CHAPTER 12

MAINTENANCE PROCEDURES AND TECHNIQUES, PART I

Essentially all electronic equipment can be subdivided into one or more of the following categories: (1) transmitter, (2) receiver, (3) amplifier, or (4) indicator

The function of any transmitter (radio, radar, or sonar) is to generate the carrier frequency and then to amplify, modulate, and finally to radiate it from a suitable antenna. Every transmitter must have the required ability to stay on the assigned frequency (frequency stability), to transmit faithfully the desired intelligence (fidelity), and to produce the required output power.

The function of any receiver (radio, radar, or sonar) is to receive, amplify, and deliver the desired intelligence in a useful form. Every receiver must have the required ability to pick up weak signals (receiver sensitivity), to pick up a signal at the desired frequency while rejecting signals on adjacent frequencies (receiver selectivity), and to amplify an incoming signal and deliver it to an indicator without distortion (receiver fidelity).

The function of any amplifier is to increase the strength of the signal fed to it without adding anything to the signal or removing anything from it.

The function of any type of indicator is to present information in the desired manner, without distortion.

When an electronic equipment deviates appreciably from normal operation, it will generally be noted by the operator. If the trouble cannot be corrected by operational maintenance procedures, technical maintenance (as outlined in the appropriate instruction book or technical manual) will be necessary. Technical (or corrective) maintenance procedures differ widely among the various electronic equipments, and therefore the appropriate instruction book must be used.

Besides the major units, you will be concerned also with the various accessories, such as transmission lines, antenna systems, motors, motor-generators, synchros and servomechanisms, switching systems, and others.

Also, external surfaces should be dusted periodically. Interiors of equipments should be cleaned carefully at weekly intervals with a soft brush and, if available, a vacuum cleaner.

Periodic cleaning of the interior of radio transmitters or other equipments employing high voltage is particularly important. Potentials in excess of 3000 volts are often present in these equipments, and dust on insulators or other high-voltage components forms a convenient path for arc-overs and consequent damage. In addition, a mixture of dust and lubricant forms an excellent abrasive, which can do considerable damage to moving parts.

An indication of the scope of the work done by the ET is contained in the list of the following items normally done by the ship's force (of course, not all of the jobs listed are performed by the ET 3):

1. Antennas—cleaning and painting; replacement of wire antennas.
2. Bearings—replacement in small motors and generators.
3. Cabling—replacement of short lengths not critical in nature.
4. Direction finders—cleaning, routine maintenance, loop checks, and calibration.
5. Field changes—all field changes of a minor nature and those designated as being accomplished by ship's force.
6. Generators—routine cleaning, maintenance, and minor repairs.
7. Insulators—cleaning and replacement as required.
8. Jacks (phone)—replacement and repair.
9. Keys (telegraph)—installation, replacement, adjustment, and repair.
10. Loran—repair and adjustment.
11. Meters—minor repairs only; replacement of meters that are integral parts of equipment.

12. Oscilloscopes—repair and adjustment.
13. Receivers (all types)—all tests and repairs except alignment.
14. Transmitters (all types)—all tests, repairs, and alterations except major changes and repairs to sealed oscillator compartments.
15. Test instruments—all repairs.

TYPES OF MAINTENANCE, ALTERATION, AND REPAIR

OPERATIONAL MAINTENANCE consists normally of inspection, cleaning, servicing, preservation, lubrication, and adjustment, as required, and may also consist of minor parts replacement not requiring high technical skill or internal alignment.

TECHNICAL MAINTENANCE (corrective maintenance) will normally be limited to maintenance consisting of replacement of unserviceable parts, subassemblies, or assemblies and the alignment, testing, and adjustment (internal) of equipment. (This work, in general, requires skill and detailed knowledge of equipment.)

PREVENTIVE MAINTENANCE is the systematic accomplishment of items deemed necessary to reduce or eliminate failures and prolong the useful life of the equipment. (These items are more specifically defined and outlined in the instruction books and POMSEE books (if applicable) furnished with each equipment. This work, in general, requires skill and a detailed knowledge of the equipment.)

TENDER/YARD MAINTENANCE requires a major overhaul or complete rebuilding of parts, subassemblies, or the end items, as required.

A ship may not informally, on her own, come alongside a repair ship or tender or enter a naval shipyard for repairs. The control and disposition of a ship is at all times a function of certain operating commands. Thus when a ship needs outside repair, the type commander, or higher authority, assigns the ship an "availability" at a repair activity. The term "availability" is defined by Navy regulations as the period of time assigned a ship by competent authority for the uninterrupted accomplishment of work at a repair activity. The three major types of availabilities are regular overhaul, restricted, and technical.

REGULAR OVERHAUL.—A regular overhaul availability is for the accomplishment of general repairs at a naval shipyard or other shore-based repair activity. The length and interval between regular overhauls vary for different type ships and are established upon recommendations by the fleet and type commanders.

RESTRICTED AVAILABILITY.—This availability is assigned by the type commander for the accomplishment of specific work by a shore-based repair activity such as a naval shipyard or ship repair facility. The conditions for which restricted availabilities may be granted include:

1. Post-shakedown repairs in the case of new construction, conversions, or recommissioned vessels.
2. Repairs which should be undertaken to ensure safe and reliable operation, prevent deterioration, ensure health and comfort of crew, or to permit a vessel to maintain scheduled operations.
3. Urgent military alterations.

The rules governing the preparation of the shipyard work list for a restricted availability are the same as those for regular overhaul except that the work requested is restricted to the specific items for which availability has been granted. No readiness-for-sea period is included for a restricted availability unless assigned specifically by the type commander.

TECHNICAL AVAILABILITY.—A technical availability is assigned to a shipyard or equivalent shore-based repair activity for work with the vessel not physically present. Technical availabilities are assigned by the type commander. Under certain circumstances, however, technical availability may be granted by the operational commander.

The most common type of technical availability repair involves shop work only. Frequently, however, technical availabilities are used when the ship is in the same port, or very near the shore-based repair facility, as a device for authorizing the sending of technical personnel aboard for inspection of trouble or to give advice; or if large numbers of workmen are not involved, for repairs as well. Technical availability should not be requested unless the repair needed is beyond the capacity of forces afloat; i.e., ships' forces and available tender and repair ships.

The procedures for submitting a request for technical availability are set forth by type commanders in appropriate type instructions.

Maintenance work accomplished on all shipboard machinery and equipment may be grouped into three general categories: (1) repairs, (2) alterations, and (3) alterations equivalent to repairs.

REPAIR is defined as the work necessary to restore a ship or article to serviceable condition without change in design, materials, number, location, or relationship of the component parts. Repair work items are determined by the ship's force. Major items are approved for accomplishment by the ship's commanding officer if the work can be accomplished by the ship's force, or the type commander concerned if the work cannot be accomplished by the ship's force.

ALTERATION is defined as any change in the hull, machinery, equipment, or fittings that involves a change in design, materials, number, location, or which involves a change in the relationship of the component parts of an assembly regardless of whether any such change is undertaken separately from, incidental to, or in conjunction with repairs.

Requests for alterations may originate from the technical bureaus, from the forces afloat, or from the Chief of Naval Operations. In any case the technical bureau having cognizance of the equipment concerned approves the alteration provided the alteration does not affect the military characteristics of the ship. Alterations under the technical cognizance of BuShips are referred to as ShipAlts. Alterations affecting the military characteristics of a ship are referred to as NavAlts, and must be approved by the Chief of Naval Operations.

ALTERATIONS EQUIVALENT TO REPAIRS.—An alteration is considered equivalent to a repair when any of the following conditions exist:

1. It involves the use of different materials from standard stock, which have been approved for similar use.

2. Worn or damaged parts requiring replacement are replaced by those of later and more efficient design previously approved by the bureau concerned.

3. The alteration consists of strengthening of parts which require repair or replacement, to improve the reliability of the parts and of the unit, but no other change in design is involved.

4. Minor modifications are made that involve no significant changes in design or functioning of equipment, but are considered essential to prevent reoccurrence of unsatisfactory conditions.

Alterations equivalent to repairs may be approved and authorized by type commanders without reference to the bureau concerned when they do not involve increase in weight or vertical moment. They are financed and administered in the same manner as repairs, except that their completion is reported to the bureau concerned.

FIELD CHANGE is any modification or alteration made to an electronic equipment subsequent to delivery to the government and authorized by the bureau or agency concerned.

MAINTENANCE BEYOND THE CAPACITY OF SHIP OR STATION FORCES is performed by tender or naval shipyards and industrial managers or by contractors or other agencies responsible to the maintenance yard.

Although there may be certain exceptions, operational maintenance is done by the operational ratings and technical maintenance (corrective maintenance) is done by the technical ratings. The duties of the two ratings are summarized as follows:

1. Operational ratings—operational use, manipulation, and operational maintenance of electronic equipment associated with the technical specialties of the ratings and such portions of preventive maintenance as do not require realignment after accomplishment.

2. Technical ratings—manipulation, technical and tender/yard maintenance, repair of electronic equipment and preventive maintenance, which requires realignment after accomplishment.

As has been stated, the operational maintenance and much of the preventive maintenance should be done by the operating personnel. This includes daily checks on the operating controls to note binding, excessive play, or other defects. Meter readings should be checked daily to determine if they are normal (the exact procedures are outlined in the appropriate Maintenance Standards Book described later). Equipments should also be checked daily for loose knobs, burned out pilot lights, loose cable couplings or bonding straps, missing spare fuses, and broken meter glasses.

PREVENTIVE MAINTENANCE PROCEDURES

In this portion of the chapter some of the more common preventive maintenance procedures are discussed briefly. It is obvious that the way the operator or the technician goes about his preventive maintenance duties depends upon the type of equipment (or equipments) to which he is assigned. In any case, the steps to be followed in performing preventive maintenance is spelled out in detail in the equipment instruction book. Generally, one section of the instruction book is devoted entirely to preventive maintenance. However, in the new specifications, preventive maintenance will be included in the operator's volume or in the POMSEE books.

Certain items like cleaning and lubricating electronic equipment, maintaining air filters, caring for motors and motor-generators, and testing electron tubes and crystal diodes are sufficiently general to be treated under separate headings. However, preventive maintenance, as applied to specific equipments, must conform to the specific routine spelled out in the Maintenance Standards Book or the equipment instruction book. To illustrate the methods commonly used in maintaining the various types of electronic equipments, a brief summary of the preventive maintenance procedure for certain typical equipments is included. For the detailed procedure, the equipment instruction book must be consulted in each case.

THE POMSEE PROGRAM

The Bureau of Ships is supplementing existing instruction books or technical manuals with two separate publications which together make up the POMSEE program. The expression, POMSEE, means "Performance, Operational, and Maintenance Standards for Electronic Equipment." The POMSEE publications are described as follows:

1. Performance Standards Sheets provide the operational performance data and basic technical measurements indicative of the minimum acceptable level of performance for electronic equipment. A binder, titled "Binder for Electronic Equipment Performance Standard Sheets (NavShips 93000)," for incorporating all sheets required on a ship under one cover, has been distributed.

2. Maintenance Standards Books provide standard methods for determining measurements affecting the performance of a specific equipment, space to record such measurements, and a preventive maintenance schedule for the equipment. The Maintenance Standards Book includes Part I, Test Procedures and Maintenance References and Part II, Preventive Maintenance Check-Off.

The Maintenance Standards Book, Part I, Test Procedures and Maintenance References provides an itemized step-by-step procedure, which enables the engineer or other person making the standard tests to set down critical or significant operating values (dial readings, etc.) representative of optimum operating conditions. Upper and lower limits or tolerances for dial readings, voltages, or currents are given so that an indication is readily available if performance is below the allowable limits. No attempt is made to show how to locate the trouble; however, a comparison with established critical circuit readings will help the ET to isolate the trouble.

Reference to the instruction book for the particular equipment is still required for troubleshooting or corrective maintenance.

The Maintenance Standards Book, Part II, Preventive Maintenance Check-Off requires that standard tests be performed at regular intervals on circuits and components and specifies what and when other routine maintenance, such as lubrication, is to be accomplished. By the proper use of this book, routine checks and routine preventive maintenance may be accomplished in a systematic manner.

In general, the same steps required for determining the standards in Part I must be repeated later by the ship's force in making routine checks for entry in Part II.

The daily and some of the weekly tests prescribed should be done by operators, not technicians, so that the ETs can concentrate on corrective maintenance. The Electronics Material Officer will determine who should undertake the routine tests.

TOOLS

Most faults in an electronic assembly cannot be prevented or corrected without the use of tools. Therefore, the first step in preparing to check out transistors or other semiconductors, tubes, printed circuits, etc., is the acquisition of the proper tools. The ease with which a check or repair can be made is often a direct function of the adequacy of the tool selected to perform the given task.

In the performance of their duties, maintenance personnel should be provided with, or have access to, at least one each of the basic tools listed in the Electronics Tool Allowance List. In general, the number and types of tools r quired are determined by the types of nuts, bolts, screws, fasteners, etc., employed in the equipment being serviced.

Since transistors and other components and equipments are extremely small, conventional-size tools frequently are unsuitable for effective use; the technician requires tools which, because of their greatly reduced size, are better able to cope with the limited space encountered in compact, miniaturized equipment. In addition, special devices which extend the vision, aid the reach, and sometimes act as a third hand are required in servicing or repairing the equipment. Figure 12-1 shows a few such special devices which are discussed below.

