CHAPTER 8

CABLE AND CONDUCTOR TERMINATIONS

8.1 CABLE TERMINATIONS

See chapter 16 for a detailed discussion of pigtail splice connectors.

Cable splicing for new (MILCON) construction, modifications, and expansion of facilities will be permitted only after it has been determined by the supervising activity that time and replacement costs are excessive. In the event that splicing is required, the splice must be accomplished in accordance with approved Navy procedures.

8.2 CABLE END SEALING

The primary purpose of cable end sealing is to prevent the disruption of power to otherwise intact electrical circuits. Because watertight cable has not been perfected to the point where leakage of water through the cable has been eliminated completely, some cable end sealing requirements must be retained. The introduction of even small amounts of water into electrical equipment via cables can jeopardize an entire system.

8.2.1 End Sealing Procedures

When electrical cables manufactured to specification MIL-C-915 are end sealed, the individual wires shall be watersealed by the use of synthetic resin tubing (MIL-I-631), and the ends sealed with watertight thimbles before installation of the terminal lugs. The cable crotch shall then be end sealed by the use of approved methods. Cables of the reduced diameter type (manufactured to specification MIL-C-2194) are of watertight construction and do not require the use of the thimbles and the synthetic resin tubing over the individual wires of multiple conductor cables, two, three and four conductor cables up to and including 9000 CM. Figure 8-1 shows typical end sealing arrangements. The instructions supplied by the end seal manufacturer should be closely followed since installation procedures differ widely from manufacturer to manufacturer.

8.2.2 Cable Supports

When a cable has been end sealed, proper support must be provided for the cable to prevent movement or strain from destroying the watertight seal. Additional cable support is not required on cables that have been watersealed in nylon stuffing tubes installed in watertight or drip-proof enclosures. Cables shall be supported as close as practicable to the water sealing assembly by use of a properly designed hanger and strap. The hanger shall hold the end of the cable or cables rigid and clear of adjacent material.

CAUTION

The cable shall be rigidly secured by the cable strap or clamp before the stuffing tube gland nut is set up. This will prevent the cable from being forced out of the stuffing tube by the pressure set up by the plastic sealer, when the gland nut is tightened.

8.2.3 Distribution Frames

A Naval Communications Station employs distribution frames for concentrating individual circuits into cables; these frames serve as the point of equipment interconnection and as the interface point between the outside world and the circuit distribution within the building. Four types of distribution frames are generally used within a communications station.

- o Main Distribution Frame (MDF)
- o Intermediate Distribution Frame (IDF)
- o Classified Intermediate Distribution Frame (CIDF)
- o Combined Distribution Frame (CDF)

Distribution frames are built up of terminal blocks composed of rows of terminals. Each terminal extends through the block so that individual wires of a cable will be terminated on one side of the block and cross-connect wires will be connected on the opposite side of the block. Frames must be planned so that sufficient room within the frames is available to permit the addition of blocks to provide for anticipated expansion requirement. All blocks used to terminate internal cabling are to be positioned vertically within a frame. Horizontal blocks are to be used only to terminate cables leaving the building or interfacing with a system that supports interside communications such as the microwave system. All spare pairs will be grounded at the distribution frame. All frames are grounded to the electronic ground system at the facility.

Wire termination methods contained in MIL-STD-1130 are approved for distribution frame installation. The wire-wrap method is approved for permanent connections only and may not be used on the cross-connect side of a terminal block. All other terminations on these frames are to be the solder or push-on type. The following types of terminal blocks are approved for use in a distribution frame:

- o Solder-to-solder connections.
- o Wire-wrap to push-on.

Wire-wrap to wire-wrap is permissible when no cross-connects are involved. Wire-wrap to solder connections are not permitted since heating of the solder side expands

the pin on the wrap side thereby losing the gas-tight fit. Taper pin terminal blocks are not to be used. A wire-wrap to push-on terminal block is shown in figure 8-2.

The terminal block wiring scheme is based on the following:

- o The terminal block pin row is lettered A, B, C, D, E, and F.
- o Coded wires are connected to pins A, C, and E.
- o Common wires are converted to pins B, D, and F.
- o All remaining wires are connected in accordance with this scheme.

a. Main Distribution Frame. The MDF is built up of horizontal and vertical terminal blocks as illustrated in figure 8-3. The horizontal blocks terminate circuit cables entering the building through fused terminals. These fused terminals protect inside equipment against excessive external circuit currents. The horizontal blocks of this frame are also used to terminate the cabling from the intersite link facilities. Vertical blocks are used to terminate cables that support internal circuit distribution of the building. The MDF is usually located above the external cable entry point, and the external cables are fed up to the frame for individual wire termination. Distribution to locations in the building is accomplished by connecting internal distribution cables to the vertical blocks of the MDF and leading the internal cable up to overhead ducts or trays. All cabling is run on the inner portions of the frame, and the individual wires are brought out through the fanning strips of the terminal blocks to the wire termination. The cables are secured to the inner portions of the steel frame to prevent any stress on the wire terminations. Figure 8-4 depicts a typical MDF.

b. IDF and CIDF. The IDF terminates internal distribution cables, equipments, and patchboards that process Black information. The CIDF terminates cables, equipments, and patchboards that process Red information. The IDF should be physically separated from the CIDF by a minimum of two inches; however, it is desirable to locate these units on opposite sides of the room.

These IDF and CIDF frames are composed of rows of terminal blocks mounted in a vertical position (see figures 8-5 and 8-6).

The blocks and the method of laying cable into the blocks are standardized by NAVELEX Standard Plan RW 10F2101. Figures 8-7 and 8-8 show the solder-to-solder type terminal blocks and wiring plans.

The individual cable wires are laid into the block in sequence according to the wire color code for each individual cable (see figure 8-9). Shields for individual pairs are provided on a special case basis. When shielded pairs are used, the shields are terminated at the intermediate distribution frame in the manner shown in wiring plans of figures 8-7 and 8-8. An approved alternate method of terminating the shields is

the commoning technique of freeing the terminal rows reserved for grounding by collecting the individual shields at one common point for ground outside the block - thus allowing more cable terminations to the board.

Cabling to the blocks is brought to the inner portion of a frame with front and back blocks and to the rear of frames with a front block arrangement only. The cabling runs to the frame from the overhead or from the bottom according to the cable distribution system used in the building. In either case, the cable is tied to the frame for support to prevent any stress on the wire termination. Typical intermediate distribution frames are shown in figure 8-10.

It is sometimes expedient and practical to route one or more multi-conductor cables from the CIDF or IDF to an equipment room and then connect the multi-conductor cables to smaller cables to form branches leading to the individual equipments. When this is practiced, a "junction box" is used to terminate the cable within the equipment room. The junction box is composed of terminal blocks similar to those used in a distribution frame. This similarity may result in the junction box being mistaken for a distribution frame. However, the junction box can be readily distinguished from a distribution frame by the absence of cross-connect wiring. In a junction box, the smaller cables are connected directly to the back of the terminal block on the terminal corresponding to the front termination of the larger cable. In a distribution frame, cables are interconnected through cross-connect wiring.

c. CDF. A CDF may be used at small stations, serving the purpose of both the IDF and MDF. When a CDF is used, the blocks that terminate cables and systems that interface with the outside world are to be positioned horizontally. Blocks used to terminate cables supporting internal distribution are to be positioned vertically.

8.3 WIRE WRAP AND PUSH-ON TERMINATIONS

Wire wrap and push-on terminations provide a means of a solderless disconnect system for high density wiring. These connections provide a permanent, gas-tight, electrical connection while still offering a "quick" disconnect capability. Figure 8-11 illustrates a typical push-on type terminal.

8.3.1 Wire Wrap

Wire wrap connections are to be accomplished in accordance with MIL-STD-1130. Figure 8-12 illustrates the two types of wire wrap connections specified within MIL-STD-1130. Figure 8-13 illustrates a hand operated version of a wire wrap tool.

8.3.2 Cross-Connects

Cross-Connects are wires that interconnect terminals of the distribution frame terminal blocks. These wires may interconnect terminals on the same block or may run from one block to another. Of the types of termination authorized for cross-connects, solder type termination is the one most often used.

Cross-Connects are made of wire designed especially for distribution frame use. Western Electric Company Type V is commonly used as the cross-connect for a distribution frame.

The cross-connect wires should be run in a manner that presents a neat uniform pattern such as shown in the examples of figure 8-14. It is imperative that cross-connect wire be run loosely to avoid subsequent breakage as additional cross-connects are pulled into place. In general, any practice that will cause the cross-connect wire to tangle, or otherwise become caught on lugs or other objects, should be avoided. When twisted pair, triplet or quad cross-connect wire is used, the conductors should be untwisted at each end so that each conductor enters the terminal block fanning strip individually. However, the wire should not be untwisted more than one regular twist back of the fanning strip.

8.4 TERMINALS

Terminals may generally be classified as either solderless or solder types. Because of the wide variety of terminal configurations and sizes, selection of the appropriate terminal depends upon its intended application. The size of the wire, type of tongue shape required (ring, slotted, spade tip, rectangular), available space, stud-clearance required, and other factors must be considered. When a specific terminal configuration has been selected, all limiting factors shall be considered before making a final selection from the manufacturer's catalog.

8.4.1 Solderless-Type Terminals

a. Crimp Terminals. Crimp terminals are attached to the conductor by use of a tool which applies pressure on the barrel of the terminal. This pressure indents the barrel and makes a mechanically strong connection that has low electrical resistance. (Diagonal pliers or similar tools shall not be used to crimp terminals.) Both insulated and noninsulated types are available in a large variety of sizes and styles. The installation of these terminals is very simple, but the proper tool must be used. When a terminal is connected to a conductor the following precautions should be observed:

(1) Make sure the wire insulation is stripped to the correct length to allow the conductor to bottom in the terminal barrel.

(2) Do not crimp the insulation within the barrel. The insulation should end at the barrel.

(3) Make sure all strands of a stranded wire are placed in the barrel before crimping.

(4) Use the proper tool specified by the manufacturer for the particular terminal used. Make sure it is adjusted properly.

(5) Be sure to use the proper die nest if an exchangeable die nest tool is used.

(6) Use a ratchet type crimping tool requiring the operator to fully complete the crimping cycle which is the only authorized crimping tool.

The crimped connection should be examined to make certain:

- The identation must be centered on, and in line with, the terminal barrel.
- The barrel is not cracked.
- The terminal insulation is not damaged (insulated terminals only).
- The insulation grip is crimped completely.

Crimp terminals are available in a wide variety of shapes and sizes.

8.4.2 Terminal Boards

Terminal boards or strips provide a convenient means of interconnecting electrical circuits. Terminal boards are available in numerous types and sizes; therefore, only a few representative types are described.

a. Barrier Boards. Barrier terminal boards have insulation barriers between the terminals. Barriers increase the leakage paths between terminals and, therefore, increase the voltage rating. In addition, direct shorts caused by frayed wires are minimized. Commercial terminal boards are usually made from bakelite. Table 8-1 lists common materials used for boards fabricated in accordance with military specifications.

Connections to terminal boards may be made in several ways. The board shown in figure 8-15 uses screw terminals; figure 8-16 illustrates the one- and two-sided solder terminals, the bottom-solder terminal, and the two-sided eyelet terminal. Other configurations are also available.

A type of terminal board used extensively by the Navy is shown in figure 8-17. These boards are available as single-row, double-row, or through-connected boards. A typical material used in the manufacture of this board is MAI-60 glass-filled Alkyd resin. Terminal identification numbers are molded into the board. Table 8-2 lists pertinent information.

b. Slotted-Terminal Boards. (See figure 8-18)—A standard terminal board that employs slotted terminals has been approved by the Naval Electronics Laboratory. These boards are of particular value when used in prototype and mockup applications.

Permanent wiring is inserted into the hollow tube of the terminal from the bottom of the board; items that are subject to change (resistors, capacitors) are laid in the terminal slots (with no wrapping) on top of the board. The conductors are then soldered to the terminal. These boards are available in 2- by 36-inch strips and in 1-1/2- by 36-inch strips and may be cut to any required length.

c. Marker Strips. (See figure 8-19)- Marker strips serve a dual purpose; they provide a means of identifying terminals and act as insulating strips. When terminal blocks are mounted on metal, these strips prevent a short circuit if too long a screw is accidently used. Marker strips are usually about 1/32-inch thick and are made from fiber or bakelite. Terminal designations are printed or engraved.

d. Fanning Strips. (See figure 8-20) - Fanning strips are used to make multiple connections to terminal blocks. These strips are available in either flat or right-angle mountings. Fanning strips may be supplied with the cable-clamp hole at either end of the strip. The cable conductors are soldered to the terminals. Fanning strips are available with either flat or upturned terminals, and must be ordered for use with a specific terminal block because of the varying terminal spacing.

Fanning strips provide a rapid method of connecting and disconnecting multiple circuits and permit the cabling to be neat. The primary disadvantage of a fanning strip is the difficulty of disconnecting individual circuits for test or troubleshooting purposes. Fanning strips should be used only when specified by the design engineer.

e. Pressure-Type Terminal Boards. (See figure 8-21) - Connection to a pressure-type terminal board is made with setscrews. This board is particularly suited to power applications where high-voltage or high-current carrying cables are joined; conductors may be easily disconnected without disturbing adjacent wires. A lengthwise barrier prevents conductors from slipping through to the other side of the board when inserted. This board may be cut to provide any number of terminals.

f. MODULOK® Boards. (See figure 8-22) - The MODULOK is a modular terminal block designed for applications using AN wire sizes 12-22. Modules are available with either 2 or 4 tier spring-loaded sockets which may be set for quick disconnect for rapid ring-out, bussing, or circuit changes. A twist of a screwdriver transforms the quick-disconnect into a permanent connection. Modules, which are snapped together and apart mount in steel tracks up to 32 inches in length. They are secured in place by end locks. Figure 8-23 illustrates a typical MODULOK installation.

Coax MODULOK assemblies are available for termination of many small sizes of coax cables, see figure 8-24. The coax cables are terminated with HYFEN contacts before insertion in the coax module. Three coax connections can be made in each module and coax modules can be locked with regular MODULOK 2 or 4 tier modules on the same track.

® Burndy Corp registered trademark.

g. CRABLOK® Terminal Blocks. These terminal boards are similar to the MODULOK boards and are available in either single or double tiers, and in groups of 5 to 15 terminals. A flat bar or similar mounting system is used. Space is provided on top of the block for terminal marking. Quick-disconnect or permanent connections can be made. Contact tips are listed in table 8-3.

8.5 CABLE AND CONDUCTOR IDENTIFICATION

Each interconnecting cable shall be permanently marked by placement of an approved type of cable tag near each cable termination. Cable tags shall be placed near the jack, plug or terminal board to which the cable terminates in a prominent manner such that associative identification is obvious.

8.5.1 Approved Cable Tags

Cable tags shall conform to the following criteria unless otherwise specified (type III is the preferred method for all new installations):

a. Type I, the least acceptable method, shall be of gray soft aluminum tape conforming to MIL-A-2877. Dimensions shall conform to those delineated in figure 8-25. Letters and numbers shall be embossed on cable tags with a minimum of 1/32 above surface of tag. Capital letters shall be used. All letters and numbers shall be 1/4 inch high.

b. Type II shall be weather resistant natural nylon adjustable identification straps conforming to MS 18035. Dimensions are delineated in figure 8-26. Lettering and numbering is to be accomplished with black nylon ink using either a nylon pen or tapewriter. Letters shall be of Gothic capitals, and numerals, and other characters shall be of similar appearance. The size of letters, numerals, and other characters shall be as necessary for legibility.

c. Type III shall be heat shrinkable tubing used as an alternate method and especially for use on cables which are too small to be compatible with Types I and II. Lettering and numbering methods shall be the same as for Type II. Refer to figure 8-27.

8.5.2 Cable Tag Designations

Designations of cable tags shall be those cable designations as delineated by the specific specifications, drawings and/or cable readout charts.

8.5.3 Cable Tag Installation

Cable tags shall be secured in a manner which will provide permanent retention of placement.

a. Type I is to be secured as illustrated in figure 8-25.

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b. Type II is to be secured by utilizing an installation tool conforming to MS-3368.

c. Type III is to be secured by application of heat from a flameless air heat gun.

8.6 COLOR CODING

Multiple conductor cables are color coded for identification purposes. Those cables are coded according to types of insulating material: plastic; woven; wrapped, or braided fabric; natural or synthetic rubber; and paper. Table 8-4 lists the color coding schemes used in wire specifications MIL-C-19547 and MIL-C-28781.

8.7 TOOLS

The following paragraphs describe several commonly used special-purpose tools required for wire and cable work. (Ordinary hand tools are not discussed.)

8.7.1 Wire- and Cable-Stripping Tools

Wire- and cable-stripping tools range widely in complexity. Tools used in normal installation and maintenance include the following:

a. Wire Stripper. A common type of wire stripper is illustrated in figure 8-28; it may be used on either solid or stranded wire. By using various cutting blades, the tool can strip wire sizes 8 to 30. The insulation may be removed from the ends or stripped at any point along the wire. Some models have a lock-open feature to permit easy wire removal and to prevent crushing of the wire.

b. Jones Cable Stripper. The basic components (figure 8-29) are a steel frame, a clamping lever, and an adjustable, hinged cutting mechanism. The cutting mechanism consists of a blade and an indexing head. By means of adjusting the head, the tool may be adapted for various depths of cut, and to accommodate cables of various diameters. This stripper may be used to make cross cuts as well as longitudinal cuts in all types of insulation, including woven armor and lead sheathing.

c. Huff Cable Stripper. This cable stripper (figure 8-30) consists of an adjustable, hinged tubular body and an indexed cutting head. The body construction allows cables of various diameters to be stripped. The indexed head permits the cutter blade to be adjusted to an exact depth of cut; a locking screw assures retention of this setting. A protruding arm on the body provides a good grip for the stripping process. Only lengthwise cuts may be made with this stripper.

d. Self-Adjusting Wire Stripper. A relatively new wire stripper is now available which makes wire stripping considerably easier. (See figure 8-31.) The stripping jaws consist of multiple cutting blades cushioned by a resilient pad. The tool requires little or no adjustment when stripping wires of various diameters. Some adjusting is required when going from a large diameter conductor to a small diameter conductor. An additional feature of this tool is its ability to strip more than one wire at a time.

8.7.2 Crimping Tools

The following paragraphs discuss some of the tools available for crimping solderless terminals on conductors.

a. Sta-Kon Crimping Tool. Thomas & Betts Co. trademark for a crimping tool (figure 8-32) used with terminals of the same trademark for wire sizes 10 to 22. Because this tool is a toggle-type with pawl, the work cannot be removed until the crimping process is completed. The die nests are color-coded to indicate which nest is to be used with each terminal.

b. Buchanan Crimping Tool. The Buchanan crimping tool (see figure 8-33) accommodates wire sizes ranging from 12-10 through 26-24. A selection knob is rotated to obtain precise crimp setting.

c. Burndy Crimping Tool. The Burndy crimping tool (figure 8-34) is used to install Burndy terminals on wire sizes 10 to 26. This tool contains a compact head that requires changes of die sets in order to accommodate all wire sizes. The die sets are easily changed by the removal and replacement of two head cap screws.

8.8 STRIPPING AND SERVING

A conductor must be properly prepared before it can be connected to a terminal or connector. The insulation should be stripped back approximately three-fourths of an inch from the wire end. This length is sufficient to connect to most terminals; exact stripping lengths are determined by specific applications.

When a stranded conductor is stripped, care must be taken not to clip individual strands in the process. If strands are accidentally clipped, those remaining must be long enough to be secured by tinning. Table 8-5 shows the maximum number of allowable clipped strands based on the total number of strands in the conductor.

8.8.1 Cable Butting

Butting is the process of cutting the outside covering or additional sheathing which may be wrapped around the conductors of a cable. A butt is the point from which enclosed cable conductors are formed or fanned to various locations. A Western Electric Company (W. E. Co.) R2060 cable-butting tool is representative of the type used. Figure 8-35 illustrates proper butting procedure.

8.8.2 Cable Stripping

Stripping is the process of cutting and removing the outside covering or additional sheathing between the butt and the end of cable.

a. Use of W. E. Co. R62267 Cable Stripper. This type of stripper is used for fabric-covered cable. Figure 8-36 illustrates use of this tool.

b. Use of W. E. Co. R2878 Cable Stripper. This type of stripper is used for plastic-, rubber-, and lead-covered cables. Figure 8-37 illustrates use of this tool.

c. Use of Jones Cable Stripper. This stripper is used in the butting and stripping of woven-armor-covered cables; however, it is not restricted to use on this type of covering. It is primarily used to strip large single conductors; it is not recommended for the stripping of conductors of multiple-conductor cables. Figure 8-29 illustrates the Jones cable stripper.

d. Use of Huff Cable Stripper. This tool is primarily used on woven-armor sheathing and insulation and is not practical for use on a single conductor unless it is large.

This stripper can be used only for making longitudinal cuts and is illustrated in figure 8-30.

8.8.3 Conductor Stripping

a. Stripping with Pliers. (See figure 8-38.) Use needle nose pliers with non-knurled tips.

STEP 1. Place the jaws of the pliers on the wire at the skinning point and crush the insulation. DO NOT nick the wire.

STEP 2. Slightly relax pressure on the handles of pliers and pull insulation off the end of the wire.

STEP 3. Remove the enamel or oxidation from the wire by scraping with the blade of the cutting pliers.

STEP 4. If insulation is frayed, it must be trimmed with cutting pliers or electrician's scissors.

b. Stripping with Knife. (See figure 8-39.)

STEP 1. Cut the insulation at the skinning point as illustrated. Be careful not to nick wire.

STEP 2. Pull the insulation off the end of the wire.

STEP 3. Clean the bare wire by scraping with the edge of knife blade. If stranded wire is used, clean each strand individually and twist the cleaned strands together again.

c. Stripping with Conventional Wire Stripper

STEP 1. Determine the wire size and insulation thickness.

STEP 2. If the stripper has an adjustable screw, set it to a depth slightly less than the thickness of the jacket.

STEP 3. Place the conductor into the notch that corresponds to wire size. Make sure that the length to be stripped extends beyond the jaws of the tool.

STEP 4. Keep the wire at a right angle to the cutting blade, and squeeze handles.

STEP 5. After insulation has been stripped from the conductor, release handles and remove the conductor.

STEP 6. Squeeze handles again to return stripper to closed position.

d. Stripping with Abrasives. Stripping that is accomplished with sandpaper may be classified as an abrasion method.

8.8.4 Serving

Serving is used to secure the loose ends of woven braid or conductors to prevent unraveling. It may be accomplished by wrapping either with tape or with twine.

a. Tape Serving. Before the butting process (described in paragraph 4.22.1) can be accomplished, the cable must be wrapped with tape to prevent initial unraveling. The cut tape must be further reinforced with three or four turns of cellophane or friction tape in order for the serving to be effective after the cut is completed.

b. Twine Serving. This method is identical to the method of serving manilla rope or line. Figure 8-40 provides step-by-step procedures.

c. Tinsel-Wire Serving. In order to terminate tinsel wire, it is necessary to serve the conductor strands. Tinsel wire is served by the following procedure (figure 8-41).

STEP 1. Remove outer braid (jacket).

STEP 2. Serve exposed inner strands with No. 34 AWG bare wire; wrap wire over jacket several turns to provide strain relief.

Solderless terminals are available for use with tinsel wire. These terminals have sharp prongs that pierce the jacket and make contact with the conductors; therefore, it is not necessary to remove the jacket.

8.8.5 Wire and Cable Cleaning

Wire and cable cleaning involves the removal of all insulation remnants, enamel, and surface film. Several of these cleaning methods are described here.

a. Cleaning by Mechanical Scraping. A knife, or the cutting blade of pliers may be used to scrape the wire clean; however, this method is the least desirable as it may result in nicking or otherwise damaging the wire. Fine sandpaper is more effective, especially on stranded conductors.

b. Chemical Cleaning. The most effective cleaning method for magnet or resistance wire is dipping into a solvent, such as Strip-X. (After immersion, the stripping solution must be wiped off with a clean rag.) This method is effective on fiberglass, Formvar, chrome oxide, silicone, enamel, and hard-baked enamel. Cleaning time varies from two seconds to two minutes.

8.9 POTTING, INSULATING AND CABLE PROTECTION

8.9.1 Potting

Potting consists of pouring a molten or liquid compound into a component housing, such as a connector. The potting compound immobilizes parts, prevents damage from mechanical shock, and seals against moisture and dirt. Among the most common potting materials are epoxy and silicone resins.

a. Epoxy Resins. Epoxy resins adhere well to clean surfaces, do not shrink, and have excellent dielectric properties. Appropriate catalysts, hardeners, fillers, and plasticizers can modify epoxy resins so that they will meet a wide range of requirements.

b. Silicone Resins. Silicone resins may be dipped, sprayed, poured, or spread in the potting process. These materials form a rubber-like solid that provides protection from extreme temperature variations, moisture, and mechanical shock. Silicone resins are supplied as two ingredients which must be mixed: when mixed, the catalysts contained in the separate ingredients combine. The mixture vulcanizes, without heat or pressure, to produce a rubbery solid. Curing takes about 24 hours: optimum physical properties are achieved in four to seven days. Silicone resins possess good dielectric properties, are resistant to fungus, do not crack with age, are particularly suitable for temperature applications up to 260°C (500°F) and possess high thermal conductivity and low moisture-absorbent properties. The following procedure should be used to pot a connector:

STEP 1. Use a small stiff brush and approved solvent to remove all dust, oil, excess rosin, and other foreign matter from the connector. Do not expose the insulation to the solvent longer than necessary for adequate cleaning.

STEP 2. Allow the connector to dry. Separate and evenly space the wires.

STEP 3. Apply a light film of lubricating oil to all external metal surfaces.

STEP 4. Use a plastic potting cup or, if none is available, use masking or cellophane tape, vinyl tubing, or an equivalent (as shown in figure 8-42A) to form a mold around the area to be potted.

NOTE

The solder joint of a large contact may extend beyond the normal potting level in a connector; therefore, the larger contacts must be potted separately. A sleeve is run over the solder pot and down into the potting area. At the same time, the potting compound is forced inside the sleeve to include the large solder joint (figure 8-42B). The sleeve must be positioned before the large contact is placed in the connector insert.

STEP 5. Slowly mix the basic compound, prior to adding the accelerator. (Fast mixing may cause air to be trapped in the sealant.)

STEP 6. Combine the accelerator and base compound, mix thoroughly until no streaks of the darker accelerator material are visible (figure 8-42C). Hand mixing usually requires about 5 to 10 minutes.

STEP 7. Test the sealant by spreading a few drops of the mixture thinly over a piece of white paper, as illustrated in figure 8-42D. If the material is adequately mixed, no specks or streaks will be visible.

STEP 8. Using a spatula or putty knife, apply the compound to the connector, as shown in figure 8-42E. A small piece of wood or metal should be used to tamp the sealant around the wires and base of the pins to eliminate air bubbles. Occasionally tap the connector to aid the flow of sealant into small recesses. An alternate method of applying is to use a flow gun, as shown in figure 8-42F. The tip of the gun should be small enough to get between the contacts to remove air bubbles.

STEP 9. Fill the connector to the brim of the mold, or to a point one-fourth inch above the end of the wire insulation.

STEP 10. Allow the compound to cure. A normal curing period is about 24 hours at room temperature 23.9°C (75°F). A more rapid cure can be attained if heat is applied after an initial air-drying period of one hour. Do not heat above 49°C (120°F). A temperature in excess of this will cause the sealant to expand and become porous.

STEP 11. Examine the potting for flaws, cracks, and air bubbles.

8.9.2 Insulating Materials

a. Insulating Tape. Vinyl tape may be used to protect a solder joint from moisture and abrasion, and to reduce strain on the joint. The tape should be installed as follows:

STEP 1. Starting from the center of the joint, wrap the tape evenly away from the joint. Overlap each turn of tape by one-half the tape width. Continue wrapping tape until several turns are placed over the existing insulation.

STEP 2. Wrap over the tape layer and joint; continue wrapping until the insulation on the other side of the joint is overlapped by several turns.

STEP 3. Tape back to the center of the joint; continue wrapping until the tape over the joint has been built up to the thickness of the original insulation.

b. Insulating Sleeves or Tubes. Insulating sleeves or tubes should be used when the following conditions exist:

o Terminal connections are very closely spaced;

o Shields of shielded wires are used as conductors and are close to terminals or other conductors;

o A bare conductor longer than four inches is used; or

o Harnesses routed between hinged assemblies require added protection. Insulating sleeving may be made from several materials: varnished cambric, polystryrene, plastic vinyl, plastic-impregnated fiberglass, and Teflon. Sleeving is commercially available with inside-diameter sizes to fit B & S gage from 0.011 inch (32 gage) through 1.25 inches. Also, a complete assortment of standard colors is available. The electrical characteristics of the various materials are quite different, and selection of the insulating material must be based on its intended use. Because of its superior characteristics, Teflon sleeving may be used for most applications. Insulating sleeves should be installed as follows:

STEP 1. Select the proper size of sleeve (refer to table 8-6), which lists approximate sizes. The sleeve should slide easily over the wire or terminal, but should be snug enough to remain securely in place.

STEP 2. Cut sleeve to a length that will extend from the end of the terminal at least one-fourth inch past the end of the wire insulation.

NOTE

When insulating sleeves must carry conductor markings the length will be determined by the space requirements of the marking. When a large number of connections are to be made in a junction box, the overall appearance will be enhanced if all sleeves are cut to uniform length.

STEP 3. Place the sleeve on the wire before it is connected to the terminal.

STEP 4. Connect the wire.

STEP 5. Slide sleeve over the terminal to the base.

c. Insulating Shrinkable Tubes. Shrinkable tubes are used for connector and and tool handle insulation, cable jackets, and terminal sleeves. A tube is applied in an expanded form so that it will easily slip over the object to be covered. When a high temperature, about 135°C (275°F) for Alpha Alphlex Tubing, is applied, the tubing will shrink to a predetermined size smaller than the object to be insulated and form a permanent, tight-fitting mechanical bond.

Tubes may be shrunk by a hot air gun (Alpha HG-1 or radiant heat), by being dipped in hot liquids, being placed in an oven, burner or match flame. When heated to the proper temperature, the tube will shrink to its predetermined size within a few seconds. This tube is available in several colors, and for wire sizes from 0.042 (24 gage) to 1 inch in diameter.

