CHAPTER 12

GENERAL MAINTENANCE

INTRODUCTION

The purpose of this chapter is to give you maintenance information, and explain techniques and procedures applicable to guided missile launching equipment in general. Maintenance information for your equipment can be found in its OP, usually Volume 2 of a series.

The effectiveness and reliability of your equipment depend largely upon the care and attention you give it. A malfunctioning launcher power drive puts an entire missile weapon system out of operation. One open lead in a launcher-to-round connector destroys the effectiveness of a missile weapon system. Heavily grounded synchro transmission circuits introduce erroneous information into the receiving units of any weapon system. Improperly lubricated loading equipment may freeze up. If you can't load missiles, you can't launch them. And if you can't get them into the air, you might as well stay tied up to the dock. But there is no point in belaboring the obvious. You can probably think of many instances of improper maintenance that would put a weapon system out of commission or reduce its effectiveness. We include the above points only to illustrate how important your maintenance activities, as a GMM, are to the fighting effectiveness of your ship. Too many of us feel that the small maintenance tasks we are called on to do, like setting up loose screws on terminal boards, are unimportant. Admittedly, this is a long and boring process. But it must be done. Otherwise the vibration of the ship will loosen the screws a little more each day until finally they fall out. What happens then? Electrical leads are detached, and you may spend hours tracing the trouble. And in the meantime your ship may be defenseless.

DEFINITION OF MAINTENANCE

The work you do on equipment falls into two broad categories: (1) actions you take to reduce or eliminate failures and to prolong the useful life of your equipment, and (2) actions you take when a part or component has failed and the equipment is out of service. Therefore, we can think of the whole business of general maintenance as consisting of PREVENTIVE maintenance and CORRECTIVE maintenance. Figure 12-1 shows these two aspects of maintenance and the phases of each type.

In maintenance work of any type you must use knowledge and skills of two fundamental kinds. First, you must have SPECIFIC information which applies only to the particular equipment you are working on. Second, you must have and use certain GENERAL skills and knowledge which apply to many kinds of equipment.

The specific information required consists of special maintenance procedures and processes. These are detailed step-by-step directions which have been approved by NAVORD SYSCOM, type commanders, or other authorized sources. You can find specific maintenance information in the equipment OP or in type commander checkoff lists, and the Maintenance Requirement Cards (MRC) for the equipment.

General maintenance skills and procedures are based on knowledge which is not contained in equipment OPs but must be learned on the job and from Rate Training Manuals such as this one. And it is this kind of information that forms the basic content of this chapter.

PREVENTIVE MAINTENANCE DEFINED

What is preventive maintenance? Let's use a familiar experience to illustrate the meaning of the term. You have probably owned a car or have taken part in keeping one in good shape. Undoubtedly you found out that there is more to having a car than simply driving it. You have to put air in the tires. Oil and water must be checked periodically. The car has to be washed and waxed to prevent the paint from peeling off.

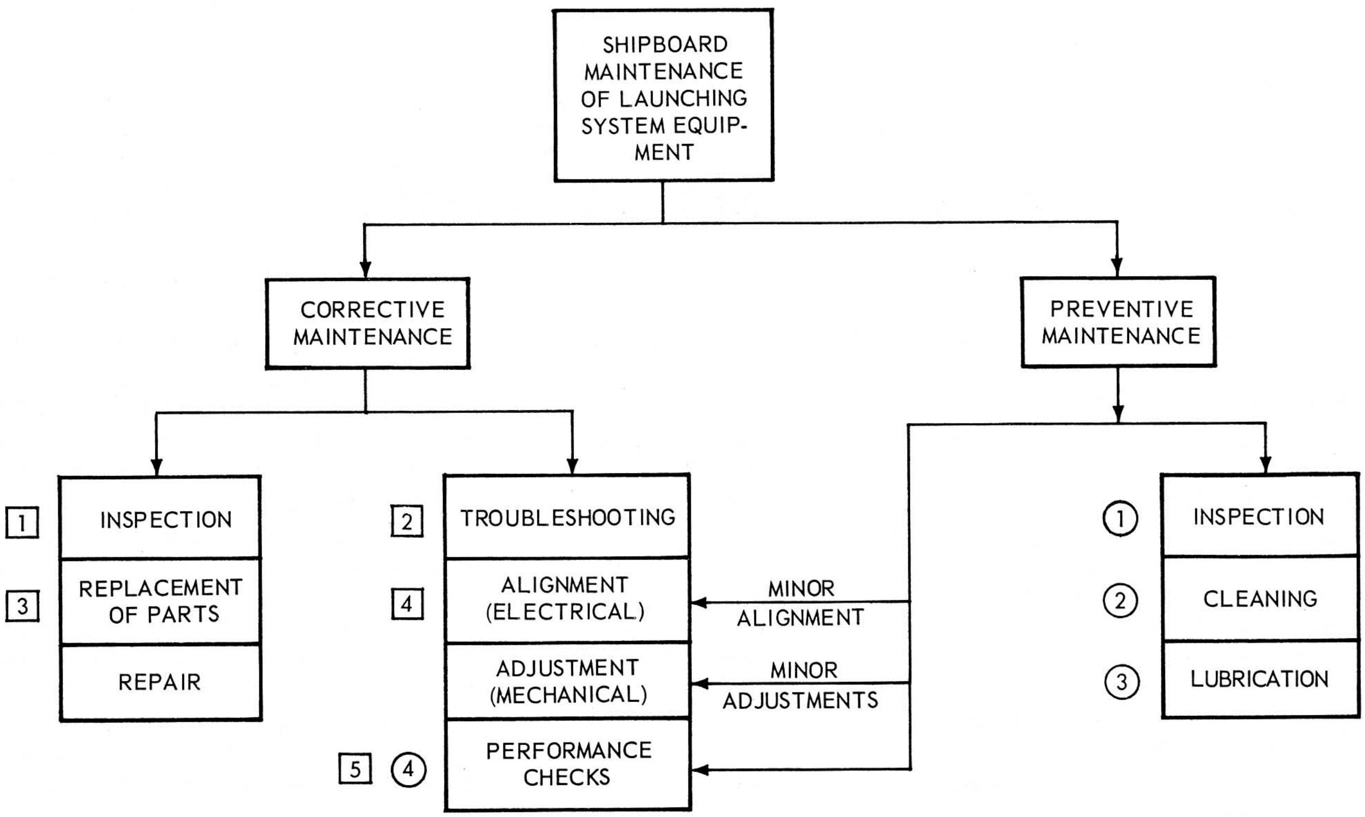

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Figure 12-1.—Phases of maintenance.

Periodically, the brakes must be adjusted, the spark plugs cleaned, and the motor tuned up. If you faithfully follow the manufacturer's suggested maintenance program, the chances are your car will not be laid up in the garage for long repair periods.

The procedures for maintaining launching system equipment are not exactly those you follow in taking care of a car, but the purpose is identical, and that is to stop trouble before it starts.

Preventive maintenance, then, consists of the care, upkeep, and minor repairs and adjustments performed by the GMM to ensure the best operation of his equipment and to reduce the chance of sudden equipment failure. It involves four major types of activity, as shown in figure 12-1:

1. Periodic inspection.
2. Periodic lubrication.
3. Periodic cleaning.
4. Periodic performance checks.

In certain of the following sections of this chapter we will discuss each of these aspects of preventive maintenance. But before we do, let's consider the second maintenance category - corrective maintenance.

CORRECTIVE MAINTENANCE DEFINED

When preventive maintenance or the poor performance of equipment reveals that a casualty or malfunction exists in a system or equipment, some form of corrective maintenance is required. Corrective maintenance includes those activities needed to restore equipment to its designed capabilities or efficiency. This includes the repair of battle damage or damage caused by wear or accident.

Corrective maintenance generally is performed in five phases: (1) inspection, (2) troubleshooting, (3) repair of replacement of parts, (4) alignment and adjustment, and (5) performance checks. Occasionally there is an overlap of some of the activities of preventive and corrective maintenance; therefore; it is difficult to find a sharp dividing line to separate the two.

MAINTENANCE LEVELS

Maintenance work on ordnance equipment is done on three distinct levels. First, there is maintenance work done on board ship. The work done here is called Organizational Maintenance. It is done on a day-to-day basis and includes the preventive and corrective maintenance performed by ship's force.

But the ship's force hasn't the facilities nor always the skills to perform certain less frequent but necessary maintenance operations. Examples of this type of operation are star-gauging guns, systems alignment, and special maintenance problems. Work of this kind is done aboard tenders and repair ships by highly skilled personnel. This second level of maintenance is called Intermediate Maintenance.

Finally, there are some jobs, such as the major overhaul of hydraulic systems, lifting of launchers to inspect and repair roller paths, and overhaul of main sprinkling control valves, that are customarily done in naval shipyards. Such work may be done by yard workers, by the ship's force, or by both. Maintenance work done in yards rather than afloat is termed Depot Maintenance.

ORDNANCE DRAWINGS

When we talk about NAVORDSYSCOM drawings or naval ordnance equipment in general, certain terms that need defining always appear. Some of these terms are: part, subassembly, assembly, and major assembly.

A PART can mean an item that is made up of a single piece of material such as a casting, or a machined or stamped piece of metal. Tachometers, synchros, valves, lubrication fittings, and other units that are not usually disassembled during maintenance fit into this category. If two or more single pieces are welded, brazed, or soldered together, you can call these items parts.

A SUBASSEMBLY refers to a combination of two or more mechanically connected parts which can be disassembled without destroying their designed use. A solenoid valve is an example of a subassembly. If you remove the solenoid, it can still function as a solenoid, and the valve can be operated by hand.

An ASSEMBLY consists of mechanically connected subassemblies and/or parts. As a combination, and assembly is capable of performing a specific function. Despite the rigorous definitions laid down here, you must keep in mind that the distinction between an assembly and a subassembly is not always exact.

A MAJOR ASSEMBLY refers to an assembly which has been assigned a Mk and Mod number. A launcher guide arm is a good example.

A SUBSYSTEM is a major functional part of a system that can operate alone. An example is a missile launcher. It can train, elevate, and launch missiles even if the feeder is out of service. Of course an inoperative feeder means that you will have to find some other way of putting missiles on the launcher. You might use a chain fall, for instance. It's been done before. But the point is that once you do load a missile on the launcher you can aim and launch the weapon independently of the rest of the system.

A SYSTEM is a major functional part of a complete weapon system. A guided missile launching system and a fire control system are good examples.

Manufacturers of ordnance equipment make drawings of their equipment. Copies of these drawings, reproduced by blueprinting, the ozalid process, or in some other way, are supplied to every ship or shore installation that has the equipment or for some other reason requires copies or prints of the drawings. Many drawings are reproduced in OPs and other technical manuals. Many of the drawings you'll see are made by the NAVORDSYSCOM; others are made by the contractors who manufacture the equipment for NAVORDSYSCOM. In any case, ordnance drawings are all set up similarly.

TYPES OF DRAWINGS

Drawings differ, depending on their purpose. The main types of drawings, as classified according to purpose by NAVORDSYSCOM, are:

1. GENERAL ARRANGEMENT DRAWINGS. This kind of drawing shows the completely assembled equipment. It indicates general appearance and relationships of important component assemblies, and identifies the drawings that describe the components of the equipment. The purpose of this type of drawing is to provide for equipment familiarization. Important dimensions of equipment are shown, and major assemblies are identified. Figure 12-2 is an example of a general arrangement drawing.

2. INSTALLATION DRAWINGS. These show such features as mounting pads and brackets, shock mounts, points of entrance for cabling and

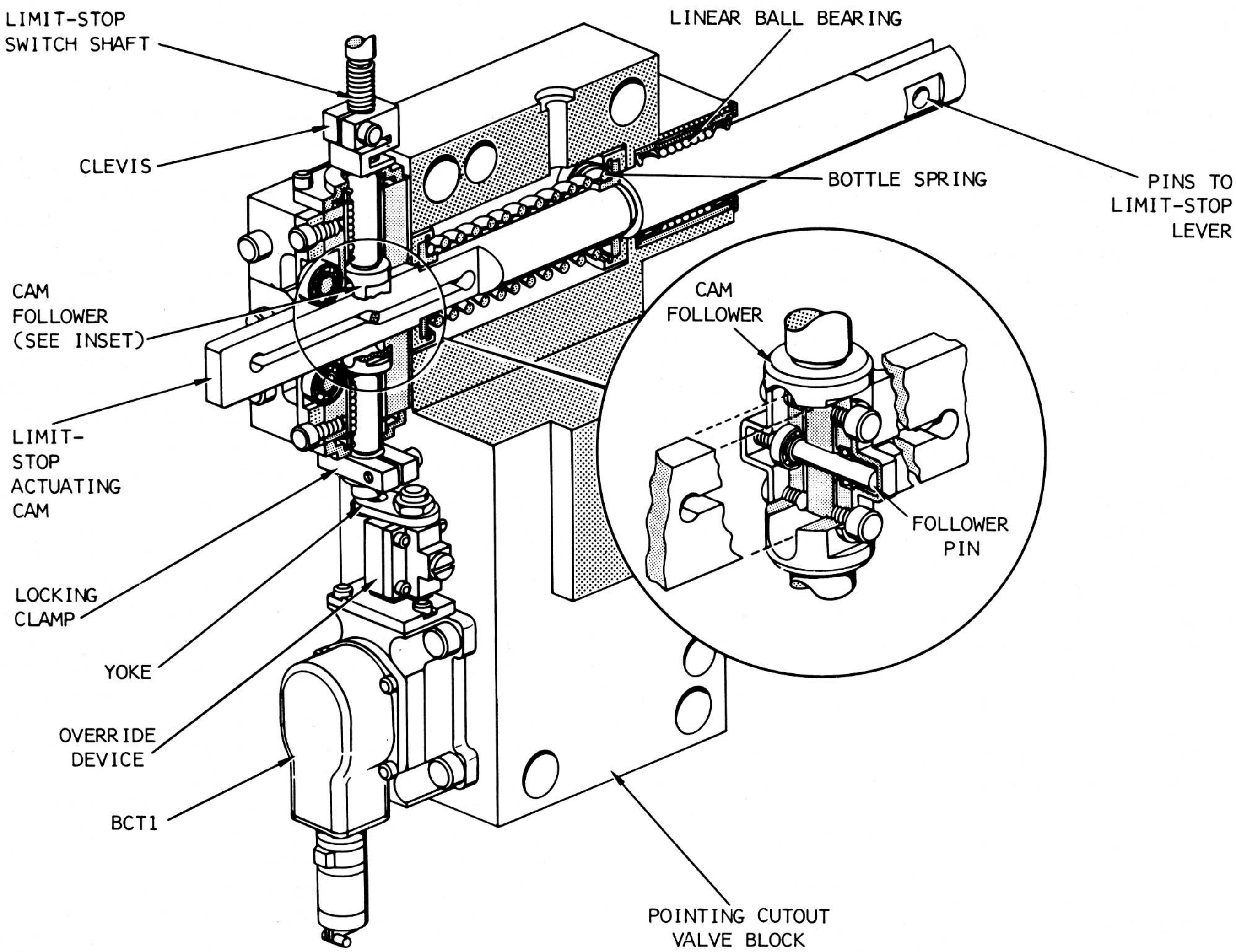

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Figure 12-2.—General arrangement drawing.

mating mechanical parts, type of cable required, dimensions of mounting hardware needed, and directions for orienting the equipment and securing it to place on bulkhead or deck. One variety of this type of drawing, called an outline drawing, shows overall dimensions and clearances required for operating and servicing equipment. These drawings may also give such vital statistics on the equipment as weigh, ventilation required, the degree to which the equipment enclosure is protected against spray and dust, and so on.

3. ASSEMBLY AND SUBASSEMBLY DRAWINGS. These show the constructional details of the assemblies of which the complete equipment is made up. In general. you can think of an assembly (or subassembly) as any group of two or more parts assembled to make up a unit. As we said before, the words assembly and subassembly are sometimes used pretty loosely, but the idea is plain enough. In any case, an assembly drawing is intended to enable a properly equipped shop to make up the finished assembly from the prescribed parts and assemble them. Along with the bill of materials (usually a part of the drawing). it shows what materials and parts, how many of each, and what sizes and types go to make up the complete assembly. It also shows dimensions, and makes reference to other drawings.

4. DETAIL DRAWINGS. When you disassemble any piece of equipment far enough, you eventually get down to individual pieces that cannot be disassembled any further. These are represented by

DETAIL DRAWINGS, which give all the information that a properly equipped shop will need to make the pieces exactly as needed.

5. WIRING DRAWINGS. The main purpose of a wiring drawing, usually called a wiring diagram. is to show you how to wire apiece of equipment or system. There are several kinds of wiring diagrams:

An EXTERNAL wiring diagram shows how to connect an item of equipment to the ship's wiring system or to other pieces of equipment. It shows terminal boards, binding posts, jacks, and other connection points and devices, and identifies them by letters and numbers. Lines denote the electrical conductors to be installed. The drawing shows the size and type of wire to be used; the kind of insulation, shielding, duct work, and armoring specified, as applicable; lengths of cable needed; where ground connections are to be made; where joints must be soldered, welded, or clipped; and so forth. And it specifies the kind of current (d-c or a-c), frequency, and voltage carried by each conductor.

An INTERNAL wiring diagram does the same for wiring inside the equipment. It also identifies and shows where fuses are, the size and type to be used, and their circuits. It locates, and identifies with standard symbols, all lamps, motors, synchros, resistors, capacitors, transformers, chokes, switches, relays, and other electrical components in the equipment, and gives their electrical values. It identifies all the terminals and connection points. This is one of the most useful kinds of drawings for electrical maintenance and troubleshooting.