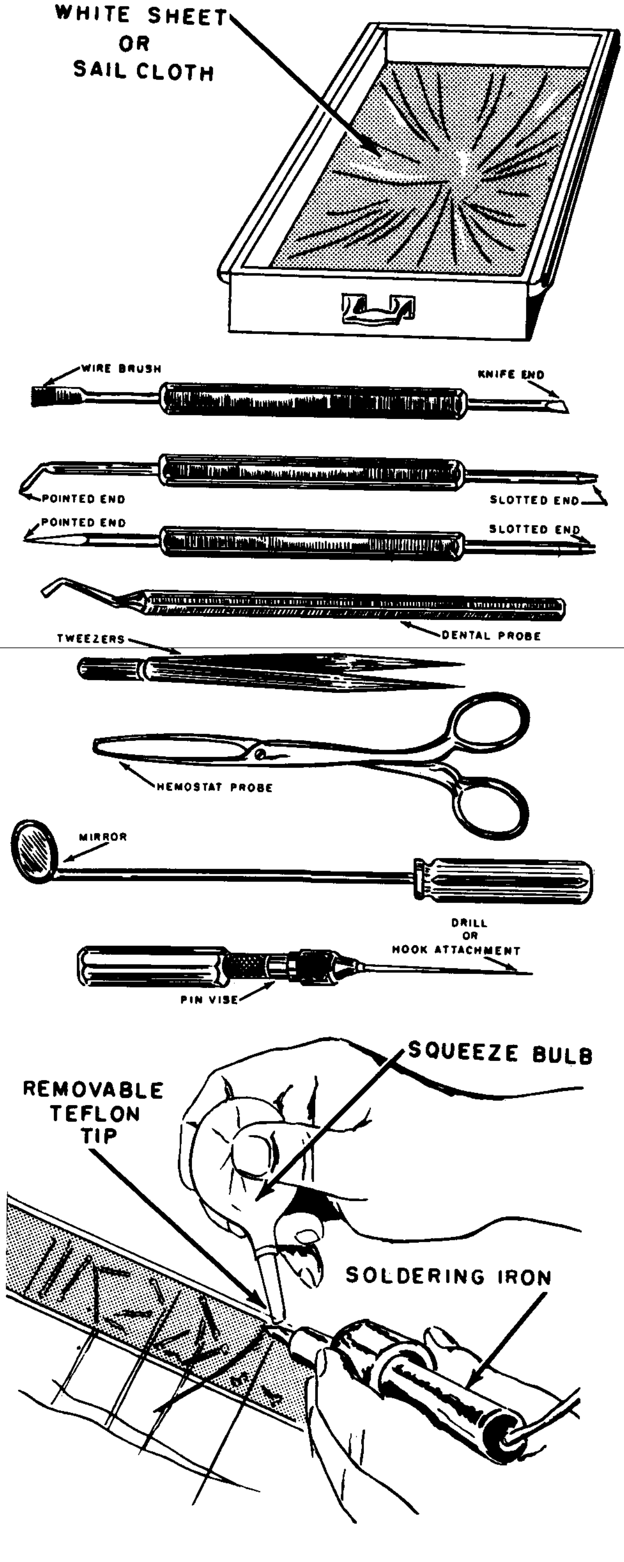
A suitable and easily fabricated device that fits into this category is the chassis-holding jig described in chapter 13 of this training course. This jig will provide support for the electronic assembly when the assembly is removed from its regular mounting for checking or repair. It will also prevent flexing or slipping which could result in unnecessary damage.

A portable drawer can be fabricated by attaching a piece of sailcloth or old white sheet to the inside of the drawer. Attaching the above jig, or similar chassis-holding jig, onto the side of the drawer and over the cloth area will prevent the loss of any tiny part that may be accidentally dropped. In attaching the cloth to the inside of the drawer, leave a small amount of slack so that it will sag in the middle; thus, if a part should be accidentally dropped, it can be easily located by gently tapping the cloth. The part will then find its way to the middle.

A portable lamp (fluorescent if approved for use in the work area) is a very desirable light source for small work in spaces which are inadequately lighted. The swivel clamp arrangement on the base of the lamp fixture can be secured to the work area or side of the equipment frame, allowing both hands to be free. This lamp is preferable to a flashlight for lengthy repairs.

In many instances, breaks in the conducting strips (foil) of a printed-wiring circuit board can be located only with the aid of a magnifying glass or device. In this case a magnifying glass or device should be kept handy for such use.

A pin vise is a very useful tool for drilling through thin plastic, bakelite, or copper-ribbon conductor strips. The pin vise also will hold various sizes and shapes of hooks and probes



70.101

Figure 12-1.—Special devices.

fabricated from spring wire, for extracting or holding small parts in limited spaces.

Many advantages also can be gained by the use of offset screwdrivers and tools which decrease the area of space required for turning action.

Surgical hemostats, tweezers, hypodermic syringes, and surgical needles are available in many types and shapes, and sizes; these implements are ideally suited for reaching into tight places, for retrieving or holding small parts, and for oiling hard-to-reach lubrication points. The surgical hemostats or tweezers also may be used as thermal shunts to dissipate heat away from heat-sensitive semiconductor devices; however, this method of application is only partially satisfactory.

Many of the special tools used by the dental and medical department can be easily adapted for use in servicing electronic equipment. They may have several special tools on hand which are no longer suitable for their work, but which would be ideally suited as labor-saving devices for the electronics technician.

The most important requirement in the checking, servicing, and repair of electronic equipment is the use of a light-duty pencil soldering iron with an assortment of interchangeable tips and soldering aids, as shown in chapter 13 of this training course.

Another very useful tool is a 1-ounce rubber syringe with a special removable Teflon Tip, such as the device manufactured by the MacDonald Company. This tool is very useful in sucking up excess solder and flux; when properly used, this device will eliminate smearing of solder over the rest of the board being repaired. It can be used as a bellows to dissipate excessive concentrated heat.

In summary, special tool requirements depend on the maintenance operations and the design characteristics of the equipment to be checked, serviced, or repaired. An adequate assortment of special tools (aids) is necessary in checking and in solving certain maintenance problems associated with present day electronic assemblies. However, the number of special tools should be held to a minimum compatible with actual equipment needs.

SAFETY PRACTICES

Safety is a major responsibility of all personnel working on or around electronics. The installation, maintenance, and operation of electronic equipment requires a stern safety code. Carelessness on the part of the electronics technician or operator can result in serious injury or death due to electrical shock, falls, burns, flying objects, etc.

After an accident has happened, investigation generally shows that it could have been prevented if simple safety precautions and procedures had been observed. Each man concerned with electronic equipment should make it his responsibility to read and become thoroughly familiar with the safety practices and procedures contained in U. S. Navy Safety Practices (OPNAV-34P1), chapter 67 of BUSHIPS Technical Manual (NAVSHIPS 250 000), NAVMEDS publication (P5056), technical manuals, schematics, wiring diagrams, etc., before performing work on electronic equipment. It is your responsibility as an electronics repairman or operator to identify and eliminate unsafe conditions and unsafe acts which cause accidents.

In pursuit of this responsibility, it must be borne in mind that deenergizing main supply circuits by opening supply switches, circuit breakers, or circuit switches will not necessarily KILL all circuits in a given piece of equipment. A source of danger that often has been neglected or ignored—sometimes with tragic results—is the inputs to electronic equipment from other sources, such as synchros, remote control circuits, etc. For example, turning off the antenna safety switch will disable the antenna, but it may not turn off the antenna synchro voltages from the ship's compass or stable elements. Moreover, the rescue of a victim shocked by the power input from a remote source often is hampered because of the time required to determine the source of power and turn it off.

NOTE: TURN OFF ALL POWER INPUTS BEFORE WORKING ON EQUIPMENT.

Hazards associated with the use of electrical power tools are electrical shock, cuts, bruises, falls, particles in the eye, explosions, etc. Safe practice in the use of these tools will reduce or eliminate such accidents. Personnel also should be aware that the removal of a unit or part from its normal location for servicing also will remove the protection given by built-in safety features.

Do NOT troubleshoot a circuit with the primary power applied, unless absolutely necessary. If it becomes necessary to work on equipment with the power applied, stand on a good insulating material keeping one hand free at all times—BEHIND YOU OR IN YOUR POCKET.

Most of the hazards which will confront you in electronics maintenance and repair will be associated with careless maintenance practices. Remember that the 115-volt power supply voltage is not a low, relatively harmless voltage (only voltages below 30 volts are in this class), but it is the most lethal voltage used in the Navy. More accidents happen with this voltage than with any other because many sailors consider such a voltage relatively harmless and disregard safety measures. When we think of electrocution, we are inclined to think in terms of high voltages, but a point always to remember is that MORE PEOPLE ARE KILLED BY 115-VOLTS THAN ANY OTHER VOLTAGE.

There are two types of injuries resulting from an accident which may require first aid immediately to save a life. In the case of severe electrical shock, the victim's system may be paralyzed; in such a case immediate artificial respiration is necessary to save the victim's life. When working with tools and equipment, it always is possible that you or someone else may receive a wound from which there is excessive or dangerous bleeding. In such a case, knowledge of how to control the flow of blood may mean the difference between life and death for you or a fellow worker. Standard first aid procedures are given in the Blue Jackets Manual and the Standard First Aid Training Course, NavPers 10081. Standard first aid measures have remained basically unchanged from those you learned as a boy scout. One of the changes is the artificial respiration methods which has progressed to mouth-to-mouth resuscitation. Important references are given in chapter 2 of this training course. These references are excellent for first aid familiarization and each man concerned with electronic equipment should make it his responsibility to understand and practice all prescribed safety precautions. REMEMBER: WORK SAFE AND BE SAFE. DON'T DAMAGE THE EQUIPMENT AND DON'T LET THE EQUIPMENT DAMAGE YOU.

CLEANING PRACTICES

The successful restoration and reconditioning of electronic equipment, especially equipment that has been subjected to contamination from foreign materials such as dust, soil, and salt water, require that the electronics technician have not only a thorough knowledge of cleaning materials, but also that he select cleaning equipment and chemicals which perform properly together to produce the desired results of cleanliness with the minimum amount of disassembly.

There are a number of cleaning solvents, compounds, and materials listed in the Navy Stock List. Although many of these items are excellent, may others have serious limitations concerning their safe use and application. Their factors include possible harmful effects on the material being cleaned, storage qualities, safety in use (flammable, toxic, or both), and relative cost. Therefore, sound judgment must be exercised by maintenance personnel in the selection of the cleaning materials used to meet the different cleaning requirements encountered, before a cleaning solvent, compound, or method of application is judged as being suitable for use.

Dirt, dust, and other foreign materials form on surfaces where they are not wanted, and thus contaminate the surfaces. For this reason, in order to maintain any equipment in the best operating condition, a scheduled cleaning program of periodic maintenance to suit the particular operating schedule in effect should be established and followed.

The cleaning of equipment which is contaminated with loose, dry dust or dirt particles or with oils, grease, etc., should be accomplished as follows:

ACCESSIBLE SURFACES.—Use a clean, dry, lint-free wiping cloth or rag, or a bristle brush moistened with a cleaning solvent.

INACCESSIBLE SURFACES.—Remove the covers and protective devices on the equipment being cleaned; attach an air hose to a dry, filtered air outlet that is regulated at less than 50 psi pressure and blow the dust or dirt particles from the contaminated surface area, or spray a cleaning solvent, with an air gun, onto the contaminated surfaces.

CAUTION: Exercise extreme care when using compressed air on delicate parts. Protective equipment (goggles, rubber gloves, protective clothing, fire extinguishers, etc.) must be provided for personnel using solvent for cleaning purposes. Ensure adequate ventilation by using exhaust fans or supply blowers. NEVER WORK ALONE.

In extreme cases, where electronic equipment has been subjected to salt water flooding or to excessive condensation from humid, salt-laden air, fresh water (preferably warm or hot) can be used to flush out the contamination. However, the use of fresh water is recommended only as an emergency substitute for a cleaning solvent, since it must be followed by a thorough drying process before the equipment can be restored to service.

In many cases, equipment flooding is accompanied by organic contamination resulting from damaged fuel lines or flooded gear boxes, etc. In such cases the viscous, adherent oil resists removal by water, but a cleaning emulsion formulation (see EIB 593) will remove most oily contaminants and sea water at the same time.

Solvents may be mixed with soaps, synthetic detergents, alkalies, and water to formulate other cleaning emulsions that will remove sea water and oil contamination from the affected parts. A wetting agent added to the cleaning solution may also increase its cleaning capabilities.

When using an emulsion cleaner, all exterior and interior contaminated surfaces should be sprayed with the emulsion, after which the surfaces should be flushed thoroughly with fresh water. After most of the oily contamination has been removed by the flushing process, the last traces of contamination and sea water can be removed by subjecting the equipment to ultrasonic radiation while it is immersed in the cleaning emulsion. This process is described in detail in EIB 593.

The following information was obtained from Chapter 67 of the Bureau of Ships Technical Manual.

1. All electronic equipment must be cleaned to assure good performance and not for appearance only.
2. Steel wool or emery in any form must not be used on or near electronic equipment.
3. Sandpaper and files will be used only with competent advice or not at all.
4. The use of a vacuum cleaner with NON-METALLIC hose and adequate dust receiver is to be resorted to wherever practicable.
5. The use of solvents is to be resorted to only where absolutely necessary and where the proper safety precautions are taken.

Alcohol or other flammable solvents must not be used on energized equipment or on equipment near other electronic equipment from which a spark is possible. They are to be exposed in the smallest possible quantity and may be used only in well-ventilated compartments. Except in locations wholly in the open, alcohol will be limited in quantity to one pint.

For additional safety precautions that the ET must observe in cleaning electronic equipment, see United States Navy Safety Precautions, OpNav 34P1.

MAINTAINING AIR FILTERS

The maintenance of air filters is EXCEEDINGLY important for the proper operation of electronic equipment. The lack of proper servicing (cleaning or replacing) of air filters will cause an enormous amount of trouble. For some reason (perhaps they are difficult to locate or their importance is not fully recognized) it appears that air filters are often neglected or disregarded until excessive heating causes a breakdown of the equipment.

Equipments that use a great deal of power and/or have high ambient temperature must be cooled. Air cooling is commonly employed, and this means moving a large volume of air over the hot portions of the equipment. The air is filtered to keep dust and other foreign particles out of the equipment. If the filters are efficient, they will remove most of this foreign material from the air that passes through them. This foreign material will tend to clog the filter and prevent the air from moving through. The result is that the equipment gets too hot and may be ruined. AIR FILTERS MUST BE SERVICED OFTEN.

