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MILITARY STANDARD

SHIPBOARD BONDING, GROUNDING, AND OTHER TECHNIQUES FOR ELECTROMAGNETIC COMPATIBILITY AND SAFETY

FSC EMCS

DEPARTMENT OF THE NAVY

NAVAL SEA SYSTEMS COMMAND

WASHINGTON, D.C. 20360

Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety

MIL-STD-1310D(NAVY)

1. This Military Standard is approved 8 February 1979 for use by all interested commands of the Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Commander, Naval Ship Engineering Center, SEC 6124, Department of the Navy, Washington, D.C. 20362 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. This revision of MIL-STD-1310 is the result of several years of shipboard testing and investigations directed towards updating the methods and materials used in reducing electromagnetic interference (EMI) aboard Naval ships. High-order intermodulation testing performed under the auspices of the Shipboard Electromagnetic Compatibility Improvement Program (SEMCIP) has identified topside items that contribute to intermodulation EMI and as a result these items have been rank ordered based on interference severity. In addition, several requirements have been deleted and bonding of other items has been materially improved. Improvements have also been made in safety grounding and EMI grounding in ship non-topside areas.

2. New in this revision is the addition of shielding and grounding for the protection of electronic functions in the presence of an electromagnetic pulse (EMP) or a self-generated severe electromagnetic (EM) environment. Improved methods are included to provide peripheral grounding of cables, piping, tubing, and waveguide to "ground out" EMP energy prior to this energy entering the ship.

3. This revision of MIL-STD-1310 should provide the shipbuilder, shipyard, and ship's force with simplified techniques for reducing EMI, provide guidance for personnel safety grounding, and provide protective measures against the threat of an electromagnetic pulse.

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1. SCOPE

1.1 Scope. This standard covers those elements of ship design requirements essential to the attainment of shipboard electromagnetic compatibility (EMC) by effecting suppression of potential sources of electromagnetic interference (EMI) and including intermodulation interference (IMI) and reduction of susceptibility to electromagnetic pulse (EMP). Requirements cover design of ground systems, use of nonmetallic topside items, and installation, bonding, grounding, and shielding methods for equipment, cables, and conduit with associated safety features.

1.1.1 Limitations. This standard does not cover other methods of EMI reduction such as filters, multicouplers, blankers, equipment location, equipment power levels, or operating frequencies. These methods are usually covered by applicable equipment or system specifications or by designated operational procedures.

1.1.2 Application. Requirements specified herein are normally applied during ship construction, overhaul, ship alteration (ShipAlt), or ship repair. Requirements which are within the ship's capability may be applied by ship's force as needed.

1.2 Classification. Classification is applicable to class of bonding method and to types of straps used for bonding.

1.2.1 Classes. Bonding methods are classified as follows:

Class A. A bond achieved through the process of welding or brazing.
Class B. A bond achieved by mounting hardware and other areas of metal-to-metal contact inherent in normal installation of an item or equipment.
Class C. A bond achieved by bridging two metallic surfaces with a metallic bond strap.

1.2.2 Types. Types of straps used for class C bonding are classified as follows:

Type I. A strap, constructed of welding cable with terminal lugs of steel or aluminum, used for topside applications where one end is welded to hull ground and the other end to the item to be bonded (see figure 1).
Type II. Similar to type I, except that only one lug is welded and the other is bolted down for installation (see figure 1).
Type III. A flat copper strap used for topside and nontopside bolted applications (see figure 2).
Type IV. A flat copper braid strap used for nontopside bolted applications (see figure 2).

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of inviation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL
J-C-175 - Cable Assembly, Power, Electrical (3-Wire, 3-Prong, Grounding Plug Connector, for 125-Volt Equipment).
W-C-440 - Clips, Electrical, General Specification for.
QQ-B-575 - Braid, Wire, (Copper, Tin-Coated, Tubular).
QQ-C-576 - Copper Flat Products with Slit, Slit and Edge - Rolled, Sheared, Sawed or Machined Edges, (Plate, Bar, Sheet, and Strip).
QQ-S-763 - Steel Bars, Wire, Shapes, and Forgings, Corrosion-Resisting.
TT-V-119 - Varnish, Spar, Phenolic-Resin.
WW-C-440 - Clamps, Hose (Low-Pressure).

MILITARY
MIL-I-631 - Insulation, Electrical, Synthetic Resin Composition, Nonrigid.
MIL-R-900 - Rubber Gasket Material, 45 Durometer Hardness.
MIL-C-915 - Cable and Cord, Electrical, For Shipboard Use, General Specification For.
MIL-C-915/21 - Cable, Electrical, 125 Volts, Type TRXF.
MIL-S-1222 - Studs, Bolts, Hex Cap Screws, and Nuts.
MIL-C-3767 - Connectors, Plug and Receptacle, (Power Bladed Type), General Specification For.

MILITARY (Continued)

MIL-W-16878/3 - Wire, Electrical, Type D, 105°C., 3000 Volts, (Insulated, High Temperature).
MIL-T-22361 - Thread Compound, Antiseize, Zinc Dust-Petrolatum.
MIL-S-22698 - Steel Plate, Carbon, Structural, for Ships.
MIL-S-24149 - Studs, Arc Welding, and Arc Shields (Ferrules): General Specifications.
MIL-C-28777 - Cable Assembly, Electronic Test Equipment, (3 Wires, 125 and 250 Volts AC and 28 Volts DC Molded) Grounding Plug Connector, General Specification for.

STANDARDS

MILITARY

MIL-STD-462 - Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-1399 - Interface Standard for Shipboard Systems.
Section 406, Digital Computer Grounding.
MIL-STD-1605 - Procedures for Conducting a Shipboard Electromagnetic Interference (EMI) Survey (Surface Ships).
MIL-STD-1680 - Installation Criteria for Shipboard Secure Electrical Information Processing Systems.
MS3188 - Backshell, 90°, Cable Sealing and Shield Termination, Connector, Electric.
MS3189 - Backshell, 45°, Cable Sealing and Shield Termination, Connector, Electric.
MS3437 - Backshell, Straight, Cable Sealing, and Shield Termination, Connector, Electric.
MS20659 - Terminal, Lug, Crimp Style, Copper, Uninsulated, Ring Tongue, Type I, Class 1.
MS21104 - Clamp, Loop, Cushioned, Wedge, Fuel, Weather Resistant, 212°F., Type II, Class A and B.
MS35207 - Screw, Machine-Pan Head, Cross-Recessed, Carbon Steel, Cadmium Plated, UNF-2A (IN/MM).
MS35333 - Washer, Lock, Flat-Internal Tooth.
MS35335 - Washer, Lock, Flat-External Tooth (IN/MM).
MS35338 - Washer, Lock-Spring, Helical, Regular (Medium) Series (IN/MM).
MS35425 - Nut, Plain, Wing, UNC-2B.
MS35436 - Terminal, Lug, Solder Type, Copper Stamping, Insulation Grip, One Hole.
MS35650 - Nut, Plain-Hexagon, Machine Screw, UNF-2B.
MS35691 - Nut, Plain, Hexagon (Jam) UNC-2B and UNF-2B.
MS51967 - Nut, Plain, Hexagon-Carbon Steel, Cadmium Plated, UNC-2B.
MS90725 - Screw, Cap, Hexagon Head (Finished Hexagon Bolt), Steel, Grade 5, Cadmium Plated, UNC-2A.

DRAWINGS

NAVAL SEA SYSTEMS COMMAND

NAVSHIPS

9000-S6202-73980 - Electric Plant Installation, Standard Methods.
804-4563125 - Climber Safety Rail Notched Tube Type Arrangement and Details.

NAVSEA

803-5003000 - Safety Shorting Probe Set and Stowage Assembly.
803-5184099 - Inclined Ladder for Exterior Locations, Glass Reinforced Plastic (GRP).

NAVAL AIR ENGINEERING CENTER

6SE00063 - Avionic Workbench, Deck Support and Ground Installation Drawing.

NAVAL AIR SYSTEMS COMMAND

63A114D4 - Back Panel and Top Shelf Assembly.
63A114D5 - Auxiliary Table Assembly and Details.
63A114F12 - Electrical Distribution Box and Terminal Board Assembly.
63A114J2 - Cabinet Assembly.
63A114J7 - Cabinet Structure Assembly and Details.
63A114J13 - Back Panel Assembly and Details.

PUBLICATIONS

NAVAL SEA SYSTEMS COMMAND
0900-LP-005-8000 - Technical Manual for Radio-Frequency Radiation Hazards.
0901-LP-920-0003 - Technical Manual for Welding and Allied Process, Chapter 074, Section I.
0900-LP-061-4010 - Handbook of Submarine ELF Electromagnetic Quieting Practices.
0967-LP-317-7010 - Technical Manual for Radio Frequency Burn Hazards Reduction.

(Copies of specifications, standards, drawings, and pulbications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

3. DEFINITIONS. The following definitions apply:

3.1 Bond (electrical). A current path between two metallic surfaces which is established by a class A, B, or C bond. The term "bonded" is thereby applied to such surfaces.

3.2 Conduit. A sheet metal enclosure normally of rectangular or circular construction used to provide electromagnetic shielding protection to cables. Conduit may vary in size from a single circular tube or pipe to a large square or rectangular trunk with cable hanger access panels provided.

3.3 Electromagnetic compatibility (EMC). That condition which exists when electronic equipment will operate in a desired location or environment in proximity one to another without causing or receiving electromagnetic interference (see 3.4).

3.4 Electromagnetic interference (EMI). Electromagnetic energy which causes a malfunction or interferes with the reception or processing of a desired signal. EMI may be intentionally generated energy. For shipboard application, EMI is identified in severity as mild, medium, or severe depending upon the response of individual equipment to given EMI levels (see MIL-STD-1605).

3.4.1 Narrowband EMI. An EMI that has its principal spectral energy lying within the bandpass of the equipment receiving the interference, is normally discrete in spectral energy, and is characterized by capability of affected equipment to tune out or minimize the EMI source signal. Examples of sources of narrowband interference are radio station transmissions, hull-generated intermodulation signals, and oscillator type signals.

3.4.2 Broadband EMI. An EMI that has its spectral energy distributed over a broad frequency range in relation to the frequency bandwidth of the equipment receiving the interference, broadly tunable, and can be present over all or a significant portion of the tuning range of an affected receiver. Examples of sources of broadband interference are atmospheric disturbances, arcing, electrostatic discharges, and short duration pulses.

3.4.3 EMI tests. Tests that will determine whether an EMI condition exists. Tests are normally conducted in acoordance with the requirements of MIL-STD-462 for equipment and MIL-STD-1605 for total ship.

3.5 Electromagnetic pulse. An electrical signal of large amplitude and broad frequency range that is generated by a nuclear weapon at the time of detonation. EMP may be present when all other weapon effects are absent and may upset or damage electronic equipment over a wide geographic area.

3.6 Enclosure. A metallic housing such as a cabinet or a case which provides physical protection and support to equipment, parts, or subassemblies. An enclosure may also provide shielding for equipment installed therein.

3.7 Equipment, electrical. Equipment designed to generate, convert, distribute, control, or utilize power frequency energy. Examples are generators, motors, power switchboards, power tools, lighting fixtures, and electrical appliances.

3.8 Equipment, electronics. Equipment designed to generate, transmit, convey, receive, store, process, or otherwise use electronics signals. Examples are transmitters, receivers, amplifiers, computers, underwater detection equipment, and fire control equipment, and associated test equipment.

3.9 Ground (ground potential). A point, line or surface utilized by electrical or electronic equipment or systems as a common reference for establishment of zero potential (see 4.1).

3.10 Grounding. The process of establishing a low impedance or low resistance path between an item or equipment and ground potential by the methods specified herein. The term "grounded" is thereby applied to such items or equipment.

3.11 Ground system. The sum total of all conductors utilized between items or equipment and common ground potential.

3.12 Intermodulation interference (IMI). Interference caused by generation, in a nonlinear junction, of frequencies equal to the sums or differences of integral multiples of two or more radio frequency currents flowing in such a junction.

3.12.1 IMI tests. Tests which are conducted in accordance with MIL-STD-1605 to determine the level of IMI generated in a ship topside area.

3.13 Nonlinear junction. A contact area between two metallic surfaces which exhibits nonlinear voltage-current transfer characteristics when subjected to an RF voltage. This nonlinearity is usually caused by the presence of corrosion or other semi-conducting materials in the contact area which will inhibit a bond between the surfaces and is referred to as the "rusty bolt" effect. It is usually present where items are bolted, pinned, or riveted.

3.14 Nontopside. Inner or inside areas of a ship not exposed to weather, including the interior of masts.

3.15 Resilient mount. A rubberized or otherwise flexible mounting support installed between an equipment and the supporting or foundation structure to provide shock or vibration isolation or acoustic damping. Four resilient mounts are normally used per equipment.

3.16 Shield (shielding). A metal barrier of solid, screen, or braid construction used to provide EMI protection to the enclosed components, wires, or cabling or to reduce the emission of EMI from such components, wires, or cabling.

3.17 Space, secure processing. An area within clearly defined perimeter barriers as defined by MIL-STD-1680.

3.18 Tack weld. One or more small welds which provides a current path between two metallic items for purpose of EMI reduction.

3.19 Topside. Shipboard areas on weather decks, such as the main deck and above, which are exposed to direct radio frequency (rf) radiation fields from ship's own antenna. Topside includes flight decks, elevator wells, antenna decks, and those portions of the gallery deck and above that are exposed. Hangar decks and interior sponson deck areas are not considered to be topside.

4. GENERAL REQUIREMENTS

4.1 Ground potential designation. On metallic hull ships, the hull shall be designated ground potential. Equipment racks, foundations, structures, and other large metal items or auxiliary ground systems which are welded, brazed, or class "C" bonded to the ship hull shall also be considered extensions of the ship hull at ground potential. On nonmetallic hull ships, the ground plates shall be designated ground potential. Ground bus cables attached to these ground plates (see 5.2.1) shall also be considered extensions of the ground plates at ground potential.

4.2 Personnel safety. The outermost metallic surface of equipment connected to electrical power and exposed to contact by personnel shall be grounded (see 5.1). Unless otherwise specified for nonmetallic hulls, resilient mounted equipment shall be grounded as specified in 5.3.1. Equipment not installed with resilient mounts shall be class B grounded (see 5.3.1). Installed equipment supplied with 115-volt single phase power shall be grounded by a ground conductor in the power supply cable. The ground conductor shall be the same size as the power feed conductors and shall be connected between the equipment ground

terminal and a ground stud or ground bus in the power panel. Rack-mounted equipment and equipment installed in environmental cabinets shall be grounded by a ground conductor connected to a ground bus bar in the rack or cabinet.

4.2.1 RF radiation/burn hazards. Posting of RF radiation hazard warning signs, RF burn hazard warning signs, the marking of safe distance limits, and other guidance for personnel safety shall be in accordance with Publications 0900-LP-005-8000 and 0967-LP-317-7010.

4.3 Secure processing spaces. In addition to the requirements specified herein, secure processing spaces shall comply with the requirements of MIL-STD-1680.

4.4 Welding equipment. Welding equipment shall be grounded in accordance with Publication 0901-LP-920-0003, chapter 074, section I.

4.5 Cables. Cables are a source of EMI due to electromagnetic couplings between cables or due to cable exposure to rf radiation fields. Reduction of susceptibility of such EMI shall be achieved by the following requirements:

(a) Cables exposed to radiation from RF communication antennas shall be shielded.
(b) Radar modulator pulse cables and sonar transducer cables shall be shielded or routed to provide maximum practicable cable separation between such cables and from all other cables.
(c) Cables not terminating in RF transmitter or modulator spaces shall not be routed through such spaces unless the cables are shielded and these shields are fully grounded at the points of entry and exit by 360-degree bonds.
(d) Cable shielding may be provided by use of shielded cable, by encasing cables in conduit, or by use of both methods when required. Where mast cables require shielding in accordance with the criteria specified in figure 3, such cables, both shielded and unshielded, shall be encased within the conduit in general accordance with figure 3 and with figure 4 where applicable. Where EMP protection is required, cables shall meet the additional requirements of 5.4.7. Cables routed within masts shall be installed in general accordance with figure 5.
(e) Outer braid of shielded cables shall be grounded in accordance with the applicable method shown on figure 6.

