NAVSHIPS 900171

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ELECTRONIC INSTALLATION PRACTICES MANUAL

CHAPTER 4

TEST EQUIPMENT

BUREAU OF SHIPS

27

NAVY DEPARTMENT

21

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ELECTRONIC INSTALLATION PRACTICES MANUAL

This manual is intended for the use of the electronic installation worker. It may be used as a reference book on installation practices or in training beginners in Naval electronic installation work.

Subject matter in this text is intended as supplementary to, but not superseding existing and applicable specifications.

Appreciation is extended to the various Naval Shipyards, Commercial Firms, Service Representatives and Manufacturers who were consulted and without whose cooperation this manual would not be possible.

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SECTION 4-1

GENERAL INFORMATION

1. INTRODUCTION.

The purpose of electronic test equipment is to measure accurately the value and to determine the nature of unknown quantities in circuits of electronic and electrical equipment. Once the measurements are made, they are used to determine the operating condition of the equipment under test.

Some of the fundamental measurements that are made in electronic testing are as follows:

Voltage, measured in volts or microvolts.
Current, measured in amperes, milliamperes or microamperes.
Resistance, measured in ohms or megohms.

Each of these measurements is used to determine the operating condition of electronic or electrical equipment. The accuracy with which these measurements are made depends on the type of instrument used, its sensitivity, its rated accuracy and its useful range.

2. GENERAL NOTES.

a. VOLTMETER SENSITIVITY. – Sensitivity is usually expressed in ohms-per-volt and is the ratio of the resistance of the meter to the voltage that will cause a full scale deflection of the meter needle. The higher the ohms-per-volt rating of the meter, the greater the sensitivity. For example, a 20,000 ohms-per-volt meter is 20 times more sensitive than a 1000 ohms-per-volt meter.

When measuring high resistance circuits, do not use a low sensitivity meter, i.e., low ohms-per-volt. The current in a high resistance circuit is usually small. The current required to operate the meter may be a large part of the current flowing in the circuit being tested, and since the meter draws current from the circuit, it causes an incorrect voltage reading. In some cases, a low ohms-per-volt meter will cause sensitive circuits to operate improperly. It is always best to use a meter of about 20,000 ohms-per-volt, or higher, when measuring high impedance circuits. Anything from 20,000 ohms-per-volt up will produce more accurate readings without affecting the operation of the circuit.

b. SCALE ACCURACY.–The accuracy rating of a meter is usually based on its full-scale reading. Good quality meters are rated at ± 2% accuracy at full-scale for direct currents (DC) and ± 5% accuracy at full-scale for alternating currents (AC). To show how the accuracy of the meter affects measurements, an example is given as follows: If a meter has a range of 1000 volts for full-scale deflection and is rated with an accuracy of ± 2%, the voltage measured by the meter will be within 2% of 1000 volts above or below the voltage being measured. Therefore, 2% of 1000 volts is 20 volts and the meter reading will be 20 volts above or below the actual voltage. It can be seen that the nearer the value of the voltage being measured is to full scale value, the more accurate is the meter reading. If a multimeter is used, switch to the lowest possible scale of the meter in order to obtain the greatest accuracy.

c. MEASUREMENTS.–By measuring the voltage, current and resistance in any circuit, the operating condition of the circuit may be determined. When making measurements, the following should be observed:

(1) POLARITY. – When a voltage is measured with an instrument such as a multimeter, on circuits where the chassis is negative or B-, make sure that the test lead marked negative (-) or "common" is always grounded to the chassis or frame of the circuit under test. This definitely decides the proper polarity. The other lead marked plus or + is then connected to any part of the circuit to determine the voltage at those points. If the leads are reversed, the meter will deflect and the pointer will move backward and off the scale. If the voltage is high, damage to the meter movement will result and the meter pointer may be bent. Some meters have a polarity switch so that the polarity of voltage being measured can be observed without reversing the test leads.

(2) UNKNOWN VOLTAGES. – Since wide voltage variations are always found in electronic testing, the voltmeters are supplied with several ranges. When measuring any unknown voltages, AC or DC, it is always best to first measure the voltage on the highest voltage range of the meter. After the voltage is measured on this range, a lower range may be selected in order to obtain a more accurate voltage reading. This method will prevent the meter pointer from being bent against the stop pin and will prevent damage to the meter movement and circuit.

(3) CURRENT.– Current flow, whether AC or DC, is measured either in amperes, milliamperes or microamperes. In all cases, current measurement must be made by connecting the ammeter, milliammeter or microammeter in series with the circuit under test.

As explained before, the highest range of the meter must be used if the approximate current flow is not known and the polarity of connections to the meter must be observed. The disadvantage of measuring current, when testing circuits, is that one end of a wire, resistance, coil, etc., must be removed from the circuit in order to connect the meter in series with the circuit.

One exception to this is the "tong" type ammeter which allows measurements of large AC currents to be taken without breaking into the circuit.

NOTE

When using an ammeter with an external shunt, be sure the proper meter shunt is used. The directions for using the ammeter are usually found on the meter case and will indicate the size shunt to be used for a given current range.

If the meter deflects backward after it has been connected to the circuit and the power turned on, turn off the power immediately. Damage to the meter will result if allowed to continue. Reverse the meter connections to get the correct meter deflection.

(4) RESISTANCE. – By means of an ohmmeter, the resistance and continuity of a circuit can be checked. Most ohmmeters are accurate around the mid-scale of each resistance range. As the meter pointer approaches the ends of the scale, the reading becomes less accurate. Because of this, a scale range should be selected that will indicate the measured resistance near the mid-point of the scale. In some cases, this may not be possible and the reading measured will only be approximate.

CAUTION

In making a resistance check of a circuit, the ohmmeter must never be used when the power of the circuit under test is turned on.

Ohmmeters usually have internal batteries to furnish power to the meter.

After a resistance check is made, always switch the meter from the ohm-scale. This should be done to insure maximum battery life. If the meter is left on the ohm scale, current is constantly drawn from the batteries and will eventually run them down, causing inaccurate measurements.

d. SAFETY PRECAUTIONS. - When voltages of 300 volts or less are being measured, always connect the alligator clip of the common (-) lead to ground first. All other leads are usually supplied with a test prod. Always keep the hand on the insulated portion of the test prod, making sure that the fingers do not come in contact with the metal tip. Keep the other hand away from the chassis of the equipment being tested. This will prevent accidental electric shock.

CAUTION

Voltages of 300 volts and higher are considered high voltage and proper precautions should be taken in measuring these voltages.

When measuring voltages over 300 volts, the precautions listed above and the following procedures must be observed.

WARNING

Never measure potentials in excess of 1000 volts by means of hand held flexible test leads or probes.

(1) Determine the correct voltage of the circuit to be tested.

(2) De-energize the equipment. Ground terminals to be measured to discharge any capacitors connected to these terminals.

(3) Connect meter to terminals to be measured, using a range higher than the expected voltage.

(4) WITHOUT TOUCHING METER OR TEST LEADS, energize the equipment and read the meter.

(5) De-energize the equipment. Ground the terminals connected to the meter before disconnecting meter.

(6) If additional measurements are required, the above steps should be repeated for each one.

(7) Make sure that additional personnel capable of giving first aid in case of electric shock are in the room.

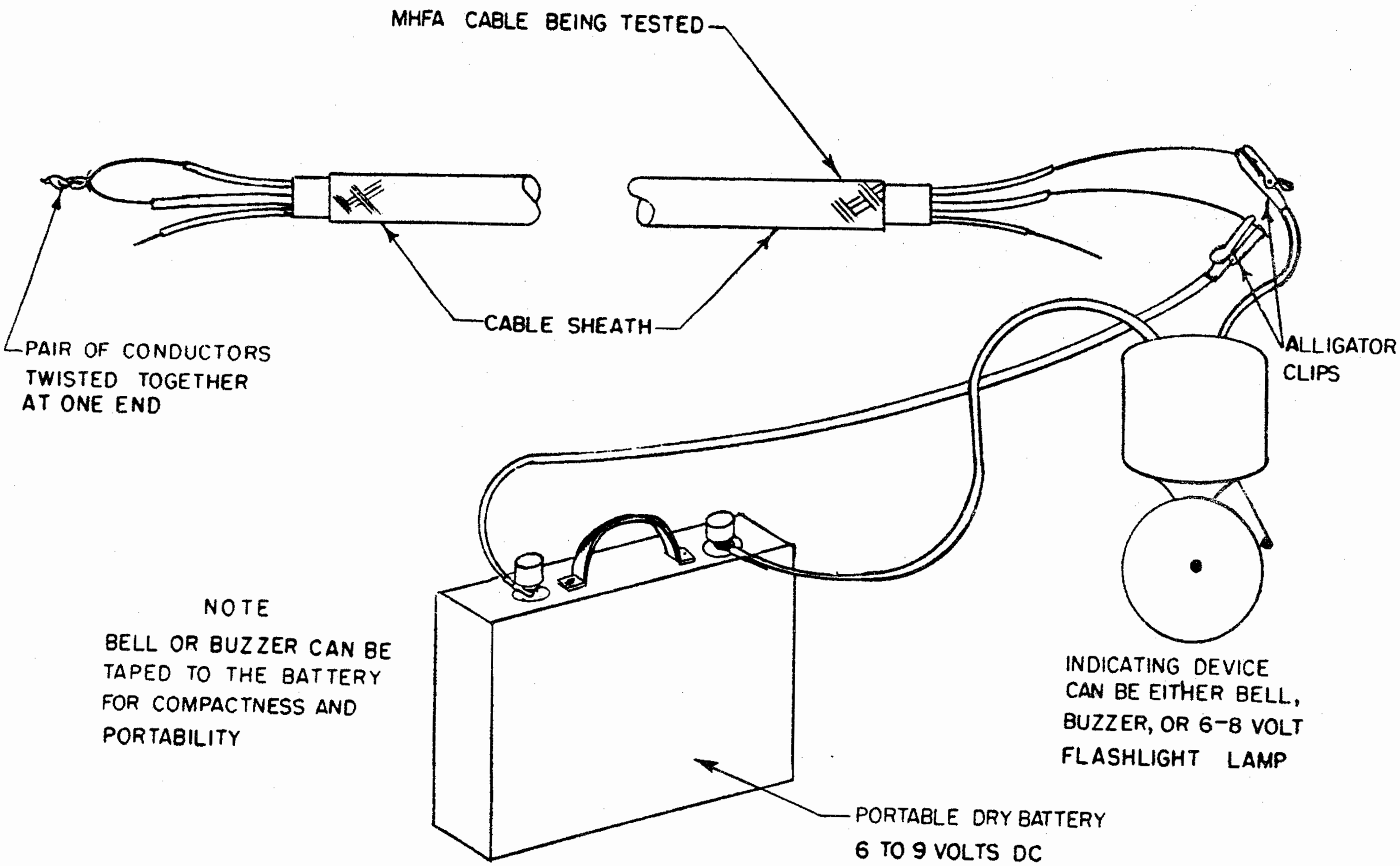


Figure 4-1. Testing a Cable with Bell or Buzzer and Battery

SECTION 4-2

COMMON TYPES OF EQUIPMENT

1. BELL OR BUZZER SETS.

a. GENERAL DESCRIPTION.- These sets consist of a bell or a buzzer, a dry cell battery and test leads. A bell rated at 3-6 volts DC (SNSN G17-B-11926) with a 6-volt battery (SNSN G17-B-59003-6775) or a buzzer rated at 6-8 volts DC (SNSN G17-B-90038-9786) with a 9-volt battery (SNSN G17-B-7725) may be used for this purpose.

b. USE.- These sets are very useful for "ringing out" circuits. "Ringing out" involves tests for continuity, shorts, and grounds. Continuity tests should be made on all wiring installations before operating voltages are supplied to insure against open circuits or wrong connections. A test for shorts is made to check against the possibility of two conductors touching each other through defective insulation. Ground tests are made to insure that the outer sheathing of an armored cable is not in contact with its conductors, or that the conductors are not in contact with the ship's structure.

c. OPERATION.

(1) TEST FOR CONTINUITY.-Connect the two leads of the bell (or buzzer) and battery to the pair of conductors being tested. Twist the conductors together at the opposite end of the cable. Continuity is indicated by the sounding of the bell, or buzzer. Repeat this test for each pair of conductors in the cable. See Figure 4-1.

(2) TEST FOR SHORTED CONDUCTORS.- Remove one of the bell (or buzzer) leads and touch the lead to all the other conductors surrounding the pair just tested. A short is indicated by the sounding of the bell (or buzzer). Repeat this test for each conductor or pair of conductors in the cable.

(3) TEST FOR GROUNDED CONDUCTORS.- With one lead from the bell (or buzzer) and battery circuit connected to the metal sheath of the cable, touch all the conductors of the cable with the other lead. Sounding of the bell (or buzzer) indicates that a conductor is grounded to the metal sheath of the cable. If the conductors are left in twisted pairs, untwist the faulty pair to find which conductor is grounded.

2. SOUND-POWERED OR BATTERY-POWERED TELEPHONE SETS.

a. GENERAL DESCRIPTION. - These sets consist of two sound-powered telephone headsets or battery-powered telephone headsets with test clips.

When using sound-powered phones, care must be taken to avoid capacitive coupling or cross talk in multi-conductor cables, thus giving false test indications. The use of battery-powered phones eliminates the risk of cross talk. The receiver part of the set is not as sensitive to very small current changes as that of a sound-powered headset and therefore is not responsive to cross talk.

b. USE.-These sets are also used for ringing out circuits. As with the bell or buzzer sets, circuits may be checked for continuity, shorts and grounds.

c. OPERATION.

(1) TEST FOR CONTINUITY. - Two headsets and two operators are required; one at each end of the cable. Ground one lead on each headset and connect the remaining lead on headset No. 1 to a preselected, color-coded, conductor in the cable. Connect the free lead of headset No. 2 to the preselected, color-coded, conductor at the other end of the cable. If there is continuity, and conversation can be made over the phones, a click will be heard in the phones. After establishing continuity, another conductor is selected and the test repeated until all the conductors are checked. See Figure 4-2.
One operator may perform this test by twisting a pair of conductors together at one end and touching each of the paired conductors at the other end with the phone tips. A click indicates continuity.

(2) TEST FOR SHORTED CONDUCTORS. - One lead of headset No. 1 is grounded, the other is left on the conductor as in the previous test. One lead of headset No. 2 is grounded and the other shifted among the various conductors surrounding the one to which headset No. 1 is connected. A click in the headphones indicates a short.

(3) TEST FOR GROUNDED CONDUCTORS.- Ground one phone lead to the metal sheath of the cable and touch all the conductors of the cable with the other lead. If a click is heard, a grounded conductor is indicated.

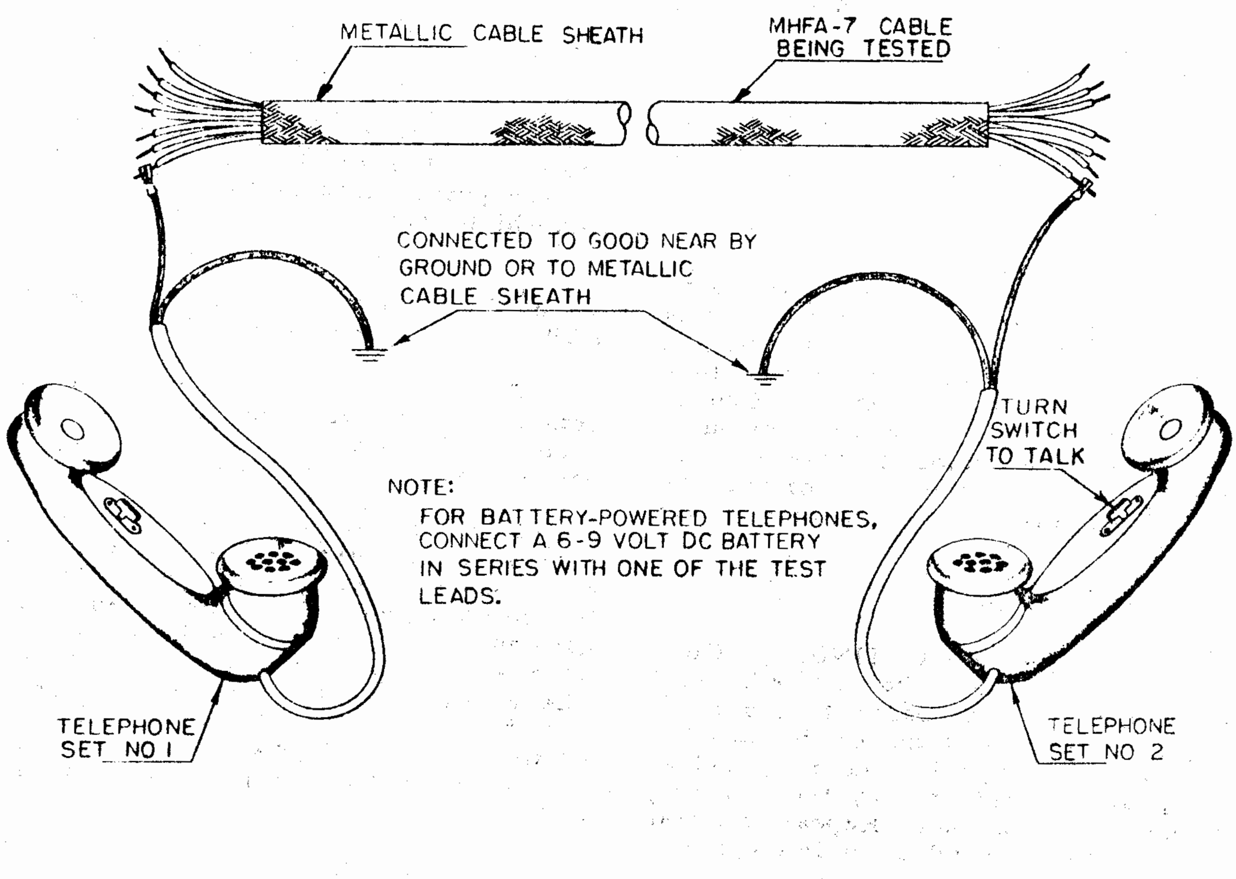


Figure 4-2. Testing Cable with Sound or Battery-Powered Telephones

3. MULTIMETERS.

a. GENERAL DESCRIPTION.– Multimeters are designed for voltage, current, and resistance tests on electronic and electrical equipment. The multimeter consists of a meter, panel controls, batteries, and circuit elements enclosed in a molded bakelite or sheet-metal case. A carrying handle is usually provided as well as a pair of test leads. Figure 4-3 shows a typical multimeter for field use. Internal dry cell batteries supply the power requirements for resistance measurements.

b. USE. – The multimeter has many uses. Because of the wide range of these instruments, they are handy in making general checks on the condition of electronic equipment under test.