An analysis of the failures of parts in electronic equipment indicates that the MAJORITY OF FAILURES CAN BE TRACED TO EXCESSIVE HEAT CAUSED BY DIRTY AIR FILTERS. This fact cannot be overemphasized; and on the basis of this alone, it would appear that the technician can reduce his workload substantially by ensuring that air filters are properly serviced.

LUBRICATING ELECTRONIC EQUIPMENT

In electronic gear, lubrication is as important as it is anywhere else, and the carrying out of the lubrication procedure is no more complicated than in other equipments. There are actually only a few types of parts that have to be lubricated. They are summarized in a general way as follows:

1. Drive motors and motor-generator sets run at high speeds and, if not lubricated properly at regular intervals, will quickly deteriorate

and fail. Determine where the motor-generators (as well as the drive motor) are located so that they will not be overlooked during routine lubrication.

2. A radar antenna is rather slow-moving and a great deal of trouble and expense has resulted from a lack of proper lubrication. In one instance the failure to use thirty cents worth of grease resulted in a $30,000 repair bill. Several factors combine to cause antenna trouble. First, the antenna is a long way up in the air, and it is a nuisance to climb all the way up the mast to lubricate it. Second, the ship spends much of its time at sea, and the mast is no place to be when the ship is heaving around underneath. Third, the rolling and pitching of the ship throws a heavy strain on the moving parts of the pedestal, and even though the antenna moves slowly, the great pressure on the moving parts causes rapid wear unless they are kept well lubricated. Fourth, the pedestal is constantly exposed to the action of salt air and salt water, which attacks the lubricant and tends to make it less slippery.

If the antenna is neglected and the pedestal freezes, the drive motor will burn up, and the radar will be out of commission. This condition involves lifting the antenna off with a crane and results in an expensive repair job. This waste of money and time, and the possible placing of the ship in jeopardy, can be prevented if the correct lubrication procedure (as outlined in the instruction book, the lubrication charts, or POMSEE books) is followed.

There are three common methods of lubricating electronic equipment.

The first is the use of the oil can. A drop of oil from the spout of the can into the oil hole on the machinery is all that is necessary. However, there are many types of oil and you must be sure that you are using the correct one. In many cases, the mixing of dissimilar oils will form a gummy substance that has little or no lubrication properties. The result may be a frozen bearing.

The second is the use of a grease gun on a pressure-type fitting. The main thing to remember is that the fitting must be clear of dirt or paint obstructions, otherwise the grease cannot enter. Even if the grease should be forced in, dirt will be taken along and eventually the bearing will be damaged. Grease fittings should always be kept as clean as bright work; and the hole should be cleaned out with a pin before the grease gun is applied.

The third is the use of the grease cup. Grease cups are generally found on the heavier motors and motor-generators, and must be used properly if damage to the machinery is to be prevented. Information on the use of grease cups is included in the section on the care of motors and motor-generators.

For certain types of electronic equipment, special lubrication charts are provided. For example, a set of twelve plastic lubrication charts, 0280-114-4000, are provided for the personnel who lubricate the antenna of Radar Set AN/SPS-8. Pictures and instructions are given to ensure adequate lubrication instructions.

CARE OF MOTORS AND MOTOR-GENERATOR

The following information on the care of motors and generators (or motor-generators) is condensed largely from Chapter 60 of the Bureau of Ships Technical Manual. The essential points to remember are: (1) keep the insulation clean and dry and of high resistance, (2) keep the electrical connections tight, and (3) keep the machines in good mechanical condition by proper cleaning, lubrication, and replacement of defective parts.

The ET 3 is expected to be able to inspect and clean commutators and collector ring (slip ring) assemblies and inspect and replace brushes on motors and motor-generators that are used with or are a part of electronic equipment. It is therefore important that he follow the approved procedures.

The four acceptable methods of cleaning motors and generators are wiping, use of suction, use of compressed air, and use of a solvent.

LUBRICATING MOTORS AND MOTOR-GENERATORS. — The ET 3 should be familiar with and be able to distinguish between grease-lubricated and permanently lubricated ball bearings.

The grease-lubricated type requires periodic lubrication with grease. The permanently lubricated type contains two seals, has been lubricated by the manufacturer, and requires no additional lubrication throughout its life. Equipment furnished with these bearings can be recognized by the absence of grease fittings or provision for attaching grease fittings. When permanently lubricated bearings become inoperative they should be replaced with new bearings of the same type.

Cleanliness is of prime importance in avoiding ball bearing failure. Due to the extremely high pressures and close fit between balls and races, even minute particles of dust may cause bearing failure. Dirt may be introduced into the bearing housing by careless handling, or by inclusion with the lubricant, or it may work its way into the housing along the shaft.

Extreme care must be exercised in the handling of bearings, grease fittings, housing parts, and tools used in maintaining the bearings to ensure the exclusion of all foreign matter, particularly when reassembling grease fittings, etc.

Improper greasing procedures are a frequent cause of trouble in rotating electrical machinery provided with grease-lubricated ball bearings. The trouble is generally caused by an excessive quantity of grease being forced into the bearing housing. When grease is forced through the bearing seals and into the windings (or onto the commutator), deterioration of the insulation is a likely result. Excessive grease in the bearing housing itself results in churning, increased temperatures, rapid deterioration of the grease, and ultimate destruction of the bearing.

The stock numbers of grease to be used for lubricating ball bearings that operate in two broad temperature ranges are given in Chapter 60, of the Bureau of Ships Technical Manual. Machines that require the special high-temperature silicone grease have a plate with the words, USE HIGH TEMPERATURE GREASE, attached near the grease fitting.

Motors and generators provided with bearings that should be lubricated with grease are normally delivered with the grease cups removed from the bearing housings and replaced with pipe plugs. The grease cups are delivered with the onboard repair parts or special tools. It is recommended that grease cups be attached to electric motors and generators only when the bearings are being greased. When the grease cup is removed from the bearing housing after a bearing has been greased, the hole that remains should be plugged with a suitable pipe plug. When this procedure is used, the grease cups should remain in the custody of responsible maintenance personnel.

Care should be taken to make sure that a grease cup is clean before it is used to add grease to a bearing and that the pipe plug used to replace the grease cup after greasing is also clean.

To avoid the difficulties caused by an excessive amount of grease, grease should be added only when necessary; and, when grease is added, it should be done as follows:

1. Wipe outside of grease fitting and drain (relief) plug free of all dirt.
2. Remove bearing drain plug, and make sure the passage is open by probing with a clean screwdriver or other suitable instrument.
3. Remove pipe plug at top of grease pipe. Select the proper grease cup and clean it (top and bottom parts) thoroughly. Install the bottom portion of the grease cup on the grease pipe.
4. Fill the bottom part (receptacle) of the grease cup with clean grease.
5. Put into the top part (the part that is to be screwed down) of the grease cup no more grease than will half fill it.
6. Screw the top part of the grease cup down as far as it will go. The purpose of screwing the grease cup down is to protect the machine from being overgreased because of accidental or unauthorized turning of the top part of the grease cup.
7. Run the machine and let the grease run out of the drain hole until drainage stops (normally about 30 minutes). Remove grease cup and replace the pipe plug and the drain plug.
8. Do not use a grease gun to lubricate bearings unless there are no other means available. If a grease gun must be used, the drain plug must be removed while greasing is being done and extreme care must be used to avoid inserting too much grease.

BRUSHES.—The correct grade of brushes and correct brush adjustment are necessary to avoid commutation trouble. For good commutation:

1. Use the grade of brushes recommended by the manufacturer.
2. The brush shunts or "pigtails" should be securely connected to the brushes and the brush holder.
3. Brushes should move freely but should not be loose enough to vibrate in the holders.
4. Brushes that are half worn, or that have chipped corners or edges, should be replaced after all dirt is cleaned from the brush holders.
5. The spring tension on the brushes should be maintained according to the manufacturers' instructions (see BuShips Technical Manual, section 60-293, for details).

6. All brush holders should be the same distance from the commutator—not more than one eighth of an inch, or less than one sixteenth of an inch.

7. The toes (forward edge in the direction of rotation) of all brushes on each brush stud should line up with each other and with the edge of one commutator segment.

8. The brushes should be evenly spaced around the commutator.

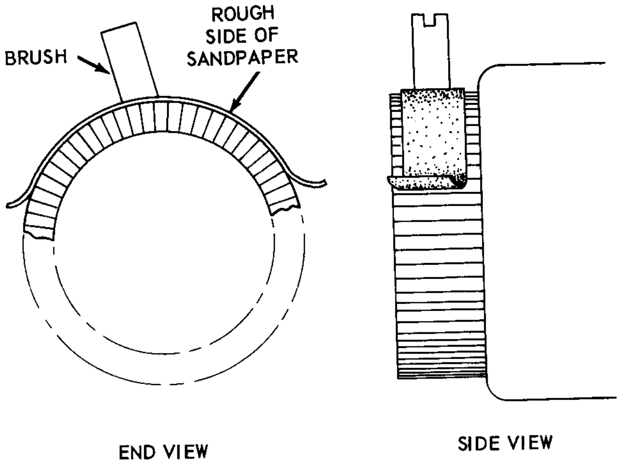
9. Brushes should be staggered in pairs (see Article 60-293 in BuShips Technical Manual) to prevent grooving of the commutator.

10. The brush surface in contact with the commutator should be an accurate fit.

When new brushes are installed, or old brushes do not fit, they should be fitted and seated. For this purpose, sandpaper and/or a brush seater should be used. Sandpaper is probably more familiar to everyone, but the use of a brush seater has certain advantages. (Never use emery paper or any other kind of paper or cloth containing a metallic abrasive.)

When using sandpaper to fit brushes, disconnect all power and make sure the machine cannot be started while the work is being done. Lift the brushes to be sanded and insert a strip of fine sandpaper (No. 1) sand side up, between the brushes and the commutator. With the sandpaper held tightly against the commutator surface (to conform to the curvature), and the brushes held down by normal spring pressure, the sandpaper is pulled in the direction of normal rotation of the machine (see fig. 12-2). When the sandpaper is reinserted for another pull, the brushes must be lifted. This operation is repeated until the fit of the brush is accurate. Always finish with a finer grade (No. 0) sandpaper. Use a vacuum to remove the dust during the sanding operation; afterwards, the commutator and windings must be thoroughly cleaned to remove all carbon dust.

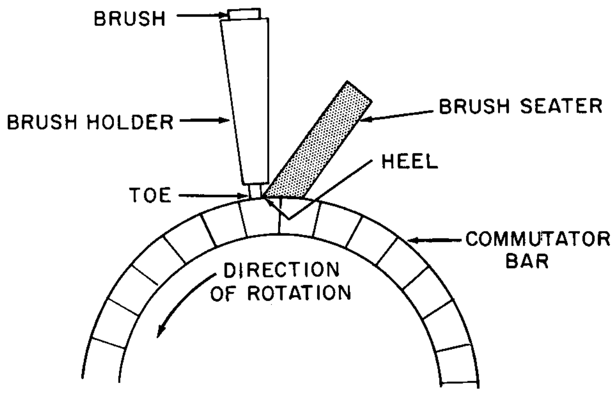
The brush seater consists of a mildly abrasive material loosely bonded and formed in the shape of a stick about five inches in length. The brush seater is applied to the commutator while the machine is running, and therefore every precaution must be taken to prevent injury to the person applying it. The brush seater is applied lightly, for a second or two, exactly at the heel of each brush (fig. 12-3). If the seater is placed even one-fourth inch away from the heel of the brush, only a small part of the abrasive will pass under the brush. Pressure is applied to the brush by setting the brush spring tension at maximum (during the seating operation) or by pressing a stick of insulating material against the brush. Dust is removed during the operation, and the machine is thoroughly cleaned afterwards the same way as when sandpaper is used.



1.52

Figure 12-2.—Method of sanding brushes.

COMMUTATORS AND COLLECTOR RINGS. —In a properly operating machine, the commutator will develop (within about two weeks of use) a uniform, glazed, dark brown polish where the brushes ride on it. A nonuniform color or surface or a bluish color indicates improper

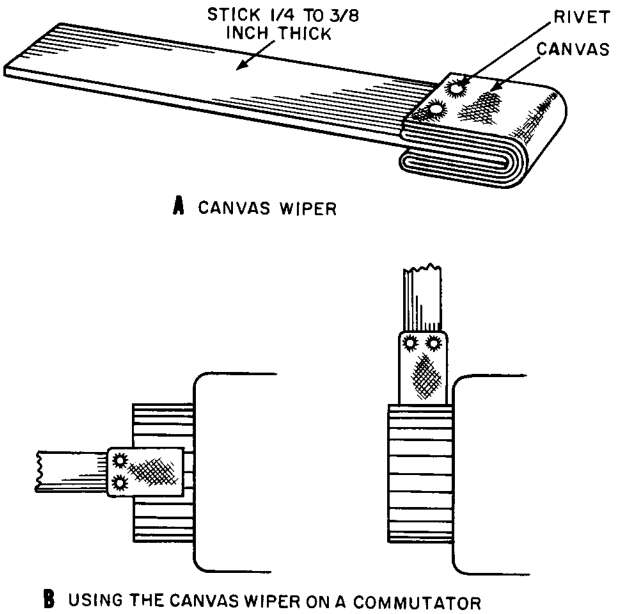


1.53

Figure 12-3.—Using the brush seater.

commutation conditions. If the commutator retains a smooth, uniform finish of the proper color and shows no evidence of poor commutation, it may be cleaned with a canvas wiper, as described in the following paragraph. If however, the commutator cannot be sufficiently cleaned with the canvas wiper, or if the surface is slightly rough, a fine grade of sandpaper may be needed. Periodic inspections and proper cleaning practices will keep commutator and collector-ring troubles at a minimum.

