## 4-1. GENERAL.

a. PURPOSE.–The operational efficiency of an electronics system is dependent on the interconnection cabling and wiring system which provides the unimpeded and constant flow of energy and electrical information to the electronic circuits concerned. Properly installed cables will contribute to the maximum of reliability in the system operation while cables which have been improperly installed will be a potential or immediate source of malfunction or failure in the electronics system. Proper planning, segregation, isolation and installation of the interconnection cables and wiring will improve operational efficiency by the reduction or complete elimination of cable and wire interaction and pickup. In order to attain a good installation the following general specifications must be followed:

(1) MATERIALS.–The materials used in the installation shall be those specified in plans or specifications and and shall not be replaced by substitute materials unless authorized by the controlling authorities.

(2) METHODS.–The methods of installation shall be in accordance with standards and the resultant installation shall be workmanlike, mechanically secure, electrically correct and efficient in operation. A neat and properly installed cable and wire system will materially aid maintenance, troubleshooting and corrective measures (if required).

(3) PROTECTION.–The interconnection cables and associated wires shall be properly protected (mechanically and electrically) by approved protective materials and methods of application in those cases where sources of any type of damage are apparent or suspected.

b. SCOPE.–This section describes and illustrates the approved materials and installation standards used in the installation of electronics systems interconnection cabling and wiring. It includes the information required in the installation process from the selection of required cables up to and including the wiring termination and connection to the equipment terminals. It does not include installation standards for coaxial cables and associated fittings which are covered in section 5, Radio Frequency Transmission Lines.

c. REFERENCE DOCUMENTS.–The materials and methods of installation are governed by the following documents:

(1) GENERAL SPECIFICATIONS FOR SHIPS OF THE UNITED STATES NAVY.
(2) BUSHIPS DRAWING #9000-6202-73980, Electrical Plant, Standard Installation Methods.
(3) MIL-A-2877.–Aluminum and aluminum alloy tape, colored.
(4) MIL-C-915.–Cable, cord and wire, electrical (shipboard use).
(5) MIL-C-5649.–Cord, cotton, braided, prewaxed.
(6) MIL-C-12599.–Coating, clear acrylic (pressurized dispenser).
(7) MIL-E-16366.–Electrical clamps, lug terminals and conductor splices, pressure grip.
(8) MIL-E-16400.–Electronic equipment, Naval ship and shore: General Specification.
(9) MIL-F-21608.–Ferrule, Shield grounding, Insulated, Crimp style, Brass.
(10) MIL-I-631.–Insulation, electrical, synthetic–resin composition, non–rigid.
(11) MIL-I-3190.–Insulation, Electrical, Sleeving, Flexible, Treated.
(12) MIL-I-3825.–Insulation tape, electrical (polyethylene–base), self–fusing).
(13) MIL-M-4528.–Marking machine, wire and plastic tubing, identification.
(14) MIL-P-18623.–Plastic coating compound, electrical cable splice sealing, Naval shipboard.
(15) MIL-S-572.–Synthetic fiber, organic, cords, yarns, and mono–filaments.
(16) MIL-S-19622.–Stuffing tubes (nylon).
(17) MIL-T-4053.–Tape, glass cloth, pressure sensitive, flame–proof.
(18) MIL-T-7928.–Terminals, lug and splice, crimp style, copper.
(19) MIL-T-15126.–Insulation tape, electrical, pressure sensitive, adhesive.
(20) MIL-T-15659.–Terminals; lug, solder type, copper.
(21) MIL-V-173.–Varnish, moisture and fungus resistant for the treatment of communications, electronic, and associated electrical equipment.
(22) JAN-T-713.–Twine and tape, lacing and tying (for use in electrical and electronic equipment).
(23) MIL-STD-440.–Soldering techniques for standard type solder terminals.
(24) MS-20659.–Terminal lug, crimp style, uninsulated.
(25) MS-25036.–Terminal, lug, crimp style, copper, insulated, Class 1.
(26) MS-25037.–Crimping tool, hand, for copper insulated terminals.
(27) MS-25311.–Ferrule, Shield grounding, One piece, Class 1, for coaxial and shielded cable.
(28) MS-25312.–Tool, Crimping, Hand, for insulated shield grounding ferrule.

d. DEFINITIONS.–Words or terms of multiple definition have been defined below in the proper meaning as used in this section.

(1) ARMOR.– A metallic sheath enclosing an electrical cable (used primarily for mechanical protection).

(2) BARREL.–The tubular portion of the lug terminal in which the conductor is soldered or crimped.

(3) BRANCH-OFF.–Two or more wires of a group which are separated and routed in a different direction from the remainder of the group.

(4) BREAK-OUT.–A single wire separated from a branch–off, or group, to connect to a designated terminal.

(5) CABLE.–One or more wires encased in an impervious insulating jacket or sheath.

(6) CONDUCTOR.–The basic metallic current carrying material used for the transfer of electrical energy. This conductor may be of solid or stranded construction.

(7) CRIMPING.–The application of a deforming pressure on the barrel of a lug terminal to force the lug terminal and conductor into a good mechanical and electrical connection.

(8) CRIMP LUG TERMINAL.–A conductor terminating device constructed of soft copper. The installation of the crimp lug terminal is effected, without the use of solder, by application of pressure with the crimping tool.

(9) FLUX.–A solution used to prevent oxidation of the metals while being soldered. Flux used in soldering conductors to copper lug terminals is a solution of water, white rosin and alcohol.

(10) FORM.–A combination of groups shaped and fastened together to make up a complete wire terminating system in an equipment unit or junction box.

(11) GROUP.–Two or more wires from one cable after the insulating jacket has been removed.

(12) JACKET.–An impervious insulating sheath enclosing the wire or group of wires in an electrical cable.

(13) LUG TERMINALS.–A lug terminal is a tie–point or terminating device used for convenience in making electrical connections. A solder lug terminal consists of a barrel, to which the soldered connection is made and a tongue end used for mechanical and electrical connection to the terminal stud or screw.

(14) SHIELD.–A braided metallic sheath enclosing a wire or wires to provide electrical insulation from circuits in other wires.

(15) SLEEVING.–Flexible composition tubing used for electrical insulation.

(16) SOLDER.–A fusible metallic alloy used when melted to join metallic surfaces. As used in this technique, solder is normally a rosin–cored wire conforming to composition SN60 of Federal Specification QQ–S–571.

(17) SOLDERING.–A metal joining process wherein the solder has a melting point lower than that of the metals being joined. A soldering opetation involves the partial forming of a new alloy between the solder and the metal that is soldered, due to a solvent action between the respective metals.

(18) TAG.–A label bearing identification or data pertinent to the item to which it is attached.

(19) TERMINAL.–This word, when used alone or in conjunction with stud or screw, indicates an electrical connection point on a unit of electronic equipment.

(20) TONGUE.–The flat portion of the lug terminal which establishes mechanical and electrical connection to the equipment terminal.

(21) TYING.–The securing or binding together of wires by means of individual cord ties to complete the form.

(22) WICKING.–The conduction (caused by capillary action) of melted solder along the strands of a stranded conductor.

(23) WIRE.–An insulated conductor.

**4-2. CABLE TYPES AND SELECTION.**—This sub-section describes the various current types of cable used in shipboard electrical and electronic installations. It includes the installation tabular data for each type of cable. Cables of the coaxial type are not included in this section.

a. CABLE TYPE AND SIZE.—Electrical cables used for supply and interconnection of electrical and electronic equipments are identified by "Type" letters and "Size" designating numbers.

(1) TYPE LETTERS.— The general construction of the cable is indicated by the type letters. These are the first letters of the words used in describing the general contruction of the cable.

EXAMPLE.—TYPE MHFA.— The general construction of this cable is multiple conductor, heat and flame resistant, armored.

(2) SIZE DESIGNATION.—The size designation is related to the conductors contained within the cable and may indicate one or more of the following:

(a) CONDUCTOR SIZE.—The conductor size is indicated by the approximate cross sectional area of the conductor expressed in thousands of circular mils.

EXAMPLE.—SSGA-9.—The circular mil area of the conductor in this cable would be approximately 9,000 circular mils.

(b) CONDUCTOR SIZE AND NUMBER OF STRANDS.—The approximate cross sectional area of the conductor in thousands of circular mils is indicated by the first number group and the number of strands in the conductor is indicated by the numbers in parentheses.

EXAMPLE.—SRI-1 1/2 (41).—The circular mil area of the conductor in this cable is approximately 1,500 circular mils and the conductor is made up of 41 individual strands.

(c) NUMBER OF CONDUCTORS.—The number of conductors contained within a multiple conductor cable will be indicated by the size number.

EXAMPLE.—MSCA-10.—This cable would contain 10 conductors of an identical circular mil area.

(d) TWISTED PAIRS.— The number of twisted pairs contained within a multiple conductor telephone type cable will be indicated by the size number (this also applies to cables with shielded twisted pairs).

EXAMPLE.—TTHFWA-20.—This cable would contain 20 twisted pairs of conductors with identical circular mil areas (a total of 40 individual conductors).

b. SPARE CONDUCTORS.—Cables selected for interconnection of Interior Communication, Fire Control and Electronic circuits shall have the required number of spare conductors as indicated in table 2-1. This table applies only to cables 75 feet or more in length which pierce a deck or bulkhead. Spare conductors will not be required for cables in which the individual conductor cross-sectional area exceeds 1,779 circular mils and for special application cables such as multiconductor shielded cable type MCOS or similar.

TABLE 2-1. SPARE CONDUCTORS

| COND. OR PAIRS | MULTI-CONDUCTOR ARMORED | | MULTI-CONDUCTOR FLEXIBLE | | TWISTED PAIR ARMORED | | TWISTED PAIR FLEXIBLE | |
|---|---|---|---|---|---|---|---|---|
| | A | S | A | S | A | S | A | S |
| 1 | -- | -- | -- | -- | 1 | 0 | -- | -- |
| 2 | 2 | 0 | 2 | 0 | -- | -- | -- | -- |
| 3 | 3 | 0 | 3 | 0 | 2 | 1 | 2 | 1 |
| 4 | 4 | 0 | 3 | 1 | -- | -- | -- | -- |
| 5 | -- | -- | -- | -- | 4 | 1 | 4 | 1 |
| 7 | 6 | 1 | 6 | 1 | -- | -- | -- | -- |
| 10 | 8 | 2 | 8 | 2 | 8 | 2 | 8 | 2 |
| 14 | 12 | 2 | 12 | 2 | -- | -- | -- | -- |
| 15 | -- | -- | -- | -- | 13 | 2 | 13 | 2 |
| 19 | 16 | 3 | 16 | 3 | -- | -- | -- | -- |
| 20 | -- | -- | -- | -- | 17 | 3 | -- | -- |
| 24 | 21 | 3 | 21 | 3 | -- | -- | -- | -- |
| 30 | 26 | 4 | 26 | 4 | 26 | 4 | -- | -- |
| 37 | 33 | 4 | 33 | 4 | -- | -- | -- | -- |
| 40 | -- | -- | -- | -- | 35 | 5 | -- | -- |
| 44 | 39 | 5 | 39 | 5 | -- | -- | -- | -- |
| 50 | -- | -- | -- | -- | 45 | 5 | -- | -- |
| 60 | -- | -- | -- | -- | 54 | 6 | -- | -- |

**NOTE**

"A" indicates the maximum permissible number of active conductors and "S" indicates the minimum number of spare conductors.

(1) TELEPHONE CABLES.—Telephone cables containing 30 or more active pairs which pass through or across a ballistic deck or bulkhead of 60 pound special treatment steel or heavier, or are installed in unbroken lengths of 30 feet or more must have at least 30 percent spare pairs (based on the number of active pairs). These spare pairs may be either in the same cables with the active pairs or in separate cables.

c. CABLE SELECTION.—When a cable is selected for use in interconnection or supply of an electronic system the rating of the cable installation must be considered before selecting the proper size of the cable.

(1) CABLE SERVICE RATINGS.—Cable installations are rated according to the ambient temperature of the area in which the cable will be installed for operation. The three cable ratings are as follows:

(a) GENERAL.—This would be a normal ambient heat condition (40 to 50 degrees centigrade) and would apply to most of the normal shipboard cable installations. The current ratings listed in the specific cable tables in this section are for the general service rating. Typical examples of this rating are:

EXAMPLE 1.—Cables installed in racks, with not more than three cables next to each other carrying current at the same time.

EXAMPLE 2.—Cables spaced one-half inch apart no matter how many of the cables are carrying current at the same time.

EXAMPLE 3.—Cables installed in armored trunks, when the load is intermittent and the armor is more than two inches thick.

(b) RESTRICTED.—This rating applies to cable installations in areas where the ambient temperature will be greater than normal (50 degrees centigrade or greater). When cables are installed where the restricted rating will apply, the current carrying capacity of the cable will be 15 percent less than the value given in the cable tables for general service rating.

**NOTE**

Install cables in such a manner the restricted rating need not be applied.

(c) ISOLATED.—This rating applies to cables installed in locations where heat producing objects or cables are not located close by or where insulation reduces the amount of heat that can reach the cable. Cables installed under this rating can be loaded 10 percent above the current carrying capacity for the general service rating. Typical examples of this rating are:

EXAMPLE 1.—Single cables supported in free air or clamped to steel or aluminum decks or bulkheads.

EXAMPLE 2.—Cables, in groups of two, clamped to decks or bulkheads of steel, aluminum or other materials which will rapidly dissipate the heat generated by the cables.

(2) CABLE SIZE.—The selection of a cable size to fit a particular installation is dependent on several factors which will assure proper operation of the cable and the associated equipment.

(a) REQUIRED INFORMATION.—The following information concerning the service the cable will furnish is necessary before the cable size can be determined:

1. LOAD.—Is the maximum connected load in amperes and is found by adding up the full-load ampere ratings of all the equipment connected to the circuit.

2. ADDITIONAL LOAD.—Any additional load in amperes due to future connection of added equipment. For interior communication, fire control and electronic systems, a spare load allowance of 10 percent shall be provided for main supply cables.

3. DEMAND FACTOR.—Is the ratio of the maximum load, averaged for a 15 minute period, to the total connected load on the cable. For power system cables supplying one single phase load, or for a lighting system branch, submain, and main circuits, or for interior communication, for control and electronic systems the demand factor shall be 1.0. If the feeder demand factor for a group of loads cannot be determined, a value of 0.9 shall be assumed.

4. CABLE SERVICE RATING.—These ratings are explained in paragraph c (1).

5. VOLTAGE DROP.—Is the maximum allowable voltage drop for the part of the circuit under consideration. The voltage drop values for electronic systems shall be calculated by using a conductor copper resistivity of 12 ohms per circular mil foot. The maximum allowable percentage of voltage drop in electronic unit interconnecting cables shall not exceed 2.0 percent.

**NOTE**

Paragraphs 1 through 4, above govern the size of the conductor necessary to carry the load without overheating. Paragraph 5 may call for an increase in the conductor size to reduce the circuit resistance enough to keep the voltage drop below the allowable value.

(b) PARALLELED CONDUCTORS.—Where paralleling of conductors is required to meet the voltage drop limitations, the number of parallel conductors per leg shall not exceed two and the total current carried shall not exceed the maximum current rating of the smallest of the paralleled conductors. Conductors shall not be paralleled to obtain additional current carrying capacity.

(c) RESULTANT LOAD.—The resultant load in amperes is found by adding the maximum connected load to the allowance for future load and multiplying this total by the demand factor. The cable service rating and the voltage drop must be considered before the cable is selected.

(d) VOLTAGE DROP.—The percentage of voltage drop is the difference in voltage between any two points in a circuit expressed as a percentage of the rated switchboard or transformer secondary no-load supply circuit voltage. For all electronic installations, the maximum allowable percentage of voltage drop from supply to equipment or unit for circuits above 100 volts is 2.0 percent. For circuits of less than 100 volts, such as control and interlock, the maximum allowable percentage of voltage drop is 5.0 percent. Since the majority of circuits use voltages above 100 volts, table 2-2 shows the number of feet of standard cable sizes that can be used at different loads without exceeding the 2.0 percent voltage drop. The figures in this table are approximate. If greater accuracy is desired, the voltage drop of the cable must be computed mathematically.

(e) USE OF TABLE 2–2.—Table 2–2 lists the approximate cable lengths in feet that can be used with various loads and not exceed the 2.0 maximum allowable voltage drop. The following two examples are given to demonstrate the use of the table:

EXAMPLE 1.—A cable size is desired to handle a 12 ampere, 117 volt, single phase load and the length of the run will be 69 feet. The cable size is obtained by reading vertically down the 12 ampere column to the figure slightly greater than 69 and then read the figure horizontally to the left in the Navy conductor size column. This indicates that a cable with a conductor size of approximately 9,000 circular mils is required for this installation.

EXAMPLE 2.—A cable size is desired to handle a 10 ampere, 117 volt, single phase load and the length of the run will be 25 feet. In this case the column under the one ampere head would be used and the length in feet would be divided by 10. This indicates that a cable with a conductor size of approximately 3,000 circular mils is required for this installation.

TABLE 2-2. CABLE SIZE AND LENGTH FOR 2% VOLTAGE DROP

| NAVY COND. SIZE | LOAD & CABLE LENGTH (FT)-DC OR 1Ø-117 VOLTS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 AMP | 3 AMP | 6 AMP | 12 AMP | 20 AMP | 30 AMP | 40 AMP | 50 AMP |
| -3 | 276 | 92 | 46 | 23 | - | - | - | - |
| -4 | 438 | 146 | 73 | 36 | 21 | - | - | - |
| -9 | 878 | 292 | 146 | 73 | 43 | 29 | 22 | - |
| -14 | 1397 | 466 | 233 | 116 | 70 | 46 | 35 | 28 |
| -23 | 2220 | 740 | 370 | 185 | 111 | 74 | 55 | 44 |
| -30 | 3004 | 1003 | 501 | 250 | 150 | 100 | 75 | 60 |
| -40 | 3794 | 1265 | 633 | 316 | 190 | 126 | 95 | 76 |
| -50 | 4785 | 1595 | 797 | 390 | 239 | 159 | 119 | 95 |
| NAVY COND. SIZE | LOAD & CABLE LENGTH (FT)-3Ø-117 VOLTS | | | | | | | |
| | 1 AMP | 3 AMP | 6 AMP | 12 AMP | 20 AMP | 30 AMP | 40 AMP | 50 AMP |
| -3 | 318 | 106 | 53 | 26 | - | - | - | - |
| -4 | 506 | 168 | 84 | 41 | 24 | - | - | - |
| -9 | 1012 | 337 | 168 | 84 | 49 | 33 | 25 | - |
| -14 | 1612 | 537 | 269 | 134 | 80 | 53 | 40 | 32 |
| -23 | 2560 | 853 | 427 | 213 | 128 | 85 | 63 | 50 |
| -30 | 3470 | 1160 | 577 | 292 | 173 | 115 | 86 | 69 |
| -40 | 4375 | 1460 | 731 | 364 | 219 | 145 | 109 | 88 |
| -50 | 5520 | 1840 | 918 | 449 | 275 | 183 | 137 | 109 |

## NOTES

1.—Where the line voltage is 220 volts, multiply the maximum allowable length by 1.88.
2.—Where the line voltage is 440 volts, multiply the maximum allowable length by 3.76.
3.—For applications where MHFA and MSCA are used, limit the current rating of each conductor to ½ ampere. With a load of ½ ampere through a single phase circuit, the following maximum length of cable may be run to keep under the 2% voltage drop requirements:

a. MHFA (2828 CM)—552 feet.
b. MSCA (1779 CM)—347 feet.

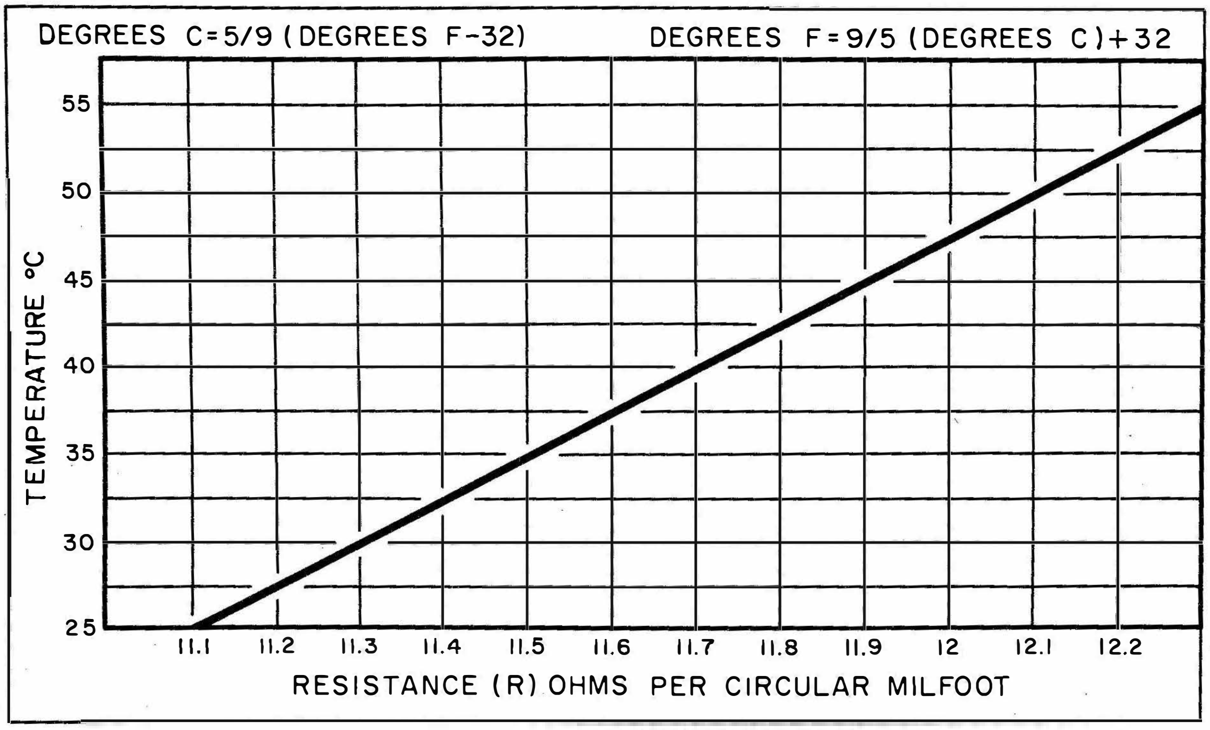
(f) MATHEMATICAL CALCULATION OF CABLE LENGTH.—If a more accurate calculation of cable size, length and voltage drop is desired, this may be determined by the following formula (for single phase operation):

$$= \frac{(\%VD)\ (CM)\ (E)}{(R)\ (2)\ (I) \times 100} \qquad (1)$$

where %VD=2=Percentage of voltage drop,
CM=Circular mil area of one conductor,
E=Supply voltage,
R=12=Resistivity of copper in circular mil feet at a given temperature (see figure 2–1),
and I=Total load current in amperes,
then l=Length of cable that may be installed without exceeding the 2.0% voltage drop.

**NOTE**

If the cable length is calculated for a supply voltage of 117 volts it may be converted to 220 volt operation by multiplying the cable length by 1.88 and to 440 volt operation by multiplying the cable length by 3.76. For three phase operation the cable length obtained by the fomula in multiplied by 1.15 for cable lengths of corresponding conductor size and load.




2-1 RESISTIVITY OF COPPER

d. THERMOCOUPLE CABLE COLOR CODE.—Thermocouple cables, types TCTX, TCKX and TCJX, are constructed for operation in high ambient temperatures. The color code for the thermocouple cable conductor pairs is listed in table 2–3.

TABLE 2-3. THERMOCOUPLE CABLE COLOR CODE.

| PAIR NO. | CONSTANTAN OR ALUMEL | IRON, COPPER, OR CHROMEL | |
|---|---|---|---|
| | | BASE COLOR | TRACER COLOR |
| 1 | Red | White | ------- |
| 2 | Red | Black | ------- |
| 3 | Red | Green | ------- |
| 4 | Red | Orange | ------- |
| 5 | Red | Blue | ------- |
| 6 | Red | White | Black |
| 7 | Red | White | Green |
| 8 | Red | White | Orange |
| 9 | Red | White | Blue |
| 10 | Red | White | Red |
| 11 | Red | Black | White |
| 12 | Red | Green | White |

e. CABLE DATA TABLES.—The cable data tables are arranged to furnish all of the necessary information on one particular "family" of cable types in two tables. The first table lists the physical and electrical characteristics of the cable or cables of that type and the second table lists the necessary data required for installation of the cables. The current types of cables and the pertinent tables are listed below:

(1) Communication and Fire Control, Non–Flexing Service.
MSCA ........ Tables 2–4 and 2–5
(2) Degaussing–Merchant Marine, Non–Flexing Service.
DDGT ........ Tables 2–6 and 2–7
MDGD ........ Tables 2–8 and 2–9
MDGT ........ Tables 2–10 and 2–11
MDGY ........ Tables 2–12 and 2–13
(3) Degaussing–Navy, Non–Flexing Service.
MDGA ........ Tables 2–14 and 2–15
MDGB ........ Tables 2–16 and 2–17
MDGL ........ Tables 2–18 and 2–19
SDGA ........ Tables 2–20 and 2–21
SDU ........ Tables 2–22 and 2–23
(4) Electronics, Non–Flexing Service.
DHFR ........ Tables 2–24 and 2–25
SHFR ........ Tables 2–26 and 2–27
THFR ........ Tables 2–28 and 2–29
(5) Electronics (Telephone and RF), Non–Flexing Service.
TTRSA ........ Tables 2–30 and 2–31
(6) Electronics (Telephone and RF), Repeated Flexing Service.
TTRS ........ Tables 2–32 and 2–33
(7) Ignition, Repeated Flexing Service.
CVSF ........ Tables 2–34 and 2–35
(8) Lighting and Power, Non–Flexing Service.
DSGA ........ Tables 2–36 and 2–37
FSGA ........ Tables 2–38 and 2–39
SSGA ........ Tables 2–40 and 2–41
TSGA ........ Tables 2–42 and 2–43

## TABLE 2-4 CABLE CHARACTERISTICS

CABLE TYPE: MSCA

USE: Communication and Fire Control, Non-Flexing Service.

