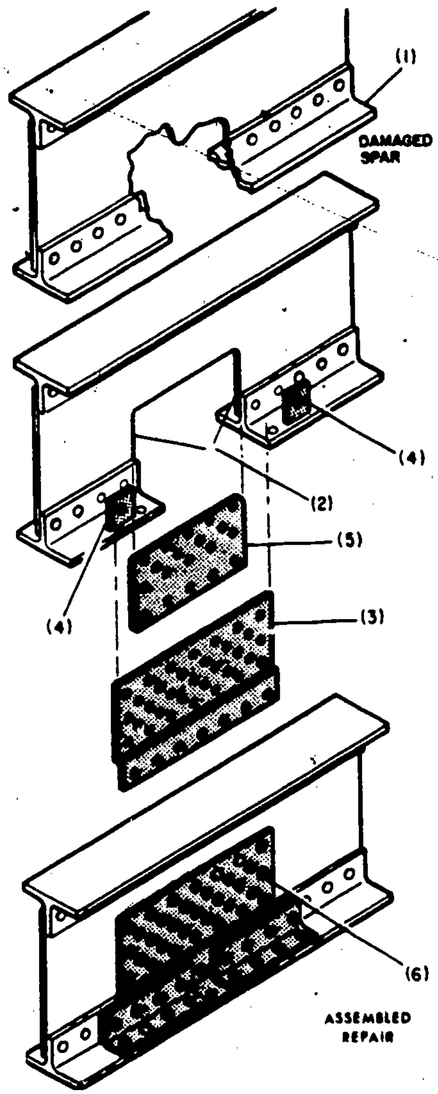
Aircraft designed for high altitude performance have one or more sections of



1. Assumed damage.
2. Damaged area smooth with corner radii.
3. Patch prepared so that it will fit flush with the flange of the former.
4. Reinforcement strip.
5. Assembled repair.

Figure 1-9 - Rib repair by patching.

the fuselage pressurized, and this factor must be taken into consideration when a repair is to be made. The fuselage is usually constructed from more than one type of metal. The most common type is aluminum alloy. On some aircraft the fuselage skin is



1. Damaged spar.
2. Damage cut out to a smooth straight edge with corner radii.
3. Joggled splice plate.
4. Two fillers of the same gage and material as splice plate.
5. Insertion.
6. Assembled repair.

Figure 1-10 - Spar repair by insertion

Chem-Milled or machine tapered and highly stressed. Figure 1-12 illustrates a Chem-Milled skin repair on a pressurized fuselage section. The repair consists of a shim, doubler, and a filler. The damage is trimmed out, and the inside corners are filed to a 1/4-inch radius. The replaced metal and rivets, or other fasteners, must be equal to or stronger than the original. The Structural Repair Manual should be consulted for fastener spacing, edge distance, and the repair procedure. During final assembly of the repair, the fabricated parts should be bonded together with an adhesive to ensure that pressurization is maintained.

Wing

The wings on most modern aircraft are usually constructed in center sections and outer sections. These sections are designed in box form and are used as integral fuel cells. Some wings are constructed with Chem-Milled or machine tapered skin, tapered to various thicknesses depending on the place the beams or posts will be attached.

Figure 1-13 illustrates a skin repair on an outer wing section. The repair consists of a repair channel and a filler. The damage is trimmed and smoothed out for an oval filler; then the surrounding area is inspected for corrosion. The repair must be equal to or stronger than the original.

The Structural Repair Manual for the specific aircraft must be consulted for the correct fasteners, their spacing, the procedure for repair, and the proper sealant to be used.

Design and Construction of Wings

The wings of a modern, high performance aircraft are normally constructed of aluminum alloy with front and rear spars or beams. These spars are connected by ribs formed from either aluminum or magnesium alloy sheet. The spanwise bending stress is carried by relatively thick center section tapered skins, which are fabricated from aluminum alloy plate.

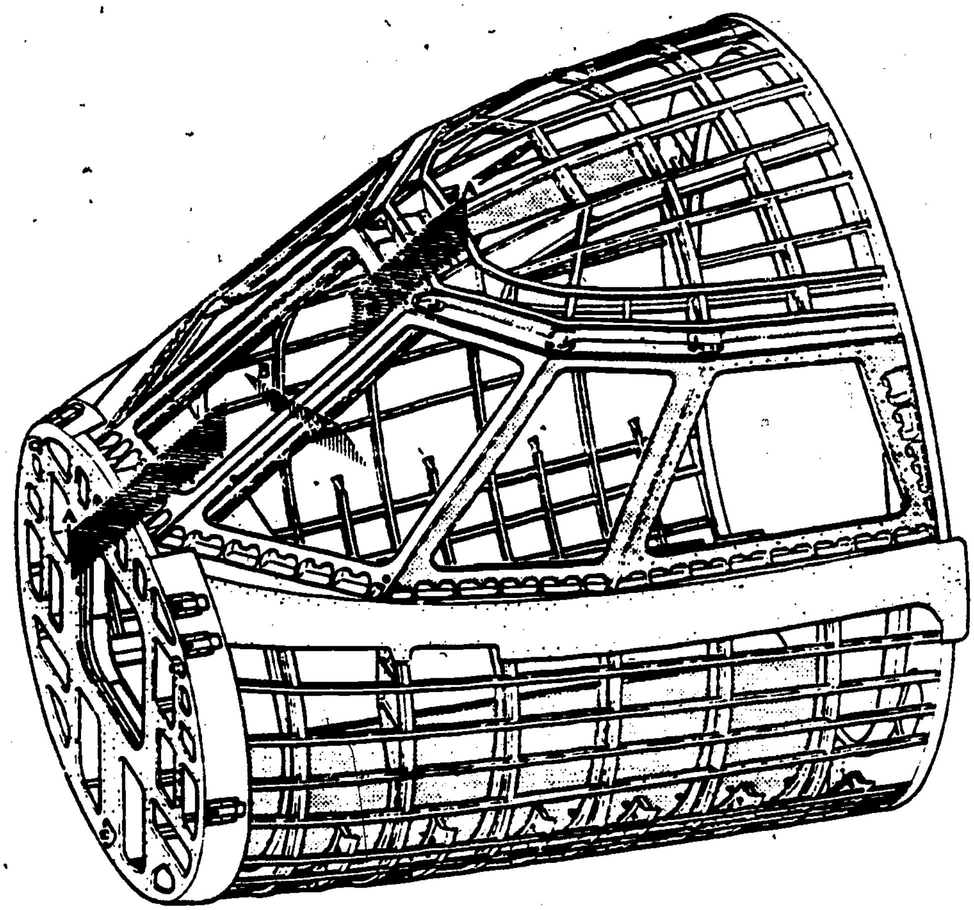


Figure 1-11 - Forward fuselage (semimonocoque).

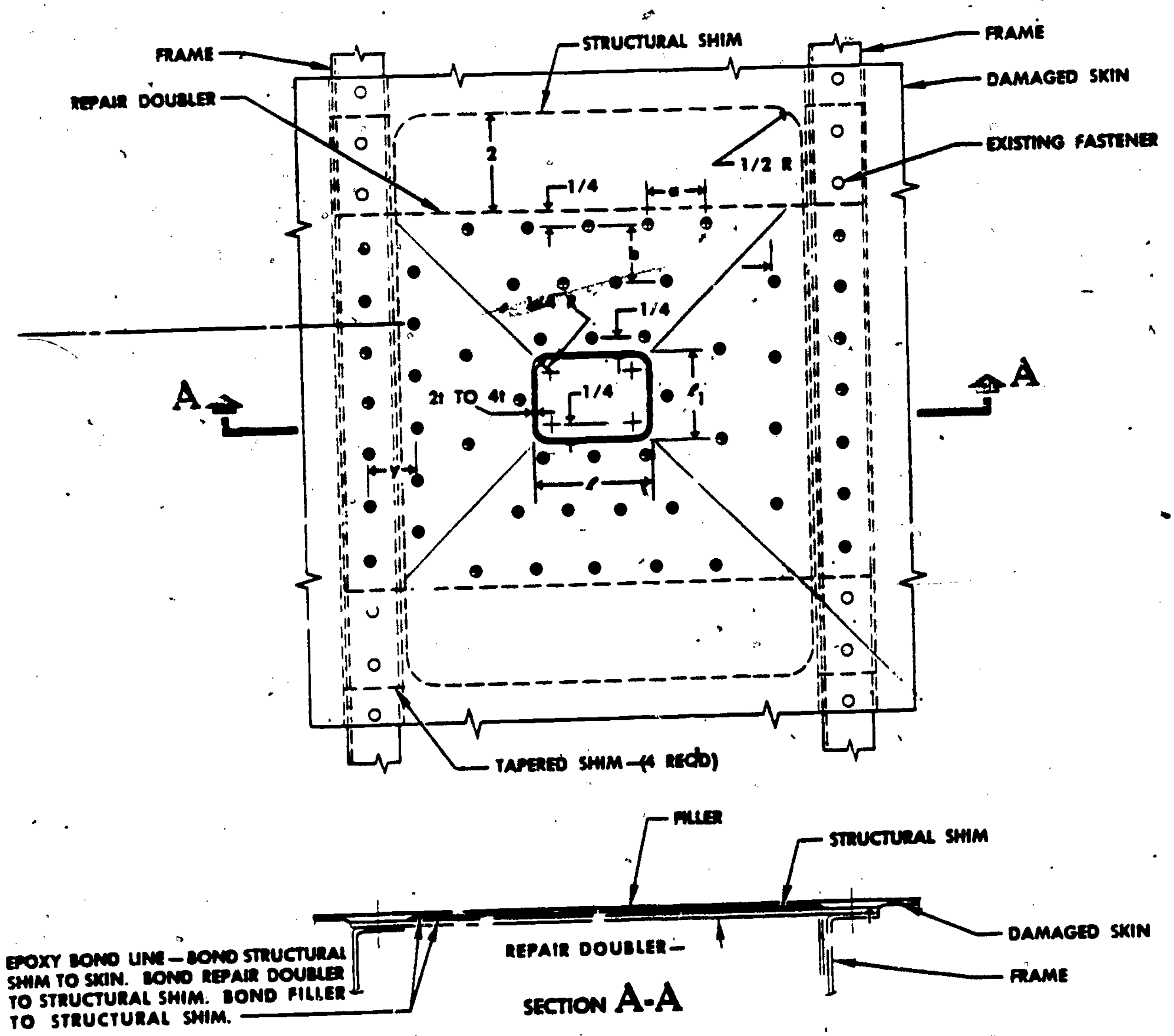
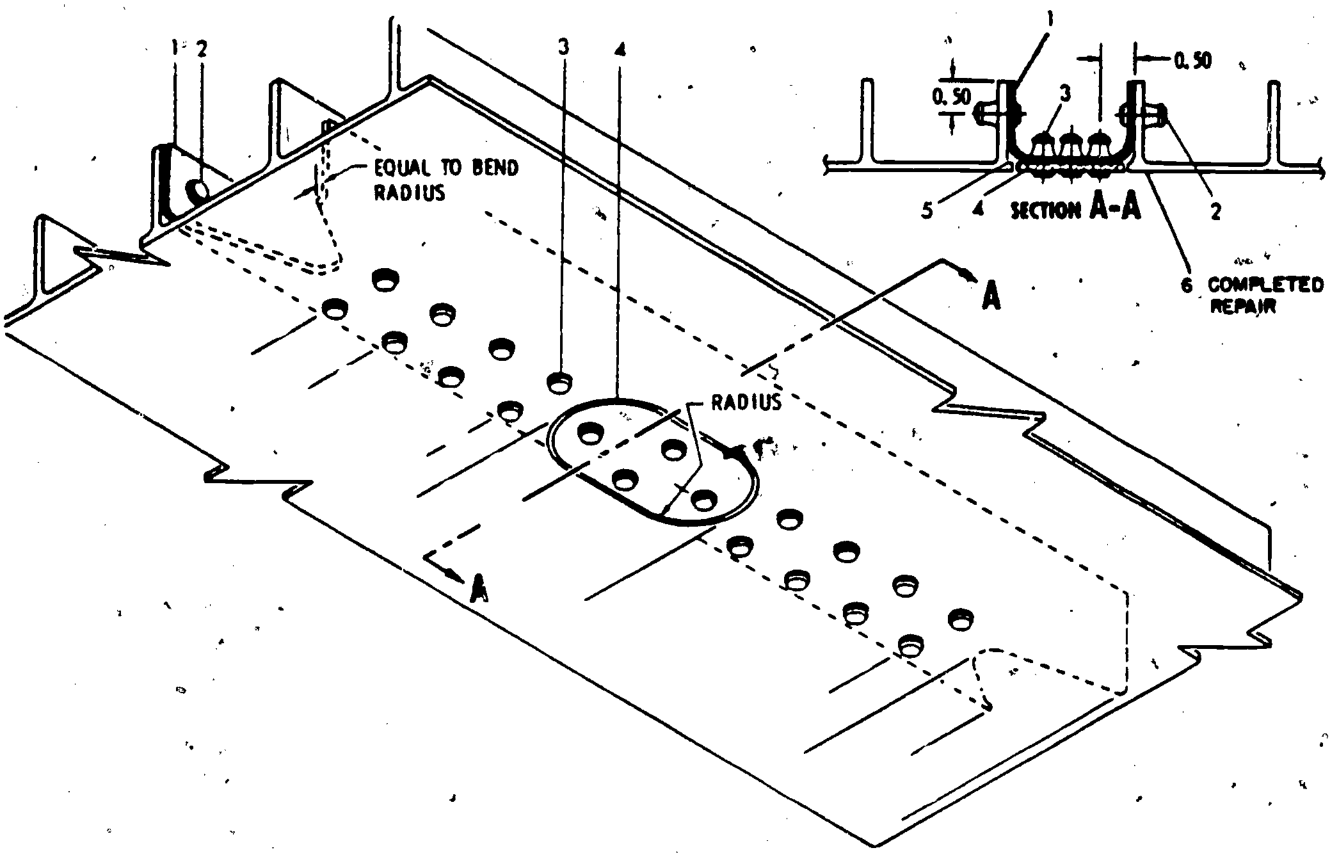


Figure 1-12 - Chem-Milled skin repair (fuselage pressurized).



1. Repair channel.
2. Riser fasteners.
3. Skin fasteners.
4. Filler.
5. Sealant.
6. Completed repair.

Figure 1-13 - Outer wing section skin repair.

The leading and trailing edge sections are usually constructed of thin aluminum or magnesium alloy sheet over ribs formed from aluminum or magnesium alloy sheet. The trailing edge section of the outer panel is sometimes constructed of some type of sandwich material. (This material may be either thin aluminum sheet laminated to balsa wood core or thin aluminum sheet laminated to a core made of aluminum honeycomb.) The wingtips are constructed from either aluminum alloy or laminated Fiberglas.

Wing design varies considerably with individual aircraft, depending upon the manufacturer and the mission of the aircraft. One commonly used design consists of a center section with outer sections and wingtips.

In another type of aircraft wing, the internal structure consists of front, main, and rear spars, auxiliary spars, ribs, and stringers. This structure is covered with flush riveted tapered and constant gage aluminum alloy skin. Aluminum faced aluminum honeycomb core sandwich material is used in the construction of the trailing edge section of the outer panel.

SKIN REPAIRS

Skin repair patches may be divided into two general types, the LAP PATCH and the FLUSH PATCH. A brief description of both types of patches follows.

A lap patch is an external patch that has the edges of the patch and the skin overlapping each other. The overlapping portion of the patch is riveted to the skin. On some aircraft, lap patches are permitted in certain areas, but only where aerodynamic smoothness is not important.

