CHAPTER 2

ELECTRONICS SAFETY PRECAUTIONS

Nothing in the ET training program can be more important to the individual ET than his own personal safety and the safety of his shipmates. Because this is such a personal matter, its importance should be obvious. In few other fields of work is the expression, "carelessness kills," more appropriate.

Electronic circuits are potentially dangerous even when the technician uses a great deal of care in his service work. The danger, however, varies inversely with the effectiveness of the safety precautions. Therefore, proven, recommended safety precautions must be observed.

When working on live equipment, watch what touches your body as well as what you touch with your hands.

Learn artificial respiration. If you know it, it may save your shipmate's life. If he knows it, it may save your life.

In cases of electric shock, artificial respiration must be given IMMEDIATELY to do any good. For example, power linemen are told to start artificial respiration before lowering the victim from the pole to the ground. This procedure saves valuable time.

Instructions for giving artificial respiration are included in the Standard First Aid Training Course, NavPers 10081.

Much material has been written on the subject of safety precautions; and much has been written especially for the benefit of electronics personnel.

All electronics personnel must become thoroughly familiar with United States Navy Safety Precautions, OpNav 34P1, including the latest changes; they should pay special attention to chapter 18. All electronics personnel must likewise become familiar with chapter 67 of the Bureau of Ships Technical Manual, NavShips 250,000, including the latest changes; they should pay special attention to section 5 of chapter 67.

Additional information that will be of value is contained in Electric Shock, its Cause and Prevention, NavShips 250-660-42; chapter 1 of the Electronic Installation Practices Manual, NavShips 900, 171, and in some issues of the Bureau of Ships Journal. Many issues of the Electronics Information Bulletin (EIB) also include safety information.

Some of the information contained in the following paragraphs is condensed from the previously mentioned references.

PERSONAL PROTECTION

The technician must not work on electrical (or electronic) equipment when his hands or clothing are wet. Never wear loose or flapping clothing or clothing with exposed zippers or metal fasteners when working on electronic equipment. The same is true of rings, wristwatches, bracelets, and similar metal items. Another very important item is the matter of shoes. Never wear thin-soled shoes and shoes with metal plates or hobnails when working on electronic equipment.

Work must never be done on live circuits where the voltage exceeds 30 volts except in case of emergency. Under emergency conditions when work must be done on live circuits, every precaution must be taken to prevent accidental grounds. Wear rubber gloves and use properly insulated tools; cover the deck with an approved insulating material; and make sure that at least one other person is present at all times. All persons must be thoroughly familiar with approved methods of rendering first aid and artificial respiration. Specific instructions pertaining to work on live circuits are contained in chapter 18 of United States Navy Safety Precautions, OpNav 34P1.

Danger signs and suitable guards must be provided to prevent personnel from coming in accidental contact with high voltages. Danger

signs must also be used to warn personnel servicing electronic material aloft against the possible presence of explosive vapors in certain locations and against the POISONOUS EFFECTS OF SMOKE AND STACK GASES.

According to OpNav 34P1, on all circuits where the voltage is in excess of 30 volts, and where the deck or walls are of metallic construction, the worker must be insulated from accidental grounding by the use of approved insulating material. Whenever work of a nature other than electrical is performed in the vicinity of exposed electrical circuits, see that suitable insulating barriers are provided to prevent accidental contact with the circuits. Dry wooden stools or platforms may be used to prevent the possibility of contact between the workmen's shoes and a wet or damp floor.

Other protective measures include (1) covering metal tool handles with rubber insulating tape; (2) ensuring that fuse boxes are securely closed except when work is being done on them; (3) checking the resistance between the metal bases, frames, and so forth of electronic equipment and ground at regular intervals and after repair work has been done; and (4) being sure that safety devices such as interlocks, overload relays, and fuses are not altered or disconnected except for replacement (no safeguard circuit is to be modified without specific authority).

In connection with insulating metal tool handles with rubber insulating tape, it is also necessary to insulate the shanks of certain screwdrivers (particularly those used inside electronic equipment) with insulating sheaths. Only 3/16 of an inch of the blade need be exposed. Where it is not practicable to tape or otherwise insulate a surface, electricians' insulation varnish may be used.