DESCRIPTION: Multi-conductor, shipboard, control, armored, watertight. Conductor insulation: Glass braid over silicone rubber. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

* Denotes-Individual Averages.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 7 | 7 | 7 | 1779 | 0.048 | 0.534 | 600 | *9/6 |
| 10 | 10 | 7 | 1779 | 0.048 | 0.672 | 600 | *9/6 |
| 14 | 14 | 7 | 1779 | 0.048 | 0.718 | 600 | *9/6 |
| 19 | 19 | 7 | 1779 | 0.048 | 0.788 | 600 | *9/6 |
| 24 | 24 | 7 | 1779 | 0.048 | 0.905 | 600 | *9/5 |
| 30 | 30 | 7 | 1779 | 0.048 | 0.951 | 600 | *9/5 |
| 37 | 37 | 7 | 1779 | 0.048 | 1.022 | 600 | *9/5 |
| 44 | 44 | 7 | 1779 | 0.048 | 1.134 | 600 | *9/4 |

## TABLE 2-5 INSTALLATION DATA

CABLE TYPE: MSCA

USE: Communication and Fire Control, Non-Flexing Service.

DESCRIPTION: Multi-conductor, shipboard, control, armored, watertight. Conductor insulation: Glass braid over silicone rubber. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 7 | 3.5 | C | 3/8A | 2 | 16178-5 | 1/2 | 3/4 |
| 10 | 4.0 | D | 3/4 | 4 | 16179-4 | 3/4 | 3/4 |
| 14 | 4.5 | D | 3/4 | 4 | 16179-5 | 3/4 | 3/4 |
| 19 | 5.0 | F | 3/4 | 4 | 16179-7 | 3/4 | 1 |
| 24 | 5.5 | G | 1S | 5 | 16189-2 | 1 | 1 |
| 30 | 6.0 | J | 1 | 5 | 16189-3 | 1 | 1-1/4 |
| 37 | 6.0 | J | 1-1/4 | 5 | 16189-4 | 1 | 1-1/4 |
| 44 | 7.0 | K | 1-1/4 | 5 | 16189-7 | 1-1/4 | 1-1/4 |

## TABLE 2-6 CABLE CHARACTERISTICS

CABLE TYPE DDCT

USE Degaussing-Merchant Marine, Non-Flexing Service.

DESCRIPTION: Double conductor, degaussing, duck tape covered. Conductor insulation: Synthetic resin for size 17; varnished cambric over oil pre-impregnated paper for sizes larger than 17, and a cotton braid over all sizes. Cable insulation: Impervious sheath (no further covering for size 17), duck tape or compound-filler tape and outer braid.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C M AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M | INCH | INCH | VRMS | AMPS |
| 17 | 2 | 7 | 16,510 | 0.146 | 0.83 | 600 | -- |
| 53 | 2 | 7 | 52,630 | 0.260 | 1.14 | 600 | -- |
| 105 | 2 | 19 | 105,500 | 0.373 | 1.46 | 600 | -- |
| 212 | 2 | 37 | 211,600 | 0.529 | 1.78 | 600 | -- |
| 400 | 2 | 61 | 400,000 | 0.729 | 2.25 | 600 | -- |

## TABLE 2-7 INSTALLATION DATA

CABLE TYPE: DDGT

USE: Degaussing-Merchant Marine, Non-Flexing Service.

DESCRIPTION: Double conductor, degaussing, duck tape covered. Conductor insulation: synthetic resin for size 17; varnished cambric over pre-impregnated paper for sizes larger than 17, and a cotton braid over all sizes. Cable insulation: Impervious sheath (no further covering for size 17), duck tape or compound-filler tape and outer braid.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 17 | 5.0 | G | 1S | 5 | 16189-1 | 3/4 | 1 |
| 53 | 7.0 | K | 1-1/4 | 5 | 16189-4 | 1-1/4 | 1-1/4 |
| 106 | 9.0 | N | 1-1/2 | 6 | 16190-4 | 1-1/4 | 1-1/2 |
| 212 | 11.0 | S | 2 | 7 | 16191-3 | ----- | 2 |
| 400 | 13.5 | W | 2-1/2 | 8 | 16192-7 | ----- | 2-1/2 |

## TABLE 2-8 CABLE CHARACTERISTICS

CABLE TYPE: MDGD

USE: Degaussing-Merchant Marine, Non-Flexing Service

DESCRIPTION: Multi-conductor, degaussing, control. Conductor insulation: Cotton braid over synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3(14) | 3 | 7 | 4107 | 0.073 | 0.590 | 600 | 8 |
| 7(14) | 7 | 7 | 4107 | 0.073 | 0.720 | 600 | 6 |

## TABLE 2-9 INSTALLATION DATA

CABLE TYPE: MDGD

USE: Degaussing-Merchant Marine, Non-Flexing Service

DESCRIPTION: Multi-conductor, degaussing, control. Conductor insulation: Cotton braid over synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3(14) | 3.5 | C | 1/2 | 4 | 16179-3 | 1/2 | 3/4 |
| 7(14) | 4.5 | E | 3/4 | 4 | 16179-7 | 3/4 | 1 |

TABLE 2-10 CABLE CHARACTERISTICS

CABLE TYPE: MDGT

USE: Degaussing-Merchant Marine, Non-Flexing Service

DESCRIPTION: Multi-conductor, degaussing, duck tape covered. Conductor insulation: Varnished cambric over preimpregnated paper and an inner braid of cotton. Cable insulation: Impervious sheath, duck tape or compound-filled tape, and an outer cotton braid.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 91(9) | 91 | 7 | 13,090 | 0.130 | 2.75 | 600 | --- |
| 34(4) | 34 | 7 | 41,740 | 0.232 | 2.75 | 600 | --- |
| 30(3) | 30 | 7 | 52,630 | 0.260 | 2.75 | 600 | --- |
| 24(2) | 24 | 7 | 66,370 | 0.292 | 2.75 | 600 | --- |

TABLE 2-11 INSTALLATION DATA

CABLE TYPE: MDGT

USE: Degaussing-Merchant Marine, Non-Flexing Service

DESCRIPTION: Multi-conductor, degaussing, duck tape covered. Conductor insulation: Varnished cambric over preimpregnated paper and an inner braid of cotton. Cable insulation: Impervious sheath, duck tape or compound-filled tape, and an outer cotton braid.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 91(9) | 16.5 | Z | 3 | 9 | 16193-7 | -- | 3 |
| 34(4) | 16.5 | Z | 3 | 9 | 16193-7 | -- | 3 |
| 30(3) | 16.5 | Z | 3 | 9 | 16193-7 | -- | 3 |
| 24(2) | 16.5 | Z | 3 | 9 | 16193-7 | -- | 3 |

## TABLE 2-12 CABLE CHARACTERISTICS

CABLE TYPE: MDGY

USE: Degaussing-Merchant Marine, Non-Flexing Service

DESCRIPTION: Multi-conductor, degaussing, steel tape armored. Conductor insulation: Synthetic rubber. Cable insulation: Impervious sheath, duck tape or compound-filled tape, outer cotton braid or jute bedding, and galvanized steel tape armor overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 17(4) | 17 | 7 | 41,740 | 0.232 | 2.45 | ---- | ---- |
| 15(3) | 15 | 7 | 52,630 | 0.260 | 2.45 | ---- | ---- |
| 12(2) | 12 | 7 | 66,370 | 0.282 | 2.45 | ---- | ---- |

## TABLE 2-13 INSTALLATION DATA

CABLE TYPE: MDGY

USE: Degaussing-Merchant Marine, Non-Flexing Service

DESCRIPTION: Multi-conductor, degaussing, steel tape armored. Conductor insulation: Synthetic rubber. Cable insulation: Impervious sheath, duck tape or compound-filled tape, outer cotton braid or jute bedding, and galvanized steel tape armor overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 17(4) | 20.0 | X | 2-1/2 | 9 | 16193-3 | --- | 3 |
| 15(3) | 20.0 | X | 2-1/2 | 9 | 16193-3 | --- | 3 |
| 12(2) | 20.0 | X | 2-1/2 | 9 | 16193-3 | --- | 3 |

## TABLE 2-14 CABLE CHARACTERISTICS

CABLE TYPE: MDGA

USE: Degaussing-Navy, Non-Flexing Service.

DESCRIPTION: Multi-conductor, degaussing, armored, watertight. Conductor insulation: Varnished cambric over felted asbestos or glass fiber and an inner braid of rayon impregnated with a moisture and flame retardant compound. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 19(6) | 19 | 7 | 6512 | 0.092 | 1.285 | 600 | 11 |
| 19(14) | 19 | 7 | 14,340 | 0.136 | 1.520 | 600 | 17.5 |
| 19(23) | 19 | 7 | 22,800 | 0.171 | 1.820 | 600 | 24 |
| 19(40) | 19 | 19 | 38,910 | 0.226 | 2.100 | 600 | 35 |

## TABLE 2-15 INSTALLATION DATA

CABLE TYPE: MDGA

USE: Degaussing-Navy, Non-Flexing Service.

DESCRIPTION: Multi-conductor, degaussing, armored, watertight. Conductor insulation: Varnished cambric over felted asbestos or glass fiber and an inner braid of rayon impregnated with a moisture and flame retardant compound. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 19(6) | 8.0 | M | 1-1/2 | 6 | 16190-2 | 1-1/4 | 1-1/2 |
| 19(14) | 9.5 | P | 2 | 6 | 16190-7 | ----- | 2 |
| 19(23) | 10.5 | S | 2 | 8 | 16192-2 | ----- | 2 |
| 19(40) | 12.5 | V | 2-1/2 | 8 | 16192-7 | ----- | 2-1/2 |

## TABLE 2-16 CABLE CHARACTERISTICS

CABLE TYPE: MDGB

USE: Degaussing-Navy, Non-Flexing Service.

DESCRIPTION: Multi-conductor, degaussing, binnacle, watertight. Conductor insulation: Synthetic resin. Cable insulation: Gray impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 12(1-1/2) | 12 | 7 | 1779 | 0.048 | 0.590 | 300 | 1 |

## TABLE 2-17 INSTALLATION DATA

CABLE TYPE: MDGB

USE: Degaussing-Navy, Non-Flexing Service.

DESCRIPTION: Multi-conductor, degaussing, binnacle, watertight. Conductor insulation: Synthetic resin. Cable insulation: Gray impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 12(1-1/2) | 8.0 | C | 1/2 | 4 | 16179-3 | 1/2 | 3/4 |

TABLE 2-18 CABLE CHARACTERISTICS

CABLE TYPE: MDGL

USE: Degaussing-Navy, Non-Flexing Service

DESCRIPTION: Multi-conductor, degaussing, leaded, watertight. Conductor insulation: Varnished cambric over felted asbestos or glass fiber and an inner braid of rayon impregnated with a moisture and flame retardant compound. Cable insulation: Duck tape or tape and an outer cotton braid over a lead sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 19(6) | 19 | 7 | 6512 | 0.092 | 1.285 | 600 | 13 |
| 19(14) | 19 | 7 | 14,340 | 0.136 | 1.550 | 600 | 22.5 |

## TABLE 2-19 INSTALLATION DATA

CABLE TYPE: MDGL

USE: Degaussing-Navy, Non-Flexing Service

DESCRIPTION: Multi-conductor, degaussing, leaded, watertight. Conductor insulation: Varnished cambric over felted asbestos or glass fiber and an inner braid of rayon impregnated with a moisture and flame retardant compound. Cable insulation: Duck tape or tape and an outer cotton braid over a lead sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 19(6) | 7.5 | M | 1-1/2 | 5 | 16189-9 | 1-1/4 | 1-1/2 |
| 19(14) | 9.0 | P | 2 | 6 | 16190-7 | ----- | 2 |

# TABLE 2-20 CABLE CHARACTERISTICS

CABLE TYPE: SDGA

USE: Degaussing-Navy, Non-Flexing Service.

DESCRIPTION: Single conductor, degaussing, armored, watertight. Conductor insulation: Varnished cambric over felted asbestos or glass fiber. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 400 | 1 | 127 | 413,600 | 0.742 | 1.270 | 600 | 440 |
| 500 | 1 | 127 | 521,600 | 0.832 | 1.360 | 600 | 520 |
| 650 | 1 | 127 | 657,600 | 0.936 | 1.460 | 600 | 610 |
| 800 | 1 | 127 | 829,300 | 1.050 | 1.580 | 600 | 710 |
| 1000 | 1 | 127 | 1,046,000 | 1.180 | 1.710 | 600 | 830 |
| 1300 | 1 | 127 | 1,318,000 | 1.325 | 1.880 | 600 | 980 |
| 1600 | 1 | 127 | 1,662,000 | 1.485 | 2.030 | 600 | 1120 |
| 2000 | 1 | 127 | 2,097,000 | 1.670 | 2.240 | 600 | 1280 |

## TABLE 2-21 INSTALLATION DATA

CABLE TYPE: SDGA

USE: Degaussing-Navy, Non-Flexing Service.

DESCRIPTION: Single conductor, degaussing, armored, watertight. Conductor insulation: Varnished cambric over felted asbestos or glass fiber. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 400 | 10.0 | M | 1-1/2 | 6 | 16190-2 | 1-1/4 | 1-1/2 |
| 500 | 10.0 | M | 1-1/2 | 6 | 16190-4 | 1-1/4 | 1-1/2 |
| 650 | 11.0 | N | 1-1/2 | 6 | 16190-6 | 1-1/4 | 1-1/2 |
| 800 | 12.0 | P | 2 | 7 | 16191-1 | ----- | 2 |
| 1000 | 12.0 | R | 2 | 7 | 16191-3 | ----- | 2 |
| 1300 | 13.0 | T | 2 | 8 | 16192-3 | ----- | 2-1/2 |
| 1600 | 13.0 | T | 2-1/2 | 8 | 16192-6 | ----- | 2-1/2 |
| 2000 | 14.0 | W | 2-1/2 | 9 | 16193-1 | ----- | 2-1/2 |

## TABLE 2-22 CABLE CHARACTERISTICS

CABLE TYPE: SDU

USE: Degaussing-Navy, Non-Flexing Service.

DESCRIPTION: Single conductor, degaussing, unarmored, watertight. Conductor insulation: Butyl rubber. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 500 | 1 | 127 | 521,600 | 0.832 | 1.210 | 300 | 588 |
| 800 | 1 | 127 | 829,300 | 1.050 | 1.465 | 300 | 820 |

## TABLE 2-23 INSTALLATION DATA

CABLE TYPE: SDU

USE: Degaussing-Navy, Non-Flexing Service.

DESCRIPTION: Single conductor, degaussing, unarmored, watertight. Conductor insulation: Butyl rubber. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 500 | 7.5 | L | 1-1/4 | 6 | 16190-2 | 1-1/4 | 1-1/4 |
| 800 | 9.0 | N | 1-1/2 | 6 | 16190-7 | 1-1/4 | 1-1/2 |

## TABLE 2-24 CABLE CHARACTERISTICS

CABLE TYPE: DHFR

USE: Electronics, Non-Flexing Service.

DESCRIPTION: Double conductor, heat and flame resistant, radio, watertight. Conductor insulation: Varnished cambric over synthetic resin with a wall of felted asbestos or glass fiber. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 4 | 2 | 7 | 4497 | 0.076 | 0.844 | 3000 | 24 |

## TABLE 2-25 INSTALLATION DATA

CABLE TYPE: DHFR

USE: Electronics, Non-Flexing Service.

DESCRIPTION: Double conductor, heat and flame resistant, radio, watertight. Conductor insulation: Varnished cambric over synthetic resin with a wall of felted asbestos or glass fiber. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 4 | 5.5 | G | 1S | 4 | 16179-9 | 3/4 | 1 |

# TABLE 2-26 CABLE CHARACTERISTICS

CABLE TYPE: SHFR

USE: Electronics, Non-Flexing Service.

DESCRIPTION: Single conductor, heat and flame resistant, radio, watertight. Conductor insulation: Varnished cambric over synthetic resin. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 4 | 1 | 7 | 4497 | 0.076 | 0.540 | 3000 | 30 |

# TABLE 2-27 INSTALLATION DATA

CABLE TYPE: SHFR

USE: Electronics, Non-Flexing Service.

DESCRIPTION: Single conductor, heat and flame resistant, radio, watertight. Conductor insulation: Varnished cambric over synthetic resin. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 4 | 3.5 | C | 3/8A | 4 | 16179-1 | 1/2 | 3/4 |

## TABLE 2-28 CABLE CHARACTERISTICS

CABLE TYPE: THFR

USE: Electronics, Non-Flexing Service.

DESCRIPTION: Triple conductor, heat and flame resistant, radio, watertight. Conductor insulation: Varnished cambric over synthetic resin with a wall of felted asbestos or glass fiber. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 4 | 3 | 7 | 4497 | 0.076 | 0.883 | 3000 | 22 |

## TABLE 2-29 INSTALLATION DATA

CABLE TYPE: THFR

USE: Electronics, Non-Flexing Service.

DESCRIPTION: Triple conductor, heat and flame resistant, radio, watertight. Conductor insulation: Varnished cambric over synthetic resin with a wall of felted asbestos or glass fiber. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 4 | 5.5 | G | 1S | 5 | 16189-1 | 1 | 1 |

# TABLE 2-30 CABLE CHARACTERISTICS

CABLE TYPE: TTRSA

USE: Telephone and RF, Non-Flexing Service.

DESCRIPTION: Twisted shielded pair, radio, armored. Conductor insulation: Polythene over each conductor with an inner cotton braid over a braided copper shield on each pair. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 2 | 4 | 7 | 1119 | 0.038 | 0.740 | 300 | ---- |
| 4 | 8 | 7 | 1119 | 0.038 | 0.800 | 300 | ---- |
| 6 | 12 | 7 | 1119 | 0.038 | 0.940 | 300 | ---- |
| 8 | 16 | 7 | 1119 | 0.038 | 1.050 | 300 | ---- |
| 10 | 20 | 7 | 1119 | 0.038 | 1.140 | 300 | ---- |
| 12 | 24 | 7 | 1119 | 0.038 | 1.160 | 300 | ---- |
| 16 | 32 | 7 | 1119 | 0.038 | 1.250 | 300 | ---- |

# TABLE 2-31 INSTALLATION DATA

CABLE TYPE: TTRSA

USE: Telephone and RF, Non-Flexing Service.

DESCRIPTION: Twisted shielded pair, radio, armored. Conductor insulation: Polythene over each conductor with an inner cotton braid over a braided copper shield on each pair. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 2 | 5.0 | E | 3/4 | 4 | 16179-5 | 3/4 | 1 |
| 4 | 5.0 | F | 1S | 4 | 16179-7 | 3/4 | 1 |
| 6 | 6.0 | J | 1S | 5 | 16189-3 | 1 | 1-1/4 |
| 8 | 6.5 | K | 1-1/4 | 5 | 16189-4 | 1 | 1-1/4 |
| 10 | 7.0 | K | 1-1/4 | 5 | 16189-7 | 1-1/4 | 1-1/4 |
| 12 | 7.0 | L | 1-1/4 | 5 | 16189-8 | 1-1/4 | 1-1/4 |
| 16 | 7.5 | M | 1-1/4 | 6 | 16190-1 | 1-1/4 | 1-1/2 |

TABLE 2-32 CABLE CHARACTERISTICS

CABLE TYPE: TTRS

USE: Telephone and RF, Repeated Flexing Service.

DESCRIPTION: Twisted shielded pair, radio flexible. Conductor insulation: Polythene over each conductor with an inner cotton braid over a braid copper shield on each pair. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 2 | 4 | 7 | 1119 | 0.038 | 0.680 | 300 | --- |
| 4 | 8 | 7 | 1119 | 0.038 | 0.740 | 300 | --- |
| 6 | 12 | 7 | 1119 | 0.038 | 0.880 | 300 | --- |
| 8 | 16 | 7 | 1119 | 0.038 | 0.990 | 300 | --- |
| 10 | 20 | 7 | 1119 | 0.038 | 1.080 | 300 | --- |
| 12 | 24 | 7 | 1119 | 0.038 | 1.100 | 300 | --- |
| 16 | 32 | 7 | 1119 | 0.038 | 1.190 | 300 | --- |

## TABLE 2-33 INSTALLATION DATA

CABLE TYPE: TTRS

USE: Telephone and RF, Repeated Flexing Service.

DESCRIPTION: Twisted shielded pair, radio flexible. Conductor insulation: Polythene over each conductor with an inner cotton braid over a braid copper shield on each pair. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 2 | ---- | D | 3/4 | 4 | 16179-5 | 3/4 | 3/4 |
| 4 | ---- | E | 3/4 | 4 | 16179-7 | 3/4 | 1 |
| 6 | ---- | G | 1S | 5 | 16189-3 | 1 | 1 |
| 8 | ---- | J | 1 | 5 | 16189-5 | 1 | 1-1/4 |
| 10 | ---- | K | 1-1/4 | 5 | 16189-8 | 1 | 1-1/4 |
| 12 | ---- | K | 1-1/4 | 5 | 16189-9 | 1 | 1-1/4 |
| 16 | ---- | L | 1-1/4 | 6 | 16190-2 | 1-1/4 | 1-1/4 |

## TABLE 2-34 CABLE CHARACTERISTICS

CABLE TYPE: CVSF

USE: Ignition, Repeated Flexing Service.

DESCRIPTION: Combination, aircraft carrier, special purpose, flexible. Conductor insulation: Three conductors, size 53(532) and one pair (2 conductors), size 2-1/2 (26) with synthetic or butyl rubber. One conductor, size 33(336) un-insulated. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 6 | 6 | 2 of 26 | 2613 | 0.061 | 1.450 | 600 | -- |
| | 1 | of 336 | 33,370 | 0.235 | | | |
| | 3 | of 532 | 53,470 | 0.304 | | | |

## TABLE 2-35 INSTALLATION DATA

CABLE TYPE: CVSF

USE: Ignition, Repeated Flexing Service.

DESCRIPTION: Combination, aircraft carrier, special purpose, flexible. Conductor insulation: Three conductors, size 53(532) and one pair (2 conductors), size 2-1/2 (26) with synthetic or butyl rubber. One conductor, size 33(336) un-insulated. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 6 | 9.0 | N | 1-1/2 | 6 | 16190-7 | 1-1/4 | 1-1/2 |

## TABLE 2-36 CABLE CHARACTERISTICS

CABLE TYPE: DSGA

USE: Lighting and Power, Non-Flexing Service.

DESCRIPTION: Double conductor, shipboard general use, armored, watertight. Conductor insulation: Sizes 3, 4, and 9 with woven glass braid over silicone rubber; sizes 14 and larger with silicone rubber treated glass tape. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 2 | 7 | 2828 | 0.060 | 0.441 | 1000 | 12 |
| 4 | 2 | 7 | 4497 | 0.076 | 0.477 | 1000 | 20 |
| 9 | 2 | 7 | 9016 | 0.108 | 0.594 | 1000 | 41 |
| 14 | 2 | 7 | 14,340 | 0.136 | 0.680 | 1000 | 55 |
| 23 | 2 | 7 | 22,800 | 0.171 | 0.781 | 1000 | 72 |
| 30 | 2 | 19 | 30,860 | 0.202 | 0.852 | 1000 | 87 |
| 40 | 2 | 19 | 38,910 | 0.226 | 0.898 | 1000 | 100 |
| 50 | 2 | 19 | 49,080 | 0.254 | 0.961 | 1000 | 116 |
| 60 | 2 | 37 | 60,090 | 0.282 | 1.031 | 1000 | 132 |
| 75 | 2 | 37 | 75,780 | 0.317 | 1.124 | 1000 | 155 |
| 100 | 2 | 61 | 99,060 | 0.363 | 1.217 | 1000 | 183 |
| 125 | 2 | 61 | 124,900 | 0.407 | 1.374 | 1000 | 210 |
| 150 | 2 | 61 | 157,600 | 0.457 | 1.479 | 1000 | 246 |
| 200 | 2 | 61 | 198,700 | 0.514 | 1.633 | 1000 | 284 |
| 250 | 2 | 61 | 250,500 | 0.577 | 1.759 | 1000 | 332 |
| 300 | 2 | 91 | 296,400 | 0.628 | 1.891 | 1000 | 380 |
| 400 | 2 | 127 | 413,600 | 0.742 | 2.119 | 1000 | 453 |

# TABLE 2-37 INSTALLATION DATA

CABLE TYPE: DSGA

USE: Lighting and Power, Non-Flexing Service.