An ELEMENTARY wiring diagram is about halfway between the diagrams we have just discussed and the SCHEMATIC, to be taken up shortly. It shows terminal and connection points, component locations and valves, and so on, but it also is so arranged that it's much easier to follow and understand the circuit than with the usual wiring diagram. The elementary wiring diagram, like the pure schematic, has little respect for the actual sizes and shapes of parts or equipment, or for their physical location or orientation. The traceability of the circuit is a much more important consideration.

ISOMETRIC wiring diagrams show the routing of cables in a large installation.

6. SCHEMATIC DRAWINGS. About the only general statement you can make about schematics is that their primary purpose is to help the user understand the functioning of the equipment. Electrical schematics are most common, but you also see hydraulic, mechanical, and pneumatic schematics of systems. You will find schematics of all the types mentioned in OPs, and they are very helpful in learning how a system works.

One type of schematic that you'll find helpful in understanding and tracing the functioning of moving parts - especially rotating mechanical components-is the MECHANICAL SCHEMATIC or GEARING DIAGRAM. When they appear as NAVORDSYSCOM drawings, diagrams have such information as pitch and number of gear teeth on a gear, functions of cams, connections between electrical and mechanical devices (such as switch contacts operated by cams), and a great deal more. You can get exact information on equipment mechanisms from a gearing diagram something that other types of schematics often give in only an approximate way, if at all.

7. LUBRICATION DRAWINGS. A lubrication drawing, called a lubrication chart, for launching systems and other ordnance equipment, is often a general arrangement drawing, or a group of them showing several views, in which lubrication fittings and other points are called out by labels. Symbols representing the types of lubrication to be used are displayed on the chart. The OP on every equipment normally has the required lubrication charts in the appendix, or in the section on maintenance.

8. SKETCHES. NAVORDSYSCOM recognizes two kinds of sketches - LINE SKETCHES and INDEX LISTS.

LINE SKETCHES are made up and treated much as regular engineering drawings are. The main difference between them and engineering drawings is that sketches apply to experimental or preliminary ordnance work. You will come across them if you are assigned to a precommissioning crew or some activity that is doing ordnance development work.

The term INDEX LIST is a general name that includes a number of different types of lists of drawings. One type, the LIST of DRAWINGS or LD, is discussed in further detail below. Others are:

Index to List of Drawings. This is the same as the Master List of Drawings, discussed below.

Index to Assemblies. This is a tabulation of all the assemblies of some type of ordnance gear-for example, all the different assemblies that make up a launcher are included in this type of list.

9. LISTS OF DRAWINGS (LDs). A List of Drawings, as mentioned above, is considered by

NAVORDSYSCOM to be a variety of a sketch. In itself. this detail of classification isn't especially important in your job. but it is worth remembering that an LD is a key to the drawing system used by the NAVORDSYSCOM. Beginning at the top of the system. a MASTER LIST of DRAWINGS, or Master LD, is prepared for each major system (such as a launching system). This list includes all components of the equipment concerned. Each component is itemized by assemblies, subassemblies, and details on a separate LD. Thus, you will have a component LD for the launcher, feeder, and so forth.

The identifying number for each component LD is given, together with the general arrangement drawing number, on the master list of drawings for the system. Each component LD also shows the special tools required to service that component. By reference to the list of drawings and the drawings for the mark and mod of a given assembly and subassembly, it is possible to work down to an individual part and to identify the correct nomenclature, drawing, piece number, design dimensions, tolerances, and all other necessary maintenance information.

HOW YOU USE DRAWINGS

When we refer to a "drawing" or "engineering drawing" without qualification, we usually refer to an assembly, subassembly, or detail drawing. Such drawings, as we have seen, explain how to manufacture some part or assembly. And they are also a valuable guide for you in overhauling and repairing the equipment. These drawings are valuable not only because they show how the parts fit (though this is very important itself). but also because they describe and enumerate the fastening hardware you need to put the assembly together (including exactly the proper bolts, nuts, patent fasteners, pins, and so on). And they also show the minor but essential parts that the assembly must have so that it will continue to function as the designer intended it to. A watertight enclosure will leak if it hasn't exactly the gasket named in the drawing; screws will loosen if they haven't been assembled with the proper lock washers specified in the drawing; and nuts will work free if they haven't been secured with the cotter pins listed in the drawing.

The other types of drawings are equally valuable. General arrangement drawings are good references for the exact nomenclature of major units and as guides to drawings on component assemblies. Installation and outline drawings contain just the information on clearances and dimensions that ship's personnel require when a new piece of equipment is to be installed, and they show how to arrange the piping and wiring to be connected to it. External wiring diagrams show just how to hook equipment into the ship's wiring; after installation, they help in troubleshooting for faulty circuits and malfunctioning components, and in electrical alignment of synchros and other data transmission devices. Internal wiring diagrams are equally useful for making circuit checks in case of trouble in the equipment. Elementary wiring diagrams are helpful in training personnel, and can be used in circuit checking too. And LDs are helpful for guidance in tracking down through the maze of drawings the particular piece of information you may be looking for.

Every ship carries copies of drawings on its equipment, in the form of blueprints and photoprints. These copies are assembled into sets, each set covering one item. Photoprints usually are bound in books. Aboard ship, both blueprints and photoprints are called "ordnance drawings."

These drawings will be available to you. You'll find them either in a special file in you shop, or in the custody of your department head. Also, many of the drawings that you will need as maintenance aids are in the OPs. In fact, all graphic and printed maintenance material will soon be incorporated in the technical manuals. Then you won't have to assemble the printed material you'll need on the job. Make use of the drawings; they'll help you to become familiar with the ordnance you will overhaul. (Remember, when you handle them. to treat confidential drawings as you would any other confidential publication.)

Down in the lower right-hand corner of each drawing you'll find a number. That's the "drawing number." On each detail that's pictured in the drawing, you'll find another smaller number. These are the "piece numbers." These numbers identify both the hardware and the drawing. Sometimes you'll find a letter after the piece number; that shows how many times that piece has been changed or modified since the original design.

Every part of every ordnance device (unless it's very small) has its drawing and piece number stamped on it. The first number is the drawing number; the second is the piece number. For example, you'll find numbers like 120460-2. Read that: drawing number 120460, piece number 2.

Look for these numbers, and use them. Refer to them when you report on a particular piece, or when you order new parts.

References on Drawings

We're not going to go on to discuss in full detail how to read other kinds of schematics of assembly and detail drawings. For elementary information on the theoretical background of drafting, on how to read drawings of all types (including other kinds of schematics), how to make them, what you can find out from the title box, standard sizes of drawings, and the like, see the basic course, Blueprint Reading and Sketching, NavPers 10077-C. If you are interested in the techniques of drafting, you may want to look up the Rate Training Manual for Engineering Aid. But with mastery of the basic course, Blueprint Reading and Sketching, NavPers 10077-C, and the material presented in this chapter, you are adequately armed to deal with ordnance drawings so far as your job as a GMM is concerned.

PLANNED MAINTENANCE

In recent years ordnance equipment has become so complex that serious maintenance problems have developed. You can understand why complexity of equipment leads to maintenance problems if you will consider for a moment what makes up a launching system. It consists, as you learned in chapter 6, of three or four major sub-systems. Each subsystem, such as a launcher, contains many components, assemblies, subassemblies, and parts. To illustrate, some launching systems contain over 1500 relays. Every item we have just listed requires some sort of maintenance. When you think of the hundreds of mechanisms and thousands of parts in launching system that need to be kept in operating condition. you can see that the scope of the maintenance task is tremendous. And since there are so many parts in a system, the chances of a malfunction increase considerably.

All the parts, assemblies, and subsystems in a missile launching system are interrelated; they work together as a whole. In some instances if a single part breaks down the entire system becomes inoperative.

Compared to other ordnance installations, launching systems are large and require many men to keep them in good operating condition. But there is a limit to the number of skilled technicians the Navy can find and assign to a launching system. And we probably don't have to tell you that GMMs are scarce. But enough men are assigned to do the overall maintenance job if it is planned, scheduled, and carried out efficiently.

To meet the challenge of the maintenance problem caused by equipment complexity and limitations on the number of personnel that can be assigned to a launching system, the Navy has set up a new maintenance program. The program is called the Planned Maintenance Sub-System (PMS). The complete system includes material and manpower management and is called the Standard Navy Maintenance and Material Management System (3-M System).

While the 3-M System is a new one, it is not the first attempt to standardize maintenance so it will be uniformly good and also simplified.

HISTORY OF MAINTENANCE PLANS

Let's briefly discuss the maintenance systems in their evolutionary order. The first such system was call POMSEE and dealt only with electronic equipment. The word POMSEE stands for "Performance, Operation, and Maintenance Standards for Electronic Equipments." The radar is an integral part of some weapons control systems and it is difficult to separate the radar's operation from that of its associated equipment.

The Satterwhite system was developed aboard ship by Chief Fire Control Technician Charles E. Satterwhite. This was a complete maintenance system for the Gun Fire Control System Mk 56. The maintenance system had a consolidated list of all the maintenance jobs arranged in a systematic schedule. Each job was described on a Job Description Card (JDC). The job was broken' down into simple, easy to follow steps; the tools, materials, test equipment, and references needed to do the job were listed. Illustrations were provided when there was a need to locate or to clarify a point in the job description. Little has been left to chance. The Satterwhite system was not confined to fire control equipment, for which it was originated, but job description cards were made for ordnance equipment, including missile launching systems.

The PRISM system, "Programmed Integrated System Maintenance," was a logical evolution of the Satterwhite System and incorporated many of its features. But some fire control systems, particularly the missile systems, are an integral part of a weapon system, and its maintenance requirements are closely integrated with the entire system. The cards to be used with the PRISM system were called Maintenance Requirement Cards (MRC).

The Integrated Maintenance Plan (IMP) was devised to provide a maintenance program for an entire weapon system instead of the individual equipment within the system. IMP contains a complete schedule of all the maintenance events for the system. The schedule is arranged to ensure efficient use of the men involved and a comprehensive testing and servicing of the equipment. Since IMP includes the whole weapon system, close coordination between ratings associated with the system is necessary. The next obvious step is to expand the maintenance system to include the entire ship.

The Daily System Operability Tests (DSOT), and other test procedures (to be performed at less than daily frequencies), comprise the testing portion of IMP. The testing portion is tied or keyed to associated system troubleshooting aids. These aids consists of Logic Trees, for isolating faulty equipment of the system, and Pyramids, for isolating faults within an equipment of the system. Logic trees and pyramids will be covered under troubleshooting in the next chapter.

The cards used with the IMP system are also called Maintenance Requirement Cards (MRC). If you were to compare a JDC and MRCs for the same equipment or type of equipment, you could readily see the similarity in the information supplied for the job at hand. An earlier printing of this text has reproductions of sample cards. An MRC may be just one card, but more often than not, there are several pages attached to each other by a spiral fastening. The cards are plastic coated to resist stain and damage.

NAVY MAINTENANCE AND MATERIAL MANAGEMENT SYSTEM

The Navy Maintenance and Material Management (3-M) System has been implemented in the Navy as an answer to the ever present problem of maintaining a high degree of material readiness. Although the 3-M system is designed to improve the degree of readiness, its effectiveness and reliability are dependent upon you the individual. The accuracy with which you perform your work, along with the neat and complete recording of required data on the prescribed forms, is one of the keys to the degree of readiness of your ship and therefore is a reflection on your success as a petty officer.

The 3-M system is a uniform plan of maintenance with an internal central management aboard ship to coordinate a shipwide maintenance system and an external central management to coordinate the Navy-wide maintenance system and maintenance data collection. The 3-M system was developed by the office of the CNO to coordinate the work of NAVSUP, NAVORD, NAVAIR, and NAVSHIP with respect to equipment maintenance.

The 3- M system is not envisioned as a cure for all equipment problems and attendant maintenance resource demands, nor does it eliminate the urgent need for good leadership and supervision based on experience and reasoned judgment. The system will, however, produce a logical and efficient approach to the solution of maintenance problems, and a large reservoir of knowledge about maintenance. Proper application of these system products will result in improved equipment performance with less maintenance effort and will lead to meaningful improvements in equipment design and logistic support.

The two basic elements of the 3-M system are the Planned Maintenance Subsystem (PMS) and Maintenance Data Collection Subsystem (MDCS). The Planned Maintenance Subsystem provides a uniform system of planned preventive maintenance. The Maintenance Data Collection Subsystem provides a means of collecting necessary maintenance and supply data, in a form suitable for rapid machine processing. A man-hour accounting system is used aboard repair ships and tenders in conjunction with the Maintenance Data Collection Subsystem.

Preventive maintenance should not be confused with corrective maintenance. Preventive maintenance is a scheduled check on select parts of a piece of equipment. Corrective maintenance is the repair of equipment.

As a third or second class gunner's mate, you will be concerned with both the Planned Maintenance Subsystem (PMS) and certain portions of the Maintenance Data Collection Subsystem (MDCS).

The organization and administration of the 3-M system are covered in Military Requirements for P.O. 3&2. NavPers 10056-C. Study this material thoroughly, for the 3-M system will eventually be used exclusively throughout the Navy.

The Planned Maintenance Subsystem (PMS) supersedes all other maintenance, systems such as POMSEE, Satterwhite, and IMP. Perhaps, we should have used the word "absorb" rather than "supersede" because most of the management tools and maintenance techniques of the former systems have been incorporated into the PMS. Thus it will not be difficult for you to become accustomed to working with the PMS.

Each piece of equipment was studied to determine the amount of servicing required to sustain its operational performance and the tests required to check its performance. The study was made on the piece of equipment as an individual item and as it functions as part of a complete system, the maintenance oriented data was processed and integrated into the PMS. The PMS contains the minimum amount of plannable maintenance necessary to keep the equipment and the system in a state of operational readiness. Each command, however, retains the prerogative to increase the maintenance to meet local conditions.

The Daily System Operability Test (DSOT) is a daily test designed to check the overall readiness and effectiveness of the entire weapon system. The DSOT will reveal almost any kind of trouble that may arise, especially in the interchange of information between systems and equipments in the weapon system. Although the entire test requires only about thirty minutes, the men of the associated ratings in each subsystem monitor the test, standing ready to find and correct the cause of any failure. This test and the tests for each piece of equipment are run on a prescribed schedule. The maintenance requirements of the system and the equipment are broken down into simple tasks that are described on Maintenance Requirement Cards (MRC), in an easy to understand step-by-step procedure. The MRC and maintenance scheduling are covered in Military Requirements for P.O. 3&2. NavPers 10056-C. and therefore will not be discussed here.

The P02 assists in the preparation of the weekly schedule of preventive maintenance.

Some of the MRCs on missile equipment are classified. The classified MRCs are stored separately and have a different color than the unclassified MRCs (classified MRCs normally are pink). The classified maintenance tasks are scheduled on the same schedule as the unclassified tasks.

General safety precautions are not listed on MRCs; only specific precautions that are related to the maintenance task are listed. Keep this fact uppermost in your thoughts while on the job. We will discuss general safety precautions pertinent to missile equipment in the next chapter of this course, and at the end of this chapter.

Moreover, only unique operating situating dealing with the task are contained on the MRC.

it is assumed that you are familiar with the normal operation of the system or equipment. Thus a basic requirement is to know the operation of your equipment.

SHIPBOARD MAINTENANCE DATA COLLECTION SYSTEM

The primary purpose of the Maintenance Data Collection Subsystem (MDCS) is to ensure that the basic maintenance data is recorded once, and only once, and that the system provides the information to all who need it. Data in the MDCS flows in three distinct but related cycles: (1) local cycle; (2) local-central cycle; (3) central-external cycle.

The local cycle - the basic source of data is the maintenanceman aboard ship who provides information to the local central. After key-punching the source data onto standard Electric Accounting Machine (EAM) cards, the punched cards are forwarded daily or at other specified time intervals to the central data processing activity, where they are recorded on computer tapes for computer processing. Navy-wide data, as applicable and appropriate, is then sent back to the reporting units. This completes the cycle - the technician now has maintenance data with which he can improve his operations; he can also compare his actions and equipment with those of the rest of the fleet.

The central-external cycle, in addition to supplying "feedback" data to the reporting units also supplies the data to the appropriate command. At the command, the maintenance data is evaluated to determine if either the equipment or the maintenance procedures can be improved.

The shipboard maintenance reports and records required by MDCS are all listed in OPNAV 43P2, and covered in your military requirements course. The MDCS provides a uniform means to record maintenance actions aboard ship. This in itself has simplified your paperwork connected with maintenance, but at the same time the data contained and retained in the data system has become more complete. The latest revision to OPNAV 43P2 has reduced the number of reportable items considerably, this will further reduce the paperwork required in reporting maintenance actions in MDCS. Many of the various reports and records used prior to the implementation of the 3-M system, were replaced or eliminated by the use of MDCS. The shipboard portion of the MDCS provides a guide for the administration of maintenance data, but local conditions as determined by the fleet or type commander may require the use of some of the former records and reports.

LUBRICATION

If you grew up in a city, perhaps the only connection you had with lubrication was taking the family car to the garage or the gas station for greasing and oil change. But if you grew up on a farm or had a car that you had to keep in running condition yourself, you are well aware of the need for regular lubrication of all moving metal parts. If your car ever burned out a bearing, you've had a lesson that you are likely to remember. And since you have been in the Navy you've heard a great deal about the importance of lubrication. We won't let you forget it.