There are certain special precautions against electric shock that must be taken. Certain pieces of equipment (for example, brushes, dusters, and brooms) not generally considered to be conductive can be dangerous, and the necessary precautions must be taken. Sufficient illumination is very important, and so is keeping one's attention directed to the work being done. Do not trust equipment insulation to protect you from high voltage when work is to be performed, and keep alert to the possibility of accidental grounds or shorts.

When working on live circuits, exercise as much care with low voltages as with high voltages; and never take a shock intentionally from any voltage regardless of how small it may be.

GENERAL ELECTRONICS SAFETY PRECAUTIONS

Because of the constant use of radio aboard ship the following precautions for radio-frequency circuits should be observed: (1) Energized high voltage output circuits should not be broken except when absolutely necessary and authorized by a qualified officer; and (2) when other transmitting equipment is in use at the same installation or close by, ETs should be on the alert to prevent shock, burns, or other injury to personnel due to energy picked up from adjacent antennas or equipment (certain circuits may have to be grounded for safety reasons).

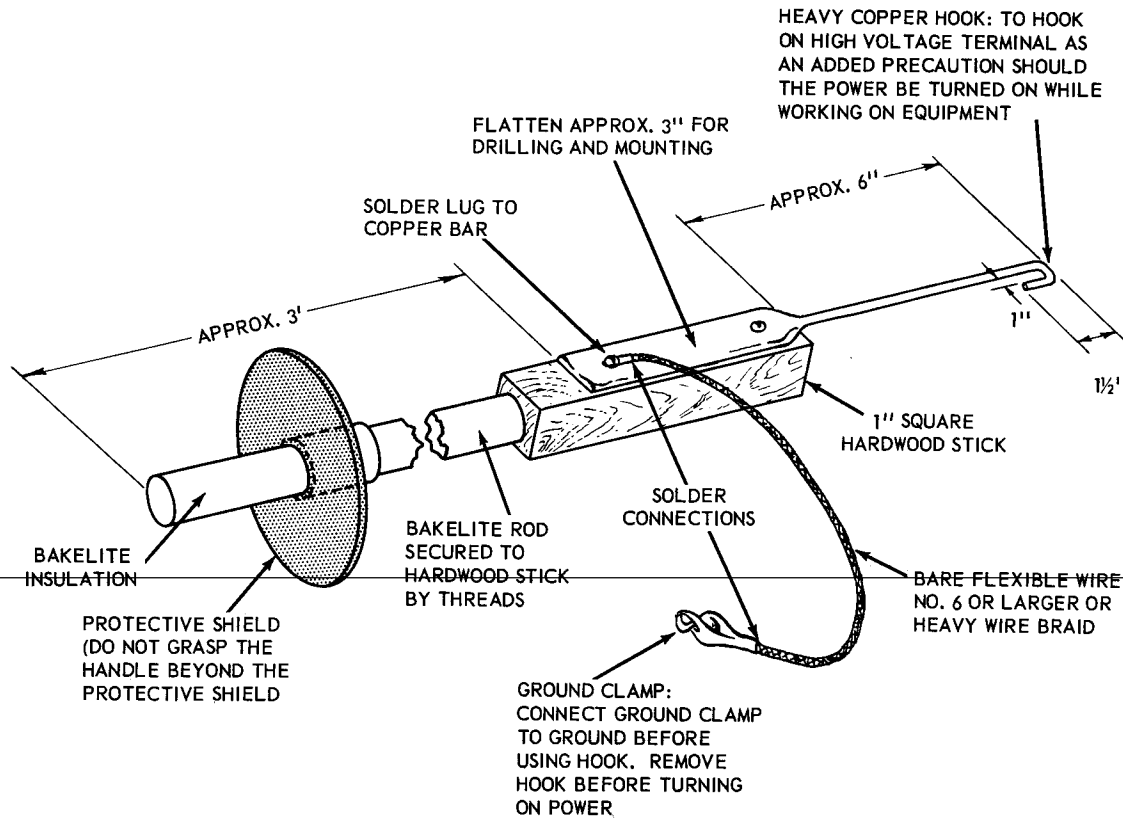
Electronic detonators or igniters, electrically fired rocket motors, and electric fuzes (ordnance) must not be located in the same compartment with or be exposed within 5 ft of any exposed electronic transmitting apparatus, or exposed antenna, or antenna lead aboard ship or at a shore electronics activity. No danger due to r-f potentials exists with detonators of any type while they are in a properly covered metal container.