DESCRIPTION: Double conductor, shipboard general use, armored,water-tight. Conductor insulation: Sizes 3, 4, and 9 with woven glass braid over silicone rubber; sizes 14 and larger with silicone rubber treated glass tape. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | 3.0 | B | 3/8A | 2 | 16178-3 | 1/2 | 1/2 |
| 4 | 3.0 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |
| 9 | 4.0 | C | 1/2 | 4 | 16179-2 | 1/2 | 3/4 |
| 14 | 4.5 | D | 3/4 | 4 | 16179-4 | 3/4 | 3/4 |
| 23 | 5.0 | E | 3/4 | 4 | 16179-7 | 3/4 | 1 |
| 30 | 5.5 | G | 1S | 5 | 16189-1 | 3/4 | 1 |
| 40 | 5.5 | G | 1S | 5 | 16189-2 | 1 | 1 |
| 50 | 6.0 | J | 1S | 5 | 16189-3 | 1 | 1-1/4 |
| 60 | 6.5 | J | 1-1/4 | 5 | 16189-4 | 1 | 1-1/4 |
| 75 | 7.0 | K | 1-1/4 | 5 | 16189-7 | 1 | 1-1/4 |
| 100 | 7.5 | L | 1-1/4 | 5 | 16189-9 | 1-1/4 | 1-1/4 |
| 125 | 8.5 | M | 1-1/2 | 6 | 16190-4 | 1-1/4 | 1-1/2 |
| 150 | 9.0 | N | 1-1/2 | 6 | 16190-6 | 1-1/4 | 1-1/2 |
| 200 | 10.0 | R | 2 | 7 | 16191-2 | ----- | 2 |
| 250 | 10.5 | S | 2 | 8 | 16192-1 | ----- | 2 |
| 300 | 11.5 | T | 2 | 8 | 16192-3 | ----- | 2-1/2 |
| 400 | 13.0 | V | 2-1/2 | 8 | 16192-7 | ----- | 2-1/2 |

## TABLE 2-38 CABLE CHARACTERISTICS

CABLE TYPE: FSGA

USE: Lighting and Power, Non-Flexing Service.

DESCRIPTION: Four conductor, shipboard general use, armored water-tight. Conductor insulation: Sizes 3, 4 and 9 with woven glass braid over silicone rubber; sizes 23 and 50 with silicone rubber treated glass tape. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 4 | 7 | 2828 | 0.060 | 0.497 | 1000 | 10 |
| 4 | 4 | 7 | 4497 | 0.076 | 0.563 | 1000 | 17 |
| 9 | 4 | 7 | 9016 | 0.108 | 0.680 | 1000 | 36 |
| 23 | 4 | 7 | 22,800 | 0.171 | 0.890 | 1000 | 57 |
| 50 | 4 | 19 | 49,080 | 0.254 | 1.100 | 1000 | 89 |

## TABLE 2-39 INSTALLATION DATA

CABLE TYPE: FSGA

USE: Lighting and Power, Non-Flexing Service.

DESCRIPTION: Four conductor, shipboard general use, armored watertight. Conductor insulation: Sizes 3, 4 and 9 with woven glass braid over silicone rubber; sizes 23 and 50 with silicone rubber treated glass tape. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | 3.0 | C | 3/8A | 2 | 16178-4 | 1/2 | 3/4 |
| 4 | 3.5 | C | 1/2 | 4 | 16179-1 | 1/2 | 3/4 |
| 9 | 4.5 | D | 3/4 | 4 | 16179-4 | 3/4 | 3/4 |
| 23 | 5.5 | G | 1S | 5 | 16189-2 | 1 | 1 |
| 50 | 6.5 | K | 1-1/4 | 5 | 16189-8 | 1 | 1-1/4 |

## TABLE 2-40 CABLE CHARACTERISTICS

CABLE TYPE: SSGA

USE: Lighting and Power, Non-Flexing Service.

DESCRIPTION: Single conductor, shipboard, general use, armored, watertight. Cable insulation: Sizes 3, 4 and 9 with glass braid over silicone rubber; sizes 14 and larger with silicone rubber treated glass tape. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 1 | 7 | 2828 | 0.060 | 0.305 | 1000 | 14 |
| 4 | 1 | 7 | 4497 | 0.076 | 0.323 | 1000 | 24 |
| 9 | 1 | 7 | 9016 | 0.108 | 0.371 | 1000 | 49 |
| 14 | 1 | 7 | 14,340 | 0.136 | 0.414 | 1000 | 65 |
| 23 | 1 | 7 | 22,800 | 0.171 | 0.453 | 1000 | 85 |
| 30 | 1 | 19 | 30,860 | 0.202 | 0.484 | 1000 | 104 |
| 40 | 1 | 19 | 38,910 | 0.226 | 0.515 | 1000 | 119 |
| 50 | 1 | 19 | 49,080 | 0.254 | 0.570 | 1000 | 137 |
| 75 | 1 | 37 | 75,780 | 0.317 | 0.652 | 1000 | 181 |
| 100 | 1 | 61 | 99,060 | 0.363 | 0.719 | 1000 | 214 |
| 150 | 1 | 61 | 157,600 | 0.457 | 0.844 | 1000 | 289 |
| 200 | 1 | 61 | 198,700 | 0.514 | 0.922 | 1000 | 332 |
| 300 | 1 | 91 | 296,400 | 0.628 | 1.051 | 1000 | 430 |
| 400 | 1 | 127 | 413,600 | 0.742 | 1.168 | 1000 | 530 |
| 500 | 1 | 127 | 521,600 | 0.832 | 1.290 | 1000 | 618 |
| 650 | 1 | 127 | 657,600 | 0.936 | 1.421 | 1000 | 722 |
| 800 | 1 | 127 | 829,300 | 1.050 | 1.535 | 1000 | 865 |

## TABLE 2-41 INSTALLATION DATA

CABLE TYPE: SSGA

USE: Lighting and Power, Non-Flexing Service.

DESCRIPTION: Single conductor, shipboard, general use, armored, watertight. Cable insulation: Sizes 3, 4 and 9 with glass braid over silicone rubber; sizes 14 and larger with silicone rubber treated glass tape. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | 2.0 | A | 3/8A | 1 | 16177-4 | 1/2 | 3/8 |
| 4 | 2.0 | A | 3/8A | 1 | 16177-5 | 1/2 | 3/8 |
| 9 | 2.5 | A | 3/8A | 2 | 16178-1 | 1/2 | 3/8 |
| 14 | 2.5 | B | 3/8A | 2 | 16178-2 | 1/2 | 1/2 |
| 23 | 2.0 | B | 3/8A | 2 | 16178-3 | 1/2 | 1/2 |
| 30 | 3.0 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |
| 40 | 3.5 | C | 3/8A | 2 | 16178-5 | 1/2 | 3/4 |
| 50 | 3.5 | C | 1/2 | 4 | 16179-2 | 1/2 | 3/4 |
| 75 | 4.0 | D | 3/4S | 4 | 16179-4 | 3/4 | 3/4 |
| 100 | 4.5 | D | 3/4 | 4 | 16179-5 | 3/4 | 3/4 |
| 150 | 5.5 | G | 1S | 4 | 16179-9 | 3/4 | 1 |
| 200 | 5.5 | G | 1S | 5 | 16189-2 | 1 | 1 |
| 300 | 6.5 | J | 1-1/4 | 5 | 16189-4 | 1 | 1-1/4 |
| 400 | 7.0 | L | 1-1/4 | 5 | 16189-8 | 1-1/4 | 1-1/4 |
| 500 | 8.0 | M | 1-1/2 | 6 | 16190-3 | 1-1/4 | 1-1/2 |
| 650 | 8.5 | N | 1-1/2 | 6 | 16190-5 | 1-1/4 | 1-1/2 |
| 800 | 9.5 | P | 2 | 6 | 16190-7 | ----- | 2 |

## TABLE 2-42 CABLE CHARACTERISTICS

CABLE TYPE: TSGA

USE: Lighting and Power, Non-Flexing Service.

DESCRIPTION: Three conductor, shipboard, general use, armored, watertight. Conductor insulation: Sizes 3, 4 and 9 with glass braid over silicone rubber; sizes 14 and larger with silicone rubber treated glass tape. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 3 | 7 | 2828 | 0.060 | 0.461 | 1000 | 10 |
| 4 | 3 | 7 | 4497 | 0.076 | 0.499 | 1000 | 17 |
| 9 | 3 | 7 | 9016 | 0.108 | 0.625 | 1000 | 36 |
| 14 | 3 | 7 | 14,340 | 0.136 | 0.718 | 1000 | 47 |
| 23 | 3 | 7 | 22,800 | 0.171 | 0.812 | 1000 | 64 |
| 30 | 3 | 19 | 30,860 | 0.202 | 0.902 | 1000 | 77 |
| 40 | 3 | 19 | 38,910 | 0.226 | 0.950 | 1000 | 88 |
| 50 | 3 | 19 | 49,080 | 0.254 | 1.019 | 1000 | 101 |
| 60 | 3 | 37 | 60,090 | 0.282 | 1.110 | 1000 | 116 |
| 75 | 3 | 37 | 75,780 | 0.317 | 1.184 | 1000 | 136 |
| 100 | 3 | 61 | 99,060 | 0.363 | 1.316 | 1000 | 160 |
| 125 | 3 | 61 | 124,900 | 0.407 | 1.458 | 1000 | 185 |
| 150 | 3 | 61 | 157,600 | 0.457 | 1.565 | 1000 | 216 |
| 200 | 3 | 61 | 198,700 | 0.514 | 1.719 | 1000 | 250 |
| 250 | 3 | 61 | 250,500 | 0.577 | 1.844 | 1000 | 290 |
| 300 | 3 | 91 | 296,400 | 0.628 | 2.007 | 1000 | 320 |
| 350 | 3 | 91 | 349,800 | 0.682 | 2.123 | 1000 | 360 |
| 400 | 3 | 127 | 413,600 | 0.742 | 2.253 | 1000 | 400 |

# TABLE 2-43 INSTALLATION DATA

CABLE TYPE: TSGA

USE: Lighting and Power, Non-Flexing Service.

DESCRIPTION: Three conductor, shipboard, general use, armored, watertight. Conductor insulation: Sizes 3, 4 and 9 with glass braid over silicone rubber; sizes 14 and larger with silicone rubber treated glass tape. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | 3.0 | B | 3/8A | 2 | 16178-3 | 1/2 | 1/2 |
| 4 | 3.0 | C | 3/8A | 2 | 16178-4 | 1/2 | 3/4 |
| 9 | 4.0 | D | 1/2 | 4 | 16179-3 | 3/4 | 3/4 |
| 14 | 4.5 | D | 3/4 | 4 | 16179-5 | 3/4 | 3/4 |
| 23 | 5.0 | F | 1S | 4 | 16179-9 | 3/4 | 1 |
| 30 | 5.5 | G | 1S | 5 | 16189-2 | 1 | 1 |
| 40 | 6.0 | J | 1 | 5 | 16189-3 | 1 | 1-1/4 |
| 50 | 6.5 | J | 1-1/4 | 5 | 16189-4 | 1 | 1-1/4 |
| 60 | 7.0 | K | 1-1/4 | 5 | 16189-6 | 1 | 1-1/4 |
| 75 | 7.5 | L | 1-1/4 | 5 | 16189-8 | 1-1/4 | 1-1/4 |
| 100 | 8.5 | M | 1-1/2 | 6 | 16190-3 | 1-1/4 | 1-1/2 |
| 125 | 9.0 | N | 1-1/2 | 6 | 16190-6 | 1-1/4 | 1-1/2 |
| 150 | 9.5 | P | 2 | 7 | 16191-1 | ----- | 2 |
| 200 | 10.5 | R | 2 | 7 | 16191-4 | ----- | 2 |
| 250 | 11.5 | S | 2 | 8 | 16192-2 | ----- | 2 |
| 300 | 12.0 | T | 2 | 8 | 16192-5 | ----- | 2-1/2 |
| 350 | 13.0 | V | 2-1/2 | 8 | 16192-8 | ----- | 2-1/2 |
| 400 | 13.5 | W | 2-1/2 | 9 | 16193-2 | ----- | 2-1/2 |

## TABLE 2-44 CABLE CHARACTERISTICS

CABLE TYPE: MCSC

USE: Marker Buoy, Special Purpose.

DESCRIPTION: Multiple Conductor steel core: Conductor insulation: Synthetic rubber. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 5 | 5 | 41 | 1630 | 0.049 | 0.595 | 600 | 5/2.5 |

## TABLE 2-45 INSTALLATION DATA

CABLE TYPE: MCSC

USE: Marker Buoy, Special Purpose.

DESCRIPTION: Multiple Conductor steel core: Conductor insulation: Synthetic rubber. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 5 | 4.0 | C | 1/2 | 4 | 16179-4 | 1/2 | 3/4 |

## TABLE 2-46 CABLE CHARACTERISTICS

CABLE TYPE: MMOP

USE: Microphone; Special Purpose.

DESCRIPTION: Multi-conductor, microphone, oil resistant, portable. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 5 | 5 | 21 | 525 | 0.028 | 0.305 | ---- | *1 |

# TABLE 2-47 INSTALLATION DATA

CABLE TYPE: MMOP

USE: Microphone; Special Purpose.

DESCRIPTION: Multi-conductor, microphone, oil resistant, portable. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 5 | 2.0 | A | 3/8A | 1 | 16177-6 | 1/2 | 3/8 |

# TABLE 2-48 CABLE CHARACTERISTICS

CABLE TYPE: FCSF

USE: Minesweeping.

DESCRIPTION: Four conductor, combination, special purpose, flexible, watertight. Conductor insulation: Butyl rubber; color coded, one black and one white on each conductor size. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 66 | 4 | 2 of 49<br>2 of 133 | 19,800<br>66,370 | 0.180<br>0.330 | 1.370 | 600 | ---- |

## TABLE 2-49 INSTALLATION DATA

CABLE TYPE: FCSF

USE: Minesweeping.

DESCRIPTION: Four conductor, combination, special purpose, flexible, watertight. Conductor insulation: Butyl rubber; color coded, one black and one white on each conductor size. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 66 | ---- | M | 1-1/2 | 6 | 16190-5 | 1-1/4 | 1-1/2 |

# TABLE 2-50 CABLE CHARACTERISTICS

CABLE TYPE: MCGC

USE: Minesweeping.

DESCRIPTION: Multiple conductor, glass core. Conductor insulation: Cotton, rayon, or glass fiber braid over synthetic rubber. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 1-1/2 | 6 | 16 | 1608 | 0.049 | 0.600 | 600 | --- |

## TABLE 2-51 INSTALLATION DATA

CABLE TYPE: MCGC

USE: Minesweeping.

DESCRIPTION: Multiple conductor, glass core. Conductor insulation: Cotton, rayon, or glass fiber braid over synthetic rubber. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 1-1/2 | ---- | C | 1/2 | 4 | 16179-4 | 1/2 | 3/4 |

# TABLE 2-52 CABLE CHARACTERISTICS

CABLE TYPE: SSF

USE: Minesweeping.

DESCRIPTION: Single conductor, special purpose, flexible. Conductor insulation: Synthetic or butyl rubber. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 300 | 1 | 259 | 300,000 | 0.714 | 1.100 | 600 | --- |

## TABLE 2-53 INSTALLATION DATA

CABLE TYPE: SSF

USE: Minesweeping.

DESCRIPTION: Single conductor, special purpose, flexible. Conductor insulation: Synthetic or butyl rubber. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 300 | --- | K | 1-1/4 | 5 | 16189-8 | 1 | 1-1/4 |

## TABLE 2-54 CABLE CHARACTERISTICS

CABLE TYPE: PI

USE: Position Indicator, Nuclear Plant.

DESCRIPTION: Twisted shielded pair, heat and flame resistant, armored, watertight. Conductor insulation: Glass braid over silicone rubber on each conductor with an inner glass braid over a braided copper shield on each pair. Cable insulation: Braided metal armor of aluminum alloy over a silicone rubber sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 6 | 7 | 1119 | 0.038 | 0.627 | ----- | ---- |
| 7 | 14 | 7 | 1119 | 0.038 | 0.817 | ----- | ---- |
| 12 | 24 | 7 | 1119 | 0.038 | 1.050 | ----- | ---- |

## TABLE 2-55 INSTALLATION DATA

CABLE TYPE: PI

USE: Position Indicator, Nuclear Plant.

DESCRIPTION: Twisted shielded pair, heat and flame resistant, armored, watertight. Conductor insulation: Glass braid over silicone rubber on each conductor with an inner glass braid over a braided copper shield on each pair. Cable insulation: Braided metal armor of aluminum alloy over a silicone rubber sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | 5.0 | C | 1/2 | 4 | 16179-4 | 3/4 | 3/4 |
| 7 | 6.0 | F | 1S | 5 | 16189-1 | 3/4 | 1 |
| 12 | 7.0 | J | 1-1/4 | 5 | 16189-7 | 1 | 1-1/4 |

# TABLE 2-56 CABLE CHARACTERISTICS

CABLE TYPE: DCOP

USE: For Repeated Flexing Service.

DESCRIPTION: Double conductor, oil resistant, portable. Conductor insulation: Synthetic rubber or resin. Cable insulation: Polychloroprene or impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 1 | 2 | 10 | 1005 | 0.038 | 0.250 | 300 | 2 |
| 1-1/2 | 2 | 16 | 1608 | 0.049 | 0.310 | 300 | 3 |
| 2 | 2 | 16 | 1608 | 0.049 | 0.330 | 300 | 4 |

# TABLE 2-57 INSTALLATION DATA

CABLE TYPE: DCOP

USE: For Repeated Flexing Service.

DESCRIPTION: Double conductor, oil resistant, portable. Conductor insulation: Synthetic rubber or resin. Cable insulation: Polychloroprene or impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 1 | -- | A | 3/8A | 1 | 16177-4 | 1/2 | 3/8 |
| 1-1/2 | -- | A | 3/8A | 2 | 16178-1 | 1/2 | 3/8 |
| 2 | -- | A | 3/8A | 2 | 16178-1 | 1/2 | 3/8 |

## TABLE 2-58 CABLE CHARACTERISTICS

CABLE TYPE: DHOF

USE: For Repeated Flexing Service.

DESCRIPTION: Double conductor, heat and oil resistant, flexible. Conductor insulation: Butyl rubber with a cotton, rayon, or glass fiber braid on sizes 3 and larger or a compound-filled tape on sizes 23 and larger. Cable insulation: Polychloroprene or impervious sheath on sizes 42 and smaller; a polychloroprene sheath on sizes larger than 42.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 2 | 26 | 2613 | 0.061 | 0.425 | 600 | 21 |
| 4 | 2 | 41 | 4121 | 0.077 | 0.460 | 600 | 28 |
| 6 | 2 | 65 | 6533 | 0.097 | 0.510 | 600 | 37 |
| 9 | 2 | 90 | 9045 | 0.120 | 0.570 | 600 | 45 |
| 14 | 2 | 140 | 14,070 | 0.145 | 0.705 | 600 | 54 |
| 23 | 2 | 228 | 22,910 | 0.190 | 0.860 | 600 | 72 |
| 30 | 2 | 304 | 30,550 | 0.220 | 0.960 | 600 | 83 |
| 83 | 2 | 418 | 84,230 | 0.380 | 1.450 | 600 | 152 |
| 250 | 2 | 1254 | 252,700 | 0.680 | 2.100 | 600 | 287 |
| 400 | 2 | 2052 | 413,500 | 0.850 | 2.500 | 600 | 382 |

## TABLE 2-59 INSTALLATION DATA

CABLE TYPE: DHOF

USE: For Repeated Flexing Service.

DESCRIPTION: Double conductor, heat and oil resistant, flexible. Conductor insulation: Butyl rubber with a cotton rayon, or glass fiber braid on sizes 3 and larger or a compound-filled tape on sizes 23 and larger. Cable insulation: Polychloroprene or impervious sheath on sizes 42 and smaller; a polychloroprene sheath on sizes larger than 42.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | -- | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |
| 4 | -- | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 6 | -- | C | 3/8A | 4 | 16179-1 | 1/2 | 3/4 |
| 9 | -- | C | 1/2 | 4 | 16179-3 | 1/2 | 3/4 |
| 14 | -- | D | 3/4 | 4 | 16179-7 | 3/4 | 3/4 |
| 23 | -- | G | 1S | 5 | 16189-2 | 3/4 | 1 |
| 30 | -- | J | 1 | 5 | 16189-4 | 1 | 1-1/4 |
| 83 | -- | N | 1-1/2 | 6 | 16190-7 | 1-1/4 | 1-1/2 |
| 250 | -- | V | 2-1/2 | 9 | 16193-1 | ----- | 2-1/2 |
| 400 | -- | Y | 2-1/2 | 9 | 16193-6 | ----- | 3 |

## TABLE 2-60 CABLE CHARACTERISTICS

CABLE TYPE: FHOF

USE: For Repeated Flexing Service.

DESCRIPTION: Four conductor, heat and oil resistant, flexible. Conductor insulation: Butyl rubber with a cotton, rayon, or glass fiber braid on sizes 3 and larger or a compound-filled tape on sizes 23 and larger. Cable insulation: Polychloroprene or impervious sheath on sizes 42 and smaller; a polychloroprene sheath on sizes larger than 42.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 4 | 26 | 2613 | 0.061 | 0.480 | 600 | 16 |
| 4 | 4 | 41 | 4121 | 0.077 | 0.550 | 600 | 21 |
| 9 | 4 | 90 | 9045 | 0.120 | 0.660 | 600 | 34 |
| 133 | 4 | 684 | 137,800 | 0.480 | 2.000 | 600 | 148 |

## TABLE 2-61 INSTALLATION DATA

CABLE TYPE: **FHOF**

USE: For Repeated Flexing Service.

DESCRIPTION: Four conductor, heat and oil resistant, flexible. Conductor insulation: Butyl rubber with a cotton, rayon, or glass fiber braid on sizes 3 and larger or a compound-filled tape on sizes 23 and larger. Cable insulation: Polychloroprene or impervious sheath on sizes 42 and smaller; a polychloroprene sheath on sizes larger than 42.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | ---- | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 4 | ---- | C | 1/2 | 4 | 16179-2 | 1/2 | 3/4 |
| 9 | ---- | D | 3/4S | 4 | 16179-5 | 3/4 | 3/4 |
| 133 | ---- | T | 2 | 8 | 16192-6 | --- | 2-1/2 |

# TABLE 2-62 CABLE CHARACTERISTICS

CABLE TYPE: MCOS

USE: For Repeated Flexing Service.

DESCRIPTION: Multiple conductor, oil resistant, shielded. Conductor insulation: Synthetic resin with copper shielding over individual pairs and over the assembly of sizes 2, 4 and 7. Cable insulation: Impervious sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 2 | 2 | 16 | 1608 | 0.049 | 0.460 | 600 | *4/4 |
| 4 | 4 | 16 | 1608 | 0.049 | 0.510 | 600 | *4/2 |
| 5 | 5 | 26 | 1034 | 0.042 | 0.390 | 300 | *2/1 |
| 6 | 6 | 10 | 1005 | 0.038 | 0.465 | 300 | *2/1 |
| 7 | 7 | 16 | 1608 | 0.049 | 0.595 | 600 | *4/1.5 |

## TABLE 2-63 INSTALLATION DATA

CABLE TYPE: MCOS

USE: For Repeated Flexing Service.

DESCRIPTION: Multiple conductor, oil resistant, shielded. Conductor insulation: Synthetic resin with copper shielding over individual pairs and over the assembly of sizes 2, 4 and 7. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 2 | ---- | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 4 | ---- | C | 3/8A | 4 | 16179-1 | 1/2 | 3/4 |
| 5 | ---- | B | 3/8A | 2 | 16178-3 | 1/2 | 1/2 |
| 6 | ---- | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 7 | ---- | C | 1/2 | 4 | 16179-4 | 1/2 | 3/4 |

TABLE 2-64 CABLE CHARACTERISTICS

CABLE TYPE: MHFF

USE: For Repeated Flexing Service

DESCRIPTION: Multi-conductor, heat and flame resistant, flexible. Conductor insulation: Felted asbestos or glass fiber over synthetic resin and an inner braid of rayon or glass fiber. Cable insulation: Impervious sheath overall.

* Denotes-Individual Averages.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 7 | 7 | 26 | 2613 | 0.061 | 0.627 | 600 | *9/6 |
| 10 | 10 | 26 | 2613 | 0.061 | 0.795 | 600 | *9/6 |
| 14 | 14 | 26 | 2613 | 0.061 | 0.844 | 600 | *9/6 |
| 19 | 19 | 26 | 2613 | 0.061 | 0.995 | 600 | *9/6 |
| 24 | 24 | 26 | 2613 | 0.061 | 1.120 | 600 | *9/6 |
| 30 | 30 | 26 | 2613 | 0.061 | 1.194 | 600 | *9/6 |
| 37 | 37 | 26 | 2613 | 0.061 | 1.290 | 600 | *9/4 |
| 44 | 44 | 26 | 2613 | 0.061 | 1.420 | 600 | *9/3 |

## TABLE 2-65 INSTALLATION DATA

CABLE TYPE: MHFF

USE: For Repeated Flexing Service

DESCRIPTION: Multi-conductor, heat and flame resistant, flexible. Conductor insulation: Felted asbestos or glass fiber over synthetic resin and an inner braid of rayon or glass fiber. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 7 | --- | D | 1/2 | 4 | 16179-4 | 3/4 | 3/4 |
| 10 | --- | F | 3/4 | 4 | 16179-9 | 3/4 | 1 |
| 14 | --- | G | 1S | 5 | 16189-2 | 3/4 | 1 |
| 19 | --- | J | 1 | 5 | 16189-5 | 1 | 1-1/4 |
| 24 | --- | K | 1-1/4 | 5 | 16189-8 | 1 | 1-1/4 |
| 30 | --- | L | 1-1/4 | 6 | 16190-1 | 1-1/4 | 1-1/4 |
| 37 | --- | M | 1-1/2 | 6 | 16190-4 | 1-1/4 | 1-1/2 |
| 44 | --- | N | 1-1/2 | 6 | 16190-6 | 1-1/4 | 1-1/2 |

# TABLE 2-66 CABLE CHARACTERISTICS

CABLE TYPE: SHOF

USE: For Repeated Flexing Service.