LUBRICANTS: QUALITIES OF

Lubricants are of two general classes-oils and greases. Oils are fluids; greases are semisolids at ordinary temperatures. Both have several qualities that determine their suitability for a particular lubrication job. One of the most important is VISCOSITY.

Viscosity is the measure of the internal friction, or resistance to flow of a liquid or a semisolid. It varies with the temperature as well as with the nature of the substance. Petroleum jelly (Vaseline) can hardly be said to flow at room temperature, but it can be melted to a rather thin liquid. On the other hand, many kinds of oil flow readily at ordinary temperatures. but become much thicker when they're cold.

Viscosity is expressed in terms of S.S.U. units. (S.S.U. means "Seconds, Saybolt Universal" and represents the number of seconds it takes a given quantity of the lubricant at a specified temperature to pass through the Saybolt Universal Viscosimeter or Viscometer.) The higher the S.S.U. number of a lubricant at a given temperature, the more viscous the liquid. The Navy uses the S.S.U. measurement, rather than the S.A.E. (Society of Automotive Engineers) Grades, to designate lubricants.

The VISCOSITY INDEX (V.I.) is an indication of the variation of viscosity of the lubricant with variation in temperature. The higher the index, the less the viscosity varies with the temperature; thus, a high index is a desirable quality. You want a lubricant that won't solidify and gum up in cold weather, nor liquefy and leak away in hot weather.

Viscosity index can be improved up to a point by putting chemical ADDITIVES into the oil. (Additives are put in by the manufacturer. Don't try to brew up your own special oil by adding anything to it.)

The FLASH POINT of a lubricant is the temperature at which it gives off flammable vapors. The FIRE POINT (always higher than the flash point) is the temperature at which it will take fire if ignited. The POUR POINT (of an oil) is the lowest temperature at which it will pour or flow.

OILINESS is the characteristic of an oil which prevents scuffing and wear. You might think this depended on viscosity, but a complicated relationship of many factors is involved. Certain substances have been found which increase the oiliness of a lubricant.

CHEMICAL STABILITY concerns a lubricant's ability to "take it." Certain oils and greases tend to deteriorate under influence of high temperatures, exposure to air or water, or introduction of impurities. A lubricant with good chemical stability will resist such deterioration. You can often detect deterioration by change in color, formation of varnish or gum deposits, formation of sludge, change in viscosity (of oil) or consistency (of grease), hardening (of grease), or by other telltale signs. Change in viscosity can be more accurately measured by viscometer but serious change is easy for the expert to detect.

These signs of deterioration means that the lubricating and corrosion-preventing qualities of the substances are impaired. You'll find it useful to know the signs of deterioration in oils and greases well enough to recognize them when they appear.

Lubricants, preservatives and hydraulic fluids all protect metal against corrosion, at least to a certain extent. Corrosion prevention is, of course, the main function of a preservative. The corrosion-resisting qualities of lubricants and hydraulic fluids can be improved by adding chemicals called INHIBITORS. In general, inhibitors are added to the substance by the manufacturer before delivery to the Navy.

Other qualities or properties of lubricants are: dropping point, penetration, neutralization number, work factor, viscosity change, aniline point. Chemists in lubrication work need to understand the meaning of the terms; we list them only to impress you with the fact that just any oil will NOT do.

FUNCTIONS OF LUBRICANTS

Now that we have discussed some of the qualities of lubricants. you can see how they apply to the jobs that lubricants have to do. Lubricants are used for three purposes-to reduce friction, to prevent wear, and as a protective cover against corrosion.

As a protective cover against corrosion, the use is obvious. As a preventive against wear, the use is equally obvious when you consider the matter of friction. Lubricants form a layer or film between the metal surfaces, which actually keeps the metals from touching. The moving parts literally "ride" on the lubricant. In the instance of two metal surfaces sliding across each other where space cannot be provided for ball bearings, the lubricants themselves serve as "liquid bearings." In all mechanical devices, lubrication is necessary to counteract friction as much as possible. Only the presence of a thin film of lubricant to separate metal surfaces keeps modern machinery going. If the film disappears, you have hotboxes, burned-out and frozen bearings, scored cylinder walls, leaky packings, and a host of other troubles - the least of them being excessive wear. All of these troubles are the result of direct metal-to-metal contact without adequate lubricant. Lubricants do not move naval guns and equipment but they keep them movable.

Specifications

Because proper lubrication is an absolute necessity, selection of high quality lubricants having the right viscosity and other properties for each job is of vital importance. When you drive your car into the local filling station and tell the attendant, "One quart of No. 30 oil, 75-cent grade." you are specifying the kind of oil you want.

When the Navy buys oil (or almost anything else), it too must specify what it wants. The Navy cannot be as offhand about its purchases as the average motorist is. To make sure that the supplier knows exactly what is wanted, the Navy prepares detailed descriptions of the things it wants to purchase. These detailed descriptions are called specifications, or specs.

Every agency of the Federal Government does its purchasing, as far as possible, by using specifications. Each agency issues specifications. Each specification is a printed or mimeographed booklet or leaflet describing a particular product or item supplied. The specifications are identified by names, numbers, and letters. Lubricants, preservatives, hydraulic fluid (and many other items) are often known by these spec numbers and symbols. An example of an item you have used is MIL-F-17111, Fluid, Power Transmission. All specifications issued by the various armed services are being coordinated and reissued as Military Specifications.

Oils

Many oils employed by the Navy in ordnance equipment are identified by four-digit symbols headed by the letters MS (Military Symbols). These were formerly called NS (Navy Symbol). You should be able to read and translate these symbols.

The following classes of Military Symbol oils are approved for use in naval ordnance.

Class 1- Aircraft-engine oils (high V.I.)
Class 2 - Forced-feed oils (low V.I.)
Class 3 - Forced-feed oils (medium and high V.I.)
Class 5 - Mineral cylinder oils

Viscosity for oils of classes 1, 3, and 5 is determined at a temperature of 2100 Fahrenheit, and for class 2 at 1300 Fahrenheit. These classes are straight mineral oils without chemical additives.

Now, assume the Military Symbol (MS) on a certain oil is 3050. What does this tell you about this oil? The first digit - 3 - tells you that the oil is class 3, a forced-feed oil of medium or high viscosity index. The last three digits - 050 - indicate the viscosity as 50 at a temperature of 210° F. That's how you read Military Symbols for oils.

Other oils used in naval ordnance gear are identified by other symbols. Thus, all Navy Department specifications for lubricants begin with 51. The stock number is different for each size of container of the material. Some lubricants and hydraulic oils are procured for use in ordnance equipment only; these are identified either by (Ord) following a Military specification (MS) number, or by the letters as (instead of MS) in front of the number. Lubricants intended for Army equipment are identified by Army specifications beginning with the number 2 (example, 2-82C). As all specifications are brought under Mil specs, the old designations will be replaced by MIL numbers.

On lubrication charts, note that the number of the lubricant to be used at each place is not repeated, but a "target" symbol is used instead.

This avoids confusion with the number used to identify the part to be lubricated, which may be used several times in the chart. The meaning of the target symbols is explained in the notes on the chart, as well as in OD 3000.

Greases

Lubricating greases are a mixture of soaps commonly, calcium soap or sodium soap - and lubricating oil. The oil may be a mineral oil (petroleum base), or a synthetic oil.

The purpose of the soap is to make the oil "stay put" at the point of application. The soap traps the oil within its mass, but the actual lubrication is done largely by the oil in the grease. You might think of it as an oil-soaked sponge. The heat of friction "squeezes" the sponge, melting the grease and releasing the oil to perform the lubrication.

Greases can be classified according to the kind of soap used in making them. Each kind of soap has specific properties.

CALCIUM (LIME) SOAP GREASE will not absorb moisture or emulsify (separate into its original ingredients). Consequently, it is specified for general lubricating purposes where bearings are exposed. However, calcium soap grease has a low melting point, and is not suitable for hot-running bearings.

SODIUM-SOAP GREASE emulsifies in the presence of moisture but has a higher melting point. It should be protected from moisture. It is used for ball and roller bearings.

Other kinds of soap bases used in greases are aluminum soap, and lithium soap, with others added to the list as found by experimentation and test at laboratories.

GRAPHITE GREASE, as the name implies, contains graphite. The graphite acts as a mild abrasive to smooth roughened wearing surfaces, as a filler to smooth over any pits in the surfaces, and as a friction reducer. However, because of its abrasive action, graphite grease should not be used in bearings that are in first-class condition except under high temperatures at which ordinary greases would be destroyed. Technically, since graphite grease contains no soap, it is classed as a lubricant oil, but it looks and is applied like other grease. Molybdenum Disulphide, Spec. MILM-7866, can be used instead of the graphite grease.

GEAR LUBRICANTS are a mixture of high viscosity oils and just enough sodium soap to cause "jellying." Gear lubricants are suitable for high gear-tooth pressure and moderate speeds where the design of the case is such that ordinary oil cannot be retained.

As with oils, the viscosity of greases varies with temperature. If temperature changes make it necessary to change oil, check your lubrication chart to find out whether you have to change the grease too.

LUBRICATING TOOLS

Some lubricants are applied by smearing them on the surfaces to be lubricated, but you'll most often use a tool (grease gun, oiler, or grease pump) especially designed to put lubricant into the equipment through a lubrication fitting.

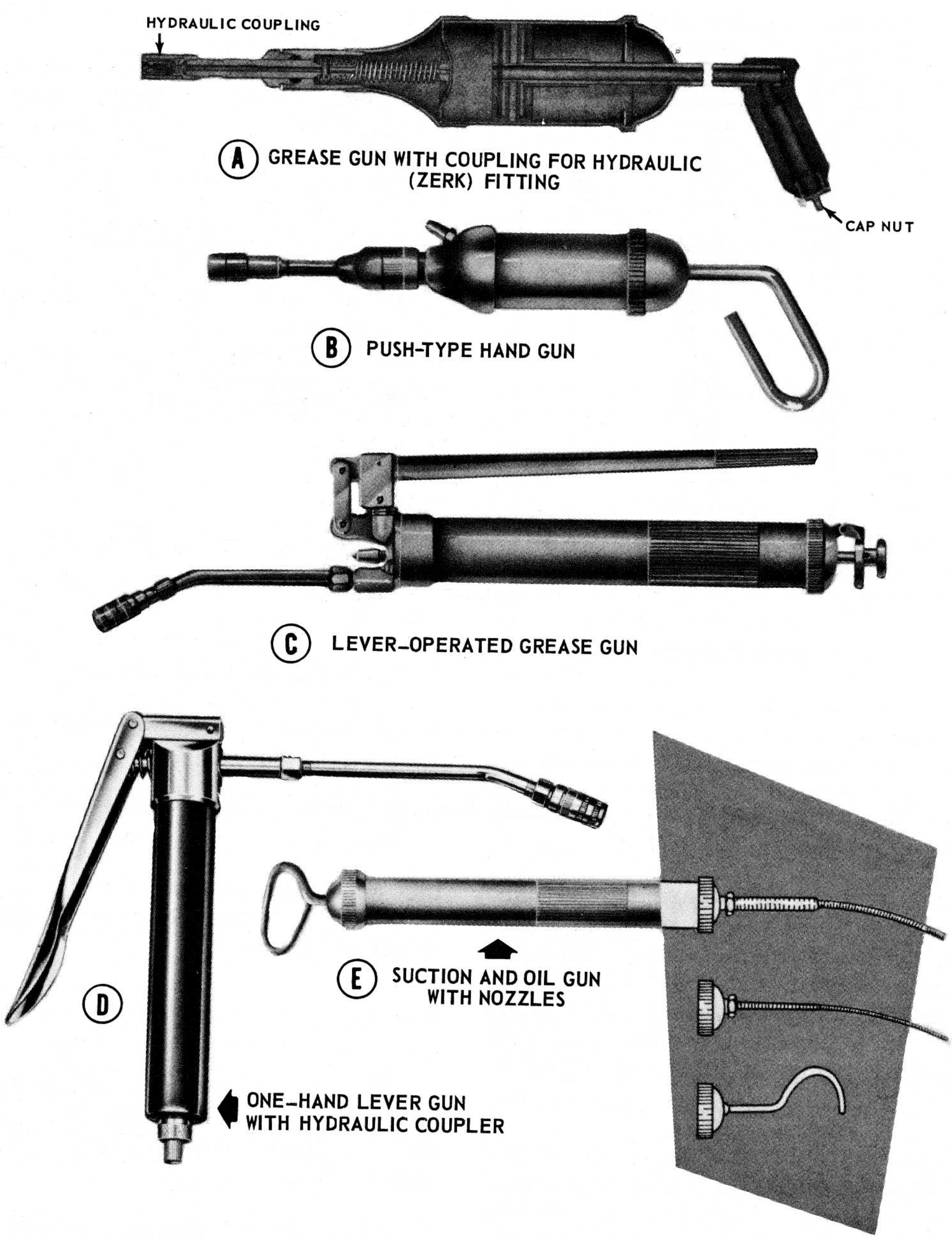
Grease Guns

Grease is applied by a grease gun or pump through a nozzle that is designed to match the fitting.

Although ordnance plants and repair shops have electrically or pneumatically powered equipment, you probably will have to depend on your own right arm for power to operate lubricating equipment. In this section we shall therefore take up only the hand-powered lubricating equipment you are likely to use.

Hand-operated grease guns are of two types, depending on how they are loaded. To load one style, you remove a cap that comes off with the handle and stem (fig. 12-3), and fill the body with grease, using a paddle or spatula. As you might expect, this method of loading can be messy, and it also exposes the lubricant to dirt and moisture. A faster and cleaner kind of gun (fig. 12-3A is loaded by removing the cap nut from the end of the hollow handle and forcing grease in through the handle with a hand gun loader (fig. 12-4A), or a bucket-type lubricant pump (fig. 12-4B).

The hand gun loader is a 25-pound container equipped with a hand-operated pump and a fitting that mates with the opening in the handle of the grease gun. The bucket-type lubricant pump makes use of a loader adapter and loader valve when it is used for loading a grease gun. One pound of lubricant is delivered with every seven full strokes of the pump. The loader will deliver lubricant only when the grease gun is placed on the loader valve. You can see how much less messy the loader is than the paddle, and how it protects the lubricant against contamination. Besides, you don't have to run back to the storeroom to refill your gun.



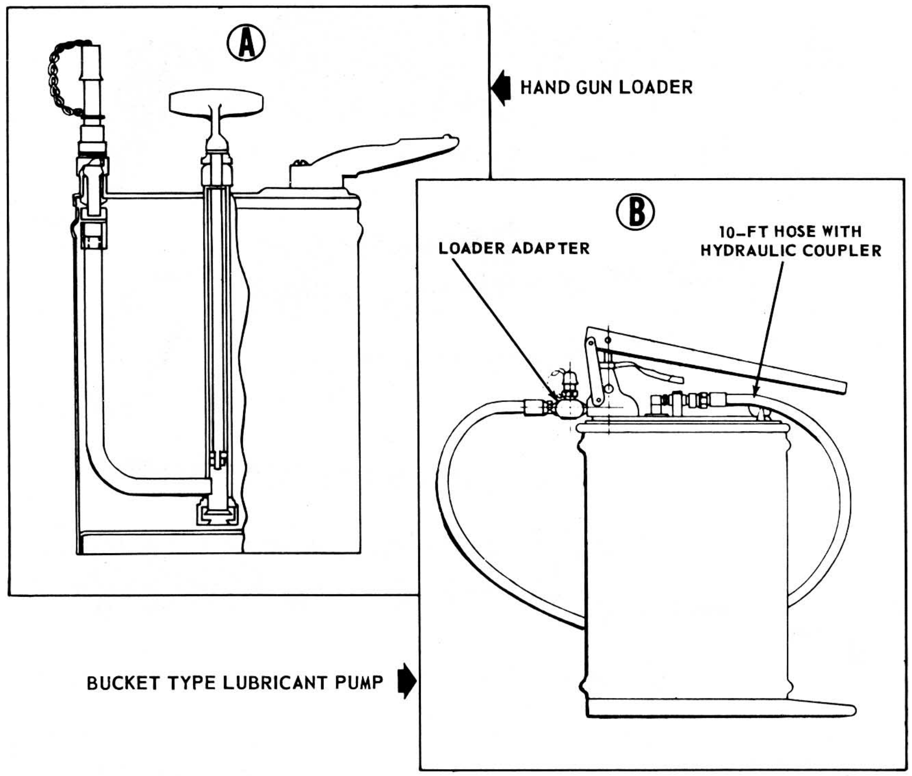
83.120
Figure 12-3. — Hand-operated grease guns.

Different nozzles can be attached to the grease guns for different types of fittings. The lubricant pump also has various couplers and adapters that attach to the hose, so that the pump can be used on different fittings.

Grease guns can be used for oil if the point to be lubricated has the proper fitting, or an oil gun (fig. 12-3E) may be used.

A lever type grease gun (fig. 12-3C and D) is being introduced; it gives more positive lubrication than the Zerk grease gun.

When you need to apply large quantities of grease - as, for example, in a launcher roller path - a grease gun is too small. The bucket type hand-operated lubricant pump (fig. 12-4B)



83.121

Figure 12-4. — Hand-operated grease pumps: A. Hand gun loader; B. Bucket-type lubricant pump.

holds the same amount of grease as the hand gun loader, and is fitted with a pump operated with a lever. It has a 10-foot hose with a hydraulic T-handle adapter and a 90° adapter for working in cramped spaces. With this pump you can build up a lubricant pressure of 3500 psi, and deliver a pound of lubricant every 20 full strokes.