8.9.3 Cable Protection

Precautions must be observed at all times when handling cable. Cables must be protected from abrasion, deformation by bending or impact, extreme temperature, and contact with water, oil or grease.

a. Temperature Considerations. All cables are subject to possible damage if installed when the cable temperature or the ambient temperature is excessively low or high. The following precautions shall be observed during the installation:

(1) Low Temperatures. Most plastic insulating materials become stiff or brittle when cold, therefore all cables except portable, flexible, and reduced diameter types shall be given the following special handling at temperatures below 35°F:

o Cable Heating. If the compartments where the cables are to be installed cannot be heated, the cable shall first be stored in a compartment heated to at least 50°F, but not above 120°F. The cable shall be warm enough so the installation will be completed before it cools to 35°F.

o Low Temperature Installation. If the cable must be installed when its temperature is 35°F, or slightly lower, extra care is required. The radius of bends shall be no shorter than necessary and never less than the minimum radius of bends listed in the cable data tables. Bends shall be made slowly and uniformly without blows or shock. Before bending the cable into the final position, it shall be warmed thoroughly at the bend area with portable warm air blowers.

(2) Portable, Flexible, and Reduced Diameter Cable. Portable, flexible, and reduced diameter cable (types SGA and MSCA) may be handled at minus 20°F and higher without the precautions listed in paragraph (1) above.

(3) High Temperature. Many plastic insulating materials become softened at high temperatures, therefore coaxial cable shall never be stored in a compartment where the temperature reaches or exceeds 150°F. If coaxial cable has been exposed to temperatures in excess of that specified, the cable attenuation shall be tested in accordance with MIL-C-17. If the attentuation is in excess of specified maximum value, the cable shall not be used in any installation.

(4) Varying Temperature. Cable shall be stored in a dry compartment, protected from the weather and subject to a minimum variation of temperature. Sudden transfer of cable from cold to warm locations which would cause moisture absorption shall be avoided.

(5) Welding and Brazing. Never weld or braze stuffing tubes and cable supports in place after the cable has been installed. Use extreme care while cutting, welding, or brazing in the vicinity of installed cables.

b. Mechanical Damage. Cable can be seriously damaged by carelessness and use of poor practices in the installation. The following precautions shall be observed during cable installation:

(1) Abrasion. Do not use chain falls or other tackle for pulling cable. This shall be done by hand only, taking care not to abrade the cable armor and jacket on sharp, protruding edges.

(2) Bending. Cables that are handled and installed with a bend radius less than that specified in the cable data tables will be subject to damage. The wires can be broken, weakened, or shorted in multiconductor cable and the center conductor in coaxial cable can shift position in the dielectric causing severe changes in attenuation characteristics, or direct shorts.

(3) Oil or Grease. Do not allow oil or grease to come in contact with the cable. Silicone rubber or other types of insulation can be damaged if exposed to oil or grease.

(4) Impact and Pressure. Cable shall be protected from any impact, while in storage or in the process of installation. Do not store cable in a location where damaging pressure may be applied by other cable or material. Do not hang coils or unreeled cable from hooks, dowels or pegs.

CAUTION

Do not walk on or allow wheeled carts, etc., to cross cables lying on floors.

8.10 CONNECTORS

Three basic types of connectors are used to terminate cable and conductors: wire, coaxial, and special-purpose.

8.10.1 Wire Connectors

Wire connectors are of the AN- or MS-types. Since AN-types have been replaced by MS-types, only the latter are discussed in this handbook. When ordering replacement connectors for older equipment, the identification number must be prefixed by an AN- since inserts for AN-types are not all interchangeable with MS-types.

MS-type connectors (figure 8-43) are identified by an MS nomenclature, such as MS3102B18-3P. This nomenclature provides the following information to aid in the identification of the wire connector:

MS	Prefix
3102	Type of Shell
B	Construction of Shell
18	Size
3	Type of Insert
P	Style of Contact

MS3057 cable clamps and MS3420 telescoping bushings are used to support and protect cables and/or conductors where they leave the connector. Table 8-7 lists the types of cable clamps used, the size connectors on which they are used, and the types of bushings required.

Table 8-8 contains a listing of the items covered by the MS-nomenclature system. (It should be noted that table 8-8 omits size information. It is beyond the scope of this manual to provide size information. All connector manufacturers supply detailed size information in their catalogs.) Figure 8-44 illustrates connector-insert arrangement data.

8.10.2 Special Purpose Connectors

Many special purpose connectors are power plugs and audio connectors for equipments whose design requirements would not permit use of standard MS-type connectors.

a. Power Plugs. (See figure 8-45.) These power plugs are waterproofed and pressure-sealed by internal gaskets and a watertight cable-clamp assembly. The mating parts are separated or drawn together by a double-thread screw which goes through the plug and is screwed into the receptacle. Figure 8-45 lists the military numbers and other technical data for power plugs of this type; installation procedures are given in figure 8-46.

b. Audio Connectors. The audio connectors are waterproofed and pressure-sealed by internal gaskets and a watertight cable-clamp assembly. The mating parts are quickly connected and disconnected with a bayonet-type lock. Figure 8-47 lists the military numbers and describes these connections; installation procedures are given in figure 8-48.

c. Ribbon Conductor Connectors. Several types of ribbon conductor connectors are available (bulkhead, ribbon-to-ribbon conductor coupling, ribbon-to-ribbon wire adapters). The methods of attaching ribbon conductors to most types of

connectors are basically the same. The installation procedure of a typical connector (figure 8-49) is as follows:

STEP 1. Remove one-half inch of the insulation from the ribbon cable approximately three-fourths of an inch from the end; use a magnet-wire stripping machine with fiberglass wheels, a hot-blade stripper, or other suitable device.

STEP 2. Double the cable back at the bared area.

STEP 3. Place the retaining bar inside the fold in the cable.

STEP 4. Press the retaining bar and doubled cable into the body of the connector; press in until the retaining bar is firmly seated.

STEP 5. Assemble the second section of the connector in the same manner.

d. Box Connectors. Box connectors of various types may be used as cable entrance fittings for lighting fixtures, fittings and enclosures not classed as watertight. This includes cable entry (other than top entrance to NWT enclosures) to splashproof, spraytight, open type and watertight enclosures (installed in locations and on services requiring only a nonwatertight classification). Some of the available types and the methods of installation are as follows:

(1) Type I and II. These box connectors (manufactured in accordance with Federal Specification W-F-406) are available in steel, malleable iron, brass, or aluminum. Care should be exercised in procurement by asserting the connectors be of like metal to the conduit system for good grounding practice.

o Type I. The type I box connector has the cable clamping member secured with two machine screws as shown in figure 8-50.

o Type II. The type II box connector has the clamping member hinged on one side by a tongue and slot combination and is secured by one machine screw as shown in figure 8-51.

o Connector Sizes. The three sizes available in this type connector are listed in table 8-9. The body of the connector is furnished with American standard pipe threads conforming to the connector size in inches.

o Cable Recess. The cable recess on types I and II shall have no lips or stops and shall permit the insertion of the full diameter of the cable for the full length of the clamp or beyond if desired. The depth of the cable recess shall not be less than that listed in table 8-10.

o Installation. When the point of cable termination has been determined and the cable end prepared for termination, proceed with the connector and cable installation as follows:

STEP 1. Install the threaded male portion of the connector in the enclosure hole positioned so as to allow access to the clamp screws for tightening. Hold the clamp firmly in position with pliers and install the locknut (locking teeth toward the enclosure), tightening in place with a spanner wrench. The locknut should be tight enough to bite into the enclosure and hold the clamp securely in place with no possibility of wobble or rotation in the enclosure entry hole.

STEP 2. Insert the prepared cable end in the connector until the impervious jacket extends a minimum 1/8 inch through the throat of the connector. Tighten the clamp screw or screws until the cable is firmly held in position in the clamp. Figure 8-52 shows a typical grounded and ungrounded armor installation.

The cable is prepared for the ungrounded installation by a double wrap of synthetic rubber tape. The grounded installation can be made by direct contact of the clamping member and the cable armor. A better ground may be obtained by (the use of) a flattened length of cable armor wrapped around the cable at the termination point under the connector clamp.

(2) Flexible Metal Conduit Type. This type of box connector is available commercially from many different manufacturers and is of the same basic construction as the type I and II.

o Straight Type. The clamping section of this connector is larger in diameter than the throat diameter and the cable recess is longer than that of the type I or II. This allows the use of split sleeves or other methods of grounded armor termination within the clamping section. Table 8-11 lists the sizes and approximate dimensions of a typical straight type connector. Figure 8-53 shows typical installations.

o 90 Degree Angle Type. This connector may be used in locations where space is limited and not sufficient to maintain the minimum bend radius for the particular type cable in use. The top section of the cable recess and clamp is removable for ease in installation of the cable. Table 8-12 lists the sizes and approximate dimensions of a typical 90 degree angle type connector.

o 45 Degree Angle Type. This connector is available in a limited number of sizes and is used the same as (alone or in combination with) the 90 degree angle type. The top section of the cable recess and clamp is removable. Table 8-13 lists the sizes and approximate dimensions of a typical 45 degree angle type connector.

(3) MS3057 Type. In cases where an aluminum box connector is required for cable entry to an enclosure, the AN3064 box connector used in conjunction with the MS3057 cable clamp will provide entry for appropriate cable diameters.

e. Safety-Wiring Procedure. In certain installations where vibration is a problem (mobile vans, shipboard), it may be necessary to safety-wire connectors to prevent them from coming apart or shaking loose. The use of safety wiring requires drilled coupling rings and cross-drilled screw heads.

Table 8-1. Terminal Boards Fabricated to Military Specifications

MILITARY DESIGNATION FOR MATERIAL	MATERIAL	USE
CFG	Cellulose-Filled Phenolic Compound	High electrical and mechanical properties for general military requirements
CMG	Cellulose-Filled Melamine Compound	Good electrical and mechanical properties for use where superior arc resistance is required
MAI-60	Glass-Filled Alkyd Resin	Best electrical-properties and low-shrinkage requirement uses
MDG	Mineral-Filled Diallyl-Phthalate Compound	Good electrical-properties and low-shrinkage requirement uses
MFE	Mineral-Filled Phenolic Compound	Low loss and high dielectric strength for uses requiring very good electrical properties
MMF	Mineral-Filled Melamine Compound	For use where good dielectric properties and arc and flame resistance are required

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Table 8-2. Navy Terminal Board Information (Sheet 1 of 2)

CLASS	DESCRIPTION*	TYPE DESIGNATION	FEDERAL STOCK NO. H5940-	MAXIMUM VOLTAGE RATING	APPLICATION**	AMPERAGE RATING	MAX NO. OF WIRES PER TERMINAL	NUMBER OF STUDS
3TB	SR	3TB10	500-5381	600	C	45	4	10
4TB	DR	4TB8	500-5378	600	C	40	4	16
		4TB20	502-8470	600	C	40	4	20
5TB	SRTC	5TB8	502-8477	600	C	50	4	8
		5TB10	502-8474	600	C	50	4	10
		5TB12	502-8472	600	C	50	4	24
6TB	DR	6TB6	500-5373	600	B	30	4	6
		6TB10	500-7372	600	B	30	4	10
		6TB24	502-4523	600	B	30	4	24
7TB	SRTC	7TB8	502-8476	600	B	40	4	8
		7TB12	502-8473	600	B	40	4	12
8TB	DRL	8TB2	500-5388	300	B-(A)	30-(20)	2-(3)	4
		8TB6	500-5462	300	B-(A)	30-(20)	2-(3)	12
		8TB8	502-4522	300	B-(A)	30-(20)	2-(3)	16
		8TB10	500-5379	300	B-(A)	30-(20)	2-(3)	20
9TB	SR	9TB2	500-5389	300	B	35	4	2
		9TB4	500-5390	300	B	35	4	4
10TB	DR	10TB8	500-5384	600	B	30	4	8
		10TB12	502-8468	600	B	30	4	12
		10TB18	502-8469	600	B	30	4	18
		10TB28	502-8480	600	B	30	4	28
11TB	SRTC	11TB4	502-8479	600	B	40	4	4
		11TB6	502-8478	600	B	40	4	6
		11TB9	502-8475	600	B	40	4	9
		11TB14	502-8471	600	B	40	4	14
15TB	DR	15TB10	502-8466	600	B	30	4	10
		15TB24	502-8465	600	B	30	4	24

*Description

SR - Single-Row
DR - Double-Row
DRL - Double-Row Linked
SRTC - Single-Row Through-Connection

**Application

A - These terminal boards are intended for use in equipment where the affect of a short circuit is limited to the terminal board and where normal operation powers up to 50 watts are involved.

B - These terminal boards are intended for use where secondary short circuit protection in the form of fuses, circuit breakers, and other parts are provided in the circuit, and where normal operating power does not exceed 2000 watts per terminal.

C - These terminal boards are for power applications in excess of 2000 watts (per terminal), but they are still protected by secondary devices in the circuit which can safely interrupt resultant short-circuit currents.

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Table 8-2. Navy Terminal Board Information (Sheet 2 of 2)

CLASS	DESCRIPTION*	TYPE DESIGNATION	FEDERAL STOCK NO. H5940-	MAXIMUM VOLTAGE RATING	APPLICATION**	AMPERAGE RATING	MAX NO. OF WIRES PER TERMINAL	NUMBER OF STUDS
16TB	DR	16TB4	500-5392	1000	C	40	4	8
		16TB10	502-8467	1000	C	40	4	20
17TB	DRL	17TB4	538-4089	600	C-(B)	40-(30)	3-(4)	8
		17TB10		600	C-(B)	40-(30)	3-(4)	20
25TB	SR	25TB2		300	A	25	3	
		25TB5		300	A	25	3	
		25TB6		300	A	25	3	
		25TB7		300	A	25	3	
		25TB9		300	A	25	3	
		25TB10		300	A	25	3	
		25TB12		300	A	25	3	
26TB	DRL	26TB2		300	A	20	2-(3)	
		26TB6		300	A	20	2-(3)	
		26TB8		300	A	20	2-(3)	
		26TB10		300	A	20	2-(3)	
		26TB12		300	A	20	2-(3)	
27TB	SRTC	27TB12		300	A	30	3	

*Description

SR - Single-Row
DR - Double-Row
DRL - Double-Row Linked
SRTC - Single-Row Through-Connection

**Application

A - These terminal boards are intended for use in equipment where the affect of a short circuit is limited to the terminal board and where normal operation powers up to 50 watts are involved.

B - These terminal boards are intended for use where secondary short circuit protection in the form of fuses, circuit breakers, and other parts are provided in the circuit, and where normal operating power does not exceed 2000 watts per terminal.

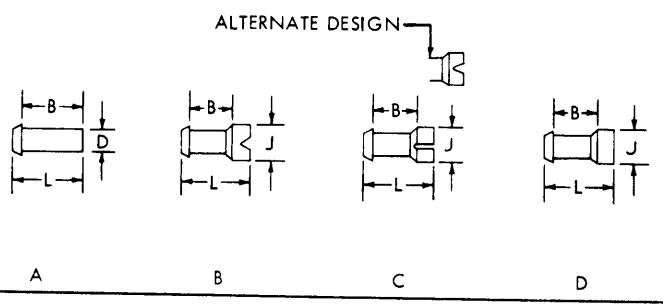
C - These terminal boards are for power applications in excess of 2000 watts (per terminal), but they are still protected by secondary devices in the circuit which can safely interrupt resultant short-circuit currents.

AIAG720

Table 8-3. Modulok and Crablok Contact Tips

WIRE SIZE AN, AWG, NAVY	INSULATION ACCOM MAX	INSULATION ACCOM MIN	BURNDY CONTACT TIP CATALOG NUMBER		DIMENSIONS (Inches) B	D	J	L	COLOR CODE	INSTALLATION TOOLING HYTOOL	M8ND & Y8ND DIE SET	Y10NCP Y10Q-1 Y10R DIE SET	YD-2 DIE SET	CARRY STRIP COLOR CODE
AN22-18	.115	.080	AYH18-H	B	.28	.16	.20	.50	Gold	Y18MRC	N18HCT	R8CT-1	-	-
22-18	.085	.045	AYH18-H2	B	.28	.16	.22	.50	Black	Y18MRC	N18HCT	R8CT-1	-	-
N1-N2	.085	.045	M-AYH18-H2	B	.28	.16	.22	.50	Black	-	-	-	YDD-11	Yellow
AN20-14	.250	-	AYH14	A	.41	.16	-	.47	Tin	Y14MRC	N14HCT	R8CT-1	-	-
20-14	.150	.077	AYH14-H	B	.26	.16	.24	.47	Tin	Y14MRC	N14HCT	R8CT-1	-	-
	.115	.070	AYH14-H1	C	.28	.16	.22	.50	Blue	Y14MRC	N14HCT	R8CT-1	-	-
N2-1/2-4	.115	.170	M-AYM14-H1	C	.28	.16	.22	.50	Blue	-	-	-	YDD-10	Brown
	.250	-	AYH12-14	A	.41	.16	-	.47	Tin	Y14MRC	N14HCT	R8CT-1	-	-
	.170	.093	AYH12-14H	B	.25	.16	.24	.47	Green	Y14MRC	N14HCT	R8CT-1	-	-
AN18-12	.142	.098	AYH12-14H1	C	.28	.16	.22	.50	Orange	Y14MRC	N14HCT	R8CT-1	-	-
	.142	.098	M-AYH12-14H	C	.28	.16	.22	.50	Orange	-	-	-	YDD-10	Brown
AN12	.187	.150	AYH12-H	D	.28	.16	.23	.50	Tin	-	N12HCT-1	-	-	-
	.187	.150	M-AYH12-H	D	.28	.16	.23	.50	Tin	-	-	-	YDD-12	Green
AN12-10 12-10 N6-N9	.312	-	AYH10	A	.36	.26	-	.42	Tin	Y8MC	*N8CT-2	R8CT-1	-	-
AN8 N23	.312	-	AYH8C	A	.44	.26	-	.50	Tin	Y8MC	*N8CT-2	R8CT-1	-	-

* Use N M8ND only



AIAG721

Table 8-4. Color Coding

Pair number	Color	Pair number	Color
1	Blue and white (or natural)	30	Slate-white (stripe) and white (or natural)
2	Orange and white (or natural)	31	Blue-white (stripe) and red
3	Green and white (or natural)	32	Orange-white (stripe) and red
4	Brown and white (or natural)	33	Green-white (stripe) and red
5	Slate and white (or natural)	34	Brown-white (stripe) and red
6	Blue and red	35	Slate-white (stripe) and red
7	Orange and red	36	Blue-white (stripe) and black
8	Green and red	37	Orange-white (stripe) and black
9	Brown and red	38	Green-white (stripe) and black
10	Slate and red	39	Brown-white (stripe) and black
11	Blue and black	40	Slate-white (stripe) and black
12	Orange and black	41	Blue-white (stripe) and yellow
13	Green and black	42	Orange-white (stripe) and yellow
14	Brown and black	43	Green-white (stripe) and yellow
15	Slate and black	44	Brown-white (stripe) and yellow
16	Blue and yellow	45	Slate-white (stripe) and yellow
17	Orange and yellow	46[1/]	Blue-white (stripe) and violet
18	Green and yellow	47	Orange-white (stripe) and violet
19	Brown and yellow	48	Green-white (stripe) and violet
20	Slate and yellow	49	Brown-white (stripe) and violet
21	Blue and violet	50	Slate-white (stripe) and violet
22	Orange and violet	51	Red and white (or natural)
23	Green and violet	52	Red-white (stripe) and white (or natural)
24	Brown and violet	Spare (For[1/] 52 or 104 pair)	Red and black
25	Slate and violet		
26	Blue-white (stripe) and white (or natural)		
27	Orange-white (stripe) and white (or natural)		
28	Green-white (stripe) and white (or natural)		
29	Brown-white (stripe) and white (or natural)		

1/ At the manufacturer's option, pair number (46) and the "Spare" pair may be used to assure the required number of (non-defective) pairs.

AIAG717

Table 8-5. Allowable Clipped Strands

NUMBER OF STRANDS IN CONDUCTOR	ALLOWABLE CLIPPED STRANDS
0-6	0
7-15	1
16-18	2
19-25	3
26-36	4
37-40	5
41 or more	6

AIAG785

Table 8-6. Insulating-Sleeve Dimension (Inches)

AWG SIZE	NOM. O.D.	NOM. I.D.
32	0.028	0.011
30	0.030	0.012
28	0.033	0.015
26	0.038	0.018
24	0.042	0.022
22	0.047	0.027
20	0.058	0.034
19	0.062	0.038
18	0.066	0.042
17	0.071	0.047
16	0.077	0.053
15	0.083	0.059
14	0.090	0.066
13	0.100	0.076
12	0.109	0.085
11	0.119	0.095
10	0.130	0.106
9	0.148	0.118
8	0.163	0.133
7	0.178	0.148
6	0.196	0.166
5	0.216	0.186
4	0.238	0.208
3	0.264	0.234
2	0.293	0.263
1	0.324	0.294
0	0.360	0.330
3/8	0.430	0.390
7/16	0.493	0.453
1/2	0.565	0.515
9/16	0.633	0.583
5/8	0.700	0.640
3/4	0.825	0.765
7/8	0.950	0.895
1	1.085	1.025
1-1/8	1.210	1.150
1-1/4	1.335	1.275

AIAG722

Table 8-7. MS Connector Accessories

TYPE OF CLAMP	SIZE OF CONNECTOR	BUSHING REQUIRED
MS3057-3A	8S, 10S	MS3420-3
MS3057-4A	10SL, 12S, 12	MS3420-4
MS3057-6A	14S, 14	MS3420-6
MS3057-8A	16A, 16	MS3420-8
MS3057-10A	18	MS3420-10
MS3057-12A	20, 22	MS3420-12
MS3057-16A	24, 28	MS3420-16 and -12
MS3057-20A	32	MS3420-20 and -16
MS3057-24A	36	MS3420-24 and -20
MS3057-28A	40	MS3420-28, -24, and -20
MS3057-32A	44	MS3420-32, -28, and -24
MS3057-40A	48	MS3420-40, -32, and -28

AIAG723

Table 8-8. MS Connector Identification

DESIGNATION	DESCRIPTION
AN	Indicates approval for use by Army and Navy. Used only as replacement in oider equipment.
MS	Indicates approval for military use under Military Specification MIL-C-5015.
	TYPE OF SHELL
3100	Wall or bulkhead receptacle for use with conduit to eliminate installation of a conduit box.
3101	Cable receptacle without mounting provisions for use with conduit and cable.
3102	Box receptacle for use with open wiring.
3106	Straight plug without mounting provisions for use on cables.
3107	Quick-disconnect plug for use where fast connect and disconnect are required.
3108	Angle plug for use with cables where a 90-degree take-off is required.
	CONSTRUCTION OF SHELL
A	Solid one-piece shell
B	Split two-piece shell
C	Pressurized
E	Environment resistance
K	Fireproof
R	Environment resistant (lightweight)
	SIZE
	See figure 4-38 for Amphenol connectors, figure 4-39 for Cannon connectors, and figure 4-40 for Bendix connectors. For other types, refer to applicable catalog.
	TYPE OF INSERT
	See figure 4-41. For special types, refer to applicable catalog.
	STYLE OF CONTACT
P	Pin contact
S	Socket contact

AIAG724

Table 8-9. Type I and II Connector Sizes

NAVY SIZE	TRADE AND K.O. SIZE	THROAT DIAMETER	CABLE RANGE	
			MINIMUM	MAXIMUM
A-C	3/8	0.625	0.250	0.625
CD	3/4	0.750	0.438	0.750
D-J	1	1.063	0.563	1.063

AIAG725

Table 8-11. Straight Type Connectors

TRADE SIZE	K.O. SIZE	THROAT DIAMETER	CLAMP DIAMETER	
			OPEN	CLOSED
3/8A	1/2	0.550	0.805	0.550
1/2	1/2	0.640	0.990	0.725
3/4S	3/4	0.660	0.875	0.750
3/4	3/4	0.790	1.140	0.840
1S	1	0.935	1.220	0.970
1	1	1.000	1.385	1.105
1-1/4	1-1/4	1.250	1.610	1.310
1-1/2	1-1/2	1.500	1.955	1.585
2	2	2.000	2.445	2.140
2-1/2	2-1/2	2.500	3.020	2.685
3	3	3.135	3.510	3.060

Note: The clamp diameter dimensions listed above will vary in connectors from different manufacturers.

AIAG727

Table 8-10. Cable Recess Depth

CONNECTOR SIZE		DEPTH OF RECESS (INCHES)
A-C	3/8	13/16
CD	3/4	1
D-J	1	1

AIAG726

Table 8-12. 90 Degree Angle Connector

TRADE SIZE	K.O. SIZE	THROAT DIAMETER	CLAMP DIAMETER	
			OPEN	CLOSED
1/2S	1/2	0.595	0.800	0.695
1/2	1/2	0.595	0.930	0.780
3/4	3/4	0.765	1.060	0.885
1	1	1.000	1.460	1.305
1-1/4	1-1/4	1.250	1.630	1.385
1-1/2	1-1/2	1.500	2.000	1.780
2	2	2.000	2.490	2.250

AIAG728

Table 8-13. 45 Degree Angle Connector

TRADE SIZE	K.O. SIZE	THROAT DIAMETER	CLAMP DIAMETER	
			OPEN	CLOSED
3/8	1/2	0.595	0.600	0.465
1/2	1/2	0.625	0.940	0.795
3/4	3/4	0.775	1.065	0.815

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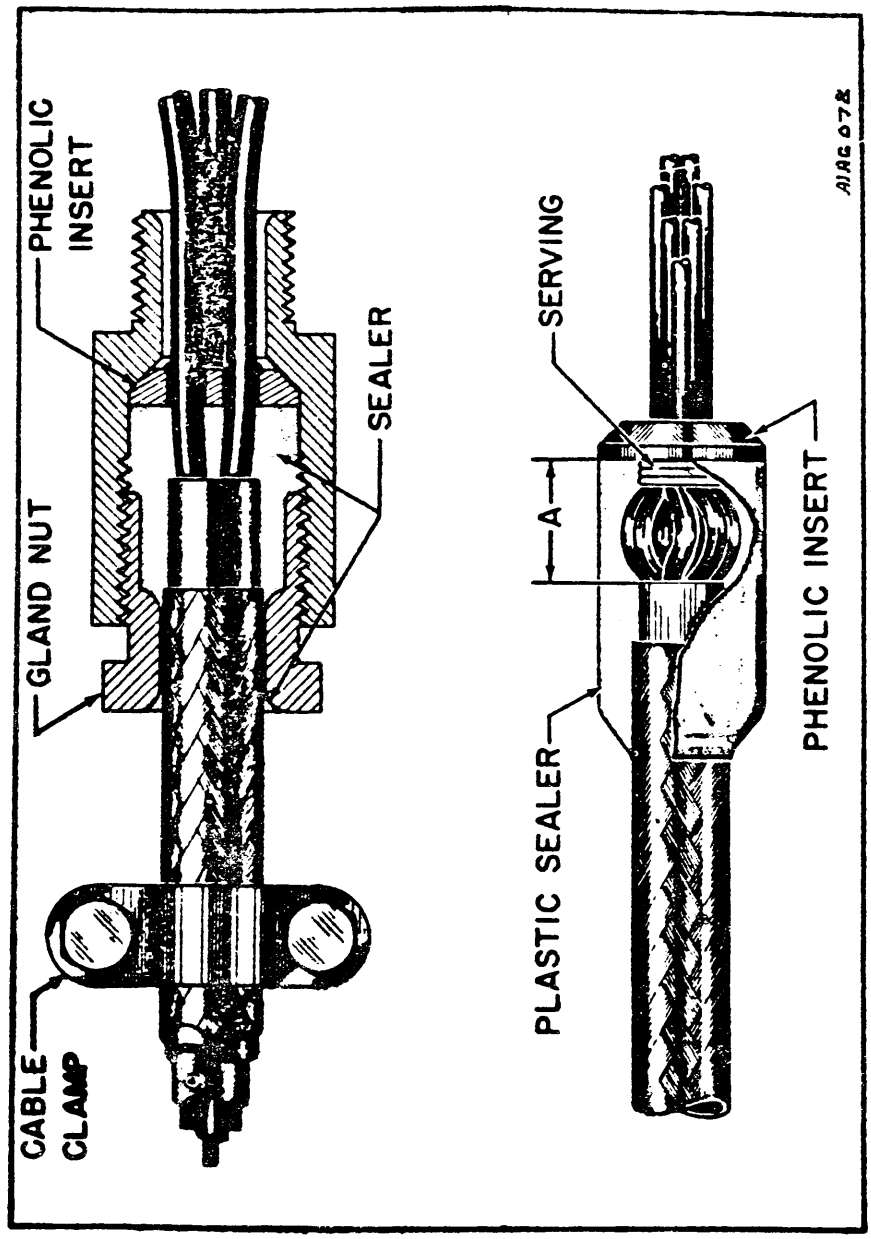
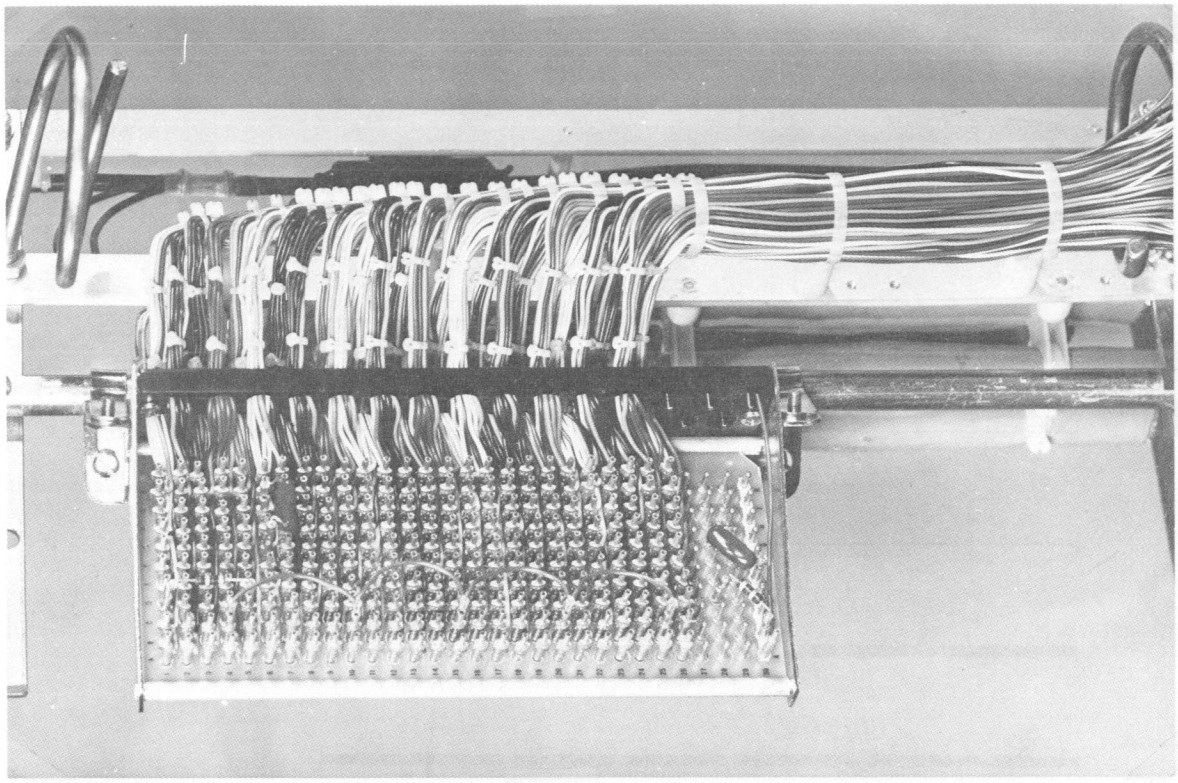
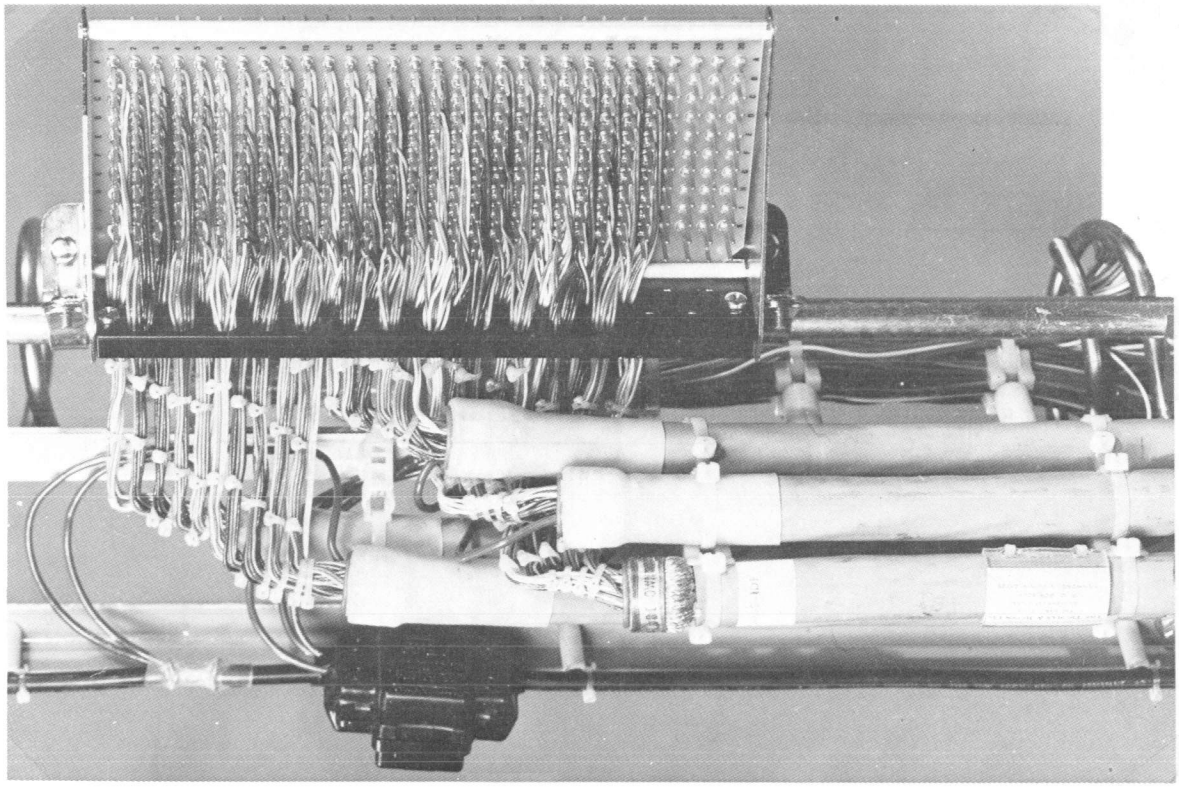