DESCRIPTION: Single conductor, heat and oil resistant, flexible. Conductor insulation: Butyl rubber with a cotton, rayon, or glass fiber braid on sizes 3 and larger or a compound-filled tape on sizes 23 and larger. Cable insulation: Polychloroprene or impervious sheath on sizes 42 and smaller; a polychloroprene sheath on sizes larger than 42.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 1 | 65 | 2594 | 0.061 | 0.210 | 600 | 18 |
| 23 | 1 | 228 | 22,910 | 0.190 | 0.460 | 600 | 80 |
| 60 | 1 | 304 | 61,260 | 0.310 | 0.600 | 600 | 153 |
| 150 | 1 | 760 | 153,100 | 0.510 | 0.870 | 600 | 263 |
| 200 | 1 | 988 | 199,100 | 0.580 | 0.980 | 600 | 306 |
| 250 | 1 | 1254 | 252,700 | 0.680 | 1.085 | 600 | 362 |
| 800 | 1 | 4033 | 812,700 | 1.150 | 1.670 | 600 | 732 |

## TABLE 2-67 INSTALLATION DATA

CABLE TYPE: SHOF

USE: For Repeated Flexing Service.

DESCRIPTION: Single conductor, heat and oil resistant, flexible. Conductor insulation: Butyl rubber with a cotton, rayon, or glass fiber braid on sizes 3 and larger or a compound-filled tape on sizes 23 and larger. Cable insulation: Polychloroprene or impervious sheath on sizes 42 and smaller; a polychloroprene sheath on sizes larger than 42.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | --- | A | 3/8A | 1 | 16177-1 | ---- | 3/8 |
| 23 | --- | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 60 | --- | C | 1/2 | 4 | 16179-4 | 1/2 | 3/4 |
| 150 | --- | G | 1S | 5 | 16189-2 | 3/4 | 1 |
| 200 | --- | J | 1 | 5 | 16189-5 | 1 | 1-1/4 |
| 250 | --- | K | 1-1/4 | 5 | 16189-8 | 1 | 1-1/4 |
| 800 | --- | R | 2 | 7 | 16191-4 | --- | 2 |

# TABLE 2-68 CABLE CHARACTERISTICS

CABLE TYPE: TCOP

USE: For Repeated Flexing Service.

DESCRIPTION: Triple conductor, oil resistant, portable. Conductor insulation: Synthetic rubber or resin. Cable insulation: Polychloroprene or impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 2 | 3 | 16 | 1608 | 0.049 | 0.345 | 300 | 5 |

# TABLE 2-69 INSTALLATION DATA

CABLE TYPE: TCOP

USE: For Repeated Flexing Service.

DESCRIPTION: Triple conductor, oil resistant, portable. Conductor insulation: Synthetic rubber or resin. Cable insulation: Polychloroprene or impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 2 | ---- | A | 3/8A | 2 | 16178-1 | 1/2 | 3/8 |

## TABLE 2-70 CABLE CHARACTERISTICS

CABLE TYPE: THOF

USE: For Repeated Flexing Service.

DESCRIPTION: Triple conductor, heat and oil resistant, flexible. Conductor insulation: Butyl rubber with a cotton, rayon, or glass fiber braid on sizes 3 and larger or a compound-filled tape on sizes 23 and larger. Cable insulation: Polychloroprene or impervious sheath on sizes 42 and smaller; a polychloroprene sheath on sizes larger than 42.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 3 | 26 | 2613 | 0.061 | 0.450 | 600 | 17 |
| 4 | 3 | 41 | 4121 | 0.077 | 0.480 | 600 | 23 |
| 6 | 3 | 65 | 6533 | 0.097 | 0.550 | 600 | 31 |
| 9 | 3 | 90 | 9045 | 0.120 | 0.600 | 600 | 34 |
| 14 | 3 | 140 | 14,070 | 0.145 | 0.750 | 600 | 46 |
| 23 | 3 | 228 | 22,910 | 0.190 | 0.900 | 600 | 64 |
| 42 | 3 | 209 | 42,110 | 0.260 | 1.250 | 600 | 86 |
| 150 | 3 | 760 | 153,100 | 0.510 | 1.820 | 600 | 180 |
| 250 | 3 | 1254 | 252,700 | 0.680 | 2.240 | 600 | 264 |
| 400 | 3 | 2052 | 413,500 | 0.850 | 2.800 | 600 | 338 |

## TABLE 2-71 INSTALLATION DATA

CABLE TYPE: THOF

USE: For Repeated Flexing Service.

DESCRIPTION: Triple conductor, heat and oil resistant, flexible. Conductor insulation: Butyl rubber with a cotton, rayon, or glass fiber braid on sizes 3 and larger or a compound-filled tape on sizes 23 and larger. Cable insulation: Polychloroprene or impervious sheath on sizes 42 and smaller; a polychloroprene sheath on sizes larger than 42.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | ---- | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |
| 4 | ---- | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 6 | ---- | C | 3/8A | 4 | 16179-2 | 1/2 | 3/4 |
| 9 | ---- | C | 1/2 | 4 | 16179-4 | 1/2 | 3/4 |
| 14 | ---- | E | 3/4 | 4 | 16179-7 | 3/4 | 1 |
| 23 | ---- | G | 1S | 5 | 16189-3 | 1 | 1 |
| 42 | ---- | M | 1-1/4 | 6 | 16190-3 | 1-1/4 | 1-1/2 |
| 150 | ---- | S | 2 | 8 | 16192-3 | ----- | 2 |
| 250 | ---- | W | 2-1/2 | 9 | 16193-3 | ----- | 2-1/2 |
| 400 | ---- | AA | 3 | 9 | 16193-8 | ----- | 3 |

## TABLE 2-72 CABLE CHARACTERISTICS

CABLE TYPE: DBSP

USE: Small Boat, Non-Flexing Service.

DESCRIPTION: Double conductor, small boat, shielded, plain. Conductor insulation: Synthetic rubber, butyl rubber, or polychloroprene with a shield of copper tape over the conductor assembly. Cable insulation: Gray impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3/5 | 2 | 7 | 703 | 0.030 | 0.206 | 125 | 2 |
| 1 | 2 | 7 | 1119 | 0.038 | 0.224 | 125 | 4 |
| 2 | 2 | 7 | 1779 | 0.048 | 0.245 | 125 | 8 |
| 3 | 2 | 7 | 2828 | 0.060 | 0.303 | 125 | 11 |
| 4 | 2 | 7 | 4497 | 0.076 | 0.359 | 125 | 15 |
| 6 | 2 | 7 | 6512 | 0.092 | 0.426 | 125 | 17 |
| 9 | 2 | 7 | 9016 | 0.108 | 0.471 | 125 | 25 |
| 14 | 2 | 7 | 14,340 | 0.136 | 0.552 | 125 | 35 |
| 23 | 2 | 7 | 22,800 | 0.171 | 0.639 | 125 | 49 |

# TABLE 2-73 INSTALLATION DATA

CABLE TYPE: DBSP

USE: Small Boat, Non-Flexing Service.

DESCRIPTION: Double conductor, small boat, shielded, plain. Conductor insulation: Synthetic rubber, butyl rubber, or polychloroprene with a shield of copper tape over the conductor assembly. Cable insulation: Gray impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3/5 | 1.5 | A | 3/8A | 1 | 16177-1 | --- | 3/8 |
| 1 | 1.5 | A | 3/8A | 1 | 16177-4 | --- | 3/8 |
| 2 | 1.5 | A | 3/8A | 1 | 16177-4 | --- | 3/8 |
| 3 | 2.0 | A | 3/8A | 1 | 16177-6 | 1/2 | 3/8 |
| 4 | 2.5 | A | 3/8A | 2 | 16178-2 | 1/2 | 3/8 |
| 6 | 2.5 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |
| 9 | 3.0 | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 14 | 3.5 | C | 3/8A | 4 | 16179-2 | 1/2 | 3/4 |
| 23 | 4.0 | D | 1/2 | 4 | 16179-4 | 3/4 | 3/4 |

## TABLE 2-74 CABLE CHARACTERISTICS

CABLE TYPE: FBSP

USE: Small Boat, Non-Flexing Service.

DESCRIPTION: Four conductor, small boat, shielded, plain. Conductor insulation: Synthetic rubber, butyl rubber, or polychloroprene with a shield of copper tape over the conductor assembly. Cable insulation: Gray impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3/5 | 4 | 7 | 703 | 0.030 | 0.232 | 125 | 1 |
| 1 | 4 | 7 | 1119 | 0.038 | 0.253 | 125 | 2 |
| 2 | 4 | 7 | 1779 | 0.048 | 0.278 | 125 | 5 |
| 3 | 4 | 7 | 2828 | 0.060 | 0.346 | 125 | 8 |
| 4 | 4 | 7 | 4497 | 0.076 | 0.413 | 125 | 11 |

## TABLE 2-75 INSTALLATION DATA

CABLE TYPE: FBSP

USE: Small Boat, Non-Flexing Service.

DESCRIPTION: Four conductor, small boat, shielded, plain. Conductor insulation: Synthetic rubber, butyl rubber, or polychloroprene with a shield of copper tape over the conductor assembly. Cable insulation: Gray impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3/5 | 1.5 | A | 3/8A | 1 | 16177-4 | --- | 3/8 |
| 1 | 2.0 | A | 3/8A | 1 | 16177-4 | 1/2 | 3/8 |
| 2 | 2.0 | A | 3/8A | 1 | 16177-5 | 1/2 | 3/8 |
| 3 | 2.5 | A | 3/8A | 2 | 16178-1 | 1/2 | 3/8 |
| 4 | 2.5 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |

## TABLE 2-76 CABLE CHARACTERISTICS

CABLE TYPE: TBSP

USE: Small Boat, Non-Flexing Service.

DESCRIPTION: Triple conductor, small boat, shielded, plain. Conductor insulation: Synthetic rubber, butyl rubber, or polychloroprene with a shield of copper tape over the conductor assembly. Cable insulation: Gray impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3/5 | 3 | 7 | 703 | 0.030 | 0.216 | 125 | 1 |
| 1 | 3 | 7 | 1119 | 0.038 | 0.234 | 125 | 3 |
| 2 | 3 | 7 | 1779 | 0.048 | 0.257 | 125 | 7 |
| 3 | 3 | 7 | 2828 | 0.060 | 0.319 | 125 | 10 |
| 4 | 3 | 7 | 4497 | 0.076 | 0.378 | 125 | 14 |
| 6 | 3 | 7 | 6512 | 0.092 | 0.450 | 125 | 18 |
| 9 | 3 | 7 | 9016 | 0.108 | 0.498 | 125 | 23 |
| 14 | 3 | 7 | 14,340 | 0.136 | 0.586 | 125 | 31 |
| 23 | 3 | 7 | 22,800 | 0.171 | 0.677 | 125 | 44 |

# TABLE 2-77 INSTALLATION DATA

CABLE TYPE: TBSP

USE: Small Boat, Non-Flexing Service.

DESCRIPTION: Triple conductor, small boat, shielded, plain. Conductor insulation: Synthetic rubber, butyl rubber, or polychloroprene with a shield of copper tape over the conductor assembly. Cable insulation: Gray impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3/5 | 1.5 | A | 3/8A | 1 | 16177-1 | ---- | 3/8 |
| 1 | 1.5 | A | 3/8A | 1 | 16177-4 | ---- | 3/8 |
| 2 | 1.5 | A | 3/8A | 1 | 16177-4 | 1/2 | 3/8 |
| 3 | 2.0 | A | 3/8A | 2 | 16178-1 | 1/2 | 3/8 |
| 4 | 2.5 | A | 3/8A | 2 | 16178-3 | 1/2 | 3/8 |
| 6 | 3.0 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |
| 9 | 3.0 | B | 3/8A | 4 | 16179-1 | 1/2 | 1/2 |
| 14 | 3.5 | C | 1/2 | 4 | 16179-3 | 1/2 | 3/4 |
| 23 | 4.5 | D | 3/4 | 4 | 16179-5 | 3/4 | 3/4 |

## TABLE 2-78 CABLE CHARACTERISTICS

CABLE TYPE: DSS

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Double conductor, special purpose, shielded, watertight. Conductor insulation: Synthetic or butyl rubber, color coded (one black and one white) with a braid of copper shielding over the conductor assembly. Cable insulation: Polychloroprene sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 2 | 2 | 7 | 1779 | 0.048 | 0.390 | 600 | * 5 |
| 3 | 2 | 7 | 2828 | 0.060 | 0.500 | 600 | * 8 |
| 4 | 2 | 7 | 4497 | 0.076 | 0.500 | 600 | * 9 |

## TABLE 2-79 INSTALLATION DATA

CABLE TYPE: DSS

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Double conductor, special purpose, shielded, watertight. Conductor insulation: Synthetic or butyl rubber, color coded (one black and one white) with a braid of copper shielding over the conductor assembly. Cable insulation: Polychloroprene sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 2 | 1.5 | A | 3/8A | 2 | 16178-3 | 1/2 | 3/8 |
| 3 | 2.0 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |
| 4 | 2.5 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |

## TABLE 2-80 CABLE CHARACTERISTICS

CABLE TYPE: FSS

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Four conductor, special purpose, shielded, watertight. Conductor insulation: Synthetic or butyl rubber, color coded (black, white, red, and green) with a braid of copper shielding over the conductor assembly. Cable insulation: Polychloroprene sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 2 | 4 | 7 | 1779 | 0.048 | 0.465 | 600 | *4 |
| 4 | 4 | 7 | 4497 | 0.076 | 0.625 | 600 | *9 |

## TABLE 2-81 INSTALLATION DATA

CABLE TYPE: FSS

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Four conductor, special purpose, shielded, watertight. Conductor insulation: Synthetic or butyl rubber, color coded (black, white, red, and green) with a braid of copper shielding over the conductor assembly. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO | MS NO. | INCH | INCH |
| 2 | 2.0 | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 4 | 2.5 | C | 1/2 | 4 | 16179-4 | 3/4 | 3/4 |

## TABLE 2-82 CABLE CHARACTERISTICS

CABLE TYPE: MSS

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Multiple conductor, special purpose, shielded, watertight. Conductor insulation: Synthetic or butyl rubber color coded (one black and one white in one pair, one red and one blue in the other pair, one yellow single and one green single) with a braid of copper shielding over the individual pairs. Cable insulation: Polychloroprene sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 6 | 6 | 7 | 1119 | 0.038 | 0.625 | 600 | *2/1 |

# TABLE 2-83 INSTALLATION DATA

CABLE TYPE: MSS

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Multiple conductor, special purpose, shielded, water-tight. Conductor insulation: Synthetic or butyl rubber color coded (one black and one white in one pair, one red and one blue in the other pair, one yellow single and one green single) with a braid of copper shielding over the individual pairs. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 6 | 2.5 | C | 1/2 | 4 | 16179-4 | 3/4 | 3/4 |

TABLE 2-84 CABLE CHARACTERISTICS

CABLE TYPE: TSP

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Twisted pair, special purpose, plain, watertight. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 11 | 22 | 7 | 703 | 0.030 | 0.735 | 600 | *3/.50 |
| 31 | 62 | 7 | 703 | 0.030 | 1.062 | 600 | *3/.50 |

## TABLE 2-85 INSTALLATION DATA

CABLE TYPE: TSP

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Twisted pair, special purpose, plain, watertight. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 11 | 4.0 | E | 3/4 | 4 | 16179-7 | 3/4 | 1 |
| 31 | 6.0 | K | 1-1/4 | 5 | 16189-7 | 1 | 1-1/4 |

# TABLE 2-86 CABLE CHARACTERISTICS

CABLE TYPE: TSS

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Three conductor, special purpose, shielded, watertight. Conductor insulation: Synthetic or butyl rubber, color coded (one black, one white and one red) with a braid of copper shielding over the conductor assembly. Cable insulation: Polychloroprene sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 4 | 3 | 7 | 4497 | 0.076 | 0.500 | 600 | *9 |

## TABLE 2-87 INSTALLATION DATA

CABLE TYPE: TSS

USE: Sonar, Non-Flexing Service.

DESCRIPTION: Three conductor, special purpose, shielded, watertight. Conductor insulation: Synthetic or butyl rubber, color coded (one black, one white and one red) with a braid of copper shielding over the conductor assembly. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 4 | 2.5 | C | 3/8A | 4 | 16179-1 | 1/2 | 3/4 |

# TABLE 2-88 CABLE CHARACTERISTICS

CABLE TYPE: TTHFWA

USE: Telephone Cable, Non-Flexing Service.

DESCRIPTION: Twisted pair, telephone, heat and flame resistant, armored, watertight. Conductor insulation: Synthetic resin. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 1-1/2 | 3 | 7 | 703 | 0.030 | 0.380 | 300 | 3/3 |
| 3 | 6 | 7 | 703 | 0.030 | 0.500 | 300 | 3/2 |
| 5 | 10 | 7 | 703 | 0.030 | 0.590 | 300 | 3/1 |
| 10 | 20 | 7 | 703 | 0.030 | 0.690 | 300 | 3/.5 |
| 15 | 30 | 7 | 703 | 0.030 | 0.800 | 300 | 3/.375 |
| 20 | 40 | 7 | 703 | 0.030 | 0.880 | 300 | 3/.25 |
| 30 | 60 | 7 | 703 | 0.030 | 1.030 | 300 | ----- |
| 40 | 80 | 7 | 703 | 0.030 | 1.130 | 300 | ----- |
| 50 | 100 | 7 | 703 | 0.030 | 1.265 | 300 | ----- |
| 60 | 120 | 7 | 703 | 0.030 | 1.350 | 300 | ----- |

# TABLE 2-89 INSTALLATION DATA

CABLE TYPE: TTHFWA

USE: Telephone Cable, Non-Flexing Service.

DESCRIPTION: Twisted pair, telephone, heat and flame resistant, armored, watertight. Conductor insulation: Synthetic resin. Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 1-1/2 | 2.5 | B | 3/8A | 2 | 16178-1 | 1/2 | 1/2 |
| 3 | 3.0 | C | 3/8A | 2 | 16178-4 | 1/2 | 3/4 |
| 5 | 3.5 | C | 1/2 | 4 | 16179-2 | 1/2 | 3/4 |
| 10 | 4.5 | D | 3/4 | 4 | 16179-4 | 3/4 | 3/4 |
| 15 | 5.0 | F | 1S | 4 | 16179-7 | 3/4 | 1 |
| 20 | 5.5 | G | 1S | 5 | 16189-1 | 1 | 1 |
| 30 | 6.5 | J | 1-1/4 | 5 | 16189-4 | 1 | 1-1/4 |
| 40 | 7.0 | K | 1-1/4 | 5 | 16189-7 | 1-1/4 | 1-1/4 |
| 50 | 8.0 | M | 1-1/2 | 6 | 16190-2 | 1-1/4 | 1-1/2 |
| 60 | 8.5 | M | 1-1/2 | 6 | 16190-4 | 1-1/4 | 1-1/2 |

# TABLE 2-90 CABLE CHARACTERISTICS

CABLE TYPE: FT

USE: Telephone, Repeated Flexing Service.

DESCRIPTION: Flexible, telephone; tinsel conductor. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 2 | 2 | Tinsel | 32 | ---- | 0.255 | 300 | ---- |
| 3 | 3 | Tinsel | 32 | ---- | 0.255 | 300 | ---- |

## TABLE 2-91 INSTALLATION DATA

CABLE TYPE: FT

USE: Telephone, Repeated Flexing Service.

DESCRIPTION: Flexible, telephone; tinsel conductor. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 2 | --- | A | 3/8 A | 1 | 16177-4 | 1/2 | 3/8 |
| 3 | --- | A | 3/8 A | 1 | 16177-4 | 1/2 | 3/8 |

# TABLE 2-92 CABLE CHARACTERISTICS

CABLE TYPE: FTS

USE: Telephone, Repeated Flexing Service.

DESCRIPTION: Flexible, telephone, small, tinsel conductor. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 2 | 2 | Tinsel | 32 | ---- | 0.195 | 300 | ---- |
| 3 | 3 | Tinsel | 32 | ---- | 0.195 | 300 | ---- |

## TABLE 2-93 INSTALLATION DATA

CABLE TYPE: FTS

USE: Telephone, Repeated Flexing Service.

DESCRIPTION: Flexible, telephone, small, tinsel conductor. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 2 | ---- | A | 3/8 A | 1 | 16177-3 | ---- | 3/8 |
| 3 | ---- | A | 3/8 A | 1 | 16177-3 | ---- | 3/8 |

## TABLE 2-94 CABLE CHARACTERISTICS

CABLE TYPE: **TTOP**

USE: Telephone, Repeated Flexing Service.

DESCRIPTION: Twisted pair, telephone, oil resistant, portable. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

* Denotes-Individual Average.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 6 | 10 | 1005 | 0.038 | 0.480 | 300 | *4/3 |
| 5 | 10 | 10 | 1005 | 0.038 | 0.590 | 300 | *4/2 |
| 10 | 20 | 10 | 1005 | 0.038 | 0.700 | 300 | *4/1 |
| 15 | 30 | 10 | 1005 | 0.038 | 0.830 | 300 | *4/.5 |

# TABLE 2-95 INSTALLATION DATA

CABLE TYPE: TTOP

USE: Telephone, Repeated Flexing Service.

DESCRIPTION: Twisted pair, telephone, oil resistant, portable. Conductor insulation: Synthetic resin. Cable insulation: Impervious sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | ---- | B | 3/8A | 2 | 16178-5 | 1/2 | 1/2 |
| 5 | ---- | C | 1/2 | 4 | 16179-3 | 1/2 | 3/4 |
| 10 | ---- | D | 3/4 | 4 | 16179-6 | 3/4 | 3/4 |
| 15 | ---- | G | 1S | 5 | 16189-1 | 3/4 | 1 |

# TABLE 2-96 CABLE CHARACTERISTICS

CABLE TYPE: PBJX

USE: Thermocouple, Non-Flexing Service.

DESCRIPTION: Pyrometer base lead, armored, watertight. One iron and one constantan conductor. Conductor insulation: Glass fiber braid over synthetic resin, color coded (gray over the iron conductor and red over the constantan conductor). Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 4 | 2 | 1 | 4107 | 0.064 | 0.480 | ---- | ---- |

## TABLE 2-97 INSTALLATION DATA

CABLE TYPE: PBJX

USE: Thermocouple, Non-Flexing Service.

DESCRIPTION: Pyrometer base lead, armored, watertight. One iron and one constantan conductor. Conductor insulation: Glass fiber braid over synthetic resin, color coded (gray over the iron conductor and red over the constantan conductor). Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 4 | 3.0 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |

## TABLE 2-98 CABLE CHARACTERISTICS

CABLE TYPE: PBTX

USE: Thermocouple, Non-Flexing Service.

DESCRIPTION: Pyrometer base lead, armored, watertight. One copper and one constantan conductor. Conductor insulation: Glass fiber braid over synthetic resin, color coded (blue over the copper conductor and red over the constantan conductor). Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 4 | 2 | 1 | 4107 | 0.064 | 0.480 | ---- | ---- |

## TABLE 2-99 INSTALLATION DATA

CABLE TYPE: PBTX

USE: Thermocouple, Non-Flexing Service.

DESCRIPTION: Pyrometer base lead, armored, watertight. One copper and one constantan conductor. Conductor insulation: Glass fiber braid over synthetic resin, color coded (blue over the copper conductor and red over the constantan conductor). Cable insulation: Braided metal armor of aluminum alloy over an impervious sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 4 | 3.0 | B | 3/8A | 2 | 16178-4 | 1/2 | 1/2 |

# TABLE 2-100 CABLE CHARACTERISTICS

CABLE TYPE: TCJX

USE: Thermocouple, Nuclear Plant.

DESCRIPTION: Twisted pair, one iron and one constantan conductor in each pair, heat and flame resistant, armored, watertight. Conductor insulation: Glass braid over silicone rubber on each conductor. Cable insulation: Braided metal armor of aluminum alloy over a silicone rubber sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 6 | 7 | 2828 | 0.060 | 0.644 | ---- | ---- |
| 7 | 14 | 7 | 2828 | 0.060 | 0.890 | ---- | ---- |
| 12 | 24 | 7 | 2828 | 0.060 | 1.117 | ---- | ---- |

## TABLE 2-101 INSTALLATION DATA

CABLE TYPE: TCJX

USE: Thermocouple, Nuclear Plant.