One of the most effective ways of cleaning commutators or collector rings is to apply a canvas wiper while the machine is running. The wiper can be made by wrapping several layers of closely woven canvas over the end of a strong, pliable wood strip and securing the canvas with rivets, as shown in figure 12-4A. The strip should be long enough so that the user can hold it securely in both hands, about one-fourth inch to three-eighths inch thick, and of a width appropriate to the size of the machine on which it will be used. Linen tape should be wrapped around the canvas wiper over the rivets to prevent all possibility of their coming in contact with the commutator. The canvas wiper is applied to the commutator



1.54
Figure 12-4.—Using the canvas wiper on a commutator.

in either of the ways illustrated in figure 12-4B. When the outer layer of canvas becomes worn or dirty, it is cut off to expose the next layer.

When the machine is secured, use a toothbrush to clean out the commutator slots, and wipe the commutator and adjacent parts with clean canvas or cheesecloth. Take care not to leave threads lodged between the commutator bars or on the brushes. Do not use cotton waste or any cloth that leaves lint.

Do not use solvents for routine cleaning of commutators, and do not use any lubricant on the commutator.

If the commutator is only slightly (blackened, scratched, or dirty) but not out of true (flat, grooved, or eccentric), a fine grade of sandpaper (No. 00) may be used. Sandpapering is also used to reduce high mica, or to finish a commutator that has been ground or turned. The machine is run under a light load at approximately rated speed. The sandpaper is attached to a wooden block that has a face shaped to the same curvature as the commutator. Move the sandpaper very slowly back and forth in a direction parallel to the axis of the machine. Rapid motion of the sandpaper will cause diagonal scratches. Do not use coarse sandpaper because this will make deep scratches. Do not use emery paper, emery cloth, or emery stone on a commutator as these materials contain carbon, which will become embedded in the commutator slots and short-circuit the armature coils.

MAINTAINING ANTENNAS AND TRANSMISSION LINES

Specific instructions for maintaining VHF/UHF and microwave antennas are given in the instruction book for a particular equipment or a particular antenna. Good practical information on testing antenna systems is included in chapter 4 (Testing Antenna Systems) of Shipboard Antenna Details, NavShips 900,121A. Equally helpful is the information on transmission lines contained in Installation and Maintenance of Transmission Lines, Waveguides, and Fittings, NavShips, 900,081. Another useful publication is Armed Services Index of R-F Transmission Lines and Fittings, NavShips 900,102B.

This portion of the chapter treats in a general way the use of meggers in testing antenna systems and the cleaning of antenna and transmission line insulators. However, before the subject of testing antenna systems is treated you may wish to review the information on the ohmmeter and the megger in Basic Electricity NavPers 10086 (revised).

Basically, an ohmmeter (or the ohmmeter section of a multimeter) is used to determine if a circuit is open, shorted, or grounded; it is likewise used to determine the resistance of a circuit or component. It is simple to use. The test leads are connected to the instrument, and the range switch and the meter adjustments are made. The probes are then placed across the circuit or component to be tested. If no reading is obtained (infinite resistance), the circuit is open (or the resistance is so high that the meter will not give an indication); if a reading is obtained, the circuit is not open. If no resistance is indicated, the circuit or component is short-circuited. If the ohmmeter indicates essentially no resistance between a point in a circuit and ground, that point is grounded. The value of the resistance of a circuit or component is indicated on the meter dial.

In general, ohmmeters are used for low or medium values of resistance; meggers and insulation test sets are used for high values of resistance (perhaps hundreds of megohms).

USE OF INSULATION TESTERS IN TESTING ANTENNA SYSTEMS.—The theory of operation of the megger is discussed in Basic Electricity, NavPers 10086 (revised). Essentially, it consists of a d-c generator supplying a 2-branch circuit, which contains an indicating meter calibrated to read in megohms the unknown resistance inserted in one of the branches.

The megger is used to check the insulation resistance of antennas, transmission lines, cables, generators, motors, transformers, and so forth. Occasional checks over a period of time with a megger will show the condition of insulating material used on antennas, transmissions, etc, and in this manner indicated likely faults. It is also widely used to detect, or track down, insulation faults after they have occurred.

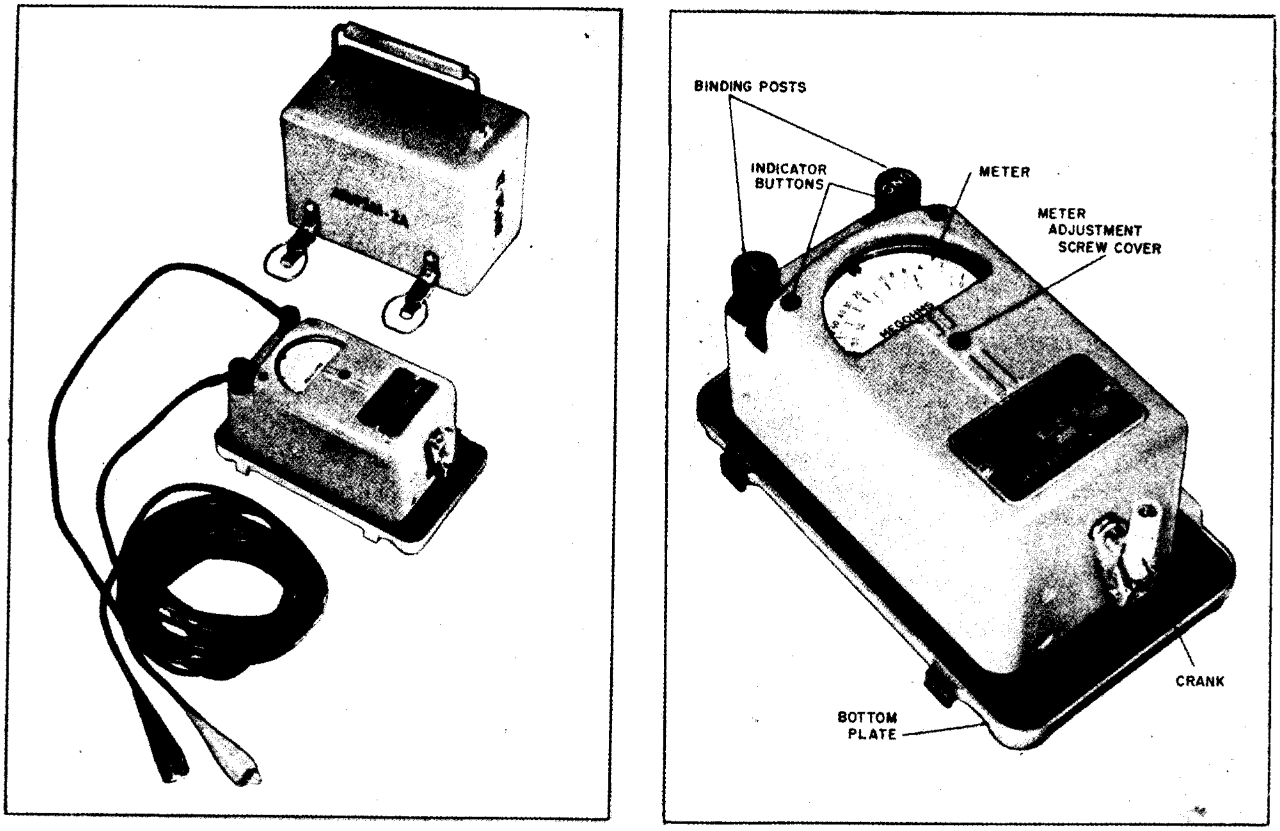
Another type of insulation test set (closely related to the megger) employing an a-c generator, a rectifier, and an ohmmeter circuit with a conventional d-c milliammeter (Insulation Test Set AN/PSM-2A) is illustrated in figure 12-5. It is designed to measure insulation resistance from 0 to 1000 megohms. The testing voltage is 500 volts d-c.

The meter pointer should read infinite resistance when there are no external connections to the output binding posts, L, and GND. If the pointer does not stand over the infinity mark, it is necessary to adjust the meter adjustment screw until the pointer stands over the infinity mark. When the meter terminals are short-circuited and the crank is turned at normal operating speed (indicator buttons glowing steadily), the meter pointer should be over the zero mark.

The operation of the insulation test set is relatively simple.

1. Be sure that the apparatus, line, or circuit to be tested is disconnected from its power supply in accordance with safety instructions. Ground the apparatus, line, or circuit to be tested to discharge any capacitors connected to it.
2. Connect the spade-type terminal lug of the black lead to the GND binding post of the test set.
3. Attach the alligator clip of the black test lead to the side of the circuit (under test) nearest ground potential.
4. Connect the spade-type terminal lug of the red lead to the L binding post of the test set.
5. Attach the alligator clip of the red test lead to the conductor to be tested.
6. Turn the crank in either direction at the minimum speed required to provide steady illumination of the indicator buttons.
7. Read the megohms of resistance offered by the material being tested. If the resistance is more than 1000 megohms at 500 volts d-c, the meter will remain at rest over the infinity mark (∞), indicating that the resistance of the insulation being tested is beyond the range of the meter.

Measuring the insulation resistance of lines and antennas is a very important and effective means of determining the condition of the antenna and its transmission line. Readings taken in these tests should be 100 megohms or greater, although lower readings will be registered on wet or humid days. Of course, megger tests are more meaningful if made during good weather. Some antennas have a d-c short circuit and therefore the insulation resistance cannot be measured directly; among those that are short-circuited with respect to direct current are the AT-150/SRC, the AS-390/SRC, the NT-66015, and the NT-66016.



1.55
Figure 12-5.—Insulation Test Set AN/PSM-2A.

Before performing any tests, the megger should be checked to determine if it is in good working order, as explained previously. Make good, positive, clean connections to antenna and ground, otherwise the contact resistance will be an appreciable part of the total megger reading.

For most antenna installations the test procedure is as follows:

1. Disconnect the transmission line at the equipment and test the line at this point. (NOTE: Do not connect the megger to the equipment at any time.)
2. If the reading registers below 100 megohms, disconnect the transmission line at the antenna and test individually both the transmission line and the antenna at this point. This will indicate that the trouble lies either in the transmission line or the antenna or both.
3. If the trouble (low-resistance indication) is shown to be in the transmission line, disconnect the line at the various coaxial connectors and test the individual sections of the line to further localize the trouble.
4. If the trouble (low-resistance indication) is shown to be in the antenna, the antenna will have to be repaired. (However, it should be recalled that certain antennas normally contain a d-c short circuit. The resistance of these antennas should be approximately zero ohms, as indicated on a low-reading ohmmeter.)

These tests are made at prescribed intervals, and the readings are recorded on the proper forms (the Maintenance Standards Books, Resistance Test Record Card, etc.).

Continuity checks are also made with the megger or a multimeter. In performing these tests, the transmission line is disconnected at both ends. At one end, the inner conductor is shorted to the outer shield. At the other end, the resistance between the inner conductor and the outer conductor is measured.

The following three steps, taken from the Maintenance Standards Book, Part II, Preventive Maintenance Check-Off for Radio Receiving Sets AN/SRR-11, 12, 13, NavShips 91875.41, will illustrate the routine measurements made on the antenna and transmission line. The steps are indicated in table 12-1 and the connections are illustrated in figure 12-6.

Four of the steps used in testing the antenna and transmission line of Radio Transmitting Sets AN/SRT-14, 15, 16 are illustrated in figure 12-7 and table 12-2. These steps are taken from Part II, Preventive Maintenance Check-Off for these transmitting sets.

NOTE 1: The jumper wire must be connected from the inner conductor to the outer conductor. The jumper wire should be as short as possible and the connections must be good. The resistance indicated is that of the inner conductor in series with the outer conductor and should be low (a fraction of an ohm).

NOTE 2: With the switches in the positions indicated, continuity is provided from the antenna through the antenna cable, and through the antenna coupler loading switches to a loading capacitor that blocks the d-c path to ground through the tuning coils. The resistance indication should be very high.

NOTE 3: With the switches in the positions indicated, continuity is provided from the meter, through the antenna cable, the antenna coupler, the cable from antenna coupler to the r-f tuner, the r-f tuner coils to ground, and back to the meter. The resistance indicated should be a small fraction of one ohm.

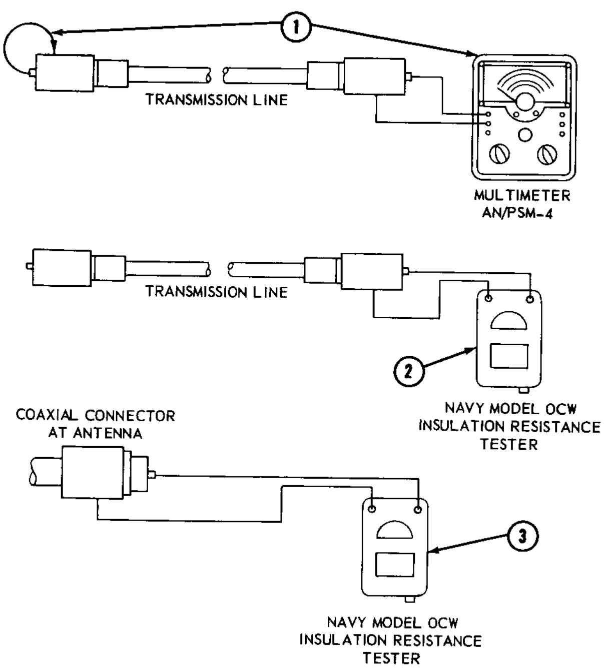
Table 12-1. Antenna and Transmission Line.