5. DETAILED REQUIREMENTS

5.1 All ships.

5.1.1 Workbenches. Electrical and electronic workbenches shall be grounded in accordance with figure 7.

5.1.2 Portable equipment. Metal cased portable electrical equipment and electronic test equipment equipped with two-wire, two-prong power cable assemblies shall be modified to use three-wire, three-prong cable assemblies of J-C-175 (for electrical equipment) and MIL-C-28777 (for electronic test equipment). In addition, power cords equipped with metal-covered plug assemblies conforming to MIL-C-3767 shall be replaced with molded-plug power cable assemblies conforming to MIL-C-28777. Portable electrical equipment encased in molded plastic housings will not require a third wire ground.

5.1.3 Shorting probes. Shorting probes (grounding rods) shall be provided and conveniently located in or near all potentially hazardous voltage sources such as transmitting equipment, equipment containing cathode ray tubes, and any other electronic equipments which include capacitor-type high voltage storage or filter circuits that may present a shock hazard to servicing personnel by retaining a voltage charge after primary power has been disconnected. Examples of such equipment are radio and radar transmitters, radar repeaters, radar modulators, and power supplies and converters. Where shorting probes are not furnished with such equipment, portable shorting probes conforming to Drawing 803-5003000 shall be provided. For existing ships, portable shorting probes may be obtained under part number NSN 1H5920-01-029-4176.

5.2 Nonmetallic hull ships. Requirements of 5.2.1 through 5.2.3 are applicable to nonmetallic hull ships only.

5.2.1 Ground system. A ground system shall be installed in accordance with 5.2.1.1 through 5.2.1.7 and figure 8.

5.2.1.1 Ground plates. A ground plate shall be installed on the port and starboard hull sides just above the keel, to provide an "earth" ground connection via contact with seawater.

5.2.1.2 Ground plate cable. Cable shall be installed between the two ground plates. A lug shall be installed on each end of the cable for connection to each ground plate through-bolt.

5.2.1.3 Transmitter ground cable. A transmitter ground cable shall be connected to the ground plates and run directly as possible to the radio transmitter spaces. This cable shall be connected to the ground plates interconnecting cable or to either ground plate through-bolt. Each radio transmitter cabinet or enclosure shall be connected to the transmitter ground cable.

5.2.1.4 Antenna tuners/couplers ground cable. Antenna tuners and couplers ground cables shall run as directly as possible from each tuner and coupler to the ground plates. In lieu of separate cable runs to the ground plates, each tuner and coupler ground cable may be connected to the main ground cable or to the electronic transmitter ground cable in order to provide the shortest direct path to the ground plates.

5.2.1.5 Main equipment ground cable. Main equipment ground cable shall be provided for grounding all other equipment and items. This cable shall be connected to the electronic transmitter ground cable or to either ground plate through-bolt and shall run throughout the ship as required to connect to equipments and metal items. Metallic decks or bulkheads may be used as extensions of this ground cable.

5.2.1.6 Branch ground wires. Branch ground wires shall be provided and shall be used to connect equipment and metallic items (see 5.2.2) to the main ground cable.

5.2.1.7 Ground cable and wire installation. Ground cable and wire shall be installed by using the minimum lengths consistent with meeting other requirements specified herein. They shall be installed in locations that provide minimum exposure to possible physical damage. Cables and wire installed on nonmetallic structures shall be supported by staples spaced approximately 18 inches apart. Where installation requires penetration of watertight decks or bulkheads, cables shall terminate at through-bolts in conformance with figure 8.

5.2.2 Equipment grounding. The following equipment and items shall be connected to the ground cable system:

(a) Equipment utilizing a.c. power.
(b) Fuel tanks and pipes.
(c) Metallic rigging.
(d) Metallic cranes, hoisting gear, and king posts.
(e) On minesweepers: deck chocks, deck wearing plates, deck padeyes, stern roller chocks, and any other metallic structures used for towing of or in contact with magnetic minesweeping cables.
(f) Railings and ladder ways.
(g) Water tanks.

5.2.2.1 Exceptions. The following items are not required to be grounded:

(a) Berths.
(b) Bitts (if not used with minesweeping operations).
(c) Chocks, except as required for minesweepers (see 5.2.2(e)).
(d) Small metal objects, such as metal parts of airports, hand tools (if not electrically operated), and other objects of comparable size.
(e) Ventilators.

5.2.3 Equipment and cable connections. Ground terminals shall be installed on equipment and items as required to receive the ground wires or cables. Equipment shall be individually connected to ground so that disconnecting one equipment ground will not result in disconnection of another equipment ground. Connections within the ground systems shall provide the same low resistance as the connected cables or wire. Where possible, connections shall be soldered in addition to being attached by crimping or bolting. Where connectors are used, they shall provide a positive low-resistance connection. Installation methods shall not result in formation of any ground loops in the ground system.

5.3 Metallic hull ships, nontopside spaces. Unless otherwise specified, the nontopside space requirements specified in 5.3.1 through 5.3.4.1 shall be applicable to metallic hull surface ships and submarines.

5.3.1 Equipment. Where electrical and electronic equipment are installed on resilient mountings, such equipment shall be grounded by use of a class C bond (with type III or IV bond straps) in accordance with figure 9. Bond straps delivered with equipment for such applications may be used if equal to or similar to bond straps specified in figure 9. Where resilient mountings are not used, such equipment, including ancillary equipment, connection boxes and equipment and assemblies that are fix-mounted by bolting on or within enclosures or cabinets, will normally require a class B bond only; however, where EMI tests indicate that a class B bond is inadequate, in such cases a class C bond shall be provided with type III or type IV bond straps installed in general accordance with figure 9. Where drawer mounted equipment, however, is not grounded by a ground wire or conductor with the applicable cable harness, a flexible ground conductor shall be installed between the drawer frame or chassis and a ground potential point on the frame of the supporting enclosure or cabinet. Such ground conductors installed shall be no smaller in cross section area than the largest conductor supplying power to the drawer equipment.

5.3.2 Nonmetallic bulkheads. Electrical equipment mounted on nonmetallic structures and bulkheads and extruded and honeycomb metal joiner bulkheads shall be grounded by one of the following methods:

(a) Where metal sheeting of nonmetallic bulkheads is grounded at installation channels or brackets to form class B or class C bonds, electrical equipment installed thereon will not require other than a class B bond.
(b) Where metal sheeting of nonmetallic bulkheads is insulated from ground potential at installation channels or brackets and equipment installed thereon is not grounded by a ground conductor in the power supply cable, a ground conductor shall be installed and tied or laced to the existing power supply cable and connected to ground potential at the available power connection or junction box or other convenient ground potential point. The ground conductor used shall be no smaller in cross-sectional area than the largest conductor supplying prime power to the equipment.

5.3.3 Cables. Electrical and electronic cables shall be routed within the ship superstructure to the maximum extent possible to shield the cables against electromagnetic radiation from ship transmitting antennas.

5.3.4 Digital computer grounding. A ground system shall be installed for digital computer equipment in accordance with MIL-STD-1399, section 406.

5.3.4.1 Common digital computer ground systems. When an interface is required between two or more digital computer systems and where each system requires a single point ground system, an EMI analysis shall be performed to determine the optimum ground system interface and single point connection to ground. The optimum method used shall provide the minimum possibility of common mode EMI.

5.3.5 Submarines. Electronic and electrical equipments and electromagnetic shielding conduit shall be grounded by the applicable requirements and methods as specified herein.

5.3.5.1 Conduit. Electromagnetic shielding conduit 10 feet or longer without insulating jacket shall be bonded to ground potential at a point not greater than 5 feet from each end of the conduit. Conduit less than 10 feet shall be bonded at one point anywhere along the run. Class "B" bonding is acceptable. Where class "B" bonding is not inherent in the installation of the conduit, bond straps shall be installed in accordance with figure 10. This bonding requirement is in addition to any bonding that may be achieved through conduit termination to equipment and shall be made to a point of ground potential other than the terminating equipment case or cabinet. Electromagnetic shielding conduit with insulating jacket shall be grounded as specified on the installation drawings.

5.4 Metallic hull surface ships, topside spaces. Topside space requirements specified in 5.4.1 through 5.4.7 shall be applicable to metallic hull surface ships only. Of these requirements, the requirements covering nonlinear junctions (see 5.4.1), IMI reduction (see 5.4.2), IMI test (see 5.4.3), and broadband (see 5.4.4) shall be applicable only to ships on which six or more high frequency (HF) transmitters have been or will be installed.

5.4.1 General. Nonlinear junctions can generate the rusty bolt type of IMI with effects that may be transient or variable, dependent, for example, on transmitter operating frequency and power parameters and subsequent reaction of the junction as effected by its corrosive condition, relative location, and effect of ship motion, and environment on junction characteristics. Elimination of potentially interfering junction sources requires that topside areas of hull surfaces shall effectively consist of a continuous electrical conducting medium free of metallic discontinuities such as bolted, pinned, or riveted junction or any junction across which there may develop a non-zero contact resistance. Elimination of topside nonlinear junctions shall require compliance with the following (see 5.4.2 for additional specific requirements):

(a) Where movability or removability is not required, metal-to-metal joints shall be class A bonded to the extent specified (see 5.4.2).
(b) Metallic items shall be welded to ship structure or alternatively either bonded with bond straps, insulated, replaced with nonmetallic equivalents, if feasible, or relocated to a nontopside area if practicable. The method selected shall be in accordance with the applicable detailed requirements. Where bond straps are used, they shall be types I, II, or III, as applicable. Use of types II and III shall be minimized in preference to use of type I straps.
(c) Loose metallic items, such as pipe, cables, and portable rigging shall not be stowed, stacked, or lashed down in ships topside area.

5.4.2 IMI reduction. The IMI and associated EMI reduction requirements of 5.4.2.1 through 5.4.2.12 apply to specific items located in topside areas which are potential sources of hull-generated intermodulation ("rusty bolt") type of interference caused by nonlinear junctions (see 3.13). Requirements are listed in descending order based on the usual interference severity of each item.

Exceptions: Portable items (such as canopies, stanchions, and rigging which are rigged only when in port) and telescoping stanchions with lifelines are exempt from these requirements. Items with largest dimension less than 6 feet are not required to be bonded.

5.4.2.1 Yardarm foot walking and hand safety ropes. Metallic foot walking ropes or hand safety ropes shall not be used on yardarms. Nonmetallic rails or welded pipe rails shall be used.

5.4.2.2 Rigging. Rigging such as antenna downhauls, full dress rigging, awning lines, lines associated with lifeboats, and other similar lines shall be nonmetallic. Metallic standing rigging shall be bonded to ground potential in accordance with figure 11.

5.4.2.3 Cable. Where electrical and electronic cables are installed during new construction or require replacement during ship repair, such cables shall be an unarmored type. Where armored cables are used on existing ships, IMI tests shall be performed (see 5.4.3) to determine whether such cables are currently, or potentially a source of IMI. Where results are positive, such cables shall be rerouted or shielded as applicable. Armored cable may be rerouted within masts or other similar structures or enclosed within conduit pipe or conduit in general conformance with figure 3, 4, or 5, as applicable. Flexible metal conduit subject to corrosion effects shall not be used in topside areas.

5.4.2.4 Lifelines. Lifelines installed in areas not subject to missile blast or jet blast shall be constructed of nonmetallic material. Metallic lines shall be insulated from terminating stanchions by the installation of lifeline insulators, Electroline Company Part No. SP-558, or equal.

5.4.2.5 Life and safety nets. Life and safety nets not exposed to missile blast or jet blast shall be constructed of nonmetallic material. Metallic nets and hinged frames shall be bonded in accordance with figure 12.

5.4.2.6 Portable flagstaffs/jackstaffs and stanchions. Portable flagstaffs/jackstaffs and stanchions not subject to missile blast or jet blast shall be constructed of nonmetallic material. Metallic staffs and stanchions shall be bonded in accordance with figure 13.

5.4.2.7 Portable items. Portable items or equipment, with the largest dimension more than 6 feet such as fog nozzles, davits and personnel stretchers shall be insulated from contact with ship structure by insulating the hangers, clips, brackets or other areas of contact with ship structure. Insulating material shall be weather resistant heat shrinkable tape or tubing, rubber matting, plastics, epoxy, fiberglass, or other similar materials.

5.4.2.8 Portable life rails. Portable life rails shall be constructed of nonmetallic material.

5.4.2.9 Ladders. Metallic inclined ladders shall be grounded in accordance with figure 14 or shall be fabricated of nonmetallic material in accordance with Drawing 803-5184099. Metallic vertical ladders are considered satisfactorily grounded when installation bolts are tightened securely. Climber safety rails are considered satisfactorily grounded when installed by welded brackets in accordance with Drawing 804-4563125. Climber safety rails installed by brackets clamped to ladder rungs shall utilize a type II bond strap at these points with the welded end of the bond strap attached to ship structure and the detachable end bolted to the safety rail.

5.4.2.10 Tilting antenna mounts. Tilting antenna mounts shall be bonded in accordance with figure 15.

5.4.2.11 Masts. Masts, mast braces, king posts, and other similar structures shall be grounded by type I bond straps in accordance with figure 16. Structures 20 inches of larger in diameter shall have four bond straps installed. Structures from 8 to 20 inches in diameter shall have two bond straps. Structures less than 8 inches in diameter shall use only one bond strap (see figure 16).

5.4.2.12 Expansion joints. Expansion joints shall be bonded in accordance with figure 17.

5.4.3 IMI testing. To determine whether a suspected item such as armored cable is a contributor to IMI, the item shall be moved or shaken while the interference level indicator meter is observed. Fluctuations in the meter level indicates that the item contributes to IMI and shall have corrective measures applied as specified herein.

5.4.4 Broadband EMI reduction. Broadband EMI will normally be generated in ship topside structures or rigging by close or intermittent contact between metal items which are in proximity to HF transmitting antennas or located within the main beam of radar antennas. Examples of such items are handrails, hooks, links, cables, chains, cable armor, and ladders. EMI reduction shall be achieved by use of bonding, grounding, shielding, or insulating such metallic items, or by replacement with nonmetallic materials by the applicable method specified herein.

5.4.5 Antenna tuners and couplers. Antenna tuners and couplers shall be class C bonded by the methods of figure 18.

5.4.6 Portable spaces. Portable spaces such as huts, vans, trailers and shelters that contain electrical or electronic equipment and are located in topside areas shall be class C grounded by type II bond straps (see figure 1). Portable spaces equipped with antennas and requiring RF grounding shall be class C grounded by type III bond straps (see figure 2). Ground terminals shall be provided for installation of bond straps. Portable spaces mounted to ship deck in nontopside areas may be class B bonded.

5.4.7 EMP protection. The requirements of 5.4.7.1 through 5.4.7.4 apply only to metallic hull surface ships when EMP protection is required.

5.4.7.1 Surge arresters. Surge arrester protection shall be provided for equipment connected to topside antennas as specified for each application. In addition, task light cables installed in plastic masts shall be provided with surge arrester protection.

5.4.7.2 Cables. Cables shall be routed to the maximum extent within the ship superstructure including the mast. Where cables are routed external to ships protective structure installation shall conform to the following:

(a) Maximum use shall be made of shielded cables in topside areas to preclude requirement to use conduit for shielding.
(b) Nonshielded cable routed topside shall be enclosed in conduit. Such conduit shall be grounded at each end.
(c) Nonshielded mast cables shall be installed in accordance with figure 4 or 5. In either application, shielded cable may be enclosed with nonshielded cable. Shielded cables shall be grounded at conduit terminations in accordance with figure 19. Nonshielded cables routed to equipment from the mast or mast conduit shall be enclosed in conduit.

(d) Circular conduit used shall be electrically continuous using threaded or welded junctions. At support brackets, conduit shall be either welded to ground or insulated to inhibit formation of nonlinear junctions.
(e) Interior cables shall not be routed within 12 inches of doors, hatches, and windows. Windshield wiper cables, window heater cables, and door alarm cables are allowable exceptions.