Capacitors are potentially dangerous. Before touching a capacitor, which is connected to a deenergized circuit (or which is disconnected entirely), short-circuit the terminals to make sure that the capacitor is completely discharged. A suitably insulated shorting stick should be used for this purpose (fig. 2-1).

The primary function of the shorting stick is to pass the discharge current from a capacitor through the ground wire to ground, NOT through the body of the person discharging the capacitor. The hook enables the technician to fasten the stick to the high-voltage terminal so that it can serve as an added protection while work is in progress. Connect the ground clamp to ground BEFORE using the hook.

Some shore stations have provided a shorting stick at each transmitter enclosure. In each case it is so placed that the technician must remove the shorting stick before he can gain access to the equipment.

No person should reach within or enter energized electronic equipment enclosures for the purpose of servicing or adjusting, except when prescribed by official applicable technical manuals and then not without the immediate presence and assistance of another person capable of rendering aid in an emergency.



1.1

Figure 2-1.—Diagram of shorting stick.

When the ship is in drydock, the electronic equipment on board may be energized only with the permission of the docking officer.

COMMON SAFETY FEATURES IN ELECTRONIC EQUIPMENT

The ET should be aware of the safety features that are generally included in electronic equipment. There is a tendency on the part of design people to pay more attention to safety measures when the equipment is to be used by unskilled persons than when it is to be used by skilled persons, but there is always the possibility that an accident will happen to a skilled, but unalert person. This is a matter to keep in mind; and the ET must remember that safety devices cannot always be counted upon to function.

Some of the common safety features are interlock switches, bleeder resistors, insulated controls, and power-line safety devices.

INTERLOCK SWITCHES

The interlock switch is ordinarily wired in series with the power-line leads to the electronic power supply unit, and is installed on the lid or door of the enclosure so as to break the circuit when the lid or door is opened. A true interlock switch is entirely automatic in action; it does not have to be manipulated by the operator.

Multiple interlock switches, connected in series, may be used for increased safety. One switch may be installed on the access door of a transmitter, and another on the cover of the power-supply section. Complex interlock systems are provided when several separate circuits must be opened with safety.

Because electronic equipment may have to be serviced without deenergizing the circuits, interlock switches are so constructed that they can be disabled by the technician. However, they are generally located in such a manner that a certain amount of manipulation is necessary in order to operate them.

BLEEDER RESISTORS

A bleeder resistor is often connected across the output terminals of high-voltage d-c power supplies. It is used to bleed the dangerous charges off the filter capacitors because a high-grade filter capacitor can maintain its charge for a long period of time.

The bleeder current is an added drain on the power supply, but the system is designed to withstand this additional burden.

In some equipments where large, high-voltage capacitors cannot be effectively shunted by bleeder resistors, the technician must discharge these capacitors before working on the high-voltage circuits. For this purpose special shorting sticks are used.

The technician must keep in mind the possibility that the bleeder resistor may burn out and thus become useless as a protective device. Filter capacitors must be discharged as a matter of routine when repair work is to be done. Do not depend on the bleeder; it is merely an added protection.

INSULATED CONTROLS

Metal knobs, dials, switches, and adjustment screws are generally used only in equipment of the "cold chassis" type; they are not used with a-c/d-c devices.

Even when insulated knobs are used, short setscrews, which do not extend beyond the recessed opening in the knob, are used to prevent the operator's fingers from coming in contact with a possible live circuit.

Rheostats and potentiometers in high-voltage circuits are placed far enough back of the panel to permit an insulated shaft coupling between the device and the control knob. Common examples are the focus, intensity, and beam-centering controls of an oscilloscope.

POWER-LINE SAFETY MEASURES

Only approved line cords in good condition should be used. Such cords must be protected with insulating grommets at the point where they pass through the chassis or panel.

In addition to the external fuses, equipments are usually supplied with one or more internal fuses.

GROUNDING OF EQUIPMENTS AND COMPONENTS

USE OF GROUNDED TYPE PLUGS (AND RECEPTACLES)

Navy specifications for portable tools require that the electric cord for such tools be provided with a distinctively marked ground wire in addition to the conductors for supplying power to the tool. The end of the ground wire within the tool must be connected to the tools metal housing. The other end must be connected to a positive ground. For this ground connection, use the specially designed grounded type plugs and receptacles, which automatically make this connection when the plug is inserted in the receptacle.