Circuits and circuit parts may be checked for opens, shorts, and continuity; and voltage and current readings may be compared with those associated with normal operation.

c. OPERATION.

(1) PANEL CONTROLS. – Multimeters, type TS-352/U, are made with the following panel controls:

(a) FUNCTION SWITCH. – This is a six position rotary switch clearly marked with the type of measurement to be taken.

(b) RANGE SWITCH. – This is a twelve position switch for one of five resistance ranges or seven current ranges. An additional current range (10 amperes) is brought out to a separate pin jack because of the magnitude of the current.

(c) OHMS ZERO ADJ.– This is a rheostat used to "zero" the pointer on the ohmmeter when the test leads are shorted together. When a battery ages, it gradually drops in voltage and this drop must be adjusted for by the "ohms zero adjust" knob.

NOTE

Always short the test leads together and adjust the meter to zero before making a resistance check.

(d) POINTER ZERO ADJUST. – Except on hermetically sealed meters, a setscrew adjustment is located just below the meter scale at the base of the pointer. A screwdriver is used to center the pointer to the zero of all voltage and current scales located at the left side of the scale. This is done before any measurements are made.

(e) TEST LEAD CONNECTIONS. – The connections for test leads are usually made in jack form where the ends of the test leads are plugged in, or in the form of terminal posts where the test leads are fastened by means of a screw nut. The instrument comes with two test leads; one red and the other black. The red lead is positive and connects to the jack or terminal marked "positive" or "+". The black lead is negative and is connected to the jack or terminal marked "negative", "common", or "-". If both leads are the same color and neither is marked, then it does not matter which lead is connected to which terminal, but the negative lead must still be connected to the negative side of a circuit.

(f) COMMON JACK.– One input jack is common to all ranges and is marked -DC ± AC OHMS.

(g) CASE GROUND JACK.– This jack is connected directly to the metal case. It is not connected to any part of the multimeter circuit. The CASE GROUND jack should be connected to the chassis or to any exposed metal bench top. This is a safety precaution and should be followed.

(2) MEASUREMENTS. – Use the highest range possible until the approximate value of voltage, current or resistance has been found. Then select

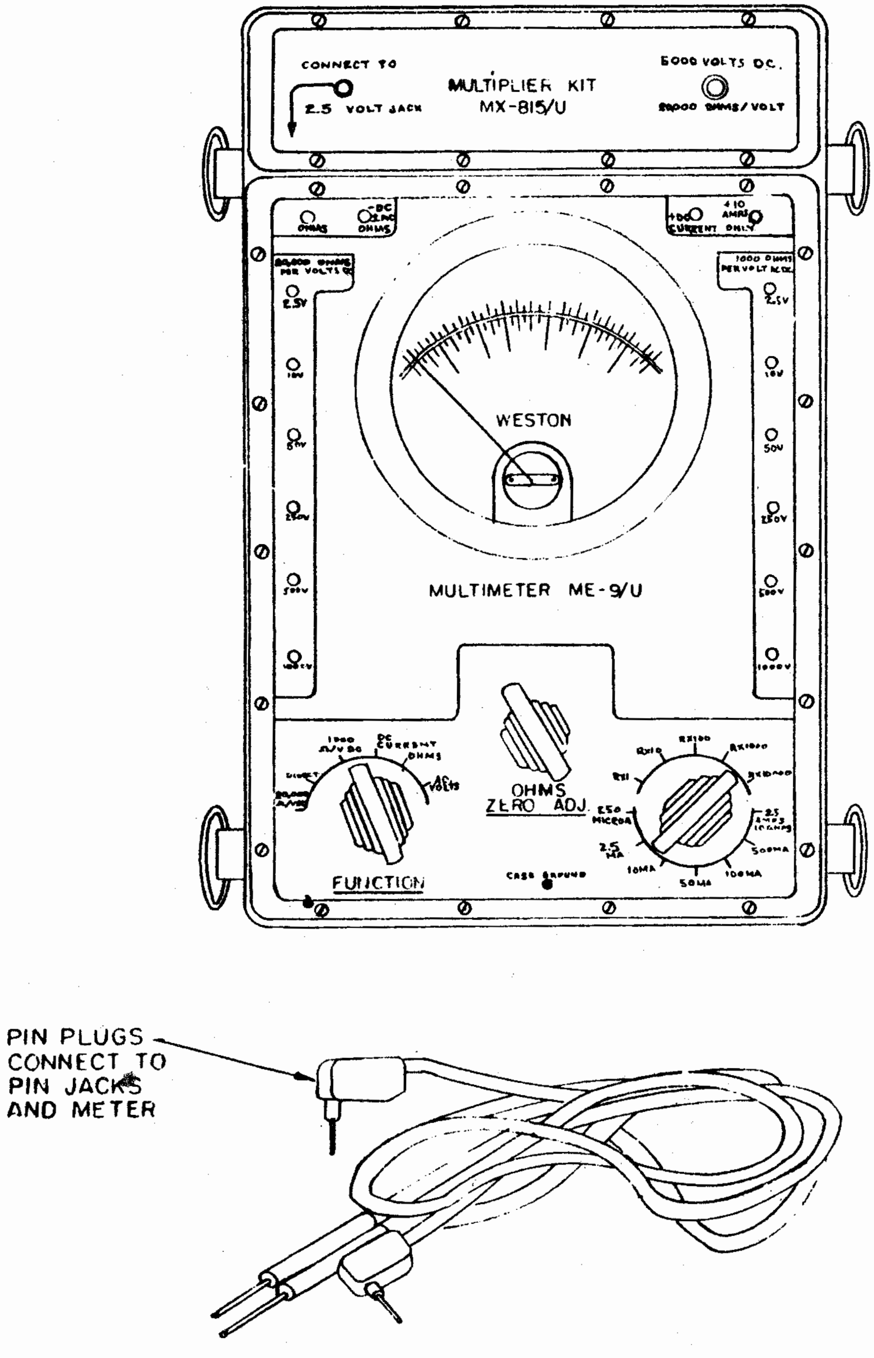


Figure 4-3. Typical Multimeter (TS-352/U Illustrated)

the proper range to obtain the most accurate reading. As mentioned earlier, the nearer the value of the voltage or current being measured is to full scale value, the more accurate is the meter reading. The nearer the value of the resistance being measured is to mid-scale, the more accurate is the meter reading.

(a) AC VOLTS.- Turn FUNCTION switch to AC VOLTS. Plug one test lead into the ± AC jack. Plug the other lead into the highest AC scale. After finding what the approximate voltage is, use the lowest possible scale.

(b) AC CURRENT. - Multimeters generally measure DC currents only. However, by means of voltage readings, the AC current in a circuit may be found if the resistance and reactance are known. If available, a separate AC ammeter should be used.

(c) DC CURRENT.- Turn FUNCTION switch to DC CURRENT. Plug the black test lead into the -DC jack. For ranges from 250 microamperes to 2.5 amperes full scale, plug the red lead into the jack marked +DC CURRENT. Use the jack marked +10 AMPS ONLY for the 10 ampere range.

(d) DC VOLTS.- Turn the FUNCTION switch to 1000 OHMS PER VOLT DC. Plug the black lead into the -DC jack. Plug the red lead into the desired range jack on the 1000 ohms per volt side. This side should be used when the load of the meter has no effect on the voltage reading.

For sensitive circuits, such as AVC, it is necessary to use the 20,000 ohm per volt side. A polarity reversing position is available at 20,000 ohms per volt measurements and is selected by turning the FUNCTION switch to DIRECT or REVERSE. This allows measurement of voltage, either positive or negative in polarity, with the leads connected either way and the instrument case grounded to the equipment under test. When DC voltage checks with 20,000 ohms per volt ranges are made, particularly with the 1000 or 5000 volt scales, the following step by step procedure should be used:

1. Plug the black lead into the -DC jack.

2. Connect the other end of the black lead firmly to the chassis or exposed metal part of the equipment under check.

3. Turn the FUNCTION switch to 20,000 ohms per volts DC DIRECT if the voltage to be measured is positive with respect to chassis.

4. Turn the FUNCTION switch to REVERSE if the voltage is expected to be negative with respect to chassis.

5. Connect the jack marked CASE GROUND directly to the chassis of the equipment under test. This eliminates any possibility of an accidental short circuit causing the instrument case to be at high voltage. Also in some instances the CASE GROUND jack may be connected directly to an earth ground or metal bench top.

To use the 5,000 VOLTS DC scale at 20,000 OHMS PER VOLT. Set the FUNCTION switch to "20,000Ω/v". Use the DIRECT or REVERSE position depending on the polarity of the voltage to be measured. Connect the short eight-inch jumper lead to the low potential jack of the multiplier (MX-815/U and to the 2.5 volt pin jack on the 20,000 ohms per volt side of the meter. Connect the -DC pin jack to the chassis or ground potential side of the equipment under test. Connect the CASE GROUND jack to the chassis or ground. Turn off the voltage to be measured and clip the rubber-covered test clip to the high voltage point. Turn on the voltage and take the reading on the meter. If the pointer deflects off scale, turn the FUNCTION switch to the DIRECT or REVERSE position as the case may be.

CAUTION

Never connect the meter across a voltage source when the range selector is set for current.

(e) OHMS MEASUREMENTS.– Turn FUNCTION switch to OHMS. Plug test leads into both OHMS jacks. Turn the range switch to the desired resistance range. Short the two test prods together and set the meter pointer to zero ohms (top mark on the indicator) by rotating the OHMS ZERO ADJ.

CAUTION

> Before making resistance measurements in a circuit, be sure that the equipment is turned off and that no voltage exists in the circuit to be tested. Do not leave the range selector switch in a resistance measurement position when the meter is not in use. The test leads may become shorted and run down the batteries.

4. INSULATION TESTER (MEGGER).

a. GENERAL DESCRIPTION. - The "Megger" is a high - voltage ohmmeter used mainly for testing insulation resistance. The reasons for the higher voltage in the megger is to accurately measure resistances up to 200 megohms or more and to detect high resistance faults that break down under higher voltages.

The voltage used by the megger is usually supplied by a built in DC generator (hand or motor driven).

As measured with a megger insulation tester, insulation resistance is the resistance to the flow of direct current through or over the surface of insulation used with electrical equipment. This insulation may consist of paper (dry or impregnated), rubber, wax, enamel, cotton or nylon coverings, ceramics, glass, plastics, etc.

In general, insulation resistance decreases with the increased size of a motor, generator, transformer or length of cable. This is due to more insulating material in contact with conductors and frame, ground or sheath.

Insulation resistance usually increases with higher voltage rating of a motor, generator, transformer or cable, not only because of the increased thickness of the insulating material but also because better insulating materials are used at high voltages.

There are several types of meggers in use today but the constant-voltage megger is almost universally used by the Navy.

(1) CONSTANT-VOLTAGE MEGGER. This type generates a constant insulation test voltage by means of a built-in hand crank magneto. The test voltages available from testers of this type usually are 500 and 1000 volts. The insulation resistance is read directly on a meter scale built in the instrument. This type megger is light in weight, completely self-contained and may be carried by means of a shoulder strap. Two heavily - insulated test leads with rubber - shielded battery clips on the ends, and lugs on the opposite ends for connection to the megger, are supplied with the instrument. See Figure 4-4.

(2) HEAVY-DUTY, MOTOR-DRIVEN MEGGER. This type of megger is essentially the same as the hand-driven types except that the magneto is driven by an electric motor. An external power source of 115 volts, 60 cycles, AC, must be used for operation of the driven motor. The megger is used where a large number of tests are to be made at one location, and also where the time duration of the test must be continued for many minutes. All the required test leads are supplied with the instrument. See Figure 4-5.

(3) RECTIFIER - OPERATED MEGGER.–This type uses a rectifier instead of a hand-driven magneto. The operation of this type megger is the same as the hand-driven types except that a 115 volt, 60 cycle, AC, power source is required for operation of the rectifier. The accuracy of the resistance reading is unaffected by voltage changes of ± 20%. See Figure 4-6.

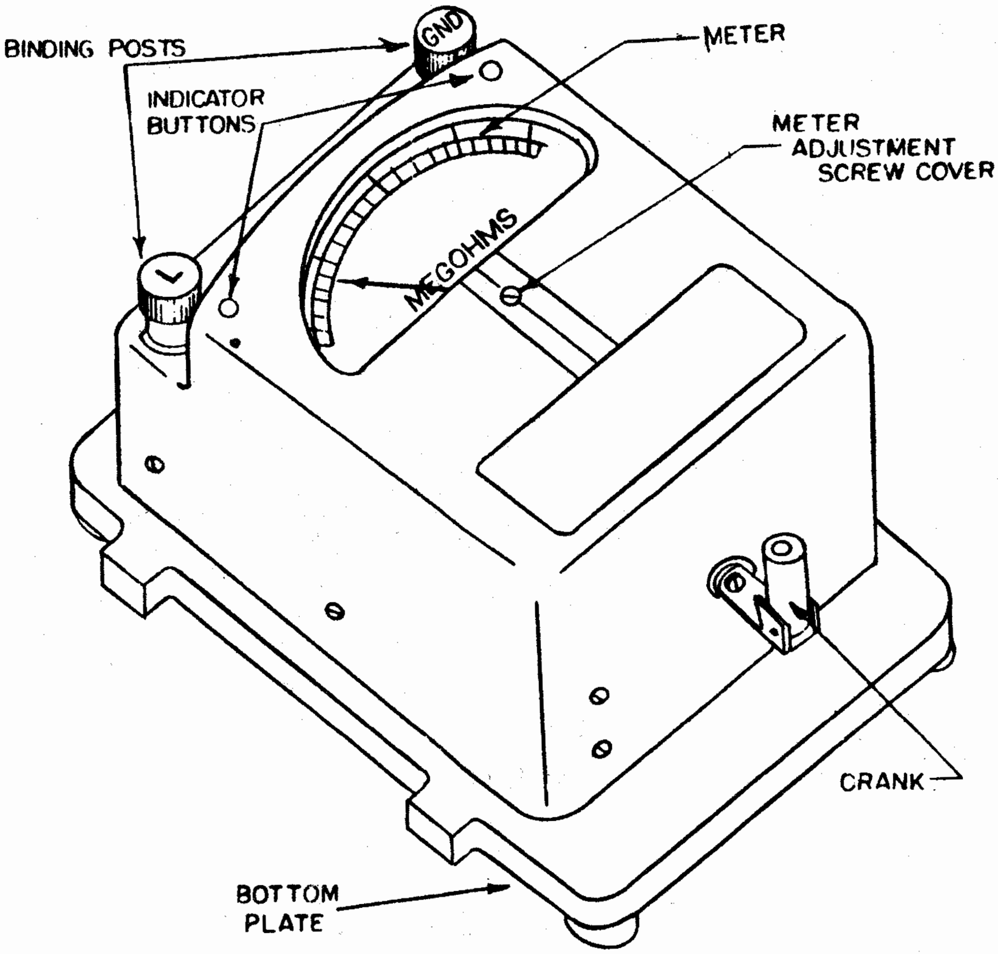


Figure 4-4. Constant Voltage Megger (AN/PSM-2 Illustrated)

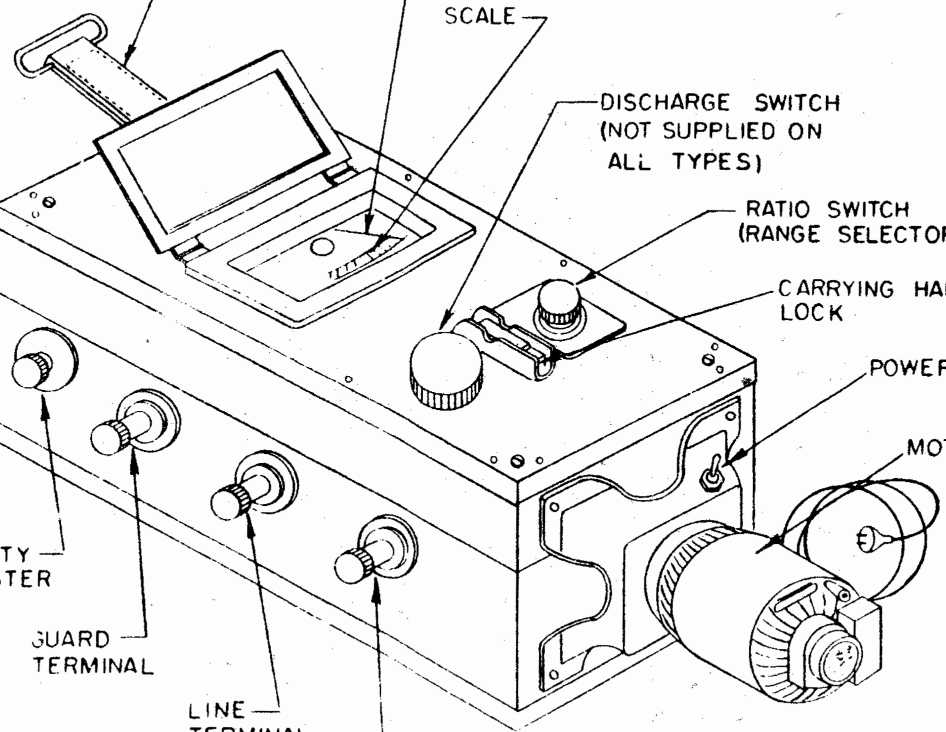


Figure 4-5. Motor-Driven "Megger" Insulation Tester

CAUTION

Do not operate the instrument any longer than necessary. This prevents undue heating and lengthens the useful life of the rectifier.