Figure 8-1. Typical End Seal Arrangements



CROSS-CONNECT SIDE



CABLE TERMINATION SIDE

Figure 8-2. Wire Wrap to Push-On Terminal Block

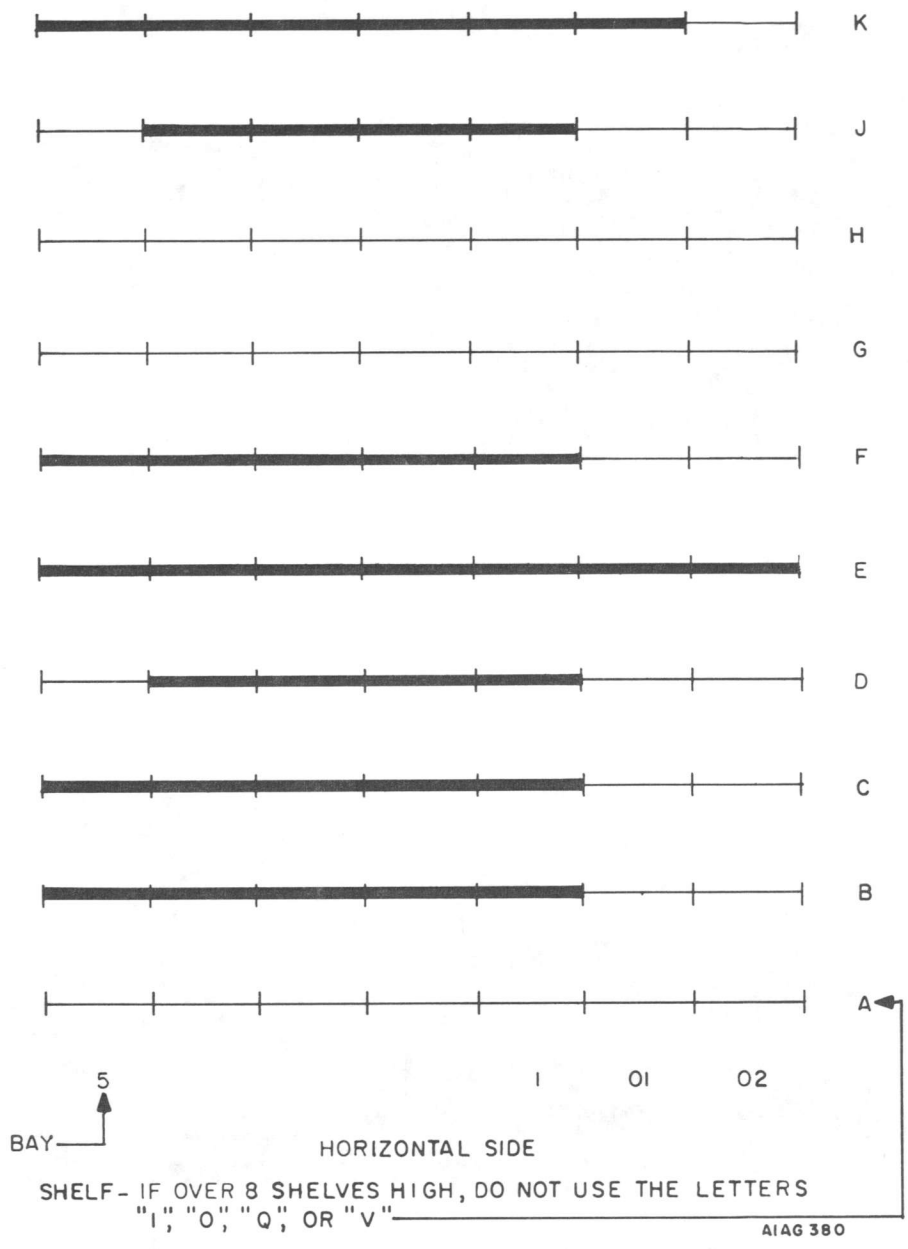


Figure 8-3. Method of Designating Terminal Blocks for Additions to Existing Job Drawings (HCDF)

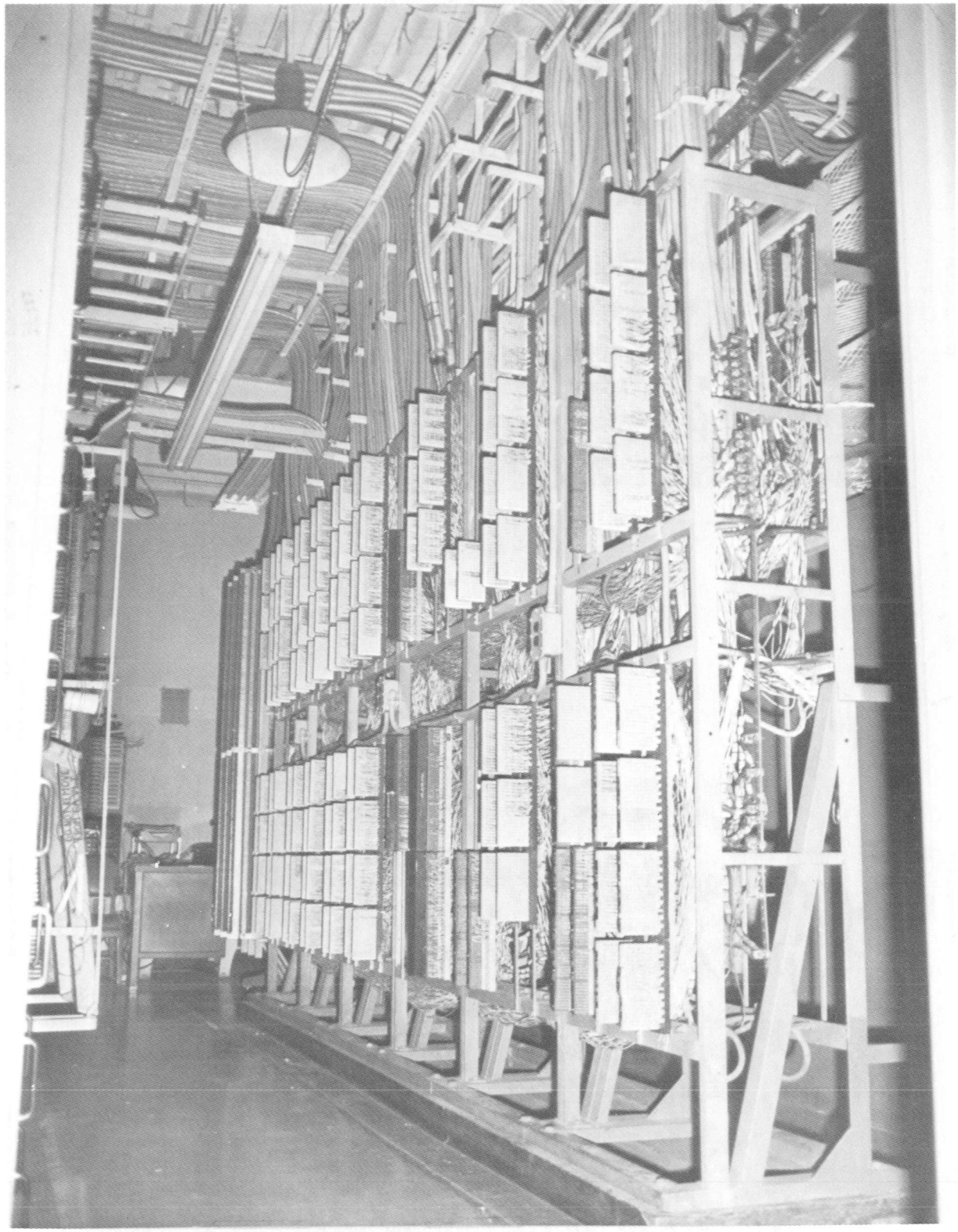


Figure 8-4. Typical Large Communications Facility Main Distribution Frame

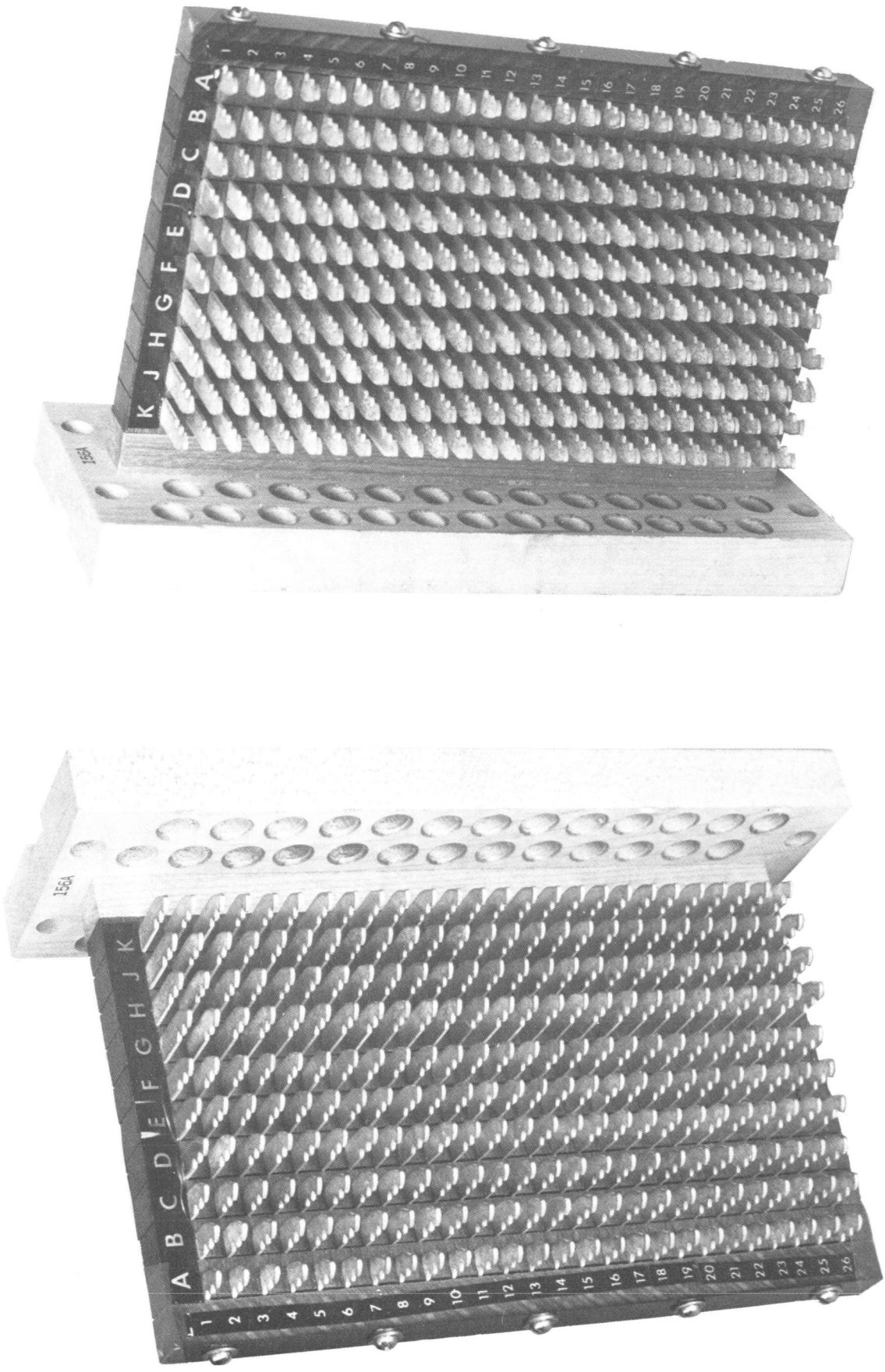


Figure 8-5. Intermediate Distribution Frame Terminal Blocks (Typical 10 x 26 Block)

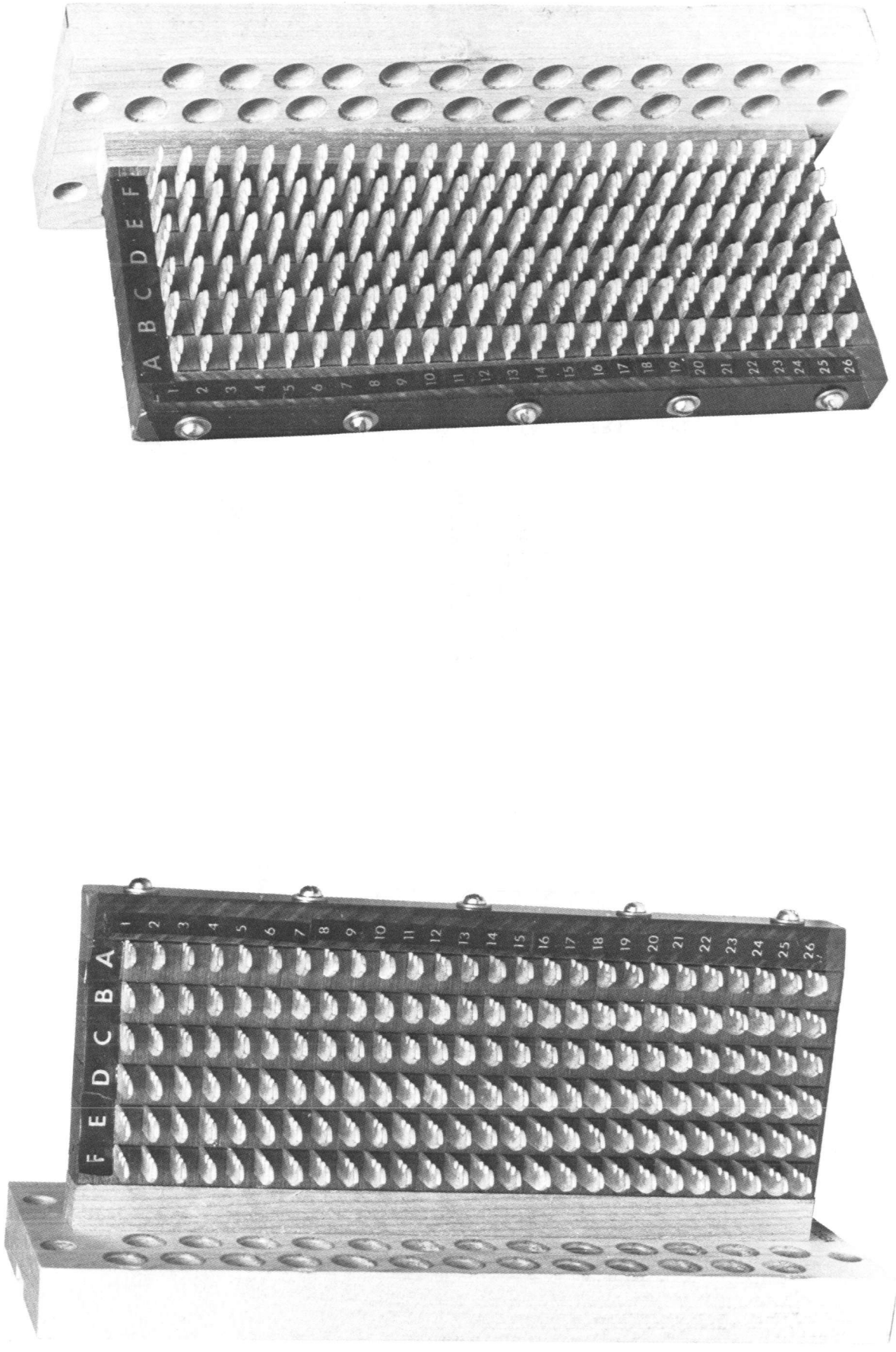


Figure 8-6. Intermediate Distribution Frame Terminal Blocks (Typical 6 x 26 Block)

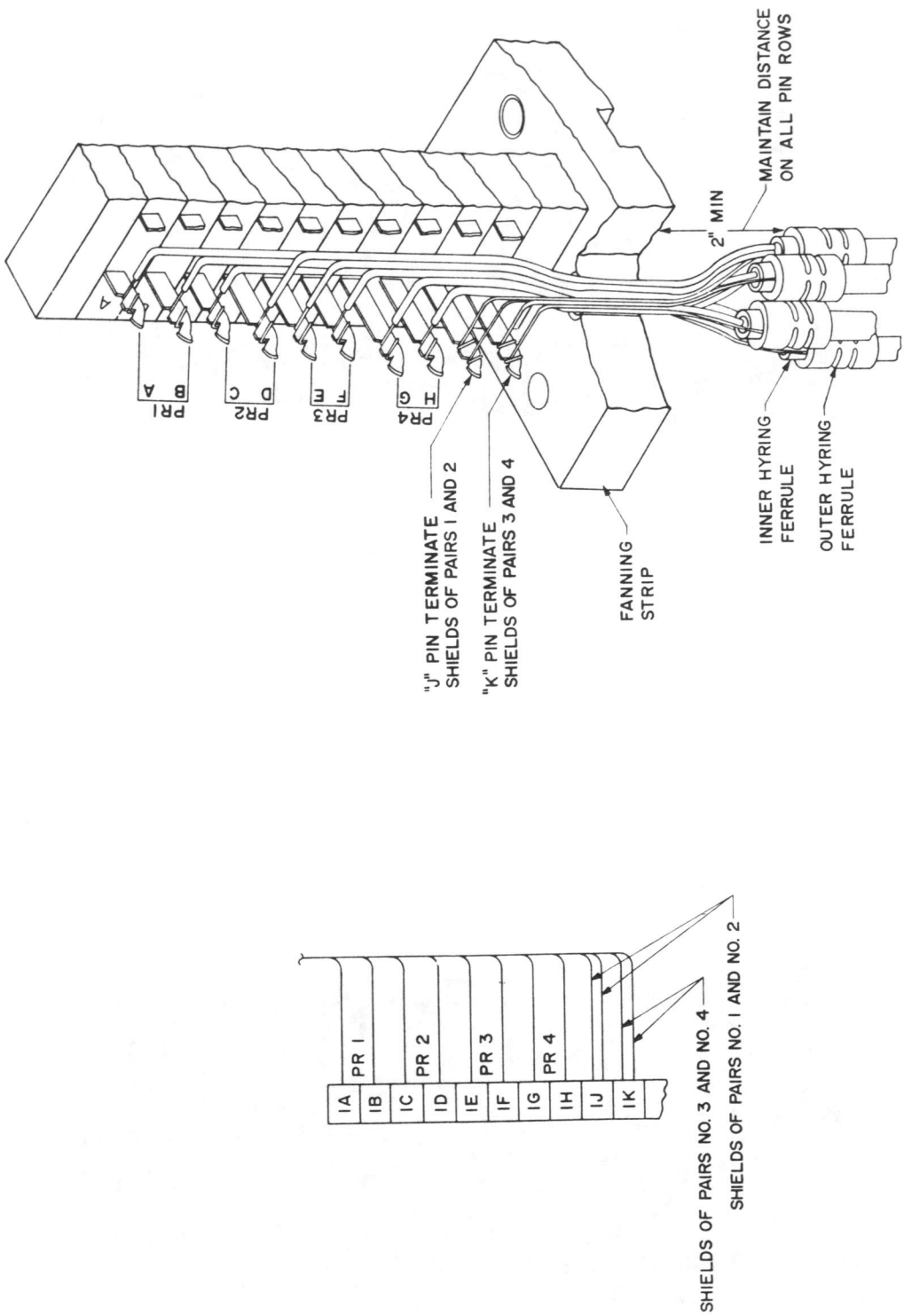


Figure 8-7. Intermediate Distribution Frame Terminal Blocks (10 x 26)

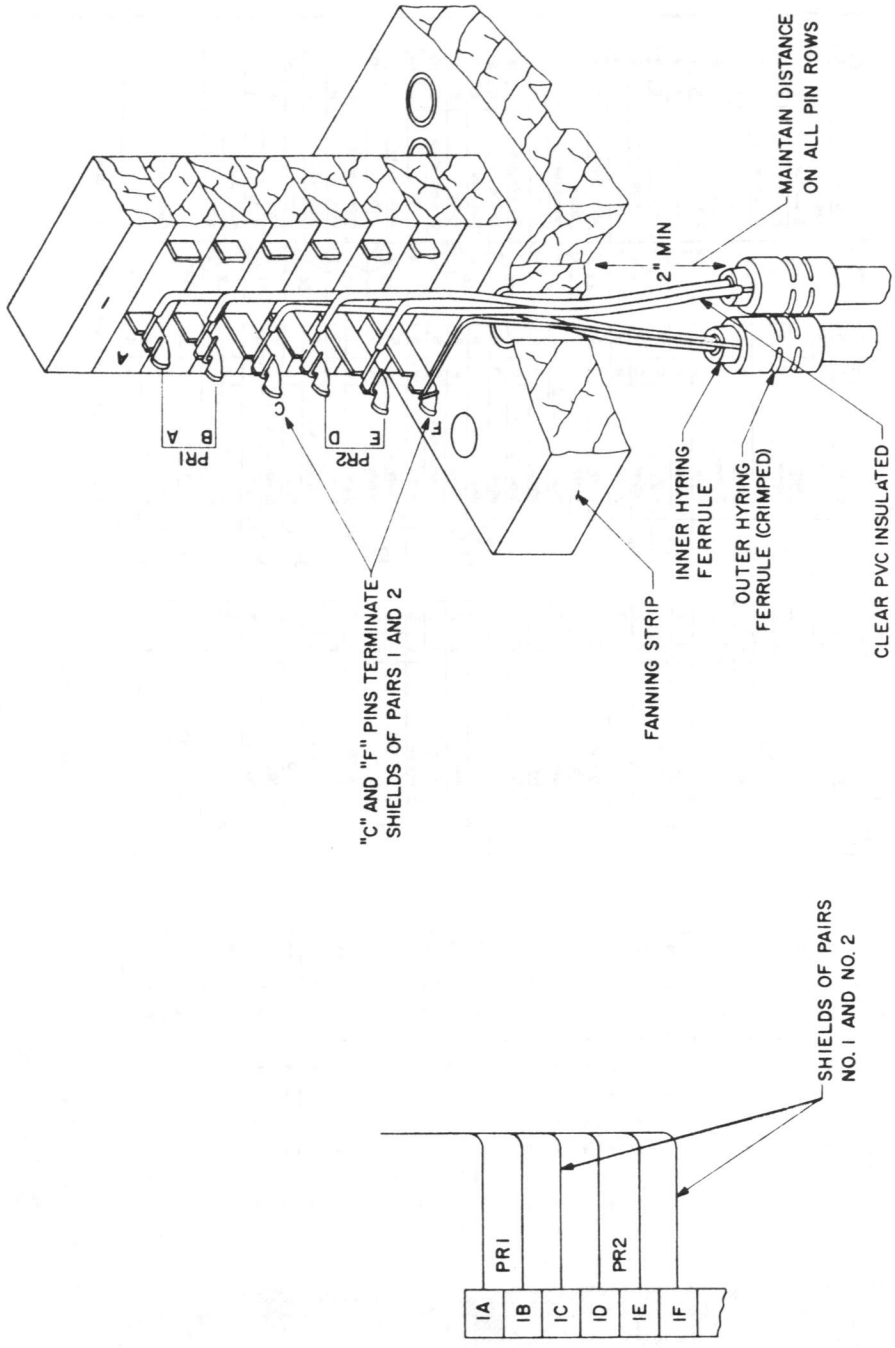
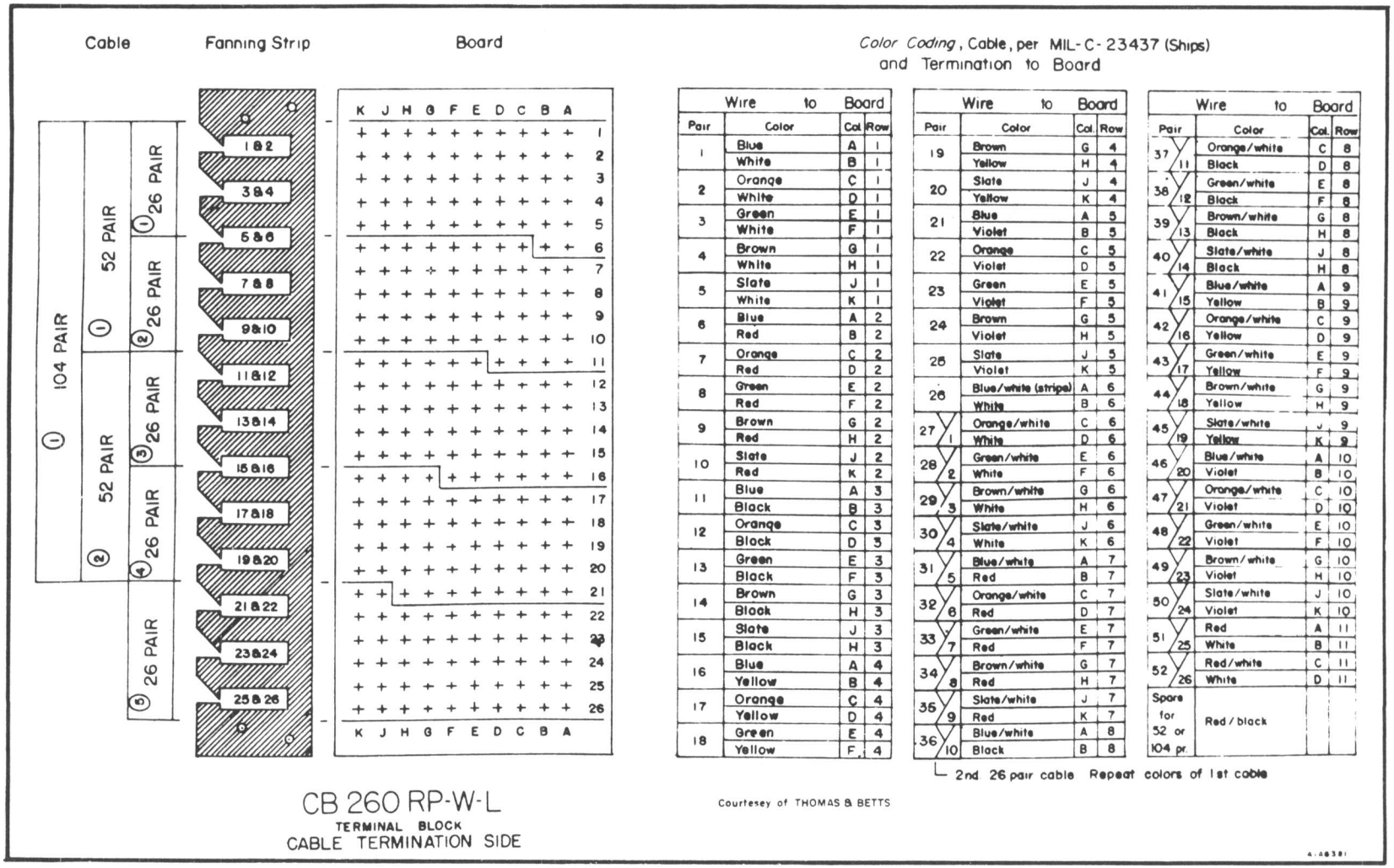