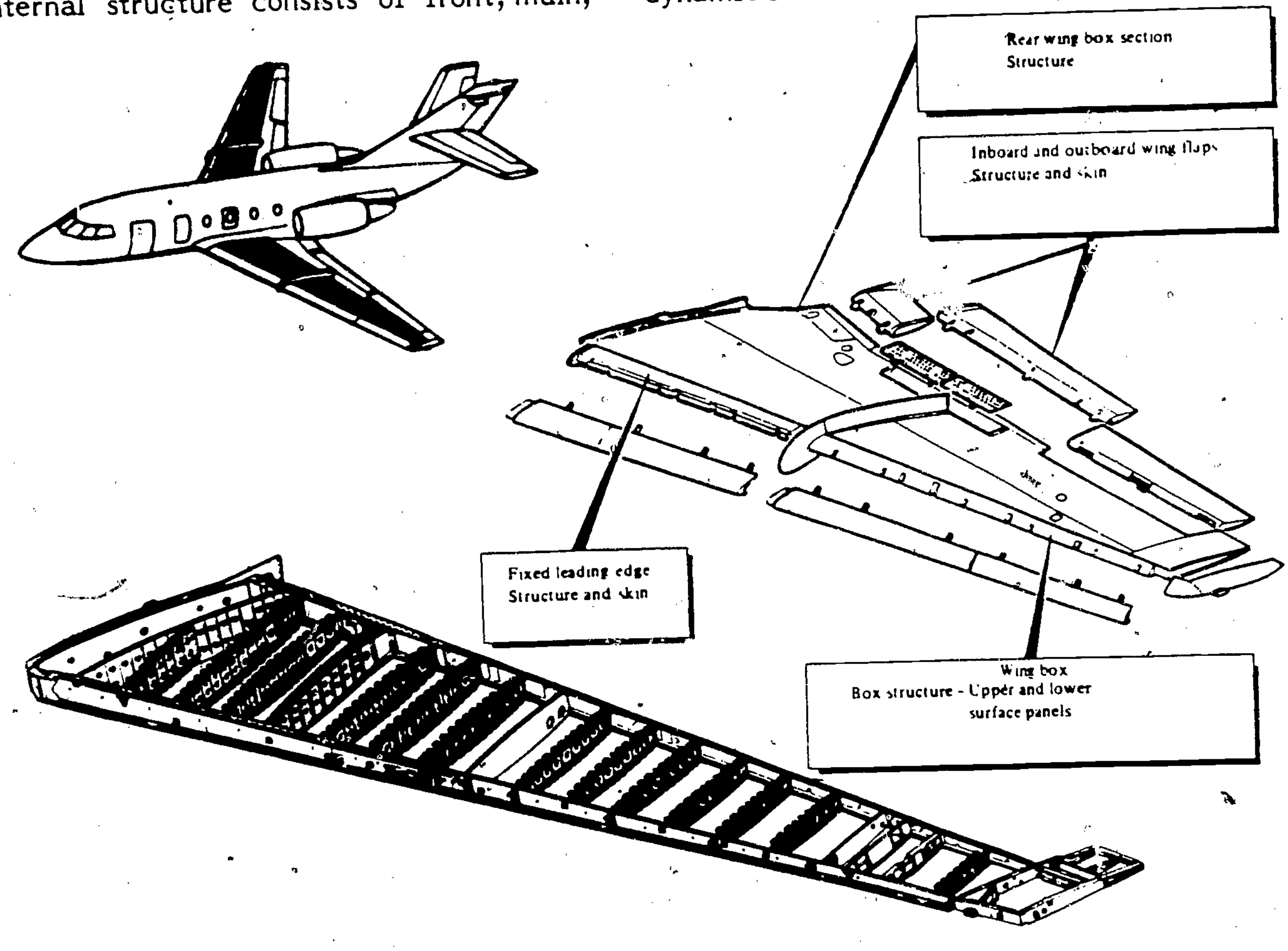


Figure 1-14 - Swept-wing.

A flush patch consists of a filler patch which is flush with the skin when inserted. The patch is backed up and riveted to a reinforcement plate which, in turn, is riveted to the inside of the skin. This reinforcement plate is usually referred to, on some repair diagrams, as the doubler, or backup plate. On some high performance aircraft, only the flush patch is permitted in making skin repairs.

OPEN AND CLOSED SKIN AREAS

One of the factors which determine the exact procedure to be used in making skin repairs is the accessibility to the damaged area. Much of the skin on an aircraft is inaccessible from the inside for making repairs. The skin in such areas is referred to as CLOSED SKIN. Skin that is accessible from both sides is called OPEN SKIN.

Repairs to open skin may usually be made in the conventional manner, using specified types of standard rivets, but closed skin repairs require some type of special blind fasteners. The exact type of fastener used will depend upon the type of repair made and the recommendations of the aircraft manufacturer.

Another of the important factors to be considered when making a skin repair is the stress intensity of the damaged panel. For example, certain skin areas are classified as highly critical, other areas as semicritical, while still other areas may be classified as noncritical. Repairs to damages in highly critical areas must provide 100 percent strength replacement; semicritical areas require 80 percent strength replacement; and noncritical areas require 60 percent strength necessary to maintain a margin of safety in skin areas. The 60 percent stress intensity repair is specified when production methods and stiffening requirements have resulted in an overstrength skin with a high margin of safety. This repair provides strength and stiffness equivalent to specific design requirements rather than the original structure of the material. The 100 percent stress intensity repair makes the strength of the repaired skin equal to, or greater than, the original undamaged skin. This type of skin usually has a low margin of safety.

Lap Patches

Lap patches may be installed in areas where aerodynamic smoothness is not important. In areas where the lap patch is permitted, it may be used in repairing cracks as well as small holes.

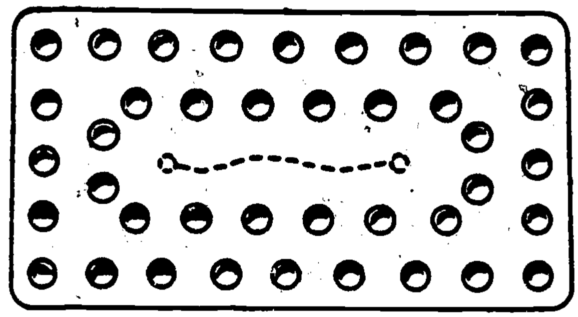


Figure 1-15 - Lap patch for repairing a crack in stressed skin.

In repairing cracks, always drill a small hole (normally called stop drilling) in each end of the crack before applying the patch. This is normally done by using a No. 30 or 40 drill bit. This prevents the concentration of stresses at the apex of the crack and distributes the stresses around the circumference of the hole. The patch must be large enough to install the required number of rivets as determined from the rivet schedule indicated for the gage material in the area. (See figure 1-15.) The recommended patch may be cut circular, square, rectangular, or diamond shaped. The edges are normally chamfered (beveled) to an angle of 45 degrees, for approximately one-half the patch's thickness.

The next step is to lay out the rivet pattern on the patch, using the proper edge distance and spacing. Then mark the installation position of each rivet with a center punch. The impression in the material made with the center punch helps to keep the drill from slipping away from the hole being drilled. (See figure 1-16.) Drill only a minimum number of rivet holes in the patch over the surface being repaired, ensuring that the correct edge distances are being maintained. Drill four holes in the surface being repaired, using the predrilled holes in the patch as a pattern for alignment. As each

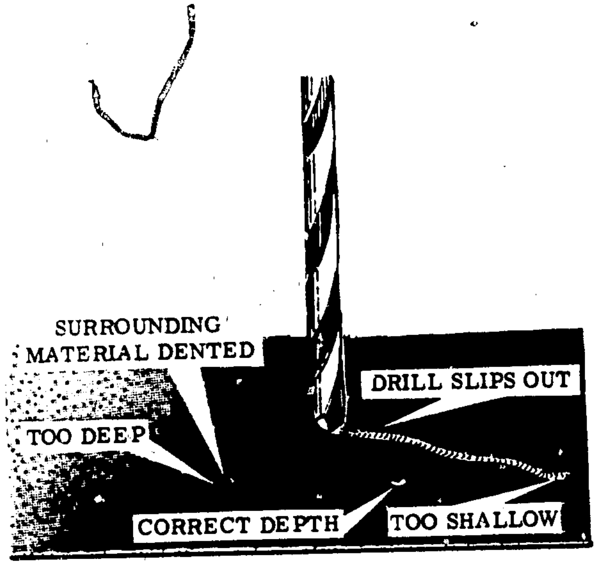
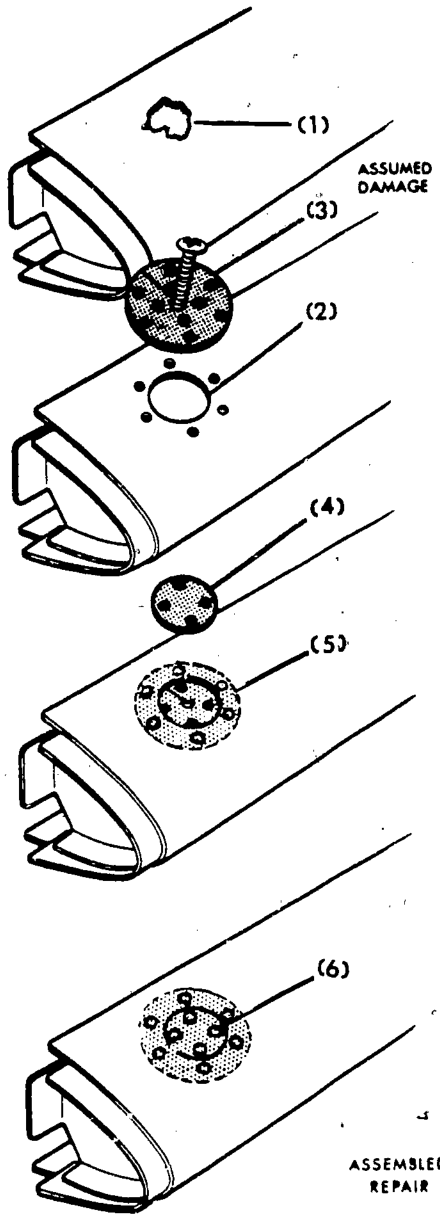


Figure 1-16 - Drilling holes for rivets.

hole is drilled, using the proper temporary fasteners, secure the patch in place. When the patch is temporarily secured, drill the remaining rivet holes through the patch and surface being repaired. Remove the patch and deburr all rivet holes, using a deburring tool or a large drill bit. Prime the repair materials with the proper corrosion preventive material prior to the riveting operation. Secure the patch in position, using temporary fasteners, to maintain alignment during riveting. Riveting procedures are covered later in another section.

Holes less than 3/16-inch in diameter in either stressed or nonstressed skin may be repaired by filling with a rivet. Drill the hole and install the proper size rivet to fill the hole. For holes 3/16 inch and larger, the AM should consult the applicable Structural Repair Manual for the necessary repair information. The damaged area is removed by cutting and trimming the hole to a circular, square, rectangular, or diamond shape. The corners of the hole should be rounded to a



(1) Assumed damage. (2) Damage cut out to a smooth round hole. (3) Doubler split for insertion through cut out. (4) Filler. (5) Doubler riveted in place. (6) Filler riveted in place.

Figure 1-17 - Repair of small holes in skin with a flush patch.

minimum of 1/4-inch radius. The lap patch is fabricated and installed in the same manner as previously explained for repairing cracks.

Flush Patches

Flush patches should be used where aerodynamic smoothness is required. The type of flush patch used depends on the location of the damaged area. One type is clear of internal structures, and the other is not. Like all types of repairs, the AM must consult the applicable Structural Repair Manual for the necessary repair information. The repairs discussed next are typical of most repairs.

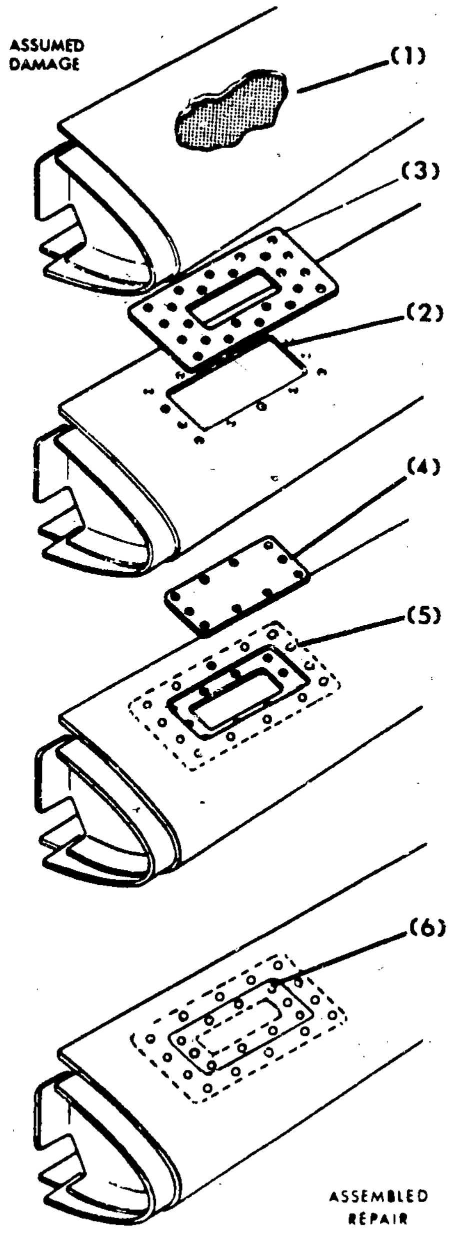
Flush Patch Clear of Internal Structures

In areas which are clear of internal structure, the repair is relatively simple to make. This is especially true where there is an access door or plate through which the rivets can be bucked. In inaccessible areas, the flush patch may be made by substituting blind rivets for standard rivets, where permissible, and devising a means of inserting the doubler through the opening.

One method is shown in figure 1-17, in which the doubler has been split. To insert the doubler, slip the split edge under the skin and twist the doubler until it slides in place under the skin. The screw in the center of the doubler is temporarily installed to serve as a "handle" for inserting the doubler through the hole. This type of patch is normally recommended for holes up to 1 1/2-inches in diameter. If the hole is larger than 1 1/2-inches in diameter, it is generally more satisfactory to trim the hole to a rectangular or elliptical shape, rounding all corners to a generous radius. (See figure 1-18.)

On larger repair areas it is usually possible to buck the doubler rivets by inserting and holding the bucking bar through the center of the doubler. The filler is then riveted in place using blind fasteners, if the repair is in a closed skin area. When blind rivets are used as substitutes for solid rivets, the Structural Repair Manual normally specifies the next larger size. The proper edge distances for the substitute fasteners must be maintained.

NOTE: Edge distance is discussed later in another section. In all flush patches, the filler should be of the same gage and material as the original skin. The doubler,



(1) Assumed damage. (2) Damage cut out to smooth rectangular shape. (3) Doubler. (4) Filler. (5) Doubler riveted in place. (6) Filler riveted in place.