(4) CONSTANT VOLTAGE BRIDGE MEGGER. - Meggers of this type combine the functions of an insulation tester and a Wheatstone bridge. A megger-ohmmeter and a Wheatstone bridge set are mounted together in the same case with a hand generator to supply test

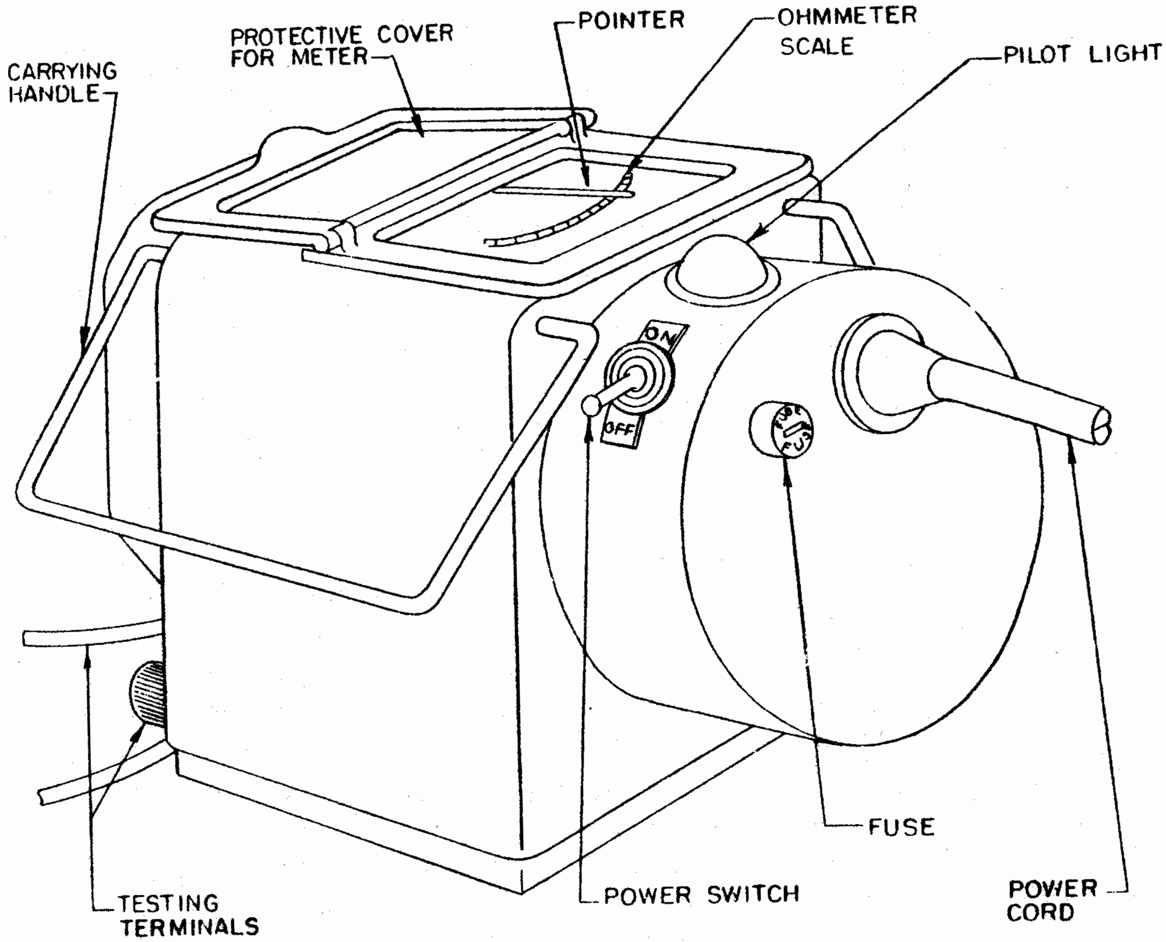
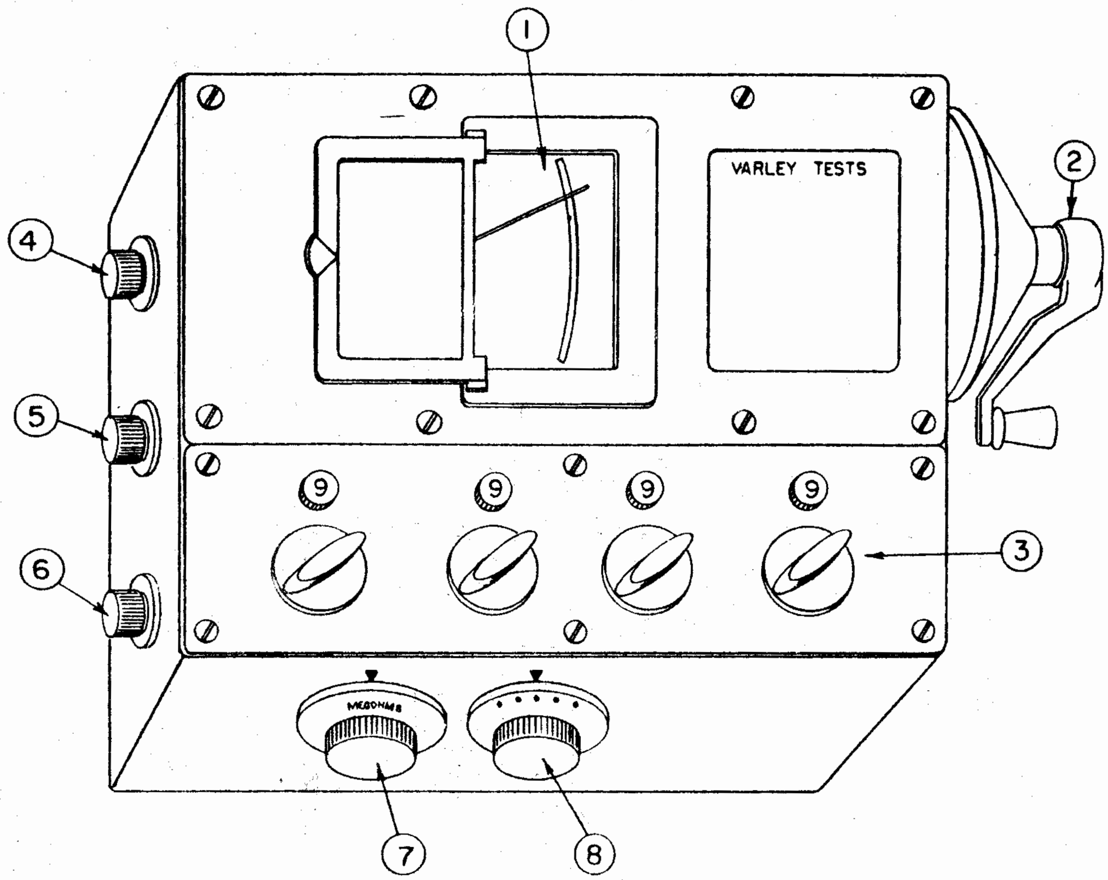


Figure 4-6. Rectifier Operated Megger



(1) SCALE. - Reads directly in ohms and megohms for insulation resistance tests. Meter pointer floats until operated.

(2) CONSTANT VOLTAGE HAND GENERATOR. - Supplies voltage for insulation resistance test and for wheatstone bridge measurements. Cranking speed 160 rpm.

(3) WHEATSTONE BRIDGE RESISTANCES. - Adjustable dials provide range of 0 to 9999 ohms.

(4, 5) TEST TERMINALS. - Terminal 4 is the ground connection and Terminal 5 the line connection. Both are used for insulation resistance tests and wheatstone bridge measurements.

(6) VARLEY LOOP TERMINAL. - Used as varley earth connection when locating cable faults.

(7) CHANGE-OVER SWITCH. - Switches circuit from wheatstone bridge section to megger section.

(8) RATIO SWITCH. - Indicates bridge resistance ranges.

Figure 4-7. Bridge Type Megger

current. A selector switch permits instant change between the two units. See Figure 4-7.

b. USE OF MEGGERS.- The megger may be used to check the insulation resistance on new installations of all types of cable, generators, motors and transformers. Occasional checks over a period of time with a megger will show the condition of insulating material used on cables, etc., and in this manner indicate likely faults. It is widely used to detect, or track down, insulation faults after they have occurred. The General Machinery Specifications S62-3 lists minimum allowable insulation resistance reading for various installations, but as a general rule, in the absence of other information, the following is given:

For equipment rated up to 1000 volts, a fair allowable lower limit for insulation resistance is one megohm.

For equipment rated above 1000 volts, the lower limit is one megohm per thousand volts.

Although this rule is somewhat arbitrary, it has stood the test of years of practical experience.

The Bureau of Standards give the following minimum values for cables, regardless of length, in the National Electrical Safety Code Handbook, H-30.

Cables used on
600 volts or less....... 1 Megohm

Cables used for
over 600 volts........ 10 Megohms

c. OPERATION.-Place the instrument on a firm and fairly level base. Avoid large masses of iron and strong magnetic fields. In the series current type of megger (i.e. AN/SPM-1 and AN/SPM-2, Figure 4-4) the pointer registers infinite resistance until the instrument is operated. In the crossed coil type of megger, the pointer may appear to stand anywhere over the scale until the instrument is operated, because the megger-ohmmeter has no control springs. In other words, the meter pointer "floats" until operated.

Check the instrument for infinity. It is not necessary to crank meggers of the series current type for this check, since their pointers should always register infinity, except when the instrument is operated. The AN/PSM-1 and the AN/PSM-2 meggers are equipped with a meter pointer adjusting screw which allows the pointer to be adjusted to infinity. When crossed coil type meggers are cranked at normal speed with no connections to the testing terminals, the pointer should register infinity. Check the instrument for zero by short circuiting the testing terminals and turning the crank. The pointer should move to zero. Check the test leads as follows:

Connect leads to the test terminals. If test leads supplied with the instrument are not available, use durable and high quality insulating material. Oil resistant, synthetic rubber insulated, single conductor, No. 14 stranded wire should be used. The outer jacket should be smooth, with no outer braid. Lugs should be fitted for attachment to instrument terminals, and strong spring clips (battery clips) should be used for connecting to the equipment or circuit under test.

Separate the opposite ends of the test leads and turn the crank at normal speed. The pointer should read infinity, otherwise there is a leak between the leads.

Short the ends of the test leads together to check for lead continuity. The pointer should read zero.

(1) CONNECTION TO EQUIPMENT.

CAUTION

Equipment to be tested must not be energized. It must be taken out of service and disconnected electrically from all other equipments. Also do not use a megger whose terminal or operating voltage is in excess of that which is safe to apply to the equipment to be tested.

For testing to ground, connect from the line terminal to a conductor of the equipment under test, and from the earth terminal to the frame of a machine, armor sheath of a cable, or to a good ground. For testing between two conductors, connect the test leads to the two conductors.

Typical connections for these tests are shown in Figures 4-8 through 4-10.

Meggers having ranges of 1000 megohms and higher are usually equipped with a guard terminal. This connection is used to determine whether a low reading is caused by conduction through the insulation or simply by surface leakage at an exposed terminal.