5.4.7.3 Waveguide. Waveguide penetrating ship superstructure or deck from topside area shall be grounded peripherally at the point of penetration by the methods shown on figure 20.

5.4.7.4 Metal pipe and tubing. Where possible, pipes shall be welded 360 degrees at weather bulkhead penetrations. Where welding cannot be performed (for example, due to dissimilar metals), grounding shall be as shown on figure 19. Metal tubing shall be grounded at weather penetrations as shown on figure 19.

5.5 Bond straps. Bond straps shall conform to figures 1 or 2 or as otherwise specified herein. Installation shall conform to 5.5.1 through 5.5.4.2.

5.5.1 Installation hardware. Bond strap installation hardware (such as nuts, bolts, washers, and studs) shall be 1/4-inch, 5/16-inch, or 3/8-inch, as appropriate. For topside areas, mounting hardware shall be corrosion-resistant steel (CRES) conforming to QQ-S-763, except where aluminum studs are required. For nontopside areas, mounting hardware (except studs) shall be plated steel. Hardware used on minesweepers shall be nonmagnetic.

5.5.1.1 Studs. Studs located in nontopside areas shall be aluminum or plated steel, as appropriate. Studs shall be in accordance with MIL-S-24149 and shall be selected to provide maximum physical contact between the bond strap lug and the stud collar or shoulder. Shoulder studs only shall be used in the installation of type II bond straps. These shoulder studs shall conform to the following dimensions: Stud size 3/8-16; threaded length 5/8-inch extending above bond strap lug to allow for flat washer, lock washer and nut; unthreaded portion (base) diameter 3/4-inch; base height 1/2-inch. Either shoulder studs or collar studs may be used in all other installations.

5.5.2 Contact surface preparation. Surface preparation for installation of all bond straps shall be accomplished by cleaning to bare metal those areas where bond straps will connect. Threaded hardware shall be coated with an antiseize compound conforming to MIL-T-22361 prior to the installation of bolted bond straps.

NOTE: The preceding cleaning requirements do not apply to surfaces plated with cadmium or chromate on items such as chassis and bond strap mounting hardware.

5.5.3 Installation. Bond straps shall be installed in locations which will permit rapid inspection or replacement and shall be installed in such a manner that vibration, expansion, contraction, or relative movement, incident to normal service, will not break or loosen the bond strap connection. Bond strap installations shall not interfere with the tightness characteristics of cabinets or enclosures, shall not weaken any structure or item to which a bond strap is attached, and shall not restrict the movement of any hinged or pinned item. Existing bolts, studs, or threaded holes shall be used for bond strap installation where possible.

5.5.3.1 Type I. Type I bond straps shall be installed as follows:

(a) Weld the lugs to ground potential and to the item to be bonded.

NOTE: Lug tongues may be bent, if necessary, to provide the most practical bond strap installation.

(b) Clean the welded areas of welding slag.
(c) Seal the lugs and the welded areas in accordance with 5.5.4.

5.5.3.2 Type II. Type II bond straps shall be installed as follows:

(a) Weld one end of the strap to hull ground or to the item to be bonded, as appropriate.
(b) Weld a threaded stud to hull ground or to the item to be bonded, as appropriate, or use existing bolts or holes, if possible.
(c) Attach the bolted end of the bond strap by use of the appropriate method and hardware as shown on figure 21.

(d) Clean the welded area of welding slag.
(e) Seal the lugs and the welded area in accordance with 5.5.4.

5.5.3.3 Type III. Type III bond straps shall be installed by securing strap to item and hull ground by use of the appropriate securing method of figure 21.

5.5.3.4 Type IV. Type IV bond straps shall be installed as follows:

(a) Secure strap across resilient mount using existing hardware, where possible (see figure 9). Where existing hardware cannot be used for bond strap installation, drill or drill and tap mounting holes or install studs for installation of bond strap as shown on figure 21.

5.5.4 Sealing.

5.5.4.1 Topside areas. The ends (lugs) of type I and II bond straps which are welded in place shall be weather-sealed by priming and painting the lugs and the areas affected by welding. The ends of type II bond straps which are installed on threaded studs or bolts shall be weather-sealed by coating the lugs and associated hardware with an application of antiseize compound conforming to MIL-T-22361. The insulating jacket of type I and II bond straps shall not be painted or coated. Where bond strap installation has affected painted surfaces, affected areas shall be restored to the original paint finish.

5.5.4.2 Nontopside areas. Bond straps installed in nontopside areas do not require painting. Painted areas affected by bond strap installation shall be restored to the original paint finish.

6. QUALITY ASSURANCE PROVISIONS

6.1 In-progress inspection. An in-progress inspection shall be conducted during the installation of bond straps, nonmetallic materials and ground systems, specified by this standard. This inspection shall consist of spot checking installation procedures, methods, and materials to determine compliance with the applicable requirements specified herein. The inspection shall also determine that:

(a) Bond straps, nonmetallic materials and ground systems are installed in conformance with requirements for personnel safety.
(b) Quality materials, methods and workmanship are used.
(c) Each installation will satisfy the intent and purpose of the requirement.
(d) Class of bond and type of bond strap (for class C) is as specified herein.
(e) Installation of strap does not interfere with tightness of enclosure.
(f) Installation of strap does not weaken structure or item to which strap is attached.
(g) Bond straps will not restrict the movement of any hinged or pinned item and installation methods will not place any bond strap in a binding or restrictive position that will lead to early breakage of the strap.
(h) Bond straps and nonmetallic materials located in topside areas are fabricated, installed and treated as specified herein to prevent deterioration through corrosion, oxidation, or weathering.

6.2 Final inspection. After completion of all required installations, a final inspection shall be made. This inspection shall determine that all requirements, specified for the particular ship involved, have been accomplished and that the quality assurance provisions of 6.1 have been met.

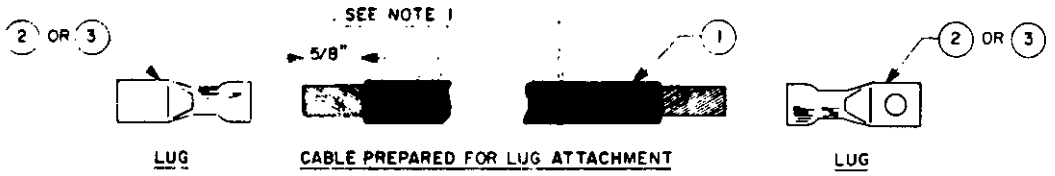
6.3 Inspection responsibility. Unless otherwise required by the contract, the contractor is responsible for performing the inspections.

6.4 Inspector certification. The contractor shall certify that the inspector is qualified to perform the inspections specified herein.

6.5 Government verification. All requirements specified by this standard shall be subject to Government verification at any time.

Review activities:
AS, OS, EC

Preparing activity:
Navy - SH
(Project EMCS-N072)



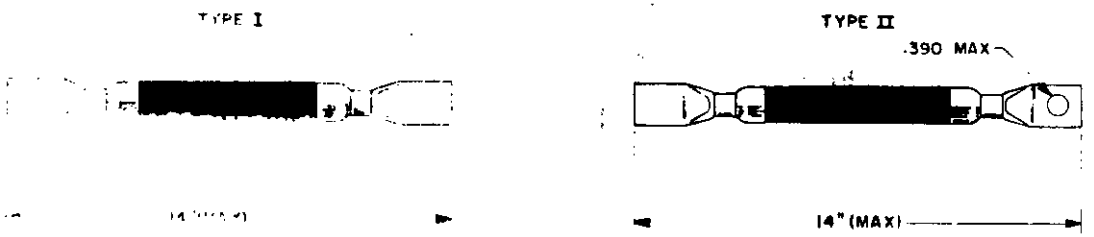
LIST OF MATERIAL			
ITEM NO	PART	SPECIFICATION	NOTE
1	CABLE, WELDING, TRXF-84	MIL-C-915/21	1,2,3
2	LUG, ALUMINUM		1,2,3
3	LUG, CRES		1,2,3

NOTES:

1. CABLE JACKET SHALL BE REMOVED 5/8 INCH, OR AS APPROPRIATE TO ALLOW THE EXPOSED COPPER CONDUCTOR AND THE JACKETED PORTION OF THE CABLE TO PENETRATE TO THE FULL DEPTH OF THEIR RESPECTIVE CHAMBERS IN THE LUG. INSURE THE CONDUCTORS ARE BRIGHT COPPER. BRUSHING, SANDING OR DIPPING MAY BE NECESSARY. THE CONDUCTORS SHALL THEN BE COATED WITH A HEAVY COAT OF ANTI-SEIZE COMPOUND CONFORMING TO MIL-T-22361. A LIBERAL AMOUNT OF COMPOUND SHALL ALSO BE PLACED WITHIN THE SMALL PORTION OF THE LUG SHROUD FOR EXPANSION INTO ALL VOID AREAS OF THE LUG TERMINAL DURING CRIMPING.
2. LUGS AND BOND STRAP ASSEMBLY TOOLS SHALL BE THOMAS AND BETTS FOLLOWING PART NUMBERS OR EQUAL:

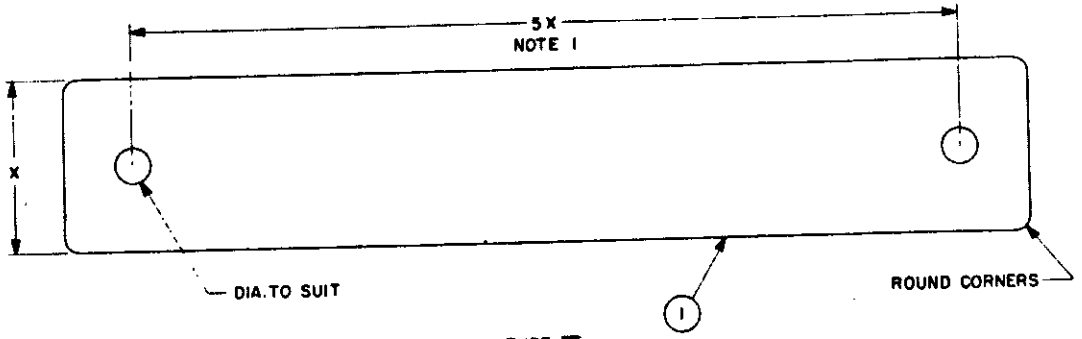
CRES LUG	271-30483-478 (WITH 5/16 INCH HOLE)
CRES LUG	271-30483-479 (BLANK TONGUE)
ALUMINUM LUG	271-30483-334
12 TON HEAD	13642
DIE, FOR STEEL LUG	297-53345
DIE, FOR ALUMINUM LUG	297-53346
HYDRAULIC HOSE	21039
HYDRAULIC PUMP	13586

3. LUG MATERIAL, STEEL VERSUS ALUMINUM, SHALL BE SELECTED TO MATCH THE CORRESPONDING MATING SURFACE MATERIAL. A MINIMUM OF 12 TONS PRESSURE SHALL BE APPLIED TO DIE ASSEMBLY FOR ATTACHMENT OF LUGS TO CABLES.



COMPLETED BOND STRAPS

FIGURE 1. Type I and Type II bond strap fabrication details

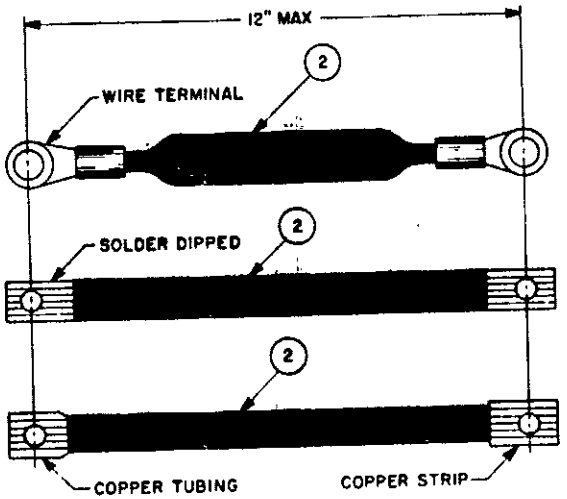


TYPE III
(NOTE 1)

LIST OF MATERIAL			
ITEM NO	PART	SPECIFICATION	NOTE
1	FLAT COPPER		1
2	FLAT COPPER BRAID	QQ-B-575	2

NOTES:

1. TYPE III BOND STRAPS SHALL BE FABRICATED FROM FLAT COPPER NOT LESS THAN 0.020 INCH THICK. TYPE III BOND STRAPS SHALL NOT EXCEED A LENGTH-TO-WIDTH RATIO OF FIVE-TO-ONE. TYPE III BOND STRAPS SHALL BE ZINC PLATED.
2. TYPE IV BOND STRAPS SHALL BE FABRICATED FROM FLAT COPPER BRAID (1/2 INCH MINIMUM WIDTH) OF QQ-B-575. PROVISIONS FOR INSTALLATION OF THE BRAID STRAP SHALL BE BY ONE OF THE FOLLOWING METHODS:
   - BY INSTALLING WIRE TERMINALS ON EACH END OF THE BRAID.
   - BY SOLDER-DIPPING THE ENDS OF THE BRAID THEN DRILLING MOUNTING HOLES.
   - BY SOLDERING FLAT COPPER TUBING OR STRIP ON EACH END OF THE BRAID THEN DRILLING MOUNTING HOLES.



TYPE IV
(NOTE 2)

FIGURE 2. Type III and Type IV bond strap fabrication details

NOTES:

1. EXCEPT AS SPECIFIED IN NOTE 4, MAST MOUNTED CABLES SHALL BE SHIELDED AGAINST MAIN BEAM RADIATIONS FROM RADARS OPERATING IN THE 200 TO 450 MHz FREQUENCY RANGE.
2. LENGTH OF RADAR SHIELD SHALL BE IN ACCORDANCE WITH THE FOLLOWING:
   A. WHEN MAST IS LOCATED WITHIN 10 FEET OF THE RADAR ANTENNA SWING CIRCLE, SHIELD LENGTH SHALL BE 15 FEET.
   B. WHEN MAST IS LOCATED BETWEEN 10 AND 50 FEET OF THE RADAR ANTENNA SWING CIRCLE, SHIELD LENGTH SHALL BE 20 FEET.
   C. THE RADAR SHIELD SHALL BE INSTALLED SO THAT THE CENTER OF THE SHIELD COINCIDES WITH THE CENTER OF THE RADAR ANTENNA REFLECTOR.
3. THE SHIELD MAY BE INSTALLED BY WELDING FLAT BAR TO THE MAST AND DRILLING AND TAPPING MOUNTING HOLES OR THE SHIELD MAY BE TACK-WELDED DIRECTLY TO THE MAST. WHEN TACK-WELDING, THE SHIELD MATERIAL SHALL BE COMPATIBLE WITH THE MAST MATERIAL (ALUMINUM OR STEEL). THICKNESS OF SHIELD SHALL BE AS REQUIRED FOR PHYSICAL SUPPORT.
4. SHIELDING OF MAST CABLES AGAINST RADAR MAIN BEAM ENERGY IS NOT REQUIRED WHEN EITHER:
   A. THE DISTANCE BETWEEN THE RADAR SWING CIRCLE AND MAST CABLES IS GREATER THAN 50 FEET.
   B. MAST CABLES ARE LOCATED INTERNAL TO MAST STRUCTURES OR COVERED BY METALLIC CONDUIT.
   C. THE MAST CABLES ARE LOCATED ON THE OPPOSITE SIDE OF THE MAST IN SUCH A MANNER THAT THEY ARE COMPLETELY SHIELDED FROM RADAR MAIN BEAM ENERGY.