Operating Conditions and Control Settings:
Antenna and transmission line disconnected from Radio Receiving Set AN/SRR-11, -12, or -13

Test Equipment Required:
Multimeter AN/PSM-4
Navy Model OCW Insulation Resistance Test Equipment

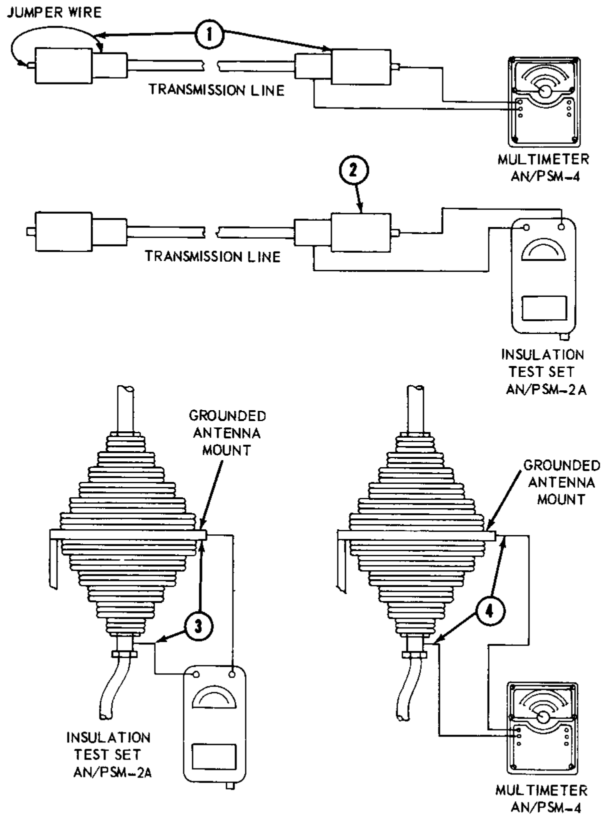
Step No.	Step Action Required	Preliminary Action	Read Indication On	Perf. Std.
1	Record resistance of transmission line.	Connect equipment as shown in fig. 12-6. Set Multimeter AN/PSM-4 function switch: Rx1.*	Multimeter AN/PSM-4	__ohms (See note at bottom of chart.)
2	Record insulation resistance of transmission line.	Connect equipment as shown in fig. 12-6.	Insulation Resistance Navy Model OCW Test Equipment.	__meg (50 or higher.)
3	Record insulation resistance of antenna.	Connect equipment as shown in fig. 12-6.	Insulation Resistance Navy Model OCW Test Equipment.	__meg (50 or higher.)

*When recording resistance of transmission line, the jumper wire must be connected from inner conductor to outer conductor. This method of connection provides continuity from meter, through inner conductor, jumper wire, and outer conductor, back to meter. Resistance reading will therefore be resistance of outer conductor plus resistance of inner conductor. To avoid error due to jumper wire connection, jumper wire must be kept as short as possible, and connections must be good. The resistance reading obtained in this step depends upon length and type of transmission line. For all normal installations, resistance is a small fraction of one ohm.



1.56

Figure 12-6.—Meter connections for making antenna and transmission-line measurements (receiver).



1.57

Figure 12-7.—Meter connections for making antenna and transmission-line measurements (transmitter).

CLEANING INSULATORS.—Leakage current over the surface of an insulator is usually due to moisture and impurities on the surface such as salt spray, soot, or dust.

All standoff insulators, end seals of transmission lines, and waveguide windows should be cleaned at least once a month, and more often if conditions warrant.

The smaller the insulator, end seal, or waveguide window, the more important is this maintenance procedure. The cleaning must be thorough with nothing left to chance.

Paint, varnish, shellac, or grease must not be applied to any portion of ceramic or phenolic insulating materials forming a part of the antenna system.

TESTING ELECTRON TUBES

The leading cause of failure or poor operation of electronic equipment (transmitters as well as receivers) is the electron tube. If all tube failures could be eliminated, the maintenance load would be reduced considerably. Tubes do not always collapse completely. Their performance may gradually deteriorate but not to the extent that it will be apparent in a tube checker. One reason for the failure of the average tube checker to give a full indication of the capabilities of a tube is the 60-cycle sine wave that is applied to the grid of the tube under test. In electronic equipment, all kinds of wave shapes may be applied at frequencies varying from a few cycles to several billion cycles per second. The usual shipboard tube tester cannot determine accurately the ability of a tube to act as an oscillator or as an ultra high frequency amplifier.

Because of the importance of the method of using the tube checker, the Bureau of Ships has issued an instruction (BuShips Inst. 9670.89) establishing the general policy for testing electron tubes.

Table 12-2.—Operating Conditions and Control Settings.

Operating Conditions and Control Settings:
All transmitter Primary Power switches set to OFF position; Antenna and Transmission lines disconnected.

Steps 1 through 4 Test Equipment Required: Multimeter AN/PSM-4 Insulation Test Set AN/PSM-2

Step		Preliminary Action	Read Indication On	Perf. Std.
No.	Action Required			
1	Record transmission line resistance. (See Note 1.)	Connect Multimeter AN/PSM-4, using R x 1 ohmmeter scale, from inner conductor to output conductor of transmission line. Connect jumper wire from inner to outer conductor at opposite end of transmission line. Record resistance (a) of line from transmitter to Antenna Coupler, and (b) from Antenna Coupler to Radio Frequency Tuner.	Multimeter AN/PSM-4.	(a)_ohm (b)_ohm
2	Record transmission line insulation resistance.	Connect Insulation Test Set AN/PSM-2 from inner to outer conductor of (a) transmission line from transmitter to Antenna Coupler, and (b) transmission line from Antenna Coupler to Radio Frequency Tuner.	Insulation Test Set AN/PSM-2.	(a)_meg (b)_meg (50 or over.)
3	Record antenna insulation resistance. (See Note 2.)	Reconnect all transmission lines. Set Antenna Transfer switch to TUNER IN, ANTENNA COUPLER LOADING switch to A, and TRANSFORMER switch to DIRECT. Connect Insulation Test Set AN/PSM-2 as shown in fig. 12-6 and record insulation resistance.	Insulation Test Set AN/PSM-2.	_meg (50 or over.)
4	Record antenna cable resistance. (See Note 3.)	With all antenna cables connected, set ANTENNA TRANSFER switch to TUNER IN, ANTENNA COUPLER LOADING switch to DIRECT, and TRANSFORMER switch to DIRECT. Connect multimeter AN/PSM-4, using R x 1 ohmmeter scale, as shown in fig. 12-6.	Multimeter AN/PSM-4.	_ohm

Table 12-2.—Operating Conditions and Control Settings—Continued.

Time Schedule: Record and initial.
Approx. Time Reqd. for Quarterly Steps—3 hrs.

Quarter		1st Quarter 19—	2nd Quarter 19—	3rd Quarter 19—	4th Quarter 19—
Step 1	a				
	b				
Step 2	a				
	b				
Step 3					
Step 4					
Initial					

The practice of wholesale removal and test of electron tubes on a periodic basis has been discontinued. If routine test of an electron tube in a designated application is necessary, the instruction book will specify an exception to the rule.

The following maintenance routine is strongly recommended:

1. When a performance deficiency is detected, make an all-out attempt to isolate the specific cause.
2. When the trouble has been localized and a tube is suspected, remove and test that tube. If found good, replace in the same socket. Interchange of tubes between sockets should be avoided.
3. If repair by tube substitution is necessary as a last resort, test the new tube (within the capability of the tube tester) before placing it in service.
4. If a new tube tests good but will not work in a particular socket, make a note of this fact and save the tube for use in another application where it will work. The Bureau of Ships is particularly interested in receiving information on cases where extensive selection of tubes for a particular socket is necessary for proper operation. Failure Report Forms (DD787) and Performance and Operating Reports (NavShips 3878 revised) are convenient ways to do this.

TESTING CRYSTAL DIODES

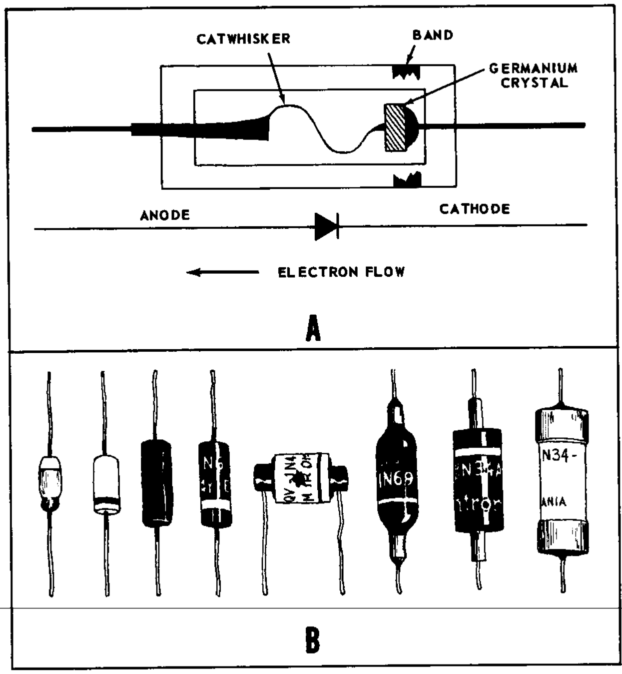
Navy electronics technicians usually will be working with three types of crystal diodes: General-purpose germanium and silicon diodes, power silicon diodes, and forward and reverse high-frequency silicon diodes (commonly called mixer crystals).

A sectional view of a typical germanium crystal diode is illustrated in figure 12-8A. A number of different types of crystal diodes are illustrated in part B. Germanium diodes are usually enclosed in a plastic or glass cylindrical case with pigtail connections.

The cathode end, usually marked with a painted band or other distinctive marking, contains a small crystal of N-type germanium. A thin catwhisker wire makes a point contact with the crystal. Electrons will flow easily from the germanium into the catwhisker; this makes the catwhisker the anode and the crystal the cathode. Some diodes of this design are being made with silicon crystals in place of the germanium. Silicon power diodes are just beginning to be produced. Their outputs and operating temperature are considerably above those of germanium.

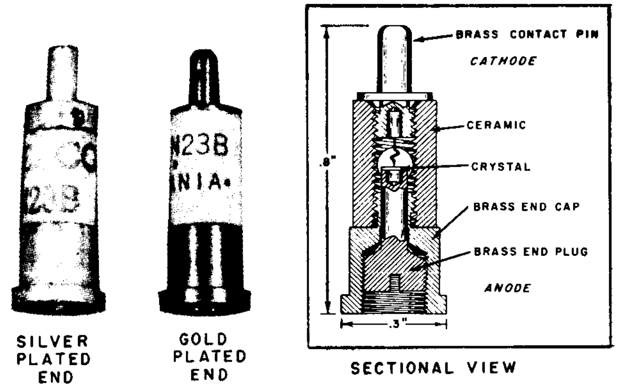
Germanium diodes, such as the 1N34A or 1N69, are used for a wide range of applications, such as video, audio, and pulse circuits. Many are used as detectors in radio and television equipment, and as mixers at frequencies up to 900 megacycles.

Mixer crystals, such as the 1N21 or 1N23, are designed for microwave detection and mixing. These are very carefully made diodes, with low-loss ceramic barrels and machined and gold-plated brass tips and bases for close fits in waveguides and coaxial fittings. Two 1N23B



1.58

Figure 12-8.—Germanium crystal diodes.



1.59

Figure 12-9.—Cartridge-type silicon crystal diodes.

silicon crystal diodes are shown in figure 12-9; a sectional view is also shown.

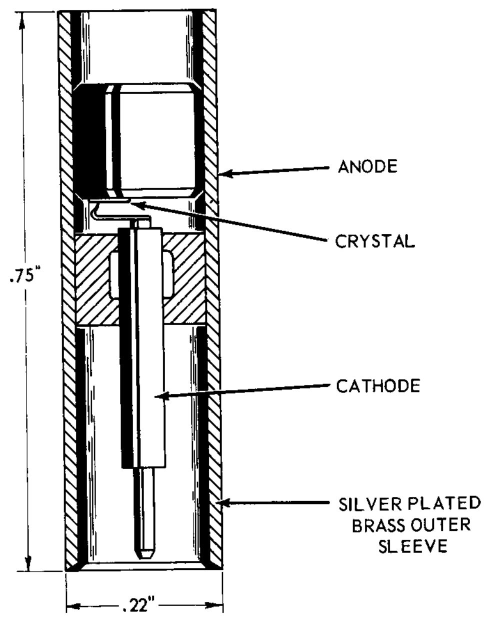
A small crystal of almost pure silicon acts as a P-type semiconductor. Electrons will pass easily from the catwhisker to the silicon, making, in effect, the base the anode and the tip the cathode. Mixer crystals of this type are available for use with frequencies from 1000 to 10,000 megacycles.

Diodes for 10,000 megacycles and above are usually of the coaxial type, as shown in figure 12-10.

Reverse crystal mixers (for example, the 1N23CR) cause considerable confusion. Reverse polarity crystals (fig. 12-11A) are identical in characteristics to the ordinary type (fig. 12-11B) whose number they carry. Thus, a 1N23CR is identical electrically to a 1N23C except for the reversal of polarity. The crystal in the reverse type (1N23CR) is fastened to the tip, making the tip the anode and the base the cathode. In the ordinary type the crystal is fastened to the base, making the base the anode and the tip the cathode.

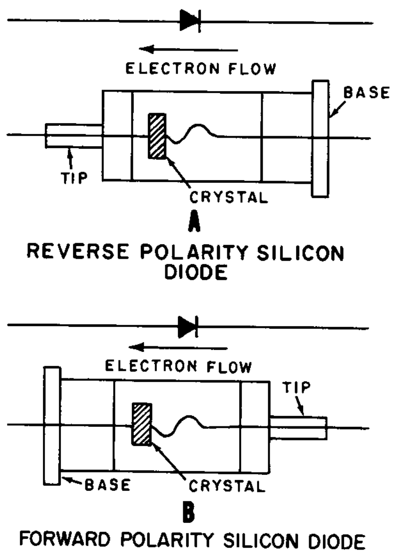
The properties of the crystal rectifier depend on the pressure, the contact area, the place of contact, etc. This has been carefully adjusted at the factory and should not be upset by tampering with the set screw.

The area of the contact is very small, and if too much power is passed through the cartridge, the resulting heat will damage it, and the crystal rectifier will be impaired. The



1.60

Figure 12-10.—Sectional view of coaxial silicon crystal diode.