DESCRIPTION: Twisted pair, one iron and one constantan conductor in each pair, heat and flame resistant, armored, watertight. Conductor insulation: Glass braid over silicone rubber on each conductor. Cable insulation: Braided metal armor of aluminum alloy over a silicone rubber sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | 4.5 | D | 3/4 S | 4 | 16179-4 | 3/4 | 3/4 |
| 7 | 5.5 | G | 1S | 5 | 16189-2 | 1 | 1 |
| 12 | 7.0 | K | 1-1/4 | 5 | 16189-6 | 1 | 1-1/4 |

## TABLE 2-102 CABLE CHARACTERISTICS

CABLE TYPE: TCKX

USE: Thermocouple, Nuclear Plant.

DESCRIPTION. Twisted pair, one chromel and one alumel conductor in each pair, heat and flame resistant, armored, watertight. Conductor insulation: Glass Braid over silicone rubber on each conductor. Cable insulation: Braided metal armor of aluminum alloy over a silicone rubber sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C.M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 1 | 2 | 7 | 2828 | 0.060 | 0.440 | ---- | ---- |
| 3 | 6 | 7 | 2828 | 0.060 | 0.644 | ---- | ---- |
| 7 | 14 | 7 | 2828 | 0.060 | 0.890 | ---- | ---- |
| 12 | 24 | 7 | 2828 | 0.060 | 1.117 | ---- | ---- |

## TABLE 2-103 INSTALLATION DATA

CABLE TYPE: TCKX

USE: Thermocouple, Nuclear Plant.

DESCRIPTION: Twisted pair, one chromel and one alumel conductor in each pair, heat and flame resistant, armored, watertight. Conductor insulation: Glass braid over silicone rubber on each conductor. Cable insulation: Braided metal armor of aluminum alloy over a silicone rubber sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 1 | 2.5 | B | 3/8 A | 2 | 16178-3 | 1/2 | 1/2 |
| 3 | 4.5 | D | 3/4 S | 4 | 16179-4 | 3/4 | 3/4 |
| 7 | 5.5 | G | 1 S | 5 | 16189-2 | 1 | 1 |
| 12 | 7.0 | K | 1-1/4 | 5 | 16189-6 | 1 | 1-1/4 |

## TABLE 2-104 CABLE CHARACTERISTICS

CABLE TYPE: TCTX

USE: Thermocouple, Nuclear Plant.

DESCRIPTION: Twisted pair, one copper and one constantan conductor in each pair, heat and flame resistant, armored, watertight. Conductor insulation: Glass Braid over silicone rubber on each conductor. Cable insulation: Braided metal armor of aluminum alloy over a silicone rubber sheath.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 3 | 6 | 7 | 1119 | 0.038 | 0.491 | ----- | ---- |
| 7 | 14 | 7 | 1119 | 0.038 | 0.640 | ----- | ---- |
| 12 | 24 | 7 | 1119 | 0.038 | 0.809 | ----- | ---- |

## TABLE 2-105 INSTALLATION DATA

CABLE TYPE: TCTX

USE: Thermocouple, Nuclear Plant.

DESCRIPTION: Twisted pair, one copper and one constantan conductor in each pair, heat and flame resistant, armored, watertight. Conductor. insulation: Glass Braid over silicone rubber on each conductor. Cable insulation: Braided metal armor of aluminum alloy over a silicone rubber sheath.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 3 | 3.0 | B | 3/8 A | 4 | 16179-1 | 1/2 | 1/2 |
| 7 | 3.5 | C | 3/4 S | 4 | 16179-4 | 3/4 | 3/4 |
| 12 | 5.5 | E | 1 S | 5 | 16189-1 | 3/4 | 1 |

## TABLE 2-106 CABLE CHARACTERISTICS

CABLE TYPE: TRF

USE: Welding and Motor Leads, Repeated Flexing Service.

DESCRIPTION: Tough rubber jacket, flexible. Conductor insulation: Synthetic or butyl rubber with cotton reinforcement. Cable insulation: Polychloroprene sheath (bonded to the conductor insulation) overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 105 | 1 | 259 | 105,500 | 0.410 | 0.760 | 600 | 121 |
| 133 | 1 | 259 | 133,100 | 0.460 | 0.810 | 600 | 141 |
| 168 | 1 | 427 | 167,800 | 0.520 | 0.860 | 600 | 170 |

## TABLE 2-107 INSTALLATION DATA

CABLE TYPE: TRF

USE: Welding and Motor Leads, Repeated Flexing Service.

DESCRIPTION: Tough rubber jacket, flexible. Conductor insulation: Synthetic or butyl rubber with cotton reinforcement. Cable insulation: Polychloroprene sheath (bonded to the conductor insulation) overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 105 | --- | E | 3/4 | 4 | 16179-8 | 3/4 | 1 |
| 133 | --- | F | 1S | 5 | 16189-1 | 3/4 | 1 |
| 168 | --- | G | 1S | 5 | 16189-2 | 3/4 | 1 |

## TABLE 2-108 CABLE CHARACTERISTICS

CABLE TYPE: TRXF

USE: Welding and Motor Leads, Repeated Flexing Service.

DESCRIPTION: Tough rubber jacket, extra flexible. Conductor insulation: None. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 84 | 1 | 2107 | 83,690 | 0.410 | 0.600 | 300 | 110 |
| 105 | 1 | 2646 | 105,500 | 0.460 | 0.680 | 300 | 121 |
| 133 | 1 | 3325 | 133,100 | 0.520 | 0.750 | 300 | 141 |

## TABLE 2-109 INSTALLATION DATA

CABLE TYPE: TRXF

USE: Welding and Motor Leads, Repeated Flexing Service.

DESCRIPTION: Tough rubber jacket, extra flexible. Conductor insulation: None. Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | BEND RADIUS (MINIMUM) | METAL TUBE SIZE | BOX CONNECTOR SIZE | NYLON TUBE SIZE | NYLON TUBE PACKING ASSEMBLY | SYNTHETIC RUBBER GROMMET | KICKPIPE SIZE |
|---|---|---|---|---|---|---|---|
| NO. | INCH | NO. | INCH | NO. | MS NO. | INCH | INCH |
| 84 | --- | C | 1/2 | 4 | 16179-4 | 1/2 | 3/4 |
| 105 | --- | D | 3/4 | 4 | 16179-5 | 3/4 | 3/4 |
| 133 | --- | E | 3/4 | 4 | 16179-7 | 3/4 | 1 |

## TABLE 2-110 CABLE CHARACTERISTICS

CABLE TYPE: JAS

USE: For Repeated Flexing Service.

DESCRIPTION: Four conductor, jet aircraft servicing, oval shape. Conductor insulation: Butyl rubber over all, with an inner cotton braid on size 6 (65). Cable insulation: Polychloroprene sheath overall.

| CABLE SIZE DESIGNATION | NUMBER OF CONDUCTORS | STRANDS PER CONDUCTOR | C. M. AREA OF CONDUCTOR | DIAMETER OF CONDUCTOR | CABLE DIAMETER (OUTSIDE) | MAXIMUM RATING 50° C. | |
|---|---|---|---|---|---|---|---|
| NO. | NO. | NO. | C.M. | INCH | INCH | VRMS | AMPS |
| 250 | 4 | 2 of 65<br>2 of 6384 | 6533<br>250,000 | 0.097<br>0.713 | Minor 1.260<br>Major 2.480 | --- | --- |

**4–3. CABLE INSPECTION AND TESTING.**–Electrical cables used for the interconnection of electronic equipment units shall be in perfect electrical and physical condition in order to assure proper and continuous operation of the equipment after installation. Electrical cables shall be inspected and tested prior to shipboard installation as follows:

a. INSPECTION.- The cable shall be carefully examined to determine whether its insulation has been cut, bruised or otherwise damaged as a result of handling or storage, or by weather, dirt, moisture, lubricating oil, or deleterious substances.

b. ELECTRICAL TESTING.–The insulation resistance of the cable and all individual wires shall be tested with a 500 volt megohmmeter to determine if the cable is suitable for use.

c. CORRECTIVE MEASURES.–If the cable shows a low insulation resistance (due to moisture intrusion) the cable may be heat treated by passage of electrical current through the conductors to force the moisture out and bring the insulation resistance up to the required minimum value.

**NOTE**

This heat treatment is effective only when the moisture is localized at the extreme ends of the cable. Cables with moisture penetration throughout the complete length must be treated with a moisture-absorbing gas (under pressure) to drive the moisture out of the cable.

d. END SEALING.–When the inspections, tests and corrective measures (if used) have been completed, and the cable has been determined as satisfactory for use in the installation, the cable ends must be resealed to preclude the possibility of moisture penetration before the actual installation of the cable.

e. PREPARATION FOR ELECTRICAL TESTING.–The ends of the cable shall be prepared for electrical testing by the removal of at least six inches of the armor and jacket, separating the wires from each other and cleaning the surface of each wire to avoid the effects of end leakage. If the inner end of the cable does not protrude sufficiently through the flange of the reel to permit preparation of that end, the cable shall be removed from the reel and be rereeled to expose the inner end for preparation and fanning of wires as described above (see figure 3-1).

f. ELECTRICAL TESTING.–When the cable ends have been prepared, proceed with the electrical test as follows:

STEP 1.–Carefully determine the temperature of the cable sheathing on the cable under test. If the test is conducted in the same space where the cable has been stored, it may be assumed that the sheath temperature is the same as that of the air around the cable. A more accurate measurement of the cable sheath temperature may be made by affixing a test thermometer to the outside of the cable by means of a pad of putty or plastic sealing compound. Press the putty or compound firmly around the bulb of the thermometer (which is in direct contact with the cable armor) and onto the cable armor. This will preclude the possibility of an erroneous reading due to circulation of air with varying temperatures around the cable under test.

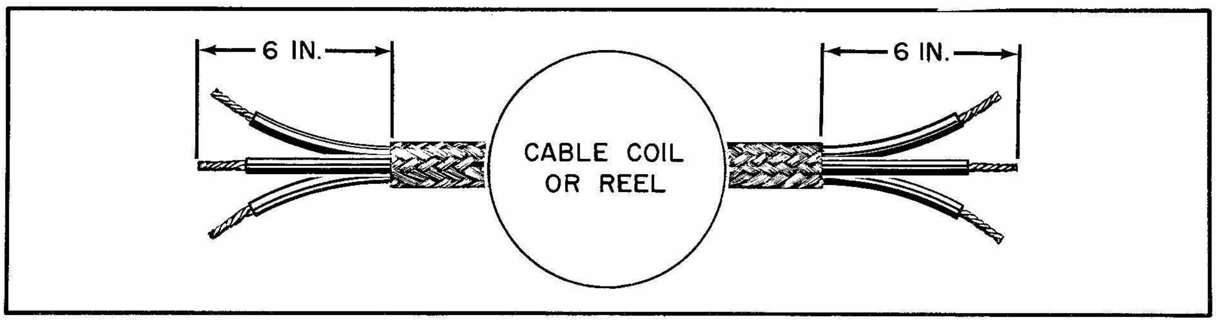



**Figure 3–1. Cable Preparation for Electrical Test.**

STEP 2.–Install a metal clamp or other connection device on the armor at one end of the cable under test. The armor should be cleaned to allow a good electrical connection between the armor and connection device. Connect all wires (with the exception of one) together and fasten to the armor clamp.

STEP 3.–Connect the negative terminal of the megohmmeter to the armor clamp, and the positive terminal to the individual wire under test. Energize the test circuit of the megohmmeter and note the insulation resistance reading of the one wire (see figure 3–2).

**CAUTION**

The voltage output of the megohmmeter is approximately 500 volts and personal contact could cause serious injury. Do not operate the test circuit if the possibility of personal contact exists.

STEP 4.--Connect the wire just tested to the armor clamp and remove one more wire from this connection for test. Proceed with the test as outlined in STEPS 2 and 3. Continue these tests until all wires in the cable have been individually tested.

**NOTE**

Keep the ends of the wire under test separated as far as possible from the wires connected to the armor.

g. MINIMUM INSULATION RESISTANCE.--Figure 3-3 is a curve showing the minimum insulation resistance for Navy cable types with braided metal armor. If a cable does not meet this minimum requirement, corrective measures can be applied to raise the insulation resistance to the required minimum, or the cable must be considered defective and not usable for the installation. The use of the curves in figure 3-3 is demonstrated by the following examples:

EXAMPLE 1.--A 300 foot length of SCA type cable shows a sheath temperature of 15 degrees C. and the megohmmeter reading is 20 megohms. The insulation resistance for one foot of this cable would be 300 x 20 or 6000 megohms. The point at which the 6000 megohm line and the 15 degrees C. line intersect on figure 3-3 is above the curve for type SCA cable and in the satisfactory zone.

EXAMPLE 2.-- A 300 foot length of SCA type cable shows a sheath temperature of 15 degrees C. and the megohmmeter reading is five megohms. The point of line intersection on figure 3-3 would now fall in the lower or unsatisfactory zone.

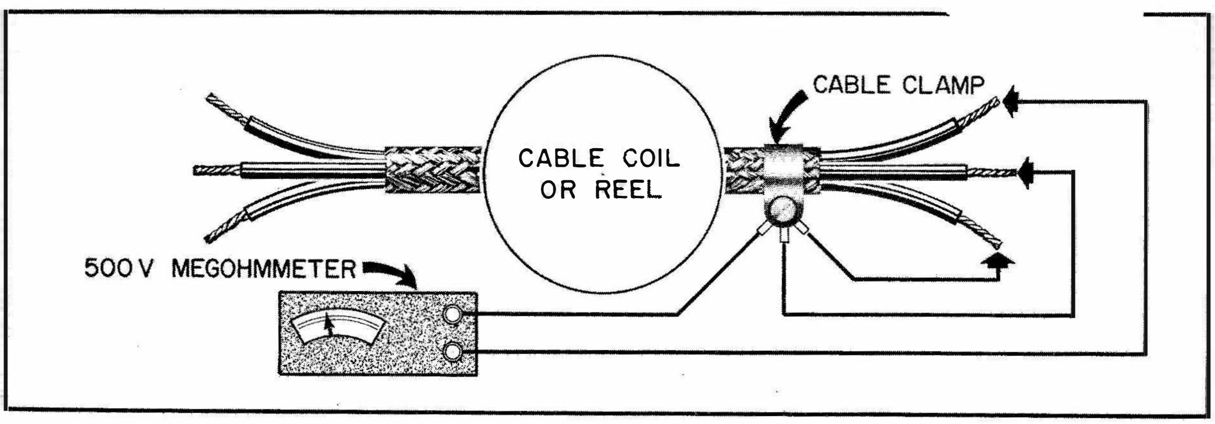



**Figure 3-2. Electrical Test Set-up.**

h. CORRECTIVE MEASURES.--If the cable under test has an insulation resistance that is unsatisfactory, the following corrective measures can be applied:

(1) CABLE END TRIMMING.--If it can be determined that the moisture penetration is confined to the ends of the cable, a length not greater than four feet shall be cut from each end of the cable and a new measurement of insulation resistance shall be made. If this method does not raise the insulation resistance to the required value, but does show a definite improvement in the insulation resistance, the method outlined below shall be applied.

(2) ELECTRICAL CURRENT TREATMENT.--If the insulation resistance is low because of moisture intrusion localized at the extreme ends of a cable, the moisture can usually be driven out by passing a current not greater than that for which the cable is rated, through the cable for a few hours. Check for temperature rise in the cable sheath, and after approximately four hours of treatment, run an insulation resistance test. If the cable shows marked improvement, continue the current treatment until the cable is satisfactory for use. If no improvement is shown after four hours of treatment, the cable should not be used (see figure 3-4).

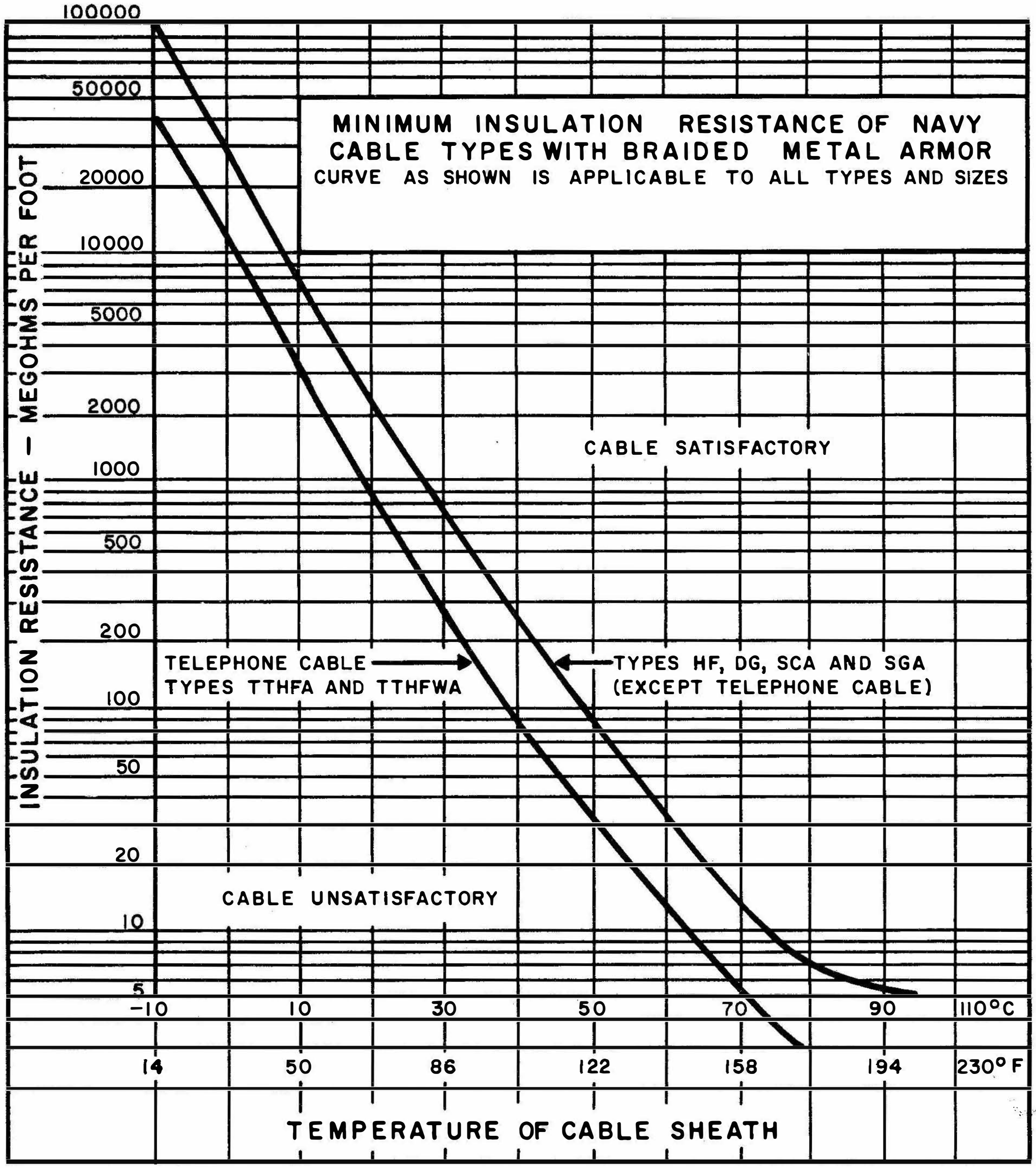



Figure 3–3. Minimum Insulation Resistance.

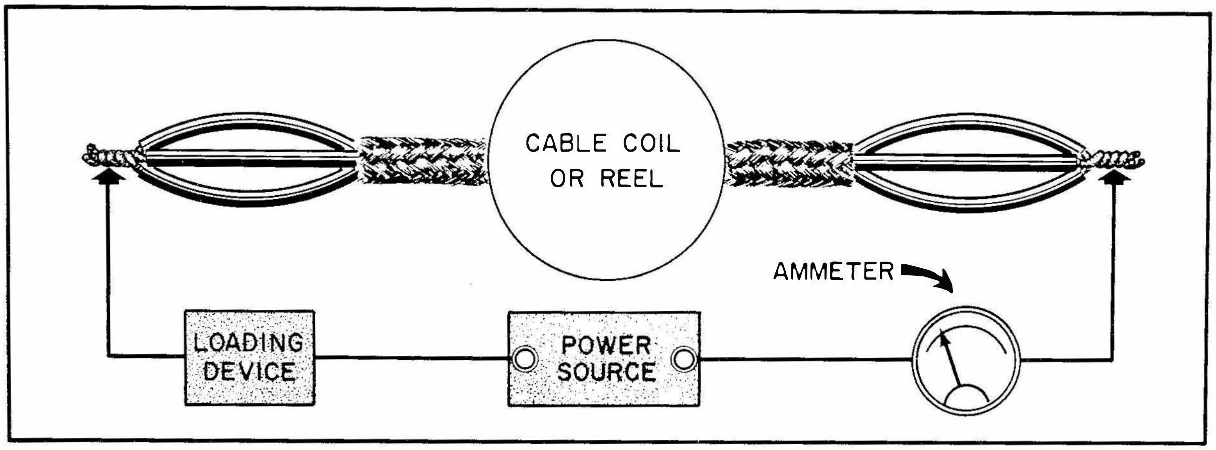



**Figure 3—4. Electrical Current Treatment of Cables.**

**NOTE**

If the size and number of conductors in the cable necessitate an exorbitant amount of current to energize all conductors, the current can be passed through a limited number of conductors and the treatment time increased accordingly.

i. CABLE END SEALING.- When the cable to be used in the installation has been found satisfactory by initial test or by subsequent tests after corrective measures have been applied, the ends shall be sealed immediately to preclude the possibility of moisture penetration while in transit to the installation location or in temporary storage prior to the installation. The proper method of end sealing cables is illustrated in figure 3-5.

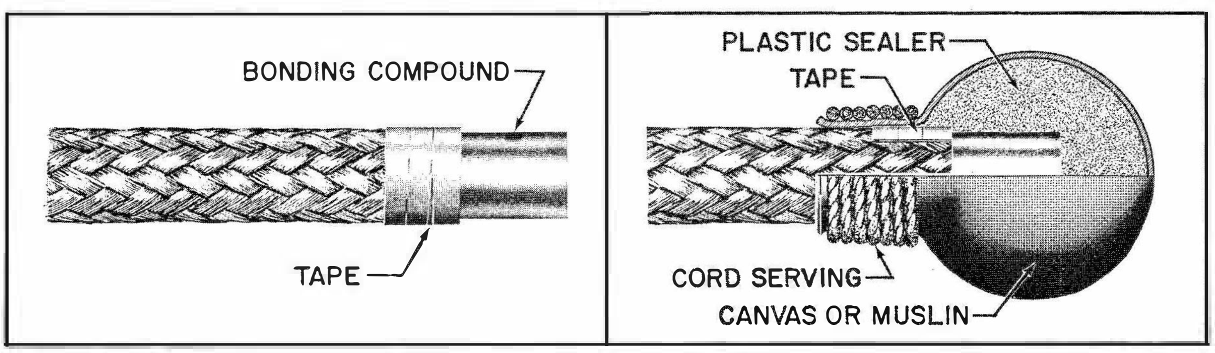



**Figure 3—5. Cable End Sealing.** **(same as Fig. 6—3.)**

**4-4. CABLE ROUTING.**-Cables use for supply and interconnection of electronic equipment units carry electrical energy of various types, amounts, and uses. It is necessary, during the planning stage and throughout the installation, to route, group segregate, and isolate the cables in categories to provide proper protection and operation of cables and circuits comprising the electronics system. When routing and installing cables, the coupling of interference currents and voltages can be materially reduced by proper planning and strict adherence to the plans while the installation is in progress. This describes the methods to be used in the installation of electronic equipment supply and interconnection cables. It includes the routing, grouping, segregation, and isolation of cables in circuit category classifications.

a. GENERAL.- The following general rules must be observed for cable routing.

(1) EXPOSED CABLE RUNS.-Cables shall not be routed and installed on the exterior of structures above the main deck, except where necessary because of the following conditions:

(a) EQUIPMENT LOCATION.- The equipment served by the cables is located in such position that an exterior run is the only possible cable route.

(b) STRUCTURAL INTERFERENCE.- The cable run may be blocked by parts of the ship's structure which can not be pierced or made accessible for a cable run.

(c) HAZARDOUS LOCATIONS.- Locations where possibilities of cable damage are apparent.

(d) HAZARDOUS CONDITIONS. -Locations where cable failure or damage could cause fire, exposion or damage to the ship.

**NOTE**

Where exposed runs of vital cables are unavoidable, a method of protection as shown in BUSHIPS Standard Plan 9000-S6202-73980 shall be used.

(2) REMOVABLE STRUCTURE.-Cable runs shall not be routed in areas where sections of the ship's structure may be removed for installation or removal of machinery.

(3) STRUCTURAL PROTECTION.-Wherever practicable, vital cables shall be routed and installed along the inboard side of beams or other structural members to afford maximum protection gainst damage by flying metal or debris.

(4) HEAT ZONES.-Cable runs in locations subject to excessive heat shall be avoided. If a run through a heat zone is unavoidable, cables of heat resistant type should be installed, or protect the cables with a heat insulating barrier or shield. A heat zone is considered as an area where the temperature reaches or exceeds 185 degrees F (85 degrees C). Areas in the vicinity of the following are heat zones.