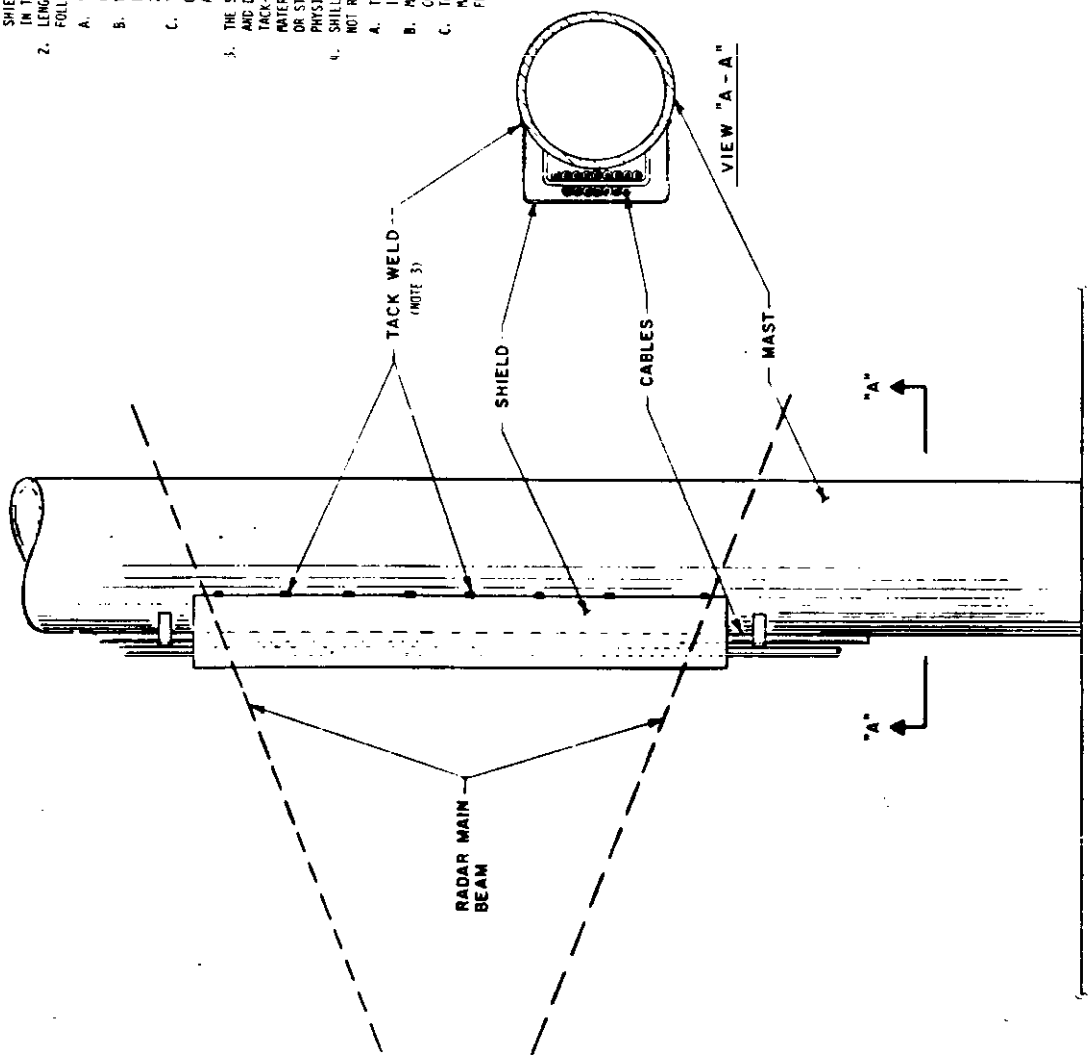


FIGURE 3. Shielding mast cables from radar

LIST OF MATERIAL			
ITEM NO	PART	SPECIFICATION	NOTE
1	CONDUIT, 1/16" GALV. STEEL PLATE		2,3
2	CONDUIT, 1/8" ALUM. PLATE		2,3
3	FLAT BAR, 2" x 1/4", GALV. STEEL PLATE		1
4	FLAT BAR, 2" x 1/4", ALUM. PLATE		1
5	BOLT, HEX. HD. 1/4" x 20" x 1/2" CRES	MIL-S-1222	
6	LOCKWASHER 1/4" SPLIT, CRES		

NOTES:

1. FLAT BAR FOR CONDUIT ATTACHMENT SHALL BE ALUMINUM FOR ALUMINUM MASTS AND GALVANIZED STEEL FOR STEEL MASTS. DRILL AND TAP THE BAR FOR 1/4"-20 THREADS SPACED AS INDICATED IN DETAIL "A". FLAT BAR LENGTH WILL BE DETERMINED BY CONDUIT REQUIREMENTS. BAR SHALL BE TACK-WELDED TO MAST AS REQUIRED FOR PROPER SUPPORT OF CONDUIT.
2. STRAIGHT CONDUIT SECTIONS SHALL BE FABRICATED IN LENGTHS OF 8 FT. OR AS APPROPRIATE. SECTIONS SHALL BE FABRICATED FROM 1/8 INCH ALUMINUM PLATE FOR ALUMINUM MASTS AND 1/16 GALVANIZED STEEL PLATE FOR STEEL MASTS. SECTIONS SHALL BE BOLTED TO FLAT BAR, ITEM 3 OR 4, BY USING ITEMS 5 OR 6.
3. CURVED PORTIONS OF THE CONDUIT RUN SHALL BE FABRICATED IN SHORT STRAIGHT SECTIONS AS REQUIRED TO FACILITATE INSTALLATION OVER CURVED SECTIONS OF CABLE RUNS. THESE SHORT SECTIONS SHALL BE TACK-WELDED DIRECTLY TO THE MAST.
4. SECTIONS OF CONDUIT (INSIDE AND OUTSIDE) SHALL BE PAINTED PRIOR TO INSTALLATION. THE CONTACT SURFACE BETWEEN THE CONDUIT AND FLAT BAR SHALL NOT BE PAINTED. AFTER INSTALLATION IS COMPLETE, ALL EXPOSED UNPAINTED SURFACES AND MOUNTING HARDWARE SHALL BE PAINTED.
5. CABLES SHOULD BE REARRANGED IF PRACTICABLE AT PLACES WHERE BENDING OCCURS TO FACILITATE CONDUIT INSTALLATION.
6. FABRICATION DETAILS ARE TYPICAL DIMENSIONS AND MAY BE MODIFIED AS REQUIRED.

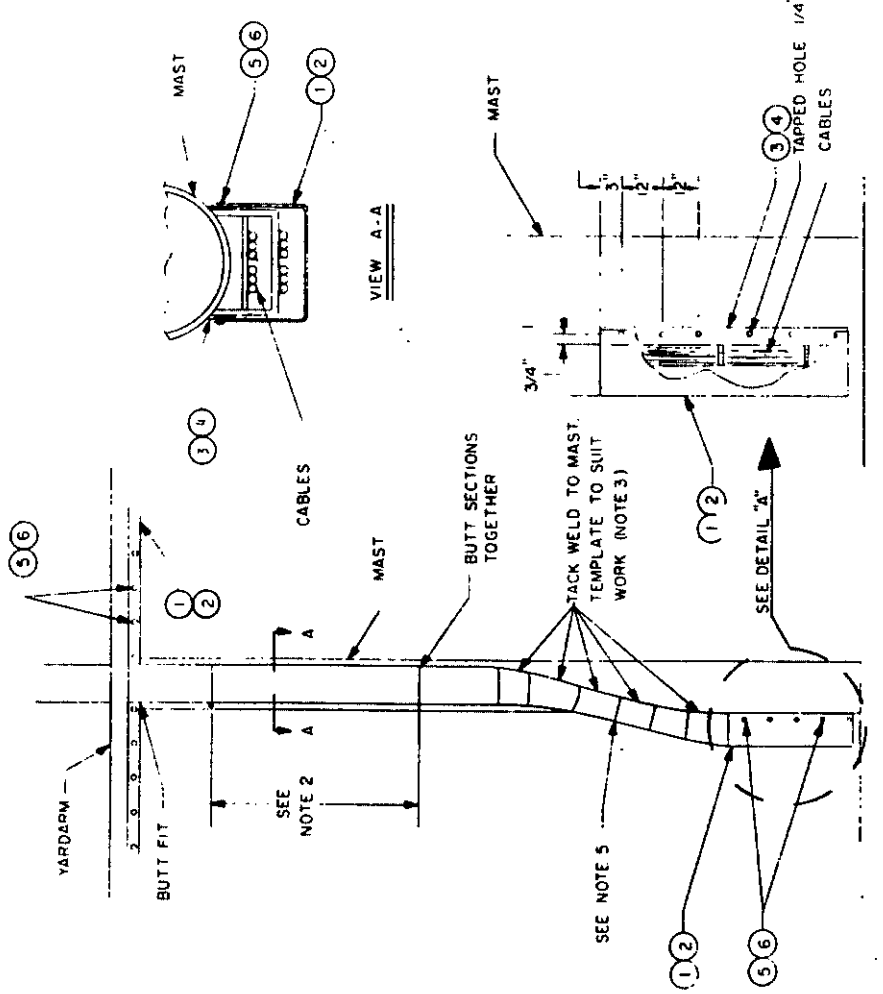


FIGURE 4. Mast cables located within conduit

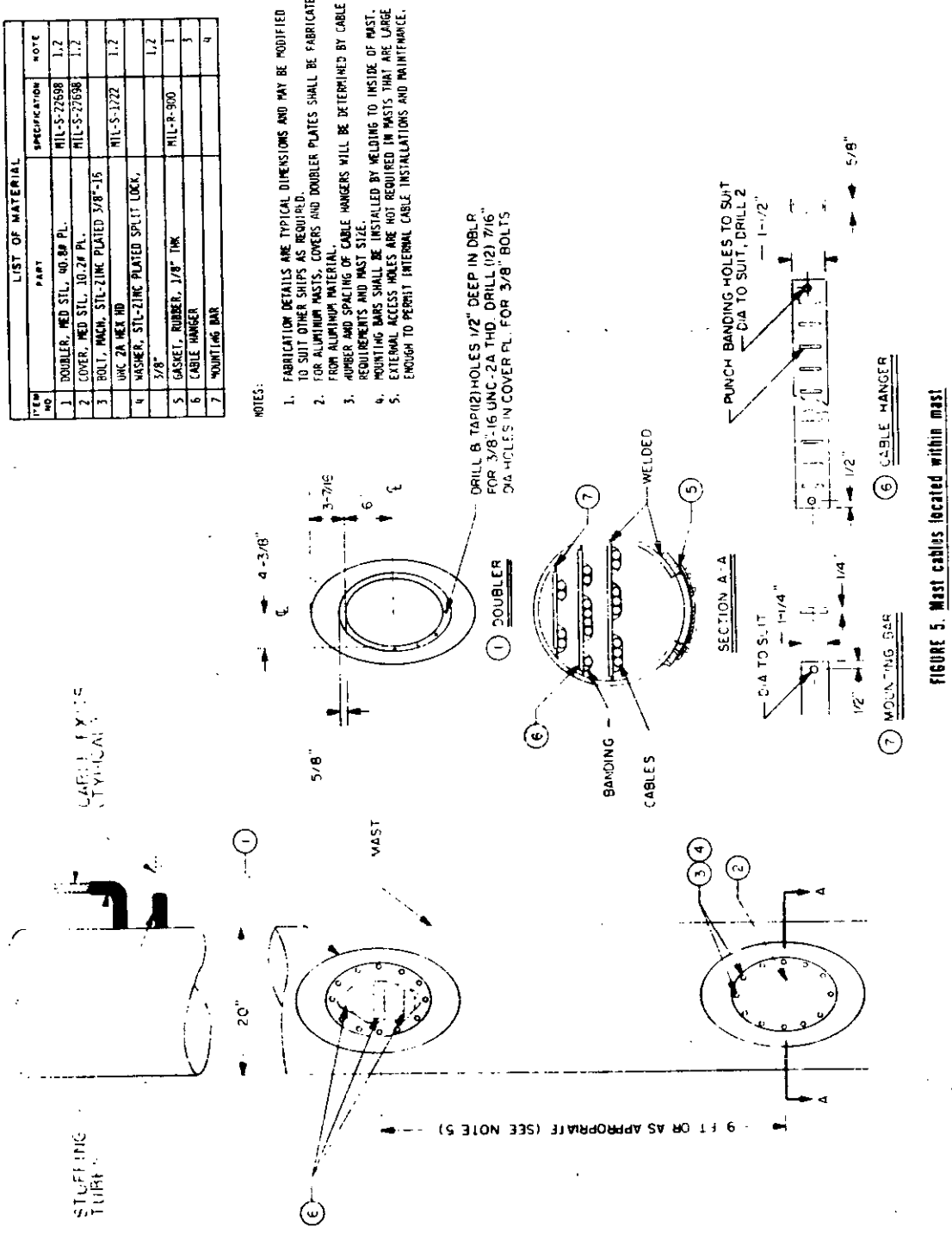
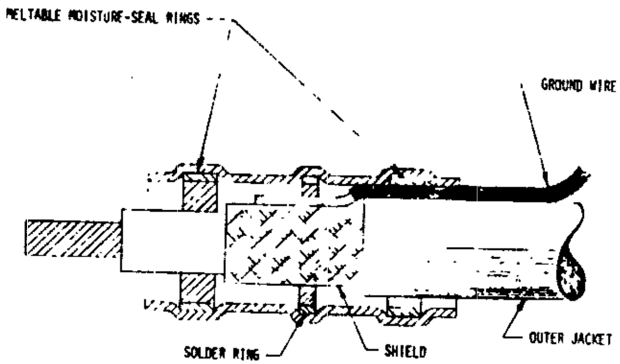
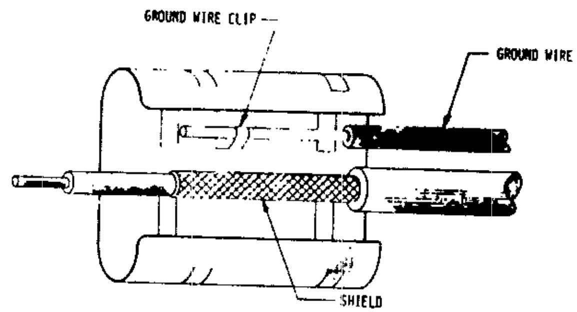


FIGURE 5. Mast cables located within mast



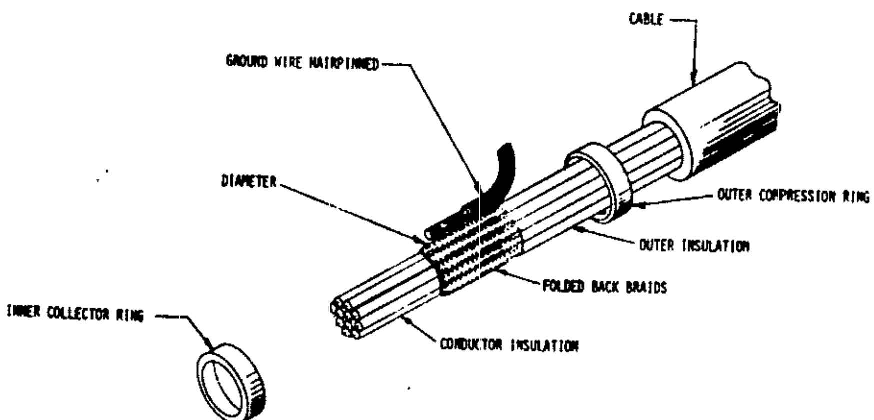
MELTABLE SOLDER RING METHOD



SHIELD CONNECTOR METHOD

NOTES:

1. CABLE SHIELD GROUNDING METHODS AND MATERIALS SHALL BE THOMAS AND BETTS COMPANY OR RAYCHEM CORPORATION, OR EQUAL.
2. OTHER APPROVED SHIELD GROUNDING METHODS ARE BY BACKSHELLS MS3437, MS3188, MS3189 AND KERN ENGINEERING & MFG. CO., "IRIS CONCEPT", OR EQUAL.