Figure 8-8. Intermediate Distribution Frame Terminal Blocks (6 x 26)



Color Coding, Cable, per MIL-C-23437 (Ships) and Termination to Board

Pair	Color	Wire to Board Col.	Row
1	Blue	A	1
	White	B	1
2	Orange	C	1
	White	D	1
3	Green	E	1
	White	F	1
4	Brown	G	1
	White	H	1
5	Slate	J	1
	White	K	1
6	Blue	A	2
	Red	B	2
7	Orange	C	2
	Red	D	2
8	Green	E	2
	Red	F	2
9	Brown	G	2
	Red	H	2
10	Slate	J	2
	Red	K	2
11	Blue	A	3
	Black	B	3
12	Orange	C	3
	Black	D	3
13	Green	E	3
	Black	F	3
14	Brown	G	3
	Black	H	3
15	Slate	J	3
	Black	H	3
16	Blue	A	4
	Yellow	B	4
17	Orange	C	4
	Yellow	D	4
18	Green	E	4
	Yellow	F	4

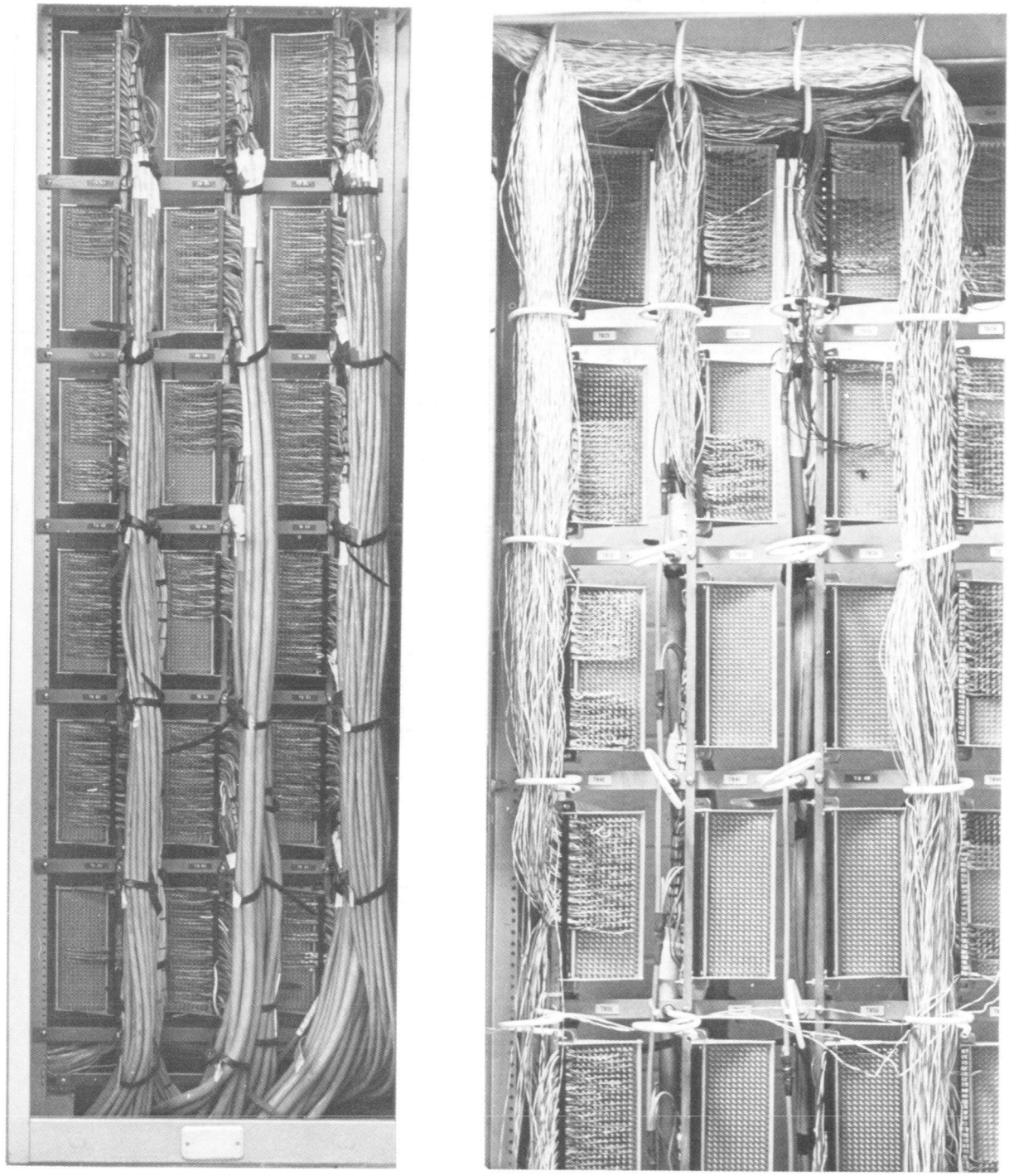
Pair	Color	Wire to Board Col.	Row
19	Brown	G	4
	Yellow	H	4
20	Slate	J	4
	Yellow	K	4
21	Blue	A	5
	Violet	B	5
22	Orange	C	5
	Violet	D	5
23	Green	E	5
	Violet	F	5
24	Brown	G	5
	Violet	H	5
25	Slate	J	5
	Violet	K	5
26	Blue/white (stripe)	A	6
	White	B	6
27 / 1	Orange/white	C	6
	White	D	6
28 / 2	Green/white	E	6
	White	F	6
29 / 3	Brown/white	G	6
	White	H	6
30 / 4	Slate/white	J	6
	White	K	6
31 / 5	Blue/white	A	7
	Red	B	7
32 / 6	Orange/white	C	7
	Red	D	7
33 / 7	Green/white	E	7
	Red	F	7
34 / 8	Brown/white	G	7
	Red	H	7
35 / 9	Slate/white	J	7
	Red	K	7
36 / 10	Blue/white	A	8
	Black	B	8

Pair	Color	Wire to Board Col.	Row
37 / 11	Orange/white	C	8
	Black	D	8
38 / 12	Green/white	E	8
	Black	F	8
39 / 13	Brown/white	G	8
	Black	H	8
40 / 14	Slate/white	J	8
	Black	H	8
41 / 15	Blue/white	A	9
	Yellow	B	9
42 / 16	Orange/white	C	9
	Yellow	D	9
43 / 17	Green/white	E	9
	Yellow	F	9
44 / 18	Brown/white	G	9
	Yellow	H	9
45 / 19	Slate/white	J	9
	Yellow	K	9
46 / 20	Blue/white	A	10
	Violet	B	10
47 / 21	Orange/white	C	10
	Violet	D	10
48 / 22	Green/white	E	10
	Violet	F	10
49 / 23	Brown/white	G	10
	Violet	H	10
50 / 24	Slate/white	J	10
	Violet	K	10
51 / 25	Red	A	11
	White	B	11
52 / 26	Red/white	C	11
	White	D	11
Spare for 52 or 104 pr	Red / black		

└ 2nd 26 pair cable Repeat colors of 1st cable

Courtesey of THOMAS & BETTS

Figure 8-9. Cable Termination Practice



CABLE TERMINATION SIDE

CROSS-CONNECT SIDE

Figure 8-10. Typical Intermediate Distribution Frames

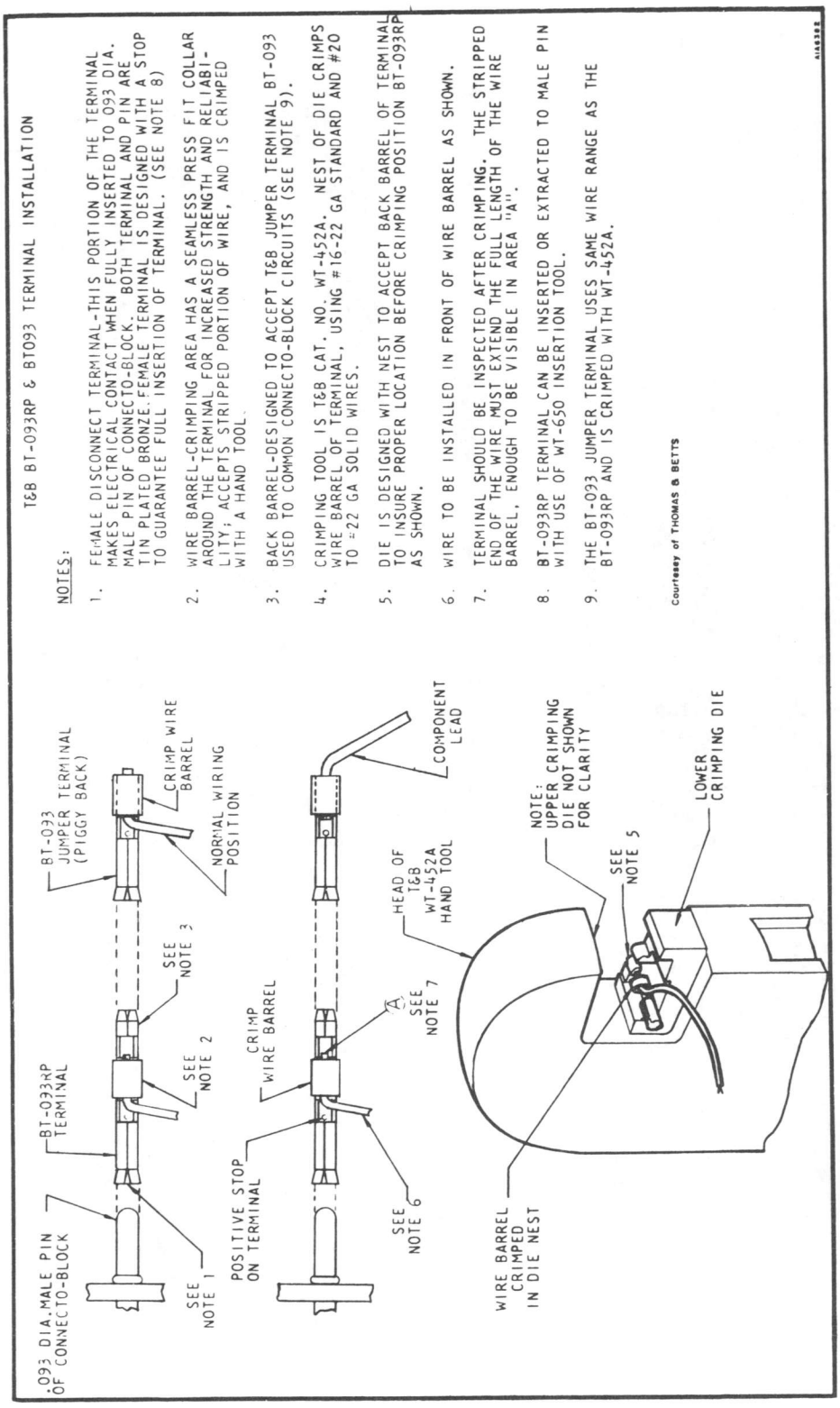


Figure 8-11. Typical Push-On Terminal

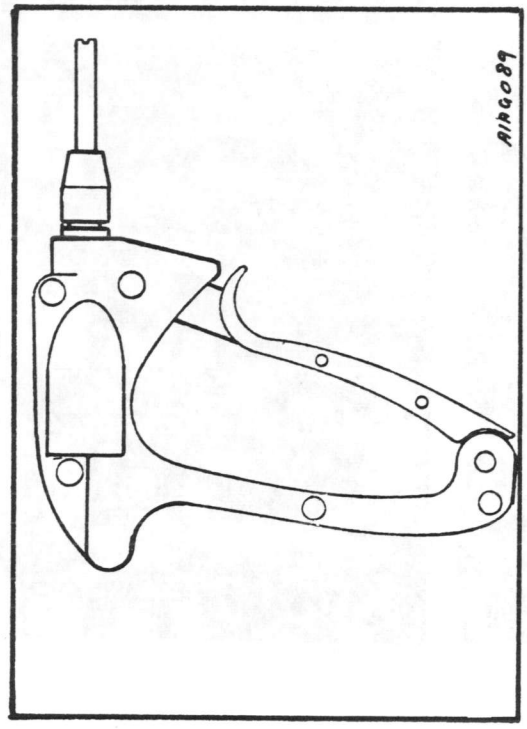


Figure 8-13. Hand Operated Wire Wrap Tool

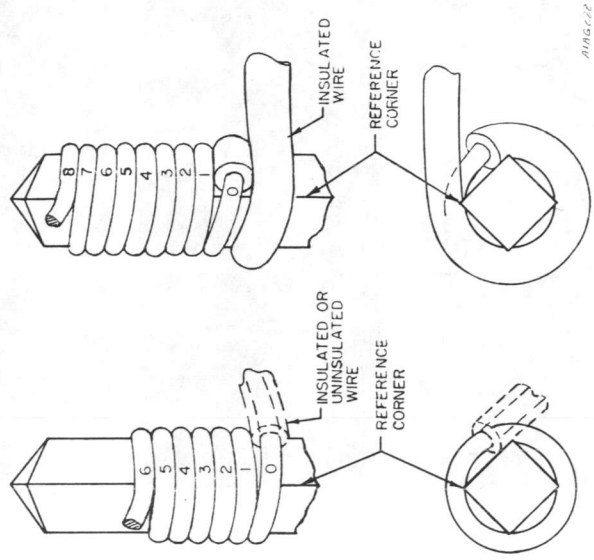
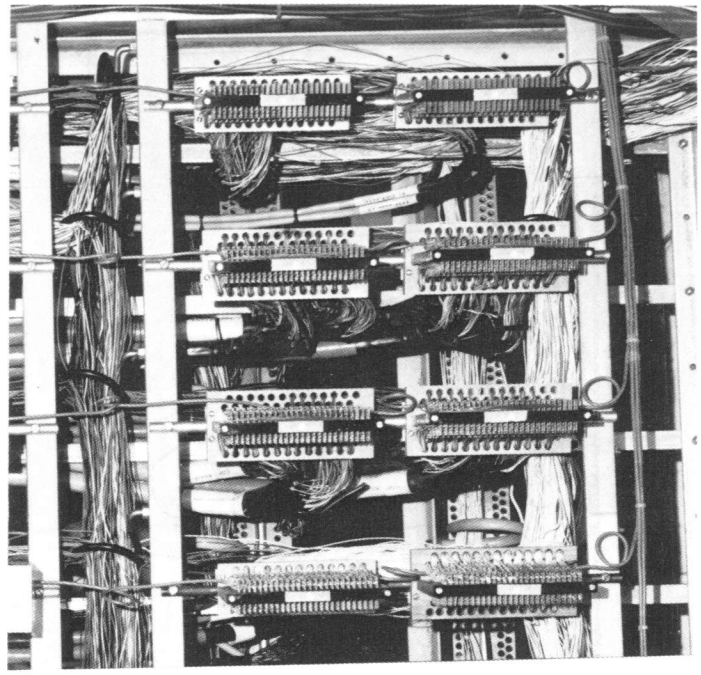


Figure 8-12. Specified Wire Wraps



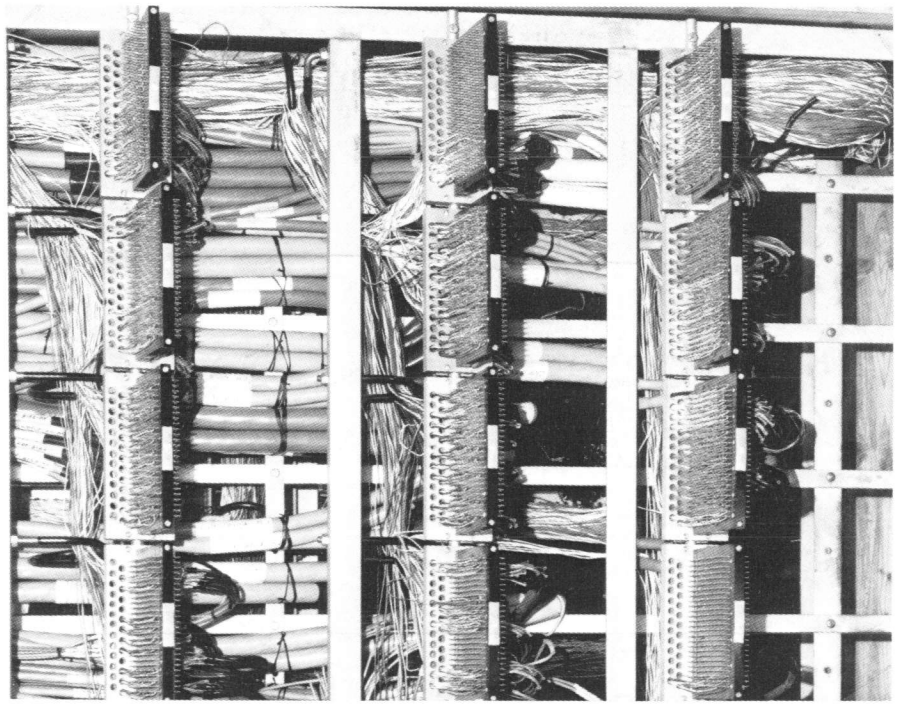


Figure 8-14. Distribution Frame Cross-Connects

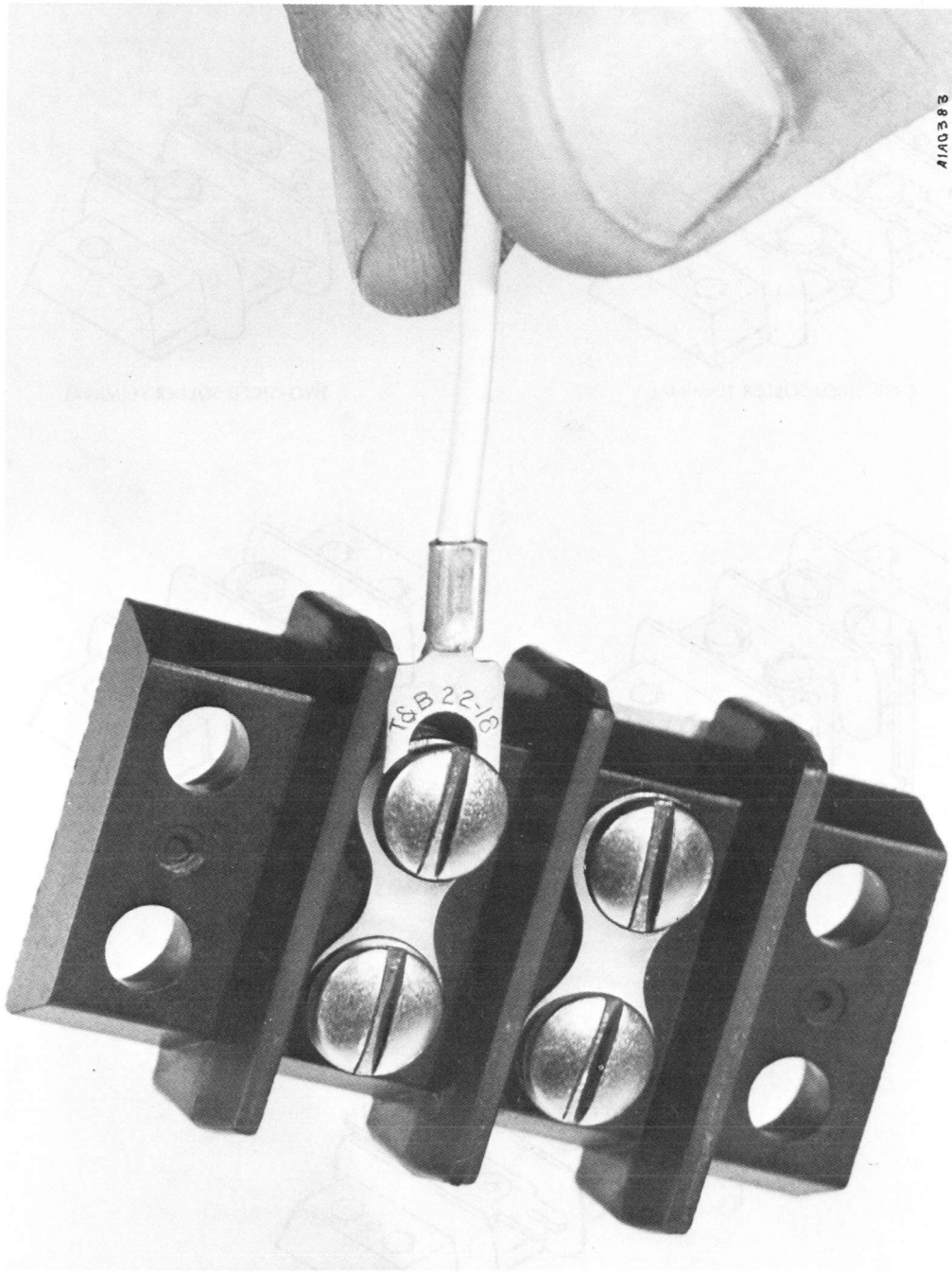


Figure 8-15. Typical Terminal Board

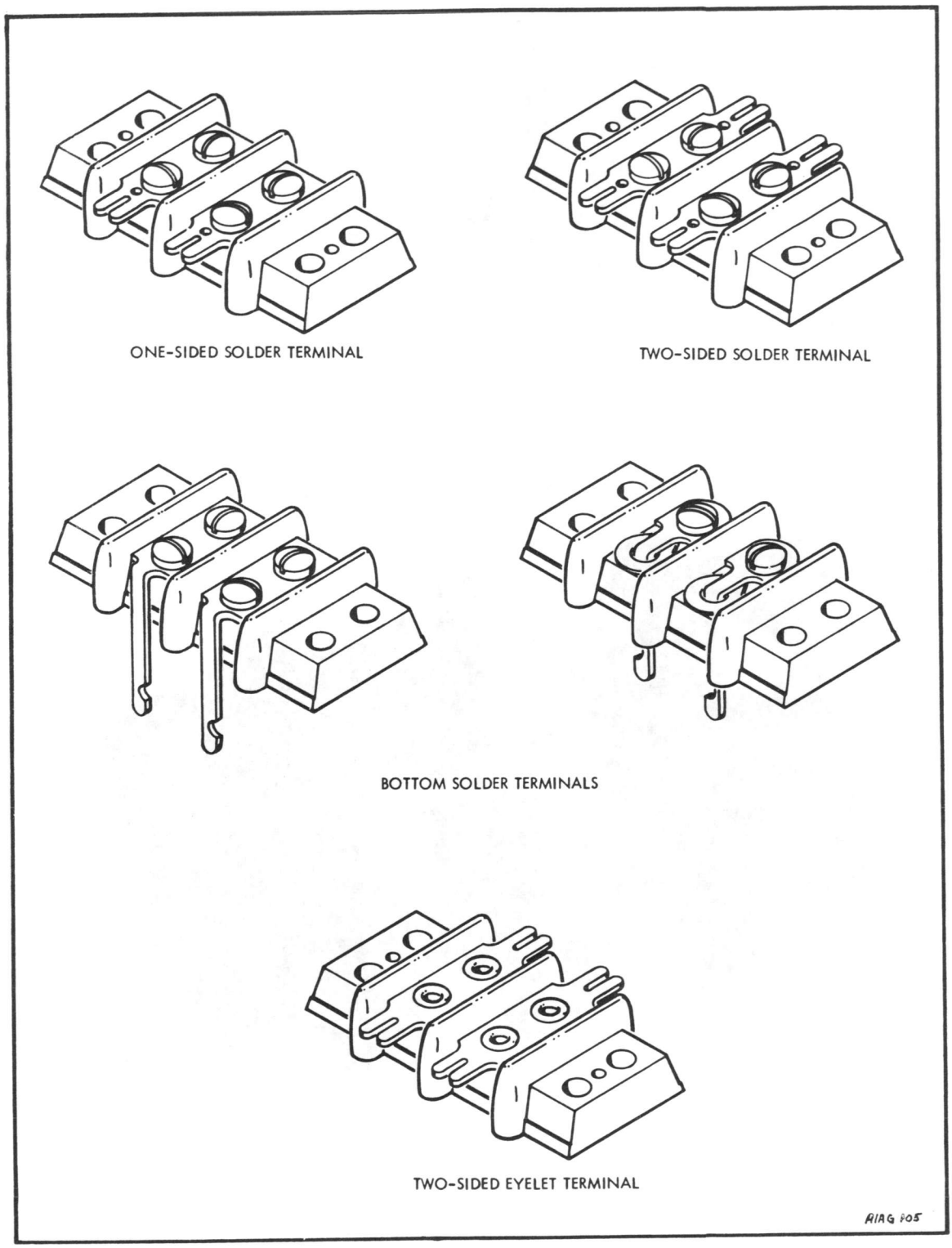


Figure 8-16. Barrier Terminal Boards, Typical

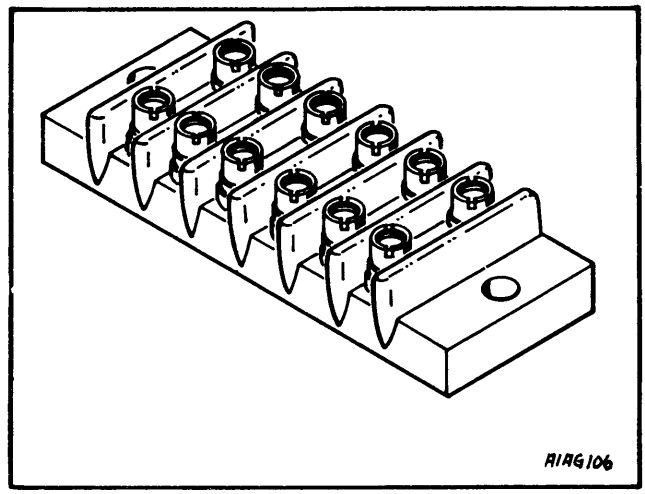


Figure 8-17. Navy Specification Terminal Board

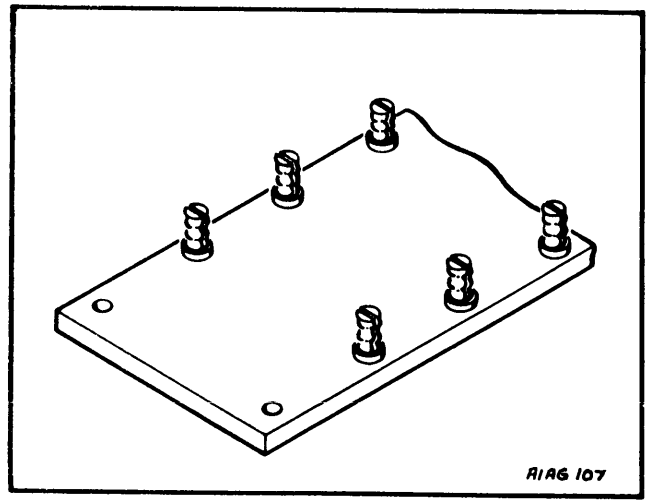


Figure 8-18. Slotted-Terminal Board

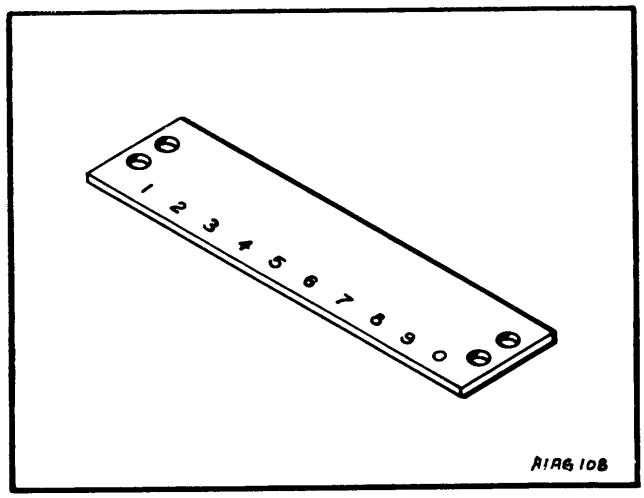


Figure 8-19. Marker Strip

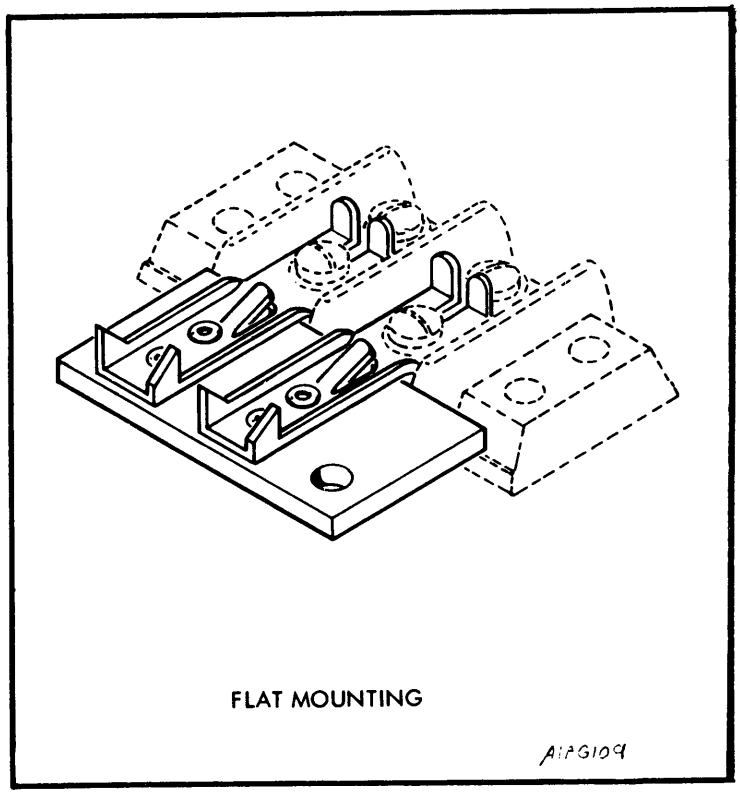


Figure 8-20. Fanning Strips

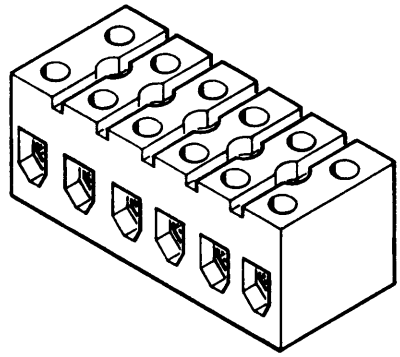


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Figure 8-21. Pressure-Type Terminal Board