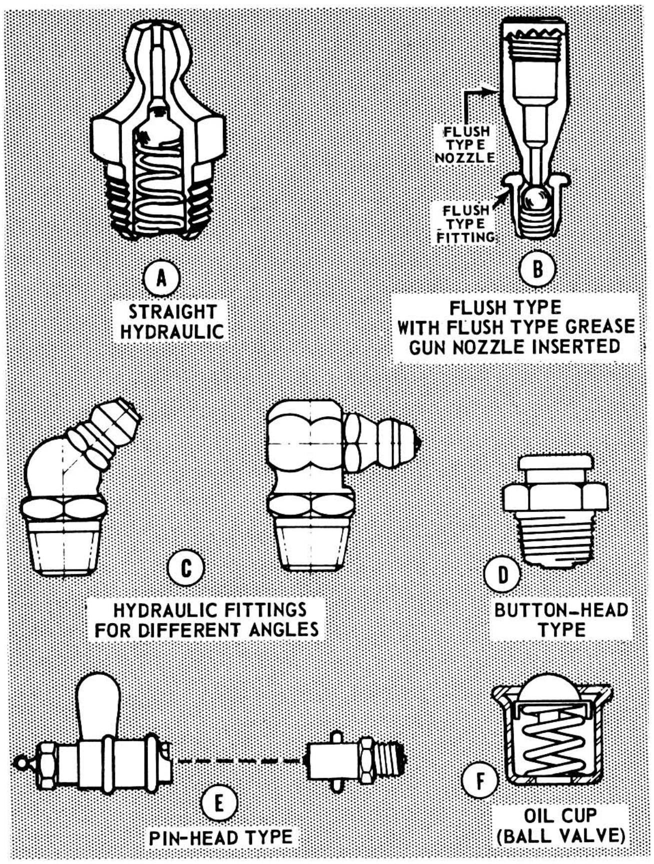
The hand-operated lubricant pump can handle any type of lubricant generally required on naval ordnance equipment except greases of calcium soap type, and MS9150-240-3155, type A, grade 4, MIL-T-3123.

If you can arrange it, use several grease guns - one for each type of lubricant you will need. Then you can save time by taking care of all the fittings requiring a specific type of lubricant before going on to apply the next type. For example, if you're working on a ready service ring, take care of all the fittings on that equipment that require MIL-G-16908 before working on those that take MIL-L-18486A. If you must use one gun for more than one lubricant, be sure the gun is as empty as you can make it before adding a different lubricant. Mixing lubricants is not good practice.

Fittings

Grease fittings are of several types - hydraulic (unofficially called the Zerk fitting, after its inventor), button-head, pintype, and flush (fig. 12-5).

The hydraulic fitting protrudes from the surface into which it is screwed, and has a spec ally shaped rounded end that the mating nozzle can grip. A spring-loaded ball acts as a check valve. The nozzle will not slip off the fitting during lubrication, but can be easily disengaged by a quick forward-backward movement. Push-type (Zerk) hydraulic fittings are being replaced by commercial button-head and pin-type fittings, which provide more positive connection with the grease gun. Figure 12-5 part A, shows a cross-section view of a straight hydraulic fitting, and part C shows hydraulic fittings made for different



83.122
Figure 12-5.—Lubrication fittings.

angles. They are made to fit most any angle, and with different threads and body lengths.

The oil cut with ball valve (fig. 12-5F) is the most popular type for oil fittings. When using a gun equipped with nozzle for hydraulic type fittings (fig. 12-5A, C), just place the nozzle on the fitting and push forward on the handle. This slips the nozzle onto the fitting and at the same time builds up hydraulic pressure in the gun, forcing the grease out of the nozzle. Then relax the pressure. A spring forces the handle back, ready for the next stroke. Three strokes are usually enough. Only one hand is needed to work this type gun. The grip action of the nozzle coupler holds the nozzle firmly to the fitting until pulled free. The Zerk grease gun can be used with the button-head fitting by adding an adapter.

The flush fitting (fig. 12-5B) is flush with (or below) the surface into which it is set, so that it will not foul moving parts. It is used also where there is not sufficient clearance to ,install protruding fittings. The flush fitting also has a ball type check valve. When using a gun equipped for flush type fittings, you must exert a steady pressure against the grease-gun nozzle to keep it in contact with the flush fitting while pumping lubricant, since the nozzle has no grip on the fitting. Otherwise, the method of use is much the same as with hydraulic fittings.

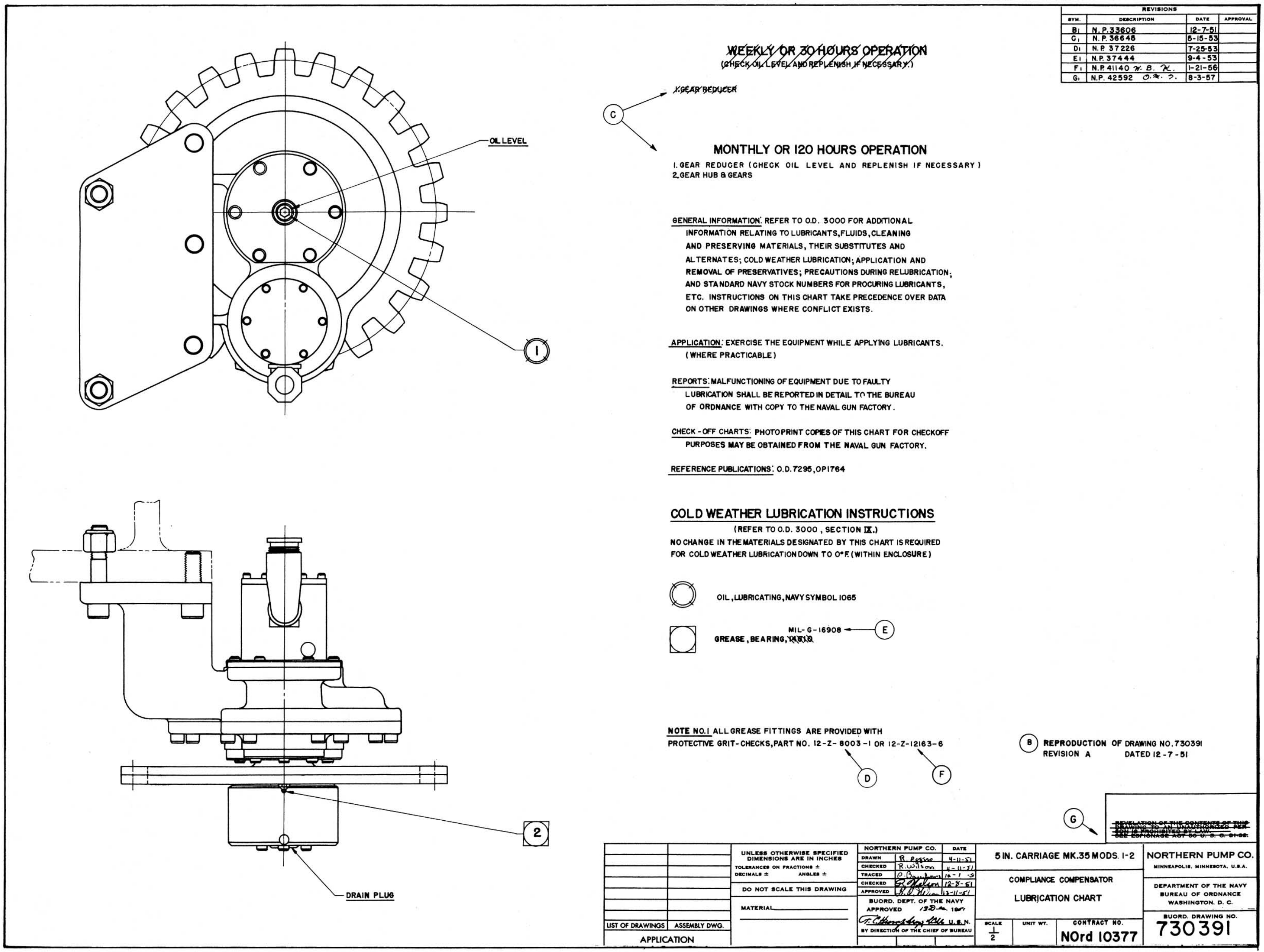
As with other routine jobs, it helps to have a standard operating procedure that you can habitually follow. Here's one that will be helpful:

1. First, consult the lubrication chart and locate the fitting.
2. Clean the fitting carefully with a lintless cloth.
3. Apply the correct amount of the specified lubricant. (Be careful of the amount you apply too much will cause excessive heat in the bearing and strain the grease retainers, while too little is on a par with too late.)
4. Wipe all excess grease from around the fitting.
5. Check off the fitting on your chart. A fitting must NOT be missed just because it is battered or "frozen" fitting probably means that the oil holes throughout the bearing are clogged. This means tearing down the bearing and cleaning all parts carefully. Grease that fitting even if it requires an hour of extra work. Plastic protective caps are often provided for fittings. These caps keep out contaminants and also aid in keeping the grease in the fitting.

LUBRICATION CHARTS

Frequent reference has been made to LUBRICATION CHARTS. They are published in the OPs for ordnance equipment and are necessary to do your maintenance job properly. Copies of some charts may be obtained for use as checkoff lists. A sample chart is reproduced in figure 12-6. On it you can see the use of "target" (Nos. 1, 2) symbols, and schedules for lubrication. Large equipments have several charts with numerous places indicated for oiling or greasing. It would be easy to forget some places or to use the wrong lubricant if you didn't have the chart to guide you and to check off as you work.

Check with your chief to be sure you have the latest revision of the lubrication charts. There may not be any change for years, but the discovery of a better lubricant results in changes in many charts. Or renumbering of items in the supply system may change the designation.



83.123

Figure 12-6.—Lubrication chart, showing points of lubrication, types of lubricant, frequency of lubrication, and other instructions.

The change may have been issued as a pen-and-ink change which is written into each affected chart by personnel in charge of the OPs and charts on your ship, or it may be a reprinted chart with the new changes. Be sure you have the latest.

Lubrication charts also show the kind of hydraulic fluid to be used and the fill level.

LUBRICATION CHART SYMBOLS. - On lubrication charts, lubricants and hydraulic fluids are identified by symbols, each symbol signifying a specific oil or grease. Examples are shown in figure 12-6. The symbols are identified in OD 3000, or any OP lubrication chart. They may be changed from time to time. If your OPs and ODs are up to date, they will give you the CURRENT meaning of each symbol.

ALTERNATES AND SUBSTITUTES. - If the lubricant prescribed in the OP or MRC for a piece of equipment is not available, you may find it necessary to use either an alternate or a substitute lubricant.

A SUBSTITUTE lubricant is one that will fill the need for a limited time, but does not have all the essential properties of the prescribed lubricant. As soon as the prescribed lubricant becomes available, all of the substitute must be removed from the equipment, which must then be completely relubricated with the prescribed material.

An ALTERNATE lubricant is one whose characteristics closely resemble those of the prescribed lubricant, so that its removal is not necessary when the prescribed material is available.

Alternates and substitutes for prescribed lubricants (as well as for cleaning materials, hydraulic oils, and preservatives) are listed in OD 3000.

If none of the listed lubricants is available and you must choose a substitute, keep in mind that the substitute should be as near as possible to the specified lubricant in lubricating and rustpreventive qualities, viscosity, and ability to withstand the temperature ranges of the equipment.

In brief, when the prescribed stuff is not to be had, use an alternate if you can, a substitute if you must.

HYDRAULICS

The fluid used in hydraulic systems is often spoken of as hydraulic oil, and many of them have an oil (petroleum) base. The term' 'hydraulic fluid" is more inclusive as it includes all liquids used in hydraulic systems. Three types of hydraulic fluids are water base, petroleum base, and synthetic base liquids. Various combinations of ingredients have been tried in each of these types. The Navy has tried quite a few of them and uses different ones in different situations. No "best" hydraulic fluid has been found. Use the one that is prescribed for the unit you are serving, and observe the precautions that go with it. For example, MIL-H-19457 (cellulube) is a fire-resistant hydraulic fluid used in the magazine hydraulic assemblies of GMLS Mk 12. However, it is highly corrosive to fibrous materials and to some paints, so you have to be careful not to spill any of it on such materials (as clothing, etc.).

A fuller discussion of the types of hydraulic fluids and their properties may be found in Fluid Power, NavPers 16193-B, and in OD3000, Lubrication of Ordnance Equipment. Since a great deal of your maintenance work will involve the hydraulic components (of which there are many) in the missile system, it is well to know something about the medium involved. The same course also tells how to test the hydraulic fluid for contaminants, deterioration, and decomposition. Probably the most frequent cause of trouble in a hydraulic system is the presence of contaminants in the fluid. How does dirt get into a closed system'? Some can get in when the system is being filled with the hydraulic fluid, or when some is being added. Bits of metal from joints in the piping or tubing get broken off by the moving stream of fluid. Chemicals in the fluid can precipitate particles of materials in the fluid when the temperature or the pressure is too high, forming sludge. These and other causes of contamination are discussed in Fluid Power, NavPers 16193-B. Before you begin working on the hydraulic component, pull the MRC from the file and study it. The general rules and cautions for draining, flushing, and refilling hydraulic systems are given in Fluid Power, but the specific directions for your equipment are on the MRCs on your ship, and the OPs for the system.

CLEANING, PAINTING, AND PRESERVING

Besides the technical maintenance details on your gear, you will be responsible for cleaning, painting, and similar housekeeping work that every member of the crew is expected to do in maintaining the space he works and lives in. It is the duty of the Division Officer to supervise the maintenance, preservation, and cleanliness of all spaces and equipment assigned to the division, but the activation of the tasks is usually undertaken by the division leading petty officer, and that may be a PO 3 or PO2. That means you have to know how to do the work and be able to teach others. Military Requirements for Petty Officer 3 & 2. NavPers 10056-C. gives you pointers on how to handle the assignments for supervising such work.

As a Gunner's Mate M. most of your cleaning and preserving work will be done on metal surfaces, principally steel. The preservatives must protect the metal against rust and corrosion; the cleaning materials must clean the surface before the preservative is applied.

Rust is caused by the slow burning (oxidation) of iron. When iron or steel rusts, it combines slowly with the oxygen in the air.

Technically, corrosion is not exactly the same as rust, since its meaning includes metal being eaten away by acid, or by the action of salt water, or other substances. Rust and corrosion are dangerous and destructive saboteurs that attack unguarded metal at the slightest opportunity.

The way to protect metal from rust and corrosion is to protect it from the air. Paint is a good protective, but many metal surfaces, such as moving parts, cannot be painted.

The lubricants used on moving parts serve as rust preventives to some extent, but often this protection is not enough. These are temporary preservatives for protecting metal from water and weather. Light oils and greases are applied to exposed gun parts and mounts as temporary protection against corrosion. Bright steel work, such as exposed cam and linkage surfaces should have such protection. SLUSHING OILS, available in several grades, are provided for this purpose. All old oil and dirt should be cleaned from the part and the surface thoroughly dried before new oil is applied.

AUTHORIZED CLEANING AND PRESERVING MATERIALS

Some lubricants (for example. preservative lubricating oil for use in small arms and light machine guns) have preservative additives (rust inhibitors) and can serve for short-term preservation, but NO preservative is intended for use as a lubricant.

When lubrication is not desired. there are special preservatives (permanent type) which may be brushed or sprayed on the surface to be protected, or in which the small parts of a mechanism may be dipped. After treatment, the preserved mechanism can be stored for a long period. (The length of time depends on the characteristics of the preservative, the kind of storage, etc.)

A rust preventive that can be used either to protect exterior surfaces or (as when pumped through a hydraulic system) for preserving interior surfaces, tubes, etc., is the THINFILM POLAR TYPE compound, which is available in several grades. HARD-FILM compound, also in several grades, is for metal exterior surfaces only.

Rust preventives are NOT lubricants, and should not be used instead of lubricants. Before treating metal surfaces with rust preventives, BE SURE TO REMOVE ALL TRACES OF RUST AND CORROSION, AND ALL OF THE OLD LUBRICANT.

BE SURE TO REMOVE ALL OF THE RUST PREVENTIVE before adding lubricant to ordnance equipment that has been stored with rust-preventive compound coating. OP 1208 (third revision) Instructions for Inactivation, Maintenance, and Activation of Ordnance in Vessels in Inactive Status, gives step-by step instructions for removing preservatives from launchers and other ordnance equipment. Chapter 5 of OD 3000, Lubrication of Ordnance Equipment (fourth revision) deals with cleaners and preservatives. It contains a chart of all cleaning and preserving materials authorized for use on ordnance materials. This chart gives the specification number, characteristics, applications, federal stock number, container size, and substitutes, while the text elaborates on the use of each item. Some of the materials will be described very briefly in the following pages.

DRY-CLEANING SOLVENT (Varsol or Stoddard Solvent) is useful for cleaning away old grease, oil and rust preventives. However, its hard on rubber (use soap and water on that). Because of its irritating, flammable fumes, it should be used only where there is plenty of ventilation and where there are fire extinguishers handy. Diesel fuel or kerosene can also be used for the same purposes as dry-cleaning solvent. The correct solvent MUST be used since some solvents leave a residue or cause corrosion. Therefore, ALWAYS check the OP for the equipment.