GROUNDING RING METHOD

FIGURE 6. Cable shields grounding methods

LIST OF MATERIAL

ITEM NO	PART	SPECIFICATION	NOTE
1	WIRE, INSULATED, TYPE D2	MIL-W-16878/3	1,2
2	CLAMP, CABLE, ALUMINUM	MS21104D-3	9
3	WASHER, LOCK, 3/8 DIA, STEEL	MS35338-46	2,3,6
4	NUT, HEX, 3/8-16 UNC-2B, STEEL	MS51967-8	2,3,6
5	STUD, 3/8 x 2 CPL	SIM OR EQ TO NELSON STUD 103-017-191	2,3,6
6	NUT, JAM, 3/8-16 UNC-2B, STEEL	MS35691-17	2,3,6
7	LUG, SOLDER TYPE, COPPER	MS35436-25	2,3,6
8	WIRE, BARE, COPPER, 1050 STRANDED	NSN 6211161N5191-0462	5,6
9	LUG, TERMINAL, COPPER	MS20659-109	5,6
10	SCREW, CAP, HEXAGON HEAD, 1/4-20X1, STEEL	MS90725-8	5,6
11	WASHER, LOCK	MS35333-40	5,6
12	NUT, HEX, 1/4-20, STEEL	MS51967-2	5,6
13	WIRE, INSULATED, TYPE WSO	MIL-W-16878/3	3,6
14	CLIP, POWER, 50 AMP, TYPE PC	W-C-440D	3
15	SLEEVE, INSULATING, BLACK	W-C-440	3
16	CLAMP, CABLE, NYLON	SIM OR EQ TO HERMAN H. SMITH 774	7
17	SCREW, PAN HD, 10-32 UNF-2A x 5/8, STEEL	MS35207-264	7,9
18	WASHER, EXT. TOOTH, NO. 10, STEEL	MS35335-32	7
19	NUT, HEX 10-32 UNF-2B, STEEL	MS.35650-302	7
20	BUSHING, SNAP, 3/8 ID, NYLON	SIM OR EQ TO HEYMAN MFG. CO. SB-500-6	8

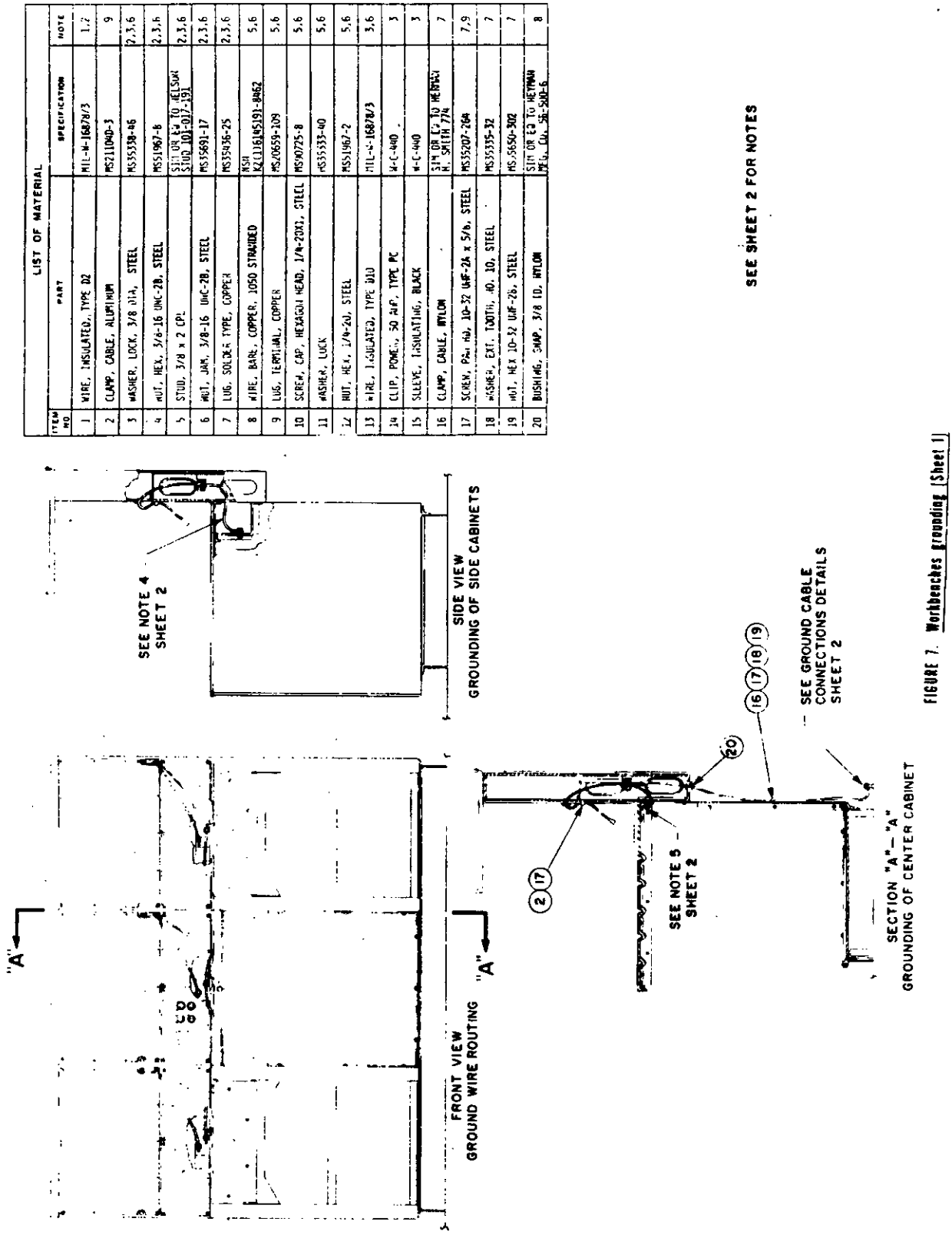
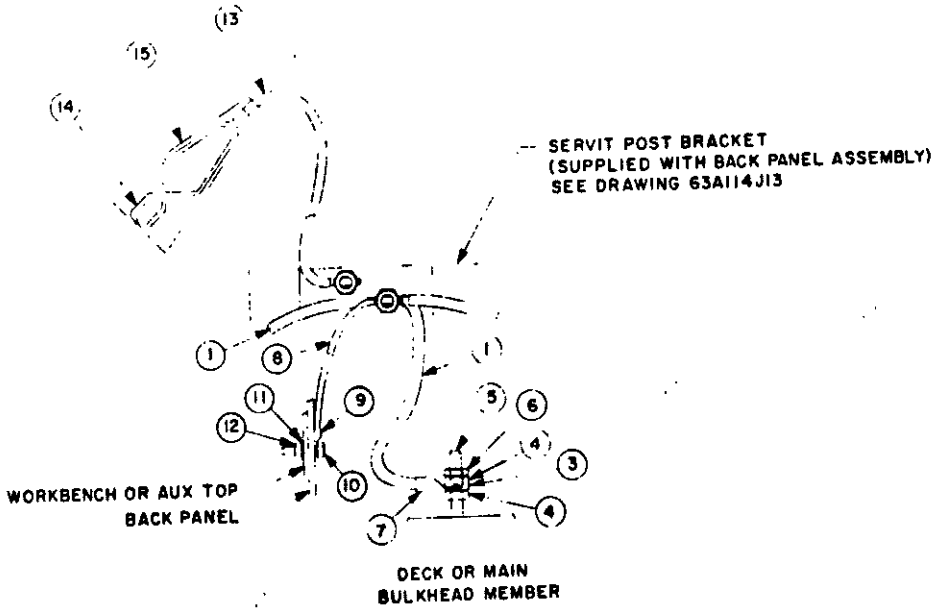


FIGURE 7. Workbenches grounding (Sheet 1)



DETAILS, GROUND CABLE CONNECTIONS

NOTES:

1. THE GROUND BUS SERVING A ROW OF BENCHES SHALL BE A CONTINUOUS (UNSPLICED) CABLE NOT TO EXCEED 50 FEET IN LENGTH. THE CABLE SHALL BE ROUTED THROUGH THE LOWER SERVIT POST OF EACH CABINET.
2. THE WORKBENCH NEAREST THE CENTER OF A ROW OF BENCHES SHALL BE GROUNDED BY A BUS WIRE FROM THE LOWER SERVIT POST OF THE BENCH CENTER CABINET TO A GROUNDING STUD. THE GROUNDING STUD SHALL BE WELDED TO THE DECK OR A MAIN BULKHEAD MEMBER.
3. EQUIPMENT GROUNDING LEADS SHALL BE CONNECTED TO THE UPPER SERVIT POST OF EACH SEPARATE CABINET. EACH GROUNDING LEAD SHALL BE 54 INCHES LONG AND SHALL TERMINATE IN A 50 AMP BATTERY CLIP AS SHOWN.
4. AT ASSEMBLY OF BACK PANEL AND TOP SHELF WITH BENCH CABINET (SEE DRAWINGS 63A114J2) THE GROUND WIRE (ITEM 8) SHALL BE ROUTED THROUGH THE 1/2" DIA. HOLE IN THE REAR OF CABINET AND SECURED TO THE 1/4-20 BOLT ON THE INSIDE OF WIREWAY.
5. AT ASSEMBLY WITH AUXILIARY TABLE (SEE DRAWING 63A114D5-1) THE GROUND WIRE SHALL BE SECURED TO THE 1/4-20 BOLT AT REAR OF AUXILIARY TABLE.
6. ALL GROUND CONNECTIONS SHALL BE CLEANED BRIGHT METAL-TO-METAL TO INSURE ELECTRICAL CONTINUITY. AFTER ALL SERVIT POST CONNECTIONS ARE MADE THE POSTS AND CONNECTIONS SHALL BE SEALED WITH TWO COATS OF FORMULA 80 VARNISH (TT-V-119) TO PREVENT MOISTURE PENETRATION. AFTER BENCH-TO-GROUND STUD CABLE IS INSTALLED THE WELDING STUD CONNECTION SHALL BE PAINTED SAME AS SURROUNDING STRUCTURE TO PREVENT MOISTURE PENETRATION.
7. POSITION AND INSTALL CABLE CLAMP AT AN APPROPRIATE LOCATION TO REDUCE THE EFFECTS OF VIBRATION ON CABINET-TO-DECK GROUNDING CABLE.
8. DETERMINE APPROPRIATE LOCATION AND DRILL .500 DIA. HOLE FOR INSTALLATION OF SNAP BUSHING.
9. REPLACE EXISTING PANEL SCREW WITH PAN HEAD SCREW (ITEM 17) TO ACCOMMODATE CABLE CLAMP.
10. FOR WORKBENCH CONSTRUCTION DETAILS SEE THE FOLLOWING DRAWINGS:

6SE00063	AVIONIC WORKBENCH DECK SUPPORT AND GROUND INSTALLATION DRAWING
63A114J2	CABINET ASSEMBLY
63A114D5	AUXILIARY TABLE ASSEMBLY
63A114J7	CABINET STRUCTURE ASSEMBLY
63A114F12	ELECTRICAL DISTRIBUTION BOX & TERMINAL BOARD ASSEMBLY
63A114J13	BACK PANEL ASSEMBLY
63A114D4	BACK PANEL & TOP SHELF ASSEMBLY

FIGURE 7. Workbenches grounding (Sheet 2)

LIST OF MATERIAL			
ITEM NO	PART	SPECIFICATION	NOTE
1	PLATE, COPPER, GROUNDING	QQ-C-576	1
2	CABLE, COPPER, 105,500 CIRCULAR MIL	MIL-C-915	2
3	CABLE, COPPER, 83,690 CIRCULAR MIL	MIL-C-915	3
4	WIRE, COPPER, 10,400 CIRCULAR MIL		4

NOTES:
1. GROUND PLATES SHALL BE LIGHT, COLD-ROLLED, OXYGEN FREE COPPER, APPROXIMATELY 1/8 INCH THICK AND SHALL PROVIDE APPROXIMATELY 16 SQUARE FEET OF TOTAL SURFACE AREA, EQUALLY DISTRIBUTED ON EACH SIDE OF THE KEEL. GROUND PLATES SHALL BE INSTALLED USING BRASS WOOD SCREWS SPACED AROUND EACH PLATE ON APPROXIMATELY 4 INCH CENTERS.
2. THE CABLE INTERCONNECTING THE TWO GROUND PLATES AND THE GROUND CABLE FOR THE ELECTRONIC TRANSMITTERS SHALL BE 105,500 CIRCULAR MIL COPPER.
3. THE MAIN GROUND CABLE SHALL BE 83,690 CIRCULAR MIL COPPER. METALLIC DECKS OR BULKHEADS MAY BE USED AS EXTENSIONS OF THE MAIN GROUND CABLE.
4. BRANCH GROUNDS SHALL BE 10,400 CIRCULAR MIL COPPER WIRE.

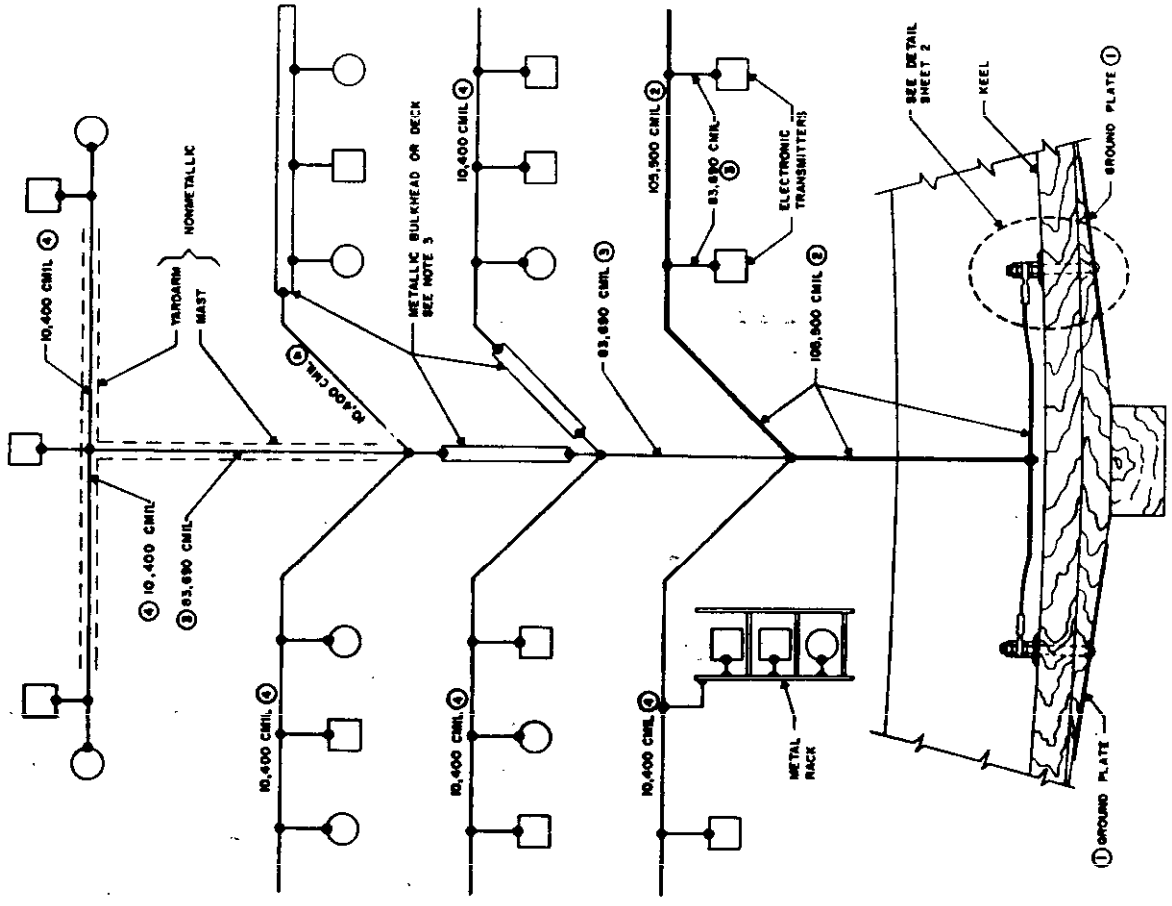
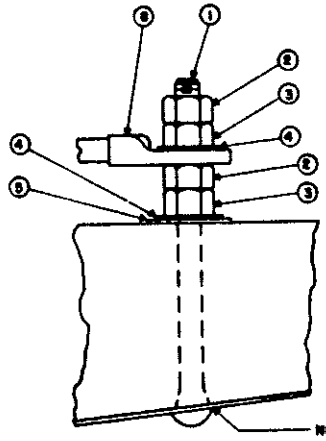