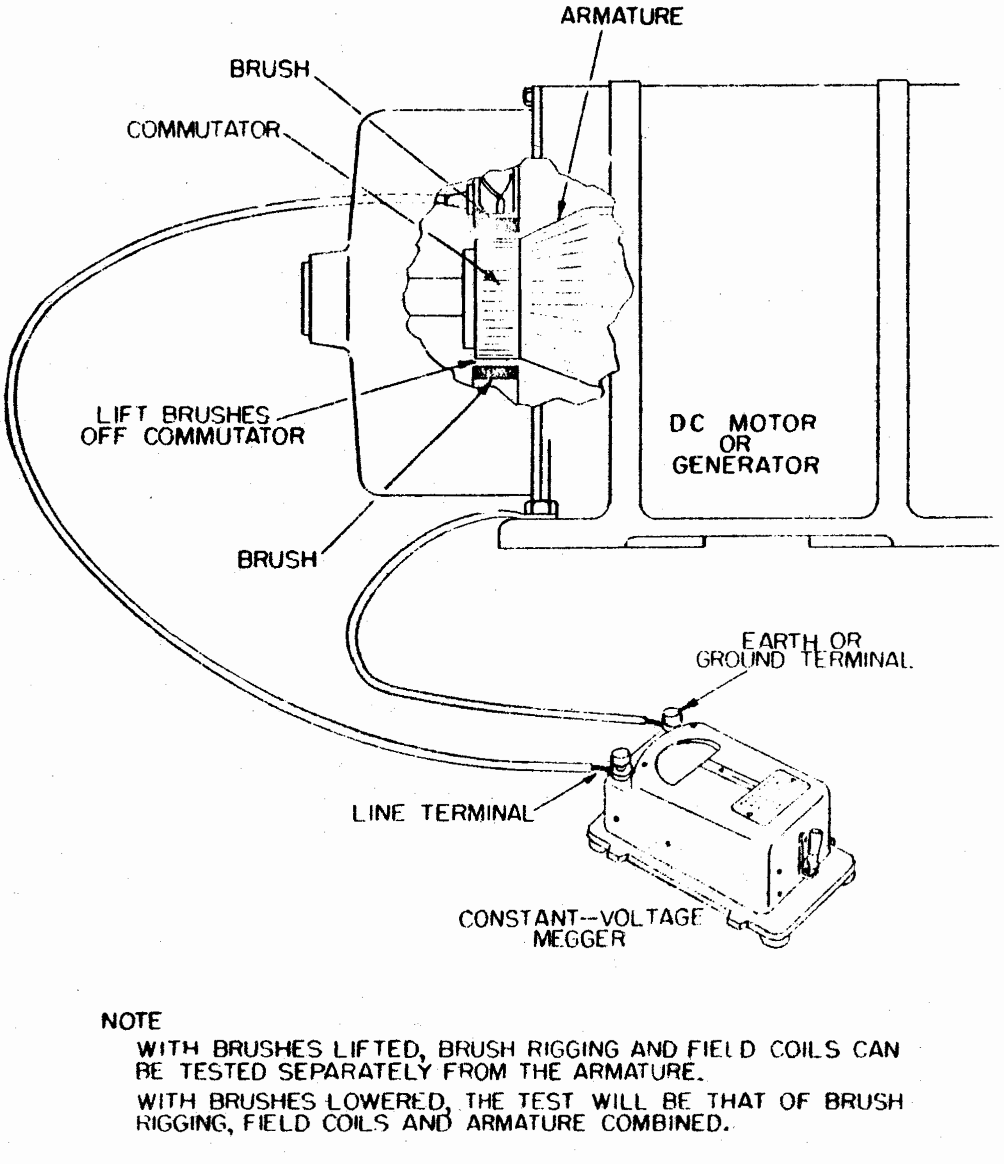


Figure 4-8. Method of Testing DC Motors and Generators

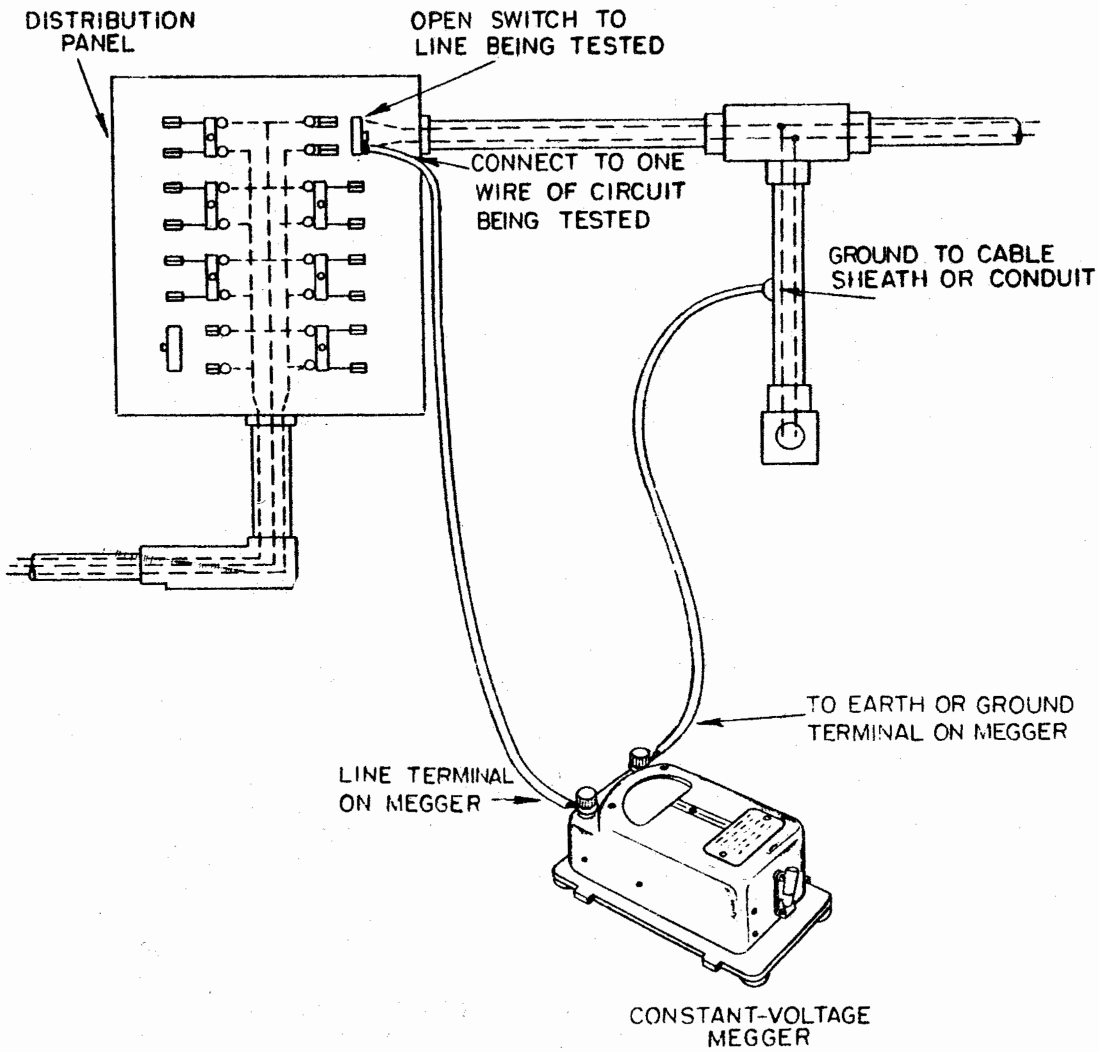


Figure 4-9. Method of Testing Wiring Installation at Distribution Panel

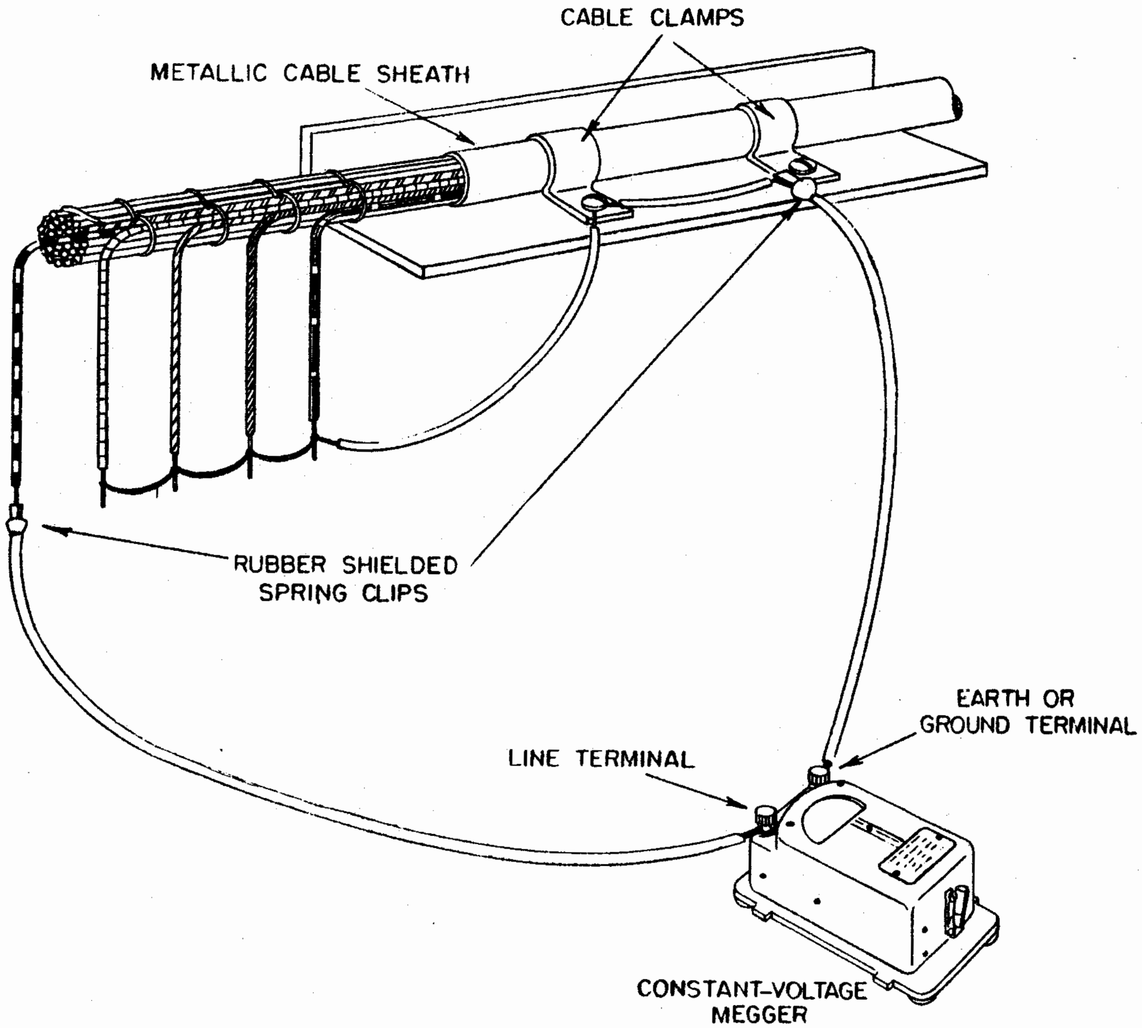


Figure 4-10. Method of Testing Insulation Resistance of One Wire of a Multi-Conductor Cable Against All Other Wires and Cable Sheath

(2) TAKING THE READINGS.- Turn the crank in a clockwise direction at normal speed which is indicated on the instrument and take the reading. Take the reading while cranking and preferably at the end of 60 seconds, so that the equipment under test may be charged up to the rated DC voltage of the megger. It is very important, especially in large equipment, that electrostatic capacitance be discharged, both before and after an insulation resistance test. This may be done by short circuiting and grounding conductors in the equipment being tested before connecting or disconnecting megger leads. Capacitance may cause the pointer to swing toward zero while the megger is brought up to speed, and to swing off scale beyond infinity when the megger generator is slowing down. This is simply the charge current flowing into and out of the capacitance, respectively, and through the deflecting coil of the ohmmeter. These effects are most noticeable in large generators, cables of more than a few hundred feet in length and in capacitors.

Normal cranking speeds are 120 turns per minute (2 turns per second) or 160 turns per minute (just under 3 turns per second). Some meggers are equipped with a slipping clutch adjusted to the right speed and no harm will result from turning the crank faster than rated turns. The type meggers with the slipping clutch are called "constant - voltage type". The other type is called "variable-voltage type". If the crank on the variable - voltage is turned faster than rated turns, the voltage will increase proportionally. Megger types AN/PSM-1, -2, have neon lite regulators. Turning the crank in either direction until the indicator buttons glow steadily red, generates 500 volts DC.

CAUTION

Do not use the megger where explosive vapors may be present, such as battery charging room, gasoline pump room, etc.

5. RADIO INTERFERENCE AND FIELD INTENSITY METERS.

a. GENERAL.- Radio interference and field intensity meters are sensitive radio receivers which operate as a selective radio frequency voltmeter over a wide range of frequencies.

Equipments are available which provide a complete coverage of the frequency spectrum from 14 kc to 1000 mc. Four of these are listed below. Power supply requirements are 105 to 125 or 210 to 250 volts, 50 to 1600 cps, AC. The equipments may also be operated from a battery pack.

(1) AN/URM-6, operates over the 14 kc to 250 kc portion of the radio spectrum. It is capable of measuring voltages from one microvolt to one volt. As a field intensity measuring equipment, it is capable of measuring field intensities from one microvolt per meter to more than one volt per meter, depending on the antenna used. A complete cabling diagram for the AN/URM-6 is shown in Figure 4-11.

(2) AN/PRM-1, operates over the 150 kc to 25 mc portion of the radio spectrum. It is capable of measuring voltages from one microvolt to one volt. As a field intensity measuring equipment, it is capable of measuring field intensities from two microvolt per meter to two volts per meter, depending on the antenna used.

(3) TS-587/U, operates from 15 mc to 400 mc. The voltage range is from 1 microvolt to 100,000 microvolts.

(4) AN/URM-17, operates from 375 mc to 1000 mc. It is capable of measuring voltages from 10 microvolts to 10 volts. As a field intensity measuring equipment, it is capable of measuring field intensities from 1000 microvolts per meter to 100 volts per meter, depending on the frequency.

b. USE.- These equipments may be used for radio interference surveys to determine the source and magnitude of radiated or conducted interference from any source within the frequency range of the equipments. Field intensity measurement surveys may be made with these equipments for adjusting directive antennas or for exploring radiation patterns, where the field intensity may vary over a wide range of values. The equipments may also be used as a sensitive radio frequency microvoltmeter.

c. OPERATION. – A detailed description of the operation of each of these equipments is by necessity confined to the instruction books for the equipments.

d. SPECIAL PERFORMANCE REQUIREMENT SPECIFICATION.–The following is taken from BuShips letter, Serial 982-169, dated September 20, 1950, and titled "Special Performance Requirement for Reduction of Electronic Interference on Vessels of the U. S. Navy. It illustrates the type of tests and manner of making tests with these equipments.

(1) MUTUAL COUPLING (or "Cross Talk"). – Mutual coupling is the ratio between the interference voltage in the circuit producing the interference and the interference voltage in the circuit affected, expressed in decibels. The formula $db = 20 \log \frac{E_1}{E_2}$ is used.

The mutual coupling between each receiving antenna or pick up element and all medium and high level circuits should be at least -90 db.

The mutual coupling between all low level receiving input circuits and all medium and high level circuits should be at least -80 db.

The mutual coupling between medium high level circuits should have a minimum of -60 db not only between themselves, but also between all other high level circuits. Mutual coupling is measured as follows:

(a) Measure the voltage across the circuit causing the disturbance. A line probe may be used for this.

(b) Measure the voltage across the circuit affected at the input terminals, or as close as practicable, of the equipment affected.

(c) Convert the values obtained above into decibels by use of the following formula:

$$-db = 20 \log 10 \frac{\text{Voltage of step 2}}{\text{Voltage of step 1}}$$

e. AREA INTERFERENCE LEVEL. – Final tests of a ship as a whole, for locally generated interference level, should be done in a area where the ambient radiated interference level is such that the output of the receivers aboard will not be increased more than 3 db above the background noise of the receivers with the receivers adjusted for maximum sensitivity. This test can be accomplished by adjusting the receiver with the antenna disconnected, noting the output meter indication, then connecting the normal receiving antenna and noting the rise in the output meter indication. The meter rise should not be greater than 3 db or 1.41 times the meter indication in volts with the antenna disconnected. The Radio Interference and Field Intensity Meter may be utilized for this test.

In final tests with all electrical and electronic equipment aboard operating, the output of any receiver aboard should not rise more than 3 db or approximately 1.41 times the output meter indication in volts as compared to the output level obtained with all equipment other than receivers turned off, excepting those frequencies plus or minus three percent of the fundamental frequency of transmitting equipment of the ship or nearby radio stations.

In the event that the interference level is not tolerable, the following steps should be taken to localize the interference source and reduce it.

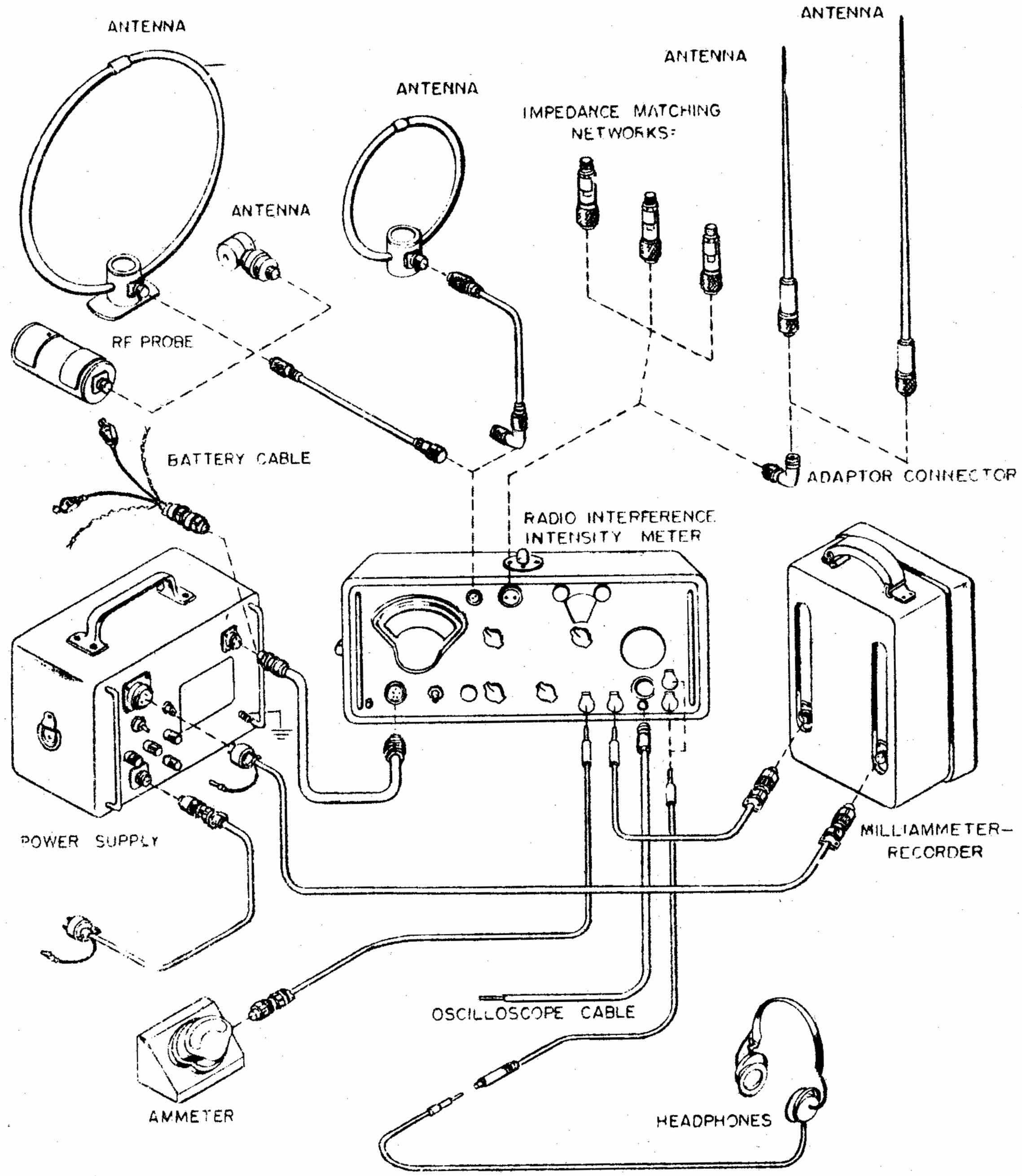


Figure 4-11. Radio Interference and Field Intensity Test Set AN/URM-6 Cabling Diagram

Those equipments and conditions which past experience has indicated as being potential sources of interference should be fully investigated. Conducted interference on power lines may be measured with line probe. (See Figure 4-12.)