1.61
Figure 12-11.—Reverse and forward-polarity silicon diodes.

crystal rectifier may be damaged, for example, by a static discharge through it. If the ET holds one end of the crystal and touches the equipment with the other end, any static charge on his body will discharge through the crystal mixer. He should first touch his finger to the mixer chassis and then insert the crystal rectifier in its holder, as illustrated in figure 12-12.

A crystal may also be damaged by exposure to a strong r-f field. Therefore crystal rectifiers must be kept in a metal box or wrapped in metal foil except when in use or being tested.

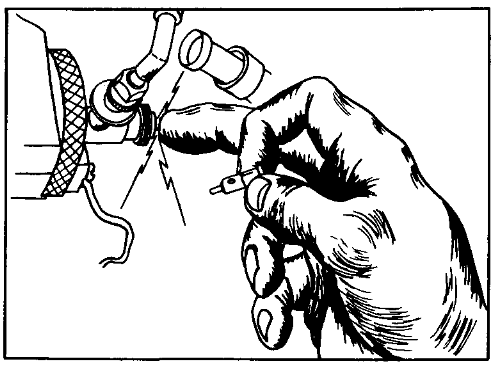
In radar equipment in which a crystal rectifier is used, it is normally protected by a TR tube. The purpose of the TR tube is to place a short across the line leading to the crystal rectifier by means of gas breakdown in the tube during the firing of the main transmitter pulse. The returning signal, or echo, is much smaller than the transmitter pulse and does not cause a breakdown. It therefore comes through to the crystal rectifier. During the main pulse, some power does leak through the TR tube because it is not a perfect short. However, this power is normally small enough not to damage the crystal.

It is obvious that if the TR tube does not function properly, the crystal rectifier may be damaged. Improper functioning may be due either to the fact that the TR tube is defective or there is incorrect TR tuning (if tuning adjustments are provided).

Another possible cause of crystal damage is a distortion of the pulse shape of the modulator. If the pulse has a sharp peak at the beginning (instead of the usual square shape), much more power will come through the TR tube than for a square pulse of equal energy (because of insufficient time for the blocking action to occur) although the TR tube may be operating normally. Faulty TR operation and distorted modulator pulses are the two main causes of crystal rectifier impairment. Continued impairment of good crystal rectifiers is an indication that the TR tube and the modulator should be checked.

The deterioration of the crystal rectifier in a receiver produces an increase in noise or a decrease in signal, or both, assuming that other factors (for example, receiver gain, transmitter strength, and target distance) remain the same. Such a change results in a decrease in the signal-to-noise ratio; and it is the signal-to-noise ratio that determines the over-all merit of a receiver. Other possible causes of a low signal-to-noise ratio are improper functioning of the first IF stage (pre-IF), or excessive losses between crystal and first IF stage (such as in the cable or connectors), or improper tuning of the local oscillator.

If produced gradually, the impairment of a crystal rectifier is quite difficult to notice. One method of detecting the impairment is to compare the operation of the crystal rectifier with that of

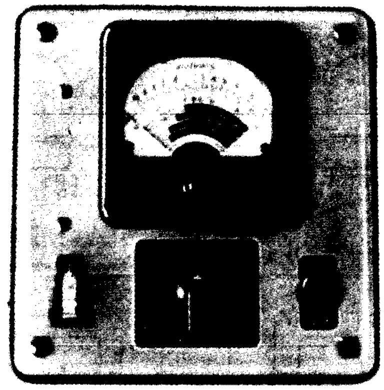


1.62
Figure 12-12.—Reinserting crystal rectifier in mixer.

a new one. If, under the same operating conditions, the noise is less or the signal is greater with the new crystal, the old crystal is probably impaired. However, if the crystal rectifier current remains unchanged, it does not necessarily mean that the crystal rectifier is unimpaired.

To test a crystal rectifier properly and completely is an elaborate matter and requires precision test equipment. However, the crystal rectifier tests sets, Model TS-268/UTS-268/U Series, supplied for Navy ET's are sufficiently accurate for field use.

A front view of Model TS-268/U Crystal Rectifier Test Set is shown in figure 12-13. The limits (minimum forward-to-reverse resistance ratio and maximum reverse (back) current) established by laboratory tests are shown in table 12-3.



1.63

Figure 12-13.—Front view of Crystal Rectifier Test Set TS-268/U.

Table 12-3.—Crystal Rectifier Limits.

Crystal Rectifier Types	Backward-to-Forward Resistance Ratio (minimum)	Back Current in ma (maximum)
1N21	10/1	0.40
1N21A	10/1	0.175
1N21B	10/1	0.125
1N23	10/1	0.4
1N23A	10/1	0.3
1N23B	10/1	0.175

TESTING TRANSISTORS

Transistors may be tested "in-circuit" or "out-of-circuit." Also, the tests may be either d-c, where the measurements are made by d.c. test equipments, or a-c where there is an a-c input to the base circuit and an output from the collector circuit. A-c measurements may be made either in-circuit or out-of-circuit. D-c measurements can be made out-of-circuit only; otherwise, the measurements might be affected by equipment d-c or biasing voltages.

Precautions to take before making any transistor test:

1. Make sure that all power has been removed from the equipment under test before servicing, testing, or removing a transistor or transistorized assembly.

2. Before employing any test equipment, it should first be determined that the test instrument meets the requirements for the test and type of circuit.

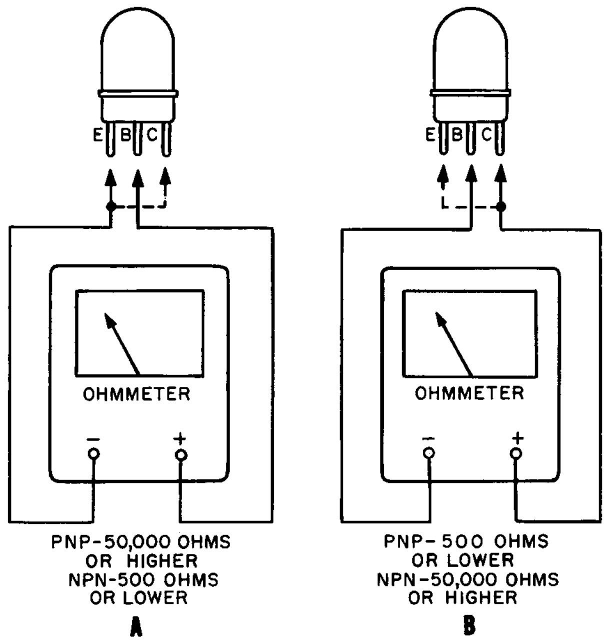
3. Be sure that any line-powered test equipment has been properly grounded to the chassis of the equipment under test.

4. Check the test equipment circuit on all ranges, to be sure that it does not pass more than 1 milliampere of current through the transistorized circuit under test. More amperage cannot safely be used for testing most transistor circuits. Use a low-resistance milliammeter in series with the test leads for this check.

5. Before making any measurements, be sure that any voltage applied is of the correct polarity for the circuit under test. Do not depend on the indicated polarity; use a voltmeter in series with the test leads for this check.

6. Do not troubleshoot transistor circuits by the shorting-to-ground method. Short circuits of any kind will damage a transistor. Extreme care must be taken to avoid these shorts—use special insulated test probes to prevent accidental shorting.

A rough check may be made on a transistor by means of d-c tests that will determine its forward and backward resistances and also any leakages or shorts. Connections for these tests are shown in figure 12-14. With the positive ohmmeter lead connected to the base of a PNP transistor (fig. 12-14A) a high-resistance reading (50,000 ohms or higher) should be obtained between base and emitter, and between base and



70.102
Figure 12-14.—Transistor resistance testing.

collector. With the negative ohmmeter lead connected to the base of a PNP transistor (fig. 12-14B) the resistance between the base and collector and between the base and emitter should be 500 ohms or less. If the same ohmmeter tests are made on an NPN transistor, the results will be reversed; that is, the high-resistance readings will be obtained with the negative ohmmeter lead connected to the base, and the low-resistance readings with the positive ohmmeter lead connected to the base. If the correct resistance readings are not obtained from the ohmmeter test, the transistor should be replaced.

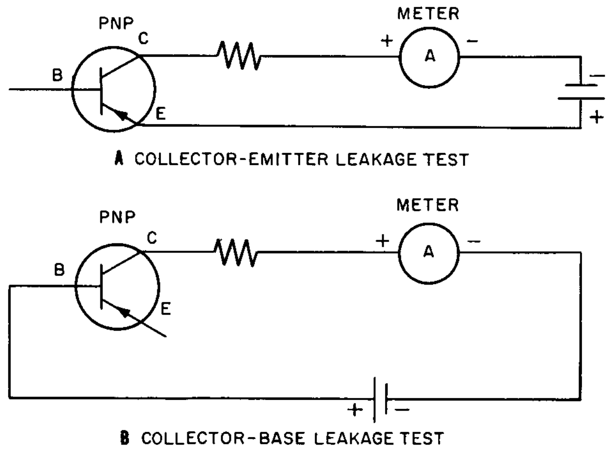
This type of test may also be used for determining the type of a transistor, PNP or NPN, when its type is unknown. With the test connection as in figure 12-14A, a high-resistance reading (50,000 ohms or higher) shows that it is a PNP type; a low-resistance reading (500 ohms or less) shows that it is an NPN type.

In checking transistors, there are two basic tests—collector current leakage and transistor gain, or amplification.

Age and exposure to higher-than-normal temperatures may develop greater-than-normal collector leakage current, generally designated as I_{CO}. Such current is greatly dependent on ambient temperature; thus extreme care must be taken to see that this temperature remains under control. One positive sign of a defective transistor is instability of I_{CO}. When there is a tendency for the leakage current to climb slowly of its own accord, it is quite evident that the transistor is defective. A high leakage current indicates a deterioration of the transistor, and is usually accompanied by lower gain.

As illustrated in figure 12-15, collector leakage current tests may be made in two ways. Figure 12-15A shows the connections for checking the leakage current in the collector-emitter circuit, with the base open. Figure 12-15B shows the connections for checking the leakage current in the collector-base circuit, with the emitter open. Any contamination on the surface of the transistor, or a short circuit within, will produce a high current reading on the meter.

In comparing the two test arrangements, the only advantage of the test in figure 12-15A is that, since the collector-emitter circuit is of low resistance (possibly about 1000 ohms), normally there will be sufficient leakage current to be read on a milliammeter, which is nearly always available. However, the test outlined in figure 12-15B requires a much more sensitive instrument, and is to be preferred if a suitable instrument is available. Since the transistor is reverse-biased (PNP-type transistor with negative terminal of battery toward collector), the



70.103
Figure 12-15.—Collector leakage current test, schematic diagram.

reverse current is very small. It is a high-resistance circuit (on the order of 50,000 to 70,000 ohms), and the leakage current is usually no more than 10 to 15 microamperes. Such small currents are best measured on a transistor test set, which is usually provided with a sensitive microammeter.

Since one of the primary functions of a junction transistor is amplification, one of the basic tests, in addition to the collector leakage test, is a check of gain (or amplification), designated BETA. The gain test is a measurement of the change in collector current for a small change in the base current.

All of the current in a transistor is supplied by the emitter, of which more than 90 percent goes to the collector and the remainder to the base. Where, for example, 95 percent of the current goes to the collector and 5 percent to the base, then beta = 95/5 = 19. A beta of 19, then, means that for any change in current in the base, the change in the collector will be 19 times as great.

To measure beta, approximately, correct results can be obtained by removing the transistor from the equipment and using d-c test methods. Better results can be obtained, however, when the test is made under operating conditions, using a-c test methods. This test can best be accomplished by use of a transistor test set designed specifically for the purpose, such as the transistor test set, TS-1100.

MAINTAINING EARPHONES AND MICROPHONES

The best way to maintain earphones and microphones is to ensure that they are handled properly. Proper handling includes, for example, hanging up earphones by the straps, not by the cord; removing a plug from a jack by grasping the plug, not the cord; avoiding kinks or other strains in the cord; avoiding rough handling of microphones and earphones, and avoiding exposure to moisture. Heat lamps may be used to protect or to dry out carbon microphones.

Repair consists largely of replacing or repairing plugs, jacks, and cords. In any case, do not place defective equipment with the ready spares. It should be repaired first.

MAINTAINING RADIO TRANSMITTERS

The correct preventive maintenance procedure for any type of transmitter is included in the instruction book that accompanies the equipment. It is the purpose of this portion of the chapter to list some of the general procedures used in maintaining one type of transmitter (Radio Transmitting Sets AN/SRT-14, 15, 16). The operation of this transmitter is discussed in chapter 9 of this training course.

GENERAL MAINTENANCE.—The ET should make every effort to become familiar with the equipment in order that he may be able to recognize and anticipate avoidable defects. Table 12-4 will be of assistance in making these observations.

The radio frequency amplifier meter readings (power amplifier current, intermediate power amplifier current, and voltmeter) should be taken under the same conditions and with the same antenna or dummy load. Weekly readings are to be made and compared with those of the previous week so as to check the various conditions existing. It should be borne in mind that production-line tubes will vary considerably in their current output readings. However, a definite trend or fluctuation in the readings is to be interpreted as an indication of trouble. By charting these fluctuations, a reliable record of tube performance is available for ready reference and trouble may be avoided by changing tubes before a critical stage is reached.

Complete instructions for taking and recording the meter readings are given in eleven steps in the POMSEE book (Part II, Preventive Maintenance Check-Off) for this equipment. The meters to be read in performing steps 3, 4, and 5 are illustrated in figure 12-16. Page five of Part II, Preventive Maintenance Check-Off (which lists the operating conditions and control settings for steps 3, 4, and 5) is reproduced as table 12-5. Following page five are charts for recording the weekly meter readings associated with steps 3, 4, 5.

Some general maintenance procedures may be listed as follows:

1. Check for unusual odors, such as that of hot potting compound, which might indicate an overloaded transformer; burning paint, due to overheated resistors; and burning rubber, due to excessive current through a rubber-covered conductor.

2. Use an air hose to remove dust, dirt, and foreign particles. Extreme care must be exercised when the air hose is used around delicate

Table 12-4.—Initial Checks.