FIGURE 8. Ground system, nonmetallic hull ships (Sheet 1)



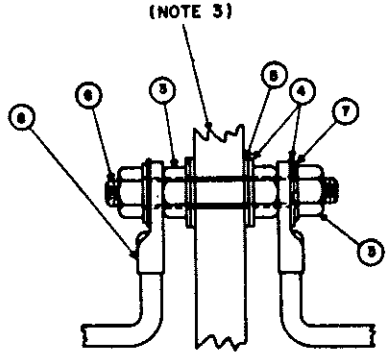
GROUND PLATE BOLT DETAILS (NOTE 3)

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOLT, COPPER, OVAL HEAD		1,2
2	NUT, JAM, COPPER		2,3
3	NUT, HEX, COPPER		2,3
4	WASHER, COPPER		2,3
5	WASHER, RUBBER		2,3
6	STUD, COPPER		2,3
7	WASHER, LOCK, COPPER		2,3
8	TERMINAL LUG, COPPER		2,3

NOTES:

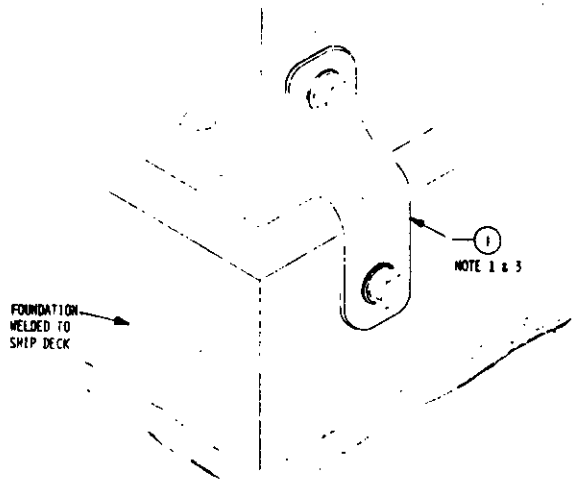
1. HEAD OF THE OVAL HEAD BOLT SHALL BE BRAZED TO THE COPPER GROUNDING PLATE.
2. SIZE OF OVAL HEAD BOLT AND THROUGH-BOLT SHALL AT LEAST EQUAL THE SIZE OF THE CABLE OR WIRE.
3. ASSEMBLY METHOD AND HARDWARE SHALL BE THE SAME FOR EACH BOLT (FOR OVAL HEAD BOLT ASSEMBLY) OR THE SAME FOR EACH SIDE OF THE DECK OR BULKHEAD (FOR THROUGH-BOLT ASSEMBLY).

WATERTIGHT DECK OR BULKHEAD(NONMETALLIC) (NOTE 3)



METHOD OF PASSING GROUND BUS THROUGH WATERTIGHT BULKHEADS OR DECKS

FIGURE 8. Ground system, nonmetallic hull ships (Sheet 2)

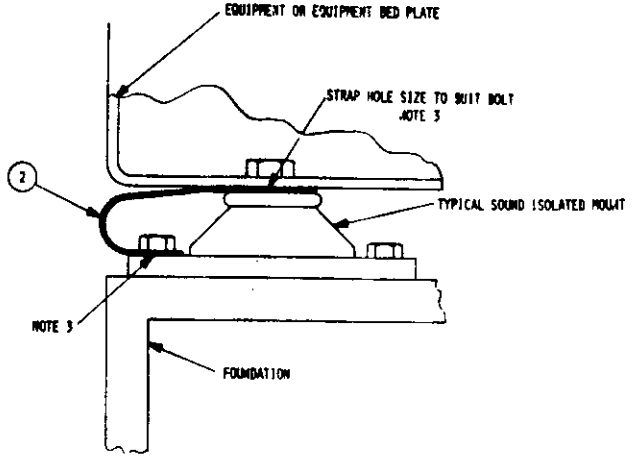


BOLTED INSTALLATION

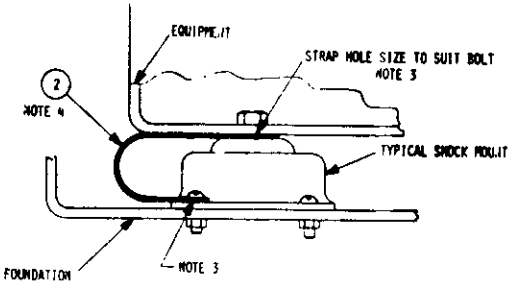
LIST OF MATERIAL			
ITEM NO	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE III		1,3
2	BOND STRAP, TYPE IV		2,3,4

NOTES:

1. TYPE III BOND STRAP SHALL BE INSTALLED ONLY IF EMI TESTS INDICATE THE NEED.
2. BOND STRAPS FURNISHED WITH ELECTRONIC EQUIPMENT BY MANUFACTURERS MAY BE USED FOR BONDING RESILIENT MOUNTED EQUIPMENTS IF EQUAL TO, OR SIMILAR TO, THE TYPE III OR IV BOND STRAP AS SPECIFIED HEREIN. WHEN A BOND STRAP IS NOT FURNISHED WITH AN EQUIPMENT, A TYPE IV BOND STRAP SHALL BE INSTALLED. BOND STRAP INSTALLATION SHALL NOT DEFEAT PURPOSE OF RESILIENT MOUNT.
3. WHERE POSSIBLE, USE EXISTING BOLTS, STUDS OR HOLES FOR ATTACHING BOND STRAP.
4. AS AN ALTERNATIVE, A TYPE III BOND STRAP MAY BE INSTALLED ON SHOCK MOUNTED EQUIPMENT.



SOUND ISOLATED EQUIPMENT



SHOCK MOUNTED EQUIPMENT

RESILIENT MOUNT INSTALLATIONS

FIGURE 9. Grounding of equipments and enclosures

LIST OF MATERIAL			
ITEM NO	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE IV		1,2
2	TUBING, PVC	MIL-I-631	2
3	CLAMP, HOSE	WW-C-440	1

NOTES:
1. AREA WHERE BOND STRAP LUG IS HELD AGAINST SHIELDING CONDUIT SHALL BE CLEAN AND FREE OF ANY NON-CONDUCTIVE MATERIALS.
2. BOND STRAP MAY BE ENCASED IN PVC TUBING.

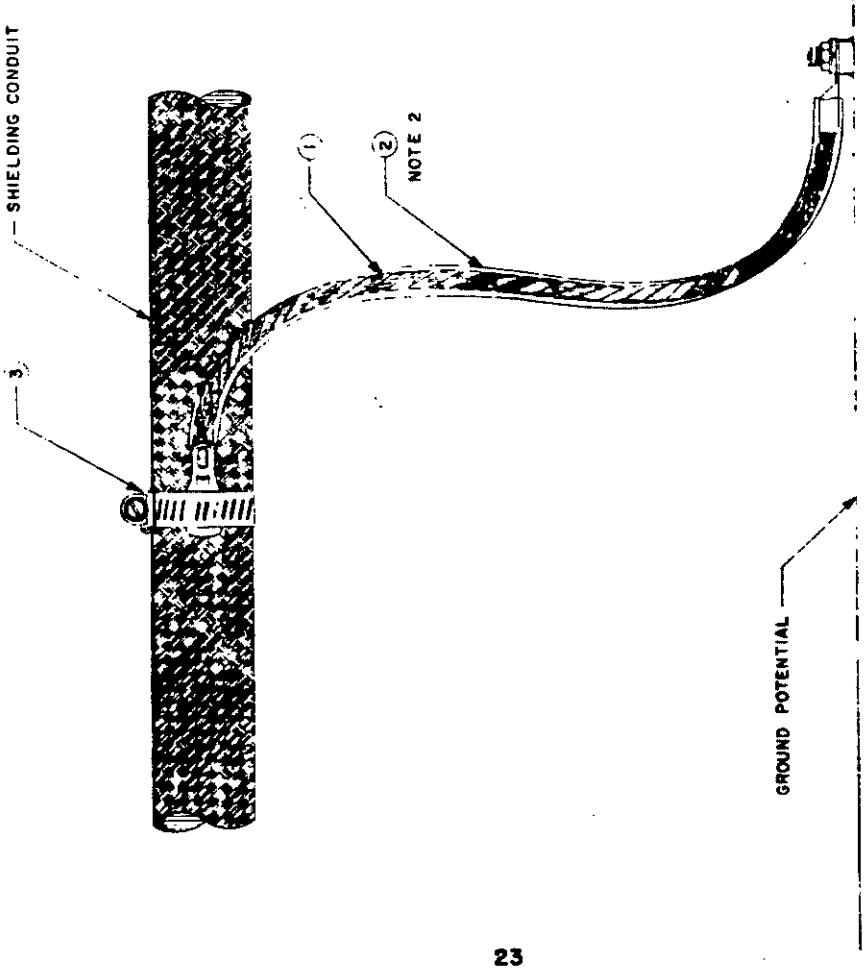


FIGURE 10. Conduit grounding, submarines

LIST OF MATERIAL

ITEM NO	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I		1
2	CABLE, WELDING, TYPE TWSF 8M	MIL-C-915/21	2

NOTES:
1. METHOD 1 - WHEN METHOD 1 IS USED, TYPE I BOND STRAPS SHALL BE TACK-WELDED TO TURNBUCKLE. TACK-WELD CAN THEN BE BROKEN WHEN TURNBUCKLE ADJUSTMENT IS REQUIRED.
2. METHOD 2 - WHEN METHOD 2 IS USED THE BONDING CABLE SHALL BE FITTED WITH LUGS TO FACILITATE BOND CABLE INSTALLATION. LUG TYPE AND INSTALLATION SHALL BE THE SAME AS FOR TYPE I BOND STRAP.

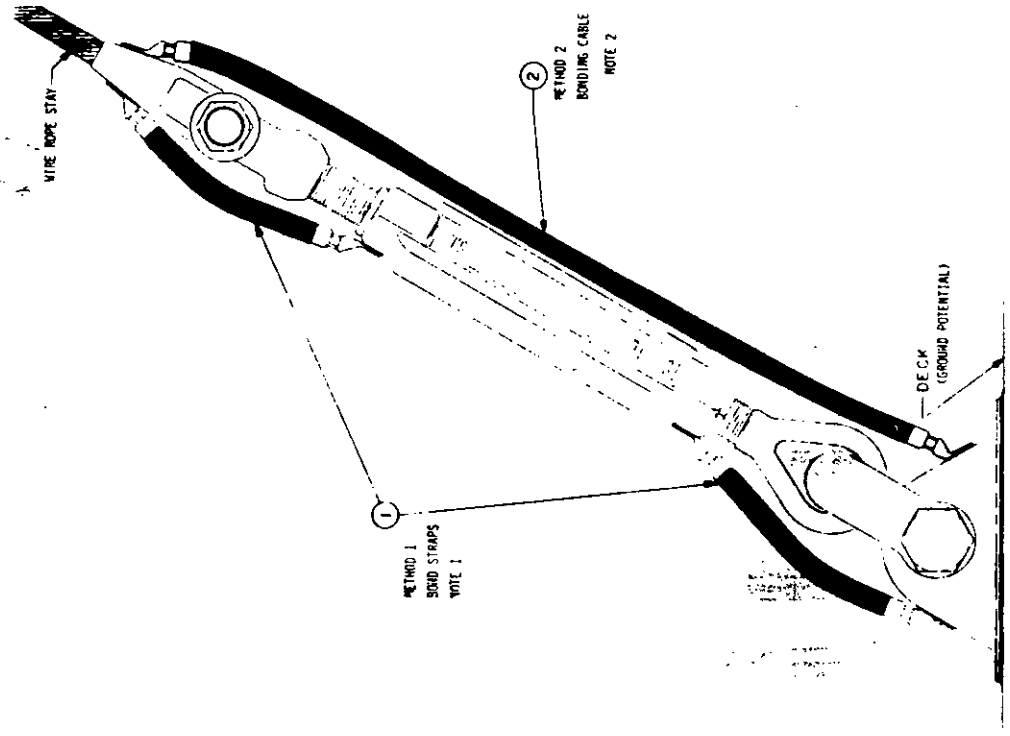


FIGURE 11. Standing rigging bonding

LIST OF MATERIAL			
ITEM NO	NAME	SPECIFICATION	NOTE
1	BONDING CABLE, (SIZE)		1
2	BOND STRAP, TYPE I		
3	"U" BOLT, CRES		1
4	SWAGE SLEEVE		1

NOTES:

1. SWAGE SLEEVE (OR SIMILAR DEVICE) SHALL BE CRIMPED TO BONDING CABLE AND WELDED TO NET FRAME.
2. A TYPE I BOND STRAP SHALL BE INSTALLED ACROSS EACH NET FRAME HINGE.
3. AS AN ALTERNATE METHOD A CRES U BOLT MAY BE INSTALLED AROUND THE MARGIN ROPE, LASHING ROPE AND BONDING CABLE.