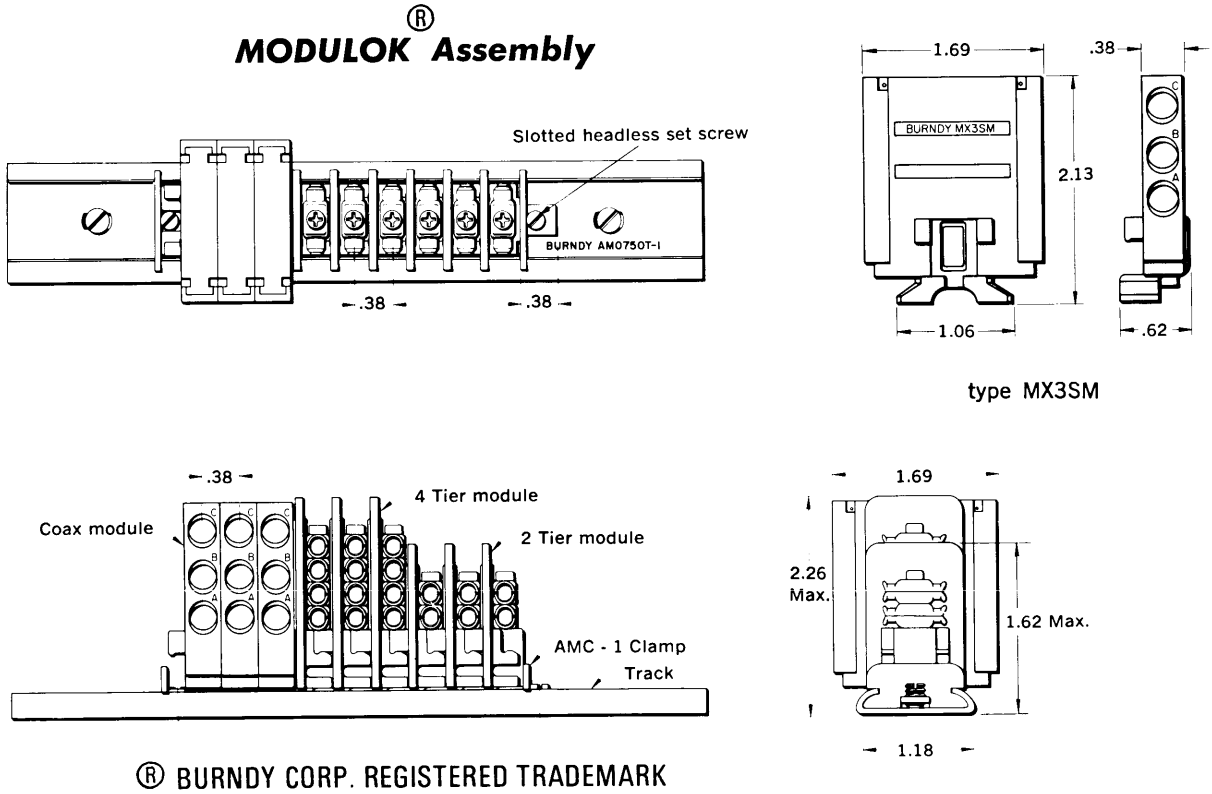


Figure 8-22. Modulok Board

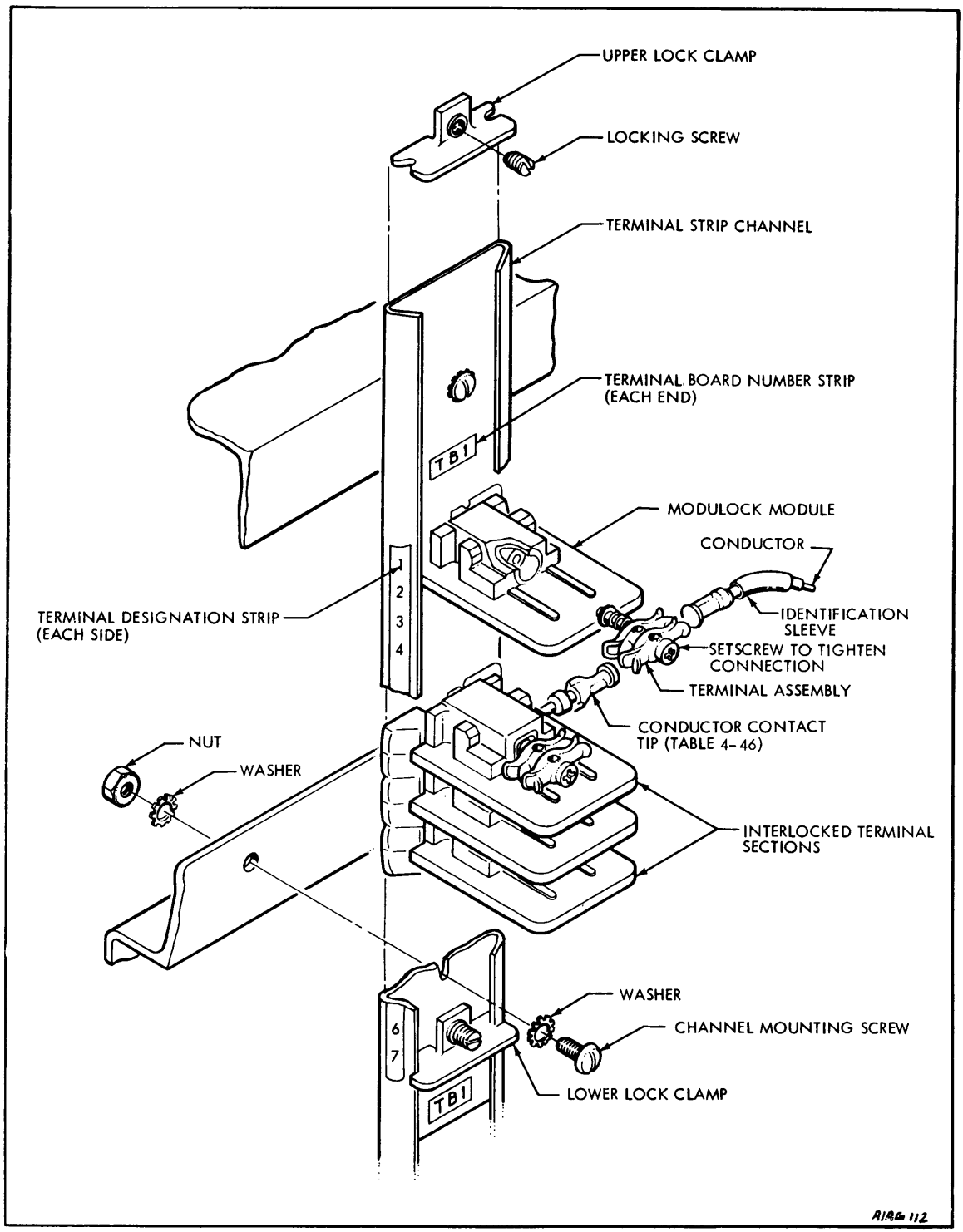


Figure 8-23. Typical Modulok Installation

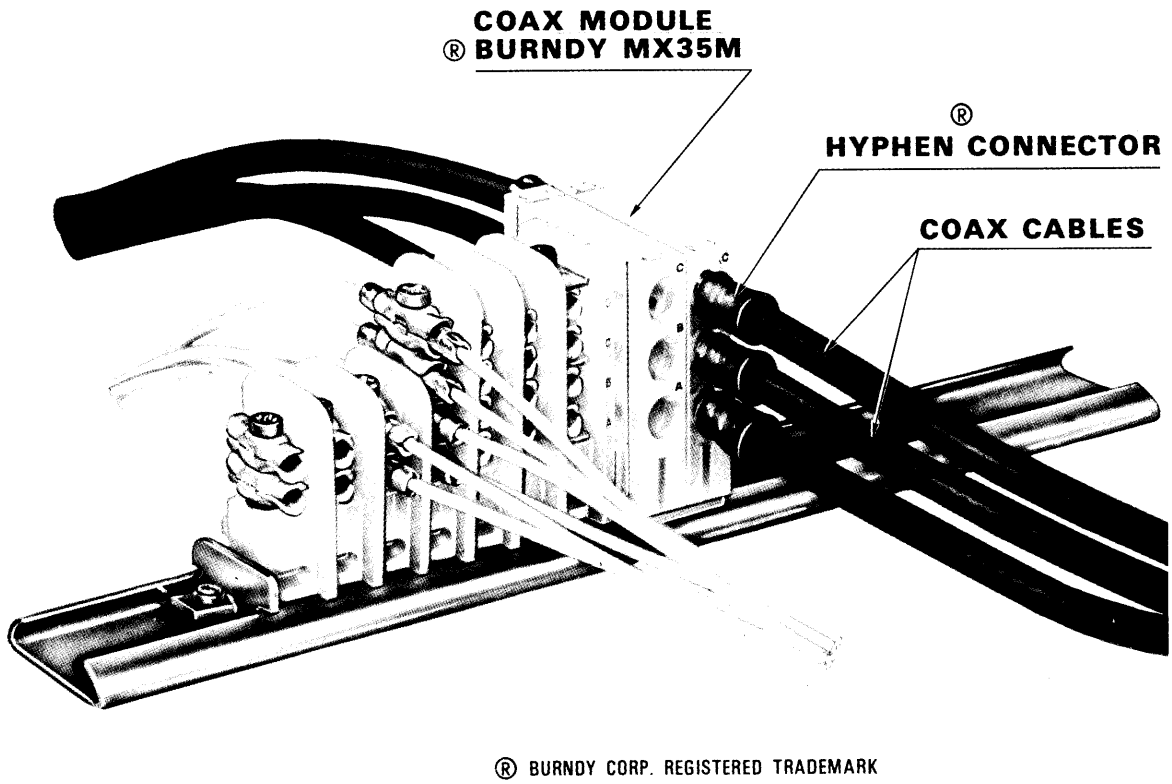


Figure 8-24. Termination of Coaxial Cables on Modulok Board

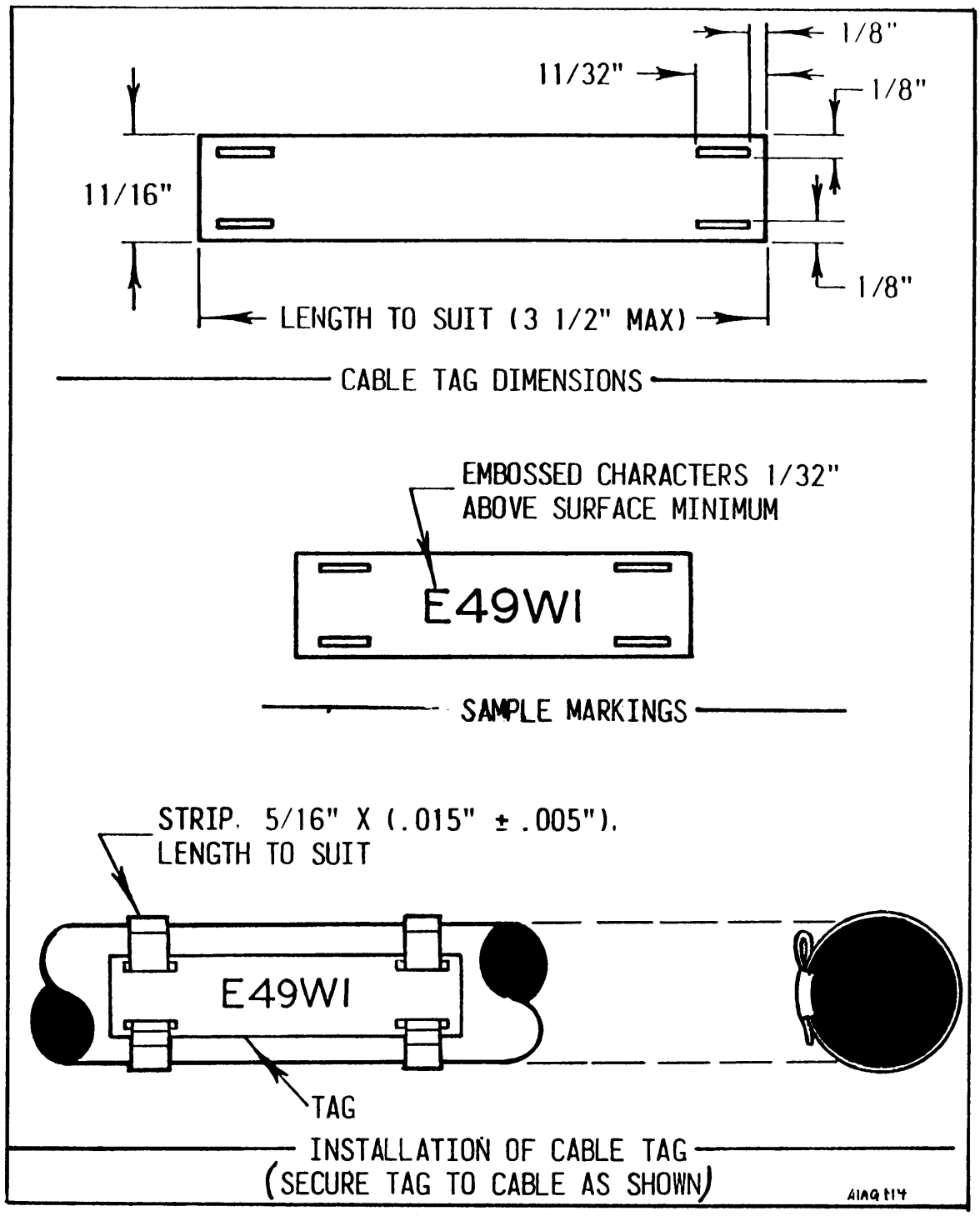
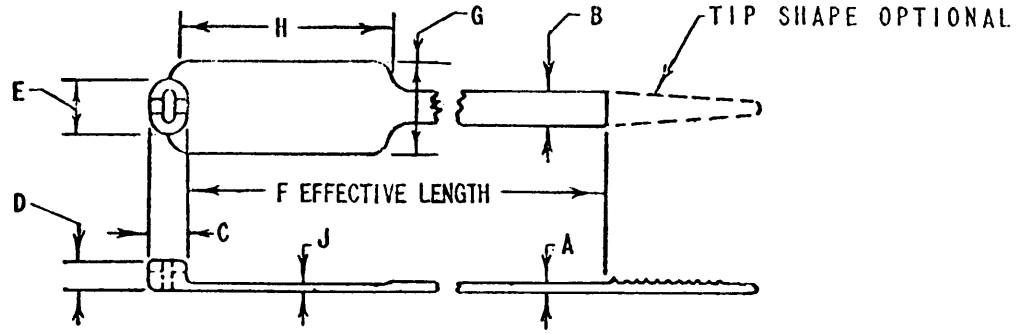
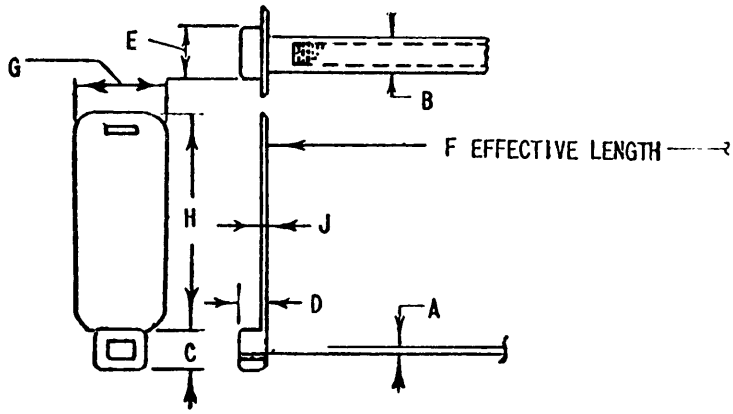


Figure 8-25. Type I Cable Tag



A SUGGESTED MARKER DESIGN



B ALTERNATE MARKER DESIGN

SIZE DASH NO	BUNDLE DIAM		TYPE	MS-3368 INSTALLATION TOOL	DIMENSIONS								
	MAX	MIN			A MAX	B MAX	C MAX	D MAX	E MAX	F MAX	G MAX	H MAX	J MAX
MS18035-1	1 3/4	3/8	THIN	1	055	.190	.275	.200	.425	6.00	.50	1.87	0.35
MS18035-2	4	3/8	THIN	2	.055	.190	.275	.200	.425	13.00	.50	1.87	0.35

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Figure 8-26. Type II Cable Tag

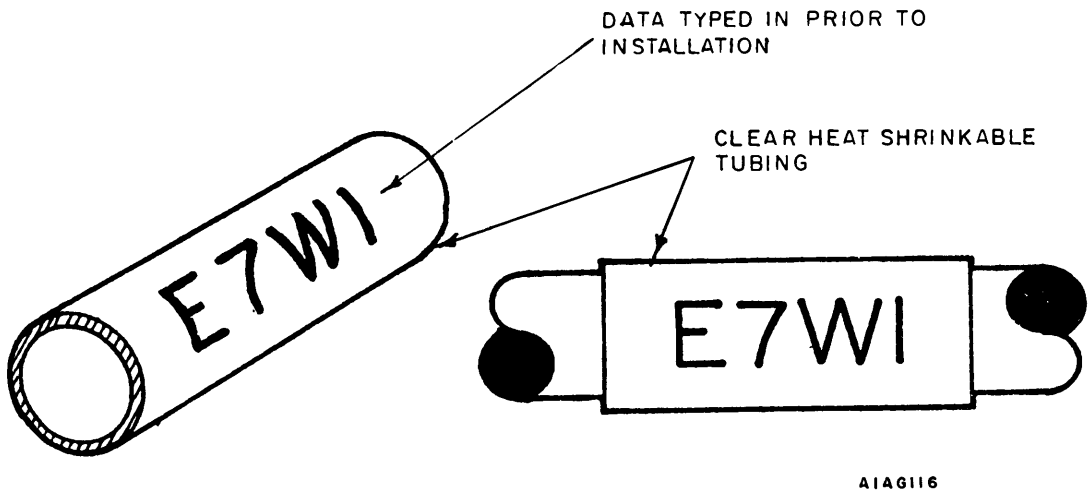


Figure 8-27. Type III Cable Tag

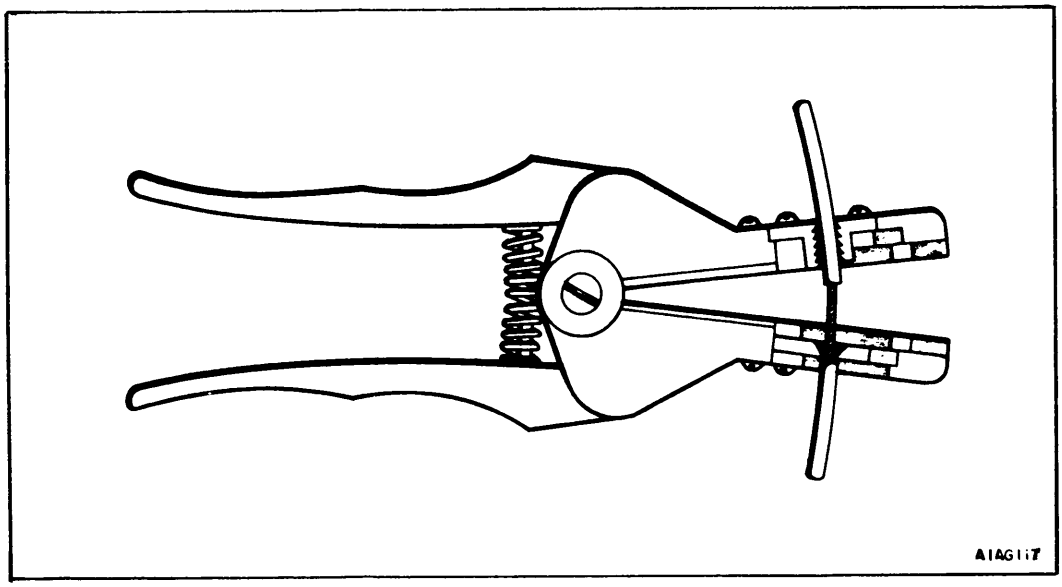


Figure 8-28. Conventional Wire Stripper

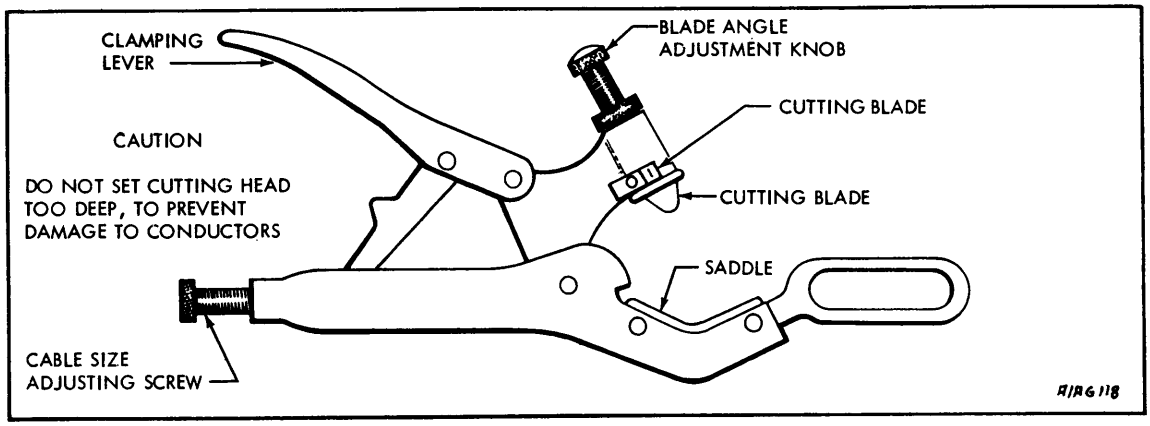


Figure 8-29. Jones Cable Stripper

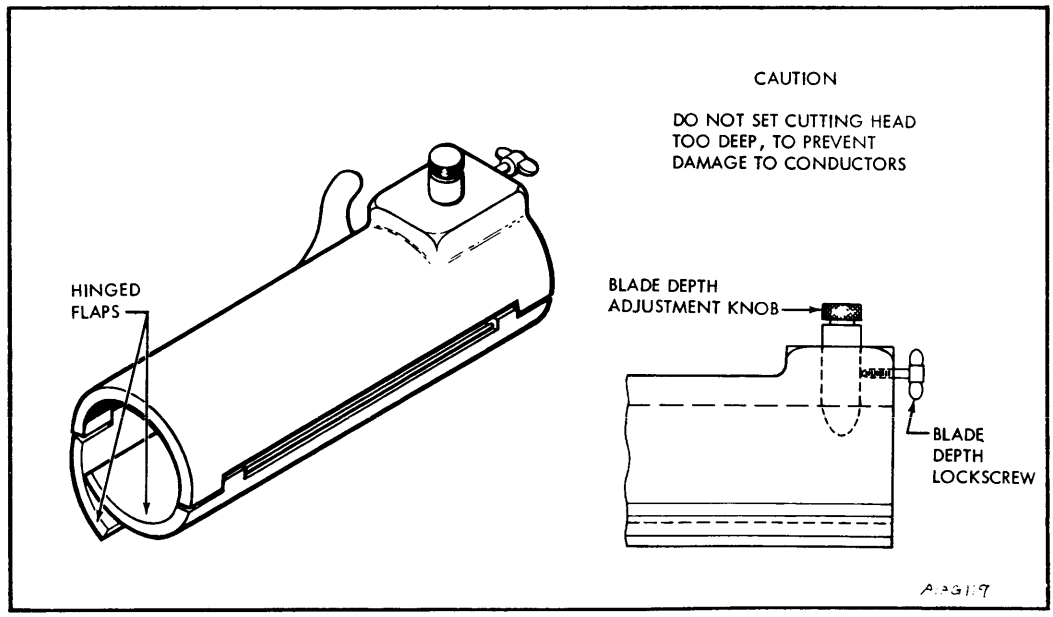


Figure 8-30. Huff Cable Stripper

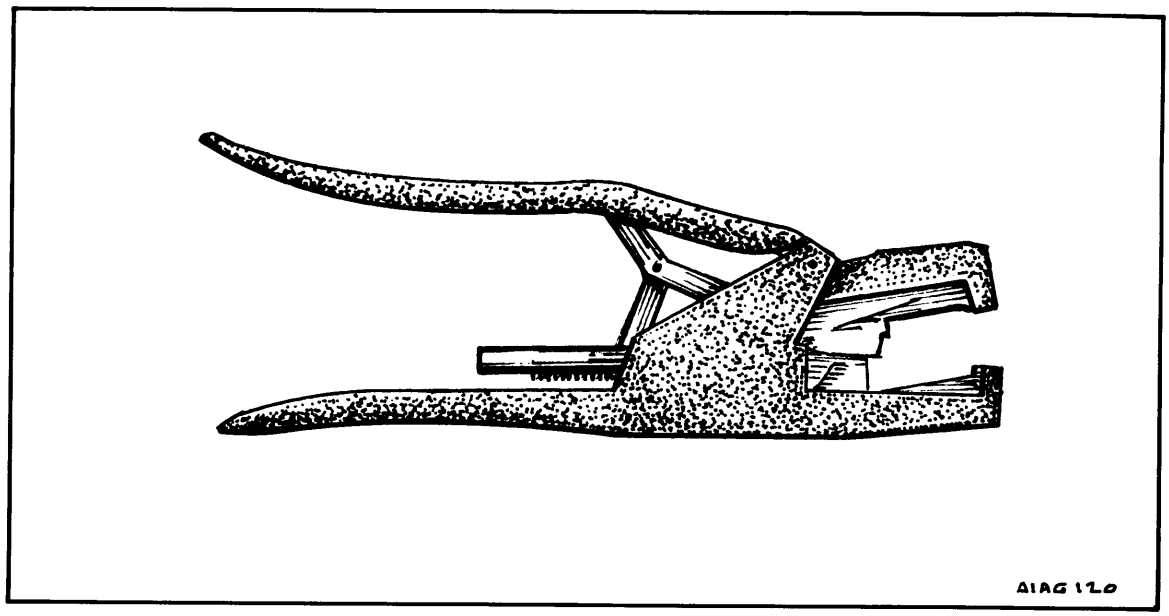


Figure 8-31. Self-Adjusting Wire Stripper

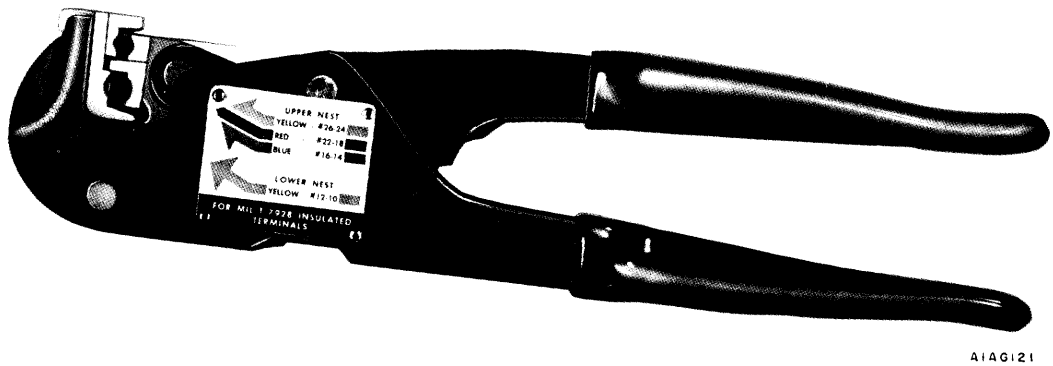


Figure 8-32. Crimping Tool (Thomas & Betts)

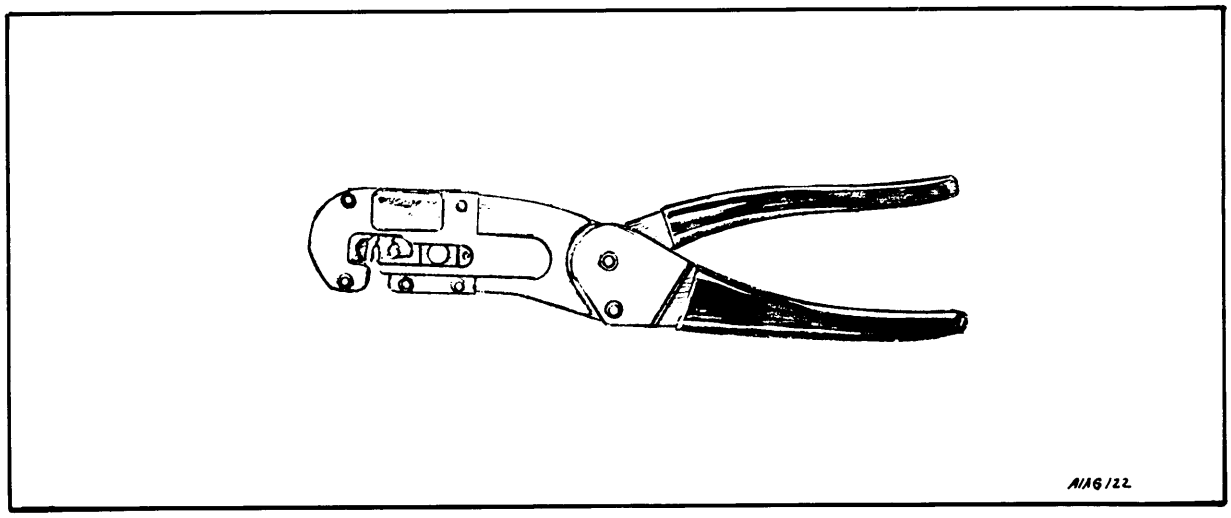


Figure 8-33. Crimping Tool (Buchanan)

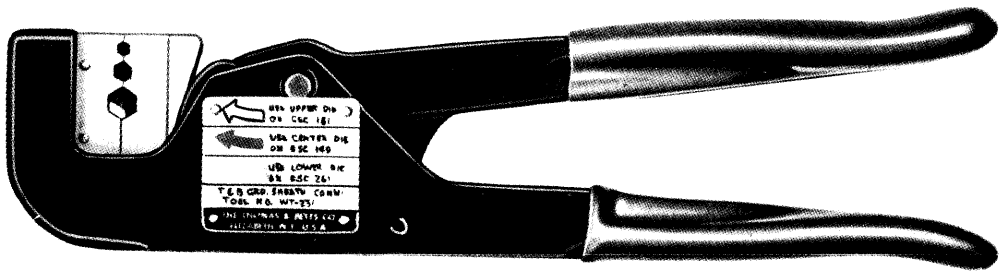


Figure 8-34. Crimping Tool (Burndy)