Figure 1-18 - Flush rectangular patch.

generally, should be of the same material, one gage heavier than the skin. Structural Repair Manuals will specify the allowable substitution of materials. This can be in the form of a note on the repair diagram. For example, one aircraft Structural Repair Manual shows the following information in the form of a note:

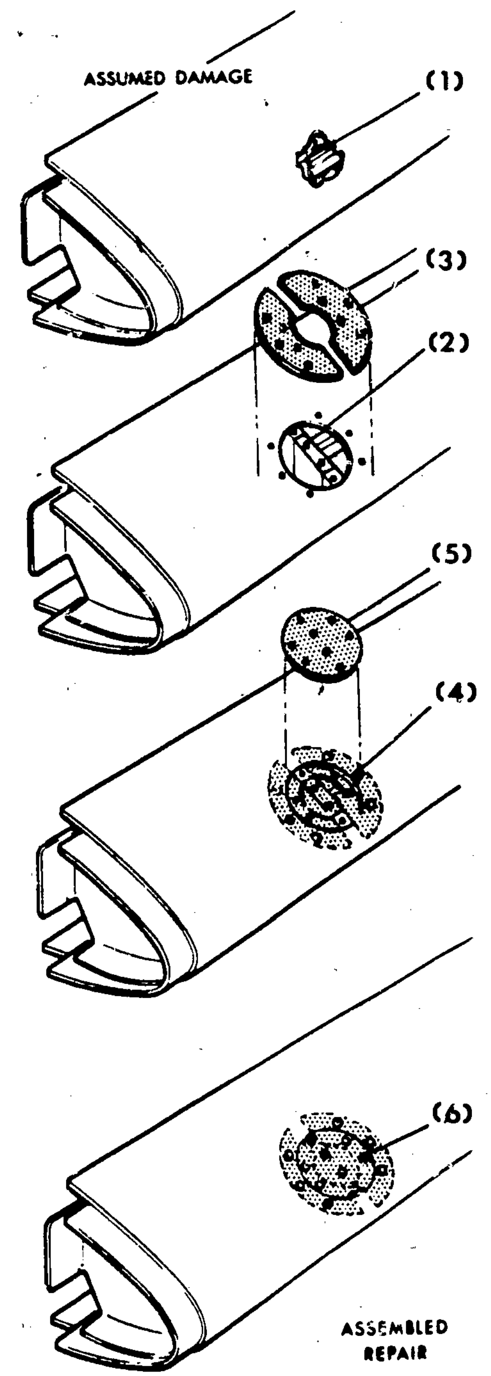
Curved sheet: When 2024-T is substituted for 0.025 to 0.071 inch 7075-T, the 2024-T should be one gage heavier than called for in 7075-T; if the gage of the 7075-T is 0.080 or 0.090 inch, the 2024-T should be two gages heavier than the 7075-T.

Flat sheet: Substitute one gage heavier 2024-T for all 7075-T skin gages.

The length of the doubler should exceed the width so that it can be slipped in through the skin and positioned for installation. This eliminates the splitting and manipulation of the patch required in installing doublers of square and round flush patch repairs.

The filler is fabricated slightly less than the dimensions of the hole being repaired. Generally, the maximum clearance between the skin and the filler is 1/32 inch. The doubler is fabricated larger than the hole being repaired to allow for the specified number of rivets required to attach the doubler to the skin being repaired. The doubler, filler, and attaching skin rivet pattern may be laid out, drilled, and deburred in the identical manner as described previously for a lap patch. After the required corrosion preventive materials have been applied, the doubler is positioned in the structure's interior and secured with temporary fasteners. Inspect the rivet holes for proper alignment and rivet the doubler in place, using solid rivets. The filler can then be riveted in place using blind fasteners.

NOTE: If the flush repair is an open skin area, the filler may be riveted to the doubler prior to installing the doubler.



(1) Assumed damage. (2) Damaged skin cut out to a smooth round hole and rib repaired. (3) Two half-round doublers. (4) Doublers riveted in place. (5) Filler. (6) Filler riveted in place.

Figure 1-19 - Flush patch over internal structure.

Flush Patch Over Internal Structures

Fabricating a flush patch over internal structure may tend to become difficult. In some instances, the repair may be made by simply using a split doubler and a filler, as shown in figure 1-19. Frequently a split doubler, filler strips, and filler are used in the repair. The filler strip is used as a spacer, if a structural component under the skin has been damaged. In all cases, the existing structure rivet holes should be used when the rivet pattern is laid out. The flush patch over internal structure is installed using the same methods as described for a flush patch clear of internal structure, except for modification of the doubler.

Flush Access Door

A flush access door installation, as shown in figure 1-20, is sometimes permitted. The door is installed to facilitate repair to the internal structure and to repair damage to the skin in certain areas. The flush access door consists of a doubler and a stressed cover plate. The cover plate is normally fabricated from material identical to the skin. A single row of nut plates is riveted to the doubler, and the doubler is then riveted to the interior side of the skin with two rows of rivets, staggered as shown in figure 1-20. The cover plate is attached to the doubler with machine screws. When an access door is permitted and installed over internal structure, screws should be installed through the cover plate into the internal structural member wherever possible.

Skin Replacement

Sometimes damage to the metal skin is so extensive that an entire panel must be replaced. Also, an excessive number of patches or minor repairs to a section or area may require the replacement of the entire panel.

As in all other forms of repairs, the first step is to inspect the damaged area

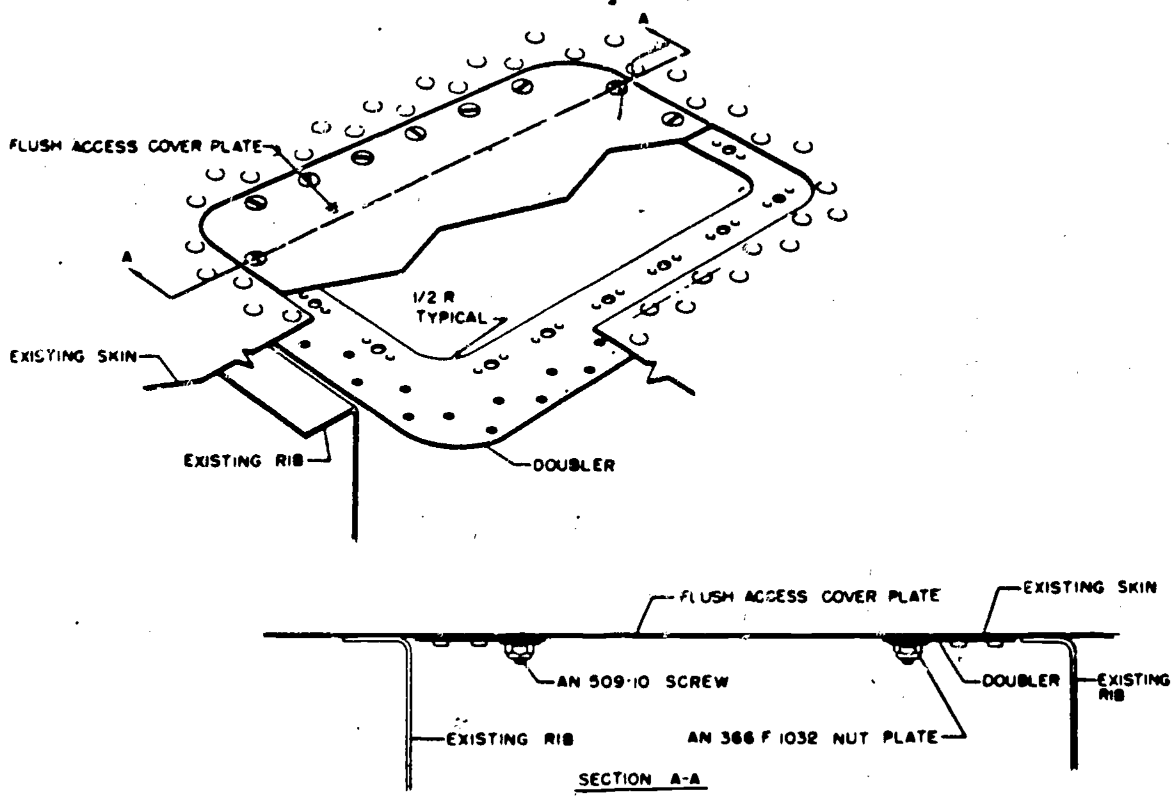


Figure 1-20 - Flush access door installation.

thoroughly to determine the extent of the damage. Inspect the internal structure for damage or signs of strain. Such members, when bent, fractured, or wrinkled, must be replaced or repaired. They may be sheared considerably without visible external evidence of such a condition. Drill out rivets at various points in the damaged area and examine them for signs of shear failure.

During the inspection, note carefully all unusual riveting problems-conditions which render riveting difficult or which make replacement impossible. Any fixtures which will hinder riveting and prevent the use of straight bucking bars will be apparent in a thorough inspection. There will also be places where flanges or reinforcing members, or intersecting stringers, longerons, formers, frames, or rings make the bucking of rivets very difficult. This problem can be solved by designing and making bucking bars to suit these particular situations.

Care must be taken to avoid mutilating the damaged skin in the process of removal. In most cases it can be used as a template for layout of and drilling holes in the new piece of skin.

The rivet holes in stringers, longerons, bulkheads, formers, frames, rings, and other internal members must be kept in as good condition as possible. If any of these members are loosened by the removal of rivets, their location should be marked so that they can be returned to their original position, as necessary, while the repair is being made.

Refer to the applicable repair material chart in the aircraft Structural Repair Manual for the gage and alloy of material to be used for the replacement panel. The size and shape of the panel may be determined in either of two ways. The dimensions can be measured during the inspection, or the old skin can be used as a template for the layout of the sheet and the location of the holes. The latter method is preferable and more accurate. Regardless of the procedure used, the new sheet must be large enough to replace the damaged area and may be cut with an allowance of 1 to 2 inches of material outside the rivet holes.

If the old sheet is not too badly damaged, it should be flattened out and used as a template. The new sheet, having been cut approximately 1 inch larger than than the old, should then be drilled near the center of the sheet, using the holes in the old sheet as a guide. The two sheets are then fastened together with sheet metal fasteners. The use of sheet metal screws is not recommended since they injure the edges of the rivet holes. The drilling should proceed from the center to the outside of the sheet, inserting sheet metal fasteners at frequent intervals.

If it is impossible to use the old sheet as a template, the holes in the new sheet should be drilled from the inside of the structure. Use the holes in the reinforcing members as guides, and insert fasteners in the same manner as described above. This is called back-drilling. Before placing the new sheet on the framework to drill the holes, make certain that the reinforcing members are aligned and flush at the points at which they intersect; otherwise, the holes in the new sheets will not be accurately aligned. For the same reason, the new sheet should have the same contour as the old before the rivet holes are drilled.

In duplicating holes from reinforcing members to skin, be extremely careful, or both frame and skin will be ruined. Since most bulkheads, ribs, and stringers depend on the skin for some of their rigidity, they can easily be forced out of alignment in the drilling process. The skin must be held firmly against the framework, or the pressure from the drilling will force it away from the frame and cause the holes to be out of alignment. This may be overcome by placing a block of wood against the skin and holding it firmly while the drilling progresses. Also, make sure that the drill is held at a 90-degree angle to the skin at all times, or the holes will be elongated and out of alignment. When drilling through anchor nuts, use a smaller pilot drill first. Be careful to avoid damaging the anchor nut threads. The pilot holes are then enlarged to the proper size.

It may be necessary to use an angle attachment or flexible shaft drill in places where it is impossible to insert a straight drill. In case neither type can be inserted, the new section can be marked carefully with a soft pencil through the holes in the old section. Another method of marking the location of the new holes is to use a transfer or prick punch as shown in figure 1-21. Center the punch in the old hole, and then tap the punch lightly with a hammer. The result should be a mark which will serve to locate the hole in the new sheet.

Still another way to locate the rivet holes without a template is to use a hole finder, similar to the one shown in figure 1-22. This device makes it possible to drill holes in the new section of skin in perfect alignment with the holes in the old section. The hole finder is made in two sections -an upper part and and a lower part fastened together at one end.

At the free end of the bottom section of the hole finder is a guide rivet which drops into the old holes in the sheet still in place. The free end of the top section of the hole finder has a hole in a position which exactly matches the position of the rivet. Through this opening the new hole is drilled. Thus, as the hole finder is moved along, the guide rivet drops into an old hole and automatically determines the position of the new hole.

After all the holes have been drilled, the temporary fasteners are taken out, and the sheet is removed from the framework. The burrs left by drilling must be removed from both sides of all holes in the skin, the stringers, and the rib flanges. Burring may be accomplished with a few light turns of a deburring tool or drill bit. In this way, particles of metal left around the edges of the drilled holes are eliminated. If the particles were not removed, the joint would not be tight and rivets might expand, or flash, between the parts being riveted.

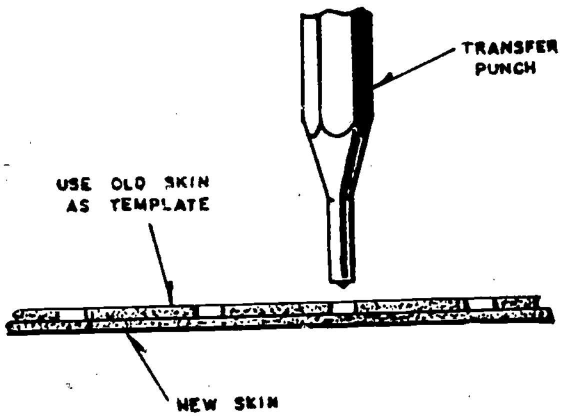


Figure 1-21 - Transferring rivet holes.

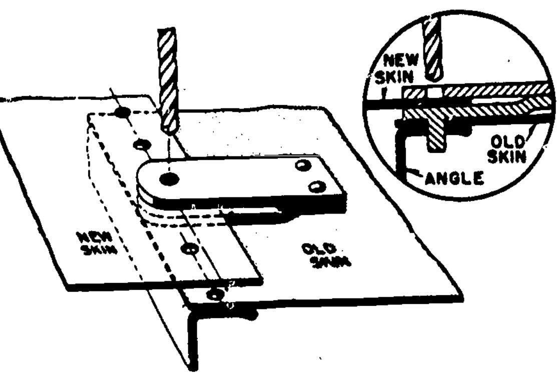


Figure 1-22 - Using a hole finder.

SECTION 1
REVIEW QUIZ

QUESTIONS

1. When an aircraft structure is damaged, secondary damage to an adjacent structure may result from ____________________.

2. Damage which cannot be repaired by any practical means is classified as ____________________.

3. What is the MAJOR requirement in making a structural repair?

4. To make all marks except cut lines on repair materials, you should use a ________________.

5. To repair a buckled bulkhead web which is not otherwise distorted, you should ________________.

6. To repair a damaged longeron, you should follow the same procedure for repairing a ________________.

7. Aircraft skin which is mostly inaccessible from the inside for making repairs is ________________.

8. Skin repairs in semicritical areas require ____________________ percent strength replacement.

9. For one-half the thickness of a lap patch, the edges should be chamfered to a/an __________ degree angle.

10. Holes less than 3/16 inch in diameter in stressed or nonstressed skin may be repaired by ________________.

11. A flush patch over an internal structure is installed in the same manner as a flush patch clear of an internal structure, except for ______________.

12. When an aircraft structure is damaged, how can you check for shearing of adjacent structural members with no apparent damage?

13. When you are replacing an entire section of aircraft skin, the MOST accurate method for determining the correct size and shape of the new panel is by __________.

14. You are using the holes in a reinforcing member as guides for drilling holes in a new section of skin. To prevent the drill pressure from forcing the new skin away from the reinforcing member and causing hole misalignment, you should ________.

(See page 1-24 for ANSWERS to Review Quiz questions.)

SECTION 1
REVIEW QUIZ

ANSWERS

1. transmission of the shock of the load that caused the primary damage (Page 1-1)

2. damage necessitating replacement (Page 1-4)

3. Duplication of strength of the original structure. (Page 1-4)

4. pencil (Page 1-7)

5. rivet an angle reinforcement over the buckled area. (Page 1-10)

6. stringer (Page 1-11)

7. closed (Page 1-16)

8. 80 (Page 1-16)

9. 45 (Page 1-16)

10. filling with a rivet (Page 1-17)

11. modification of the doubler (Page 1-20)

12. Drill out rivets at various points in the damaged area and examine for signs of shear failure. (Page 1-21)

13. using the old skin as a template (Page 1-21)

14. hold a block of wood firmly against the skin during the drilling process (Page 1-21)

SECTION 2

REINFORCED PLASTIC AND SANDWICH CONSTRUCTION REPAIR

OBJECTIVES

When you have completed this assignment, you should be able to:

1. State the classes of reinforced plastic damage.
2. Describe the repair method for each class of reinforced plastic damage.
3. Describe the precautions and procedures to be observed when finishing a reinforced plastic repair.
4. State the types of structural sandwich construction damage.
5. Describe the repair method for each type of structural sandwich construction damage.