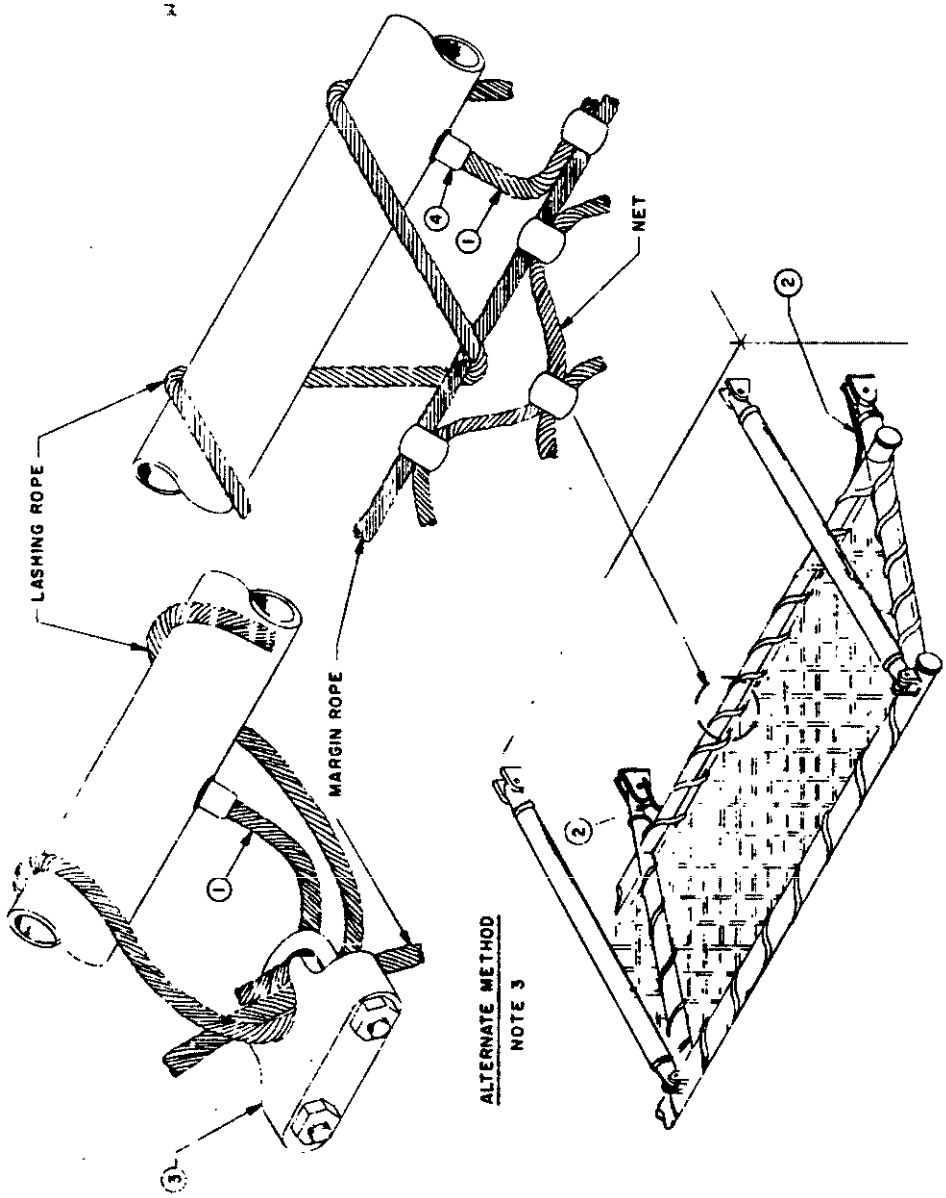


FIGURE 12. Metallic life and safety nets bonding

LIST OF MATERIAL

ITEM NO	PART	SPECIFICATION	NOTE
1	BOARD STAND, TYPE II		

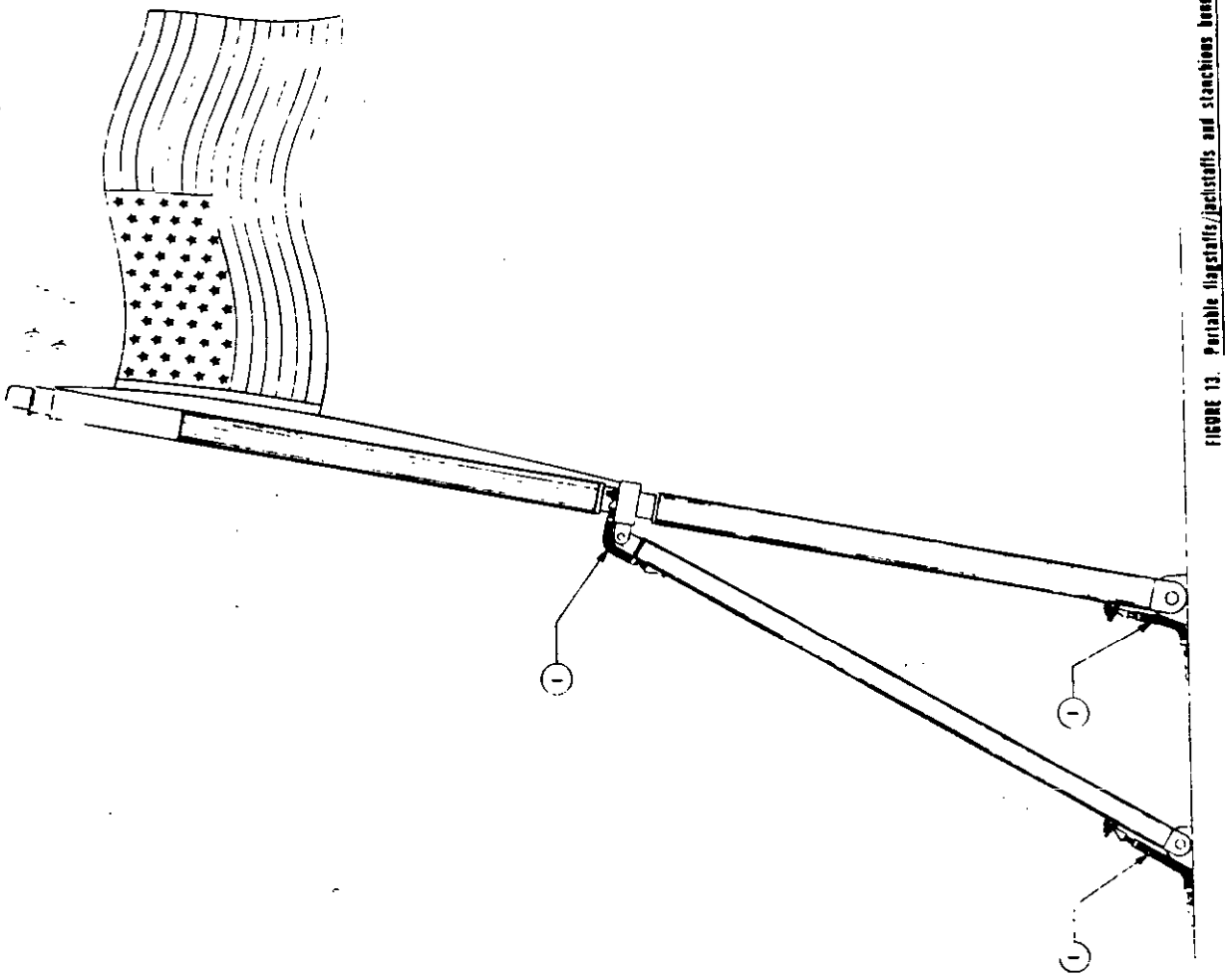


FIGURE 13. Portable flagstaffs/jackstaffs and stanchions bending

LIST OF MATERIAL

ITEM NO	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I OR II		1

NOTES:
1. INCLINED TREAD LADDERS SHALL BE BONDED TO GROUND POTENTIAL BY THE INSTALLATION OF A BOND STRAP ACROSS EACH PIVOTED MOUNT.

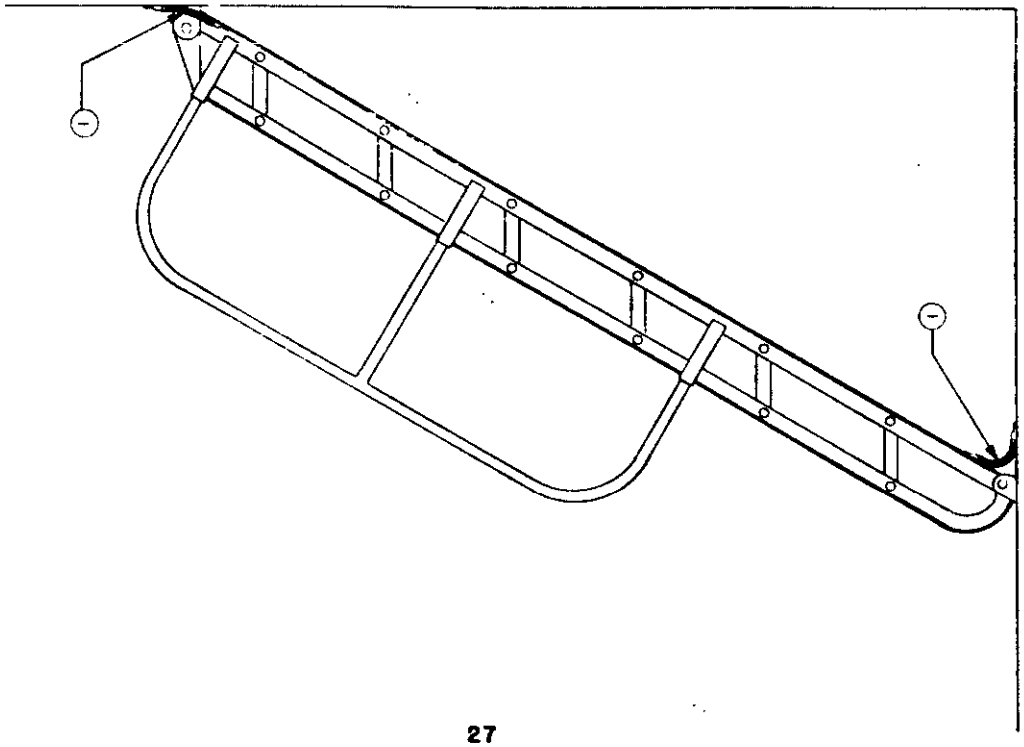
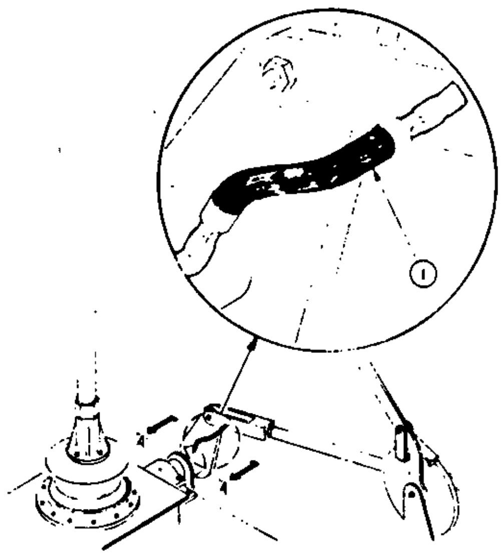


FIGURE 14. Bonding of inclined tread ladders

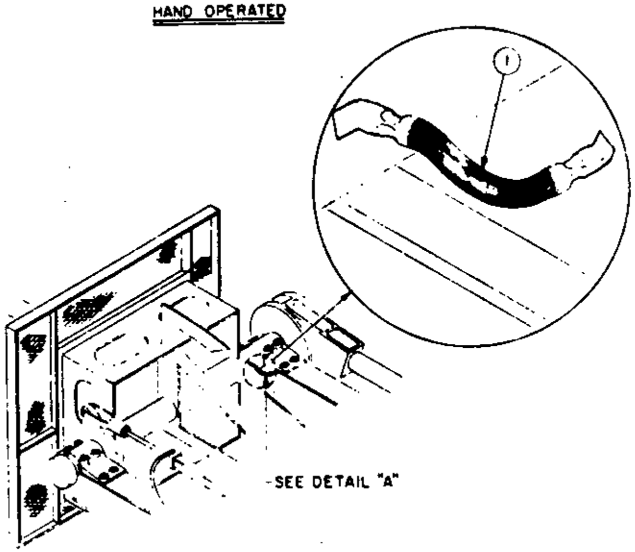
LIST OF MATERIAL			
ITEM NO	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I		1

NOTES:

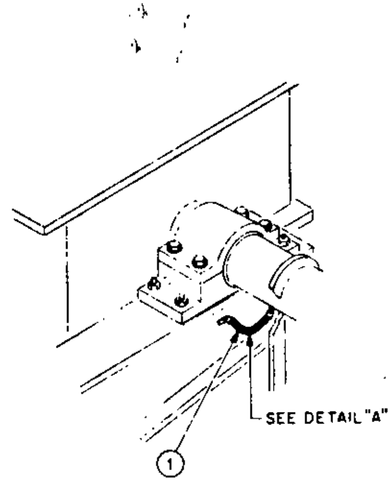
1. BOND STRAP LENGTH AND METHOD OF INSTALLATION SHALL ALLOW FOR MAXIMUM TRAVEL OF ANTENNA TILTING MECHANISM.



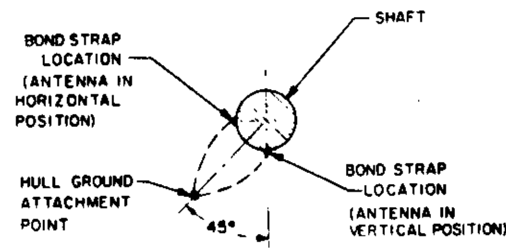
HAND OPERATED



ELECTRIC/HYDRAULIC OPERATED

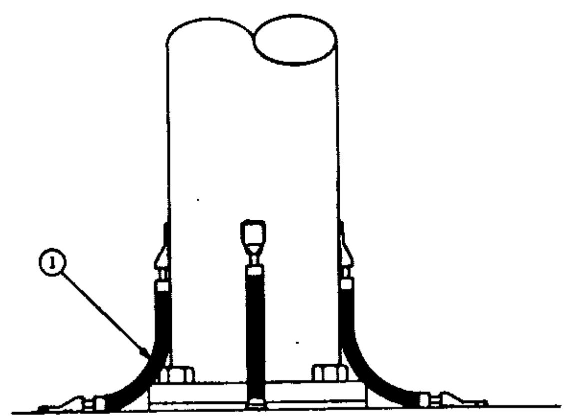


VIEW "A"-"A"



DETAIL "A"

FIGURE 15. Tilting antenna mounts bonding

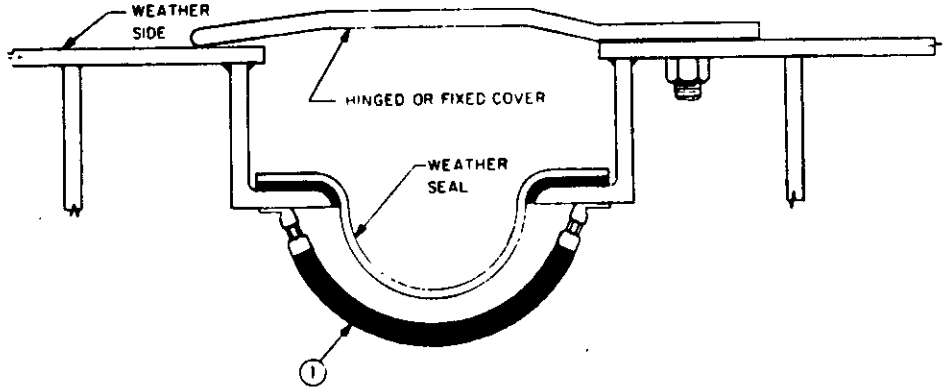


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I		* 1

NOTES:

1. BOND STRAPS SHALL BE EQUALLY SPACED AROUND EACH MAST STRUCTURE.

FIGURE 16. Masts bonding

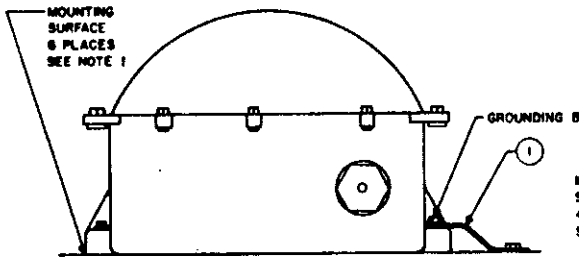


LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE I		1,2

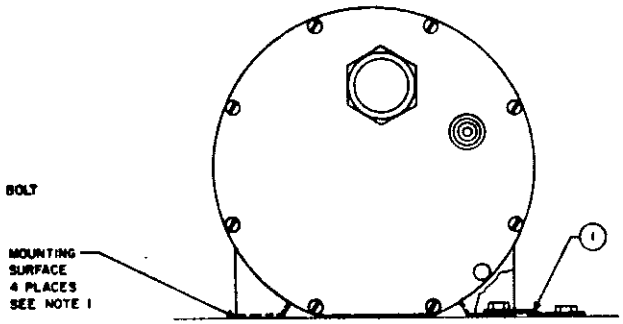
NOTES:

1. BOND STRAPS SHALL BE INSTALLED ACROSS EXPANSION JOINTS AT INTERVALS OF APPROXIMATELY 5 FEET AND LOCATED ON THE SIDE OF THE JOINT NOT EXPOSED TO THE WEATHER.
2. THE LENGTH OF THE BOND STRAP SHALL BE SUFFICIENT TO PERMIT MAXIMUM EXCURSION OF THE EXPANSION JOINT.