Spraying or splashing of the solvent must be avoided during cleaning. If the solvent were to fall upon a bearing surface, it would cut or render the lubricant less effective, causing excessive wear. After the solvent has been used, the parts must always be wiped dry with a clean lint-free cloth.

REMOVING RUST

When using abrasives to remove rust, be careful to select the proper type (see OD 3000) and use it sparingly.

NEVER use abrasives without permission from the proper authority. Only experienced personnel may use abrasives or wire-brushing. Carelessly used abrasives can do more damage than rust. A few strokes of even a fine abrasive would destroy the accuracy of many closefitting parts which are machined to close tolerances, and would lead to costly replacements. Always be extremely careful to keep grit from getting into bearings or between sliding surfaces.

After the rust has been removed, the parts must be thoroughly cleaned and dried. Avoid leaving your own fingerprints on the metal. Cleaned surfaces should not be touched by bare hands before the rust preventive is finally applied. When the surface is clean and dry, you are ready to start applying paint or preservative.

PAINTING POINTERS

Painting is one of your important maintenance jobs. Instructions for using the chipping hammer in preparing metal surfaces for painting are given in Basic Handtools, NavPers 10085-A.

Except for special applications like camouflage, the primary purpose of painting in the Navy is preservation rather than decoration. You don't paint just for the sake of appearances, nor as a substitute for cleaning. But when you do paint, you do a thorough and neat job. Thorough means that you cover every square inch of the surface to be painted, and neat means that you keep paint off places where it doesn't belong. You have learned before now that it is much better and easier to keep the paint off the places where it shouldn't be than to clean it off afterward. Always keep paint off gaskets, bright work, grease fittings, rubber parts and rubber covered wires, electrical leads and contacts not protected by armor or conduits, instruction or data plates, and working parts of surfaces that are normally supposed to be protected by a coat of lubricant.

The first thing to do when you are given a painting job is to remove the old paint, which you have been taught to do properly.

The paint stripping solution recommended in OD 3000 is 8 ounces of sodium hydroxide (0-S-598, Type 1) in 1 gallon of near-boiling water. Rinse with clean, hot water after paint is removed.

Before applying paint, be sure the surface is clean and dry. Paint will not adhere to damp or oily surfaces, or to surfaces covered with dirt, rust, or solvent. Galvanized surfaces must be wiped with ammonia, vinegar, or a special priming solution called "wash primer" before the paint will adhere. Brush the solution on, allow it to dry, and then wipe it off. Never use an abrasive on galvanized surfaces.

O-S-598 may not be used on aluminum, zinc, tin, terne, or lead.

Soap and water are one answer to the problem of removing all dirt and traces of old oil or grease from metal surfaces to be treated with rust preventives, paint, or other preservative. Wash away all soap; then see that the surfaces are DRY, and finally, apply rust preventives (or paint) without delay. It's sometimes hard to get at pockets or cavities in which water collects; be sure they are not neglected.

The standard finish for United States naval ship super-structures is a gray paint whose exact color and composition are prescribed by NAVSHIPS. You will use that paint for the exterior of launchers and the missile house.

A prescribed gray-blue paint is used for exterior steel decks. Interior bulkheads and overheads are painted with a white paint prescribed by NAVSHIPS, and interior steel decks are usually finished with gray deck paint, though white is prescribed for decks in ammunition spaces. These are the general rules for painting; you'll get details on painting jobs from your chief.

Safety Lines

A special kind of painting job that you, as a Gunner's Mate, are responsible for is that of painting safety lines to mark off safe working areas. Circular safety lines are painted on the deck around a launcher to indicate the areas you should stay out of when the launcher is being trained. "Blast area" lines are painted on the decks around missile launchers to show how far away you must get to be safe from the hot rocket blasts. Similar safety lines are necessary to show safe working areas around overhead handling equipment and other machines that may be dangerous to men who fail to keep away from working parts.

CLEANING ELECTRICAL COMPONENTS

Ever since you were handed a paint brush aboard ship, you have been warned not to paint electrical equipment. If you were headless, you had to painstakingly clean it off, and you surely have learned your lesson on that score. However, dust and dirt on electrical equipment still require removal regularly. When cleaning electrical and electronic equipment, always use an approved cleaning agent.

Alcohol should never be used for cleaning electrical equipment. Not only is it afire hazard, but it also damages many kinds of insulation.

Cleaning Electrical Contacts and Switches

SWITCH MAINTENANCE. - While the switch itself is relatively simple to check- it sometimes offers difficulty in maintenance because it is inaccessible. After a visual inspection of the connections and the switch, a continuity test will indicate any malfunctions. When the switch mechanism is found to be defective, it normally is not repairable and therefore should be replaced.

When enclosed switches are used, failure to seal properly around cable openings causes the most difficulty. Atmospheric changes permit "breathing" of moist air into enclosures with improperly sealed cable openings, and the moisture in the air may condense within the switch enclosure. The condensation can short across the switch terminals and can corrode the switch actuators in a manner that may make them inoperative. This difficulty can be corrected by careful sealing of openings or by using hermetically-sealed switches. Hermetically-sealed switches will also prevent dust and dirt from reaching the contacts and thereby causing high resistance and open circuits.

Some switches are damaged during installation, particularly those with plastic housings. Proper care in installing or replacing plastic enclosed switches will eliminate this.

Some switches depend upon pressure for their operation. These switches have adjustments so that they will operate at the correct time or pressure. In many cases if the adjustments are not accurate- damage can result.

RELAY MAINTENANCE. - The relay is one of the most dependable electromechanical devices in use but, like any other mechanical or electrical device. relays occasionally wear out or become inoperative for one reason or another. Should relay inspection show that a relay has exceeded its safe life, the relay should be removed immediately and replaced with another of the same type. Care should be exercised in obtaining the same type replacement because relays are rated in both voltage and amperage.

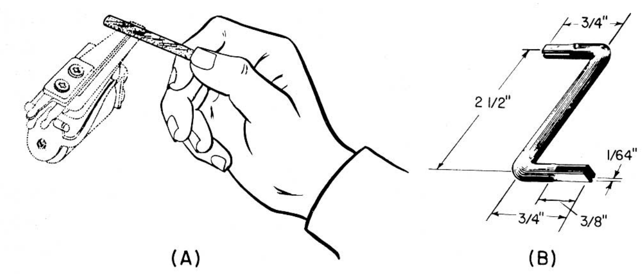
As guides for spotting potential relay trouble during preventive maintenance, the following are suggested. Check for charred or burned insulation on the relay. Check for darkened or charred terminal leads coming from the relay. Both of these indicate overheating. If there is even a slight indication that the relay has overheated, it should be replaced with a new relay of the same type. An occasional cause of relay trouble is not the fault of the relay at all, but is due to overheating caused by the power terminal connectors not being tight enough. This should always be checked on preventive maintenance.

It is not recommended that covers be removed from semi sealed relays in the field. Removal of a cover in the field, although it might give useful information to a trained eye, may result in entry of dust or other foreign material which may cause contact discontinuity. What is even more serious, removal of the cover may result in loss of or damage to the cover gasket. One of the prime advantages of hermetically-sealed relays is that they cannot be taken apart.

Relays can be ruined by the use of sandpaper or emery cloth for cleaning the contacts. A BURNISHING TOOL should be used for this purpose. Two types of burnishing tools are stocked at naval supply activities, and either type can be obtained through regular supply channels. The appearance and use of one kind of burnishing tool are shown in figure 12-7 A. The surfaces of the tool that are used to clean the relay contacts should not be touched by the fingers prior to use; and. after use, the burnisher should be cleaned with alcohol.

When relays contain bent contacts, no attempt should be made to straighten them with long nose pliers. Such as attempt often causes further damage with the result that the entire relay must be replaced. Bent contacts can be straightened effectively by using a CONTACT BENDER. The bender can be made locally from 0.125-diameter rod stock according to the dimensions shown in figure 12-7B.

Be sure the power is off and remains off while you are working on an electrical contact or switch, or relay.



12.242
Figure 12-7.—Relay special tools: A. Burnishing tool; B. Point bender.

Cleaning Rotating Machinery

Rotating machinery should be inspected and cleaned at prescribed intervals (periodic checks) and whenever repairs to the machinery have been made. For such cleaning and inspection, the following procedure is suggested.

1. Unfasten and remove end cover.
2. Remove dust and dirt from machine and end covers, using clean, dry compressed air or a soft brush.
3. Loosen, gently remove, and inspect brushes, being extremely careful not to nick or mar edges of brush. Note the location and position from which each is removed so that it can later be replaced in exactly the same position.
4. Check commutators or slip rings for excessive wear, pitting, dirt, thrown solder, or other defects. A highly polished commutator or slipring is desirable, but a dark-colored one should not be mistaken for a burned one. If the surface is dirty, clean with a lint-free cloth moistened in a cleaning solution (Specification P-D-680) and wipe dry. Avoid fingermarking the commutator or slipring surface.
5. Secure all brushes in their holders, making certain they are replaced in exactly the position from which they were removed.
6. Replace and secure end covers.

Sliprings

Sliprings are solid metal rings mounted on the rotor of alternating current machines to transfer the power to or from external circuits through brushes or wipers. Slip rings are also used on synchros, director connections, and stable element connections. Slip rings are usually made of silver, copper, bronze, or other nonferrous metals, although iron and steel have been used.

While they vary in size and type, the maintenance of sliprings is essentially the same for all types. They should be inspected periodically for wear, grooving, and cleanliness. Normally, the surface of the rings should be bright and smooth.

Wiper contacts are used with devices that do not require high current and consequently require only light pressure when making contact. Excessive pressure will result in excessive wiper wear, because the wiper contact is usually of a softer material than the rings. Any contacts showing considerable wear should be replaced.

If sliprings are inspected and found rough, scratched, or grooved, corrective action must be taken. They can be smoothed with a fine crocus cloth or sandpaper. However, care should be exercised not to cause high and low spots which will interfere with high speed operation. Further repairs, such as cutting with a lathe, should be performed at overhaul activities (Navy yards and tenders). Also, in cleaning with a solvent, be careful not to allow the solvent to enter the bearings since the solvent will cut oil or grease. This, of course, will cause the lubricant to flow out of the bearing.

Commutators

Commutators have been called the "soft spot" of d-c machinery because they require considerable maintenance. Unlike the slipring, the commutator is a series of copper segments separated by an insulator. When the brushes make contact with a pair of segments, and armature coil is connected into the circuit. Thus, when the motor or generator is moving, the brushes and commutator switch coils in and out in the proper sequence. Basic Electricity, NavPers 10086-B. shows commutator construction.

The normal appearance of the commutator is a shiny, smoothly worn, chocolate brown color. A blackened or pitted commutator is caused by poor brush and segment contact, open or shorted coils, overloads, etc. If the brushes are causing the blackened appearance, they should be replaced and then the commutator should be cleaned. Cleaning is accomplished by the use of fine sandpaper and the recommended solvent. The sandpaper should be held against the commutator by a piece of wood that is grooved to fit the commutator. NEVER USE EMERY CLOTH. Emery is an electrical conductor which will cause a short circuit.

If the fault is other than brush and segment contact, that is, a short or open coil, the machine should be replaced and sent to overhaul. Another fairly common defect is HIGH MICA. As the copper of the commutator wears down, the mica, which is the insulation separating the segments, does not. Consequently, it may be higher than the segments. The high mica gives a bounce to the brush every time it passes underneath; this results in arcing because the brush is constantly breaking contact. High mica can be spotted by rubbing your fingernail over the surface of the commutator. There should be a small depression between each segment. If there is high mica, this depression disappears. Undercutting is the remedy for high mica, and this operation is normally reserved for the overhaul activities.

PROTECTION AGAINST MOISTURE

Aside from mechanical injury, the biggest source of electrical trouble on board ship is moisture. And salt water moisture is the worst kind because it is a conductor of electricity. Thus, when a cable or box becomes saturated with salt water, two things happen: First, a current path to the ship's hull is formed which is a ground; and second, especially where dissimilar metals are involved, electrolysis and corrosion occur, and the connections or wire fittings are slowly eaten away.

The battle against moisture is never-ending. Moisture creeps into the smallest openings. Watertight covers must be kept watertight. When you remove a cover, check the condition of the gasket, the knife edge, and the securing bolts or dogs. Where possible, when checking an electrical circuit, use a connection box in a protected space. When moisture is discovered in an instrument or connection box, dry it out with a hot-air blower or an electric lamp.

A reasonable degree of protection against the accumulation of moisture is obtained by a daily energizing and workout of the equipment.

Variations in temperature cause air to be breathed through any opening or vent in the equipment. As the temperature rises, the air inside a piece of equipment expands and is partly expelled. When the temperature falls, the air inside the equipment contracts and outside air is admitted. As the air cools, condensation or sweating takes place. Electrical heaters are installed in some instruments to eliminate this source of moisture. The heater keeps the interior of the instrument at a temperature higher than that of the surrounding air. In many instruments, the circuit to the heater bypasses the power switch, and voltage may be present even though the power switch is off. Remember this when working around the heater circuit. Some equipments use an air drier, or desiccator unit, to moisture proof the mechanisms within the unit. The unit is sealed by dust covers and is airtight except for the connection to the air drier. The air drier consists of a unit that contains silica gel crystals. The silica gel crystals absorb moisture from the air within the unit.

SALT AND FUNGUS. - Salt and fungus found in your equipment should be removed immediately. A salt, when moisture is present, will corrode metals and is a conductor of electricity. Fungus growth causes decay, rapid deterioration of insulating materials, and shorts or grounds in electrical circuits. Under some circumstances you can use fresh water to remove them. After cleaning the equipment, however, make sure the water is completely evaporated. An approved cleaning solvent, inhibited methyl chloroform (O-T-620), can be used to clean away salt or fungus. But inhibited methyl chloroform will attack electrical insulating materials and bare ferrous surfaces if it is not completely evaporated or otherwise removed at the completion of the cleaning operation. Contact time with this solvent should be limited because it is toxic. Care in the use of this solvent should be exercised since concentrations of the vapor can be fatal. Adequate ventilation is necessary when it is used.

MAINTENANCE SKILLS AND PROCESSES

SOLDERING

A discussion of soldering is found in Basic Electricity, NavPers 10086-B and in Basic Handtools, NavPers 10085-A. Here we will review the highlights of that discussion and then consider some aspects peculiar to your work.

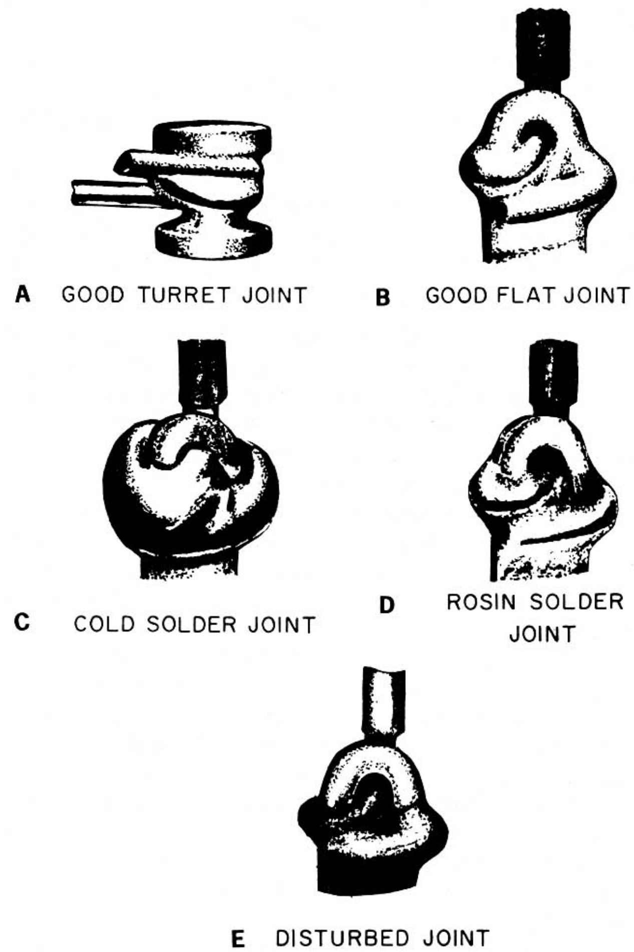
Soldering is the uniting of two or more metals by means of fusible alloy. There are two general classes of solder, hard and soft. The differences between the two are in composition, melting temperature, and strength. Soft solder, and alloy of tin and lead, is used in electronic wiring. In most naval electronic equipment, a solder of 60 parts tin and 40 parts lead is preferred because it flows at a lower temperature and solidifies faster than standard tin-lead solders. Use only rosin flux in soldering electrical connections.

Besides the soldering iron (copper) discussed in the basic text, soldering guns are also used by the GMM. Several sizes and types are illustrated in Basic Electricity. The induction type is illustrated and its use described in Basic Handtools. The soldering gun consists of a stepdown transformer with the primary connected to 115-volt a-c, and a soldering copper forming a loop across the secondary. The heat is generated by the secondary current and concentrated at the tip. This concentration of heat is due to the shape of the soldering end. It is a relatively safe device since it heats in a matter of seconds. Upon release of the trigger, the tip will cool in a correspondingly short period of time. However, do not lay it down on flammable material, but rest it on the metal holder provided.

You should exercise caution in any soldering operation. One common misuse of the soldering iron is the improper removal of excess solder from the iron. Avoid striking the iron on a solid object to remove the excess solder. This may damage the heater element. A practice occasionally used in the field is the whipping or swinging of the iron. This practice can prove to be very dangerous to nearby workers. Excess solder should be removed with a damp cloth. During the soldering operations and while the soldering iron is not actually in use, keep it in its holder to avoid a fire hazard. Contact with a hot iron or molten solder can cause serious and painful burns.