This section deals with the materials and procedures to be used in repairing reinforced plastic and sandwich construction components. The procedures discussed are general in nature. When actually repairing reinforced plastic and/or sandwich construction components, refer to the applicable Structural Repair Manual.

REPAIR OF REINFORCED PLASTIC

The repair of any damaged component made of reinforced plastic requires the use of identical materials, whenever they are available, or of approved substitutes for rebuilding the damaged portion. Abrupt changes in cross-sectional areas must be avoided by tapering joints, by making small patches round or oval instead of rectangular, and by rounding the corners of all large repairs. Uniformity of thickness of core and facings is exceedingly important in the repair of radomes. Repairs of punctured facings and fractured cores, therefore, necessitate removal of all the damaged material, followed by replacement with the same type of material and in the same thickness as the original.

All repairs to components housing radar or radio gear must be made in accordance with the manufacturer's recommendations. This information may be found in the aircraft Structural Repair Manual or in drawings and specifications.

INVESTIGATION OF DAMAGE

Before a thorough inspection of the damage can be made, the area should be cleaned with a cloth saturated with methyl-ethyl-ketone (MEK). After drying, the paint should be removed by sanding lightly with No. 280 grit sandpaper; then clean the sanded area with MEK. The extent of damage can then be determined by tapping the suspected areas with a blunt instrument. The damaged areas will have a dull or dead sound, while the undamaged areas will have a clear metallic sound.

Damages are divided into four general classes: surface damage, facing and core damage, puncture damage (both facings and core), and damage requiring replacement.

SURFACE DAMAGE

The most common types of damage to the surface are abrasions, scratches, scars, dents, cuts, and pits. Minor surface damages may be repaired by applying one or more coats of room-temperature catalyzed resin to the damaged area. More severe damages may be repaired by filling with a paste made from room-temperature resin and short glass fibers. Over this coated surface, apply a sheet of cellophane, extending 2 or 3 inches beyond the repaired area. After the cellophane is taped in place, work out all the air bubbles and excessive resin with the hand or a rubber squeegee. Allow the resin to cure at room temperature, or if necessary, the cure can be hastened by the use of infrared lamps or hot sandbags. After the resin has been cured, remove the cellophane and sand off the excess resin; then the entire repaired area is lightly sanded preparatory to refinishing.

Ply Damage (Sandwich Type Laminates).

When the damage has penetrated more than one ply of the cloth in the sandwich type laminates, the repair may be made using the scarfed method illustrated in figure 2-1. This repair is made in the following manner: Sand out the damaged laminate plies as shown in view (B). The area should be sanded to a circular or oval shape, then tapered uniformly down to the deepest penetration of the damage.

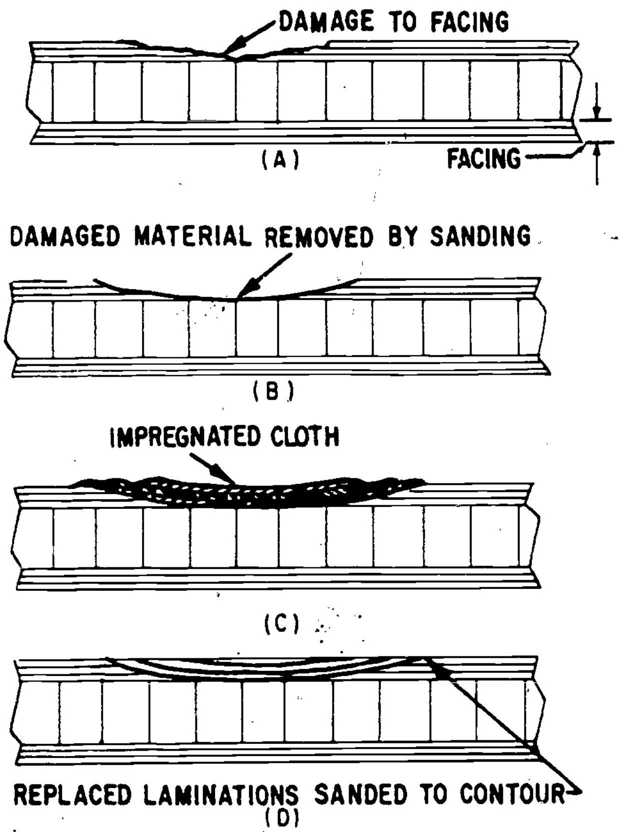


Figure 2-1 - Ply repair (scarfed method).

The diameter of the scarfed (tapered) area should be at least 100 times the depth of the penetration. Be careful when using a mechanical sander. Excess pressure on the sander can cause the sandpaper to grab, resulting in the delamination of the undamaged plies.

****

CAUTION

The sanding of glass cloth reinforced laminates produces a fine dust that may cause skin irritation. In addition, breathing of an excessive amount of this dust may be injurious; therefore, precautions for skin and respiration protection must be observed.

****

Brush coat the sanded area with one coat of room-temperature-setting resin and apply the contoured pieces of resin-impregnated cloth, as shown in (C) of figure 2-1. Tape a sheet of cellophane over the built-up repair and work out the excess resin and air bubbles. Cure the repair in accordance with the resin manufacturer's instructions; then sand the surface down, if necessary, to the original surface of the facing.

Ply Damage (Solid Laminates)

Ply damage to solid laminates may be repaired using the scarfed method described for sandwich type laminates, or the stepped method shown in figure 2-2(A) may be used.

When the wall is being prepared for the stepped repair, use a cutting tool with a controlled depth to make the cutout to avoid possible damage to the layers underneath. If the layer of glass cloth underneath is scratched or cut, the strength of the repair will be lessened. Be careful not to peel back or rupture the adhesion of the laminate layers beyond the cutout perimeter. The cutouts may be removed by peeling from the center and working carefully to the desired perimeter of the cutout. Scrape each step, wipe clean with cloths moistened with MEK, and allow to dry thoroughly. Cut the replacement glass fabric pieces to an exact fit with the weave direction of the replacement plies running in the same direction as the existing plies. Failure to main-

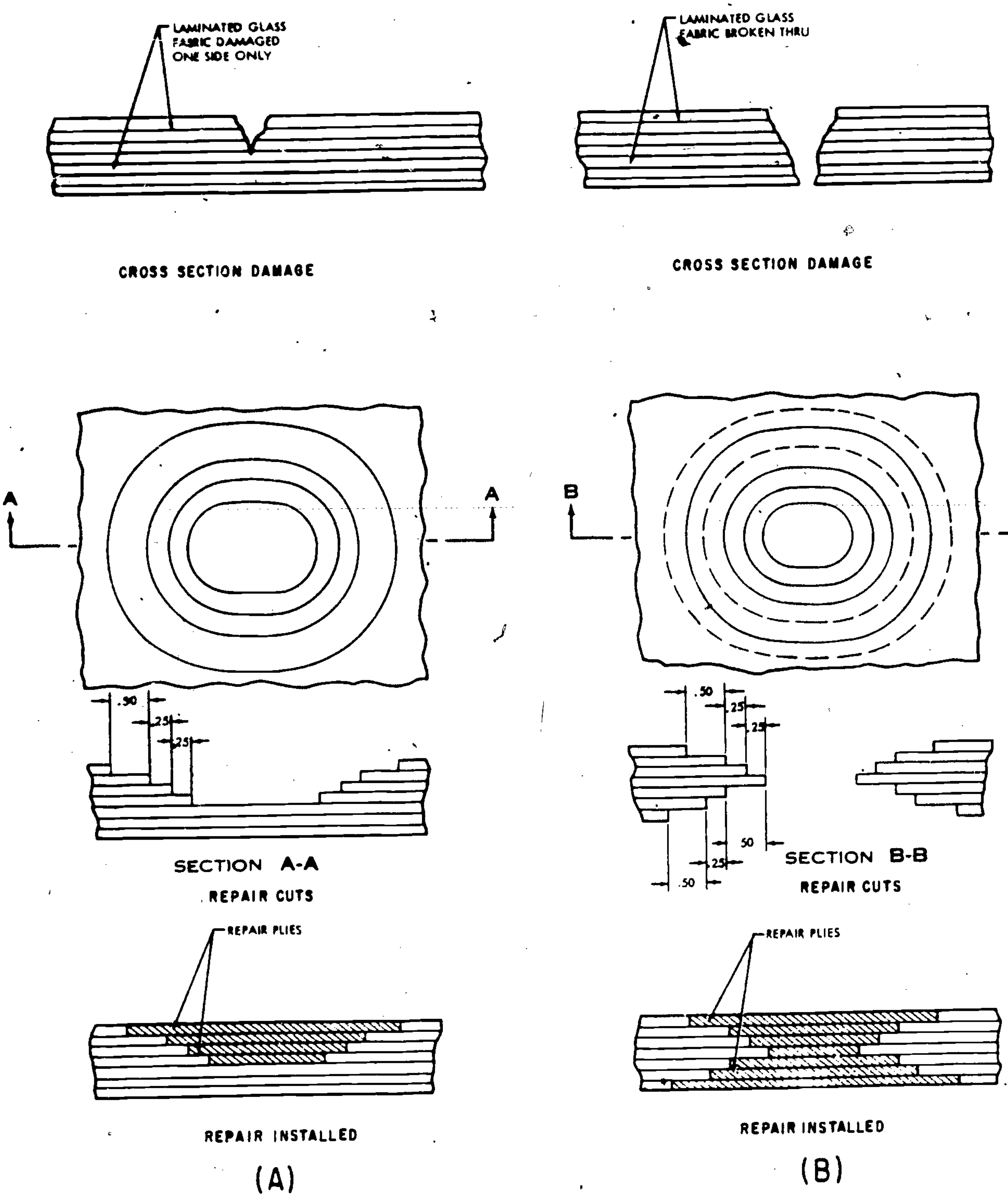


Figure 2-2 - Repair of solid laminates (stepped method).

tain the existing weave direction will result in a repair that is greatly under strength. Replace each piece of fabric, being careful to butt the existing layers of fabric plies together, but do not overlap them. The laminate layers should be kept to the proper matching thickness.

When the entire wall has been penetrated, as shown in figure 2-2(B), one-half of the damaged plies should be removed from one side and the replacement buildup completed; then repeat the removal and buildup procedure on the opposite side. If the damage occurs over a relatively large or curved area, make up a plaster mold conforming to the contour and extending 1 inch past the damage. Insert the mold in the damaged area when repairing the first half of the plies. When the stepped method of repair is used, the dimensions should be maintained as illustrated.

In areas that have become delaminated, or contain voids or bubbles, clean the area with MEK and determine the extent of the delamination; then drill holes at each end or on the opposite sides of the void using a No. 60 drill bit, extending through the delaminated plies. Figure 2-3 illustrates the procedure for repair of delaminated plies.

Additional holes may be needed if air entrapment occurs when the resin is injected. Using a hypodermic needle or syringe, slowly inject the appropriate amount of resin until the void is filled and resin flows freely from the drilled holes. After the voids are completely filled, bring the area down to proper thickness by working the excess resin out through the holes; then cure and refinish.

FACING AND CORE DAMAGE

Honeycomb Core

Damages extending completely through one facing of the material and into the core require removal of the damaged core and replacement of the damaged facings in such a manner that normal stresses can be carried over the area. The scarfed method illustrated in figure 2-4 is the preferred method for making small repairs of this type. Repairs of this type may be accomplished as follows:

Carefully trim out the damaged portion to a circular or oval shape and remove the core completely to the opposite facing. Be careful not to damage the opposite facing. The damaged facing around the trimmed hole is then scarfed back carefully by sanding. The length of the scarf should be at least 100 times the facing thickness as shown in (B) of figure 2-4. This scarfing operation must be done very accurately to a uniform taper.

Cut a piece of replacement core material (or a suitable substitute) to fit snugly in the trimmed hole. It should be equal in thickness to the original core material. Brush coat the repair area and the replacement honeycomb, exercising care to prevent an excessive amount of resin from entering the honeycomb cells.

Insert the honeycomb repair section and place the resin-impregnated cloth over the repair area as shown in (C) of figure 2-4. Cover the repair area with cellophane sheeting, and cure the repair in accordance with the resin manufacturer's instructions.

After the repair has been cured, sand the surface to its original contour. The entire area should be lightly sanded before refinishing.

Foam Type Core

The damaged core should be removed by cutting perpendicular to the surface of the face laminate opposite the damaged face. To ensure good bondage of the foam to the laminate, scrape the inner facing surface clean, making sure there is no oil or grease film in the area. Fill the area where the core has been removed with the filler material specified in the aircraft Structural Repair Manual. Figure 2-5 illustrates the replacement of a foam type core.

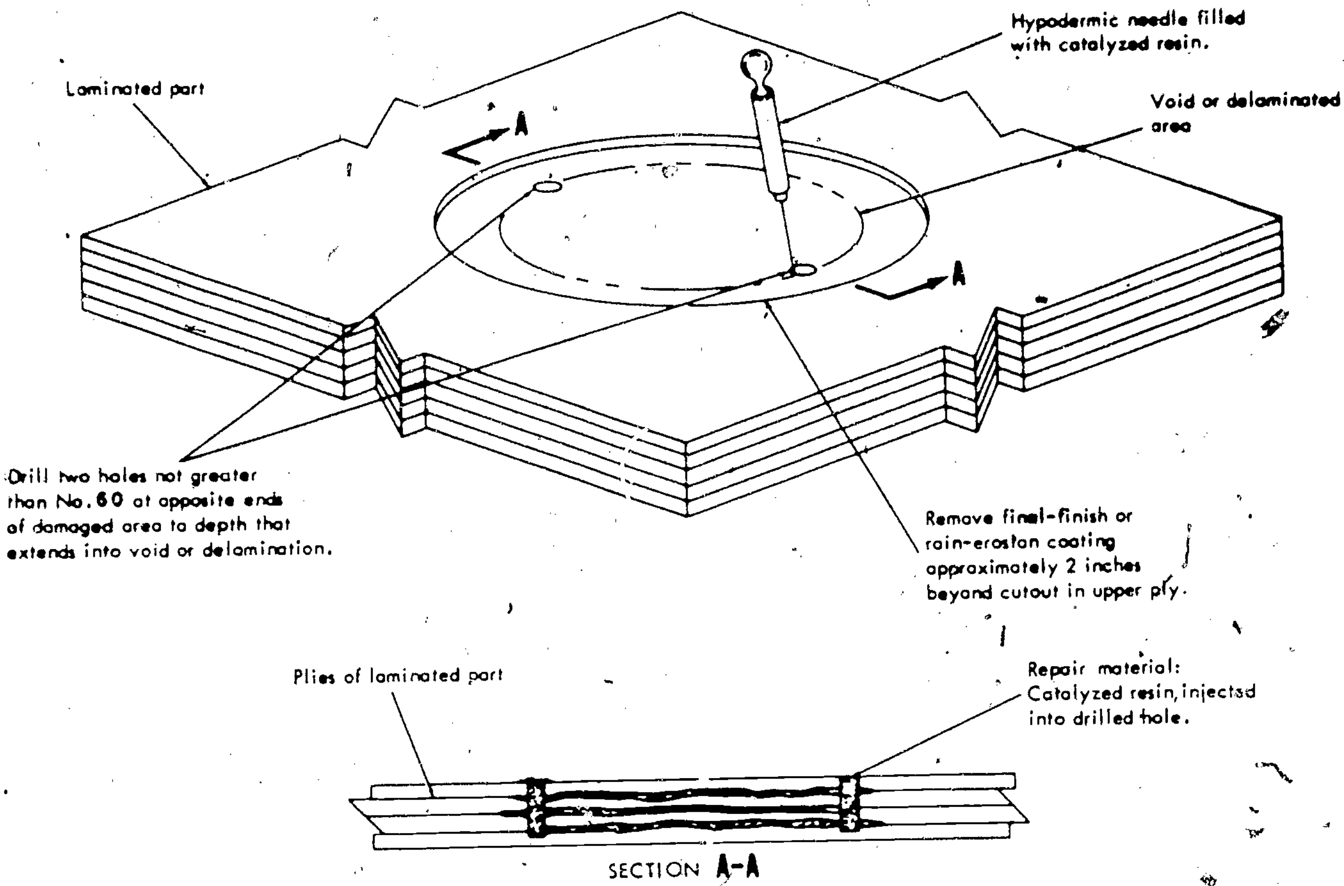


Figure 2-3 - Delaminated ply repair.