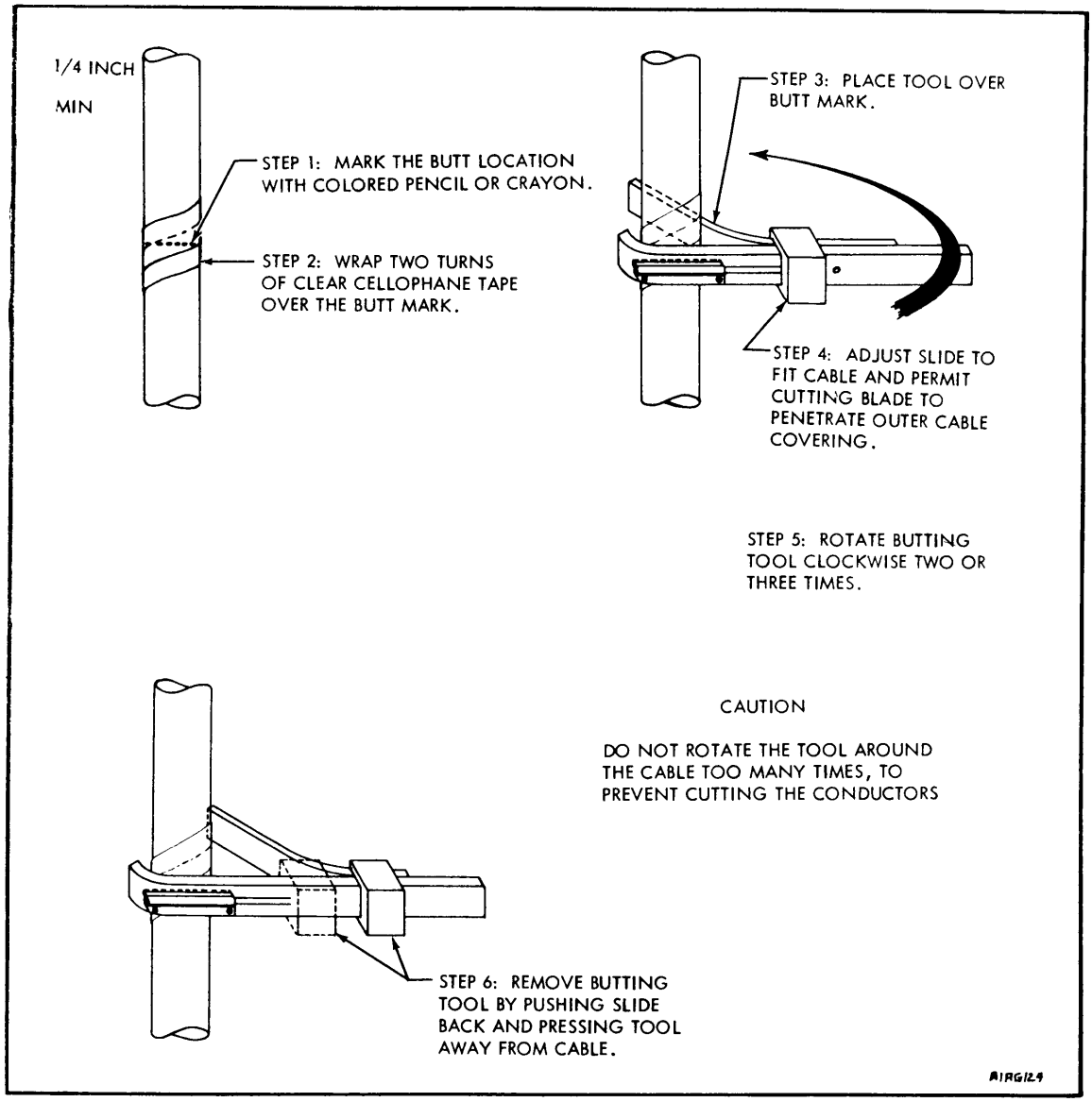


Figure 8-35. Cable Butting

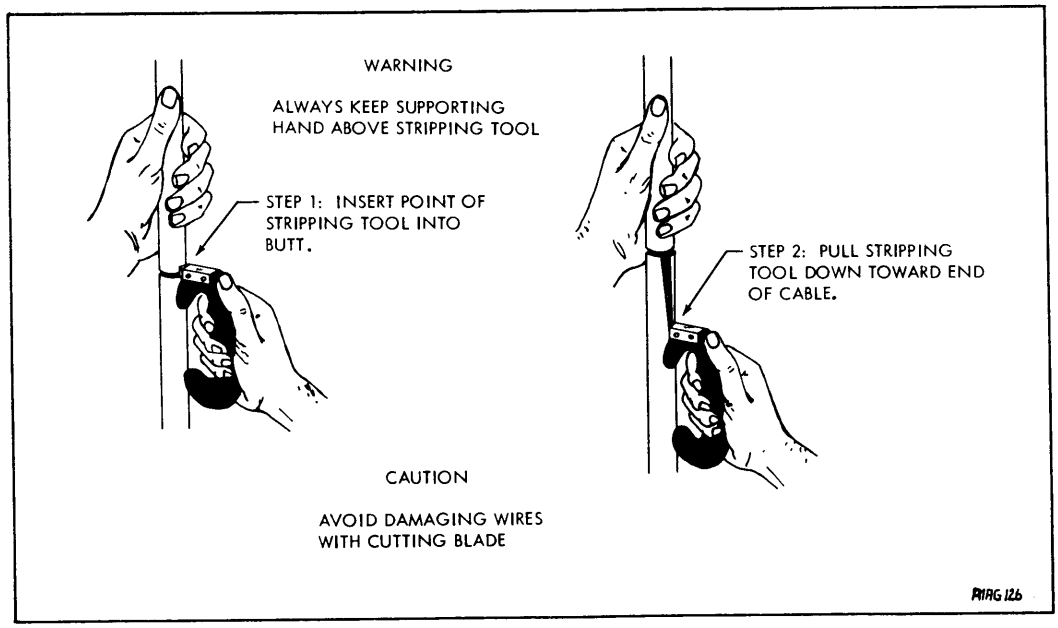


Figure 8-36. Use of W. E. Co. R62267 Cable Stripper

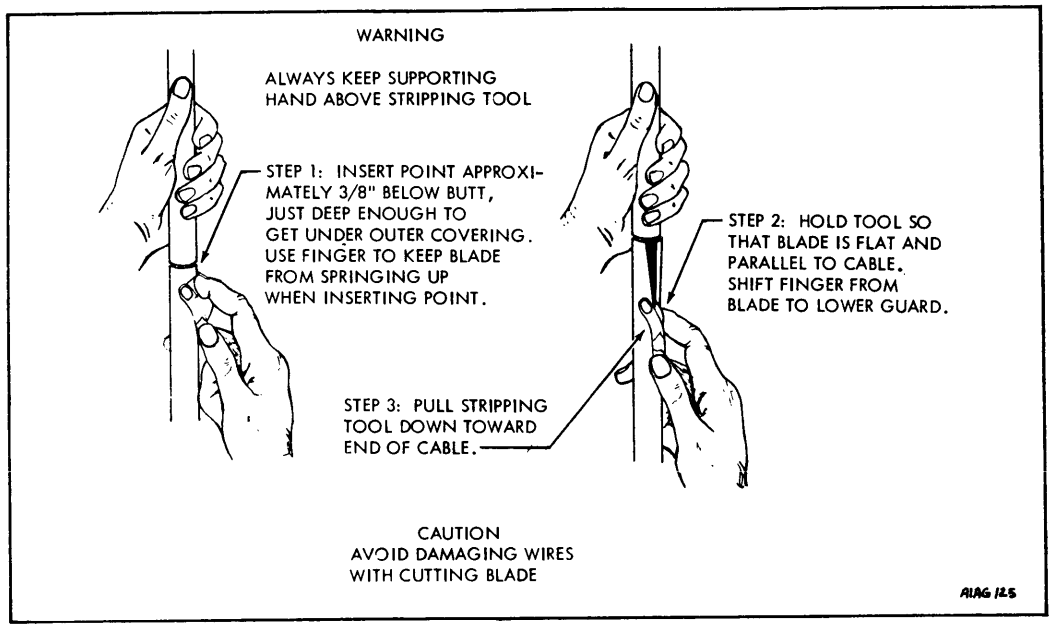


Figure 8-37. Use of W. E. Co. R2878 Cable Stripper

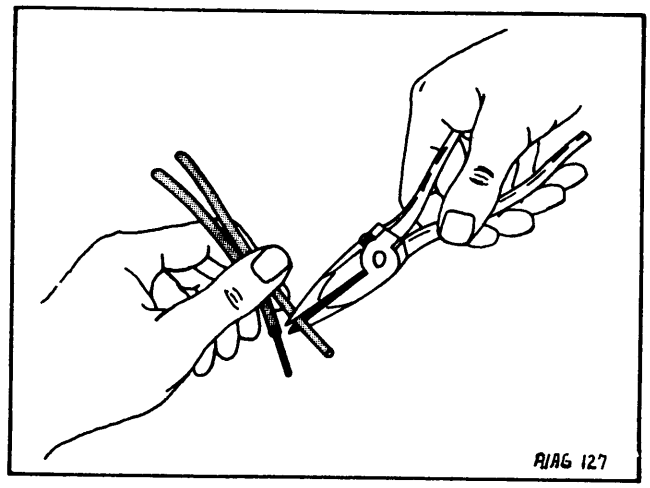


Figure 8-38. Stripping With Pliers

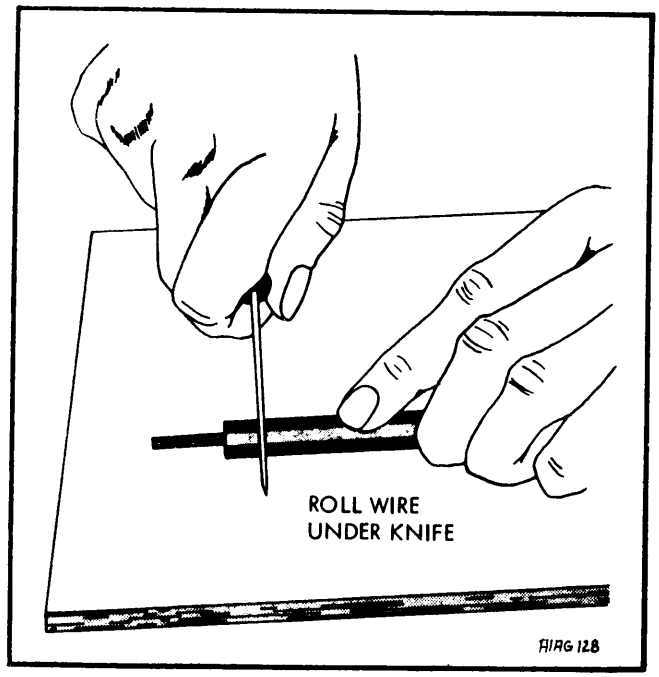


Figure 8-39. Stripping With a Knife

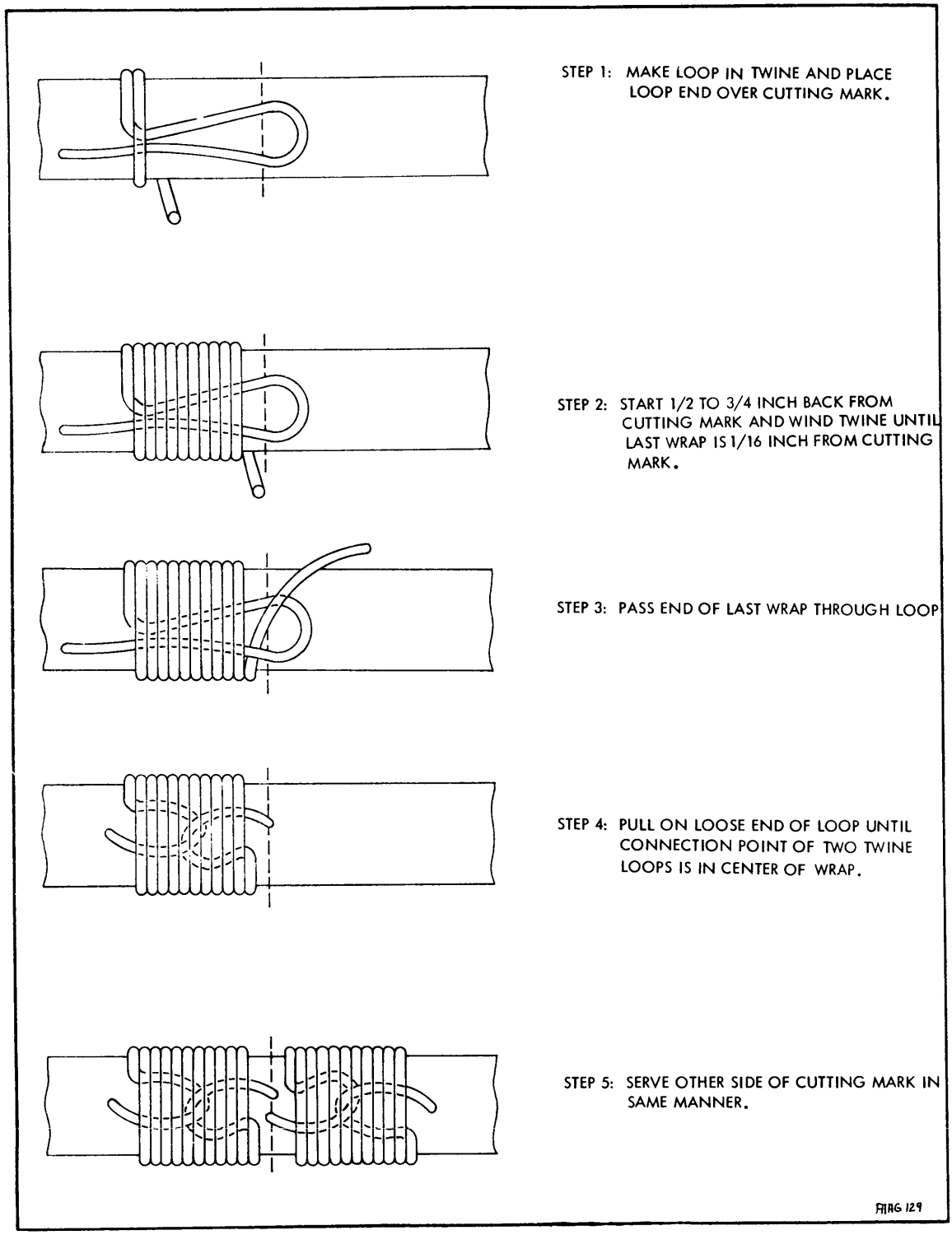


Figure 8-40. Twine Method of Cable Serving

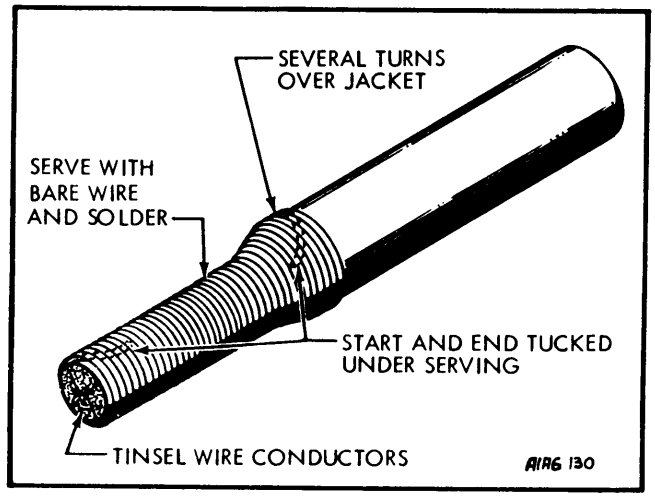


Figure 8-41. Tinsel-Wire Serving

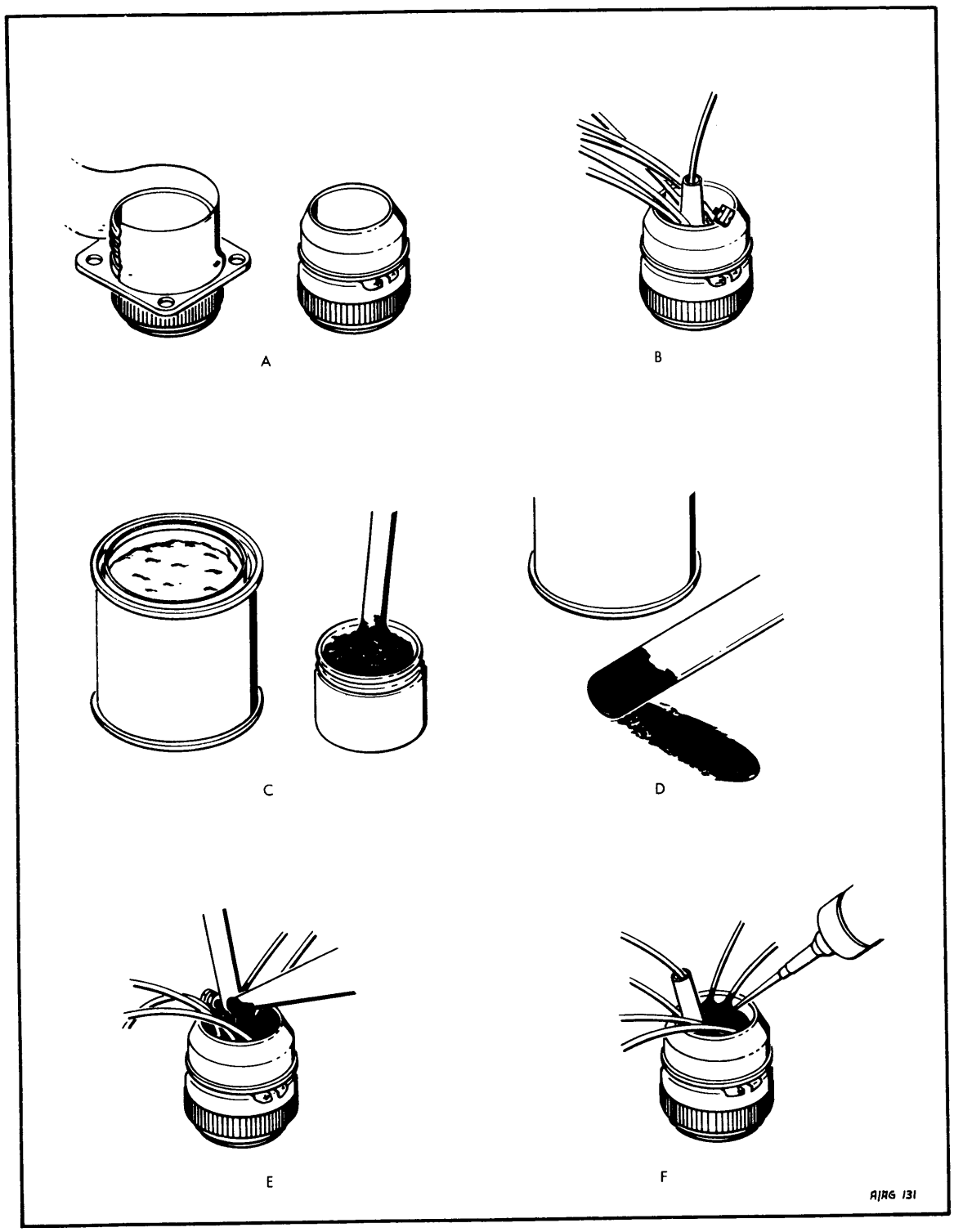


Figure 8-42. Potting

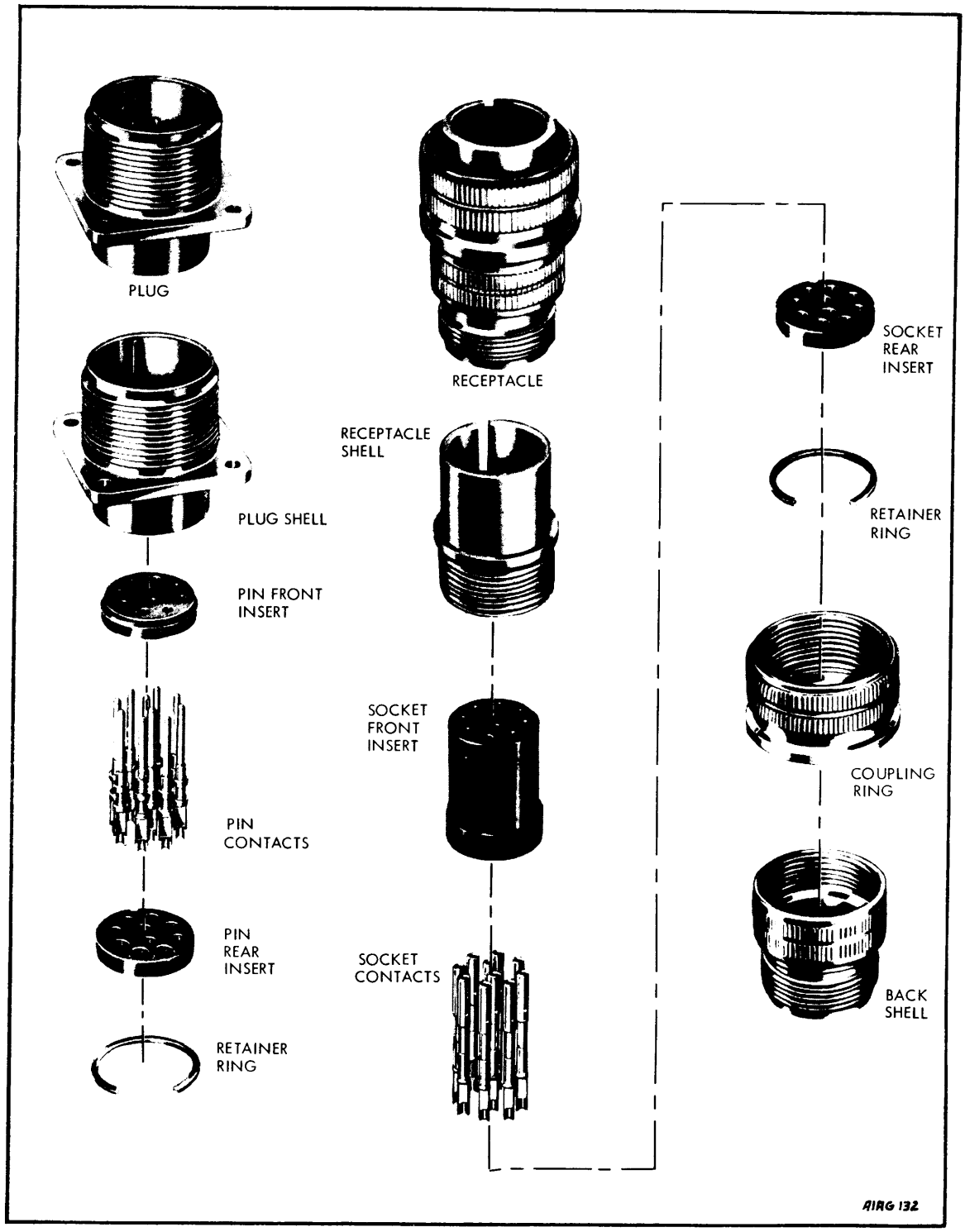


Figure 8-43. Typical MS Wire Connector

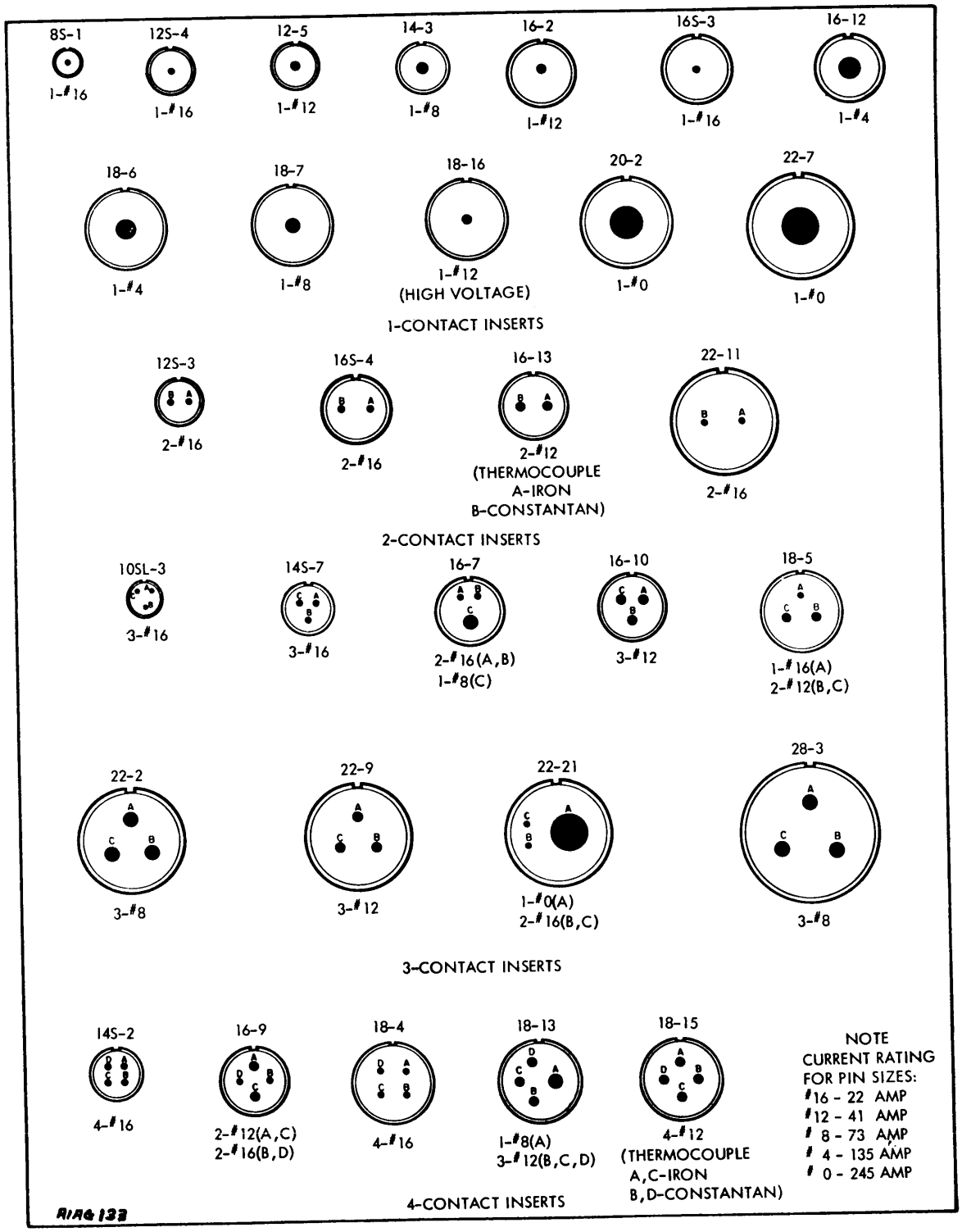


Figure 8-44. Connector Insert Arrangements (Sheet 1 of 8)

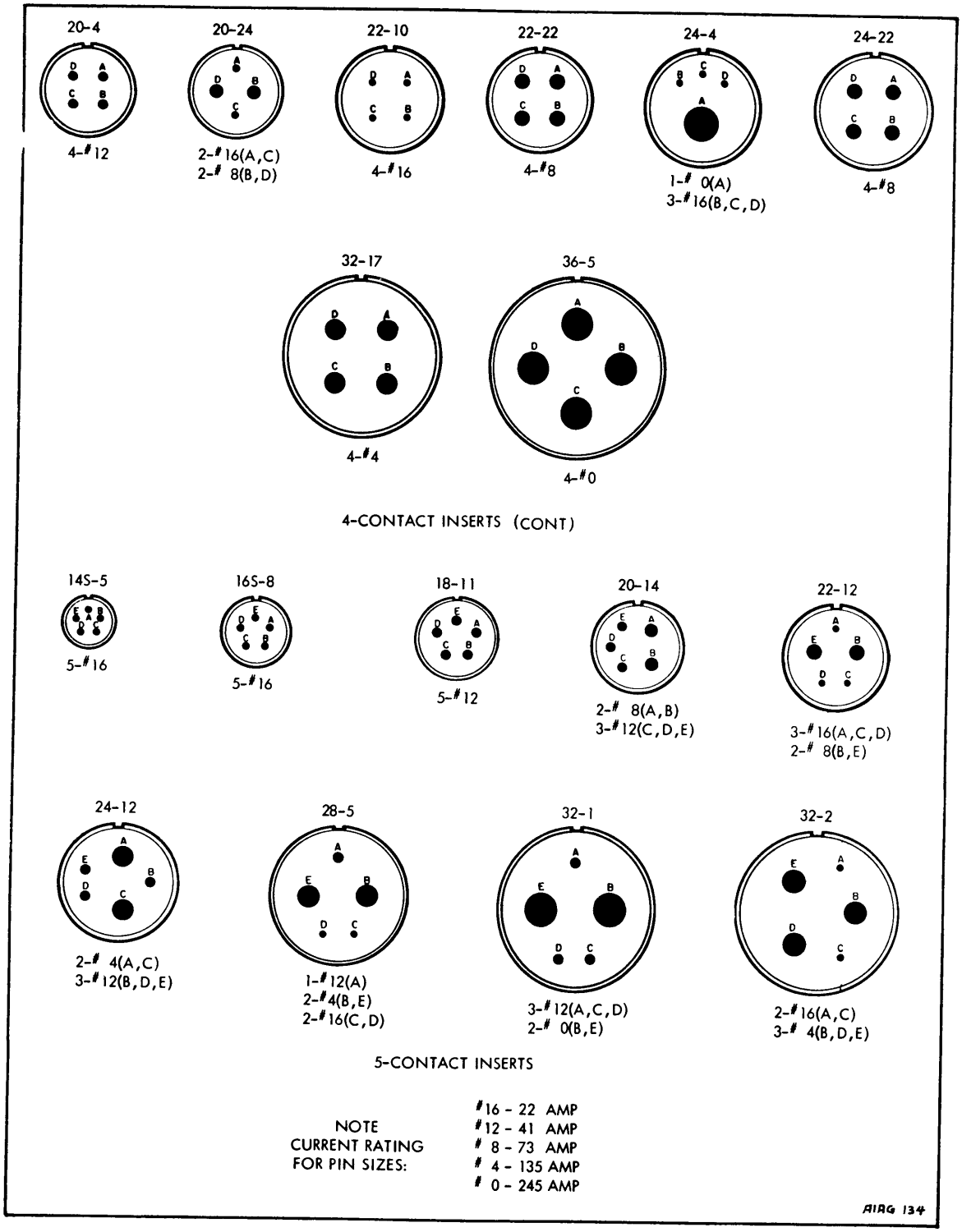


Figure 8-44. Connector Insert Arrangements (Sheet 2 of 8)