Portable tools not provided with the grounded type plug, and miscellaneous portable electric equipments, which do not have a cord with a grounded conductor and grounded plug, must be provided with a 3-conductor cord and with a standard Navy grounded type plug. Connect the ground wire to a positive ground so that the total resistance from the tool enclosure to the ground to which it is connected does not exceed a small fraction of an ohm.

Because the ET is responsible for the portable power tools assigned to his division, he must be familiar with the Bureau of Ship's approved methods of installing plugs and cords. The methods are spelled out in detail in Article 60-27 of the Bureau of Ships Technical Manual. The following information is condensed from this article.

All 115-volt or 230-volt single-phase a-c and all 115-volt or 230-volt two-wire d-c electrically operated equipment now on board ship that does not have a cord with a grounding conductor and grounded plug, and all such equipment subsequently issued to the ship without a cord that has a grounding conductor and grounded plug, should be provided with a three-conductor flexible cable with standard Navy grounded plug, type D-2-G, shown on Bureau of Ships plan 9-S-4440-L. The three-conductor flexible cable should be type SO or ST color

coded black, white, and green, as listed in the Navy Stock List of General Stores, group 61.

All 115-volt 3-phase electrically operated portable equipment now on board ship or subsequently issued that does not have a cord with a grounding conductor and grounded plug should be provided with a type FHOF four-conductor flexible cable color coded black, white, red, and green, with standard Navy grounded plug, type EEE-125, shown on Bureau of Ships plan 9-S-4861-L.

The length of the cord for portable tools should be 25 feet. The green conductor should be used for the grounding conductor.

Extreme care must be exercised to see that the ground connection is made correctly. If the grounding conductor (green), which is connected to the metallic equipment casing, is connected by mistake to a line contact of the plug, a dangerous potential will be placed on the equipment casing. This might easily result in a fatal shock to the operator. To guard against this danger, the connections must be tested after they have been made, to make certain that the leads are connected properly and that a good ground is assured.

GROUNDING ELECTRONIC EQUIPMENT CASES

Ungrounded electronic equipment cases create an unnecessary hazard and frequently produce electronic interference. All missing ground connections must be replaced, and all ground connections must be checked with an ohmmeter.

GROUNDING WORKBENCHES

Special precautions must be taken to ground workbenches (when used for the repair of electronic equipment) by providing two or more ground straps symmetrically placed at diagonally opposite corners or posts, using low-resistance flexible braid securely welded or bolted to steel deck or bulkhead. After completing the grounding of the bench, test it with a low-reading ohmmeter for positive grounding. Positive ground will be indicated by a low meter reading.

PRECAUTIONS AGAINST ACCIDENTAL ENERGIZING

SECURING SWITCHES

When electrical equipment is to be worked on, it must be disconnected from the source of supply by opening main or branch supply switches, circuit breakers, or cutouts so as to completely eliminate the possibility of current flowing to the equipment. Switches, circuit breakers, or cutouts opened for this purpose must be secured in the open position and must have tags attached. Only the individual placing the tag may remove it and reenergize the circuit. Specific instructions are given in United States Navy Safety Precautions, OpNav 34P1, chapter 18.

INDUCED VOLTAGES

The use of electronic equipment in the frequency range of 30 megacycles and below will cause voltages to be induced in the standing rigging and other portions of the ship's structure, which, under certain conditions, are considered hazardous.

The voltages caused by resonant circuits set up in a ship's structure or rigging will cause shock to personnel, or produce open sparks when contact is made or broken—for example, when the circuit is opened, or when metallic objects make contact with the structure.

Although there are too many variables to give even an approximation of the voltages that may be encountered, the following examples are cited: (1) Excessive r-f pickup from ship antennas has been noted on smokestack guys, davit head spans, and the like; (2) a similar high-frequency pickup has been observed on board ship, particularly carriers, when the length involved in reeling in or paying out wire cable and wire hausers becomes resonant to the emitted frequency; and (3) it has been discovered that flammable liquids may be ignited in close proximity to an energized radar antenna if the liquid is in a metal container or near metal objects.