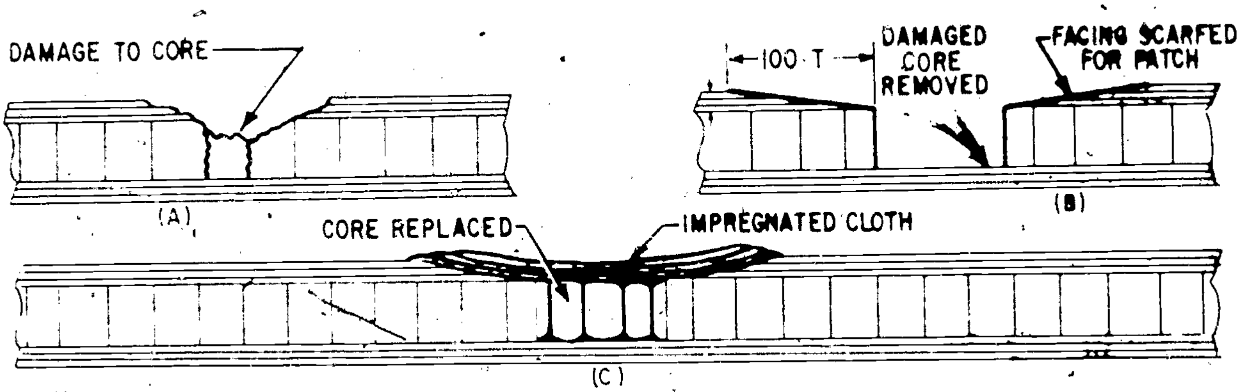


Figure 2-4 - Honeycomb type core repair.

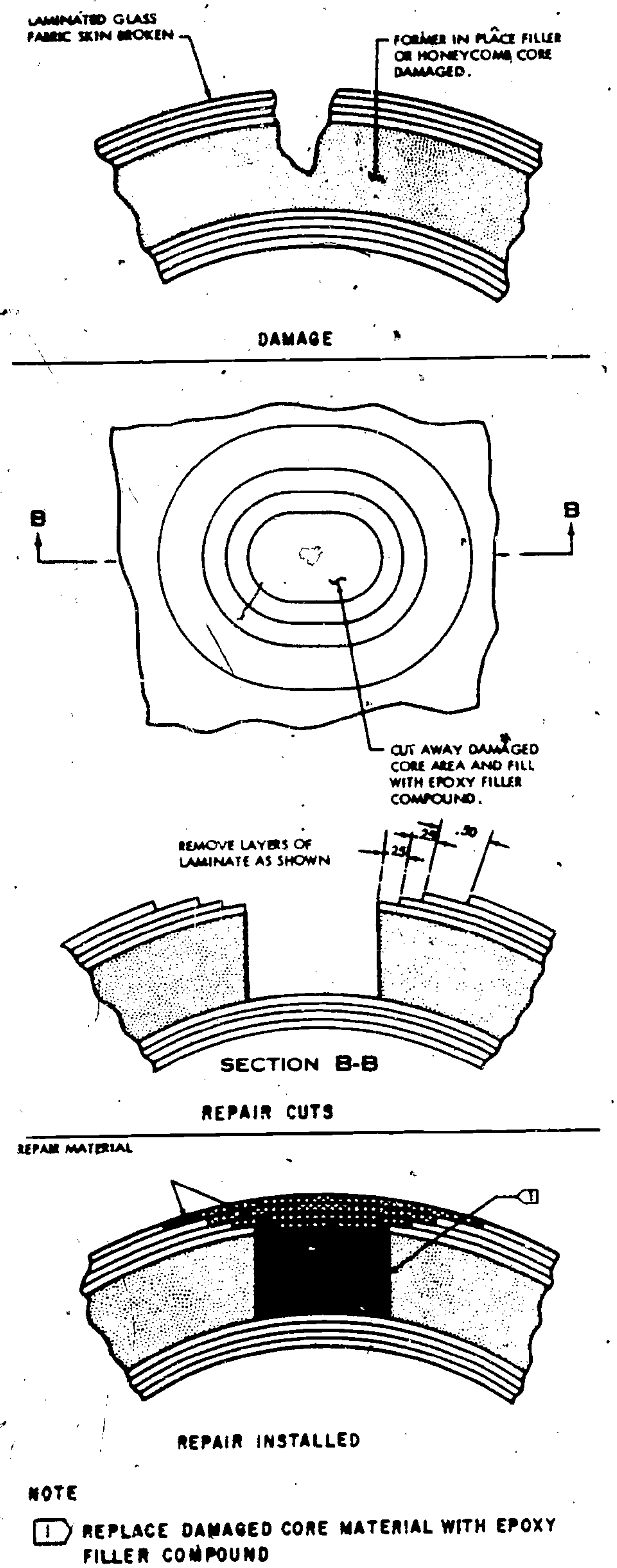


Figure 2-5 - Foam type core repair.

NOTE: Do not use MEK to clean the damage because it may soften and weaken the foam.

PUNCTURE DAMAGE

Honeycomb Core

Repairs to damages completely through the sandwich structure may be accomplished either by the scarfed method (similar to the repair described for damage extending into the core) or the stepped method.

The scarfed method is normally used for small punctures up to 3 or 4 inches in maximum dimension and in facings made of thin cloths (which are difficult to peel). The stepped method is usually employed for larger repairs to facings composed of thick cloths.

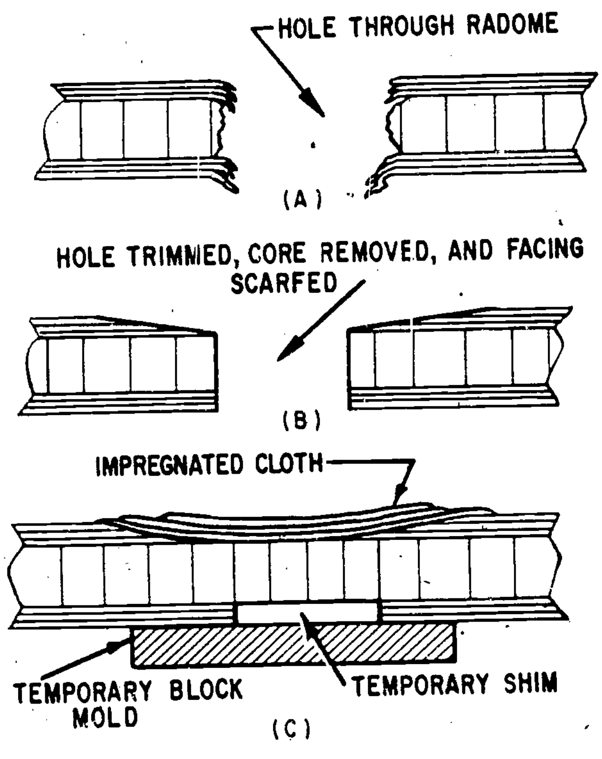


Figure 2-6 - Scarfed repair method.

The scarfed method of repair for punctures is the same as that used for damage extending into the core, with one exception: The opposite side of the sandwich is provided with a temporary mold or block to hold the core in place during the first step. (See (C) figure 2-6.)

After the first facing repair is cured completely, the mold and the shim (temporarily replacing the facing on the opposite side) are removed. The repair is then completed by repeating the procedure used in the first step. When this facing is cured, the surface should be sanded down to the original contour and the repair area lightly sanded in preparation for refinishing.

When using the stepped method of repair, first trim out the damaged area to a round or oval shape, or to a rectangular or square shape (preferable having rounded corners).

The individual plies are then cut out as illustrated in figure 2-7. Each ply is "stepped" back 1-1/2 inches and trimmed out using a sharp knife. The sides of the repair should be parallel with the weave of the cloth, if possible.

NOTE: Do not cut through more than one layer of cloth. If the layer of cloth underneath is scratched, the strength of the repair will suffer.

The opposite facing is shimmed and backed up with a mold, and the core material is inserted as previously described. The outer repair plies are soaked in the resin and laid over the damaged area. An extra layer of thin cloth is laid over the repair area to extend one-half inch over the undamaged facing. The repair area is then covered with a sheet of cellophane to apply pressure, and allowed to cure.

The inner facing is then replaced in the same manner as the outer facing. After the inner repair has been cured, the entire repair area should be sanded to the original contour and prepared for refinishing.

Foam Type Core

When the puncture penetrates the entire wall, remove the damaged core and face laminates to one-fourth inch past the perimeter of the hole on the inner face. Make a plaster support to replace the removed core, conforming to the curvature of the inside layer of the inner face. Figure 2-8 illustrates a punctured repair with a plaster support.

After repair to the inner face has been completed, remove the plaster support and continue the repair on the opposite side.

FINISHING OF REPAIRED AREAS

In the repair of reinforced plastic parts, the final step is to refinish the part with a finish identical to the original, or an

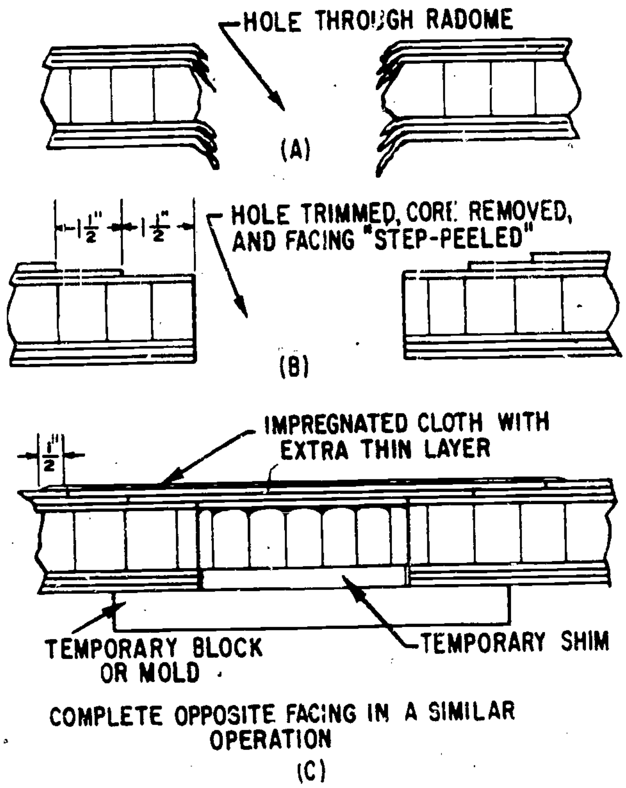


Figure 2-7 - Stepped repair method.

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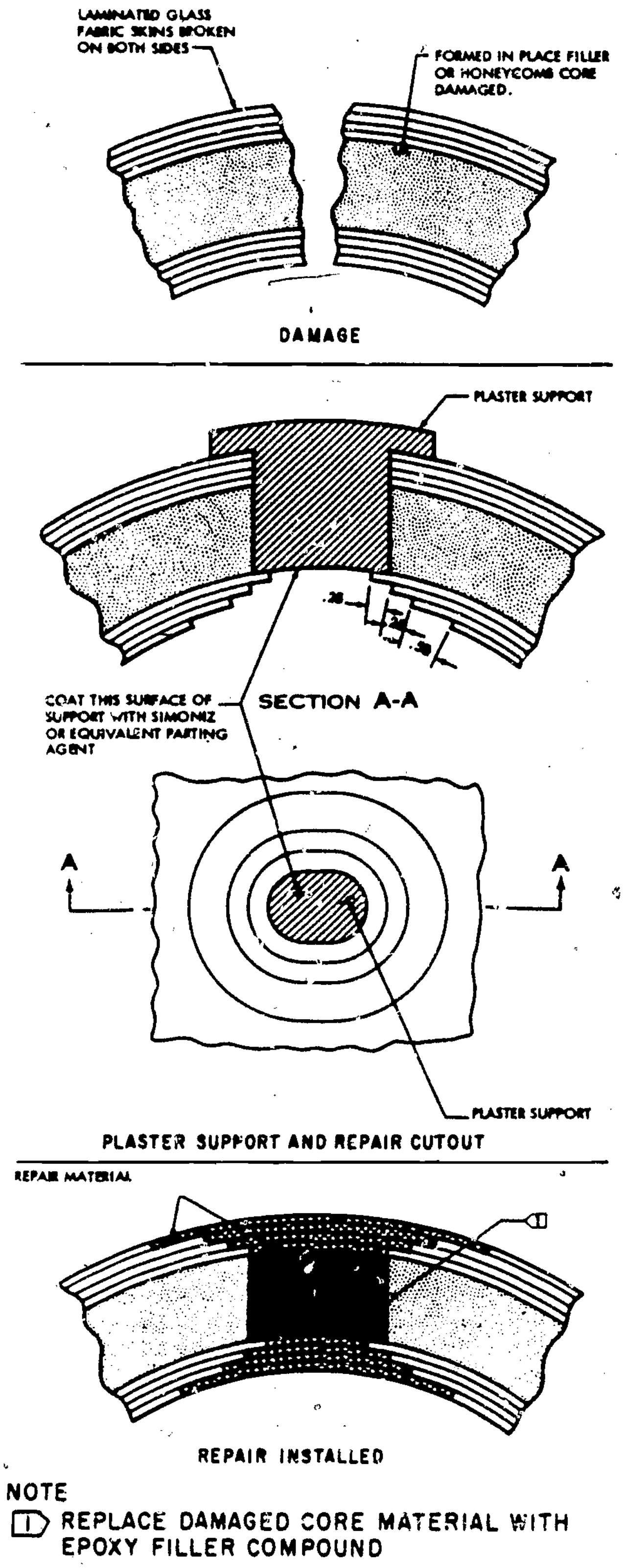

Figure 2-8 - Foam type puncture repair.

acceptable substitute. In refinishing radomes and other surfaces which enclose electronic equipment, do not use metallic pigmented paints or other electronic reflective type materials because of undesirable shielding and interference effects. Always use the materials recommended in the applicable Structural Repair Manual for refinishing both the interior and exterior surfaces of reinforced plastic components.

Reinforced plastic components whose frontal areas are exposed to high speeds are frequently coated with a rain erosion coating. Rain erosion coatings protect the component against pits which are caused by raindrops hitting the component at high aircraft speeds. These pits or eroded areas can cause delamination of the component glass cloths if allowed to progress unchecked.

Rain Erosion Resistant Coatings.

Rain erosion resistant coatings for reinforced plastic components conform to Specification MIL-C-7439. Coatings conforming to this specification are classified as follows:

Class I is a rain erosion resistant coating which is furnished in kit form. This kit consists of a primer, accelerator, diluting solvent, and neoprene.

Class II is a rain erosion resistant coating with an additional surface treatment to minimize radio noise resulting from precipitation static on the coated surface. This coating is also supplied in kit form and consists of a primer, accelerator, diluting solvent, neoprene, and antistatic coating.

These kits (MIL-C-7439, Classes I and II) are packaged unaccelerated to provide longer shelf life. The neoprene is ready to use only after the catalyst (accelerator) has been added. The material in these kits should be mixed and applied in accordance with the instruction sheet supplied by the kit manufacturer.