Radiation interference may be measured with a rod or dipole antenna and a loop may be used to trace the radiated interference right to its source. The following lists common sources or types of interference:

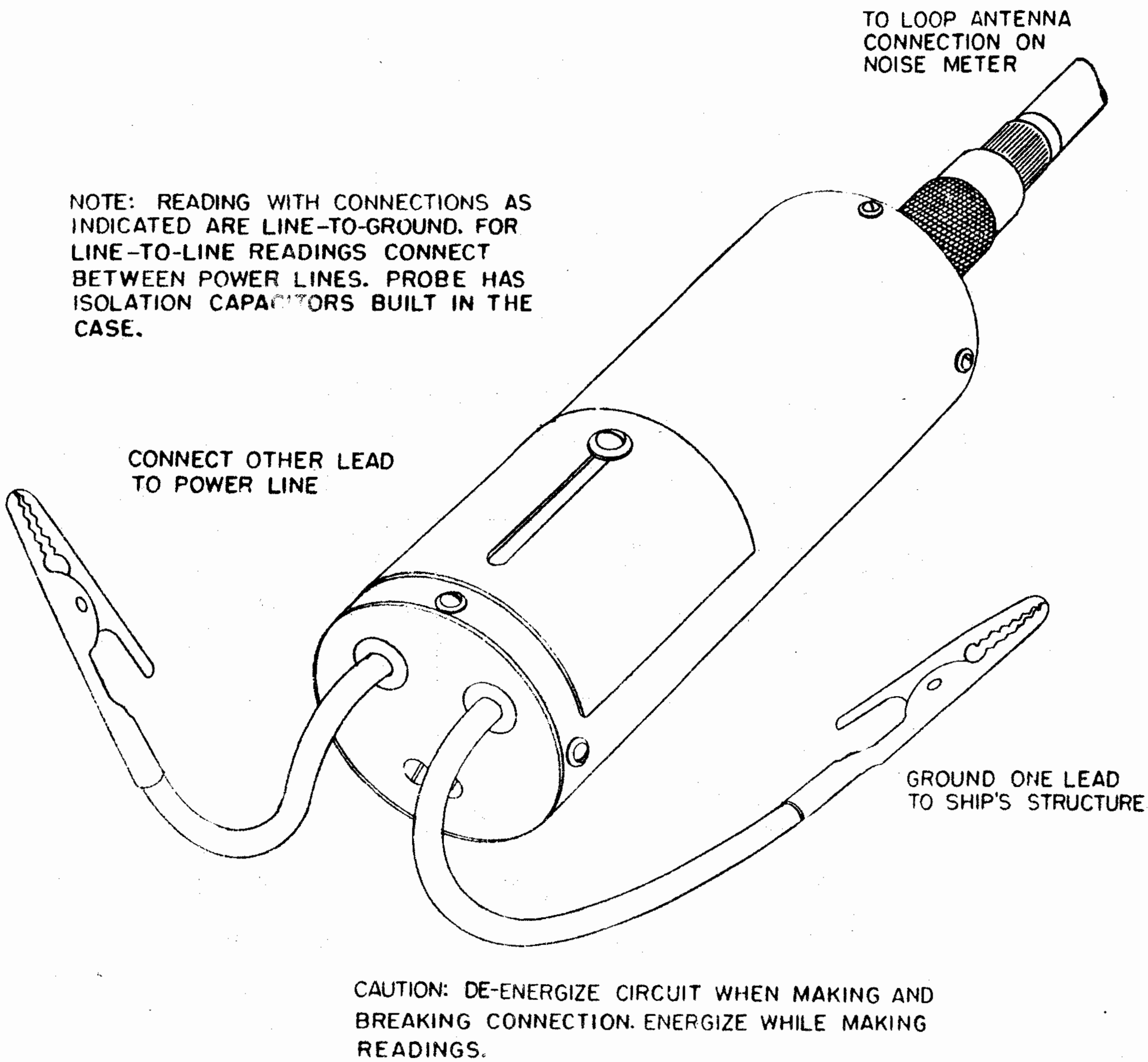


Figure 4-12. Use of the Line Probe for Measuring Conducted Interference

DC fans
Rotating electrical machinery.
Ignition systems.
Radar and other pulse modulated transmitters.
Receiver oscillator radiation.
Communication carrier interference.
Lack of filtering, shielding and grounding.
Inferior or poorly located antennas.
Teletype
Arc welders.

Conducted interference may be localized by cutting out portions of the circuit affected while observing readings taken with a line probe.

Frequency consideration are important and very useful in applying corrective measures.

When making conducted and radiated measurements, always record the frequency and intensity of interference. This information may be a clue to the source of interference from receiver oscillators, transmitter carriers and radar.

For corrective measures, see Chapters 19, 20, and 21 (Grounding, Shielding and Filtering respectively) of NavShips 900,171.

6. ELECTRONIC MULTIMETER.

a. GENERAL DESCRIPTION. - The electronic multimeter is similar to the type TS-352/U in application. In most cases they are designed to measure AC and DC volts and resistance. It has the advantage of greater accuracy and sensitivity over a wider frequency range than is possible with the TS-352/U type multimeters. Another advantage is that it presents a high impedance input, thus requiring negligible power from the circuit being measured. The instrument may be operated from 115 volts, AC, or in some cases, it may have an internal battery pack for portable operations. Figure 4-13 shows the ME-25/U.

The input impedance of these units is in the order of megohms on all DC ranges, and approximately 12 megohms shunted by 6 uuf on all AC ranges.

The voltage range is usually from 0 to 1000 volts DC and 0-250 volts AC in several steps, and resistance up to approximately 1000 megohms may usually be measured. Higher voltages may be measured with the use of multipliers or probes.

RF voltages as high as 100 v may be measured up to UHF range with the use of special probes.

Direct current up to 1000 milliamperes may be measured.

b. USE.- Since the sensitivity and input impedance are so high, measurements may be made on most types of circuits without appreciably affecting its operation. In addition to having the same uses as the multimeter, the electronic multimeter may also be used for measuring plate voltages, grid voltages, bias voltages, and in checking many RF circuits in which the TS-352/U is limited.

c. OPERATION. - Panel controls are similar to those found on any multimeter; that is, there is usually a range selector, a function selector, zero adjust, ohms adjust, and test lead jacks. A coaxial cable and connector are used for the AC-DC test lead to prevent coupling by stray capacitance from affecting meter readings.

To operate the meter, plug in the power cord and turn the meter switch to an "on" position. Allow the instrument to warm up for several minutes. The meter pointer will rise and then fall slowly back to zero. The instrument is ready for use when the pointer is steady after warm-up. Select the function and range desired and plug in the test leads. Before proceeding with measurements, the meter must be adjusted on zero for each scale used.

In connection with voltage measurements using an electronic voltmeter, the following check chart is reprinted from EIB #327.

Before using an electronic voltmeter, it is important to check several things.

(1) IS THE FREQUENCY OF THE VOLTAGE TO BE MEASURED WITHIN THE RANGE OF THE INSTRUMENT?

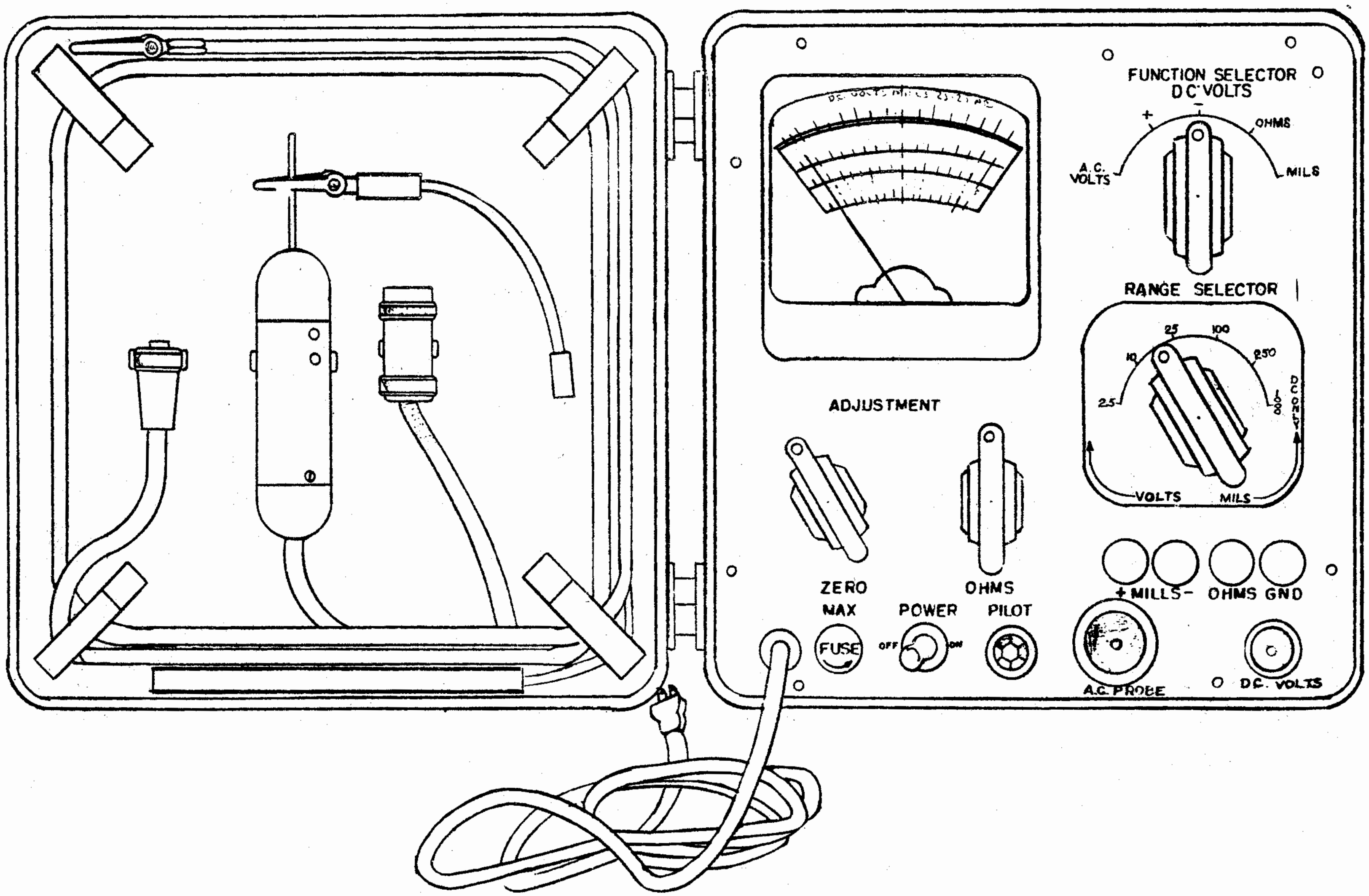


Figure 4-13. Electronic Multimeter (ME-25/U Illustrated)

If the frequency is near or beyond the primary range limits, a correction may be required.

(2) WHAT IS THE EFFECT OF THE VOLTAGE BEING MEASURED ON THE VOLTMETER READINGS? Sine - wave voltage is assumed in most voltmeter calibrations; an input with a waveform other than sine wave will cause varying errors. An oscilloscope is useful in such cases for interpreting the voltmeter readings.

(3) WHAT IS THE EFFECT OF THE VOLTMETER INPUT IMPEDANCE UPON THE CIRCUIT UNDER TEST? If detuning and loading is to be kept to a minimum in making measurements on tuned and other high impedance circuits, the highest possible input impedance meter must be chosen.

(4) IS THE VOLTMETER RANGE SWITCH SET FOR THE HIGHEST VOLTAGE? The ranges are then progressively reduced until there is a sufficient deflection of the pointer to allow a convenient reading. It is conceivable that two settings of the voltage range switch may result in two different voltage readings. If the error on either range exceeds the rated accuracy of the instrument, it indicates a defect in the equipment on one of the two ranges. It must be remembered that the rated accuracy applies to full scale readings.

The higher the frequency of operation the greater the possibility of errors in excess of the equipment's rating. Generally speaking, accuracy ratings are a compromise. No device is absolutely flat in its response over a wide frequency range; as the outlying portions of the frequency range are approached, the greater will be the possible departure from the rated accuracy.

(5) HAS THE POSITION OF THE PROBE GROUND BEEN ALTERED WHILE MAKING R-F MEASUREMENTS ON TWO VOLTAGE RANGES? If so, changes in readings may be expected; first, because the difference of potential between the probe tip location and the ground point may be different due to standing waves; second, because resonance conditions are subject to change along a ground bus at high frequencies; and third, because the "ground" may be ineffective as a ground. Signal voltages are often present at "grounded" points decreasing the effectiveness of the point as a ground. In the final analysis, the importance of such variations depends upon the criticalness of the measurement. Whenever possible, the high side of the voltmeter input system should be joined to the exact point where the voltage is to be measured, particularly at high frequencies. A very substantial difference in indication results if the input tip makes contact with the plates or the control grid of a tube rather than with the high side of the tuned circuit located in these systems. This is a very important precautionary note because many systems contain circuit elements between the tube electrodes and the tuned circuits, so the signal voltage at the tuned circuit is not the same as will be found at the tube electrodes. When the aforementioned circuit elements are absent, it is quite satisfactory to measure at the tube electrode terminals.

7. ELECTRON TUBE TESTERS.

A. GENERAL DESCRIPTION. - There are two types of tube testers used in electronic testing that show an indication of electron tube life expectancy and operating conditions. The tube testers that provide these indications are the transconductance tester and the emission tester.

Both types are usually equipped with an indicating meter which reads Bad, Good, and Questionable. An exception to this is the transconductance tester TV-3/U. Transconductance testers, beside having a bad and good scale, have a scale calibrated in micro-mhos which provides a means of testing tubes under actual operating conditions.

Small tube testers are supplied with enough controls to make a cathode emission test, short, gas, and noise test. The transconductance tester is larger, in comparison with the emission tester,

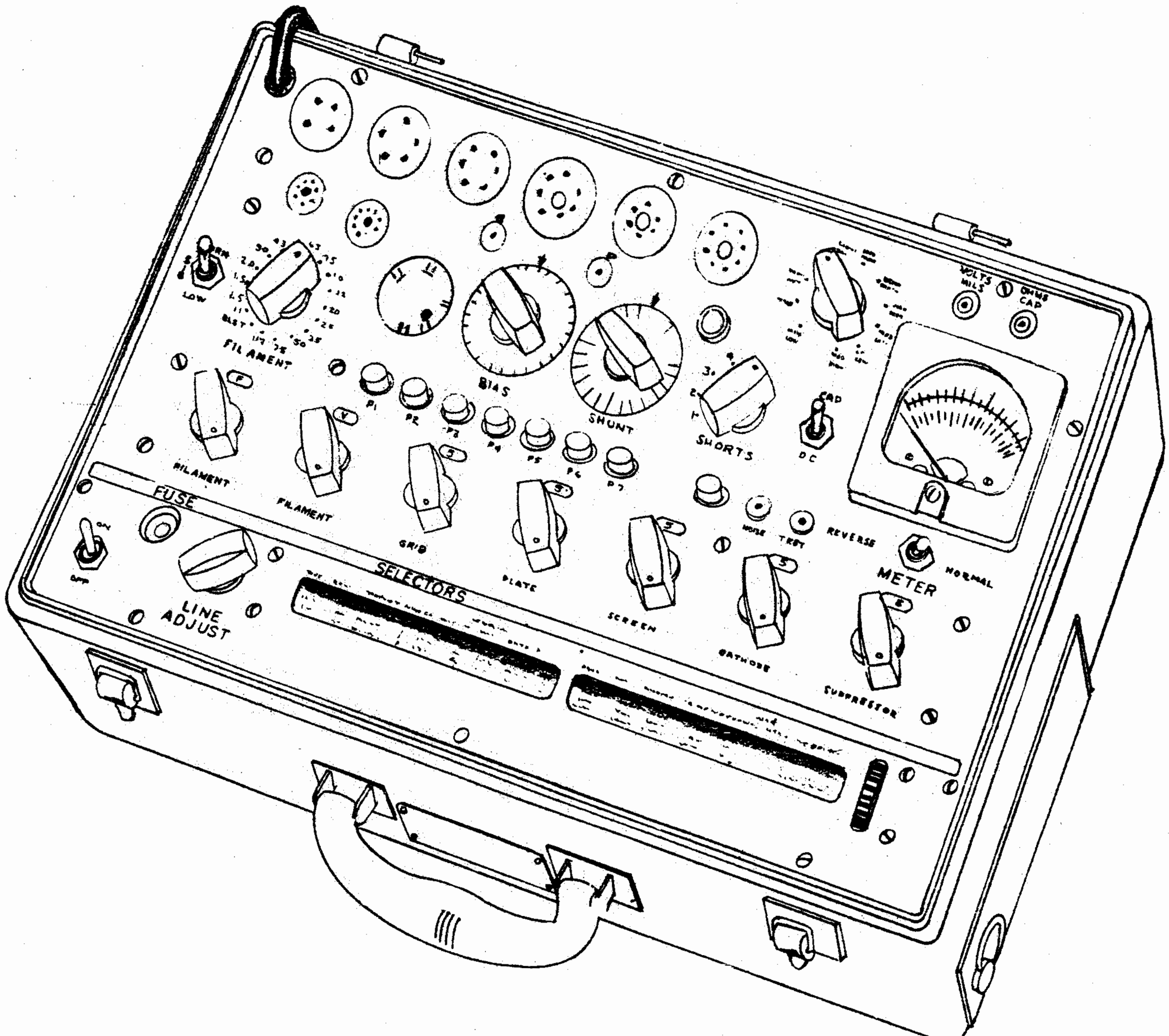


Figure 4-14. Tube Tester (TV-3/U Illustrated)

in that more circuit elements and controls are required to make a transconductance test besides those mentioned. Both types are portable in that they may be carried from place to place provided there is a power source (115 volts, AC, 60 cycles) available. The test results of a transconductance tube tester is more reliable than the results given by an emission tester, except for rectifiers, diodes, and cold cathode electron tubes.