Item	Check
1. Primary Power	The ship power supply must be available at all times.
2. Control Equipment	Radiophones, teletype; facsimile, hand keys and other control equipment must be in good working order and connected properly.
3. Insulators	Antenna and line insulators must be kept clean and free of unwanted grounds.
4. Cables	All internal and external cables must be firmly and properly connected.
5. Dirt and	Leakage paths are often caused by dirt and moisture, resulting in arcovers and loss of efficiency.
6. Loose Parts	In operation, some mountings or fittings may work loose or become damaged. Correct this condition as quickly as possible.
7. Visual Check	Check for broken, damaged, or loose hardware; meters; knobs; dials; or lamps. Replace damaged parts without delay.

parts such as tuning capacitors. As a precautionary measure, the air line should be purged of moisture by directing the nozzle toward the floor and releasing the air in the line before directing it toward the equipment.

3. Avoid, if possible, disturbing the layout of the wiring. If wiring must be removed, be sure to return it to its original position after the cleaning procedure to prevent oscillation, feedback, and other circuit disturbances. Check all sockets, and remove any dirt or corrosion with solvent or with fine sandpaper or crocus cloth.

4. After cleaning, inspect the equipment for faulty or damaged parts. Some of these parts include tube sockets and contacts, springs, gears, tuning capacitors, potentiometers, bandswitches, insulators, terminal strips, jacks, plugs, and hinges. Check for and replace or secure loose or damaged hardware.

5. The operating controls should be given a careful visual inspection and then checked for correct operation and setting. Turn each control slowly to its maximum clockwise limit, then to its maximum counterclockwise limit. Binding or scraping should be noted and corrective measures taken.

6. In gear assemblies and in tuning mechanisms backlash must be held to a minimum. Hence, trouble of this sort should be noted and corrected or reported as soon as possible.

7. Replace damaged parts, such as shorted or leaky capacitors or burned out resistors. However, before actual replacement of the damaged part, the circuit should be carefully inspected to find the cause of the trouble. Only in extreme emergencies should replacement be made without a checkup.

8. It is important to remove dirt or corrosion on the prongs of plug-in parts, such as tubes, jacks, and plugs, to avoid a high-resistance connection between the prong and its socket. Use crocus cloth or fine sandpaper.

9. Cables and cords and their jacks and plugs must be checked for damage to their inserts and insulation. Look for opens, shorts, and intermittent contacts. The latter may often be found by wiggling the plugs in their sockets. If damage is found, or if trouble is suspected, use an ohmmeter to check for continuity in the cords and cables.

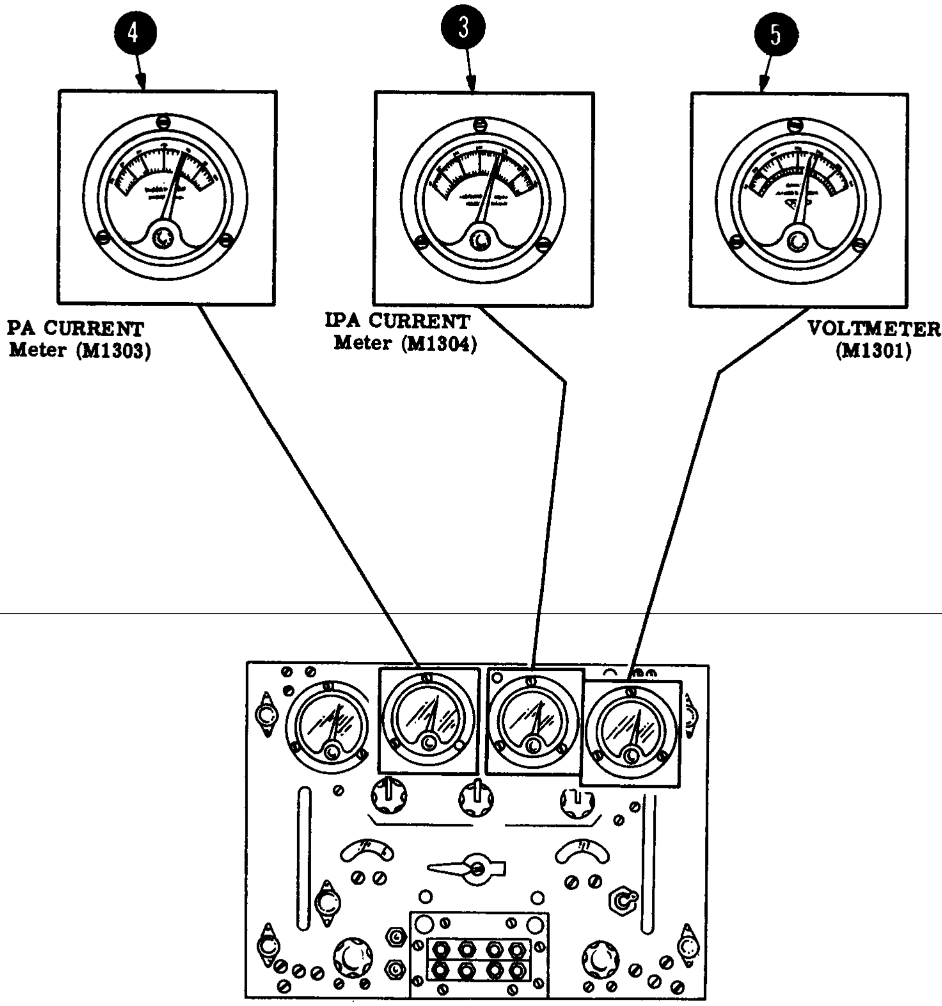
LUBRICATION.—The lubrication procedure is spelled out in the instruction book.

When dispensing a lubricant, wipe all dirt, dust, or moisture from around the opening of the container. The containers must be kept closed when not in use to prevent moisture condensation on the surface of the lubricant and to keep dust and dirt out of the container. It is extremely important that lubricants be kept free of foreign matter.

Many of the bearings used in this particular equipment are made of oil impregnated bronze and require no lubrication.

Special Maintenance.—Noise, loss of sensitivity, and improper tuning may be caused by faulty or dirty tuning capacitors. (Serious losses may also occur in certain other tuned circuits.)

Rotor contacts, bearings, and plates may be cleaned with an approved solvent. Pipe cleaners (if available) are especially useful for cleaning between capacitor plates. A small brush, dipped in solvent, may also be used for this purpose. Be careful not to damage or bend any of the plates.



1.64
Figure 12-16.—Meters to be read in performing steps 3, 4, and 5 in part II, Maintenance Standards Book.

Some relay contacts are plated with thin coats of silver. In cleaning this type of contact, avoid the use of abrasives, which may damage the contact surfaces. These surfaces are cleaned with solvent.

Pitted contacts on heavier relays, such as those used for power contact circuits, are cleaned with a fine grade of crocus cloth. Badly pited contacts should be replaced singly, if possible; if not, a complete new relay may have to be installed. After being cleaned, the contacts or relays are finished with a burnishing tool.

The moving parts of relays are checked as follows:

1. Check the armature pivot points. They should be free of burrs, rust, corrosion, or any other defect that may prevent free movement. Remove burrs or corrosion with a fine file or fine sandpaper. However, be sure that the shape and location of the pivot points have not been changed.

2. The return spring should be inspected for correct tension. Replace the spring if rusted or damaged.

3. Examine the relay winding for damage to the insulation. Damaged wires or insulation may be repaired with tape or insulated tubing (spaghetti).

4. Check the relay core for corrosion. If corroded, the relay should be replaced to avoid possible future failure.

5. Check the frame; repair or replace if damaged.

Wafer switches and detents should be examined carefully to ensure firm spring tension. Weak spots require restoration of spring tension. However, long telephone-type switch or relay contacts should never be bent. These contacts should be replaced, if possible. If the contacts cannot be replaced singly, the entire switch may have to be replaced, because poor contact pressure leads to trouble and eventual failure.

Check the detent actions and the switch shaft. These parts, as well as the switch contacts, may be cleaned with solvent. The various detent assemblies, especially those in the various subunits of the RFO, need careful attention. After a switch or detent has been cleaned, the part should be relubricated as directed in the instruction book.

When inspecting the miniature sprocket-type chains, be sure to check the adjustment of the sprocket idlers. Proper tension on the chains must be maintained at all times. To achieve correct tension, a balance must be found which

Table 12-5.—Operating Conditions And Control Settings.

Operating Conditions and Control Settings:
Transmitter adjusted for 100-watt, CW operation.
TEST KEY: locked ON position.

Step		Preliminary Action	Read Indication On	Perf. Std.
No.	Action Required			
3 **	Record IPA METER readings.	Set IPA METER SELECTOR switch (S1386) to I_{c1}, I_{c2}, and I_k, in turn. Record meter indication for each position and with transmitter adjusted for each of the frequencies indicated in PERF. STD. column.	IPA CURRENT meter (M1304).	mc I_{c1} I_{c2} I_k .35 ___ ___ ___ ma 2.5 ___ ___ ___ ma 5.5 ___ ___ ___ ma 6.5 ___ ___ ___ ma 11.0 ___ ___ ___ ma 15.5 ___ ___ ___ ma 16.5 ___ ___ ___ ma 21.0 ___ ___ ___ ma 25.5 ___ ___ ___ ma (0.1 to 2) (4 to 8) (50 to 85)
4 **	Record PA METER readings (100-watt operation).	Set PA METER SELECTOR switch (S1386) to I_{c1}, I_{c2}, and I_k, in turn. Record meter indication for each position and with transmitter adjusted for each of the frequencies indicated in PERF. STD. column.	PA CURRENT meter (M1303).	mc I_{c1} I_{c2} I_k .35 ___ ___ ___ ma 2.5 ___ ___ ___ ma 5.5 ___ ___ ___ ma 6.5 ___ ___ ___ ma 11.0 ___ ___ ___ ma 15.5 ___ ___ ___ ma 16.5 ___ ___ ___ ma 21.0 ___ ___ ___ ma 25.5 ___ ___ ___ ma (10 to 20) (20 to 80) (150 to 300)

Table 12-5.—Operating Conditions And Control Settings—Continued.

Step No.	Step Action Required	Preliminary Action	Read Indication On	Perf. Std.
5 **	Record VOLTMETER indications.	Set VOLTMETER switch (S1384) to BIAS, LV, MV, PA E_{c2}, and PA E_b, in turn. Record meter indication for each position and with transmitter adjusted for each of the frequencies indicated in PERF. STD. column. Set SERVICE SELECTOR switch (S1101): PHONE. Set VOLTMETER switch (S1384): PA E_b.	VOLTMETER (M1301).	mc BIAS LV MV .35 ____ ____ ____ VDC 2.5 ____ ____ ____ VDC 5.5 ____ ____ ____ VDC 6.5 ____ ____ ____ VDC 11.0 ____ ____ ____ VDC 15.5 ____ ____ ____ VDC 16.5 ____ ____ ____ VDC 21.0 ____ ____ ____ VDC 25.5 ____ ____ ____ VDC (-210 to -230) (270 to 330) (450 to 550)
				mc E_{c2} E_b E_b PH .35 ____ ____ ____ VDC 2.5 ____ ____ ____ VDC 5.5 ____ ____ ____ VDC 6.5 ____ ____ ____ VDC 11.0 ____ ____ ____ VDC 15.5 ____ ____ ____ VDC 16.5 ____ ____ ____ VDC 21.0 ____ ____ ____ VDC 25.5 ____ ____ ____ VDC (950 to 1150) (1200 to 1400) (270 to 330)

is a compromise between ease of operation and minimum backlash. In case of severe damage to the chain, it should be replaced. Remove dirt and grease with solvent.

MAINTAINING RADIO RECEIVERS

INSPECTION, CLEANING, AND ADJUSTMENTS.—The instruction book for each radio receiver lists certain preventive maintenance procedures that must be followed if the equipment is to be maintained in peak operating condition. Of course the instructions will vary, depending on the particular type of receiver, but the preventive maintenance instructions for Radio Receiving Sets AN/SRR 11, 12, 13 are typical.

The MONTHLY checks include the following: (1) Inspect to determine if the mounting bolts in the cabinet are tight, and tighten mounting bolts and all external fasteners when loose; and (2) inspect cords and plugs for wear and broken parts. Replace any cord that causes clicking sounds in the earphones when shaken during operation.

The QUARTERLY checks include the following: (1) Remove and replace the chassis in the cabinet. (If the chassis binds on the rails, adjust the chassis tilting fulcrum accordingly and lubricate according to the instruction book.); (2) check each plug-in unit for loose connections and appearance of the component. If the components show signs of overheating, apply corrective maintenance, as given in the instruction book; (3) inspect the chassis for loose interstage connectors (multisockets) on the chassis, and tighten as required; (4) inspect the band selector and reception control for loose crank pins that connect to the wafer shafts. If pins are loose they should be tightened according to the instructions given in the instruction book; and (5) remove dust from the chassis and assemblies by the use of a small blower. Remove excess lubricant from the band switch and reception control racks, miter gears, and dial gears. After the cleaning is accomplished, the equipment is lubricated according to instructions.

The SEMIANNUAL checks include the following: (1) Inspect spare assemblies for evidence of physical damage; (2) check alignment of tuning dial and the operation of the dial light, check the mirror assembly (mirror used for reflecting the frequency scale onto the groundglass screen), and align the tuning dial and clean the mirror according to instructions. Another semiannual check is that of receiver sensitivity. This is somewhat involved and is treated separately in the following section.

SENSITIVITY CHECK.—The setup for checking the sensitivity of the AN/SRR-11, 12, 13 receiving sets is shown in figure 12-17. Sensitivity checks (in microvolts) are made at various frequencies in the five bands covered by the receiver and under various operating conditions—for example, A1 broad and FSK, A1 sharp, A2, A3 broad, and A3 sharp.

Details for making the sensitivity checks are included in the instruction book and the Maintenance Standards Book; and a general treatment of sensitivity measurements is included in chapter 6 of this training course. However, the following brief description of the procedure for making one check (band 1, 14 kc, A1 broad) on the AN/SRR-11 is sufficient to give the general idea.