Let us consider for a moment the end product properly and improperly made soldered joints. You can see them in figure 12-8.

A good, well-bonded connection is clean shiny, smooth, and round. See figure 12-8A and 12-8B. It shows the approximate outline of the wire and terminals. The wire and terminals are completely covered, and the solder adheres firmly. The insulation is close to but not in the hole or slot; it is approximately 1/16-inch from the terminal. It is not charred, burned, nicked, or covered with rosin. A film of rosin may remain on the joint and need not be removed unless fungus proofing is anticipated.



83.124
Figure 12-8.—Types of properly and improperly made soldered joints.

Defective Soldered Joints

Proper preparation of the soldering iron (cleaning, tinning) described in Basic Handtoo1s, will prevent many defects. Soldered joints may be defective for a variety of reasons, such as the following.

A COLD solder joint (fig. 12-8C) has a dull appearance and a crystallized texture. Because of the poor union between the wire and terminal, the joint will in time develop high resistance as the metals oxidize. This type of joint is caused by insufficient heat during soldering, and may be the result of too Iowa wattage soldering iron, by a copper bit that is too small, or poor contact between iron and joint. A cold solder joint may be repaired by reheating; however, it may be necessary to take the joint apart and resolder it if dirt or oxide covers the wire.

A ROSIN joint (fig. 12-8D) is so named because the wire is held by rosin rather than solder. The flux is spread over the terminal, and instead of the solder bonding with the terminal, the solder settles on top of the rosin. The joint may have all the appearances of a good joint, but a little pressure will cause movement or an ohmmeter will indicate an open. A rosin joint occurs when using a "cold" iron or one that is too small. In most cases, merely applying a hot iron will clear up a rosin joint.

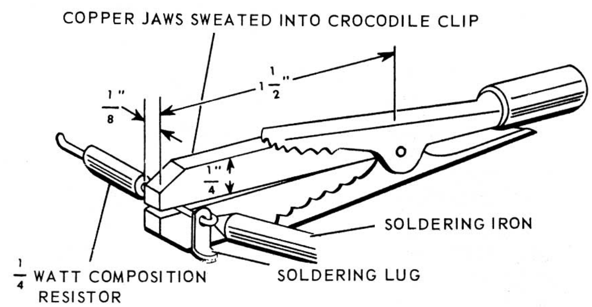
A DISTURBED solder joint (fig. 12-8E) has an irregular on crystallized appearance and the solder may be chipped off with a fingernail or a pointed tool. It is caused by the wire being moved before the solder has fully set. Since it may loosen later in service. it should be repaired in the same manner as the cold solder joint. This type of joint is often the source of noise in the equipment.

An INSUFFICIENT solder joint can introduce high resistance in the circuit and, as current flows, undesirable heat. It may loosen and cause an open or intermittent operation, depending upon the amount of oxide present. This heat, or a visual inspection may reveal this condition, but it may be necessary to use an ohmmeter to detect this type of solder joint. To repair it, it should be taken apart; and after cleaning off the oxide, the joint should be resoldered correctly.

A NO-SOLDER joint may cause noise due to oxide or vibration; the circuit may open entirely. A visual inspection and an ohmmeter will indicate this condition. The joint should be taken apart, cleaned, and then resoldered correctly. There are many other soldering defects, such as excessive solder, loose solder, and insulation too close or too far from the joint. Invariably these defects can be traced to the technician making the connection.

Occasionally some special techniques are required in soldering. In equipment using miniaturized components, the physical dimensions of resistors have greatly decreased and application of a soldering iron close to the body of these small carbon composition resistors causes a PERMANENT change in resistance. Overheating of these resistors and other components during soldering can be avoided only by restricting heat conduction along the terminating leads.

The most acceptable means of preventing this overheating is by use of a thermal shunt. (fig. 12-9). This shunt should be placed as close to the resistor and as far from the joint as possible. Be certain that the clamp does not contact both the resistor and the joint. If you don't have a clamp type shunt, and don't have time to make one, you can use a small pair of needle-nose pliers. If you wrap a rubber band tightly around the handles, the pliers will grip the resistor lead so that you won't have to hold them in place while you solder.



12.243

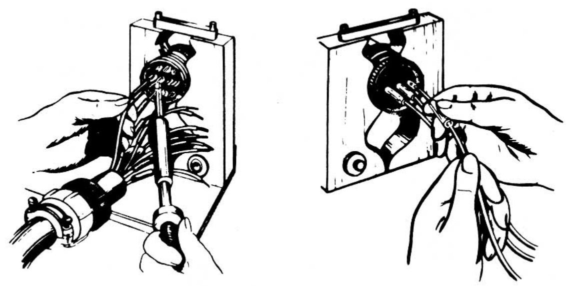
Figure 12-9.—Thermal clamp type shunt used while soldering resistors or other small components.

Procedure for Soldering Wires to Connector Terminals

One of the most difficult and exacting jobs is soldering wires to connector terminals. The terminals are all jammed together in a small space, leaving little room to work in. Figure 12-10 shows a typical connector and part of the soldering procedure used to connect wires to the connector terminals.

When you solder wires to a connector in a panel or in a jig, you should start at the side away from the iron. When the connector is free and you can hold it in your hand, you can solder with a stationary iron. Position the iron so that the tip is facing you. The solder by holding the terminal and wire against the tip. When you use this method, start at the center of the connector. You can then rotate the connector as your work continues.

Don't forget to tin the wires and terminals before you start to solder. Another preliminary step that is often forgotten is to put sleeving over the wires. And after you finish soldering and the joints have cooled, slip the sleeving over the cooled joints. The sleeving should fit snugly over each soldered terminal and wire. This helps support the wire and the soldered joint. In Basic Handtools, NavPers 10085-A, the section on miscellaneous skills describes soldering of electrical connections with a soldering iron and also by "sweating" the joint. The method of stripping insulated wire with a pocket knife and with side-cutting pliers is described and illustrated in the same text.



83.125
Figure 12-10.—Soldering leads to a connection.

Mechanical Connections for Soldering

No connection should depend upon the strength of solder alone for security, because solder is relatively soft. All electrical connections should be made mechanically strong before they are soldered. If you crimp or wrap the wire tightly around the terminal before you begin to solder, you will have a secure base upon which to solder. When properly done, crimping or wrapping prevents disturbing the joint while you are soldering and while the solder is cooling.

To make a good mechanical connection you don't have to wrap the wire around the terminal two or three times. Just wrap the stripped end of the wire around the terminal 1 1/2 turns. These are enough turns to make the connection mechanically strong. If you put on more turns, they add nothing to the strength of the connection and simply make it more difficult to remove them from the terminal. Be careful to bring the end of the insulation as close to the terminal as possible without allowing insulation to interfere with the soldering operation. The wire should be wrapped around the terminal so that the tension on the wire will be transmitted to the terminal and not to the solder.

Sometimes you may have to crimp a wire wrap to make a good mechanical connection. Use a pair of pliers to squeeze the wire wrap against the terminal.

After you finish making the connection, and before you begin soldering, cut off the ends of the leads. Leave about 1/16 inch of lead from the connection. This will leave enough wire to get a grip on when you need to remove the wire.

Types of Terminals

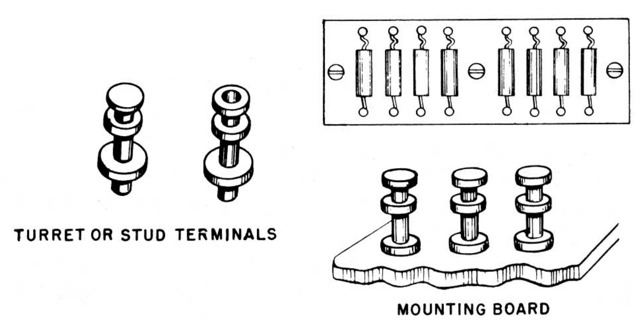
There are four basic types of terminals:

1. Turret or stud terminal.
2. Flat terminal.
3. Hook or eyelet terminal.
4. Split terminal.

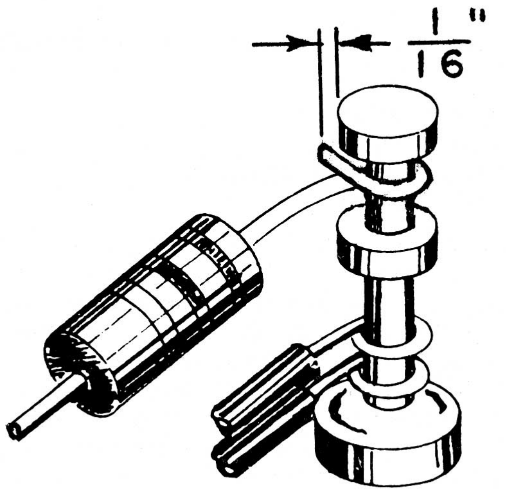
The TURRET or STUD terminal is used primarily on component mounting boards; see figure 12-11. To make the wrap, lead the wire directly to one side of the terminal. Wrap the lead 1 1/2 turns around the terminal, and crimp if necessary. On the turret terminal. it is best to wrap the component (resistor, capacitor. and so forth) lead on the upper portion of the terminal, and the connecting wires or wire on the lower part. (See figure 12-12). For easy maintenance, it is best to wrap the wire over the terminal post from the bottom up and to be consistent in either clockwise or counterclockwise wrapping. Clockwise wrapping is preferred because there is a natural tendency for people to attempt unwinding the wire in a counterclockwise direction.

The FLAT. PERFORATED terminal (fig. 12-13) is used on most tube sockets, potentiometers, wafer switches, and micro-switches. To make the wrap, insert the wire through the hole and wrap the wire 1 1/2 turns around the body of the terminal.

If you use heavy wire, or space does not permit you to wrap properly, you can make a good mechanical connection by crimping. Just feed the wire through the hole, bend the wire



83.126
Figure 12-11.—Turret or stud terminals and application.



83.127
Figure 12-12.—Correct wrap on stud terminal.

around the lug 180°, and crimp firmly. Look at figure 12-13C.

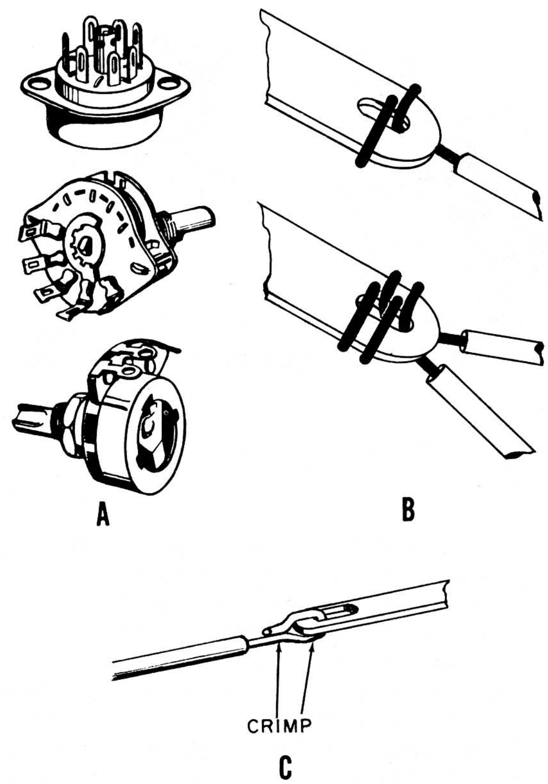
The HOOK or EYELET terminal is used on most relays. (See figure 12-14). To make a good mechanical connection on this type terminal, you can feed the wire through the loop and wrap one full turn on the shank.

The SPLIT terminal (fig. 12-15) is used on transformers and heavy components. Lay the wire in the slot and wrap 1 1/2 turns around the body.

Basic Electricity. NavPers 10086-B. classifies terminal lugs as soldered and solderless, and describes and illustrates them according to that classification. The solderless terminal lugs are further classified according to the method of mounting with different splicer sleeves.

CRIMPING

In naval electronic equipment almost all of the permanent connections are made by soldering. In the electrical systems which are incorporated in launching systems however, the permanent connections may be made by crimp-on terminals. This use of crimping is relatively new and avoids some of the limitations of soldered terminals. The quality of soldered connections depends mostly upon the operator's skill. Such factors as temperature, flux, cleanliness, oxides, and insulation damage due to heat, all affect the quality of soldered connections.

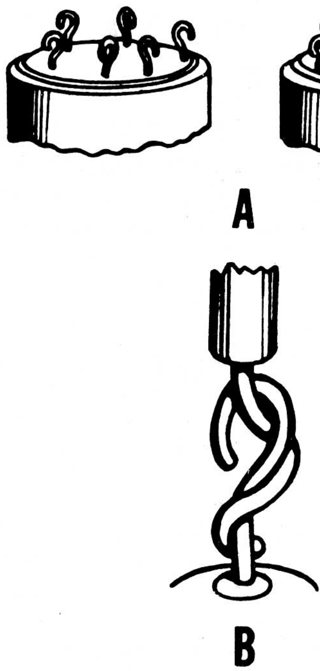


83.128:.129
Figure 12-13.—Flat perforated terminals: A. Applications; B. Correct wraps; C. Crimping a flat terminal lug.

The crimp-on or solderless terminals require relatively little operator skill. Another advantage is that the only tool necessary is the crimping tool. The connections are made more rapidly; they are cleaner and more uniform. Due to the pressures exerted and the materials used, the crimped connection or splice, properly made, has an electrical resistance that is less than that of an equivalent length of wire.

The basic types of terminals are shown in figure 12-16. (A) shows the straight type, (B) the right angle type, (C) the flag type, (D) the splice type, and (E) the disconnect splice type. There are also variations of these types, such as the use of a slot instead of a terminal hole, three-and four-way splice type connectors, etc.

Various size terminal or stud holes will be found for each of the different wire sizes. A further refinement of the solderless terminals is the insulated terminal; the barrel of the terminal (fig. 12-16) is enclosed in an insulating



83.130
Figure 12-14.— A. Hook and eyelet terminals; B. Correct wrap.

material. The insulation is compressed along with the terminal barrel when crimping, but is not damaged in the process.

This eliminates the necessity of taping or tying an insulating sleeve over the joint.

There are two types of crimping tools used with copper terminals. For wire sizes AWG (American Wire Gage) 10 or smaller, a small pliers type of crimper is used. For the larger wire sizes, a large and powerful pincer type crimper is used. The small pliers type crimper has several sizes of notches for the different size terminals. The large pincer type is adjusted to an index mark for the different size terminals. Care should be exercised to select the correct crimping tool for the particular terminal. Do not tin stranded wires. (The solder forms a line of stress concentration on each strand, which may result in vibration failure.) Always use insulation-grip terminals for wire sizes No. 10 AWG and smaller, regardless of application, to protect conductors from mechanical vibration and fatigue.

The procedure for crimping a cooper terminal to a cooper wire is as follows:

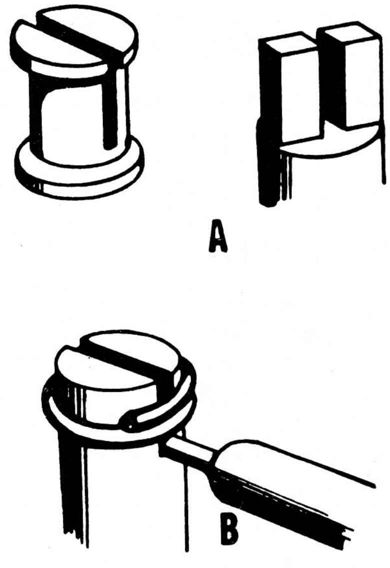
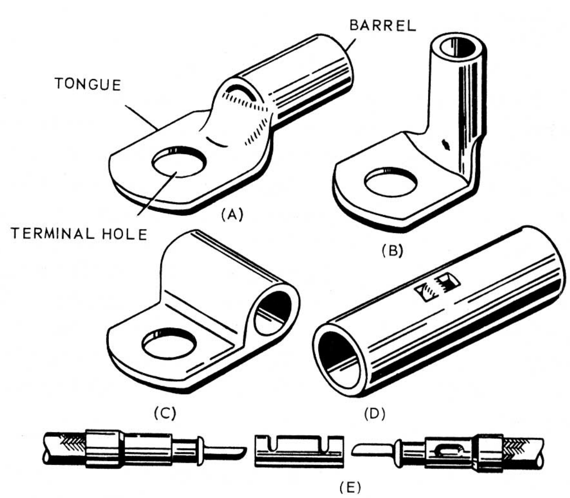


Figure 12-15.— A. Split terminals; B. Correct wrap. 83.131

1. Strip the cable insulation carefully to avoid cut or nicked strands. Remove the proper length of insulation.

2. See that the stripped cable end extends into the terminal barrel for the full length of the barrel.



12.244
Figure 12-16.— Basic types of solderless terminals: A. Straight type; B. Right angle type; C. Flag type; D. Splice type; E. Disconnect splice type.

3. Center the terminal barrel in the crimping tool so that pressure on the strands, from the crimped strands to the unsecured strands, will be gradual, thus preventing stress concentrations.
4. Now crimp the terminal, making sure that the crimper is fully closed to ensure proper crimping.
5. Inspect the joint with a probe through the inspection hole. The end of the conductor must come to the edge of the inspection hole.