PRECAUTIONS WHEN WORKING ON ANTENNAS

Personnel should keep clear of r-f fields of exposed antennas. Under no circumstances should personnel approach closer than 1 foot

to a radio antenna unless it is definitely established that the antenna is not energized.

Specific instructions covering working aloft are given in Section 3, chapter 18, of United States Navy Safety Precautions, OpNav 34P1, a portion of which is included in the following paragraphs.

"Before any work may be done aloft, authorization must be obtained from the commanding officer. (The OOD usually gives permission for the commanding officer.) While antennas are energized by radio transmitters, men shall not be permitted to go aloft except by means of ladders and platforms rendered safe by grounded handrails or similar structures. Before sending men aloft, except as noted previously, the commanding officer shall direct the communication watch officer to secure the proper transmitter in order to render safe this area, and shall notify the engineer duty officer that men will be working in a prescribed area aloft in order that the engineer duty officer may take the necessary precautions to prevent the boiler safety valves from lifting (these are vented up the stack). Until he has received a report from the communication watch officer that the proper transmitters are secured, the commanding officer shall permit no man to go aloft. After the work has been completed, a report shall be made to the commanding officer, and his authorization must be obtained before the circuit is again energized.

"Radar and other antennas which rotate or swing through horizontal or vertical arcs may cause men working aloft to fall. Therefore, the motor switches which control the motion of these antennas shall be locked open and tagged before men are permitted to ascend or go within reach of them."

In connection with antennas it is extremely important to maintain a safe distance (perhaps hundreds of feet) in the field of an antenna of a high-powered radar set. Minimum safe distances from the various radar antennas are listed in chapter 67 of the Bureau of Ships Technical Manual, and EIB-558 dated 10 April 1961.

Under no circumstances should a person look into a waveguide of a radar set when the power is on. It is well to realize, too, that X rays are generated at the surface of cathode-ray tubes. At voltages of 20,000 volts or less, the glass is a shield. Above 20,000 volts the glass is progressively a poorer shield as the voltage goes up. Looking directly at a 30,000-volt projection cathode-ray tube is definitely dangerous, especially at a short distance (2 ft).

PRECAUTIONS WHEN HANDLING ELECTRON TUBES

CATHODE-RAY TUBES

The use of larger cathode-ray tubes has increased the danger of implosion, flying glass, and injury from high voltage. The danger is greatly reduced if the tubes are properly handled. If they are handled carelessly, struck, scratched, or dropped, they can very well become an instrument of severe injury or death. The following precautions should be taken: (1) Goggles should be worn to protect the eyes from flying glass particles, (2) suitable gloves should be worn, and (3) no part of the body should be directly exposed to possible glass splinters caused by implosion of the tube. (The coating on some tubes is poisonous if absorbed into the blood stream.)

Cathode-ray tubes must not be unnecessarily exposed to possible damage. When a tube is being unpacked, remove it from the packing box with caution, taking care not to strike or scratch the envelope. Insert it into the equipment socket cautiously, using only moderate pressure. When the tube must be set down, it is important that it be placed on a clean, soft padding. If special tube-handling equipment is available, it should be used according to instructions.

RADIOACTIVE ELECTRON TUBES

Poisoning from radioactive materials contained in electron tubes such as radiac, spark gap, TR, glow lamp, and cold cathode tubes may be of 3 types:

1. ASSIMILATION—Eating, drinking, or breathing radium or radium compounds or absorbing them through cuts. Radium-bearing dust, which may be present in certain tubes, is dangerous in this respect.

2. BREATHING RADON—Radon is a tasteless, odorless, colorless gas that is given off by radium and radium compounds at all times. When breathed into the lungs it may cause severe injury.

3. RADIATION—Radium and radium compounds give off harmful, invisible radiations that can cause dangerous burns.

Useless unbroken electron tubes containing radioactive material are treated as any other radioactive waste material. Broken radioactive electron tubes are disposed of in accordance with BuShips Instruction 5100.5 of 28 November 1955. Additional instructions concerning handling, storage, and disposition of radioactive electron tubes are contained in BuShips letter S67/9-11(871C), ESO Instruction 5100.1, and NavMed P-1325.