Transconductance testers are usually capable of testing all types of receiving tubes and some small transmitting types. However, the cathode emission tester is most commonly used when making spot checks in order to determine the general condition of a filament or cathode type tube. Each tester is supplied with a chart listing all the tube types and the proper settings of the selector switches required for each particular type. Some testers have a roll chart built into the instrument in order to decrease time wasted in thumbing through a separate chart. These are usually gear-driven and thumb-operated so that no time is lost finding a particular tube type.

NOTE

Don't lose the tube chart. Without this, the tube tester is useless.

Some instruments such as the TV-3/U have a separate volt-ohm milliammeter built into the same cabinet. This section increases the usefulness of the tube tester for general testing of electronic equipment. Figure 4-14 shows a typical tube tester.

Keep in mind that a tube tester can only indicate the difference between characteristics of a particular tube and those characteristics of a standard for that particular type. Therefore, it should not be used as a final authority when determining whether or not a tube is satisfactory. The equipment in which the tube is being used will best determine the value and capabilities of the tube.

b. USE. - Most electron tube testers will perform the following tests on electron tubes:

(1) Emission test (for spot check and general condition).

(2) Transconductance or mutual conductance test (gives best indication as to the electron tube's condition).

(3) Short test (detects short circuits between tube elements).

(4) Noise test (detects intermittent shorts and loose tube elements).

(5) Gas test.

c. OPERATION.- The basic procedure for most tube testers is as follows:

After turning on the tester, rotate the LINE ADJUST KNOB until the meter pointer lines up with the mark on the meter face. This establishes a reference or base line so that the tube can be correctly compared to a standard.

Before inserting the tube in the correct socket, set all the selector switches and controls to the positions indicated on the tube chart.

Insert the tube in its proper socket and proceed with the short test first. Move the SHORT test selector switch to each position shown on the panel so that all the elements of the tube may be checked for shorts. If the tube is shorted at any one of the settings of the selector switches do not carry out any further tests, the short in the tube may damage the instrument.

NOTE

The instantaneous flash of the short indicator lamp as the switch is turned should be disregarded. This is caused by capacity within the circuit. Of course, if the indicator lamp remains on or flashes intermittently in any position of the short selector switch, the tube is internally shorted.

Transconductance tube testers follow the same procedure, except the BIAS CONTROL is always set to its proper position before the tube is tested. If this control is neglected, a tube with no bias may draw excessive plate current and will probably result in damage to the tube.

Also the MICROMHO or Gm range selector switch should be set to its highest range. Then the switch is set to a lower range that will cover the indication more accurately.

If necessary, readjust the line voltage by means of the line adjust knob.

The meter scale is read very simply. In most cases when the meter is equipped with a BAD-GOOD- QUESTIONABLE scale, the left end of the scale up to almost mid-scale, is colored red with the word BAD or REPLACE printed on it. At mid-scale a small section is left white with a question mark printed on it. From this white section to the end of the scale, the scale is colored green with the word GOOD printed on it. These scales give a rough idea of the condition of the tube.

Usually, right below the BAD - GOOD scale is a scale calibrated in micromhos.

Testers of the type TV-3/U (Figure 4-14) are not equipped with a BAD-GOOD scale, but instead are equipped with only one scale which is calibrated in micromhos. A chart is provided giving the acceptable values of mutual conductance in micromhos that may be expected after the correct settings have been made.

After testing the tube, check it again for shorts, this time with the tube thoroughly warmed up.

Electron tubes should be tested for gas. Some tubes develop gas after being heated for a period of time. If a tube is suspected, allow it to heat up for a few minutes. In tube tester TV-3/U a gas test consists of two operations. In one operation the value of tube plate current as indicated on the meter is noted. In the second operation, the presence of gas causes the plate current to increase. Therefore, if the tube contains gas, the pointer of the meter will move up scale a small amount.

8. CATHODE RAY OSCILLOSCOPE.

a. GENERAL DESCRIPTION. - The primary purpose of a cathode ray oscilloscope is to graphically and visually represent rapidly varying voltages and currents, relative to a reference time base.

The size of a cathode ray oscilloscope depends, generally, upon the screen diameter of the CR tube. Typical screen diameters range from 1 inch to the most commonly used 5 inch types. The small 1 to 3 inch screen diameter tubes are used in small portable types of oscilloscopes. Most types of oscilloscopes use the electrostatic deflection type CR tubes and systems.

A power source of 115 volts, AC, 60 cycles per second, serves the power requirements for most "scopes". Carrying handles are usually provided on top of the case so that it can be easily carried from place to place. The case which encloses the oscilloscope is usually sheet aluminum or steel. It is designed so that tubes can be removed by sliding the unit out of its case. Electrical interlocks guard against accidental shock due to the high voltages required for the operation of electrostatic type cathode ray tubes.

The sensitivity of a cathode ray oscilloscope is always given in the amount of voltage required to deflect the beam one inch horizontally or vertically. The lower the voltage required to produce a beam deflection of one inch, the greater the sensitivity of the oscilloscope. The vertical sensitivity of an oscilloscope is usually greater than the horizontal sensitivity.

A frequency response of 5 cycles per second to as high as 2 megacycles is common for good oscilloscopes.

Some typical cathode ray oscilloscopes are shown in Figures 4-15 thru 4-18.

b. USE.- A few of the applications for the cathode ray oscilloscope are as follows:

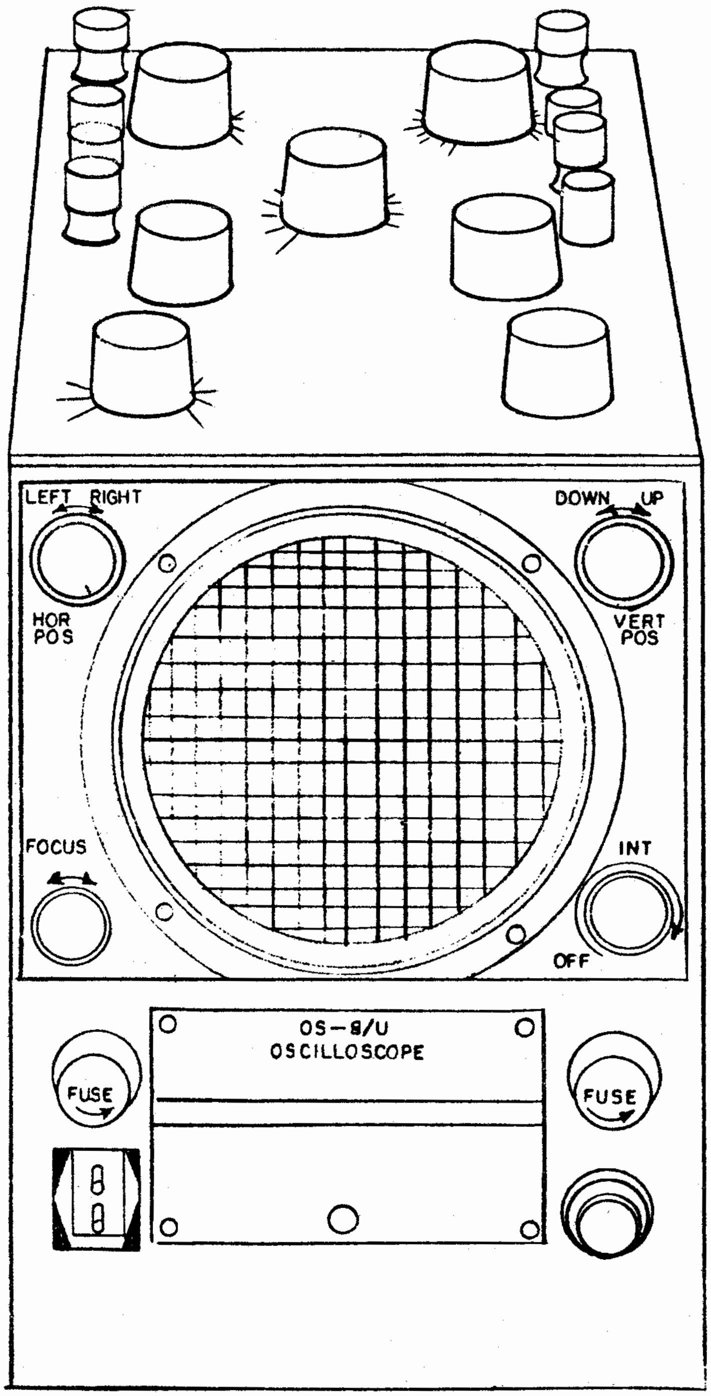


Figure 4-15. OS-8/U Oscilloscope - Front View

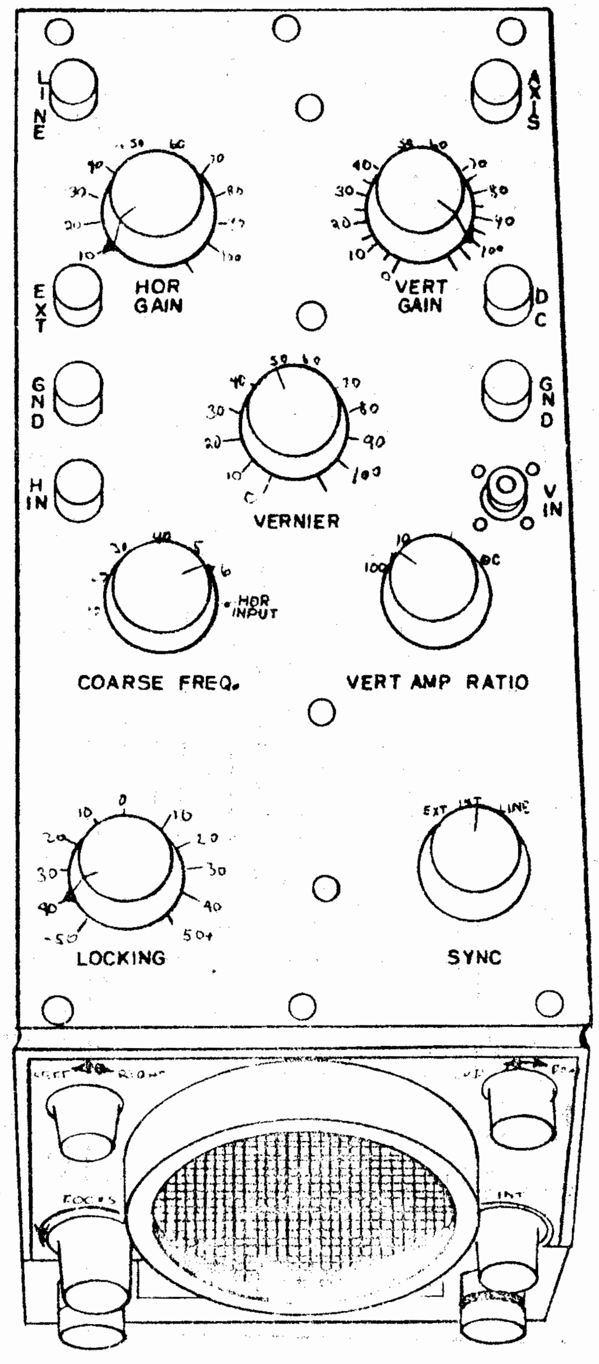


Figure 4-16. OS-8/U Oscilloscope - Top View

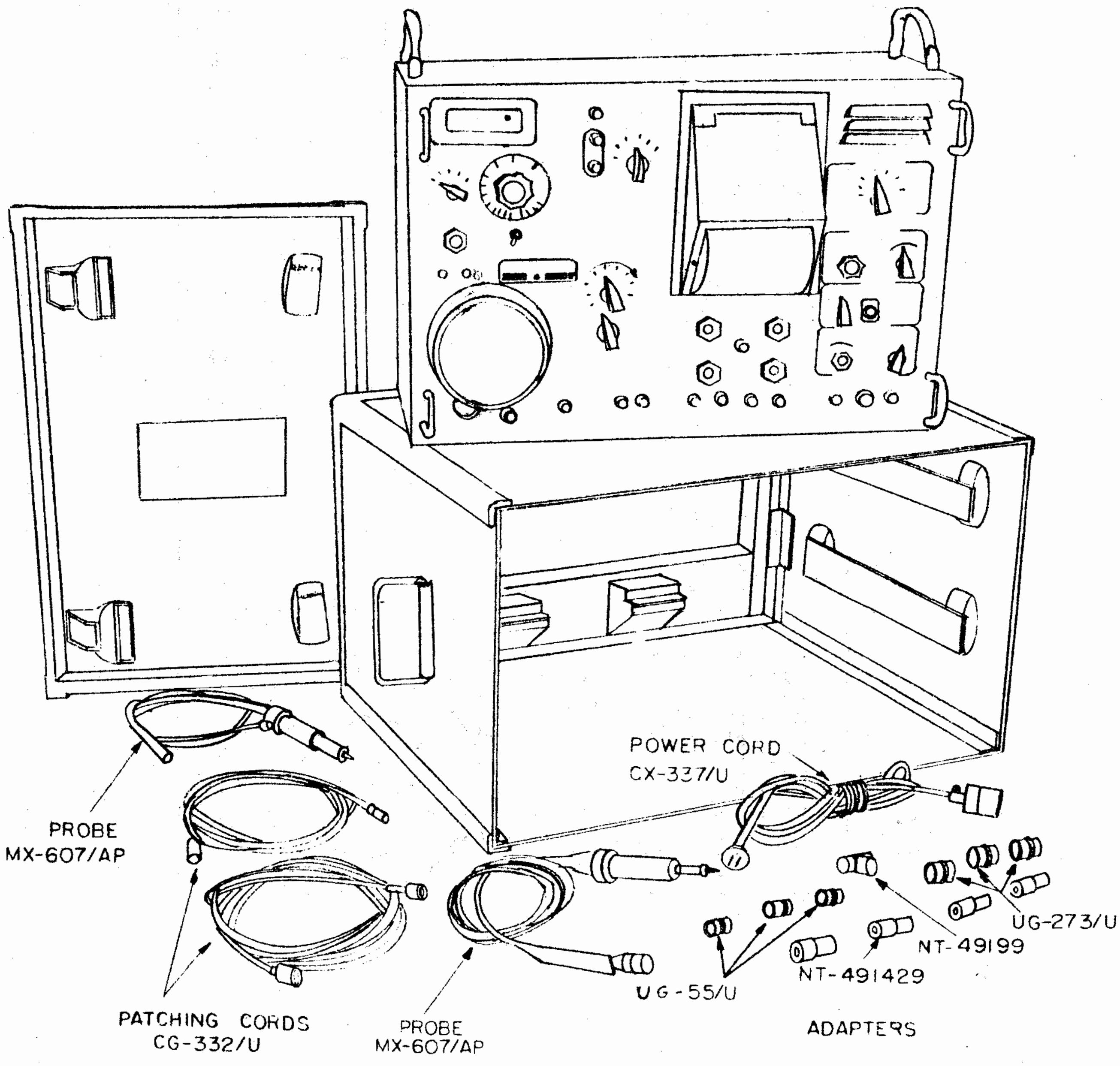


Figure 4-17. TS-239A/UP Oscilloscope - Complete

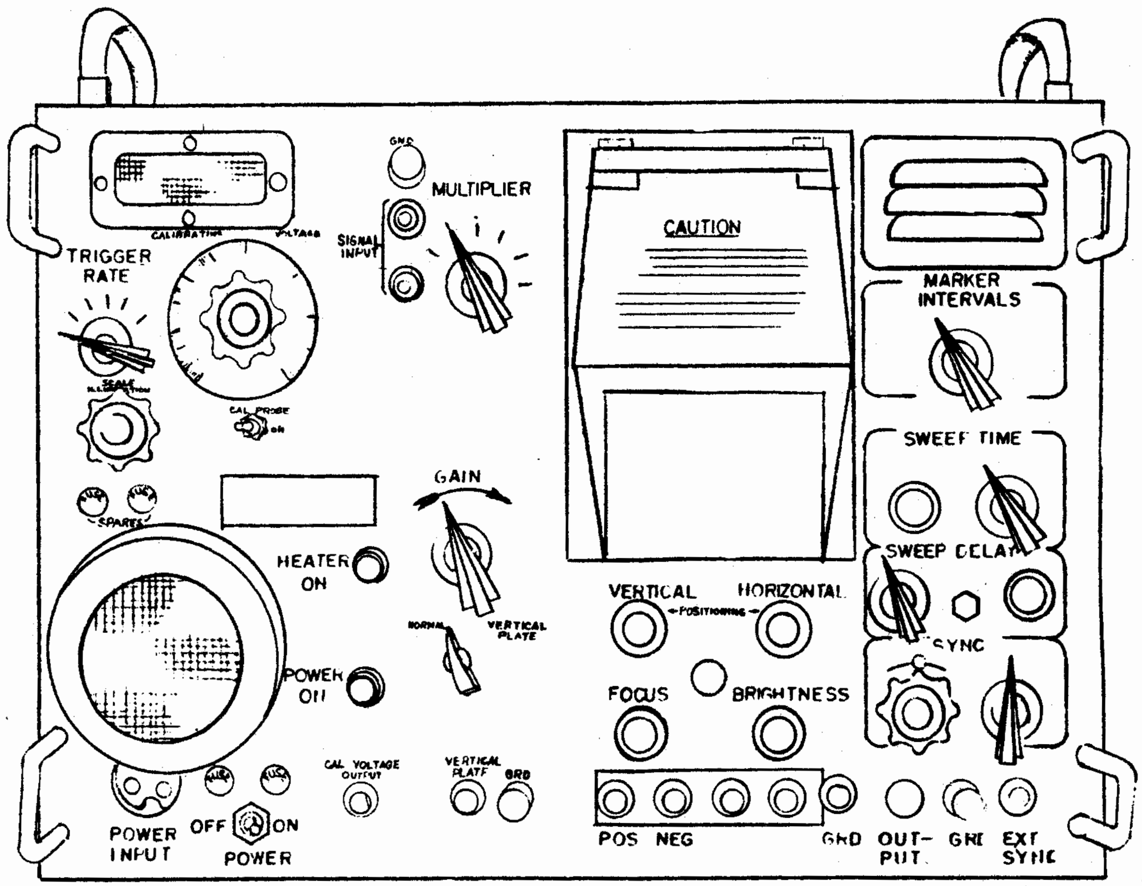


Figure 4-18. TS-239A/UP Oscilloscope - Control Panel

(1) To study wave forms on generators of all types.