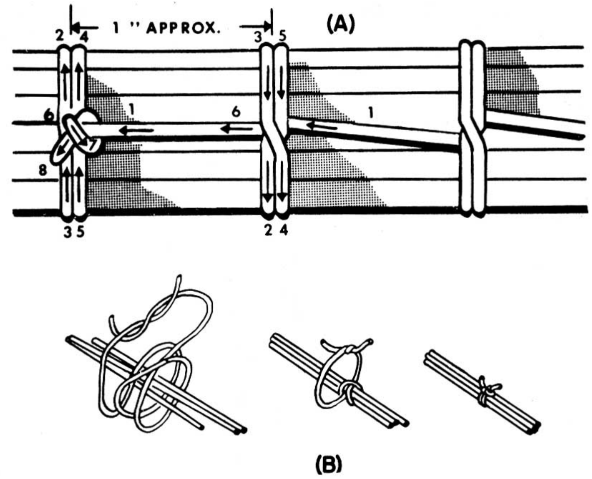
Take care with this procedure because improper procedures will eventually cause terminal failure. Be particularly careful of undercrimping, overcrimping, the use of the wrong crimping tool, improper cleaning methods, and cutting or nicking the conductors. A loose contact will allow an oxide film to form between the wire and terminal; this will result in increased resistance.

If the correct tools are used, and the proper procedures followed, the connections will be more effective electrically, as well as mechanically, than soldered connections. A visual inspection is very important for it will reveal oxidation, deterioration, overheating, and broken conductors. In some cases it may be necessary to check these connections with an ohmmeter; the proper resistance, for all practical purposes, is zero. Any defective terminal should be removed and a new terminal crimped on.

TYING AND LACING

While making repairs or fabricating a new cable, it may be necessary for you to tie or lace the cable. The accepted method for lacing cable harnesses is shown in figure 12-17A. The use of the continuous lacing method is restricted to panels and junction boxes. The purpose of lacing is to keep all cables neatly secured in groups and to avoid possible damage from chafing against equipment or interference with equipment operation. When continuous lacing is used, it shall not include cables of more than one harness group.

Continuous lacing is restricted in its use because, if the cord is broken, the lacing has a tendency to unravel. In place of continuous lacing, typing (or short-section lacing) is used. The method of tying is shown in figure 12-17B. In the first method, tie a clove hitch about the wires. Then tie a half hitch over the clove in such a manner as to produce a square knot.



12.247

Figure 12-17.—Lacing and tying of electric wires: A. Harness; B. Method of tying.

On color conductors, the lacing twine should be the same color as the insulation of the conductor. When repairs have to be made on wiring that is laced, the lacing may have to be removed to make the repairs, and a new harness made after the repairs are made. Before lacing, lay the conductors out straight and parallel to each other; do not twist them together.

SHIELDING AND BONDING

Shielding

Shielding is the enclosing of cables or electrical units in metal to prevent high frequency interference. Shielding causes the high frequency voltage to be induced in the shield rather than in the units or cables. Shielding is used where a unit is to be protected from radio frequency noise. It is also used to keep cables or units from emitting radio frequency noise. Thus, shielding is used to keep outside noise out and inside noise in.

Where shielding of cables is used. it is very important that it be well grounded at one end of the cable. (Radiating circuits such as pulse cables and transmission lines use coaxial cables. The outer flexible conductor of "coax" often serves as the shield, but occasionally an additional braid is used for shielding.) Regardless of the system used, the conductor forming the shield is grounded.

Disturbances caused by spark discharges are the most difficult to control. A spark discharge not only radiates but also causes voltage variations in the circuit. Shielding is effective for the radiations but not for line variations. These variations in the line can be smoothed out by the use of filters. The function of such filters is to block or bypass voltages and currents of frequencies which would cause interference.

Bonding

Bonding straps are used to tie together, electrically, any parts of an equipment or system which are insulated from the ship's structure. Bonds are used, for example, to connect the various panels of launching systems to the ship's structure. Some of the reasons for bonding are:

1. To minimize interference to electronic equipment by equalizing the static charges that accumulate.
2. To provide a proper "ground" for electronic equipment.
3. To provide a low resistance return path for single-wire electrical systems.
4. To aid in the effectiveness of shielding.

A bond is usually made of a flexible metal strap provided with a crimped-on terminal at each end. It is usually made of tinned copper wire.

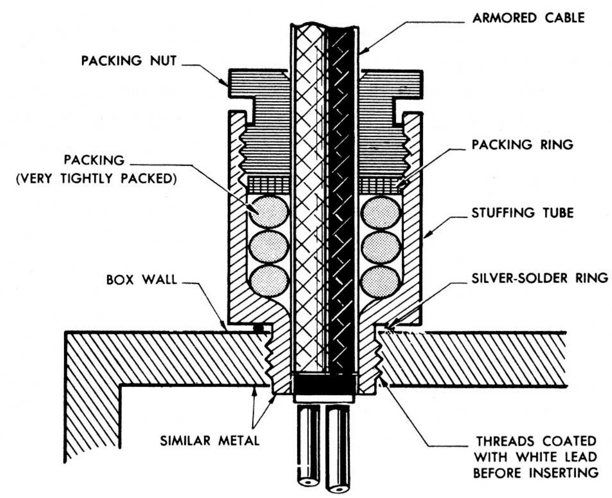
The bond must be intact and make a good electrical connection at all times. In replacing a bond, be careful to make a good metal contact. If, in preparing the surface for the bonding connection, you have to clean the surface with sandpaper, be sure not to damage the original finish on the metal. Place bonds in such a position that they will not interfere with the operation of the unit and will not be damaged or broken loose because of the motion or vibration of the unit.

CABLE SPLICING

Cable splices should not be used except as an EMERGENCY measure.

If an emergency condition exists, solder may or may not be used, as the condition warrants, but in any case the splice should give a good electrical and mechanical joint without solder. The splice should be taped to give insulation equivalent to the rest of the cable. A permanent repair must be made as soon as it is possible.

Ordinarily there is not enough slack wire for making splices. However, if there is enough slack, the two splices used by GMM s are the



12.248
Figure 12-18.— Cross section of watertight stuffing tube with cable inserted through it.

"western union splice" and the "flexible wire splice." These and other splices and joints are covered in Basic Electricity. NavPers 10086-B; chapter 7, for types of tape used over splices, and methods of applying.

WATERTIGHT BOXES AND FITTINGS

Aside from mechanical injury, the biggest source of electrical trouble on board ship is moisture. And salt water moisture is the worst kind because it is a conductor of electricity. Thus, when a cable or box becomes saturated with salt water, two things happen: First, a current path to the ship's hull is formed, which is a ground; and second, especially where dissimilar metals are involved, electrolysis and corrosion occur, and the connections or wire fittings are slowly eaten away. Therefore, practically all of the electrical wiring aboard ship is run in waterproof, fire-resistant, armored cables which terminate in watertight boxes.

The cables are run into boxes through stuffing tubes, also called terminal tubes. When renewing cable, these tubes must be repacked with a standard packing corresponding to the size of tube, and the packing ring and nut must be tightly secured. Figure 12-18 shows a cross-sectional diagram of a stuffing tube properly assembled with an armored cable in place. Stuffing tubes similar to the one shown are used to ensure watertight integrity where cables pass through decks and bulkheads. Where cables pass through the deck, pipe risers are used in order to prevent mechanical injury to the cable. The stuffing tube is then inserted at the top of the pipe.

Terminal and junction boxes used for most fire control work are rated according to the number of terminals they contain, for example, 10-wire box, or 50-wire box. All wires are lugged at the ends to ensure solid connections at the terminal strips or blocks within each box. The lugs are, or should be, stamped with circuit designation numbers to assist the maintenance men in tracing out circuits. You'll find the cable leads laced together with cord and neatly arranged in each box to make for compactness and ruggedness. Always rearrange the box in this manner after pulling out leads for inspection, making tests, or relugging.

SAFETY WIRING

Screws, bolts, electrical and mechanical connectors, and other devices are safety wired as an additional security against the effects of vibration. Figure 12-19 shows the basic principles of safety wiring. The wire is threaded through the bolthead in such a direction that if a bolt tends to loosen, the wire will become tighter.

The wire used in safety wiring usually is made of annealed brass or annealed stainless steel. The size is not critical, depending mainly on the size of bolt being secured. The bolt used has a hole drilled through the head.

Refer to figure 12-19. The general procedure for safety wiring is to follows:

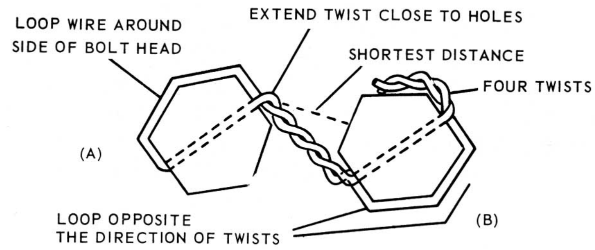
1. Thread the wire through the first bolt so that the wire exits on the side nearest the second bolt (point A).

2. Loop the wire around the side of the bolthead. The loop should be opposite the direction followed by the twisted wire so as not to interfere with it. Never kink the wire as it will be weakened at this point.

3. Twist the wire by hand; hold the wires so that an angle of about 90 degrees is formed between them. Do not use pliers as this tends to develop kinks and nicks, and to make the twist too small and tight.

4. Thread one end through the second bolthead, and the other end around the side of the bolthead that is opposite to the direction of the twisted wire.

5. Pull both ends tight, and give a minimum of four twists on the far side of the second bolt.



12.245
Figure 12-19.— Safety wire.

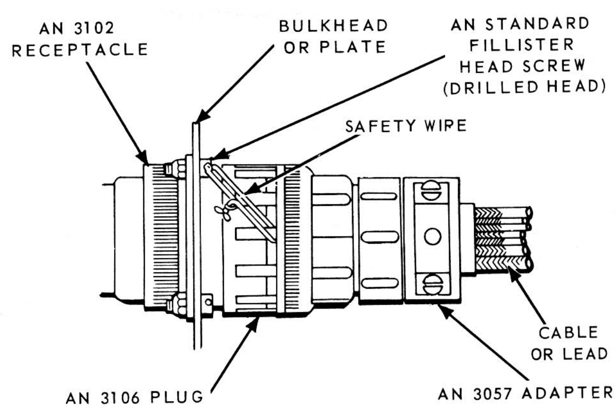
6. Cut off the wire and bend it along the side of the bolthead.

Under conditions of severe vibration, the coupling nut of the AN connector may vibrate loose; and with sufficient vibration, the connector will come apart. When this occurs the circuit carried by the cable will open. The proper protective measure to prevent this occurrence is a safety wiring attachment as shown in figure 12-20. Remember, any time a safety wire is NOT replaced a failure may result.

The safety wire should be as short as practicable and must be installed in such a manner that the pull on the wire is in the direction which tightens the nut on the plug.

MOUNTING BALL BEARINGS

If one is available, you should always use an arbor press for mounting ball bearings on a



12.246
Figure 12-20.—Safety wiring for plug connectors.

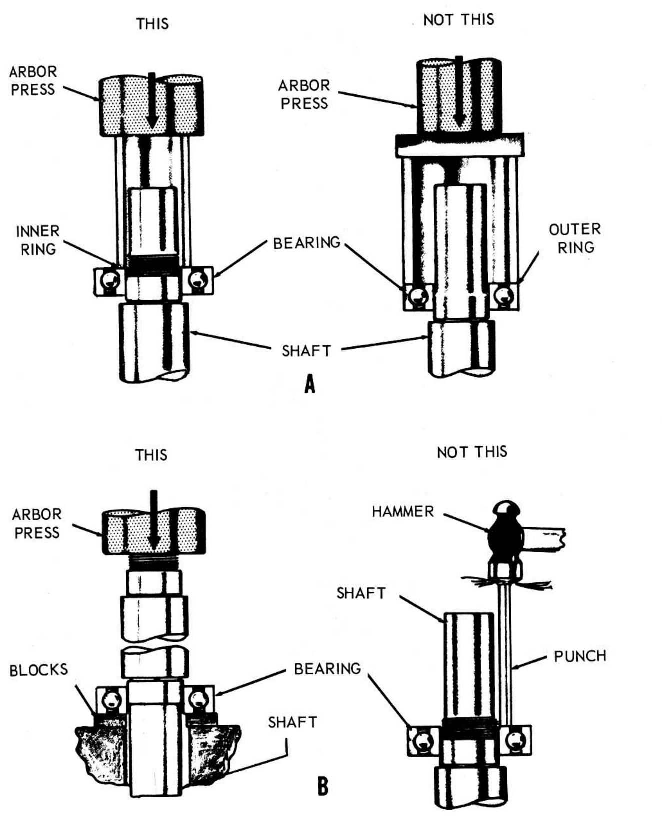


Figure 12-21.—Mounting ball bearings, correct and incorrect methods: A. With an arbor press; B. Without an arbor press.

shaft. Figure 12-21 shows the right and wrong ways to use this tool. A word of caution - never put the full force of the press on the OUTER RING of the bearing. This will apply a heavy load on the balls and races before they are seated and may seriously damaged the bearing. You should always apply force on the inner ring.

Before you put the full force of the arbor press on the bearing, make sure it is started straight and not misaligned. If you force a cocked bearing. it will twist the inner race and may crack it. Also, because the inner race is extremely hard. it is likely to burr or score the shaft seat.

Never use a hammer and punch to drive a bearing to its seat. If you do, the bearing will be cocked from side-to-side and may score the shaft or damage the bearing. And what is worse, the damage may not show up until after the bearing is in service. You end up with a job to do over. Use the proper tool; it will save you trouble and time in the long run.

The bearing mounting method we've just described is fine if the shaft is free of the equipment. Then you can put it in an arbor press. But how can you put a ball bearing on a shaft that is in an equipment? Just get a piece of round copper pipe whose internal diameter is larger than the shaft. The diameter of the pipe should also be about the same diameter as the inner ball bearing ring. Start the bearing on the shaft. Get the bearing on straight. Slip the piece of stock over the free end of the shaft and bottom the pipe on the inner ring of the bearing. Center a block of wood on the other end of the pipe. Now gently tap the wood near its center. This helps to distribute the force of successive hammer blows evenly on the inner bearing ring.

Removal of Ball Bearings

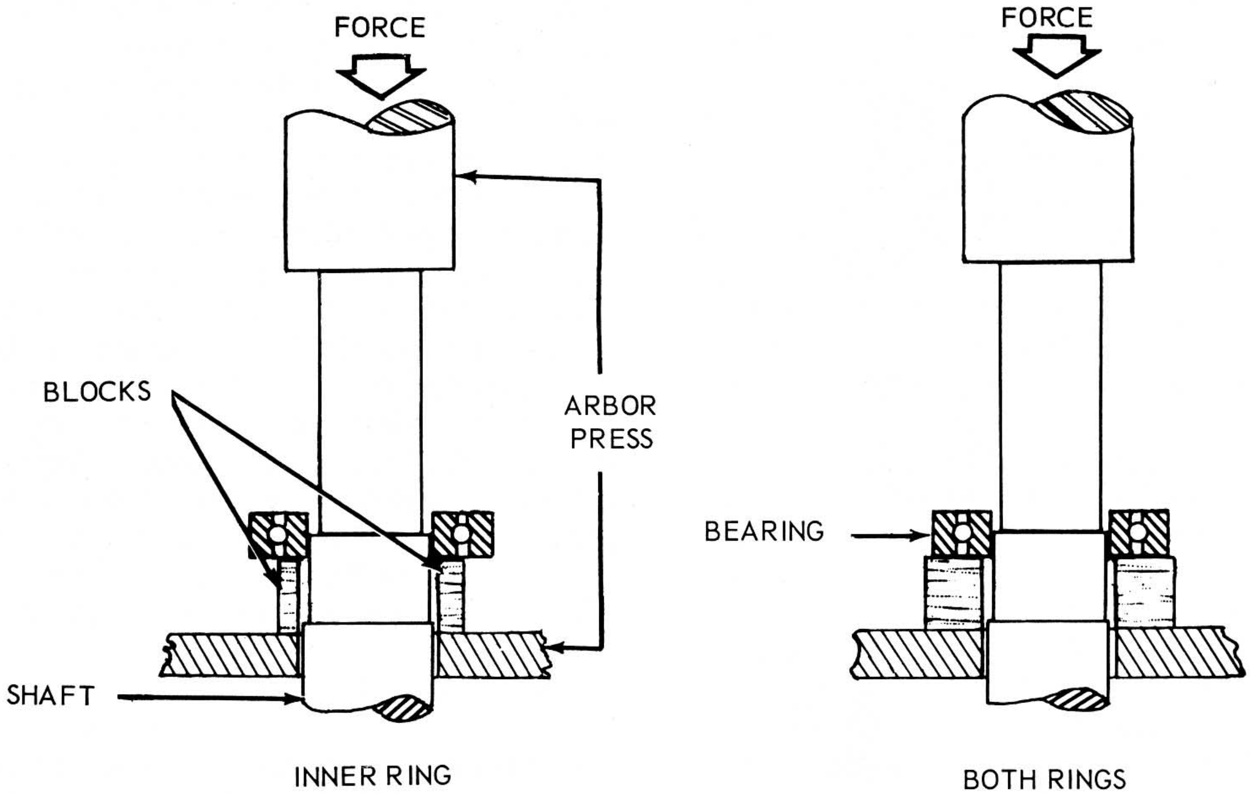
You can also use an arbor press to remove ball bearings from a shaft. The correct removal methods are illustrated in figure 12-22.