1. Set the reception control (fig. 9-15) to A1 BROAD, the output control to maximum (10), and the tuning dial to 14 kc.
2. Disconnect the antenna simulator (dummy antenna) from the signal generator and connect a short across the input of the antenna simulator.
3. With the add decibles switch in the -10 db position, adjust the gain control for a noise level of -10 db, as read on the output meter. (This is a total of -20 db with respect to 6 milliwatts, or the equivalent of an output level of 60 microwatts, or 0.19 volts across 600 ohms.)
4. Remove the short across the input of the antenna simulator and reconnect the dummy antenna to the signal generator.
5. With the signal generator set for an unmodulated output, tune the signal generator for a maximum indication on the receiver tuning meter.
6. Set the reception control to A1 SHARP, and adjust the receiver freq vernier to produce a beat note of 1000 cycles per second. This condition produces a maximum reading on the output meter.
7. Set the reception control to A1 BROAD.
8. With the add decibels switch in the 0 db position, adjust the signal generator for 0 db reading on the receiver output meter. (This is the equivalent of an output level of 6 milliwatts, or 1.9 volts across 600 ohms.)
9. Under this condition, the signal generator output level (in microvolts) is a quantitative

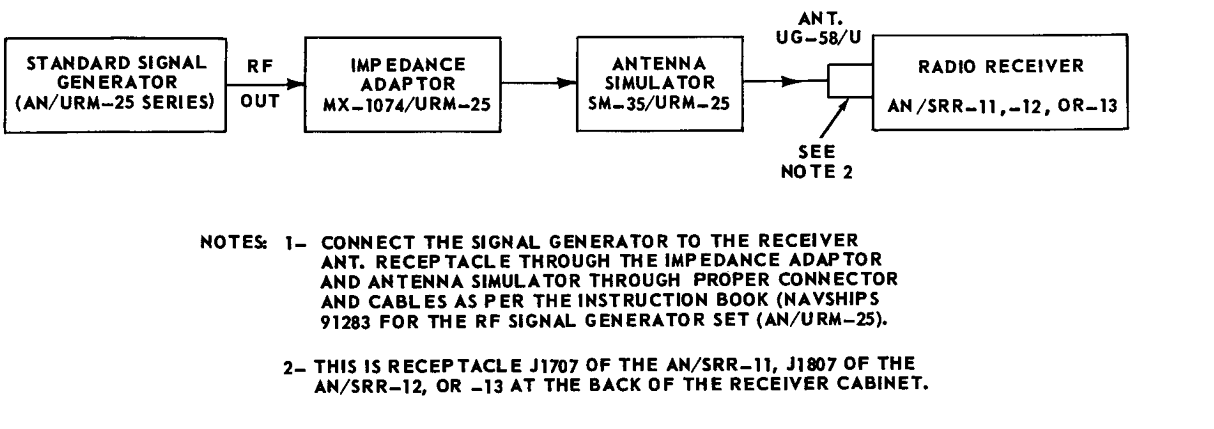


Figure 12-17.—Test setup for receiver sensitivity measurements.

measure of the receiver sensitivity. This value should be checked against the corresponding value given in the tables in the instruction book. For the particular check discussed (band 1, 14 kc, A1 BROAD) the sensitivity should be 4.7 microvolts.

MAINTAINING RADAR EQUIPMENT

Preventive maintenance (normally done by operators of radar equipment) includes the periodic inspection, cleaning, lubrication, checking of brushes, cleaning and tightening of contacts, calibration, and checking of system performance.

The routine maintenance schedule includes daily, weekly, monthly, quarterly, semiannual, and annual checks. In each case the necessary safety precautions must be taken.

The detailed steps to be taken in the preventive maintenance of radar equipment depend, of course, on the particular equipment being maintained. The following preventive maintenance procedures apply to Radar Set AN/SPS-10 which is described in chapter 11, of this course, Common Operating Adjustments.

DAILY CHECKS include checking the echo box ringing time of the transmitter.

WEEKLY CHECKS include cleaning out dust, wiping parts (especially insulators), wiping tubes and checking their seating (including tube clamps), testing spare fuses and replacing any missing spares, and cleaning plastic windows. Other weekly checks include CHECKING AIR FILTERS (a most important check) and making sure that the blowers are running, checking for any arcing in the r-f system, and checking to ensure that the crystal currents are within the correct range (0.4 to 0.6 ma).

MONTHLY CHECKS include such items as checking electrical contacts and the action of interlocks; checking the oil level in the antenna assembly and making sure that the nozzle is clean; lubricating gears; replacing TR and ATR tubes every 500 hours if necessitated because of poor signals or poor recovery time; and listening along the waveguide, r-f system, and antenna for arcing.

QUARTERLY CHECKS are largely of a mechanical nature. Stuffing tubes are checked and repacked if necessary, terminal strips and cables are checked, ferrule resistors and fuses are cleaned, and blown-fuse indicators and dial lights are checked to ensure that they are operative. Other monthly maintenance procedures include such items as replacing tubes missing from tested emergency spares, checking tube pins and sockets for corrosion, checking for corrosion in other places and applying touchup paint as needed, lubrication, checking brushes, on the antenna main drive motor and the slip rings, and cleaning the r-f system and tubes as needed.

The SEMIANNUAL CHECKS include greasing certain points in the antenna well, checking the brushes on the antenna selector switch motor, checking the brushes on the pulse-length switch motor, and oiling hinges and rotors.

ANNUAL CHECKS include a visual inspection of resistors for evidence of overheating, antenna overhaul, synchro and slip ring check, tightening of flange bolts, and certain greasing operations.

The chassis and cabinets are best cleaned with a vacuum cleaner or with clean cloths. A cloth moistened with an approved solvent may be used to clean high-voltage insulators and metal surfaces; the surfaces are finally polished with a dry cloth. Oil and dust must be cleaned out thoroughly, both inside and outside the cabinets. Oil inside a cabinet will usually be caused by a leaky oil-filled capacitor, which should be found and replaced. Oil inside the antenna assembly may be caused by leakage, carelessness in lubrication, or excessive lubrication.

Compressed air or portable blowers may blow dust into relay contacts and into open switches, and should be used cautiously, if at all.

Plastic windows and color filters should be cleaned on both sides with lens tissue or a soft cloth free from abrasive. An approved solvent may be used when needed. Care should be taken to avoid scratching because the plastic is relatively soft.

Air filters are used in the cabinet, modulator, and transmitter. The filters must be cleaned periodically (at least monthly). The accumulated dust is removed by hosing the cleaner with hot water or allowing water to float through the cell from the clean side. The cell is then washed in a solution of hot water and washing compound, rinsed, and allowed to drain. The cell is then recharged by immersion in light machine oil and allowed to drain for at least twelve hours. An alternative method of recharging is to spray the cleaner with a hand-operated spray gun until the cleaner has received as much oil as it will take without dripping.

Ceramic insulators should be kept clean to prevent leakage and possible arc overs. If wiping with a clean cloth is not sufficient, a cloth moistened with an approved solvent may be used. The insulator is then polished dry with another clean cloth.

Ferruel resistors and fuses should be removed from their clips, and corrosion and dirt removed from the components and the clips. To ensure correct replacement they should be removed and replaced one at a time, FIRST TURNING OFF ALL POWER. A clean cloth moistened with an approved solvent will usually be sufficent, but in some cases crocus cloth or fine sandpaper may be required.

A clean dry cloth (which will not leave any lint) will usually suffice to remove dust from tubes. Great care must be exercised in cleaning tubes that operate at high temperature because a layer of dust interferes with heat radiation and raises the operation temperature of the envelope. When cleaning is completed, the tubes must be inspected to see that they are properly seated and all clamps locked.

Both sections of the TRANSMITTER INTERLOCK SWITCH should be inspected. These ordinarily will not required attention unless a switch is opened under load, such as during conditions of extreme shock or when the unit is opened when the power is on. Contacts should be cleaned with crocus cloth or fine sandpaper. A burned switch should be replaced.

The CABINET INTERLOCKS are of the microswitch type and require no servicing except replacement in case of failure.

The GROUNDING SWITCH in the modulator power supply is a safety switch and normally will receive very little use. When necessary its contacts may be cleaned with corcus cloth.

RELAYS and RELAY CONTACTS should be cleaned periodically. Any dirt found should be removed and the contacts inspected. If the contacts are clean and bright and the relay is functioning normally, it should be left alone; but if the contacts are dirty or pitted, they should be cleaned. The use of carbon tetrachloride or alcohol for cleaning contacts is not satisfactory because they leave an insulating film. Other unsatisfactory methods include the use of a file (it leaves a rough surface that impairs the wiping action), crocus cloth (it leaves a rough surface and a coating of rouge), emery cloth (it leaves emery embedded and causes arcing), and sandpaper (it leaves sand particles and causes arcing). The use of a burnishing tool is the accepted method.

It is extremely important to maintain electrical contacts in good condition because faulty electrical contacts can cause equipment failure at a critical time.

ANTENNA SLIP RINGS should be inspected once a year during overhaul. If dirty, they should be cleaned with a cloth pad on a stick; if extremely dirty or oxidized, they may be burnished with crocus cloth or very fine sandpaper sufficiently worn to remove loose sand particles. DO NOT use emery cloth on slip rings.

In general, all R-F CONTACT SURFACES and the interiors of resonant cavities should be kept as clean as possible to ensure maximum performance. A vacuum cleaner may be used to remove loose (dust) particles. Where the surfaces can be reached, as in TR and ART cavities, they should be cleaned with lens tissue moistened with an approved solvent and then dried carefully with clean tissue.

CORROSION SPOTS on metal surfaces should be cleaned and touched up with suitable paint. The cause of the corrosion should be carefully investigated and steps taken to prevent its recurrence. Possible causes may be open heater resistors or defective thermal switches.

LUBRICATION is an extremely important part of preventive maintenance. Insufficient lubricant in the antenna will eventually cause failure of the equipment. Routine lubrication at these points as well as at other less vital points is indicated in the lubrication chart in the instruction book.

BRUSHES are used only in the modulator and antenna. The two modulator brushes are in the pulse-length switch motor; they should last almost indefinitely because of their light service. The antenna brushes receive moderate service and must be checked more frequently.

Certain ROUTINE MECHANICAL CHECKS are necessary. Terminal strips should be cleaned and terminal screws checked for tightness at regular intervals. It is important not to overtighten terminal screws, but because they sometimes work loose, they should be checked.

Cables should be inspected for looseness or damage at unit entrances, and at any other point in a run where the cable is subject to damage from heat or other abuse. Cables showing signs of damage should either be rerouted or suitably protected. Particular attention should be given to coaxial cables, which are easily damaged by dents or sharp bends.

Certain ROUTINE ELECTRICAL CHECKS are also necessary. Blown-fuse indicators are checked by removing and replacing the fuses, one at a time, with the power on. INSULATED FUSE PULLERS MUST BE USED for all fuses held by fuse clips, and care must be taken to avoid injury from shock. With the circuit energized, the indicator lamp should not glow when a good fuse is in place but it should glow when the fuse is removed. If the operation is abnormal, corrective maintenance will be required.

When a dial lamp burns out, it must be replaced.

The echo-box ringing time is very important, and a check should be made during each day of operation. The check will be made during each operator's watch if so prescribed. This check along with mds (minimum discernable signal) will enable the ET to maintain, and ensure peak performance of the system, and minimize system failure by indicating faulty operation in its early stages.

The magnetron is the heart of most radar sets; and, although it is capable of generating high-pulse power, it can be damaged easily by careless handling. A damaged magnetron can be costly both in safety and in money, and therefore proper handling must be emphasized.

The magnetron shipping container is necessarily bulky in order to protect the tube during shipment and storage. There are two principal reasons why the magnetron must be carefully protected. Excessive vibration or shock can damage the tube, particularly the cathode portion, which is relatively long and suspended only at one end. Also, the magnetic properties of these tubes must be protected during shipment and storage as well as during the time they are in use. If these tubes are not properly spaced in storage (by means of one container with another) the magnetic fields may interact to the detriment of both permanent magnets.

When it becomes necessary to transfer a magnetron from its container to a radar transmitter, care must be exercised to make certain that the parts that are normally protected by the shipping container are not injured in handling. Some of the larger magnetrons (tube and magnet) may weigh as much as 70 lb; therefore handling them may be an immense chore.

The size and weight of some magnetrons may lead one to assume that they are rugged; however, this is not the case. For example, if the heater terminal is struck during handling, it is possible that the cathode may be moved sufficiently (a few thousandths of an inch) to cause permanent damage.

Magnetrons (the integral magnet type) must be kept away from iron or steel (tools, decks, tables, etc.). Read and follow the instructions on the caution label.

Additional precautions may be summarized as follows:

1. DO NOT USE STEEL WOOL for cleaning a magnetron because the strong magnetic field may cause the steel particles to stick to the insulated portions of the tube.
2. Do not write on the ceramic parts of a magnetron; for example, a pencil mark could cause arcing and a permanently damaged tube.
3. When water is used as a coolant, be certain that all water is drained before the tube is stored in a compartment that will be subject to freezing temperatures. If water freezes in the tube, it will very likely be ruined. (Be sure to wipe the moisture from the insulated portions of any magnetron that has been stored in such a compartment before it is put into use.)
4. The oil required in the cathode bushing of some magnetrons must be kept free from dirt and moisture. Use only the oil specified in the instructions.
5. Tubes to be returned to the manufacturer should be handled carefully and packed according to instructions; consult the latest ESO publications for information on the disposal of magnetrons.

MAINTAINING RADIAC EQUIPMENT

Station personnel may perform limited maintenance of radiac equipment, but such work is restricted to repairs that DO NOT AFFECT CALIBRATION. Radiac repair is accomplished by technicians at a radiac repair facility.

Currently, most of the difficulty with shipboard radiac equipment seems to be caused by dead batteries, electronic circuit failure, corroded battery compartments and physical damage, of which corrosion appears most frequently and proves most serious.