(2) Alignment of resonant circuits.

(3) Measurement of modulation percentage.

(4) Distortion measurements.

(5) Vacuum tube characteristics.

(6) Comparison of wave shapes.

(7) Measurement of voltage and current values.

(8) Frequency comparisons.

(9) Phase determination.

(10) Signal tracing and many other associated uses.

c. OPERATION. - Most of the panel controls on the cathode ray oscilloscope are self explanatory. The signal from equipment under test is applied to the vertical input and ground. An external horizontal sweep voltage may be applied at the horizontal input and ground when the sweep selector switch is set at the external sweep position.

The following operating procedure is basic to most types of oscilloscopes.

Plug in the power cord. Before turning on the instrument make sure that the intensity and focus controls are set to zero.

Turn on the instrument and let it warm up for about 5 minutes. The power switch may be combined with one of the scope controls or it may be a separate switch entirely.

After the warm up period, advance the intensity control until a trace is seen on the screen. Some scopes have an off position on the sweep selector switch, which turns the sweep circuit on and off.

NOTE

Make sure the sweep is turned on. This prevents the possibility of a high intensity spot from burning the CR tube screen.

Advance the focus control until a fine line trace is shown on the CR tube screen.

Adjust the horizontal gain control until the trace is long enough for convenient viewing purposes. Don't let the trace extend beyond the end of the CR tube screen.

Adjust the vertical gain control until the figure is large enough for convenient viewing purposes. If high AC voltages are being viewed, always keep the gain control at a setting that does not overload the vertical amplifiers. If the vertical amplifiers are overloaded, excessive pattern distortion will result.

When synchronizing the unknown frequency with the internal sweep, always use as little "Sync" ("Sync" refers to horizontal frequency sweep and Sync Amp adjustments) as possible to keep the pattern motionless. If excessive "Sync" is used, distortion of the pattern will result.

WARNING

The voltages utilized in cathode ray oscilloscopes are dangerous. Should it be necessary to take reading within the instrument for maintenance purposes, observe all safety precautions commonly taken with high voltage. See Chapter 1, NavShips 900,171, Safety and First Aid.

SECTION 4-3

SPECIAL TYPES OF TEST EQUIPMENT

1. RF SIGNAL GENERATORS.

a. GENERAL DESCRIPTION.–A signal generator is a device for producing accurately known radio frequency voltages that may be continuously adjusted from about 1 microvolt in amplitude to approximately 1 volt. In some cases, the maximum amplitude may be as high as 10 volts. They consist of a completely shielded oscillator that can be modulated, together with an attenuator and metering means for measuring small voltages. Most signal generators have a built-in audio oscillator that is used to modulate the RF output signal.

The size of the instruments depend on the design features; that is, accuracy, frequency stability, power output and the frequency range covered. Most instruments are designed so that they may be made portable so long as an external power source of 115 volts, 60 cycles, AC, is available. For this reason carrying handles are provided.

b. USE. – A signal generator may be used for a variety of tests; the most common are the following:

(1) For measuring receiver sensitivity, selectivity, fidelity, overload, distortion, automatic gain control, noise and stage gain characteristics.

(2) Alignment of RF and IF stages of receivers.

(3) Attenuation characteristics of filters.

(4) Source of RF for bridges and slotted lines.

2. HETERODYNE FREQUENCY METERS.

a. GENERAL DESCRIPTION. – Frequency meters, in most cases, are of the heterodyne or beat frequency type. Their operation consists of beating a signal of unknown frequency with the frequency meter, and calibrating the unknown frequency by means of accurately calibrated known frequencies. Besides the usual heterodyne system, a crystal oscillator is built into the same case so that accurately calibrated frequencies may be generated. The crystal oscillator is also used to check the heterodyne section of the frequency meter.

The dials are sometimes calibrated to give direct frequency readings and sometimes are calibrated in terms of thousands, hundreds, tens, units and tenths. In the latter case, the frequency cannot be read from the dials directly but the dial readings are converted to units of frequency by means of frequency tables. A table of accurately calibrated frequencies for each dial setting is supplied with the instrument. From this table any frequency within the range of the instrument may be found directly or by interpolating the nearest known frequencies and dial setting in order to find the correct frequency.

Equipment of this type may be powered by 115 volts, AC, 60 cps, or by means of batteries. When batteries are used, the instrument is entirely portable.

Most frequency meters can detect an input RF signal as low as 20 microvolts, and will provide an audio output power of from 4 to 75 milliwatts depending on the frequency of the incoming signal.

These equipments are made to cover frequencies up to approximately 10,000 megacycles. A typical unit is shown in Figure 4-19. A detecting device, such as head phones or a speaker is used to dectect the zero beat.

b. USE.– Frequency meters are used for calibration of receivers, transmitters, signal generators, and oscillators. They may also be used as a signal generator with variable output.

3. WAVEMETER TEST SETS.

a. GENERAL DESCRIPTION. – Wavemeter test sets (Figure 4-20) are test and monitoring instruments. They are suitable for use with a wide range of Navy equipments operating in specified frequency ranges. Wavemeter Test Set AN/UPM-2 consists of two absorption type wavemeters covering the frequency ranges of 80 to 360 megacycles (TS-211/UPM-2) and 330 to 1220 megacycles

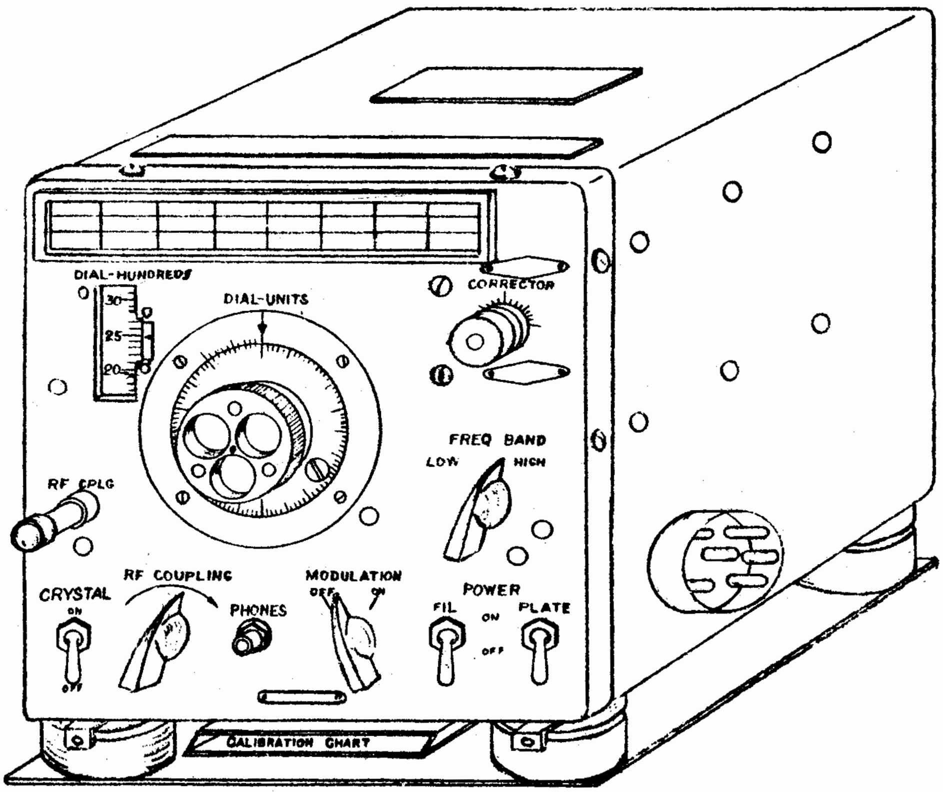


Figure 4-19. Crystal Calibrated Frequency Indicating Equipment - Navy Model LM-20 Illustrated

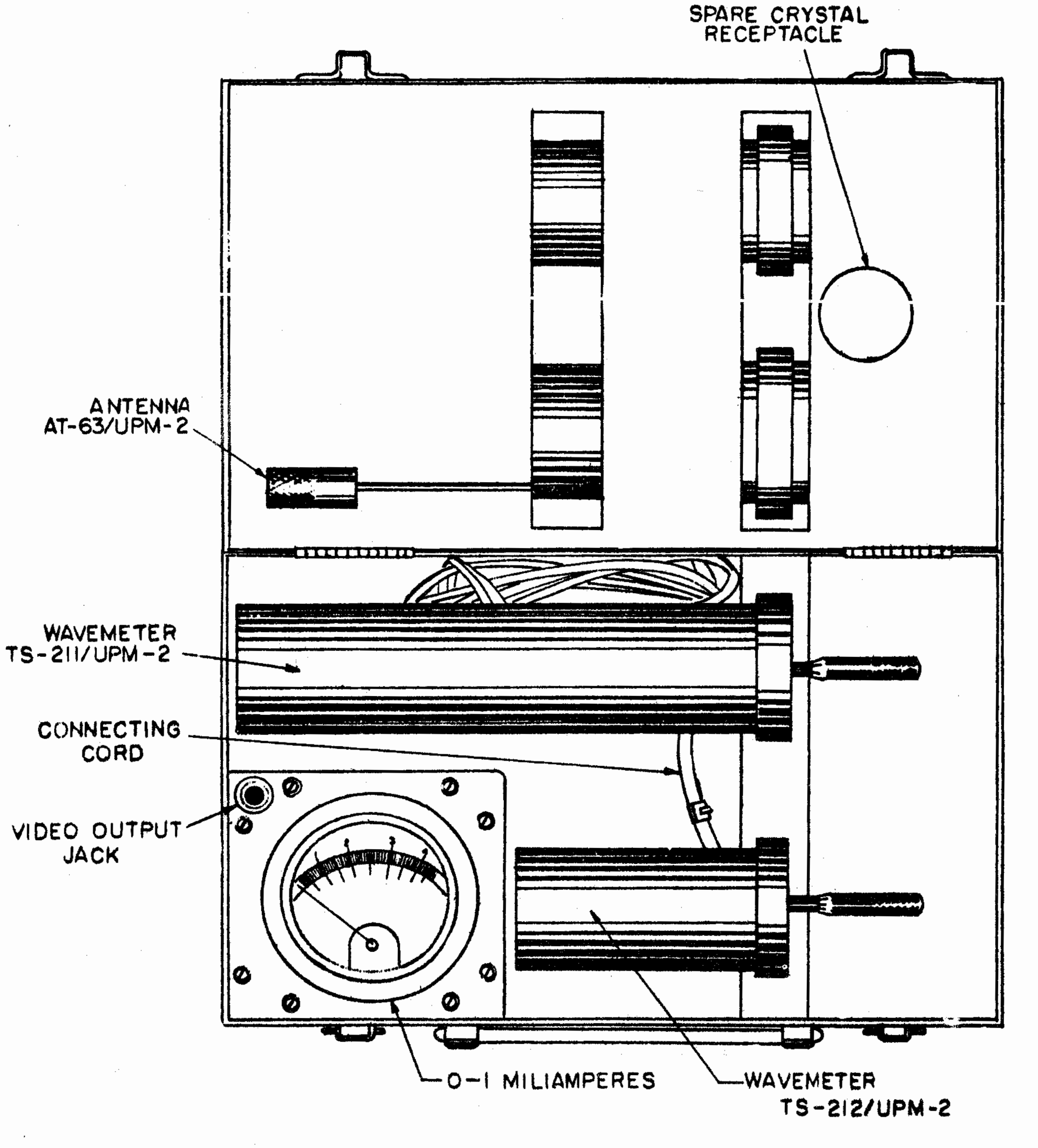


Figure 4-20. Wavemeter Test Set

(TS-212/UPM-2). It uses quarter wave resonant lines and is tuned by means of a micrometer adjustment. Resonance indication is on a 0 to 1 milliammeter housed in the carrying case and connected to the wavemeter by flexible interconnecting cable. Direct current for the milliammeter is furnished by a 1N21 crystal rectifier. The two wavemeter units are housed in the carrying case when not in use. The set requires no external power source. All power is obtained from the signal being measured and is rectified by the crystal rectifier.

b. USE.–Wavemeter test sets are used for the following:

(1) Tuning transmitters to frequency.

(2) Measuring the amplitude of harmonics in the transmitter frequency.

(3) Adjusting antenna systems for best performance.

(4) Monitoring a transmitter during operation.

4. CAPACITOR ANALYZERS.

a. GENERAL DESCRIPTION.– Capacitor analyzers are used to determine the condition of capacitors and resistors used in electronic devices. Actually, instruments of this type are capacity-resistance bridges. They rely on the null method for balancing the bridge circuits. A visual means of detecting null points, such as electronic eye tubes, is usually provided. Instruments of this type are self-contained and portable. They are usually enclosed in sheet metal cases, but sometimes they are enclosed in wooden cases. A power source of 115 volts, 60 cycles, AC, is usually required for this type of equipment.

In most cases, they are capable of capacitance measurements from 10 micromicrofarads to 100 microfarads and resistance measurements from 1 ohm to 1 megohm. On capacitance measurements, they also measure power factor. A typical unit is shown in Figure 4-21.

b. USE. – These instruments may be used to measure capacitance, power factor of capacitors, resistance, leakage current in electrolytic capacitors, insulation resistance and may be used as a test voltage source for low current demands.

5. DUMMY ANTENNAS.

a. GENERAL DESCRIPTION. – Dummy antennas do not radiate RF; they absorb RF power from the transmitter under test and dissipate it in heat. Each type of dummy antenna or dummy load is designed to operate over a specified range of frequencies. They are used for testing transmitters from the very low frequencies to the highest radar frequencies. The dummy antenna shown in Figure 4-22 is of the radar type. It is constructed of a waveguide with a high loss, tapered, ceramic insert. Almost all the RF energy is converted into heat. This is given off, by means of cooling fins surrounding the waveguide. The input end is equipped with a flange cover plate to a choke coupling (such as UG-52/U) of the RF transmission line of the radar.

The voltage standing wave ratio (VSWR) determines how good the dummy antenna is at absorbing RF energy. They usually have a VSWR ratio of 1.05 to one or less.

Dummy antennas are constructed in sizes according to the amount of power that is to be absorbed. A typical unit will dissipate a transmitter power output of at least 200 watts of average RF power. The power is dissipated in the form of heat through the cooling fins of the dummy antenna.

b. USE. – Dummy antennas are used as an RF load in the alignment and testing of radar or radio transmitters.