PRECAUTIONS TO BE OBSERVED WHEN PAINTING ELECTRONIC EQUIPMENT

Adequate ventilation must be provided for all enclosed compartments in which painting is to be done. Exhaust ventilators as well as power blowers should be used. Blowers should be so arranged as to ensure rapid and complete removal of all explosive, combustible, and/or toxic vapors which may be present. Vapors must be exhausted in such a way that they will not be sucked into any of the ship's supply vents which may be running, or in any way contaminate other areas.

Where paint vapors or fumes are known to be explosive, any electrical equipment used in the vicinity of the painting operations in enclosed compartments must be of the explosion-proof type. Do not permit smoking or allow any type of work that may produce flames or sparks to be performed within the danger area.

Maintain good housekeeping practices and keep all unnecessary objects and materials picked up and out of the way. Particular attention must be given to rags, sweepings, waste, etc., which may be paint-saturated or contaminated. These materials must be placed in covered metal containers or buckets containing water.

The exits to the compartment in which painting is being done must not be blocked in any manner. Adequate firefighting equipment must be at hand.

PRECAUTIONS IN USING SOLVENTS

Carbon tetrachloride is definitely toxic, actually about four times as toxic as carbon monoxide, and serious accidents have resulted from the improper use, storage, and handling of this solvent.

A new solvent, methyl chloroform, has been approved for cleaning electrical and electronic equipment. It is now available from General Stores, and should be used in place of the more dangerous carbon tetrachloride.

Even though methyl chloroform is less toxic than carbon tetrachloride, the solvent does present some hazards to personnel, and the following precautionary note is required on the container label:

"Caution—Use with adequate ventilation. Avoid prolonged or repeated breathing of vapor. Avoid prolonged or repeated contact with skin. Do not take internally."

The solvent may be applied by wiping, brushing, or spraying. Methyl chloroform, like carbon tetrachloride, will attack electrical insulating materials, particularly the air-dried varnishes. Therefore contact time should be limited.

SOME SAFETY RULES TO REMEMBER

1. Do not rely on safety devices such as interlocks and high-voltage relays.
2. Do not work alone on high-voltage circuits.
3. Observe all warning signs.
4. Do not intentionally come in contact with an energized circuit.
5. Avoid working on energized circuits.
6. Do not smoke, eat, or drink while painting.
7. Remember that solvents are potentially dangerous.
8. Use a shorting stick for discharging capacitors.
9. Use approved fuse pullers.
10. The appearance of the work is a measurement of the worker's ability; the same is true of the work space.
11. Remember that personnel may be killed or injured by high-voltage equipment that is assumed to be off. Take nothing for granted. Make certain that the power is off by securing the power-line switch in the OFF position.
12. Observe carefully the instructions about tagging open switches. The following is quoted from the Bureau of Ships Technical Manual:

"When any electronic equipment is to be overhauled or worked on, the main supply switches or cutout switches in each circuit from which power could possibly be fed shall be secured in the open (or safety) position and tagged. The tags shall read 'This circuit was ordered open for repairs and shall not be closed except by direct order of_____' (usually the person making, or directly in charge of,

the repairs). After the work has been completed, the tag or tags shall be removed by the same person.

"When more than one repair party is engaged in the work, a tag for each party shall be placed on the supply switch. Each party shall remove only its own tag upon completion of the work.

"When switch-locking facilities are available, the switch shall be locked in the open (SAFETY) position and the key retained by the person doing the work so that only he, or a person designated by him, can remove the lock and restore the circuit."

13. Even after switches have been opened and tagged, make an additional check at the equipment with a voltmeter known to be in good working order to ensure that the correct switch or switches have been opened.

14. Remember that aboard ship a person must exercise the greatest precaution when working with electrical circuits because of the metal structure (good ground), dampness, and crowded working conditions. This does not mean that a technician should be less cautious at shore stations. He should be cautious whenever he works with electricity; but, in general, the chances of being injured aboard ship are greater if the necessary additional precautions are not taken.

15. Be thoroughly familiar with OpNav 34P1 (United States Navy Safety Precautions), especially chapter 18; section 5 of chapter 67 of the Bureau of Ships Technical Manual, NavShips 250,000; and the Standard First Aid Training Course (NavPers 10081), especially those sections dealing with the treatment for electrical shock and burns.