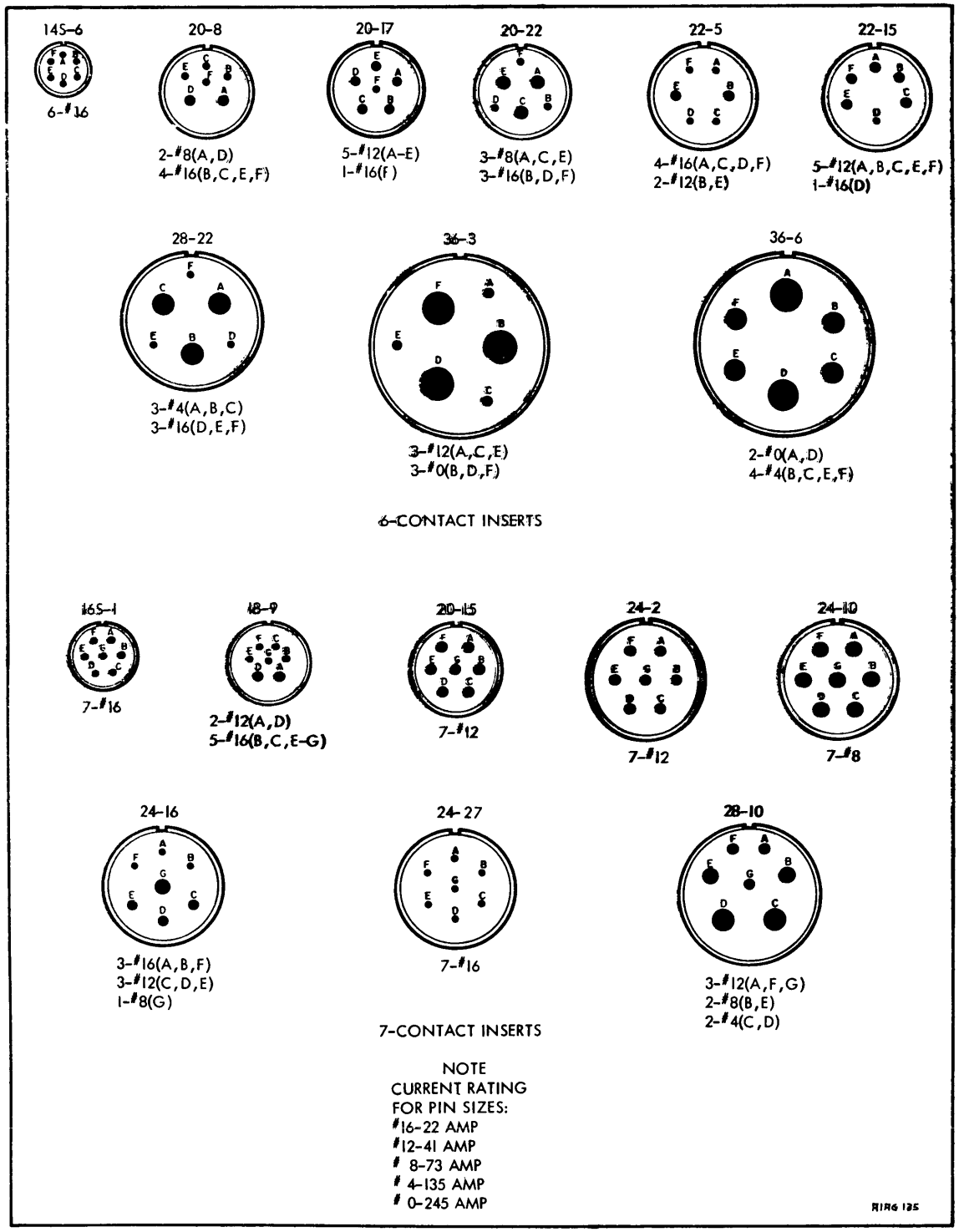


Figure 8-44. Connector Insert Arrangements (Sheet 3 of 8)

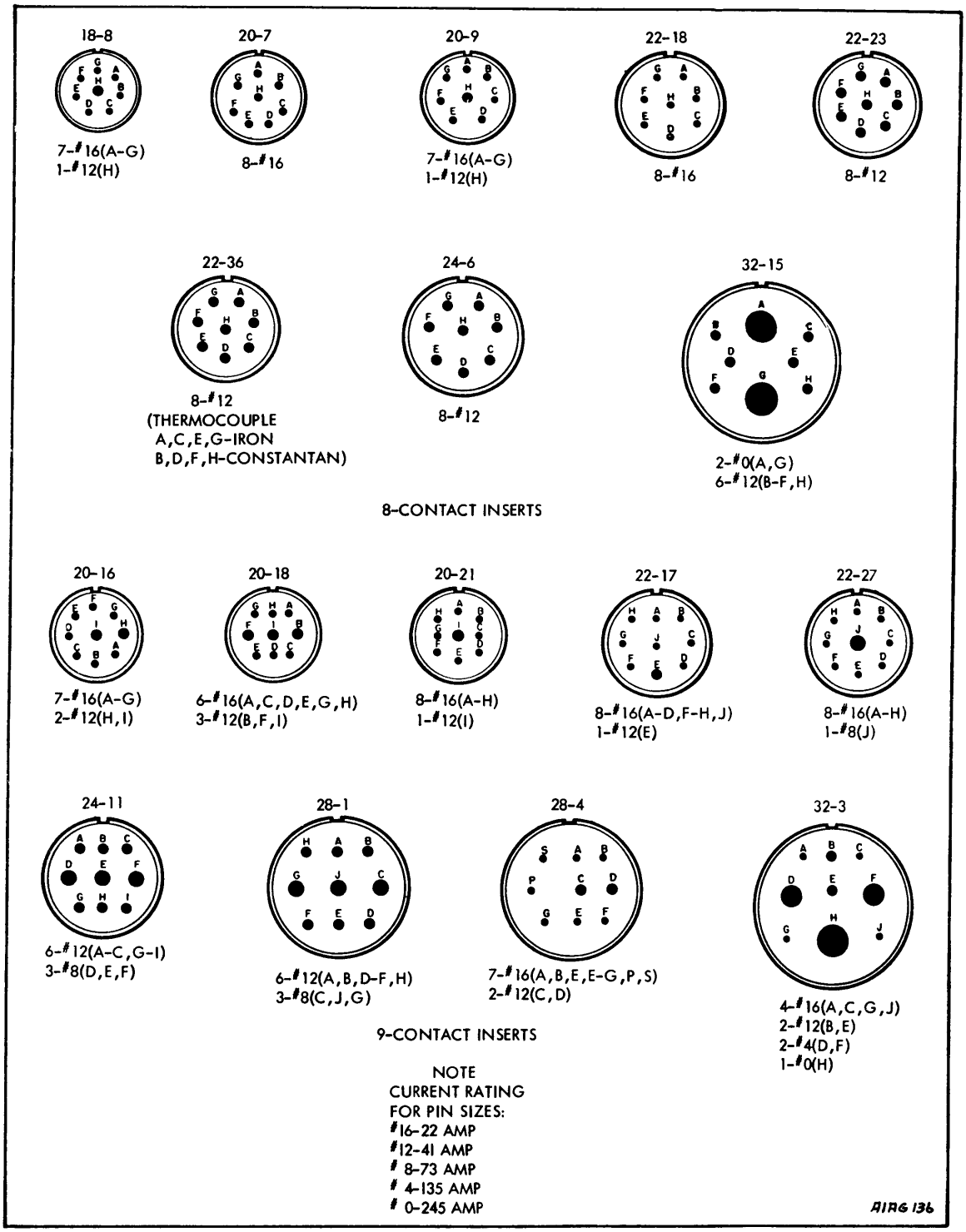


Figure 8-44. Connector Insert Arrangements (Sheet 4 of 8)

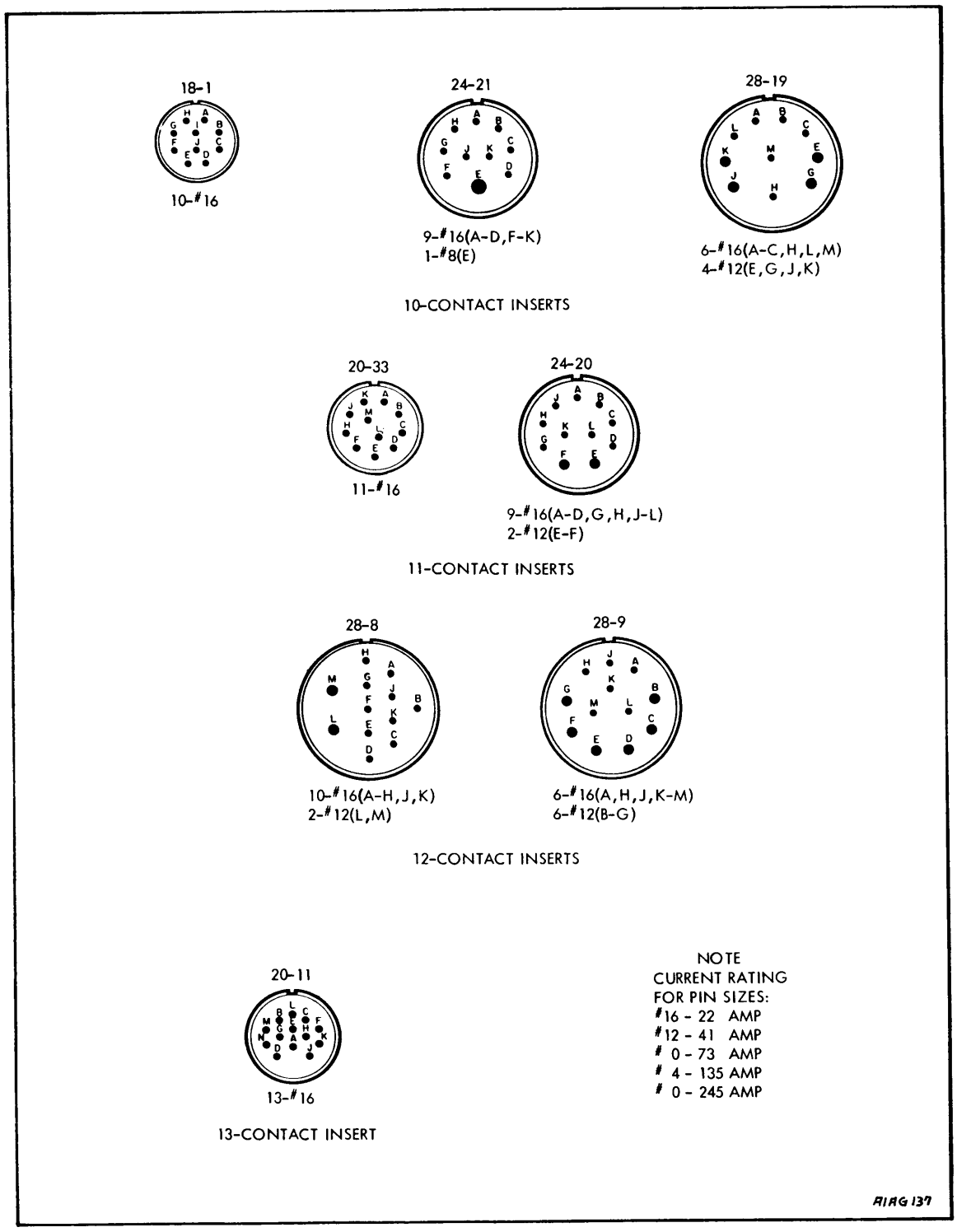


Figure 8-44. Connector Insert Arrangements (Sheet 5 of 8)

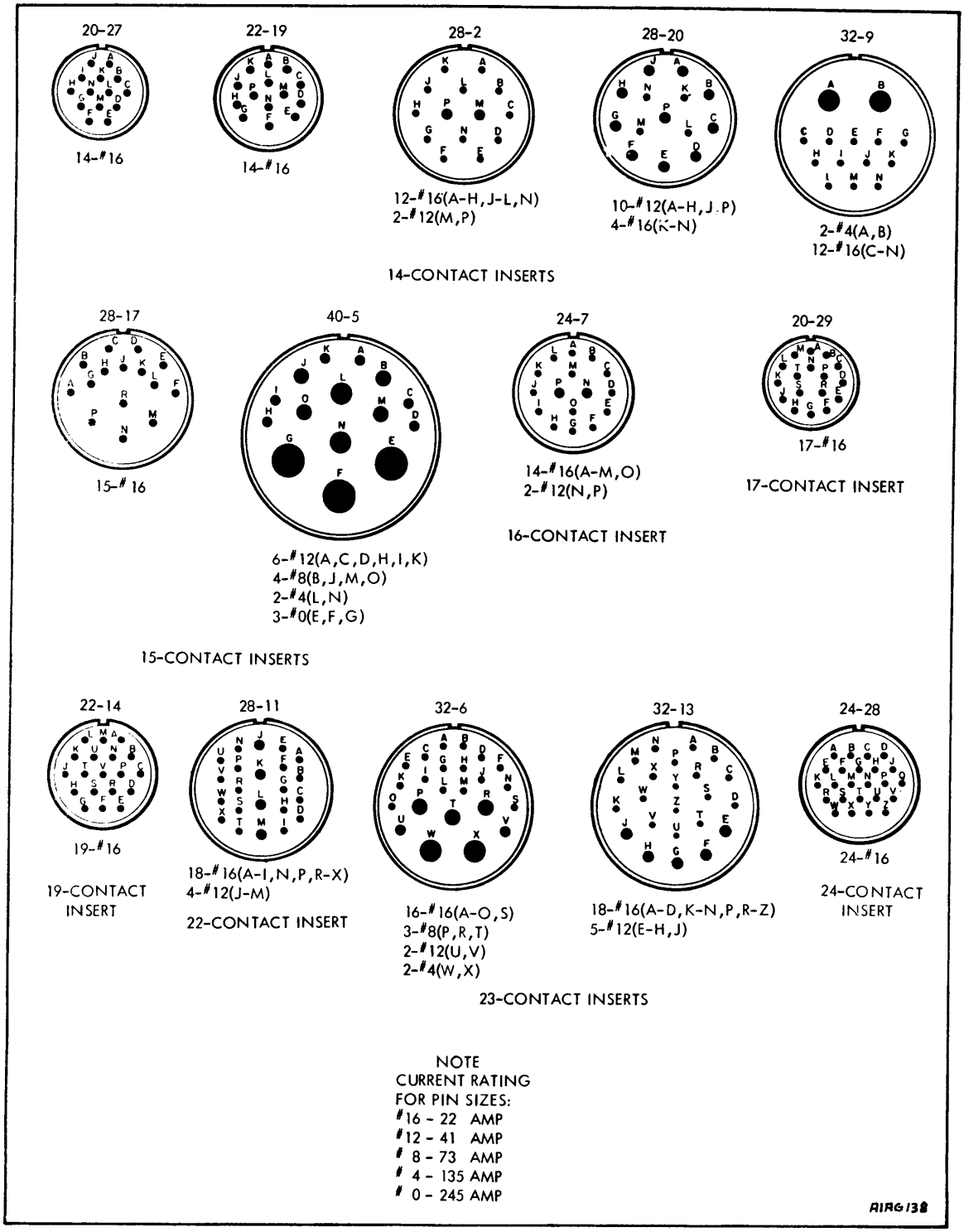


Figure 8-44. Connector Insert Arrangements (Sheet 6 of 8)

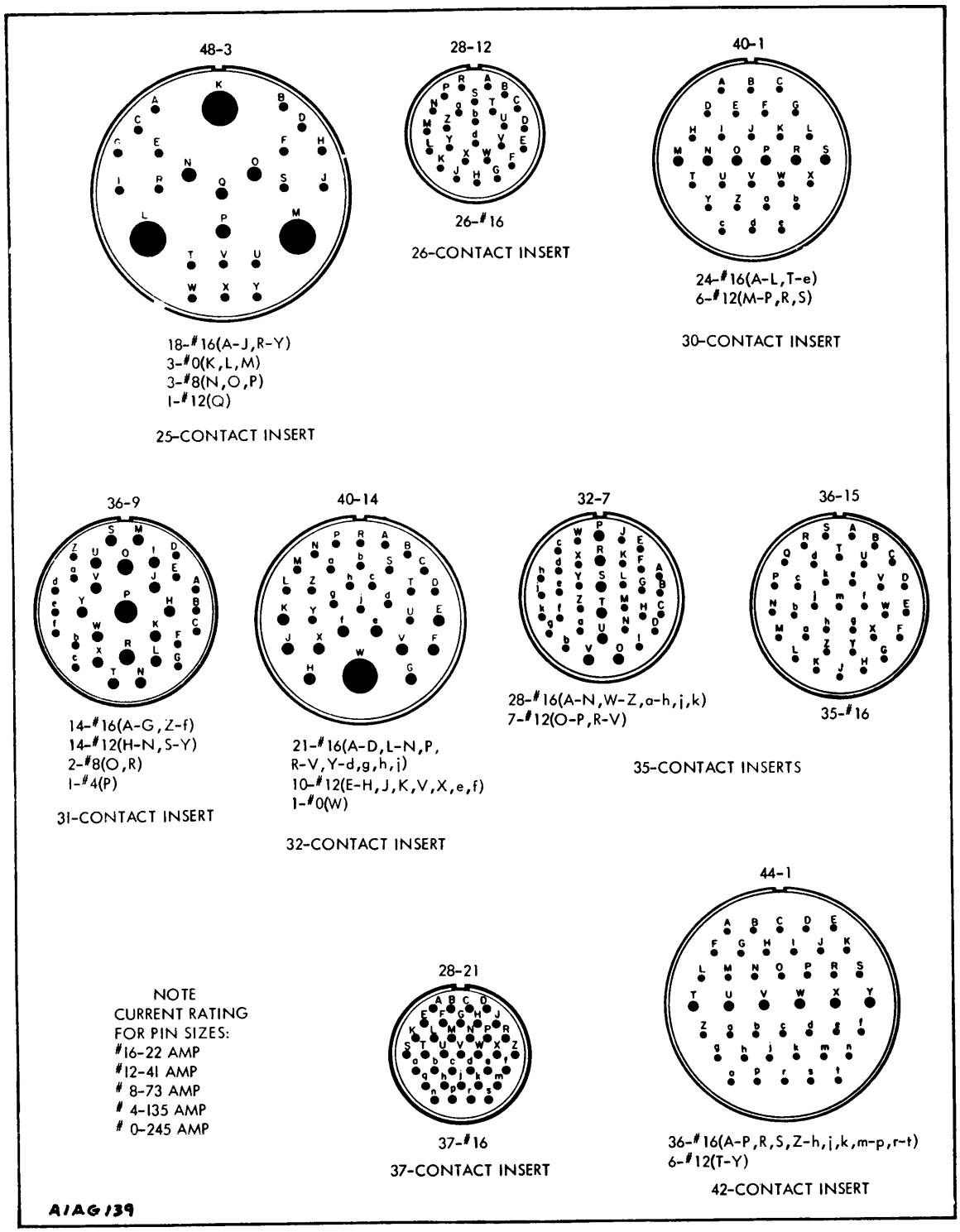


Figure 8-44. Connector Insert Arrangements (Sheet 7 of 8)

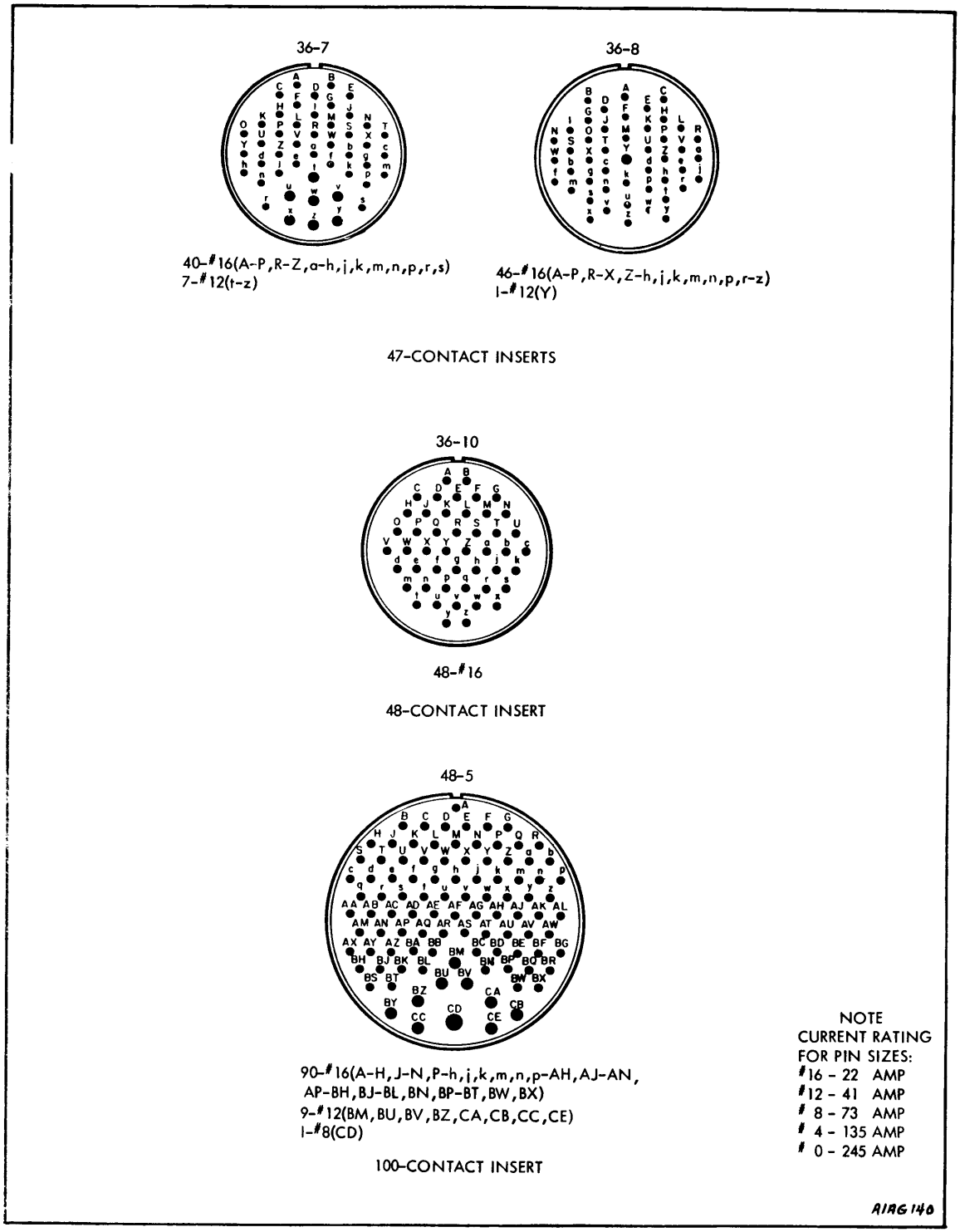
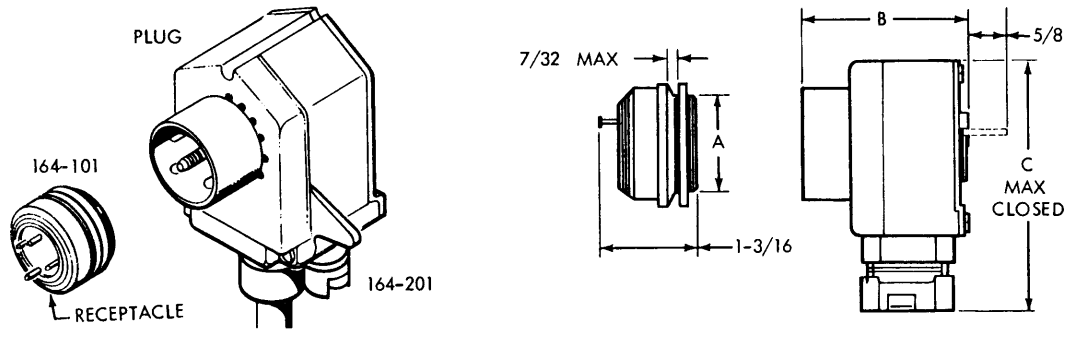


Figure 8-44. Connector Insert Arrangements (Sheet 8 of 8)



SIGNAL CORPS NUMBER	AMPHENOL NUMBER	A*	B*	C*
CS2020	164-101	1-1/4		
CS2026	164-102	1-5/8		
CS1320	164-201 (CABLE O.D. OF 0.261-0.531		1-11/16	2-53/64
CS1320	164-201 (CABLE O.D. OF 0.511-0.781		1-15/16	2-53/64
CS1326	164-202 (CABLE O.D. OF 0.511-0.781		1-7/8	3-7/32
CS1326	164-202 (CABLE O.D. OF 0.761-1.031		2-1/8	3-7/32
	*ALL DIMENSIONS IN INCHES			

PLUGS		MATING RECEPTACLES		CONTACTS	CURRENT RATING	VOLTAGE RATING
SIGNAL CORPS NUMBER	AMPHENOL NUMBER	SIGNAL CORPS NUMBER	AMPHENOL NUMBER			
CS-1320-(1)(S)	164-201-1S	CS-2020-(1)(P)	164-101-1P	4 #12	35 amps	1000V RMS
(P)	1P	(S)	1S			
	164-201-2S		164-101-2P	2 #12	35 amps	1000V RMS
	2P		2S			
CS-1320-(2)(S)	164-201-3S	CS-2020-(2)(P)	164-101-3P	9 #16	20 amps	1000V RMS
(P)	3P	(S)	3S			
CS-1326-(1)(S)	164-202-5S	CS-2026-(1)(P)	164-102-5P	14 #16	20 amps	1000V RMS
(P)	5P	(S)	5S			
	164-202-6S		164-102-6P	12 #16	20 amps	1000V RMS
	6P		6S	2 #12	35 amps	
	164-202-7P		164-102-7S	14 #16	20 amps	1000V RMS
				2 HI-VOLT	20 amps	2500V RMS
CS-1326-(2)(S)	164-202-18S	CS-2026-(2)(P)	164-102-18P	4 #8	60 amps	1000V RMS
(P)	18P	(S)	18S			
CS-1326-(3)(S)	164-202-20S	CS-2026-(3)(P)	164-102-20P	19 #16	20 amps	1000V RMS
(P)	20P	(S)	20S			
CS-1326-(5)(S)	164-202-23S	CS-2026-(5)(P)	164-102-23P	30 #.050	10 amps	1000V RMS
(P)	23P	(S)	23S			

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Figure 8-45. Waterproof Power Plugs

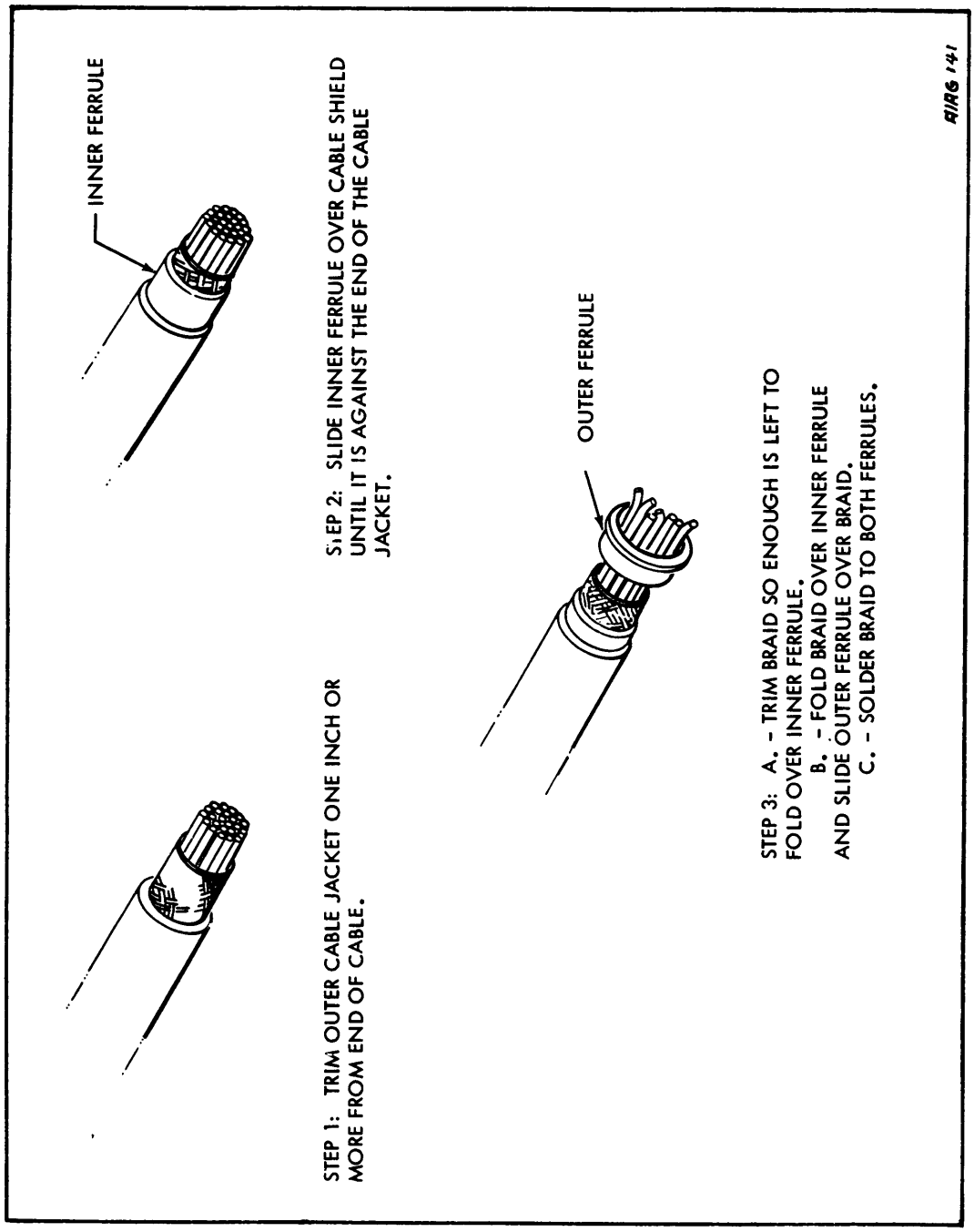


Figure 8-46. Installation of Power Plugs (Sheet 1 of 3)