(a) MACHINERY.- Units of machinery which may, by operation, produce excessive amounts of heat.

(b) PIPING.- Piping used for the transfer of hot water or steam.

(c) GALLEY EQUIPMENT.- When in operation.

(d) BOILERS. -Boilers in any location are a source of excessive heat.

(e) HOT AIR OR GAS DUCTS.- Ducts or pipes carrying forced hot air or gas.

(f) FIRE ROOMS.- The upper portions of fire rooms contain hot air pockets.

(g) STACKS.- Areas on or around the fire room stacks.

(h) STACK GASES.- Portions of the masts and upper superstructure exposed to excessive temperature from stack gases.

(5) MOISTURE.-Cables shall not be routed or installed in locations where they may be subject to excessive moisture unless structural or other factors make the routing necessary. If this type of run is unavoidable, dripproof moisture barriers or shields shall be installed for cable protection.

(6) FLOODING.-Cables in spaces subject to flooding shall be installed as high as practicable above the flooding area.

(7) BILGES.-If cables are to be installed in fire and engine room bilges where the distance between cable supports would be excessive, intermediate supporting members shall be provided.

(8) WATER TANKS.- Cabling through water tanks shall be enclosed in a single pipe of suitable diameter and, if required to preserve watertight integrity of adjacent spaces, shall be equipped with a stuffing tube at each end. The pipe shall be sloped to provide drainage and the cable shall be supported on spacers clear of the lower inside surface of the pipe. Drain holes with pipe plugs shall be provided at the lower end of the pipe.

(9) SUBMERGED CABLE.-Cables that would be installed in normally submerged locations shall be enclosed in a single pipe as specified for water tanks.

(10) HAZARDOUS SPACES.-Spaces in which cable failure or damage could cause serious damage to the ship, should, if practicable, not be used for the passage of cables. The most common of these hazardous spaces are as follows:

(a) ELEVATORS.- Elevator trunks and pits for special weapon elevators.

(b) FUEL TANKS.- Tanks used for the stowage of diesel and fuel oil. This includes compartments used for stowage of diesel and fuel oil in separate tanks or containers.

(c) GASOLINE TANKS.- This includes compartments used for stowage of gasoline in separate tanks or containers, gasoline pump rooms, access trunks to gasoline compartments, and cofferdams adjacent to such compartments.

**NOTE**

Spaces containing stowage facilities for other flammable or volatile fluids should be treated the same as gasoline stowage.

(d) MAGAZINES.- Powder magazines and other spaces where powder is stored (spaces where exposed powder is handled are also in this category). Magazines for warheads, depth charges, mine charges, and aerial bombs.

(e) WORKSHOPS.- Workshops and similar spaces that may be used for doping operations on aircraft parts.

(f) STORAGE COMPARTMENTS.- Compartments used for the stowage of explosive signaling apparatus, ready service ammunition, chemical warfare materials, photographic materials, paint, compressed oxygen, chlorine and other flammable gases.

(11) CABLE RUNS IN HAZARDOUS SPACES.–If cables must be routed and installed through hazardous spaces, special treatment shall be given to eliminate, insofar as practicable, hazards from electrical casualty and from fire or explosion which might be caused by excessive heat, striking of sparks, molten metal or explosive mixtures. In all cases the cable installation shall comply with the following specific requirements:

(a) CABLE TYPES.- Only heat and flame resistant armored cable shall be used except that IC and FC cables totally within a compartment may be of the flexible or unarmored type.

(b) THROUGH CABLES.- Through cables shall be of unbroken lengths within spaces.

(c) TERMINATED CABLES.- Cables terminating at equipment or fixtures within spaces shall be of unbroken lengths. Separate cables to each lighting fixture are not required. A single cable may be run between fixtures where more than one fixture is installed in such spaces.

b. CABLE GROUPING.- The general rules for grouping, segregating, and isolating various cables used in the electronic equipment installation are as follows:

(1) CIRCUIT CATEGORY CLASSIFICATION.–Cables used for high and low level circuits are classified in the categories listed below for the purpose of establishing their location with respect to other cables.

(a) ACTIVE (HIGH LEVEL).- This category includes modulator cables (radar), radar and radio transmitter cables (except VHF and UHF), sonar transducer cables and IFF antenna cables.

(b) PASSIVE (MEDIUM LEVEL).- This category includes power and lighting cables, IC and FC cables, electronic cables not specifically listed under active and susceptible and all control cables for electrically controlled systems.

(c) SUSCEPTIBLE (LOW LEVEL).- This category includes radio receiving antenna cables (including LORAN, ECM, and AEW), sonar hydrophone cables, and transceiver antenna cable (including IFF).

(2) CABLE SEPARATION.–The following rules shall be applied to all new and relocated cable installations.

(a) RADAR MODULATOR PULSE CABLES.- Pulse cables shall be segregated from all other cables (active, passive, and susceptible). The distance of separation shall be the maximum distance practicable but in no instance less than 18 inches except at the point of entrance to the modulator and transmitter.

(b) ACTIVE CABLES.- All active cables shall be separated at least 18 inches from passive cables.

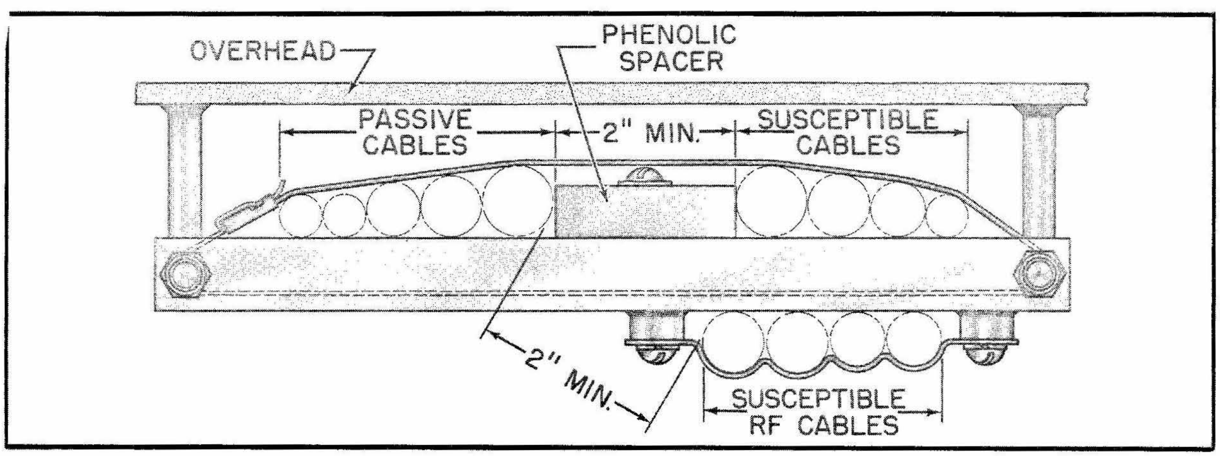



**Figure 4–1 Cable Segregation**

(c) SUSCEPTIBLE CABLES.- Susceptible cables shall be separated at least two inches from passive cables.

(d) SHIELDING.- Additional shielding as approved will be permissible where segregation of active or susceptible cables is physically impracticable. However, neither segregation nor special shielding will be required where cables cross at a 90 degree angle.

(e) DIRECT CURRENT CABLES. Spacing and arrangement of direct current cables shall be such as to reduce to a minimum undesirable external magnetic fields.

(f) ALTERNATING CURRENT CABLES.- For alternating current, where it is necessary to run separate phase conductors, the individual conductors shall be as close as practicable throughout their entire length.

**NOTE**

These cables shall not be grouped on the same cable hangers with cables carrying direct current.

(g) VARYING CURRENT OR VOLTAGE CABLES.- Cables of this type, where the current or voltage is intentionally varied, shall be routed separately from cables carrying DC.

(h) AUDIO FREQUENCY CABLES.- Cables carrying audio frequency shall be separately routed. In installations where adequate separation is not practicable, audio frequency lines should be twisted pairs with an outer shield.

(i) NEGATIVE POWER LEADS.-One wire system negative power leads shall be routed as directly as possible to basic ground with the leads as short as possible. Loops made for neatness of appearance can be very detrimental to reduction of interference.

(j) INDIVIDUAL EQUIPMENT CABLES.- Cables interconnecting the units of individual equipments should be grouped and routed separately (radar equipment particularly).

(k) COAXIAL ANTENNA CABLES.- Coaxial antenna cables shall be routed separately from all other antenna cables.

(l) UNSHIELDED ANTENNA LEADS.- Unshielded antenna leads shall be routed in the shortest, most direct route practicable, and as free from other antenna leads or cabling as possible throughout their length.

## 4-5 CABLE CLEANING*

**a. GENERAL -** This sub-section describes the procedure for cleaning interconnecting cables during and upon completion of an installation project. During installation, cables have a tendency to become coated with dust, metal particles, foreign matter, and oil film. Some types of cable hava a film or preservative which must be removed. In general, interconnecting cables may be cleaned by the following methods.

**b. CLEANING METHODS**

(1) **SUCTION BLOWER -** A suction blower with a flexible rubber hose is the preferred method of removing loose particles of dirt and foreign matter from interconnecting cables.

(2) **SOLVENTS -** An acceptable solvent furnishes the best practical method for removing oil and preservative film from the surface of cables.

(a) **INHIBITED METHYL CHLOROFORM (FSN GM6810-664-0388) -** This solvent should be applied by moistening a lintless cloth with the fluid and lightly rubbing the surface to be cleaned. Allow the surface to dry and repeat the process if necessary. After cleaning, the surface should be dried thoroughly by wiping with a clean dry cloth. Though this solvent is an effective cleaning agent, it has the following disadvantages and should be used only when necessary.

1. **DISADVANTAGES -** Though inhibited methyl chloroform is a relatively safe material, it does have toxic properties (refer to paragraph c. for safety precautions). It is very corrosive in its action on metals and may prove injurious to certain varnishes used to coat electrical insulation. Before using inhibited methyl chloroform, apply it to a small piece of the cable to determine its effect on the insulation.

(b) **SOLVENT, DRY CLEANING, TYPE II -** This solvent, as covered by the latest issue of Specification P-S-661 (Stock No. W6850-274-5421) is a safety type solvent in which the fire and health hazards have been minimized. Nevertheless, precautions against fire and explosion should be observed. The efficiency of this solvent will be somewhat less than that of the chlorinated solvents but ill effects to personnel will also be reduced. Experience has shown that this solution has an injurious effect upon some types of insulation. Before using dry cleaning solvent Type II, a test should be made by applying the solvent to a small piece of the cable concerned to determine its effect on the insulation.

**c. SAFETY PRECAUTIONS -** While using solvents the following rules should be observed:

(1) Guard carefully against fire.
(2) Use vapor-proof or watertight portable lights if supplementary lighting is required.
(3) Have fire extinguishers available for immediate use.
(4) Prevent sparks caused by one metallic object striking another.
(5) If a spray or atomizer is used, ground the nozzle.
(6) Avoid saturation of the operator's clothing with the solvent.
(7) Provide liberal ventilation by supply and exhaust fans or portable blowers.
(8) When using inhibited methyl chloroform, protection against breathing the fumes must be provided and the operators should be under the observation of someone familiar with artificial respiration.
(9) If the cleaning must be accomplished in a space which lacks adequate ventilation, an air respirator or self-contained breathing apparatus should be used. Preferably the space should be adequately ventilated by supply and exhaust fans or portable blowers. When inhibited methyl chloroform is used, a chemical cartridge respirator is ineffective because it will not filter the harmful fumes.
(10) Do not apply solvents on hot equipment or use them in the presence of open flames.
(11) No less than two persons should be assigned to cleaning operations in a compartment.

**4-6. CABLE PROTECTION.**–This sub-section describes the precautions to be observed during installation of electrical cables. It also includes protection of cables in storage prior to, or during the installation, and after installation when equipment is removed for overhaul. Cables used for electronic equipment installations shall be protected from damage by abrasion, deformation by bending or impact, temperature extremes and contact with water, oil , or grease. A cable that has been damaged by any of the above shall not be used in the installation.

a. TEMPERATURE CONSIDERATIONS.- All cables are subject to probable 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.–All cables except portable, flexible, and reduced diameter types shall be given the following special handling at temperatures below 35 degrees F:

(a) 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 degrees F, but not above 120 degrees F. The cable shall be warm enough so the installation will be completed before it cools to 35 degrees F.

(b) LOW TEMPERATURE INSTALLATION.- If the cable must be installed when its temperature is 35 degrees 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 handied at minus 20 degrees F and higher without the precautions listed in paragraph (1) above.

(3) HIGH TEMPERATURE.–Cable of the coaxial type shall never be stored in a compartment where the temperature reaches or exceeds 150 degrees 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 attenuation is in excess of specified maximum value, the cable shall not be used in the 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.–Do not 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 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 contact the cable. Cable of the reduced diameter type, with silicone rubber insulation can be damaged if the insulation is 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 of unreeled cable from hooks, dowels or pegs.

(c) CABLE END PROTECTION.- When cable is stored or set aside for later installation, and after the cable installation when equipment units are removed for overhaul or replacement, the ends of the cable shall be sealed to prevent the intrusion of moisture (see figure 6-1).

(1) CUT CABLE ENDS.–If cable (including coaxial type) is to be stored prior to installation, the cable ends shall be protected as follows:

STEP 1.- Mold the flameproof insulating filler tape (MIL-I-17695) around the cable end.
STEP 2.- Apply two servings (minimum), half lapped, of one inch wide plastic electrical tape (MIL-I-7798).
STEP 3.- Coat the entire seal with three coats of protective plastic coating (MIL-P-18623).

**NOTE**

STEP 3 may be omitted if the cable ends are not exposed to moisture.

(2) COAXIAL CABLES WITH CONNECTORS.–Coaxial cables with end connectors installed, that are disconnected from equipment (units to allow removal of the equipment) for overhaul, shall be end sealed as follows:

STEP 1.- Apply two servings (minimum), half lapped, of one inch wide plastic electrical tape (MIL-I-7798).
STEP 2.- Coat the entire seal with three coats of protective plastic coating (MIL-P-18623).

**NOTE**

STEP 2 may be omitted if the cable end is in a protected, moisture-free location and not exposed to the weather.

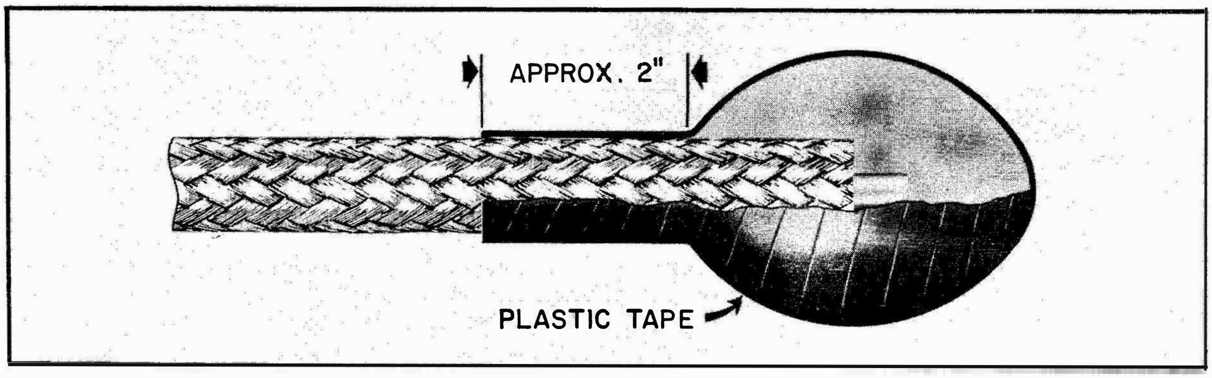



**Figure 6-1. Cable End Protection**

**NOTE**

This end sealing may be omitted only when the interval between cutting a length of cable and the attachment of end fittings is 48 hours or less and the exposed cable ends are not subject to moisture contact or rapid temperature changes.

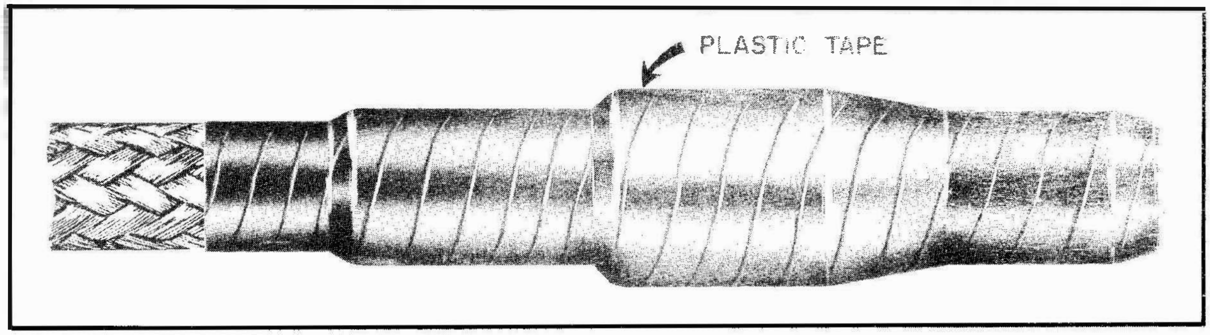



**Figure 6-2. Coaxial Cable and Connector Protection.**

(3) STORED CABLE.–Cable that is to be stored on reels or in coils in a location where the possibility of moisture contact and temperature change exists shall be end sealed as follows:

STEP 1.- Remove about one inch of the cable armor (if cable is armored).

STEP 2.- Seize the armor with one layer of friction tape.

STEP 3.-Apply a bonding agent such as a solution of battery sealing compound and carbon tetrachloride to the cable end and jacket.

STEP 4.- Prepare a pad of plastic sealer (MIL-I-3064, type HF) about one-half inch thick, knead and shape as shown in figure 6-3.

STEP 5.-Cover the prepared cable end with light canvas or muslin.

STEP 6.- Serve with heavy cotton cord to force the plastic sealer tightly against the cable side and end.

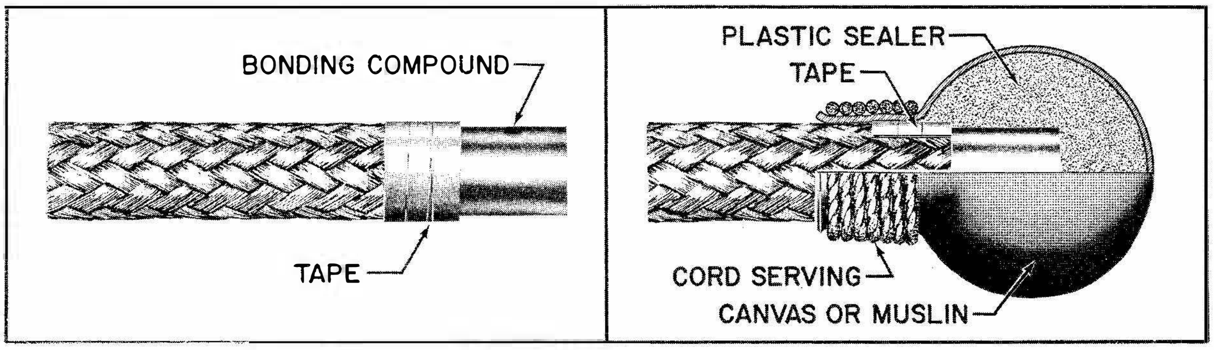



Figure 6-3. Cable End Sealing

## 4-7. HANGER TYPES*

**a. GENERAL** - The majority of electrical cables and cables of the solid dielectric type, in present day installations, are supported by square-tube banding hangers. Square-tube banding hangers have the following advantages in comparison with formed hangers previously used: improved high impact shock and vibration characteristics, lighter weight, reduced cost of fabrication and installation, elimination of central stocking of hangers in a wide range of sizes. Square-tube hangers are fabricated from pre-formed commercial tubing which may be readily cut, drilled, punched, or otherwise adapted for a particular application.

**b. SPACING** - Maximum spacing between square-tube hangers is 32 inches with the exception that a closer spacing varying down to 16 inches minimum is permissible under situations such as the following:

(1) Where a more economical and lighter installation will result by varying the spacing to suit existing beams and stiffners with a minimum addition of intermediate supports to maintain cable row alignment.

(2) Where headroom clearance under cable racks is 79 inches (76 inches minimum), the hanger spacing shall be reduced to 21 inches.

(3) Hangers for overhead multiple-tier aluminum wireways, where welded to aluminum decks, shall be spaced 16 inches and the number of tiers shall be limited to three.

(4) The spacing of hangers for single cables or a single row of cables shall in general be 32 inches, however, it may be adjusted as necessary to suit particular ship conditions.

**c. CABLE SUPPORT MATERIAL** - Cable support components shall be of the following materials.

(a) NON MAGNETIC VESSELS

| | | |
|---|---|---|
| 1. Hangers | - | Aluminum |
| 2. Supports | - | Aluminum |
| 3. Bands | - | CRES or aluminum |
| 4. Ferrules | - | CRES oa aluminum |
| 5. Bolts and nuts | - | CRES or aluminum |

(b) OTHER VESSELS

| | | |
|---|---|---|
| 1. Hangers | - | Aluminum or Steel |
| 2. Supports | - | Aluminum or Steel |
| 3. Bands | - | Steel, zinc, or cadmium plated |
| 4. Ferrules | - | Mild steel, CRES, aluminum or nylon |
| 5. Bolts and nuts | - | Steel, zinc, or cadmium plated |

**d. INSTALLATION METHODS** - Various applications of square-tube banding hangers are illustrated in figures 7-1 through 7-11. Detailed information concerning materials, fabrication, and installation is available in the Bureau of Ships Plan 9000-S6202-73980, Sections 1 and 2.