SAFETY PRECAUTIONS

The following general safety precautions should be observed when making

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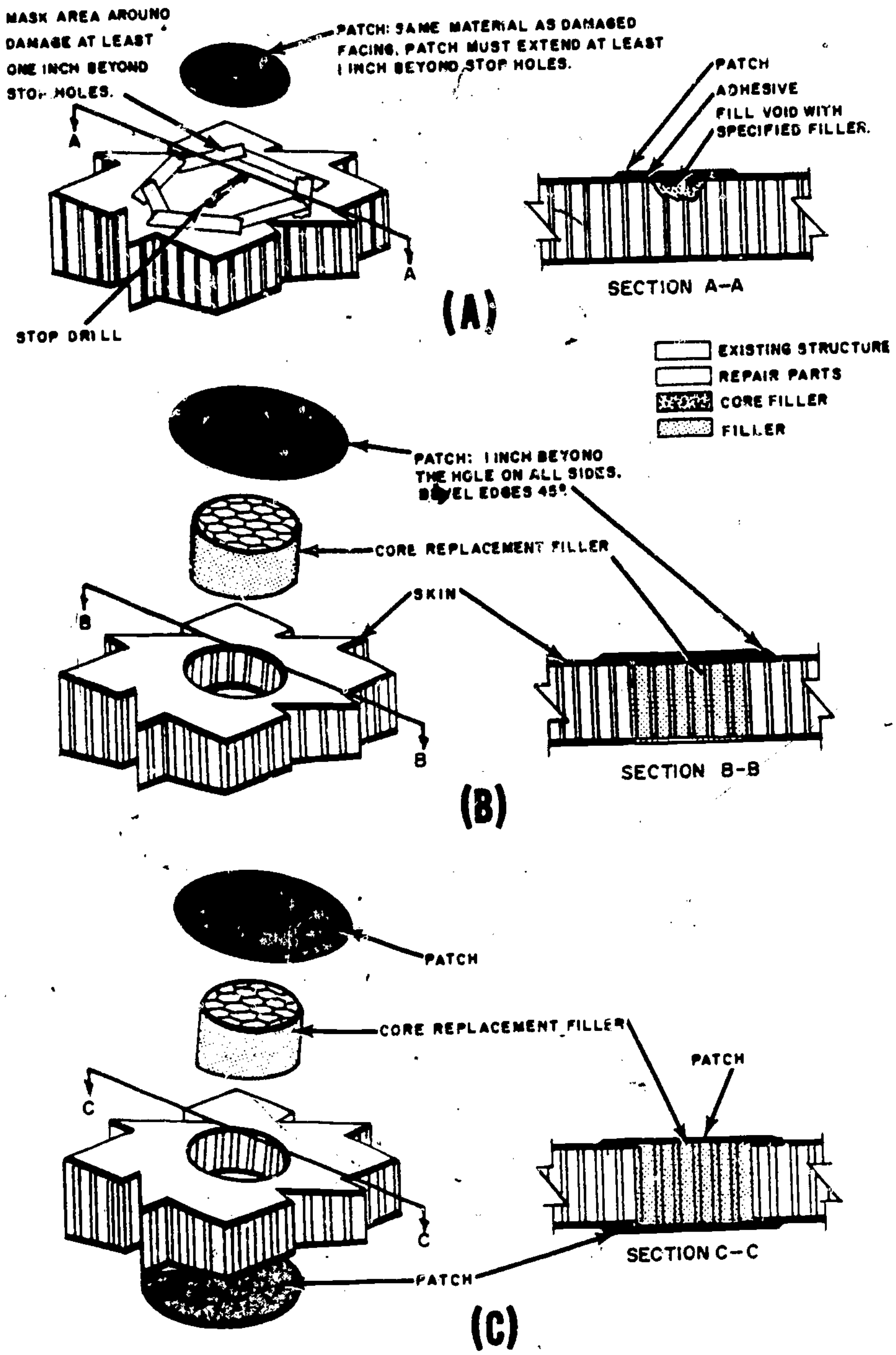


(A) Skin facing, minor damage to core;
(B) Skin facing, extensive damage to core;
(C) Skin facings and core damaged.

Figure 2-9 - Sandwich construction puncture repair (honeycomb core).

repairs to reinforced plastic components. These safety precautions should be reviewed before attempting any repairs to reinforced plastics.

1. Local station safety regulations as to fire and health hazards must be complied with.

2. All solvents are flammable; therefore, observe proper handling procedures.

3. Personnel involved in the mixing or handling of catalyzed resin prior to the curing operation should wear rubber gloves. After rubber gloves are used, the hands should be cleaned with soap and water and rinsed wih vinegar to neutralize any catalyst particles.

4. Never mix the catalyst and promoter together because they are explosively reactive as a mixture. Always mix the promoter with the resin first and then add the catalyst to the mixture.

5. The toxicity of polyester formulation has not been definitely established. Some of the components are known to cause nasal or skin irritation to certain individuals. Adequate ventilation should be provided.

6. The sanding operation on glass cloth reinforced laminates gives off a fine dust that may cause skin or respiratory irritations. Inhalation of excessive amounts of this dust should be avoided. Protection should be provided for respiration and skin.

7. Do not store catalyzed resin in an air-tight container or an unvented refrigerator.

REPAIR OF SANDWICH CONSTRUCTION (HONEYCOMB AND BALSA-WOOD CORE)

The repairs discussed in this section are applicable to structural type sandwich construction consisting of aluminum alloy facings bonded to aluminum honeycomb and balsa wood cores.

MINOR SURFACE DAMAGE

The most common types of damage to the surface are abrasions, scratches, scars, and minor dents. These minor surface damages require no repair other than the replacement of the original protective coating to prevent corrosion, provided no breaks, holes, or cracks exist.

DELAMINATION

Facing-to-core voids of less than 2.5 inches in diameter can usually be repaired by drilling a series of holes 0.06 to 0.10 inch in diameter in the upper facing over the void area. An expandable foaming resin, such as Thermofoam 607, or equivalent, is then injected through the holes with a pressure type caulking gun.

When the void is on the lower surface of the panel, only sufficient resin must be injected to completely fill the void. With voids on the upper surface, the core area should be filled until the resin comes out of the injection holes. These holes should be sealed with a thermosetting epoxy resin adhesive, and the entire assembly cured with lamps, as required for the adhesive system.

When the void areas are large, it is necessary to remove the facing over the damaged area and follow the repair procedures for a puncture. (see figure 2-9.)

PUNCTURES

A puncture is defined as a crack, break, or hole through one or both skin facings with resulting damage to the honeycomb and/or balsa wood core. the size of the puncture, amount of damage to the core, assembly to be repaired (rudder,elevator, etc.), and previous repairs to the damaged assembly are factors to be considered in determining the type of repair to be made. If damage to a honeycomb and/or balsa wood core assembly exceeds a specified length or diameter in inches or if the total number of repairs exceeds a specified percentage of the total bonded area, the assembly must be replaced.

NOTE: These figures are found in the applicable Structural Repair Manual.

Honeycomb Core

The repair shown in figure 2-9(A) is used when a puncture through one skin facing has caused only minor damage to the core material. To repair this type damage, proceed as follows: Cover the component with a suitable protective covering (polyvinyl sheet or kraft paper). Cut out a section of the protective covering that will extend approximately 2 inches beyond the damaged area. Use masking tape to hold the cutout in place. Stop-drill as necessary through the skin facing only.

Strip the paint and protective coating 1 1/2 inches beyond the stop-drilled holes. The stripped area is then cleaned with a special cleaning paste. Fill the void with the specified filler material to within approximately 0.063 inch of the skin facing and cure as directed.

Prepare a round or oval patch large enough to overlap the damaged area at least 1 inch. Apply sealant to the undersurface of the patch and to the filler and skin surface. Install the repair patch, maintaining correct overlap, and clamp to the assembly to assure contact with the skin facing. Cure as directed. Remove the excess adhesive and refinish as necessary.

The repair shown in figure 2-9(B) is used when a puncture through one skin facing has caused extensive damage to the honeycomb core. When the core has been damaged extensively, the damaged material must be replaced.

Prepare the assembly as previously described. Cut out the damaged skin facing with a hole saw or aviation snips. File the edges of the hole smoothly. Using a pocket knife, carefully cut out the damaged core. **CAUTION:** Do not damage the opposite facing. Install a new core filler and complete the repair as previously described for view (A) of figure 2-9.

The repair shown in figure 2-9(C) is used when both skin facings and the core have been damaged. Use the same procedures as described above for view (A) and (B) to facilitate this repair.

Balsa Wood Core

The repair shown in figure 2-10 is used when no gain in structural strength is desired and is only to be used for sealing holes of 1 square inch or less in external surfaces. The damaged area should be cut out to a smooth circular or rectangular shape. A 3/8-inch minimum radius must be provided at the corners of rectangular cutouts.

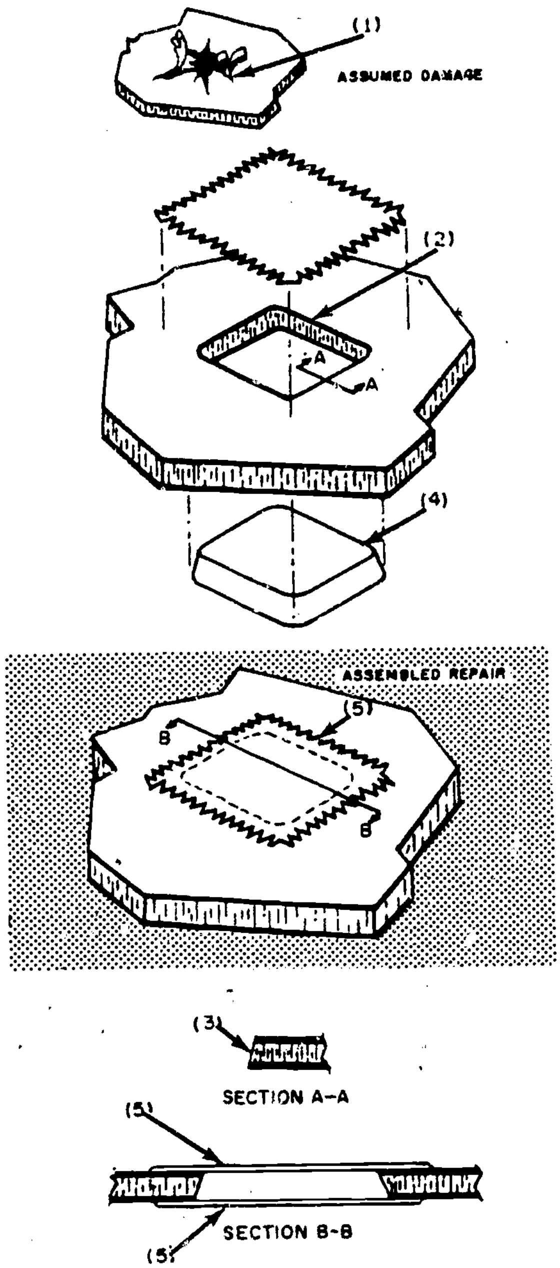
NOTE: The aforementioned information applies to all repairs made to balsa wood core panels. In cutting out the damaged area, take care not to separate the metal faces from the core. This can be accomplished by using a very fine-toothed coping or hacksaw blade for straight cuts, and cylindrical saws (hole saws) for cutting holes or rounding corners.

After the damaged section has been cut out, file the edges smooth using a fine cut file only. Then inspect the area for separation of the skin facing from the balsa wood core. If the facing has separated from the core, rebond the two surfaces, using the procedures outlined in the previous section on skin separation. Then complete the repair as shown in figure 2-10.

Figure 2-11 illustrates one flush type balsa wood core repair that is used on puncture damages larger than 1 inch. To make this type repair, cut out the damaged area as previously described. After the damaged area has been cut out, the inner metal face is cut back 1 inch and the core material is removed. (See (3) figure 2-11.)

Inspect the adhesion of the face to the core and seal the exposed filler material to prevent the entry of moisture. Lay out the required rivet pattern and drill pilot holes in the panel. (See (4) figure 2-11.) **NOTE:** The rivet size, rivet spacing, and number of rows of rivets are given in the appropriate repair section of the applicable Structural Repair Manual.

Next, prepare two patch plates; a wood, plywood, or phenolic filler; and a metal filler. (See (5) figure 2-11.) The outer patch plate should fill the hole in the core, and the inner patch plate should overlap the hole in the core approximately 1 inch for each row of rivets.



(1) Assumed damage. (2) Damage cut out to a smooth rectangular hole. (3) Inner metal face cut back and beveled. (4) Filler plug. (5) Filler glued in place, sealed, and fabric patches applied.

Figure 2-10 - Balsa wood repair with filler plug and fabric patch.

Locate the patch plates and wood filler. Using the pilot holes in the panel as a guide, drill pilot holes through the patch plates and wood filler. The patch plates and wood filler are then bonded to the panel using the specified adhesive. Next, locate the metal filler and drill pilot holes through both patch plates and the wood filler.

All pilot holes are then size drilled and machine or press countersunk, as applicable. Complete the repair by installing the specified rivets.

When aerodynamic smoothness is not desired, a nonflush patch such as the one shown in figure 2-12 can be used. Notice that this type repair utilizes two patch plates, a wood filler, and nonflush rivets. Otherwise, the procedures described for the repair shown in figure 2-11 are applicable to this type repair.

TRAILING EDGE REPAIR

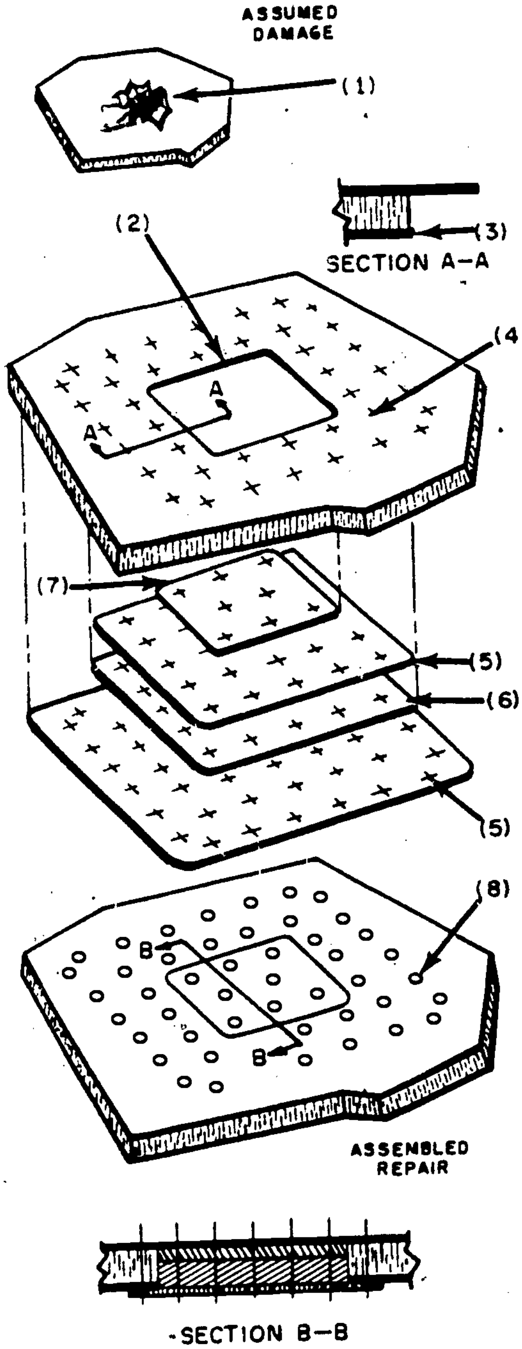
A trailing edge is the rearmost edge of an airfoil (wing, flap, rudder, elevator, etc.) It may be a formed or machined metal strip or possibly a metal covered honeycomb or balsa wood core material which forms the shape of the edge by tying the ends of a rib section together and joining the upper and lower skins. These trailing edges are very easily damaged. The majority of this type damage can be avoided if care is taken when moving aircraft in confined spaces, and/or when positioning ground support equipment around parked aircraft.

NOTE: The trailing edges on some high performance aircraft are almost knife edge in construction. Be extremely careful when working around these surfaces to avoid injury.

The following paragraphs briefly describe the procedures to be used in repairing damage to both the all-metal and sandwich construction trailing edges.