You can use pullers to remove bearings. This tool is shown in figure 12-23, and you can see there the technique of using the puller. Where gears and other removable parts won't let you get at the bearing directly, the puller jaws can be placed behind the part. Then the part and bearing may be removed as a unit as shown in part B of figure 12-23.

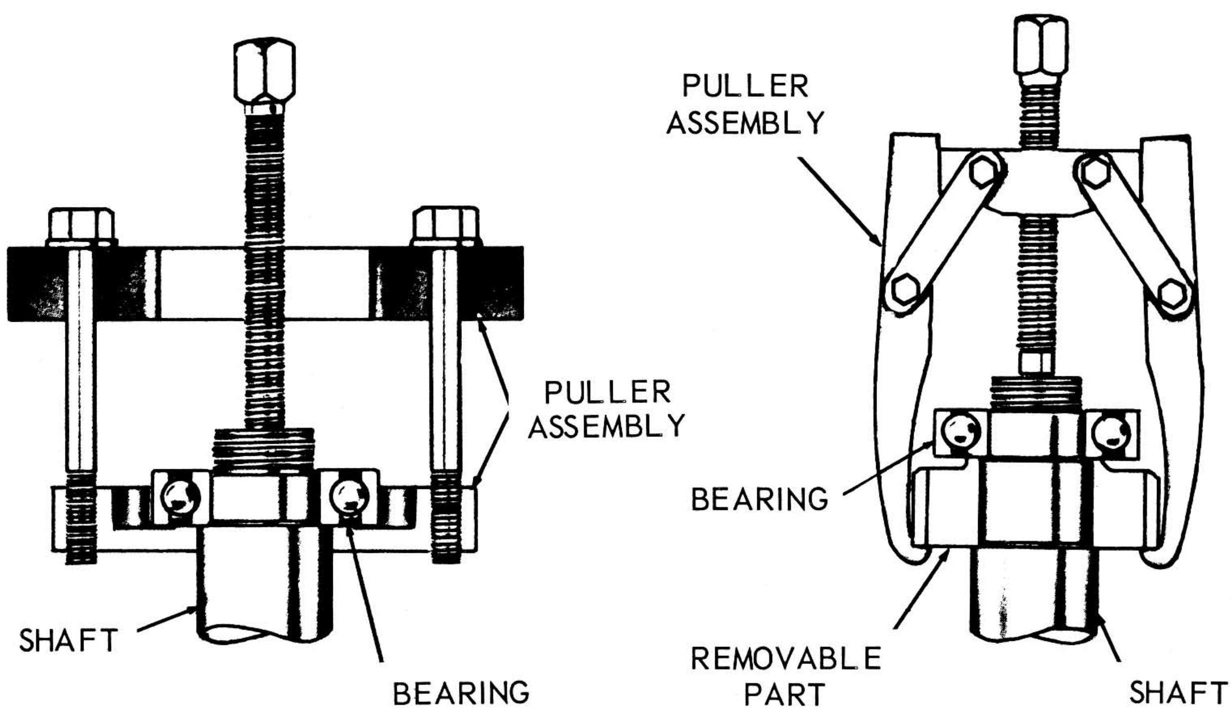
REMOVAL AND REPLACEMENT CONSIDERATIONS

Planning is the most important step in the removal and replacement of equipment units. Planning covers such items as getting the correct tools, removing hazards to personnel and equipment, and finding a working space, if you have no shop. Study the equipment OP. Find the section that has the disassembly and assembly instructions in it. Read the procedures and rehearse in your mind what you plan to do. Go by the book. If these things are not considered, time may be lost, or equipment damaged.

As we said before, when you remove a unit from an equipment for maintenance, periodic check, or lubrication, planning is the first step. Clear the route the unit will take to the working space. This includes removing all obstacles such as doors and hatches, if the unit is large. Clear and clean the working area.



83.133
Figure 12-22.—Removal of ball bearings with an arbor press.



83.134
Figure 12-23.—Removing ball bearings with a puller assembly.

Before you remove the unit, disconnect all cables. Be sure you tag and identify each lead. You'll need this information when you reinstall the unit. Since only cables with electrical connectors have to be unplugged, there is, of course, no tagging problem here. But you must note the alignment of mechanical connections. If the connections have zero positions, they should be disconnected when the unit is on zero. Mark with a scribe the mating gears or any other part that will give you a zero reference. If you install a unit the same way you removed it, this will save you a lot of time in the realignment process.

Common and special tools should be obtained and laid out. If the unit is heavy, get a chain fall. Get a Boatswain's Mate to help you, if you haven't had much experience with rigging. Explain to your strikers the entire removal or replacement procedure. Tell each man what his specific job is and what you want him to do. You will issue all instructions. Time them so that the procedure will go smoothly and effectively. Work cautiously. This eliminates the possibility of injury to your men and damage to the equipment. Observe all safety precautions.

When the unit is in the shop, or at the working space, you should follow certain precautions before you disassemble the unit. Clean the outside of it. When you remove the covers inspect the gaskets. If you find them damaged, get new ones.

In conclusion, plan every job before you start it. If you've never done it before, assemble and study every maintenance aid about the job that you can think of. Get the OP and MRC and study them. Look over the appropriate ordnance drawing. Talk over the job at hand with someone with more experience.

Before you discard any part, be sure to check supplies and confirm that there is a part to replace. You might have to make a temporary repair of the old part. The MRC states whether the part is to be repaired or replaced, and by whom. The Supply Department should have all the necessary parts, but check to be sure before you deep six anything.

Reinstallation

Reinstallation of major units is usually just the reverse of the removal procedure. You should take special pains to see that gear meshes, and coupling and linkage connections, are made properly.

The meshing of gears is extremely important. An incorrect gear mesh causes excessive wear and binding. This shortens the life of the equipment. The gear faces must face squarely. If the mesh is square but too tight, there will be no lost motion. This may sound like an ideal situation. But it is not. No lost motion results in excessive gear wear.

Before you connect couplings, check their shafts for alignment. If the shafts are at an angle to each other, they may bind. When you connect linkages, the connecting pin or bolt must be checked to ensure that when the linkage is moved it will not catch or bend.

Be careful when you plug electrical connectors into their receptacles. You might bend or break the connecting pins. Make all connections tight.

Brushes

Brushes are found in numerous sizes and shapes and are made of various materials and compounds. Many brushes used in electrical equipment are made of a composition of graphite and other forms of carbon. In all probability, the majority of the maintenance you will perform on rotating machinery will be concerned with brushes. Brushes should be checked for wear, chipping, oil soaking, sticking in the brush holders, spring tension, length, and area of contact with the commutator. If for any reason a brush is removed and is to be replaced, it should be marked or tagged so it may be replaced in the same brush holder in the same position it occupied before removal. Never attempt to change the location of the brushes.

Brushes that show excessive or improper wear, chipping, or are oil soaked, should be replaced. Care should be exercised in obtaining the correct replacement. It is important that the brushes be changed before they are completely worn away, in order to prevent damage to the equipment in which they are used.

In order that the technician can tell when replacement is necessary, a brush marking system has been developed. Brushes are marked by a readily noticeable groove in their edges to indicate allowable wear. This groove extends from the top of the brush down to a point 75% of the brush wearing depth. (The top is the end opposite the wearing face.) Thus, if the brush is worn down to the groove, it must be replaced. If no groove is present, consult the equipment OP for acceptable minimum brush lengths.

In the replacement of brushes, you will find that some new brushes are ready to use. That is. the brush face is slightly concave so that it fits tightly on the commutator. However, because other new brushes are NOT ready for use, they must be sanded in. This sanding, or seating, can be accomplished by wrapping fine sandpaper around the commutator. The paper is placed sand side up with a lap following the direction of normal rotation of the device, and is held in place by a rubber band. Do NOT use glue or tape. The brushes are placed in their holder under spring tension, and the armature is rotated slowly by hand in the direction of normal rotation. In so doing, the contact surfaces of the brushes are sanded until their curved surfaces match the curvature of the commutator. The carbon dust from the brushes must be removed from the device by using dry compressed air, followed by cleaning with solvent.

TORQUE WRENCHES

There are times when, for engineering reasons, a definite pressure must be applied to threaded fasteners (nuts and bolts, as they are commonly called). This pressure can properly be applied by a torque wrench. Proper torque aids the locking of all types of thread locking fasteners. After tightening, nuts and bolts are held by the static friction of the nut and bolt head against the surface of the items being held together and the friction on the threads of the nut and bolt against each other. This friction is caused by the clamping force created by a slight stretching of the bolt when the nut is tightened. The metal being slightly elastic will pull back towards its original dimensions creating large clamping forces. Excessive tightening will cause the metal to pass its limit of elasticity and cause a permanent stretch.

The principle of torque is based on the fundamental law of the lever, that is, force times distance equals a moment, or torque, about a point. Torque is often called a torsional or twisting moment. It is a moment which tends to twist a body about an axis of rotation. If a common end wrench is used to tighten a bolt for example, a force times a distance, a torque is applied to overcome the resistance of the bolt to turning.

Figure 12-24 shows three torque wrenches, the deflecting beam, dial indicating, and the micrometer setting type. The deflecting beam which operates on the deflecting beam principle is probably the simplest and most common type evolved from the three principles listed in the preceding paragraph. The primary component is the beam or measuring element. It is alloy steel and may be round, double round, straight flat, or tapered flat. To one end of the beam is attached a head piece containing the drive square (tang) and fixed pointer mounting. A yoke is attached to the other end. Mounted on the yoke is the torque scale handle and, when provided, the signaling mechanism. As a force is applied to the handle, the beam deflects with the scale. The pointer remains fixed, hence a torque is indicated on the scale.

The torsion bar or rigid case type wrench, also shown in fig. 12-24, has its actuating element enclosed in a rigid frame with a removable access cover. The deflecting beam, used in some rigid case wrenches, is similar to that explained above.

The third torque wrench shown is the micrometer setting type. To use the micrometer setting type, unlock the grip and adjust the handle to the desired setting on the micrometer type scale, then relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull in a clockwise direction with a smooth, steady motion.

There are several different types of torque wrenches, but all of them have two basic parts - something that will deflect with the load and something to show how much the sensing element has deflected.

The torque wrench should be calibrated frequently. One that hasn't been recently calibrated and isn't normally stored in its protective case is a dangerous tool. You can't expect to get a meaningful reading from a precision instrument which has been abused. The flat and round beam types will normally give true readings as long as their pointers indicate zero and the drive heads are tight. Because this type can be kept in calibration, they are recommended for shipboard use.

Other type wrenches that indicate by means of dial indicator or by releasing or signaling when a preset load is reached are more sensitive to shock and dirt, hence should be calibrated whenever possible. A minimum of 30 days between calibration is recommended. Never check one torque wrench against another.

An important point to remember is: "Always use the proper size wrench;" one with the desired torque near the 3/4 mark of full scale.

When torquing, the critical maneuver is the application of force to the wrench handle. It must be applied slowly and evenly until the desired torque value is indicated on the wrench scale. When installing a unit which is circular

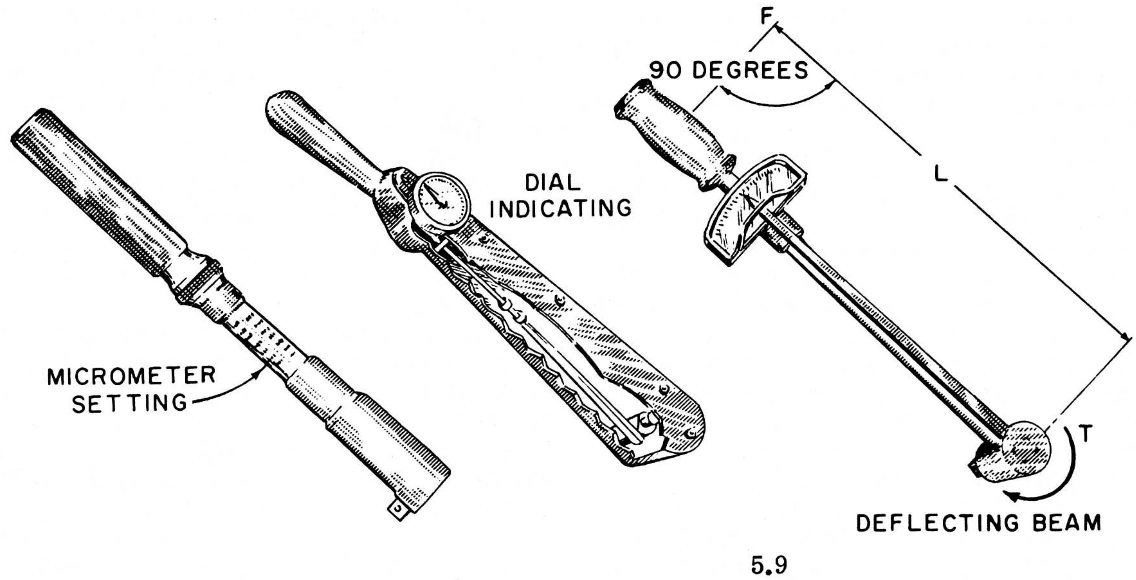


Figure 12-24. — Torque wrenches.

or has more than one side, the bolts should be cross torqued. It may be necessary to cross torque two or three times before an even torque is reached, but be sure the maximum torque is not exceeded.

Nuts and bolts should be tightened to the torque reading required by the installation drawings. The formula often used is that torque in foot-pounds is 0.2 times the bolt diameter times the desired bolt load. A load of about 60 percent of the yield stress of the bolt material is used for most naval applications. However, bolt load varies depending upon whether the bolt or stud is used to support the load itself or to hold together two load supporting members. Installation drawings will indicate the torque value specified by the designer.

If the bolts are loaded in tension, the torque must be great enough to maintain tightness when the assembly is unloaded and not so large that the bolts yield under load. With this type of loading, all bolts must be equally torqued to share the load.

NOTE: Always inspect for clean lightly oiled threads and clean surfaces before torquing. Discard all hardware with burred threads. For more detailed information on the use and care of torque wrenches refer to NAVSHIPS Technical Manual, Chapter 9090.

SPECIAL TOOLS

Special tools are used only for one purpose and only on one type of equipment. They are supplied by NAVORD, and instructions for their proper use are provided in publications applicable to the specific type of equipment.

NONSPARKING TOOLS

Nonsparking or nonferrous tools are special tools made from a nonferrous metal, (metal containing no iron). These tools are used by Gunner's Mates in area where a spark may create a conflagration, such as on or around explosives. Nonsparking tools generally are made of copper alloy (bronze), however they may be made from other nonferrous materials. The material from which these tools are made is relatively soft so care must be exercised when using them to prevent breakage or distortion of the tool. Nonsparking tools should be stowed in separate tool boxes and should not be used as common tools.

SAFETY PRECAUTIONS

The only really safe practice around machinery is to be sure all the power is off before you begin doing your maintenance work. Routine lubrication jobs are not done in the heat of battle, so there is no excuse for having any of the machinery running.

If you must use power to rotate or move some of the equipment, be sure no one is in the way of the moving parts, and observe all safety precautions. That means a safety watch must be maintained.

Never wear loose or torn clothing or neckerchiefs that can get entangled in machinery. Gloves, long sleeves, rings, and bracelets should not be worn while working on machinery.

Wipe up any spilled oil or grease at once. Be careful to keep lubricants away from electrical contacts, from electric wires, and from all rubber parts. All petroleum products have a bad effect on rubber. Overpacking of bearings can cause runoff of lubricants which might then contact electrical parts or rubber parts.

Obey NO SMOKING rules.

When it is necessary to use kerosene or dry-cleaning solvent to remove caked or gummy lubricants before applying fresh lubricant, observe fire precautions and ventilation requirements. Remember also that these solvents are skin irritants.

When you've finished, recharge the lubricating guns, clean up, and stow the gear. Check your chart once more to be sure you haven It slipped up anywhere.

Some new type lubricants for use at low temperatures contain substances harmful to the skin. Observe the caution on the containers.

In spite of repeated precautions and warnings about the danger of fumes, fatal and near-fatal accidents continue to occur. Whenever work is undertaken in a small compartment with any toxic solvent, such as those used in paints, trichlorethane, or dry-cleaning solvent, adequate precautions must be taken before the work is begun. Even though the outcome is not fatal. exposure to toxic fumes can do permanent damage to the kidneys, brain, or nervous system.

Precautions should include:

(1) Sufficient mechanical ventilation to reduce the concentration of toxic fumes to a safe level. When possible, ventilation should include an exhaust for fumes as well as an intake for fresh air.

(2) When a safe level of ventilation is doubtful, workers in the compartment should wear an air line respirator provided with a pure air supply.

(3) Men working in a compartment where fumes may be above a safe toxic level should always work in pairs, so that one man remains outside the compartment as a safety watch at all times. The man outside should have a respirator so he won't be overcome if he has to go into the compartment to bring out an overcome man.

(4) Under no circumstance is 1.1.1-trichlorethane (methyl chloroform) to be used in a closed compartment.

As a petty officer, you must see that the regulations are observed by the men in your charge.

Basic Military Requirements, NavPers 10054C, contains several pages of safety rules in the chapter on seamanship. Basic Electricity, NavPers 10086-B, devotes a whole chapter to electrical safety. Appendix III of Basic Handtools, NavPers 10085-A, consists of electrical safety rules, and all the OPs for the equipment have a summary, in the front of the book of the safety rules scattered through the volume. The illustrated chart of instructions for mouth-to-mouth resuscitation should be posted in one or more places in the working spaces. The danger from electricity is present in all parts of the ship.

Special safety rules applicable to a particular component or to a particular maintenance process are given on the MRC for that part or process.