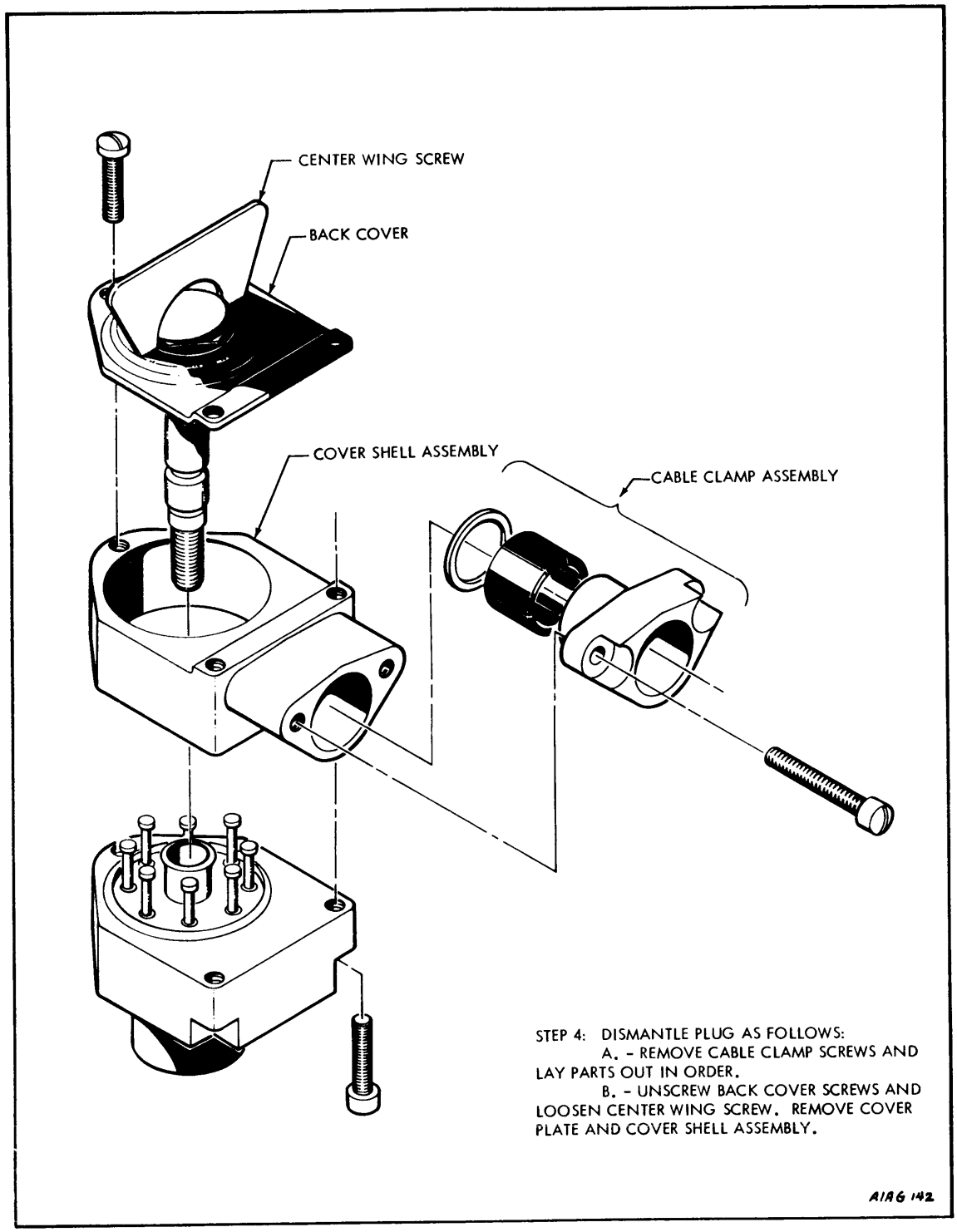


Figure 8-46. Installation of Power Plugs (Sheet 2 of 3)

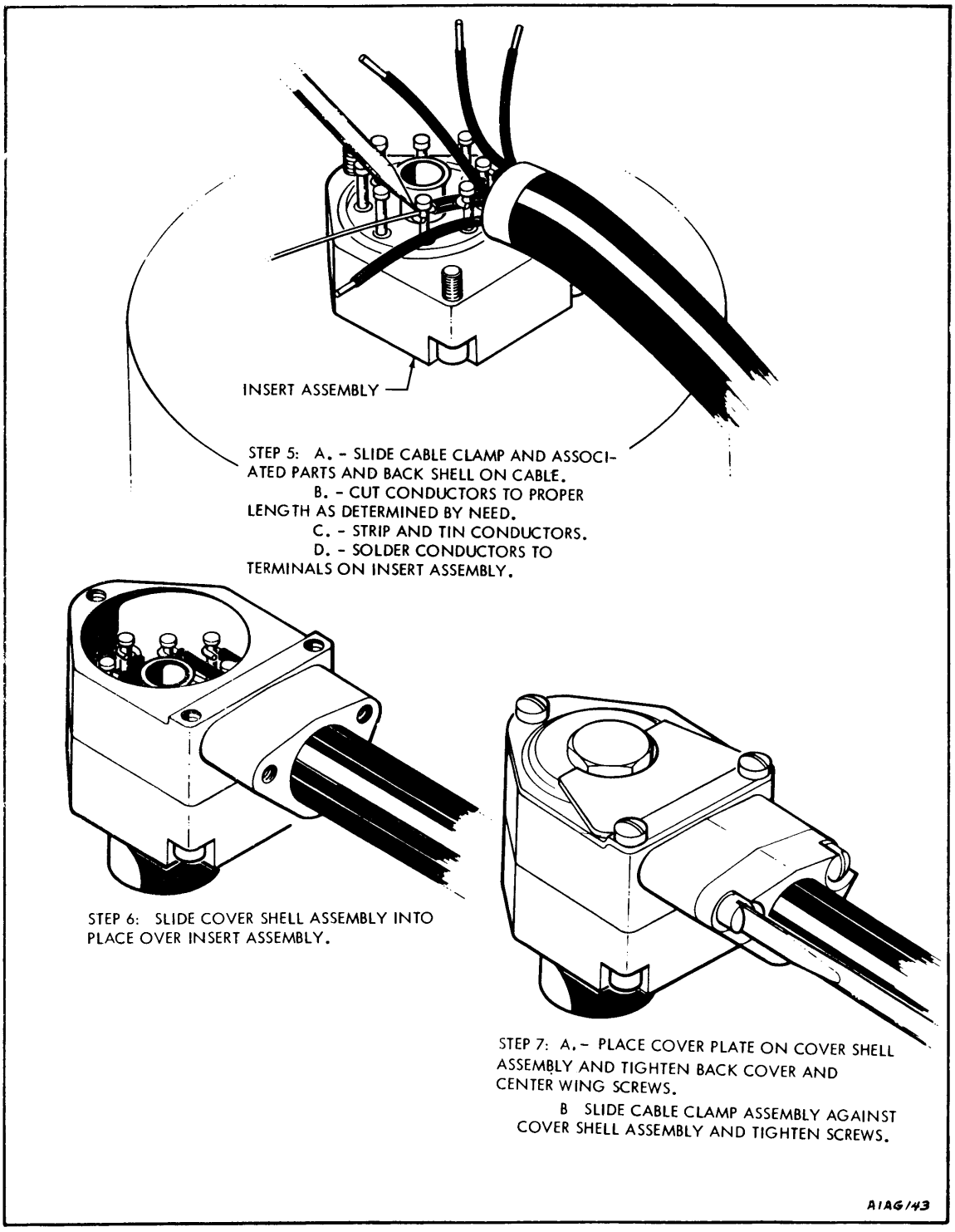
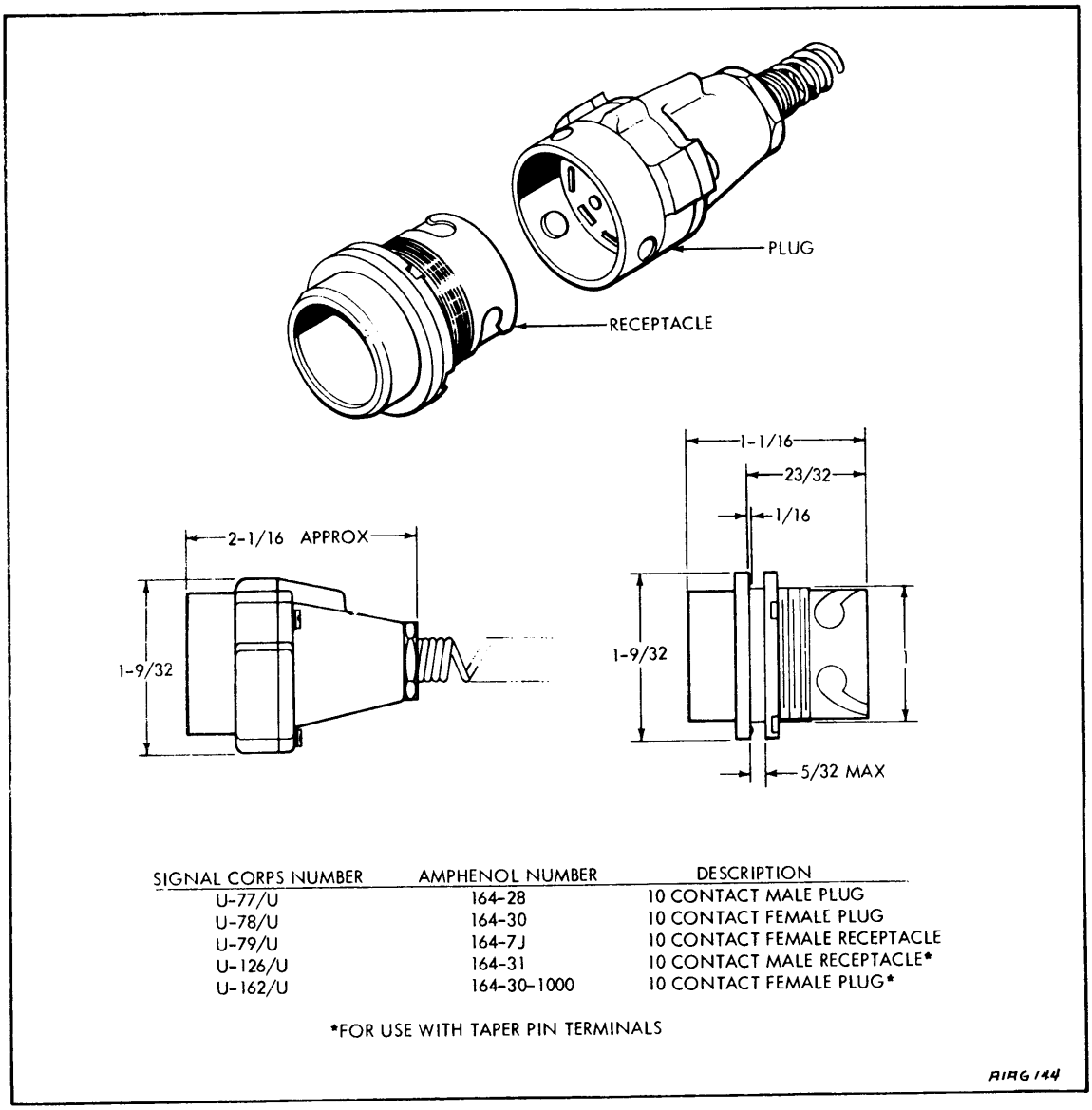


Figure 8-46. Installation of Power Plugs (Sheet 3 of 3)



SIGNAL CORPS NUMBER	AMPHENOL NUMBER	DESCRIPTION
U-77/U	164-28	10 CONTACT MALE PLUG
U-78/U	164-30	10 CONTACT FEMALE PLUG
U-79/U	164-7J	10 CONTACT FEMALE RECEPTACLE
U-126/U	164-31	10 CONTACT MALE RECEPTACLE*
U-162/U	164-30-1000	10 CONTACT FEMALE PLUG*

*FOR USE WITH TAPER PIN TERMINALS

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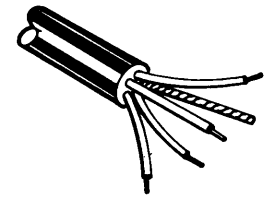
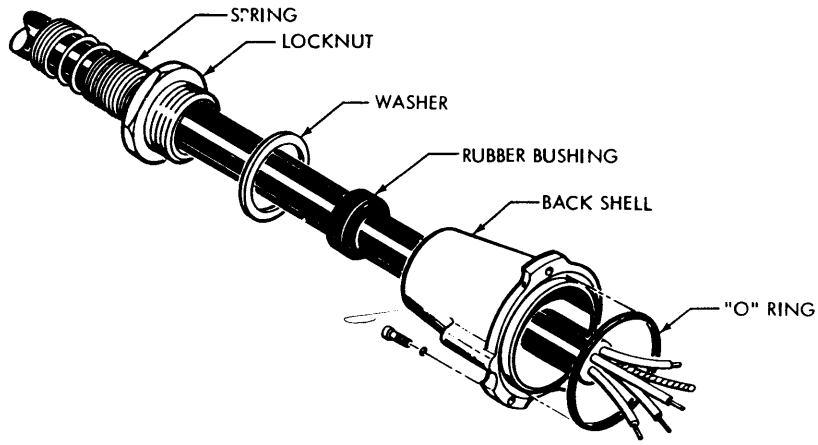
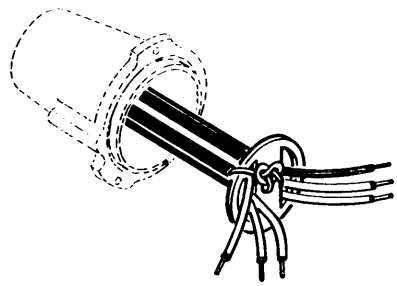
Figure 8-47. Waterproof Audio Connectors



STEP 1: A. - TRIM CABLE JACKET ONE INCH OR MORE FROM END OF CABLE.
B. - REMOVE WRAPPING CORD AND FILLER, DO NOT CUT STAY CORD.
C. - CUT INDIVIDUAL CONDUCTORS TO LENGTH (APPROXIMATELY ONE INCH), STRIP ENDS OF CONDUCTORS, AND TIN.



STEP 2: SLIDE LOCK NUT, SPRING, WASHER, RUBBER BUSHING, AND BACK SHELL ON CABLE.



STEP 3: TIE STRAIN RELIEF RING ON END OF CABLE WITH STAY CORD.

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Figure 8-48. Installation of Audio Connectors (Sheet 1 of 2)

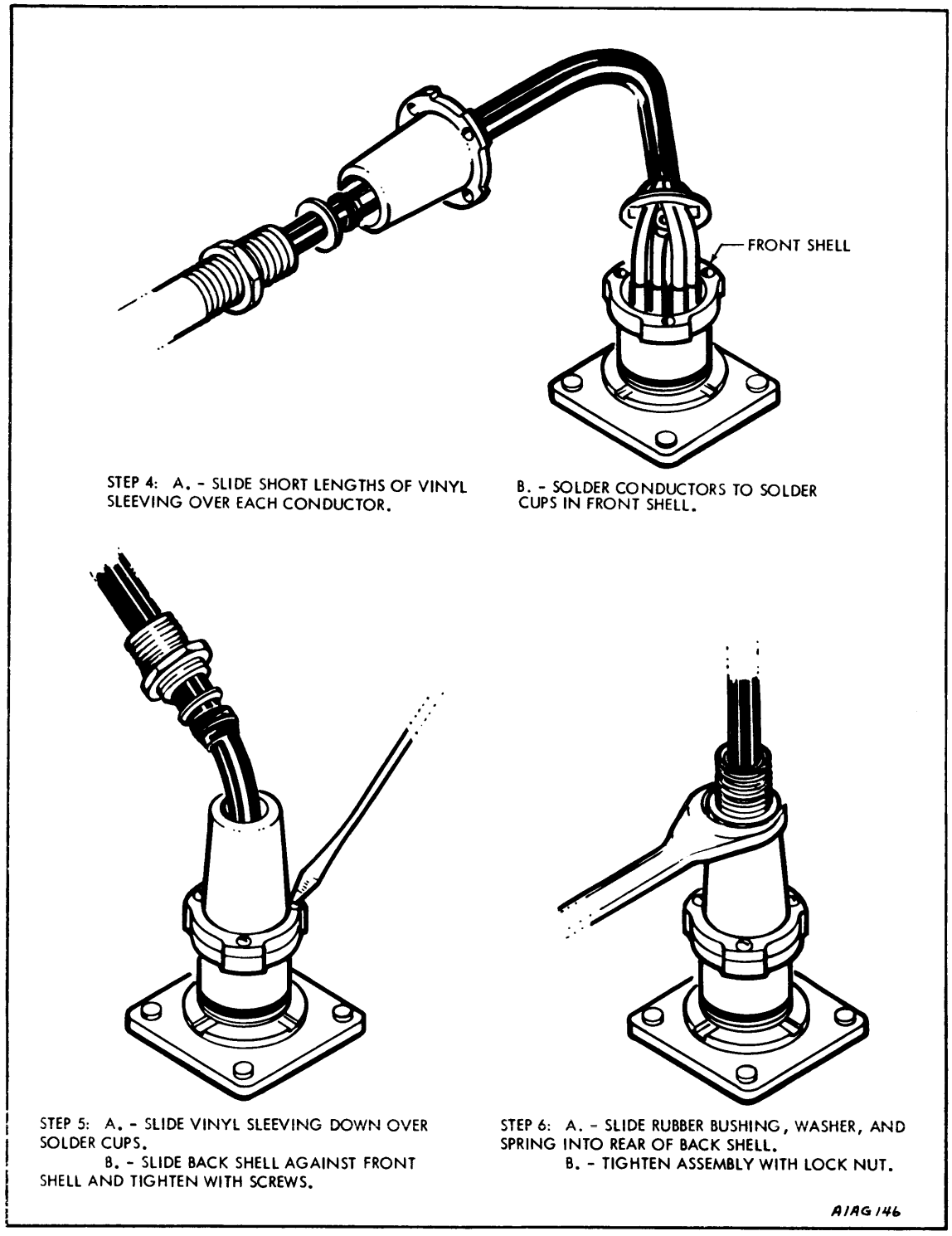

Figure 8-48. Installation of Audio Connectors (Sheet 2 of 2)

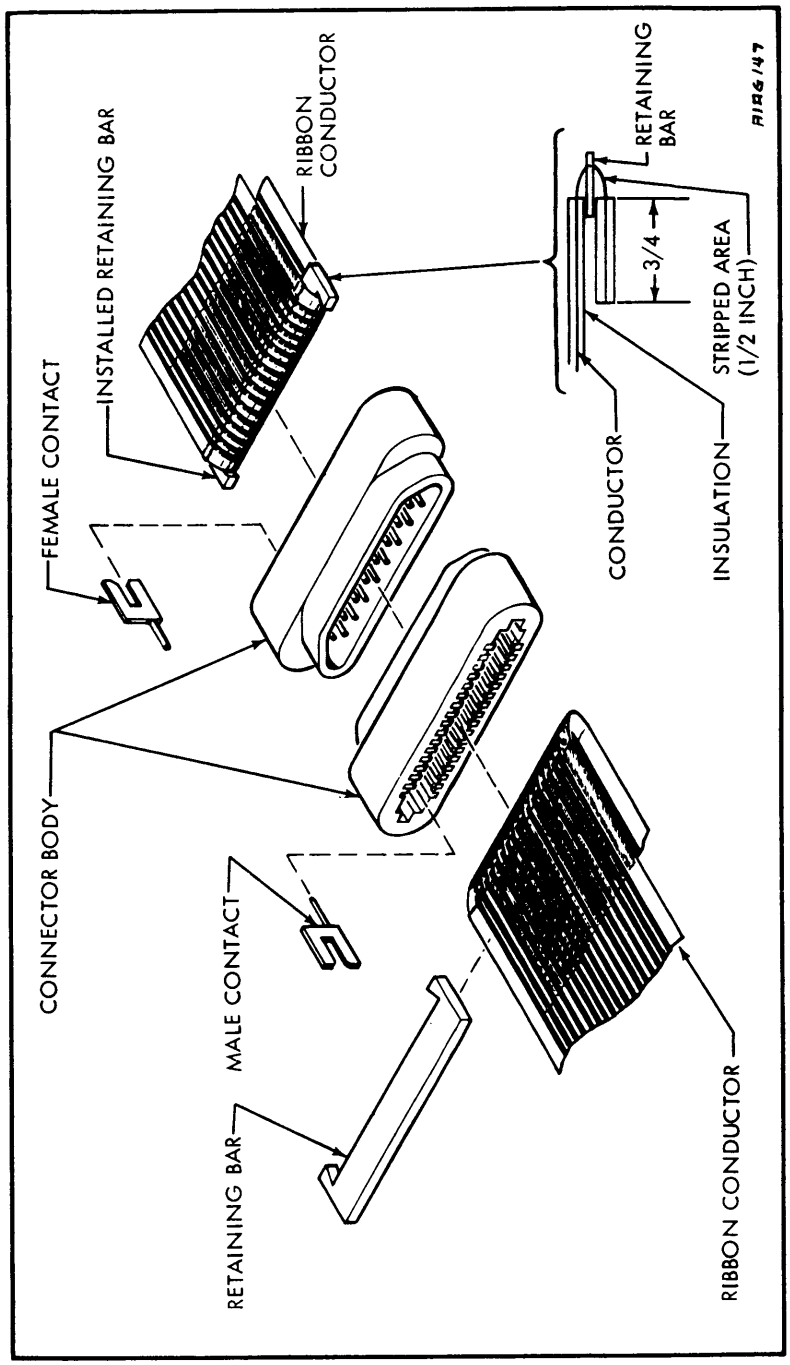

Figure 8-49. Installation of Ribbon Conductor Connector

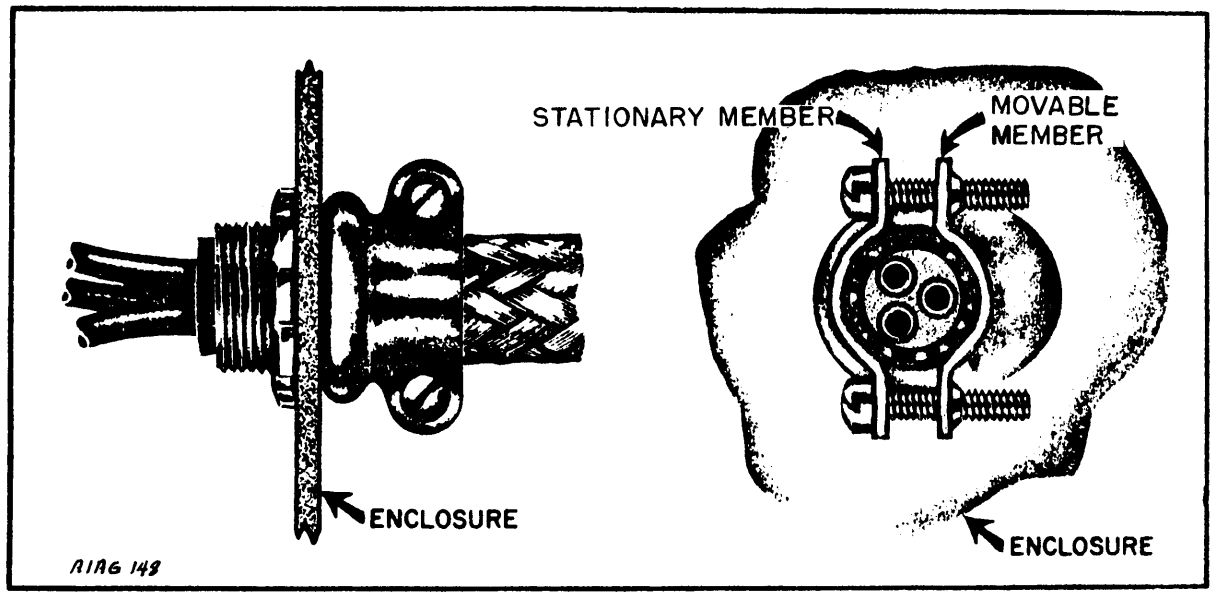

Figure 8-50. Type I Box Connector

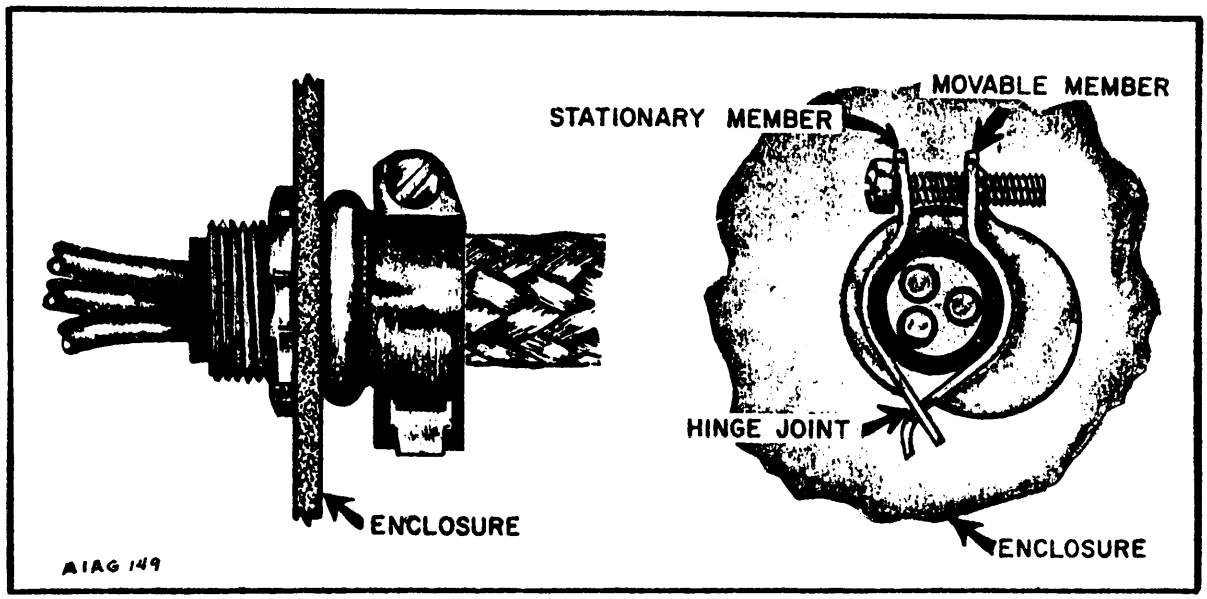

Figure 8-51. Type II Box Connector

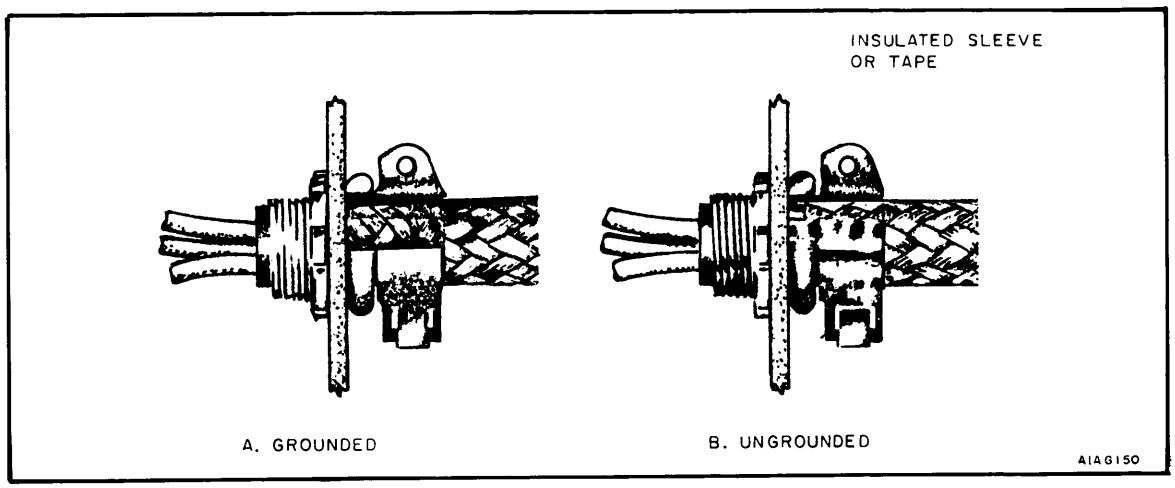

Figure 8-52. Cable and Clamp Installation

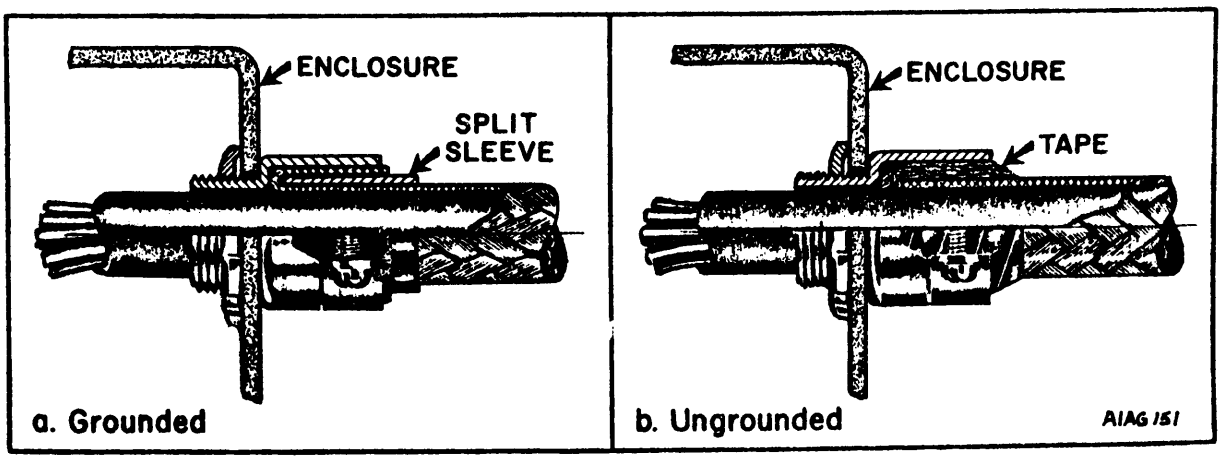

Figure 8-53. Greenfield Clamp and Cable Installation