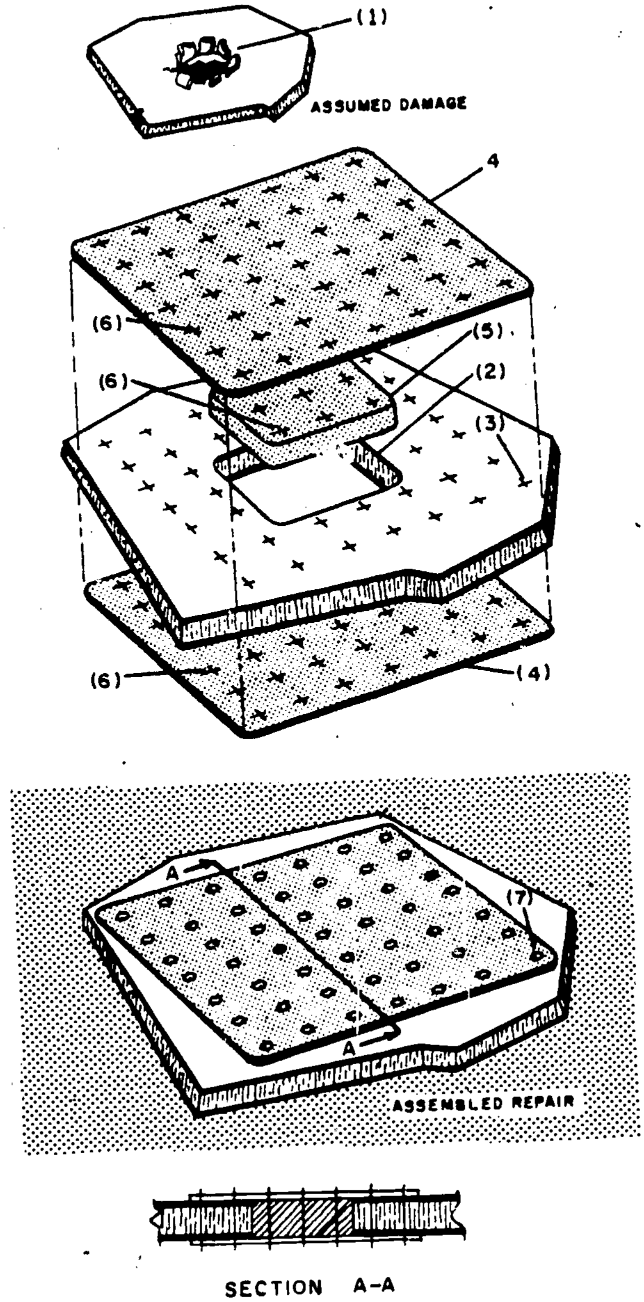
ALL METAL

Trailing edge repairs to all-metal construction assemblies and/or control surfaces



(1) Assumed damage. (2) Damage cut out to a smooth rectangle. (3) Inner metal face cut back and core removed. (4) Rivet pattern. (5) Patch plates. (6) Wood, plywood, or phenolic filler. (7) Metal filler. (8) Flush rivets installed.

Figure 2-11 - Balsa wood repair with flush patch.



(1) Assumed damage. (2) Damage cut out to a smooth rectangle. (3) Rivet pattern. (4) Nonflush patch plates. (5) Wood filler. (6) Rivet patterns. (7) Nonflush rivets installed.

Figure 2-12 - Balsa wood repair with nonflush patch.

are performed using basically the same procedures outlined previously in this pamphlet.

The lap or flush patch may be used, depending on the size of the damage, type aircraft, and the assembly or control surface to be repaired.

NOTE: Normally, the flush patch is used on control surfaces to ensure aerodynamic smoothness.

SANDWICH CONSTRUCTION

A typical trailing edge repair to a sandwich construction assembly is shown in figure 2-13.

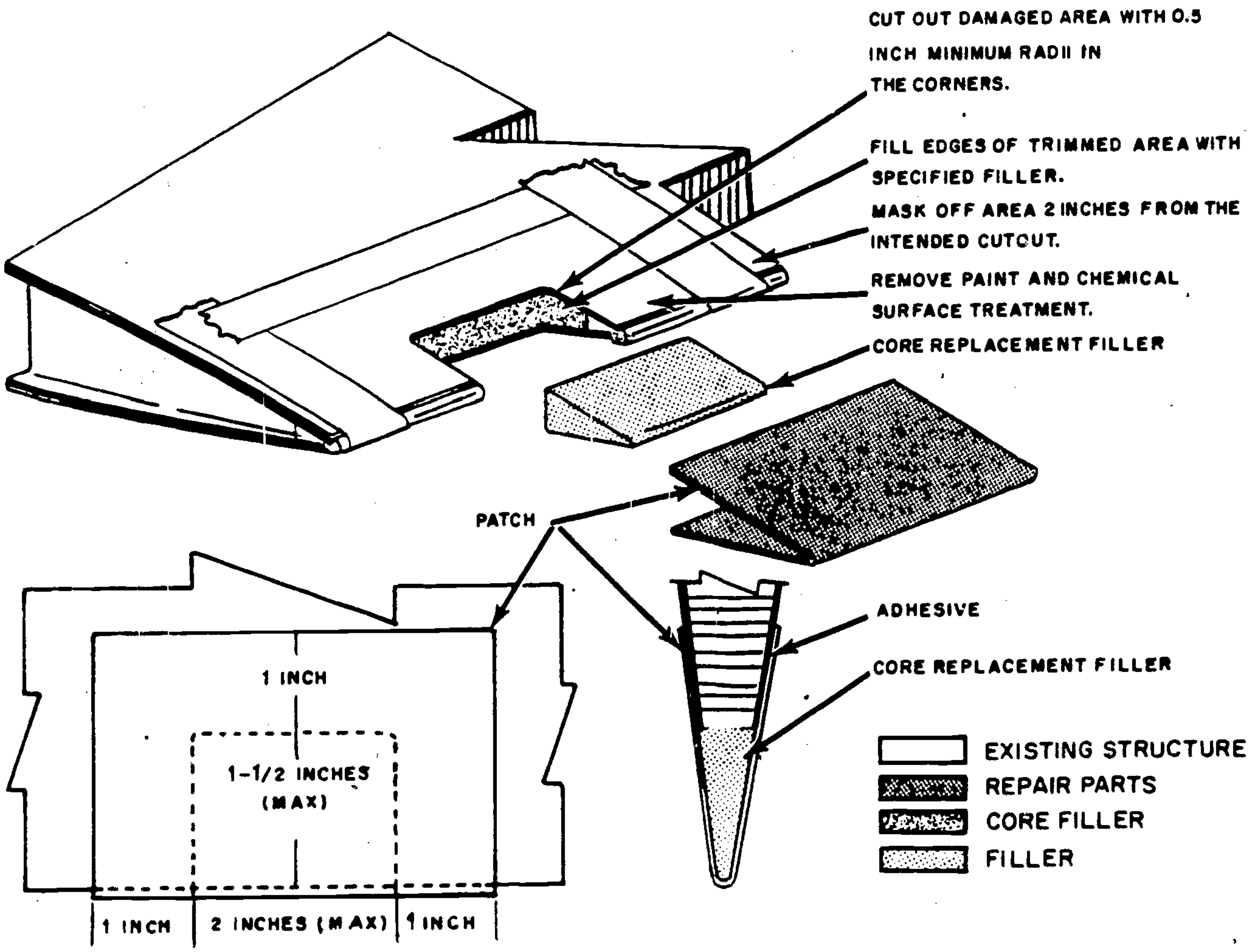


Figure 2-13 - Trailing edge repair (sandwich construction).

SECTION 2
REVIEW QUIZ

QUESTIONS

1. When tapped with a blunt instrument, damaged reinforced plastic will have a ______________ sound.

2. What are the four general classes of reinforced plastic damage?

3. Minor surface damage to reinforced plastic may be repaired by ____________.

4. You can hasten the cure of resin in a repair to a reinforced plastic by using ______________.

5. You are removing laminate layers for a stepped repair to a reinforced plastic. To prevent damage to layers underneath, you should use ______________.

6. When preparing to repair delaminated plies of a reinforced plastic by injecting resin, you should drill the injection holes with a No. __________ drill bit.

7. If a small damaged area extends through one facing and into the core of a reinforced plastic, what is the PREFERRED repair method?

8. If allowed to progress unchecked, rain erosion pits can cause __________ of glass cloth components.

9. After using rubber gloves to mix or handle catalyzed resin, you should clean your hands with ________________.

10. To repair a facing-to-core void larger than 2.5 inches in diameter in structural sandwich construction, you should follow the same repair procedure used for a ___________.

11. You are making a flush type balsa wood core repair to structural sandwich construction. After cutting out the damaged area, you should cut back the inner metal face _________ inch and remove the core.

(See page 2-16 for ANSWERS to Review Quiz questions.)

SECTION 2
REVIEW QUIZ

ANSWERS

1. dull or dead (Page 2-1)

Surface damage, facing and core damage, puncture damage (both facings and [illegible]), and damage requiring replacement. (Page 2-1)

3. applying one or more coats of catalyzed resin to the damaged area (Page 2-1)

4. infrared lamps or hot sandbags. (Page 2-2)

5. a cutting tool with a controlled depth (Page 2-2)

6. 60 (Page 2-4)

7. The scarfed method. (Page 2-4)

8. delamination (Page 2-8)

9. soap and water, and rinse with vinegar (Page 2-10)

10. puncture (Page 2-10)

11. 1 (Page 2-11)

SECTION 3

RIVETING PROCEDURES

OBJECTIVES

When you complete this assignment, you will be able to:

1. State the strength, head style, and dimension requirements you must consider when selecting rivets for an aircraft repair.

2. Explain how rivet spacing, transverse pitch, and edge distance are determined for a repair.

3. Describe the correct procedures for drilling and countersinking rivet holes.

As an AM, you must use your knowledge, ability, and experience when planning an aircraft structural repair. This does not end after the proper materials have been selected. Each type of rivet must be selected and driven in a precise manner to meet riveting specifications. Some of the specifications are rivet spacing and edge distance, diameter of rivet hole, aerodynamic smoothness, and size of the rivet bucktail. These can be accomplished only through determination, practice, and accurate manipulation of all standard layout and riveting equipment.

RIVET SELECTION

The following rules govern the selection and use of rivets in making a repair:

1. Replacements must not be made with rivets of lower strength material unless they are larger than those removed. For example, a rivet of 2024 aluminum alloy should not be replaced by one made of 2017 aluminum alloy unless the 2017 rivet is a size larger. Similarly, when 2117 rivets replace 2017 rivets, the next larger size should be used.

2. When rivet holes become enlarged, deformed, or otherwise damaged, use the next larger size as a replacement.

3. Countersunk-head rivets are to be replaced by rivets of the same type and degree of countersink, either AN426 or MS20426.

4. All protruding head rivets are to be replaced with universal head, either AN470 or MS20470.

5. Rivets of smaller diameter than 3/32 inch will not be used for any structural parts, control parts, wing covering, or similar parts of the aircraft.

6. Minimum rivet diameter is one times the thickness of the thickest sheet to be riveted.

7. Maximum rivet diameter is three times the thickness of the thickest sheet to be riveted.

8. The proper length of rivet is an important part of the repair. Should too long a rivet be used, the formed head will be too large, or the rivet may bend or be forced between the sheets being riveted. Should too short a rivet be used, the formed head will be too small or the riveted material will be damaged. The length of the rivet should equal the sum of the thickness of the metal plus 1 1/2 times the diameter of the rivet, as shown in figure 3-1. The formula for determining rivet length is specified as follows:

$$1\ 1/2\ D + G = L,$$

where D = rivet diameter, G = grip (total thickness of material), and L = total length of rivet.

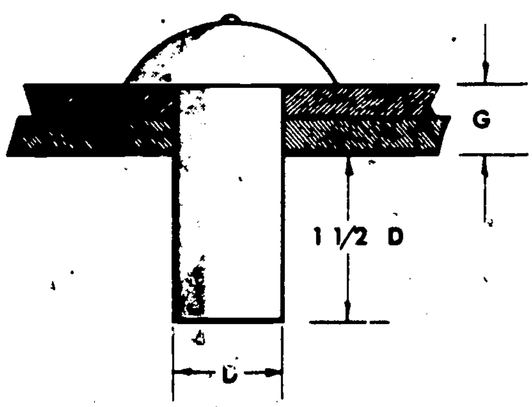


Figure 3-1 - Rivet length.

SPACING AND EDGE DISTANCE

RIVET SPACING, also referred to as RIVET PITCH, is the distance between rivets in the same row, and is measured from rivet center to rivet center. TRANSVERSE PITCH is the distance between rows of rivets and is measured from rivet center to rivet center. EDGE DISTANCE is the distance from the center of the rivet to the edge of the material being riveting.

There are no specific rules which are applicable to every case or type of riveting. There are, however, certain general rules which should be followed.

RIVET SPACING

Rivet spacing (pitch) depends upon several factors, principally the thickness of the sheet, diameter of the rivets, and the manner in which the sheet will be stressed. Rivet spacing should never be less than 4D (4 times the rivet diameter) nor should it be more than 10D (10 times the rivet diameter). Spacing is seldom more than 8D.

TRANSVERSE PITCH

When two or more rows of rivets are used in a repair job, the rivets are staggered to obtain maximum strength. The distance between the rows of rivets is called transverse pitch. Transverse pitch is normally 75 percent of existing rivet pitch but should never be less than 2 1/2D.

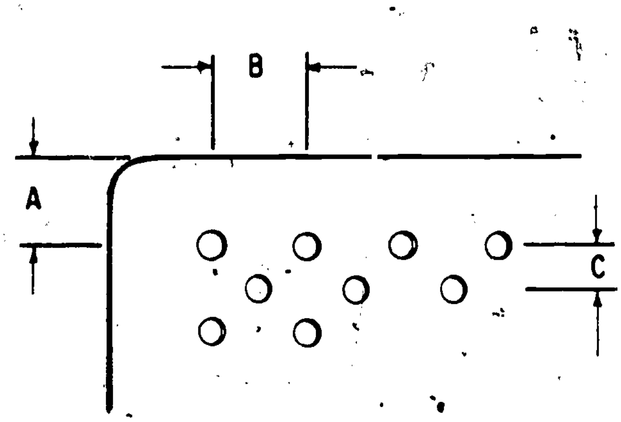


Figure 3-2 - Rivet spacing and edge distance.

EDGE DISTANCE

Edge distance for all rivets, except those with a flush head, should not be less than 2D (twice the diameter of the rivet shank) nor more than 4D. Flush-head rivets require an edge distance of at least 2 1/2D. If rivets are placed too close to the edge of the sheet, the sheet is apt to crack or pull away from the rivets; and if rivets are placed too far away from the edge, the sheet is apt to turn up at the edge.

NOTE: On most repairs, the general practice is to use the same rivet spacing and edge distance that the manufacturer used in the surrounding area, or the Structural Repair Manual for the particular aircraft may be consulted. Figure 3-2 illustrates rivet spacing and edge distance.

DRILLING RIVET HOLES

Standard twist drills are used for drilling rivet holes. Figure 3-3 specifies the size for the various size rivets. Note that in each case there is a slight clearance, which prevents binding of the rivet in the hole.

Rivet diameter	Drill size	Drill size
3/32	No. 41	0.0960
1/8	No. 30	.1285
5/32	No. 21	.1590
3/16	No. 11	.1910
1/4	No. F	.2570
5/16	No. P	.3230
3/8	No. W	.3860

Figure 3-3.- Drill sizes for various size rivets.

Locations for the rivet holes should be center-punched and the drilling done with a power drill, either electric or pneumatic. Electric drills constitute a fire hazard when drilling on or near an aircraft due to the arcing of the brushes; therefore, the pneumatic drill must be used. The center-punch mark should be large enough to prevent the drill from slipping out of position, but the mark must not be made with enough force to dent the surrounding material. The drilling can be done with a hand drill if no power drill is available. All burrs must be removed before riveting by using a larger size drill, or by using a deburring tool.