**e. REFERENCES** - The following references pertain to square-tube banding hangers.

(1) BuShips Plan 9000-S6202-73980

(2) BuShips Notice 9620

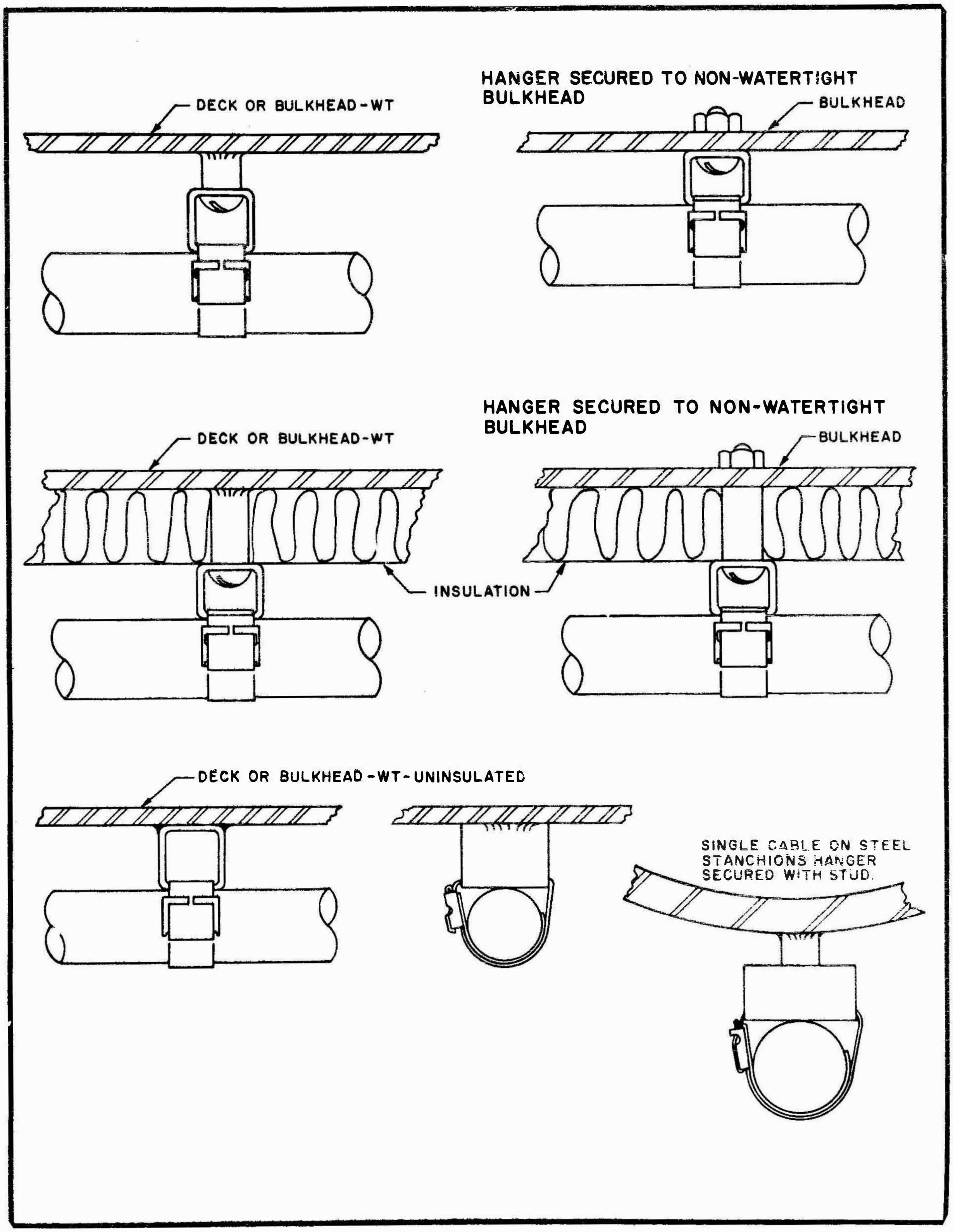



Figure 7-1. Single Cables on Steel or Aluminum Decks and Bulkheads, and on Steel Stanchions