FIGURE 17. Expansion joints bonding



AN/URA-38



CU-937/UR

LIST OF MATERIAL			
ITEM NO.	PART	SPECIFICATION	NOTE
1	BOND STRAP TYPE III		1
2	BOND STRAP TYPE II		1

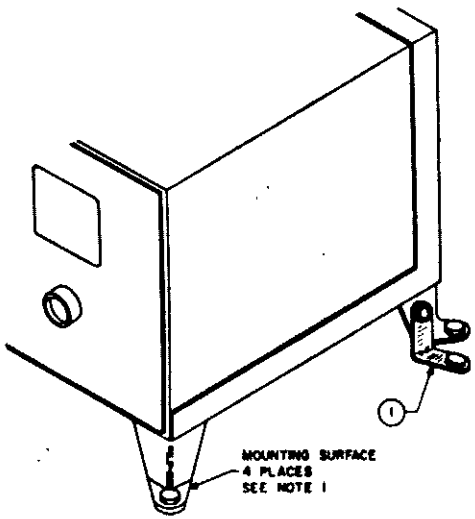
NOTES:

1. ANTENNA TUNERS AND COUPLERS SHALL BE GROUNDED BY THE FOLLOWING METHODS AS SHOWN:

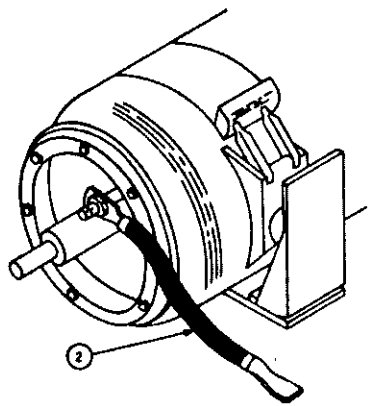
   AN/URA-38, CU-937/UR, AN/SRA-22
   THE MOUNTING SURFACES BETWEEN EACH TUNER/COUPLER AND GROUND POTENTIAL SHALL BE CLEAN AND FREE OF CORROSION. A HEAVY COAT OF ANTISEIZE COMPOUND OF MIL-T-22361 SHALL BE APPLIED TO THE CLEANED AREAS AND THE TUNER/COUPLER FIRMLY BOLTED IN PLACE. THE MOUNTING HARDWARE SHALL THEN BE WEATHER SEALED WITH ADDITIONAL ANTISEIZE COMPOUND, OR OTHER SUITABLE SEALANTS SUCH AS PAINT OR ASPHALT.

   IN ADDITION TO THE ABOVE, TYPE III BOND STRAPS SHALL BE INSTALLED ON EACH TUNER/COUPLER. BOND STRAP CONNECTION TO GROUND POTENTIAL SHALL BE BY STUD, STUD PAD OR BOLT AS SHOWN. IN EITHER CASE THE CONTACT SURFACE BETWEEN THE BOND STRAP AND GROUND POTENTIAL SHALL AT LEAST EQUAL THE WIDTH OF THE BOND STRAP. CONTACT SURFACE AREAS FOR BOND STRAPS SHALL BE THOROUGHLY CLEAN AND COATED WITH ANTISEIZE COMPOUND OF MIL-T-22361 PRIOR TO BOND STRAP INSTALLATION. ALL HARDWARE AND BOND STRAPS SHALL BE WEATHER SEALED AS SPECIFIED FOR TUNER/COUPLER MOUNTING HARDWARE AFTER INSTALLATION OF BOND STRAPS.

   TN-342/WRT-2, TN-345/WRT-1
   A TYPE II BOND STRAP SHALL BE INSTALLED BETWEEN EACH TUNER GROUND STUD AND A GROUND POTENTIAL POINT. AFTER THE ADDITION OF ANTISEIZE COMPOUND THE GROUNDING STUD AND BOND STRAP TERMINAL SHALL BE WEATHER SEALED AS SPECIFIED ABOVE.



AN/SRA-22



TN-342/WRT-2 OR TN-345/WRT-1

FIGURE 18. Antenna tuners and couplers grounding

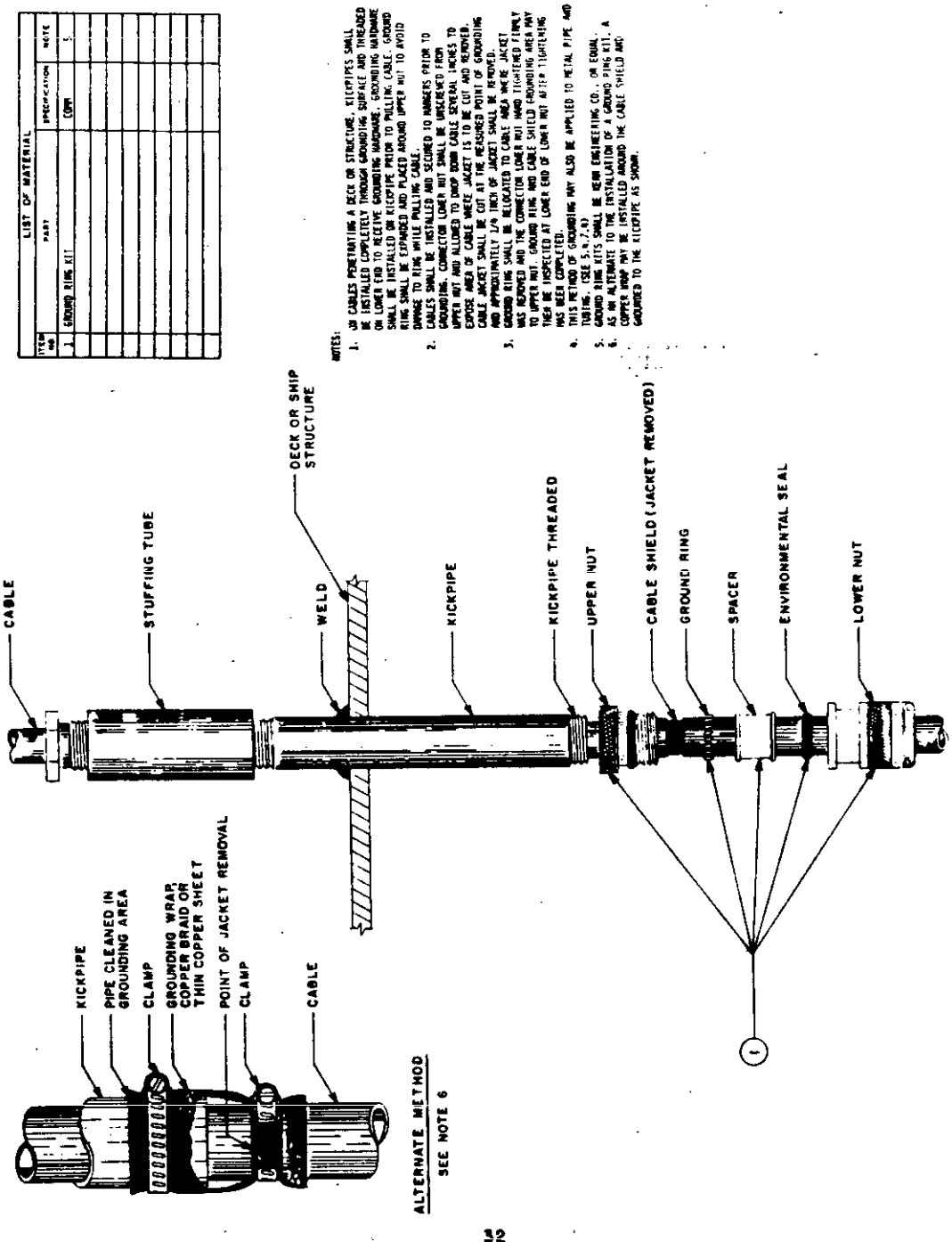
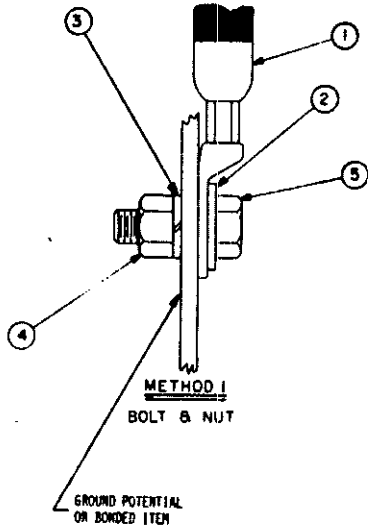
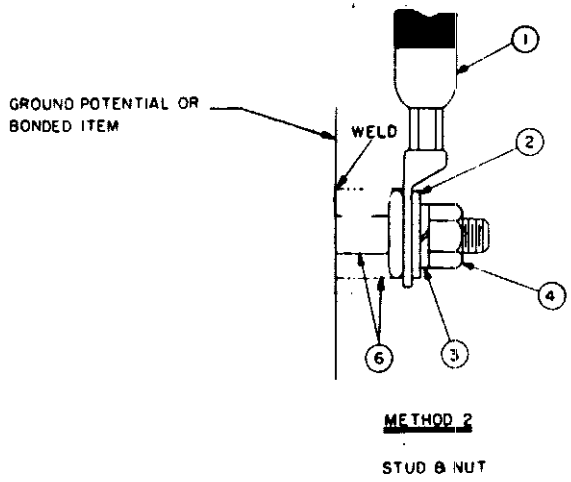
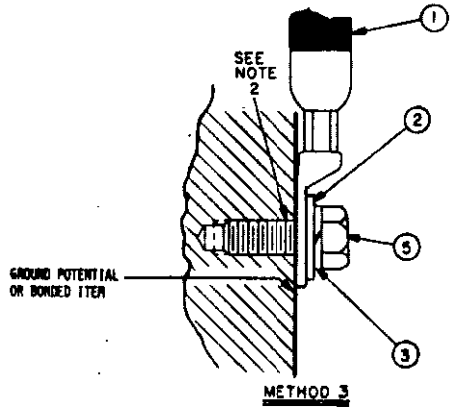


FIGURE 19. Cable shield grounding for EMP protection







LIST OF MATERIAL			
ITEM NO	PART	SPECIFICATION	NOTE
1	BOND STRAP, TYPE II, III OR IV		
2	WASHER, FLAT		1
3	LOCKWASHER, SPLIT		1
4	NUT		1
5	BOLT		1
6	STUD, SHOULDER OR COLLAR	MIL-S-24149	1,3,4

NOTES:

1. FOR SHIPBOARD EXTERIOR APPLICATIONS ITEMS 2-6 SHALL BE CORROSION RESISTANT STEEL OF QQ-S-763, EXCEPT AS MODIFIED BY NOTE 3.
2. EXISTING BOLTS, STUDS OR THREADED HOLES MAY BE USED FOR BOND STRAP ATTACHMENT.
3. TO PERMIT WELDING, STUDS SHALL CORRESPOND TO THE MATING SURFACE, ALUMINUM STUDS FOR ATTACHMENT TO ALUMINUM SURFACES AND STEEL STUDS FOR ATTACHMENT TO STEEL SURFACES. STEEL STUDS SHALL BE ZINC PLATED.
4. SHOULDER STUDS OF MIL-S-24149 SHALL BE USED FOR ALL TYPE II INSTALLATIONS. THESE SHOULDER STUDS SHALL CONFORM TO THE FOLLOWING DIMENSIONS:

   STUD SIZE -- 3/8-16
   THREADED LENGTH -- 5/8" EXTENDING ABOVE BOND STRAP LUG(S) TO ALLOW FOR FLAT WASHER, LOCK WASHER AND NUT
   UNTHREADED PORTION (BASE) DIAMETER -- 3/4"
   BASE HEIGHT -- 1/2"

   EITHER SHOULDER STUDS OR COLLAR STUDS MAY BE USED IN ALL OTHER INSTALLATIONS.
5. THE INSTALLATION PROCEDURES FOR BOLTED BOND STRAPS SHALL PROVIDE FOR A CLEAN METAL-TO-METAL CONTACT BETWEEN THE BOND STRAP TERMINAL AND THE MATING SURFACE. THREADED HARDWARE SHALL BE PREPARED AND SEALED IN ACCORDANCE WITH THE REQUIREMENTS SPECIFIED HEREIN.

FIGURE 21. Methods of attaching nonwelded bond straps

LIST OF MATERIAL

ITEM NO	PART	SPECIFICATION	NOTE
1	CAULKING, CONDUCTIVE OR RF GASKET	COMM.	1,2

NOTES:
1. WAVEGUIDE GROUNDING SHOWN IS BASED ON STANDARD INSTALLATION TECHNIQUES FOR WAVEGUIDE. GROUNDING IS ACHIEVED BY THE ADDITION OF CONDUCTIVE CAULKING OR RF GASKETS IN THE AREAS SHOWN. CONDUCTIVE CAULKING SHALL BE EMERSON & CUMING, INC., ECCOSHIELD VV, OR EQUAL. RF GASKETS SHALL BE POLYSHEET, METEX CORP., OR EQUAL.
2. ALL SURFACES WHERE CAULKING OR RF GASKETS ARE USED SHALL BE CLEAN AND FREE OF NON-CONDUCTIVE COATINGS. GROUNDING AREAS CLEARED TO BARE METAL SHALL BE RECOATED WITH A PROTECTIVE COATING OF CONDUCTIVE CAULKING. WEATHER EXPOSED AREA SHALL BE REPAINTED. AFTER ASSEMBLY FLANGE PLATE AND SLEEVE EDGES SHALL BE WEATHER SEALED AS REQUIRED.

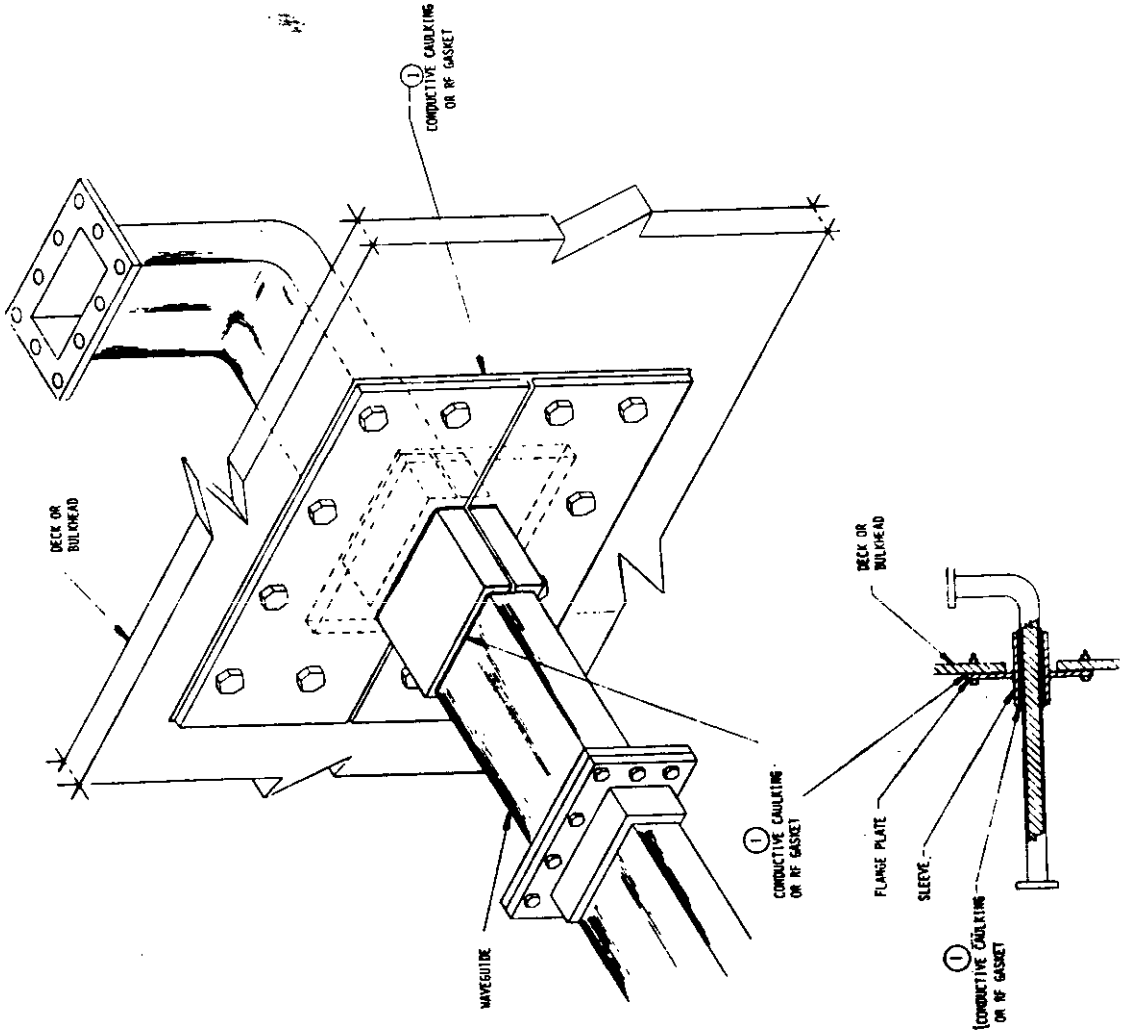


FIGURE 20. Waveguide grounding for EMP protection

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