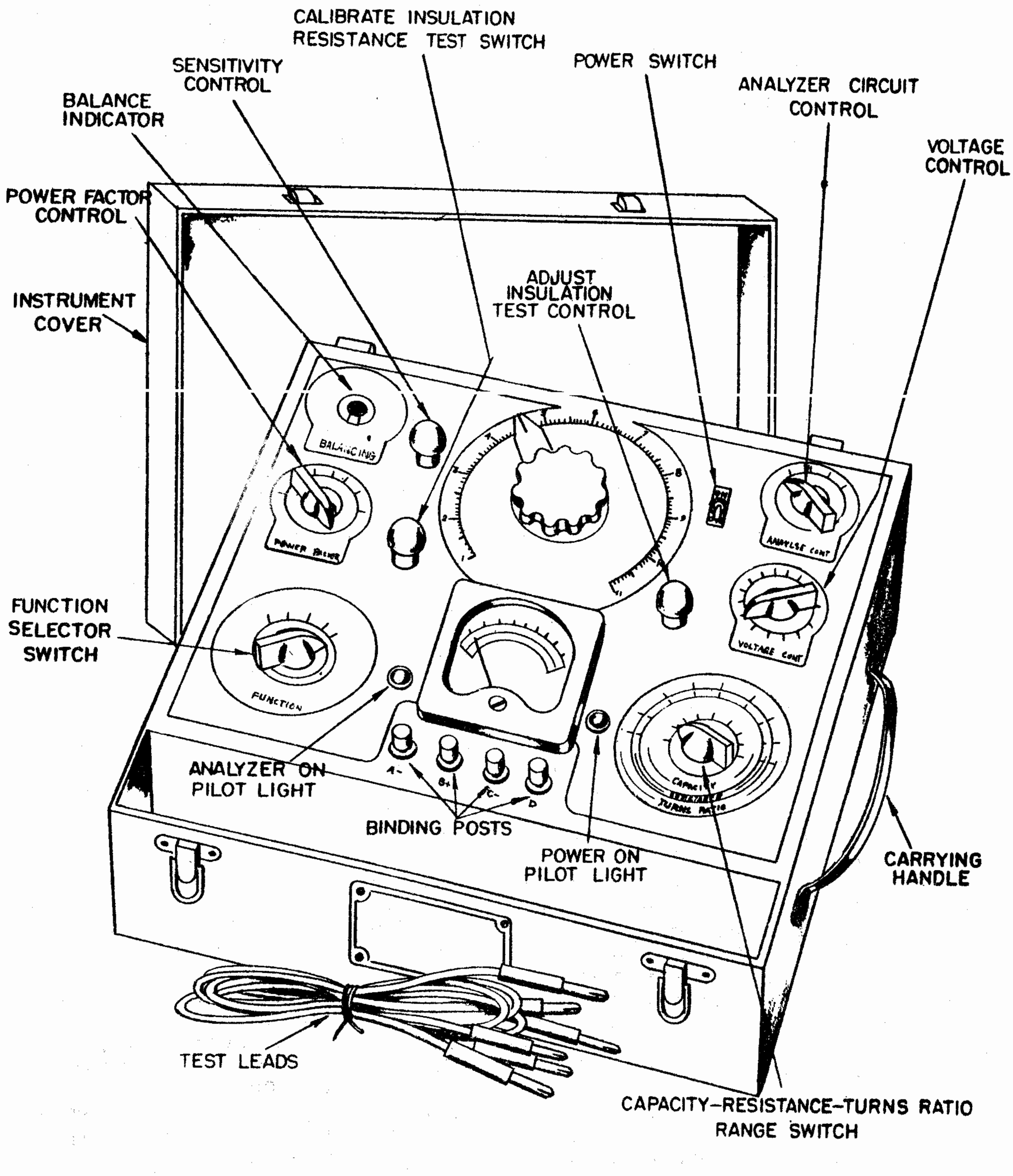


Figure 4-21. Capacity Analyzer

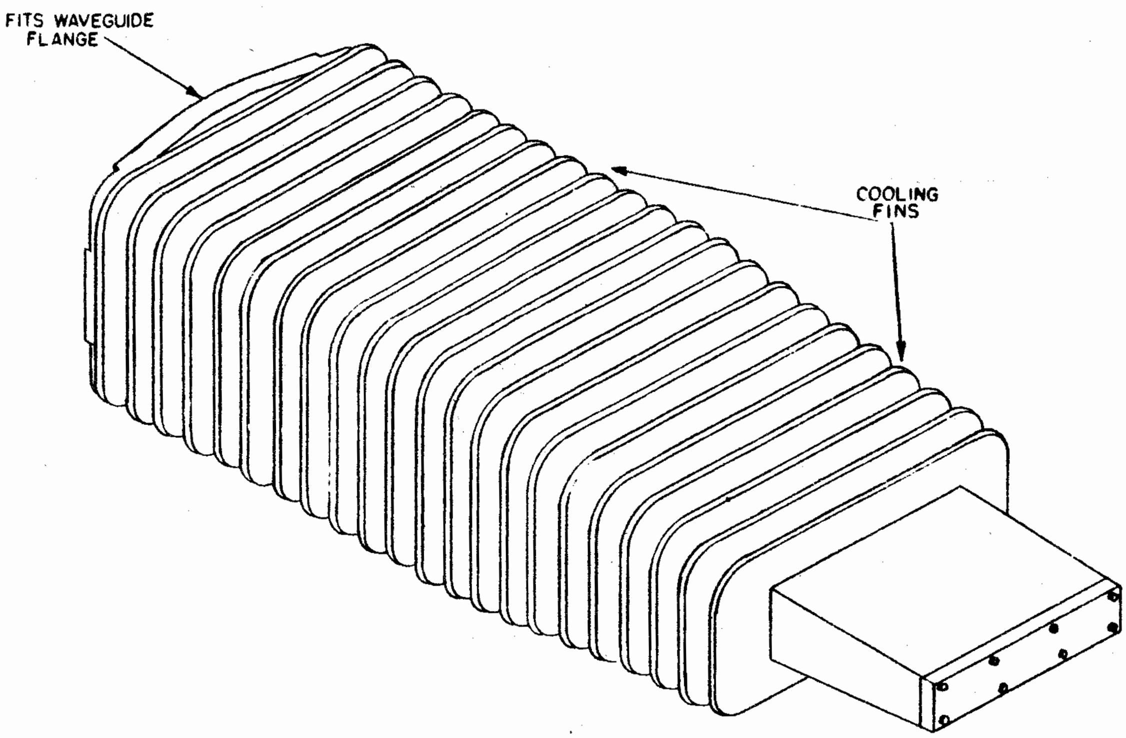


Figure 4-22. Typical Dummy Antenna for Radar Transmitter

6. ECHO BOXES.

a. GENERAL DESCRIPTION.- Echo boxes are ringing cavities that are designed to operate at specific radar frequencies. They are portable, self-contained test sets that are used to check the overall performance of a radar set. Echo boxes are powered by the RF energy picked up from the radar set under test and with this energy they produce an artificial signal. It may be used to localize many of the troubles commonly encountered in radar systems.

Echo boxes are usually housed in splash-proof cases and are equipped with a removable cover and carrying handles. A typical echo box is shown in Figure 4-23.

b. USE. An echo box may be used to perform the following:

(1) To check the radar receiver for proper tuning when no other targets are available.

(2) Overall performance check of radar sets.

(3) Comparative measurements of the power output of a radar transmitter.

(4) Spectrum analysis of a radar transmitter.

(5) Check for multiple moding of radar transmitter.

(6) Check for transmitter frequency pulling.

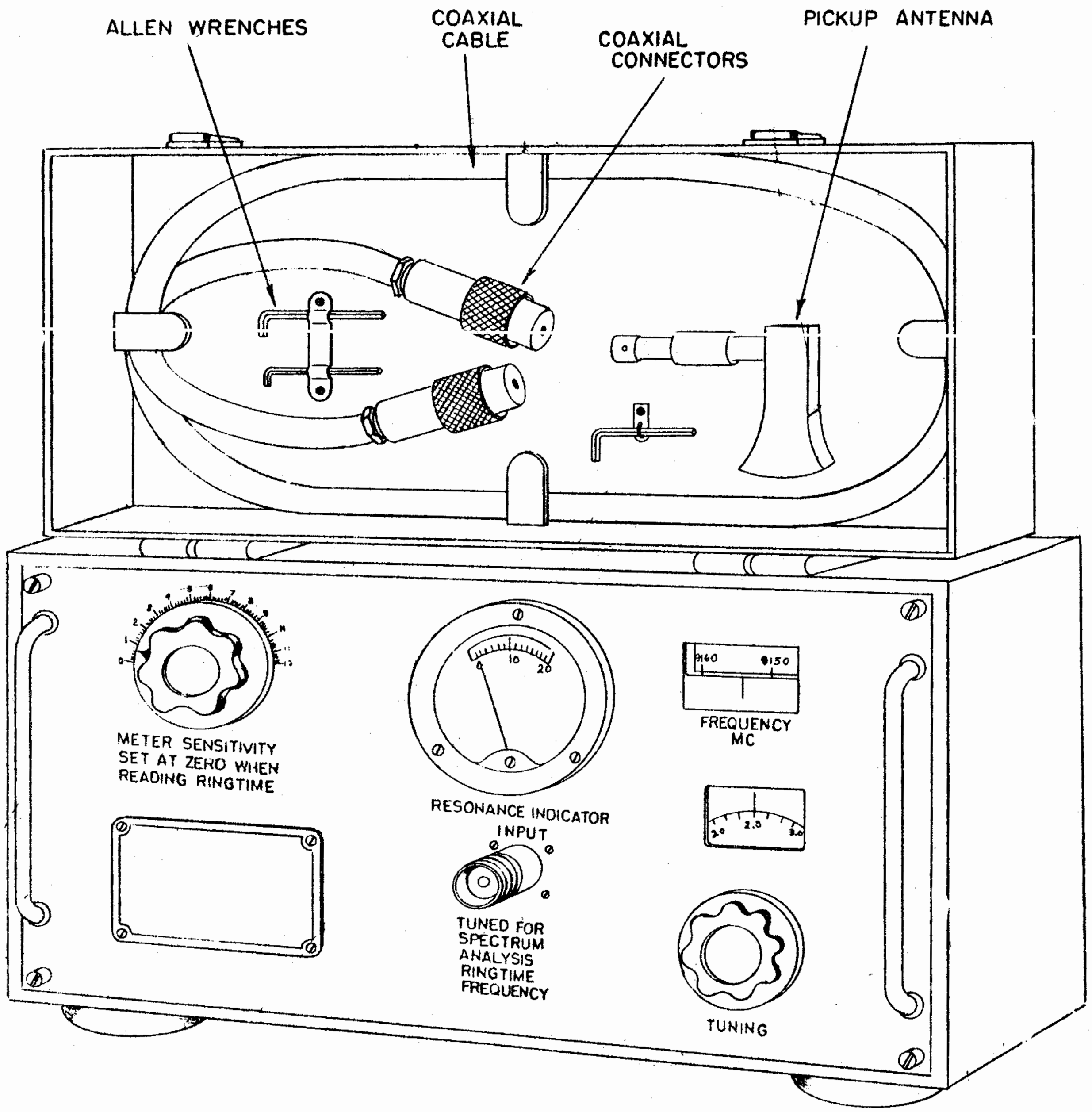


Figure 4-23. Typical Echo Box Test Set

(7) Check on the speed of recovery of a radar T-R box and receiver.

(8) Comparison check of crystal rectifiers while radar is operating.

(9) Automatic frequency control check.

(10) Test for unstable' radar operations.

7. UNDERWATER SOUND MONITORS.

a. GENERAL DESCRIPTION.– Underwater sound monitors are test instruments that are designed for measuring the performance of shipboard underwater sound echo ranging and listening equipment. Equipment of this type consists of an oscillator-amplifier unit, a hydrophone with a length of cable, an extension hydrophone cable, a power cable and a fixed attenuator. The equipment is portable.

The oscillator generates power at supersonic frequencies to energize the hydrophone for use as an underwater sound transmitter. The amplifier amplifies the response of the hydrophone to underwater sound impulses when used as a receiver. It is, therefore, a combination transmitter and receiver of underwater sound impulses. The power requirement of equipment of this type is 115 volts, 60 cycles, AC.

A typical underwater sound monitor test set is shown in Figure 4-24.

The hydrophone is an instrument that is used to convert underwater sound energy to electrical energy. It also works in reverse by converting electrical energy to supersonic sound energy. Because of this, it is used as either a transmitter or receiver of underwater sound.

A typical hydrophone used for test purposes is shown in Figure 4-25. A line is attached to the top cap to support the weight of the hydrophone, and a weight can be attached to the bottom cap to hold the unit steady in the water.

b. USE.– An underwater sound monitor test set may be used for the following purposes on underwater sound equipment:

(1) Tuning the ship's sound transmitter.

(2) Plotting a transmitting frequency response curve.

(3) Tuning the ship's sound receiver.

(4) Plotting a receiving frequency response curve.

(5) Plotting directivity patterns.

(6) Testing of BDI equipment. (Bearing Direction Indicator.)

(7) Checking the ship's sound transmitter and receiver efficiency.

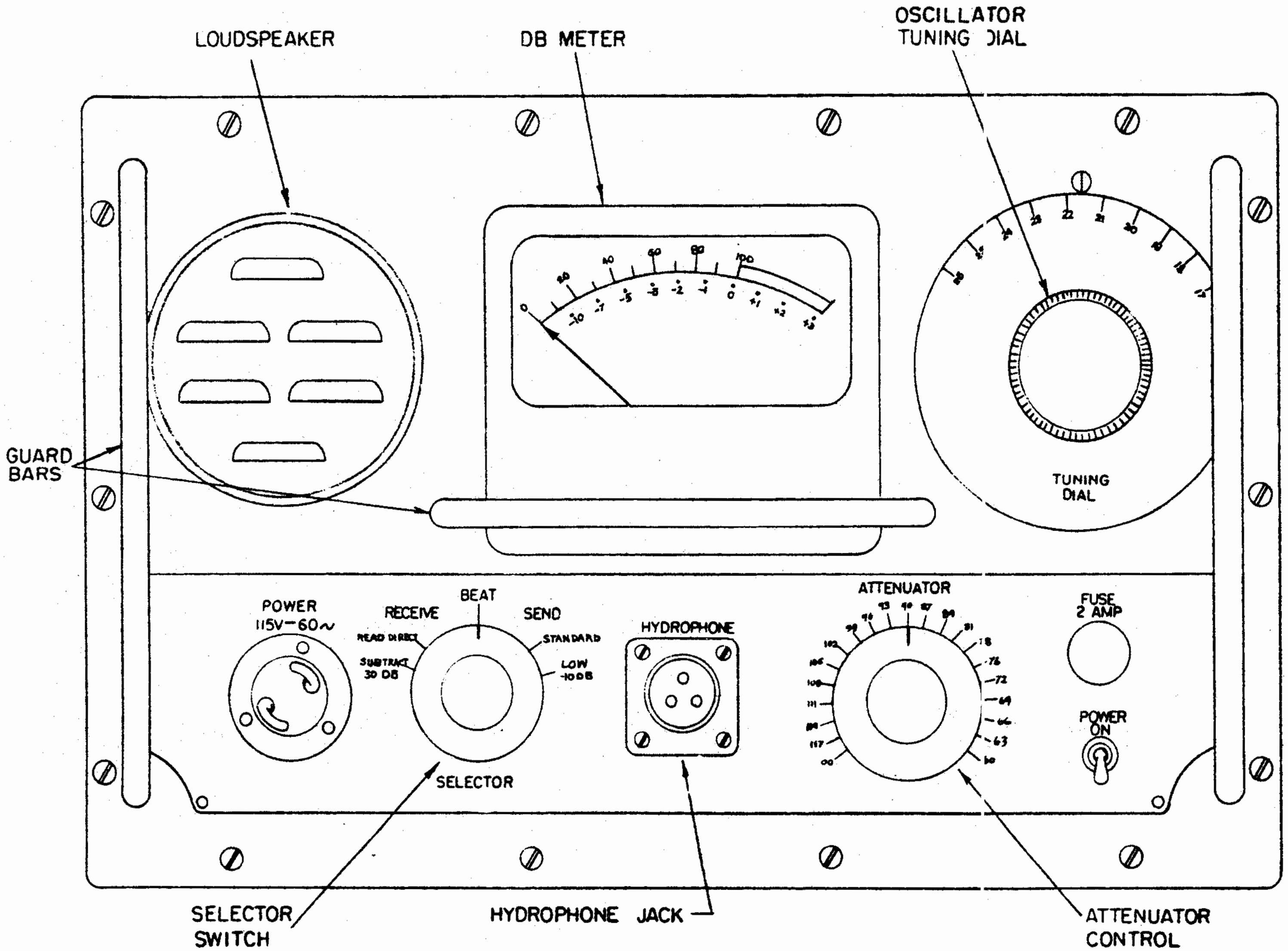


Figure 4-24. Typical Underwater Sound Monitor Test Set

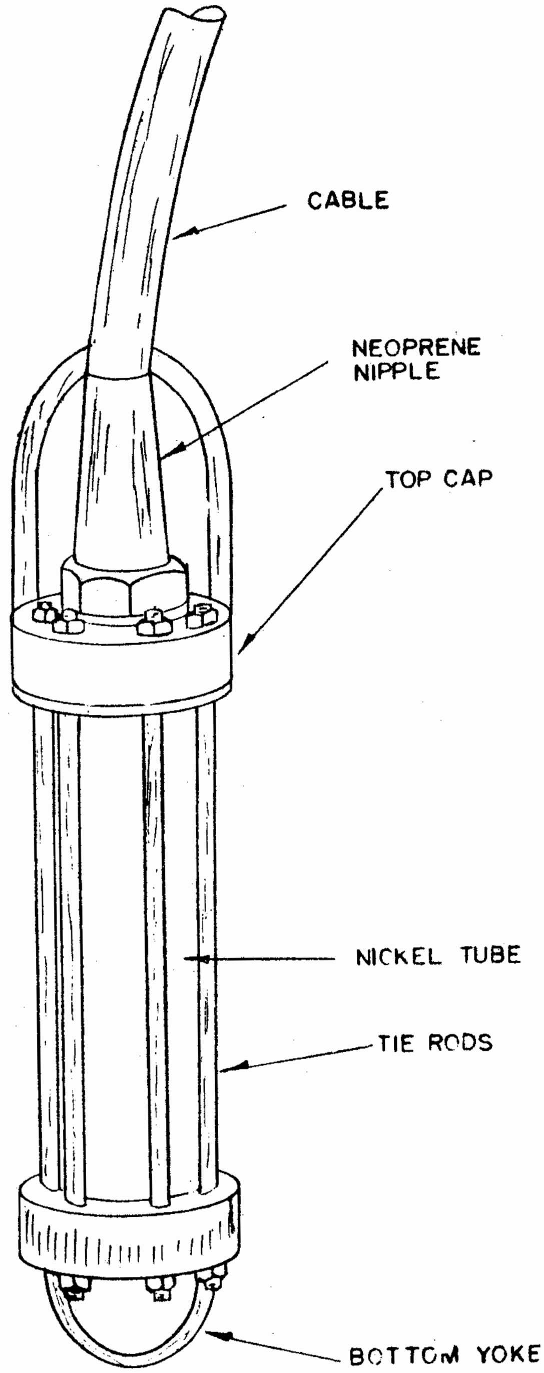


Figure 4-25. Hydrophone Unit

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