FLUSH RIVETING

Progression towards higher speed aircraft has been made possible by improved design, stronger and lighter aluminum alloys, and more powerful engines. Attention has been turned towards the elimination of protruding head rivets on the exterior surfaces of aircraft. In fabricating stressed metal skin on modern aircraft, countersink all exposed rivet heads to lie flush with the outer surface of the skin. It is essential to provide an aerodynamically smooth surface.

Flush rivets are more difficult to install, since the parts being riveted must be countersunk. This is one extra operation following drilling. Another hazard is the closeness of the rivet set to the metal during riveting. If considerable skill is not used, the metal will be damaged by the rivet set. Flush rivets are made with heads of several different angles, but the 100-degree rivet is standard for most aircraft.

The two methods used in countersinking for flush riveting are dimple and machine countersinking. In some instances, a combination of the two may be used; in other words, the top sheet of an assembly may be dimpled, while the under sheet is machine countersunk.

COUNTERSINKING FOR INSTALLATION OF RIVETS

When using a hand-operated countersink to countersink the surface of a material, try the hole with a rivet so the

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recess will not be too deep. It is best to use a stop countersink with an electric drill motor so that the depth of the hole can be controlled. The minimum sheet thickness for machine countersinking 100-degree rivets is subject to the limitations shown in figure 3-4.

RIVET SIZE	3/32	1/8	5/32	3/16	1/4
GAGE	.040	.050	.064	.072	.072

Figure 3-4 - Minimum sheet gage for 100-degree machine countersink.

DIMPLING FOR INSTALLATION OF RIVETS

Dimpling is done with a punch and die set. The punch has a guide pin the size of the rivet hole and the same degree countersink as the rivet. The die has a hole and the same degree countersink as the punch. Dimpling is accomplished by inserting the punch in the rivet hole and then into the die, which should be resting on a solid surface. The punch is then struck, forming a dimple. Care must be taken to keep the striking surfaces parallel with the skin surface. Coin dimpling is accomplished by inserting the proper countersunk rivet in the hole. A recessed gun draw tool is placed over the rivet shank. As the rivet is driven, the head forms its own dimple and the rivet shank is upset in the usual manner. Power squeezers may be used for these operations. Countersunk pin rivets are used only with machine countersinking or machine subcountersinking, then the top or outer sheet is coin dimpled when the rivet is installed.

RIVET SIZE	3/32	1/8	5/32	3/16	1/4
GAGE	.040	.064	.072	.072	.072

Figure 3-5 - Minimum gage for subcountersinking.

SUBCOUNTERSINKING FOR INSTALLATION OF RIVETS

Subcountersinking is the process in which the inner structure or skin is machine countersunk and the outer surface is dimpled or coin dimpled. The sheet thickness limitations for subcountersinking are shown in figure 3-5.

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SECTION 3
REVIEW QUIZ

QUESTIONS

1. When replacing an aircraft 2024 aluminum alloy rivet with a 2017 aluminum alloy rivet, you should use the next __________ size.

2. The smallest diameter rivet you should use for any structural part is ______ inch.

3. The MINIMUM transverse rivet pitch is ___________.

4. Flush head rivets require an edge distance of __________.

5. What size twist drill should you use to drill a hole for a 5/32 inch diameter rivet?

6. When you are subcountersinking for a 5/32-inch-diameter countersunk rivet, the MINIMUM sheet thickness should be ______ inch.

(See page 3-6 for ANSWERS to REVIEW QUIZ questions)

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SECTION 3
REVIEW QUIZ

ANSWERS

1. larger (Page 3-1)
2. 3/32 (Page 3-1)
3. 2 1/2 times the rivet diameter (Page 3-2)
4. 2 1/2 times the rivet diameter (Page 3-3)
5. No. 21 (Page 3-3)
6. 0.072 (Page 3-4)

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PAMPHLET REVIEW QUIZ

PAMPHLET REVIEW QUIZ

QUESTIONS

1. During the preinspection of a damaged area on an aircraft, the FIRST step is to ______.

   A. disassemble removable components
   B. remove paint in the vicinity of the damage
   C. perform a dye penetrant inspection
   D. check for secondary damage

2. To ensure a thorough investigation has been made of a damaged area, the three methods of inspection are visual inspection, nondestructive inspection for cracks, and ______.

   A. paint removal
   B. a check for secondary damage
   C. a hardness test
   D. disassembly of removable components

3. Prior to hardness testing a metal having an anodized surface, you should remove the anodizing at the point of penetrator contact because anodizing is ______.

   A. harder than the base alloy
   B. softer than the base alloy
   C. not electrically conductive
   D. electrically conductive

4. During the investigation and cleanup of damage, you should treat deep abrasions as ______.

   A. severe corrosion
   B. minor scratches
   C. shallow dents
   D. complete breaks

5. When it is impossible to obtain a straight edge on a sheet of metal to start a layout, you should use a ______.

   A. reference line
   B. protractor
   C. steel straight edge
   D. T-square

(See page 4-2 for ANSWERS to PAMPHLET REVIEW QUIZ questions)

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PAMPHLET REVIEW QUIZ

ANSWERS

1. B - When any part of the airframe has been damaged, the first step is to clean off all grease, dirt, and paint in the vicinity of the damage so that the extent of the damage may be determined. (Page 1-1)

2. C - To ensure that a thorough investigation of damage has been made, the three methods are visual inspection, hardness testing, and nondestructive inspection for cracks. (Page 1-1)

3. A - If the alloy to be tested is either clad or anodized, the surface coating must be removed to the bare metal at the point of penetrator contact. This is necessary because clad surfaces are softer, and anodized surfaces are harder, than the base alloy. (Page 1-2)

4. D - CAUTION: DEEP SCRATCHES AND ABRASIONS MUST BE TREATED AS COMPLETE BREAKS. (Page 1-2)

5. A - If it is impossible to obtain a straight edge on a sheet to start a layout, or if the distance from the edge is too great, a reference line may be used. (Page 1-7).

PAMPHLET REVIEW QUIZ

QUESTIONS

6. If pencil marks are not removed from aluminum, what will be the result?

   A. Paint will not adhere
   B. Electrolytic action will cause corrosion
   C. Alcladding will separate from the base alloy
   D. The metal temper in the area of the mark will eventually be destroyed

7. You can repair a damaged stringer using the reinforcement splice and filler splice method if the damage does not exceed ______.

   A. 10 inches in length
   B. four times the normal rivet pitch
   C. one-half the width of one of the stringer's legs
   D. two-thirds the width of one of the stringer's legs

8. The web between the capstrips of a reinforced rib is reinforced by ______.

   A. lightening holes
   B. formed beads
   C. vertical and diagonal angles
   D. equally spaced doublers

9. A small hole in the web of a bulkhead may be repaired in the same manner as ______.

   A. stressed skin
   B. nonstressed skin
   C. a longeron
   D. a stringer

10. When making a skin repair to a pressurized fuselage, you should bond the parts together with the adhesive specified in the ______.

    A. Maintenance Instruction Manual
    B. aircraft Structural Repair Manual
    C. General Structural Repair Manual
    D. Technical Manual for General Use of Cements, Sealants, and Coatings

(See page 4-4 for ANSWERS to PAMPHLET REVIEW QUIZ questions)

PAMPHLET REVIEW QUIZ

ANSWERS

6. B - The pencil mark should be removed from aluminum and magnesium to prevent an electrolytic action that will eventually cause corrosion. (Page 1-7)

7. D - The reinforcement splice and filler splice method is permissible when the damage does not exceed two-thirds of the width of one leg of the stringer and is not over 12 inches in length. (Page 1-7)

8. C - The web is reinforced between the capstrips by vertical and diagonal angles. (Page 1-9)

9. A - When damage to the web is a crack, dent, or small hole, it may be repaired in the same manner as fully stressed skin. (Page 1-10)

10. B - The Structural Repair Manual for the specific aircraft must be consulted for the correct fasteners, their spacing, the procedure for repair, and the proper sealant to be used. (Page 1-12)

PAMPHLET REVIEW QUIZ

QUESTIONS

11. Aircraft skin having a low margin of safety requires a __________ percent stress intensity repair.

    A. 60
    B. 75
    C. 80
    D. 100

12. When trimming a damaged area, you should round the corners of the hole to a MINIMUM radius of __________ inch.

    A. 1/8
    B. 3/16
    C. 1/4
    D. 5/16

13. When blind rivets are substituted for solid rivets in a skin repair, the blind rivets must __________.

    A. be of the same alloy as the solid rivets
    B. be the next larger size than the solid rivets
    C. be used only on the filler
    D. have a brazier head style only

14. In a closed skin repair, you should rivet the filler to the doubler by using ________.

    A. blind rivets after installing the doubler
    B. blind rivets before installing the doubler
    C. solid rivets before installing the doubler
    D. solid rivets after installing the doubler

15. When using the old section of skin as a template for drilling holes in the new skin, you should begin by drilling __________.

    A. holes at the top and proceeding to the bottom of the sheet
    B. holes at the center and proceeding to the outside of the sheet
    C. all bulkhead rivet, screw, and bolt holes
    D. all longeron and stringer rivet holes

(See page 4-6 for ANSWERS to PAMPHLET REVIEW QUIZ questions)

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PAMPHLET REVIEW QUIZ

ANSWERS

11. D - The 100 percent stress intensity repair makes the strength of the repaired skin equal to, or greater than, the original undamaged skin. This type of skin usually has a low margin of safety. (Page 1-16)

12. C - The damaged area is removed by cutting and trimming the hole to a circular, square, rectangular, or diamond shape. The corners of the hole should be rounded to a minimum of 1/4-inch radius. (Page 1-18)

13. B - When blind rivets are used as substitutes for solid rivets, the Structural Repair Manual normally specifies the next larger size. (Page 1-18)

14. A - On larger repair areas it is usually possible to buck the doubler rivets by inserting and holding the bucking bar through the center of the doubler. The filler is then riveted in place using blind fasteners, if the repair is in a closed skin area. (Page 1-19)

15. B - The drilling should proceed from the center to the outside of the sheet, inserting sheet metal fasteners at frequent intervals. (Page 1-21)

PAMPHLET REVIEW QUIZ

QUESTIONS

16. When duplicating holes from reinforcing members to new skin, you should prevent damage to anchor nuts by ____________.

    A. removing the nuts before drilling the holes
    B. marking the holes with a pencil
    C. marking the holes with a center punch
    D. drilling the holes with a smaller pilot drill

17. Before you can thoroughly inspect the damage to a reinforced plastic component, you should clean the area with a cloth saturated with __________.

    A. acetone
    B. toluene
    C. a mixture of xylene and acetone
    D. methyl-ethyl-ketone

18. When the scarfed method is used to repair ply damage to a sandwich-type reinforced plastic, the diameter of the tapered area should be AT LEAST __________ the depth of the damage penetration.

    A. 100 times
    B. 50 times
    C. twice
    D. one-half

19. When using the stepped repair method for a reinforced plastic, you should cut replacement fabric pieces with the weave direction running __________ the weave of the existing plies.

    A. oblique to
    B. diagonal to
    C. perpendicular to
    D. in the same direction as

20. To repair damage to a sandwich-type laminate, you should use the stepped repair method for __________.

    A. punctures up to 3 or 4 inches in maximum dimension extending completely through the sandwich structure
    B. small holes through one facing and into the core
    C. larger repairs to facings composed of thick cloths
    D. smaller repairs to facings made of thin cloths

(See page 4-8 for ANSWERS to PAMPHLET REVIEW QUIZ questions)

PAMPHLET REVIEW QUIZ

ANSWERS

16. D - When drilling through anchor nuts, use a smaller pilot drill first. Be careful not to damage the anchor nut threads. (Page 1-21)

17. D - Before a thorough inspection of the damage can be made, the areas should be cleaned with a cloth saturated with methyl-ethyl-ketone (MEK). (Page 2-1)

18. A - The diameter of the scarfed (tapered) area should be at least 100 times the depth of the penetration. (Page 2-2)

19. D - Cut the replacement glass fabric pieces to an exact fit with the weave direction of the replacement plies running in the same direction as the existing plies. (Page 2-2)

20. C - The scarfed method is normally used for small punctures up to 3 or 4 inches in maximum dimension and in facings made of thin cloths (which are difficult to peel). The stepped method is usually employed for larger repairs to facings composed of thick cloths. (Page 2-6)

PAMPHLET REVIEW QUIZ

QUESTIONS

21. When repairing reinforced plastic components, you should NEVER mix a resin catalyst and promoter together because, as a mixture, they ____________.

    A. cause severe corrosion
    B. are explosively reactive
    C. promote spontaneous ignition
    D. cause resin coagulation

22. To repair a large void area in an aluminum faced, aluminum honeycomb sandwich structure, you should ____________.

    A. cut out the entire area and install inserts
    B. remove the facing over the area and repair as a puncture
    C. drill holes and inject resin into the area
    D. drill holes, inject resin into the area, and install a lap patch over the area

23. When a balsa wood core sandwich structure has puncture damage larger than 1 inch completely through the structure, you should repair the structure by ________.

    A. making an outer facing metal flush-type repair
    B. making an outer facing phenolic flush-type repair
    C. installing a phenolic lap patch
    D. installing a fabric lap patch

24. The majority of airfoil trailing edge damage is caused by ____________.

    A. hard landings
    B. runway debris
    C. excessive speeds in flight
    D. moving aircraft in confined spaces

25. In an aircraft repair, you can use rivets of lower strength than the rivets removed if the ____________.

    A. replacement rivets are larger than those removed
    B. repair/replacement parts are of a different alloy than the original
    C. area has a high margin of safety
    D. area requires only an 80 percent stress intensity repair

(See page 4-10 for ANSWERS to PAMPLET REVIEW QUIZ questions)

PAMPHLET REVIEW QUIZ

ANSWERS

21. B - Never mix the catalyst and promoter together because they are explosively reactive as a mixture. (Page 2-10)

22. B - When the void areas are large, it is necessary to remove the facing over the damaged area and follow the repair procedures for a puncture. (Page 2-10)

23. A - Figure 2-11 illustrates one flush type balsa wood core repair used for puncture damages larger than 1 inch. (Page 2-11)

24. D - The majority of airfoil trailing edge damage can be avoided if care is taken when moving aircraft in confined spaces, and/or when positioning ground support equipment around parked aircraft. (Page 2-12)

25. A - Replacements must not be made with rivets of lower strength material unless they are larger than those removed. (Page 3-1)

PAMPHLET REVIEW QUIZ

QUESTIONS

26. The MAXIMUM edge distance for all rivets is __________.

A. 2D
B. 2 1/2D
C. 3D
D. 4D

27. To drill a 3/16-inch rivet hole, you should use a No. ____ drill.

A. 21
B. 11
C. F
D. P

28. When you use a drill motor to countersink a hole, the BEST method for controlling the depth of the countersink is to __________.

A. stop repeatedly and check for rivet head fit
B. use a stop countersink
C. use a four-fluted countersink
D. use a slower drilling speed than normal

29. Subcountersinking is the process in which __________________.

A. the inner and outer surfaces of a piece of metal are countersunk
B. only the inner surface of a piece of metal is countersunk
C. the inner structure or skin is machine countersunk and the outer surface is dimpled
D. the inner structure or skin is coin dimpled and the outer surface is machine countersunk

(See page 4-12 for ANSWERS to PAMPHLET REVIEW QUIZ questions)

PAMPHLET REVIEW QUIZ

ANSWERS

26. D - Edge distance for all rivets, except those with a flush head, should not be less than 2D (twice the diameter of the rivet shank) nor more than 4D. (Page 3-3)

27. B - Figure 3-3 (Page 3-3)

28. B - It is best to use a stop countersink with an electric drill motor so that the depth of the hole can be controlled. (Page 3-4)

29. C - Subcountersinking is the process in which the inner structure or skin is machine countersunk and the outer surface is dimpled or coin dimpled. (Page 3-4)