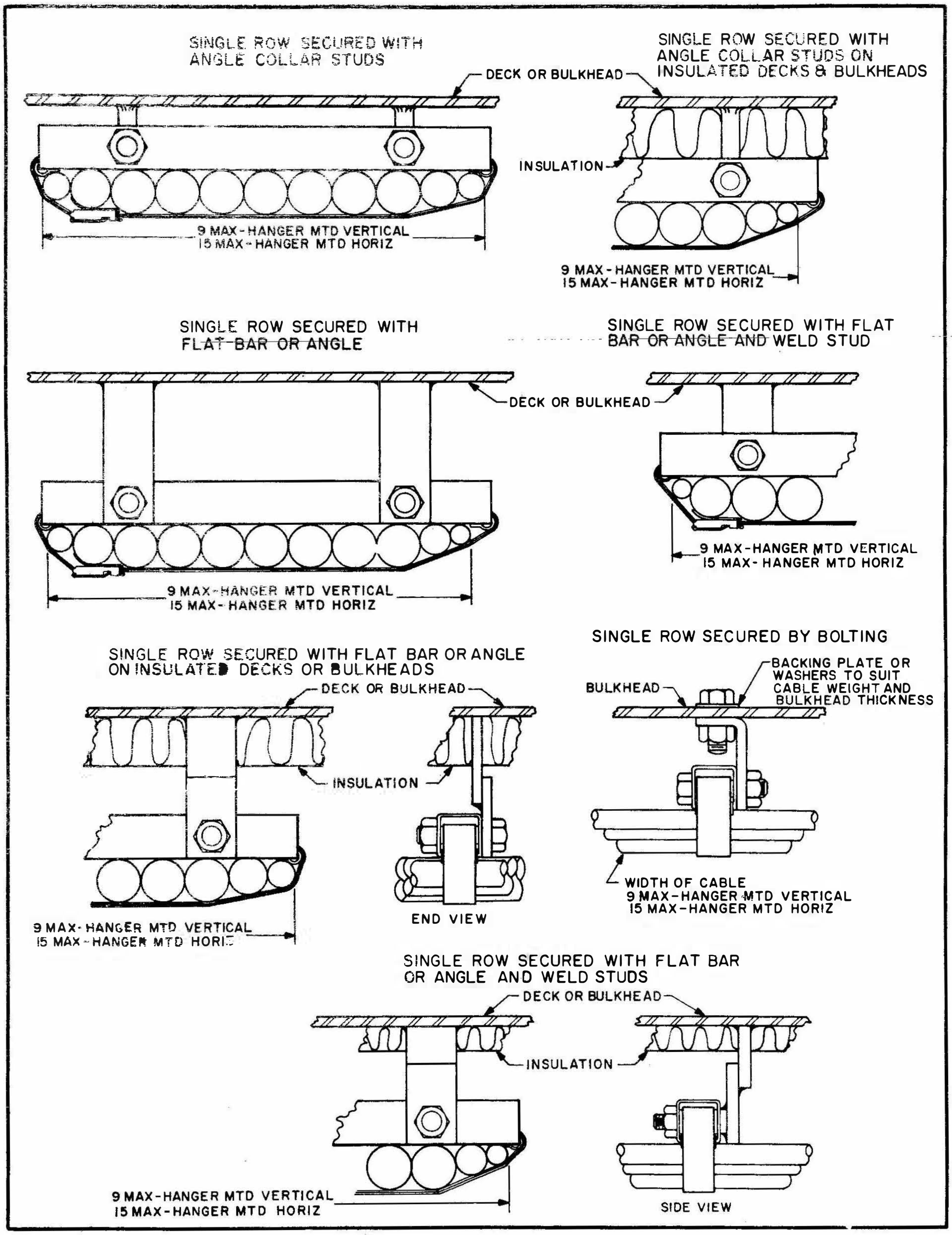



**Figure 7-2. Single Rows of Cables on Aluminum or Steel Structures**

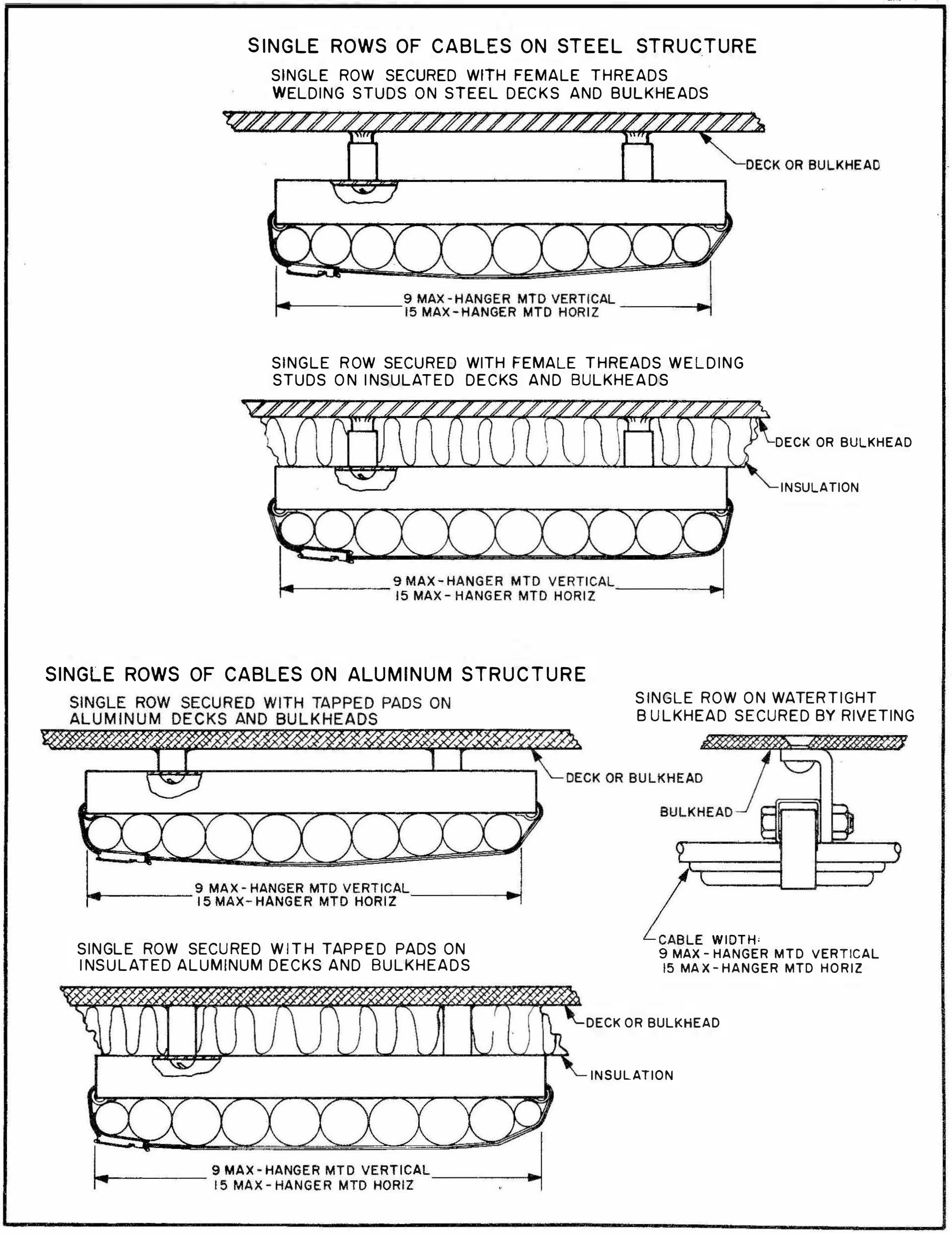



Figure 7-3. Single Rows of Cables on Aluminum or Steel Structures

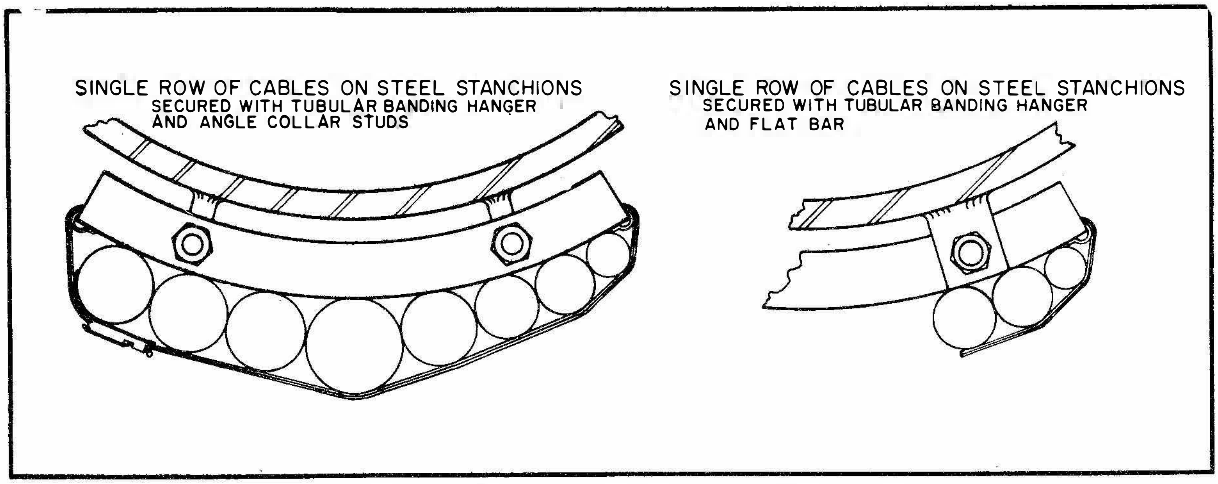



Figure 7-4. Single Rows of Cables on Steel Stanchions

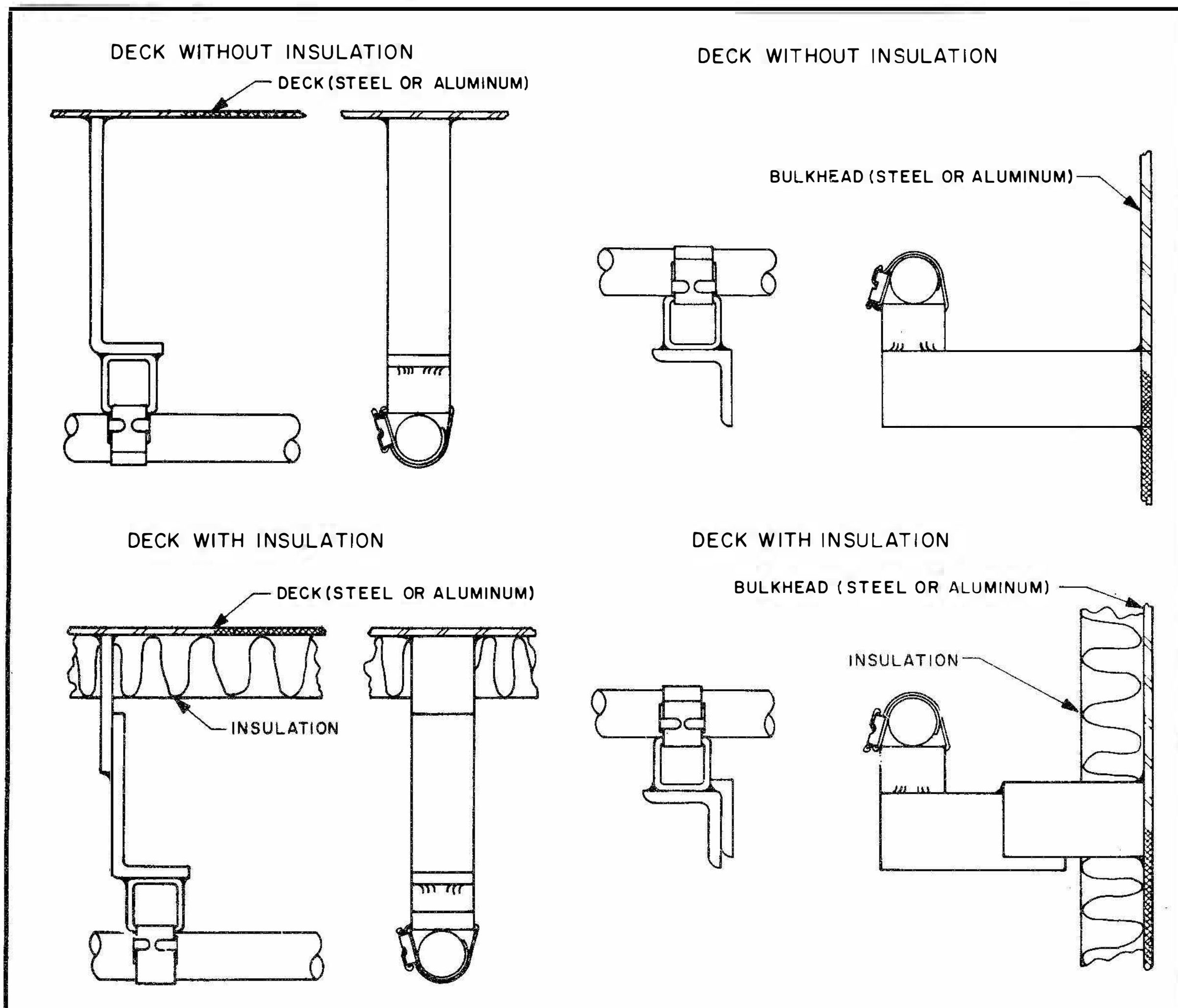



Figure 7-5. Single Cables Away From Steel or Aluminum Decks and Bulkheads

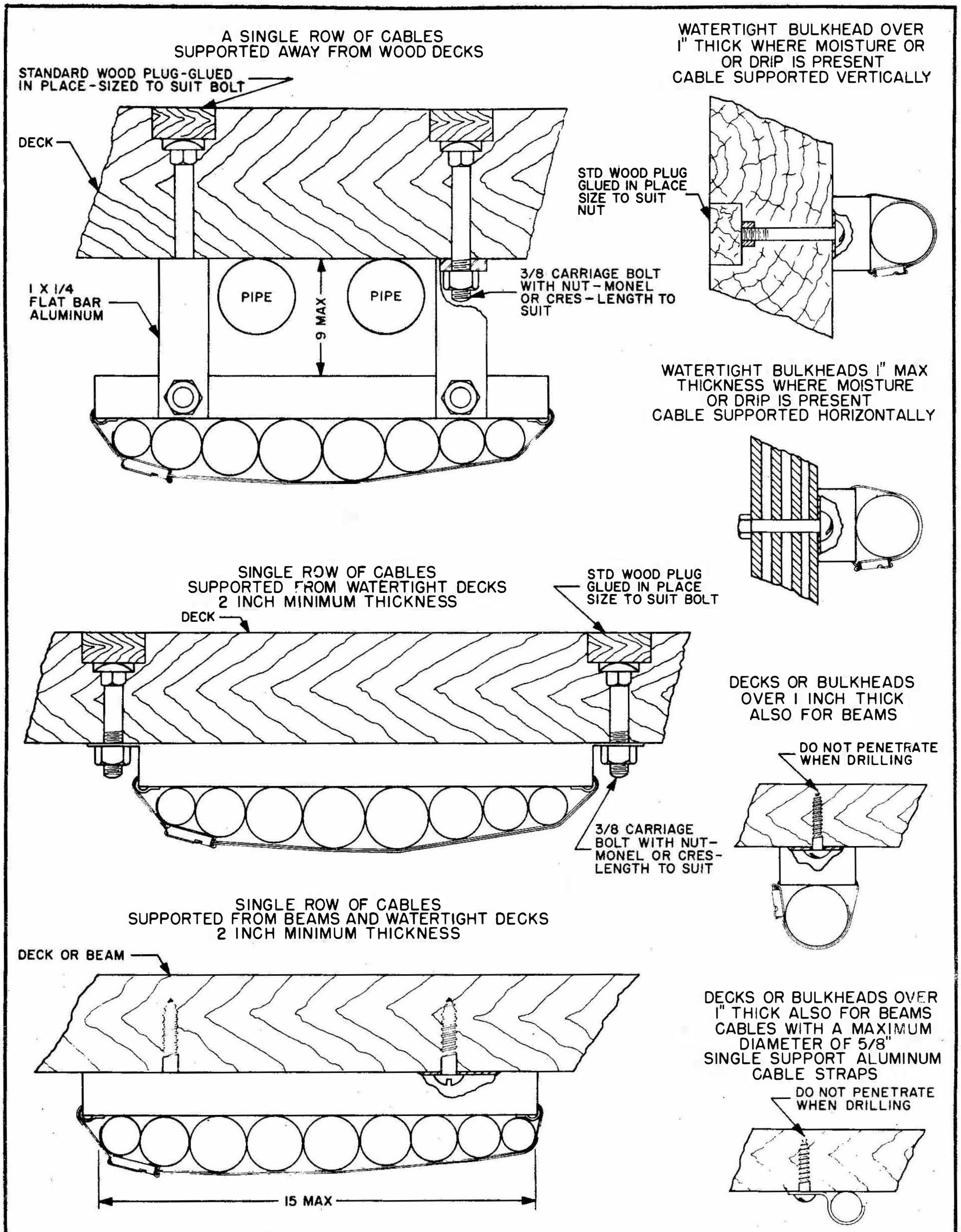



Figure 7-6. Cables on Wooden Vessels

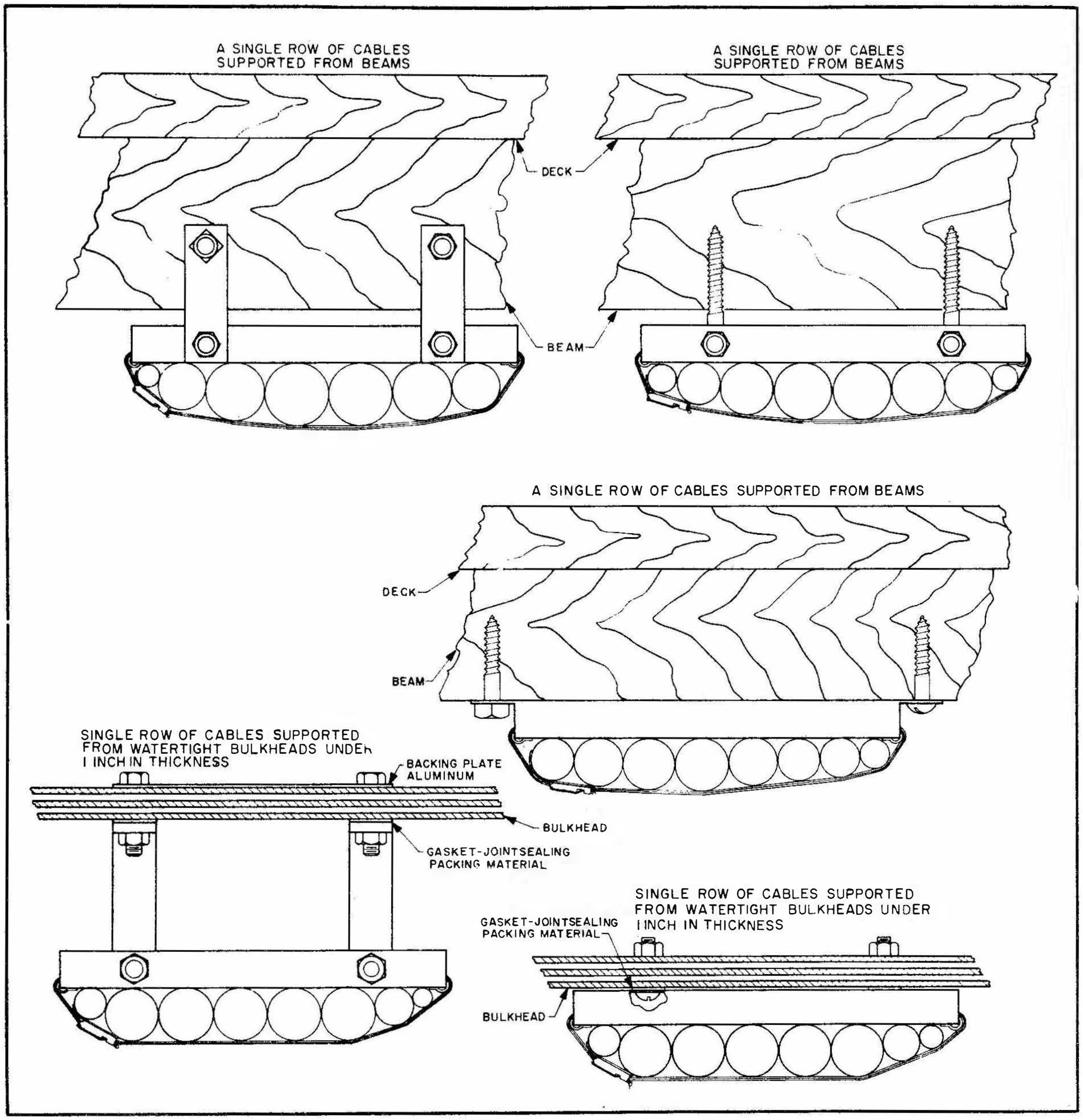



Figure 7-7. Cables on Wooden Vessels

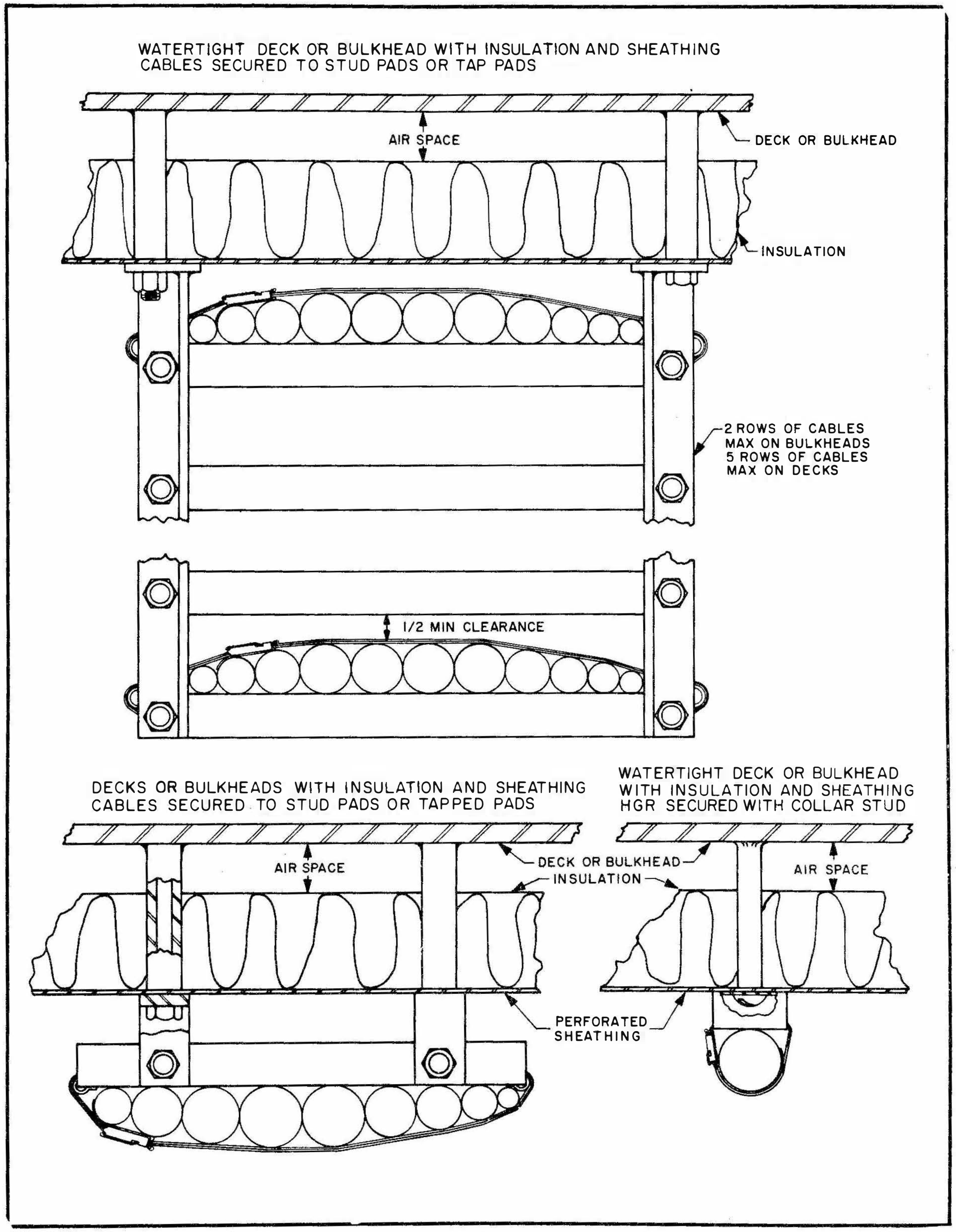



Figure 7-8. Cables in Acoustical Spaces

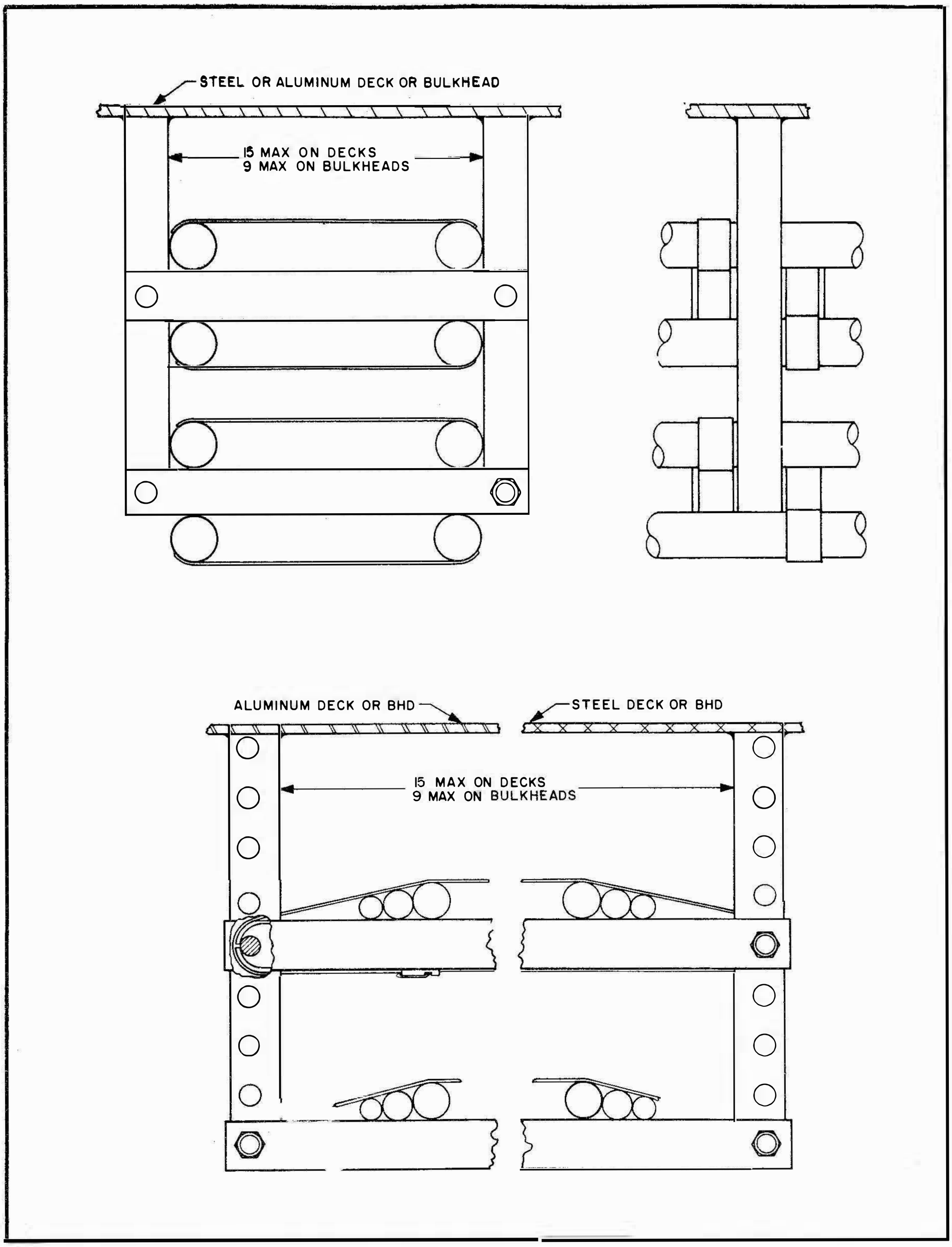



Figure 7-9. Multiple Rows of Cables on Aluminum or Steel Decks and Bulkheads

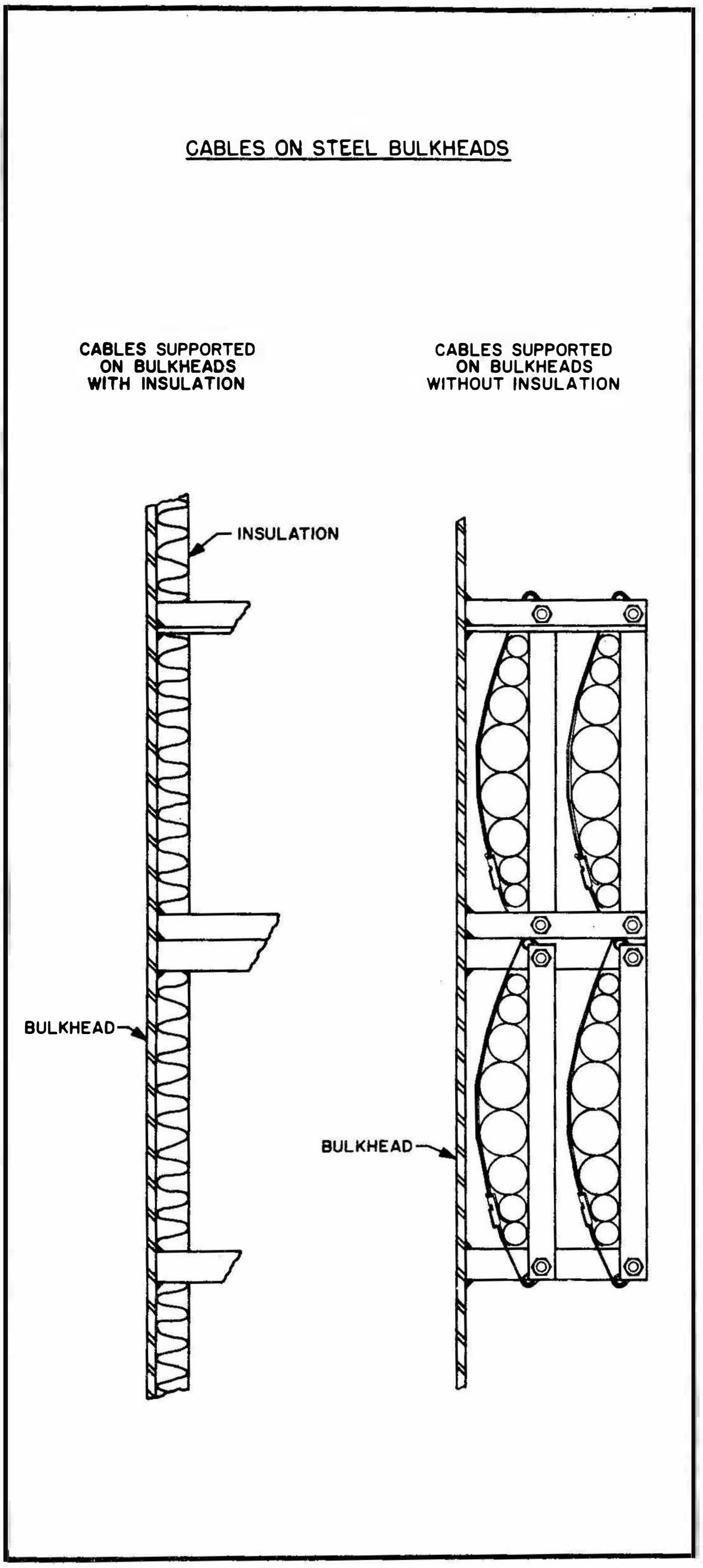



Figure 7-10. Multiple Cable Rows on Steel Bulkheads

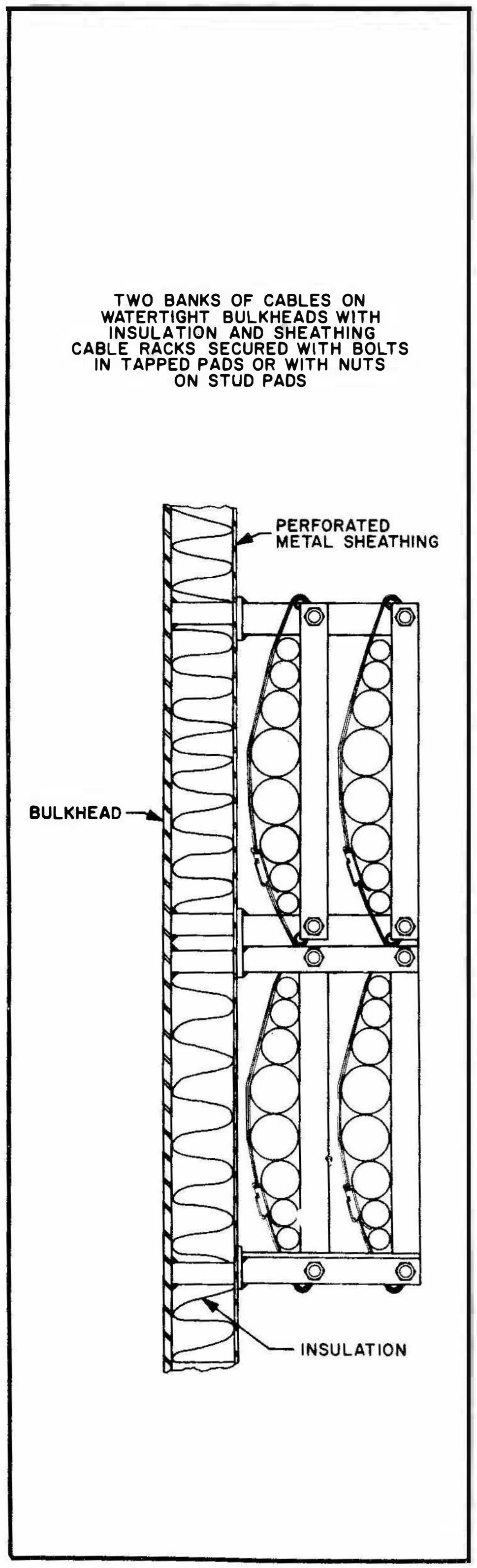



Figure 7-11. Multiple Cable Rows on Steel Bulkheads - Acoustical Spaces

## 4-8. BANDING STRAPS*

**a. GENERAL** - Cables other than semi-solid coaxial cables, which are secured with contour straps (see Sub-section 4-9), may be secured to hangers with banding straps. Figure 8-1 illustrates typical banding configurations for partially loaded hangers, hangers with large and small cables intermixed, and fully loaded hangers. It also illustrates methods of banding cables on small stanchions, methods of modifying existing old type strap hangers to banding methods; and the stirrups, ferrules, and buckles used in cable banding.

**b. BANDING MATERIALS** - Banding material is available in steel, CRES, and aluminum. In nonmagnetic minesweepers use CRES banding except that aluminum banding (0.025 thick) may be used where cables are under 2 inches in diameter and hanger spacing is 21 inches on centers maximum. On weather decks use CRES banding with copper armored cables and steel or aluminum banding with steel or aluminum armored cables.

**c. BANDING REQUIREMENTS** - Banding requirements are:

(1) Single cables 1 inch in diameter and under, 1 turn of banding material 0.015 inch thick.

(2) Single cables over 1 inch in diameter, 2 turns of banding material 0.015 inch thick.

(3) Multiple cables 2 inches in diameter and under, 2 turns of banding material 0.015 inch thick.

(4) Multiple cables over 2 inches in diameter, 3 turns of banding material 0.015 inch thick or 2 turns of banding material 0.020 inch thick.

**d. BANDING TENSION** - The banding tension on coaxial cables shall be limited to 90 pounds plus or minus 10 pounds. The banding tension on other cables shall be approximately 120 pounds.

**e. BANDING TOOLS** - A variety of banding tools are available through commercial sources. Figure 8-2 illustrates the operation of the Royal "HL" strapper, manufactured by the Independent Strap Company, Inc. However, many of the banding tools in use have been devised by the installing activities. They are special tools designed to best suit the needs at the particular activity.

Operation of the Royal "HL" Strapper is as follows:

**STEP 1** - Take the end of the strap material from the reel and insert it through the winged seal. The wings of the seal should be away from the operator.

**STEP 2** - Wind strap around cable or cables and pass strap end through seal again.

**STEP 3** - Bend end of understrap under seal (about 1 inch) to hold strap in place. Pull strap taut by hand.

**STEP 4** - Hold stationary handle (A) of tool in right hand, depressing cam handle (B) with thumb at same time. Insert strap, pushing the nose of the tool flush against the seal and pulling the strap with the left hand to tighten it as much as possible.

**STEP 5** - Stretch strap to desired tension by repeatedly compressing the lower moveable stretcher handle (C).

**STEP 6** - When desired tension is effected, with left hand holding the stationary handle, bend strap away from operator as far as it will go.

**STEP 7** - Still holding stationary handle in left hand, place right palm against the base of the tool with the fingers gripping the cutting handle (D). Squeeze fingers to palm of the hand, thus cutting the strap.

**STEP 8** - Move tool away from cut strap. Bend and hold cut end of strap flat against the seal while tapping wings down into closed position.

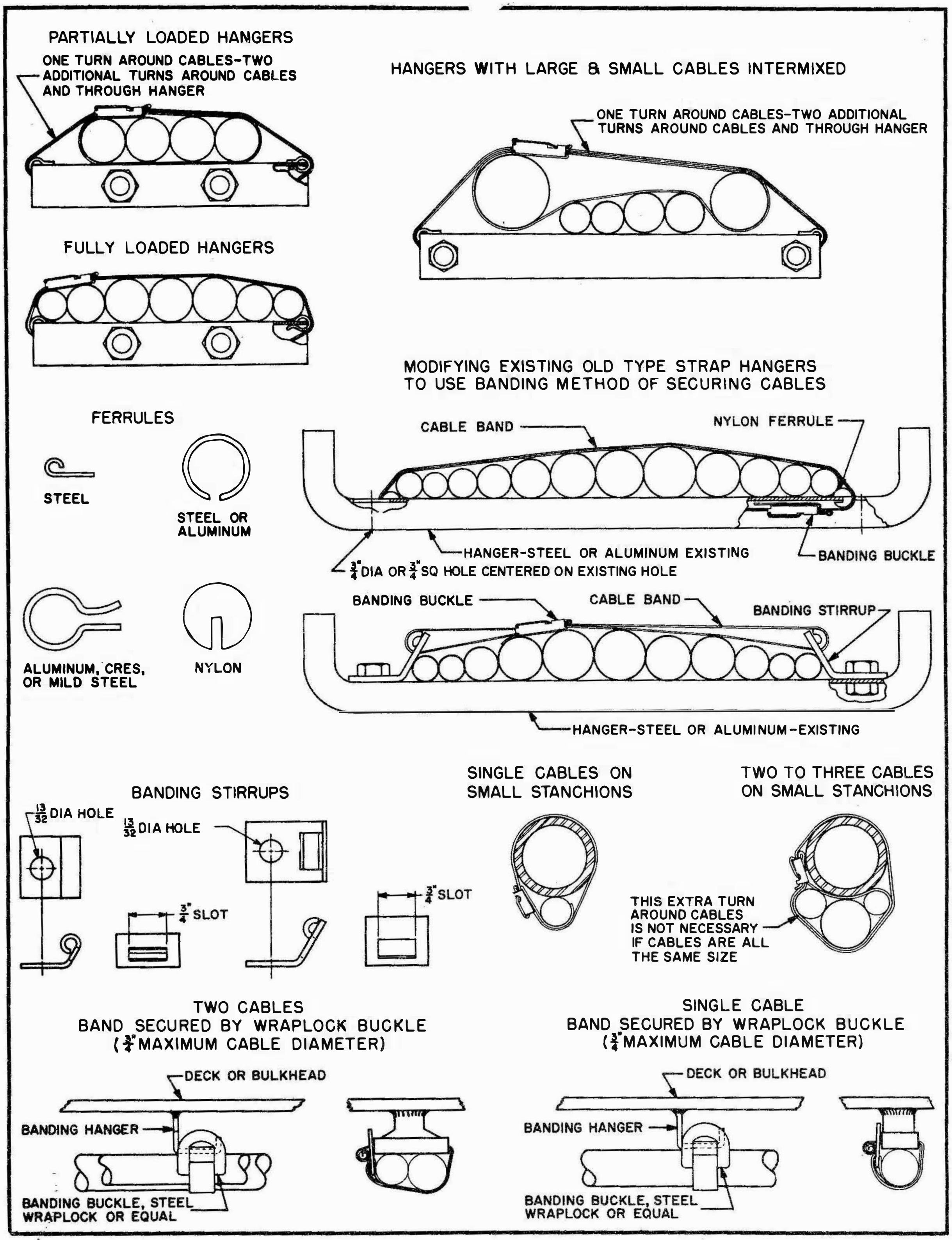



**Figure 8-1. Typical Banding Configurations**

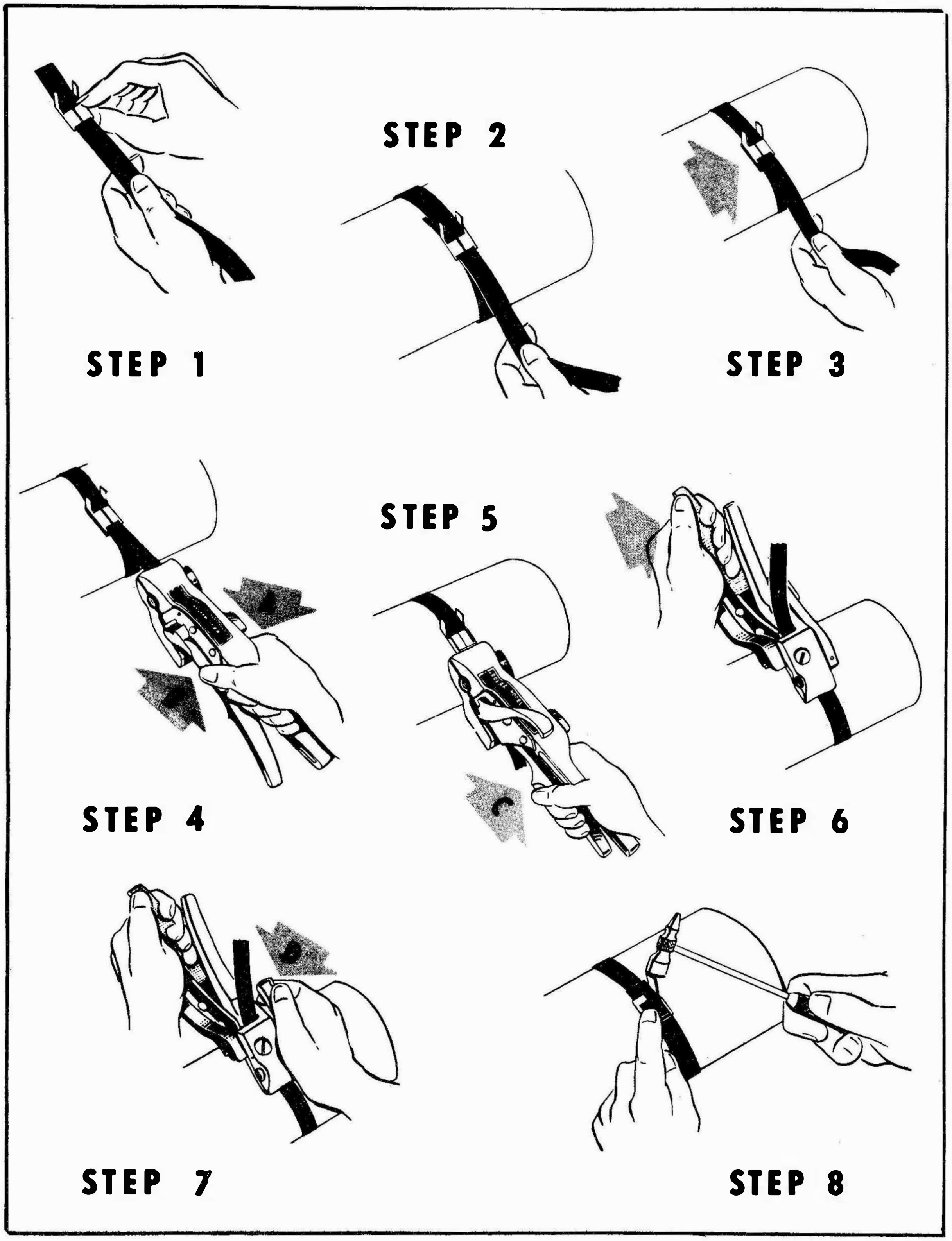



Figure 8-2. Royal "HL" Strapper

## 4-9. CONTOUR STRAPS*

a. **GENERAL** - Coaxial cables having a semi-solid dielectric are secured by contour straps. To avoid damage to cables from vibration or ship's movement, the straps must fit the cable contour snugly.

b. **STRAP MATERIAL** - Strap steel 3/4 inch by 3/32 inch thick is used in the fabrication of straps for overhead spans of cables up to six inches wide; for all vertical and horizontal runs, and overhead spans over six inches wide, 3/4 inch strap steel 1/8 inch thick is used.

To establish a low resistance contact to ground by providing and maintaining metal to metal contact between the cable strap and the cable armor, cable straps should be protected by a metallic plating homogeneous with the cable armor.

c. **FABRICATION** - A variety of jigs are used in the fabrication of contour straps, figure 9-1 illustrates the general design upon which most strap fabricating jigs are patterned. The jig consists of a set of short steel-rods in sizes corresponding to the diameters of all commonly used cables and a clamping mechanism for holding any desired grouping of these rods. The strap is placed over the rods and clamped at one end. Using a hammer, and a chisel with a rounded nose, the strap is formed to the contour of the rod grouping. The strap is then removed from the jig, cut to size, the ends rounded, and holes are punched or drilled in the ends to accommodate the securing bolts, studs, or screws; whichever are used. All sharp edges should be removed from the strap and the punched or drilled holes.

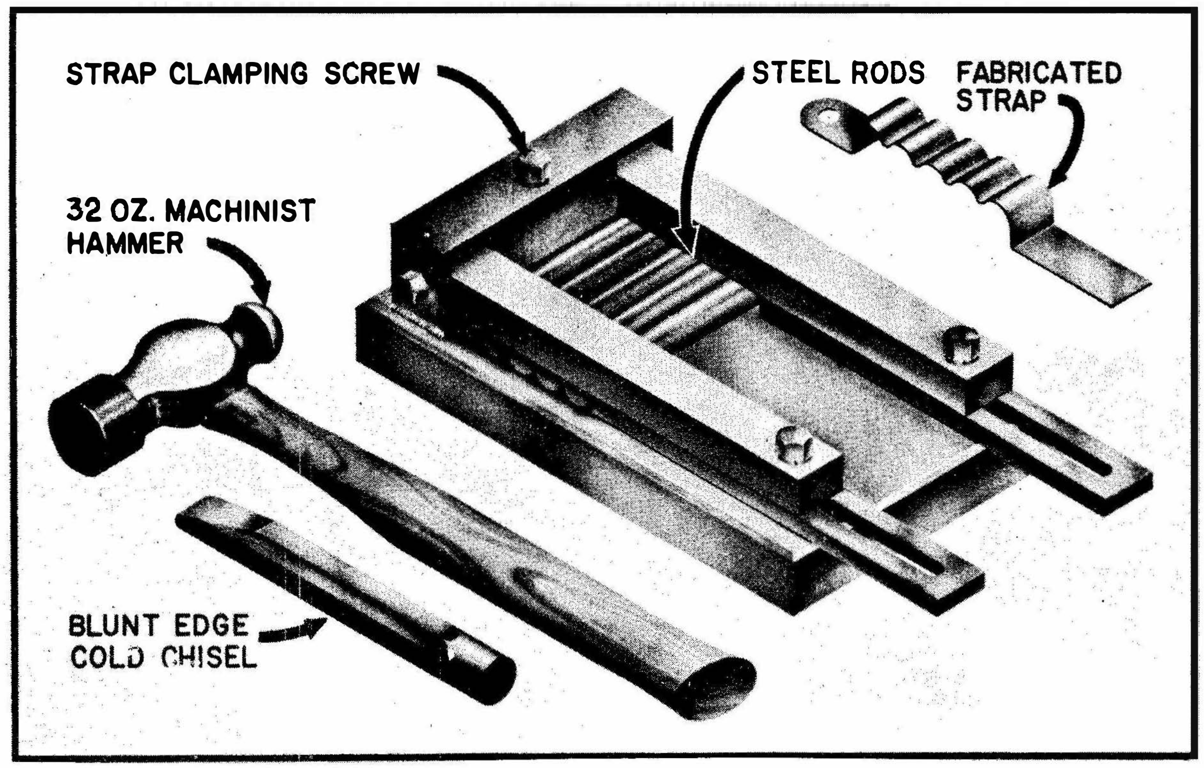



Figure 9-1. Cable Strap Fabrication Jig

d. **INSTALLATION** - Contour straps may be installed by a variety of methods depending on the number of cables to be strapped and the type of bulkhead or deck from which the strap is to be supported. In selecting the method of installation, consideration must be given whether the bulkhead or deck along which the cable is to be secured is subject to moisture condensation and whether or not the bulkhead or deck is insulated. Figure 9-2 illustrates some of the methods used in installing contour straps for single cables. Figure 9-3 illustrates methods of installing contour straps for single cable rows. Detailed information concerning materials, fabrication and installation is available in BuShips Plan 900-S6202-73980.

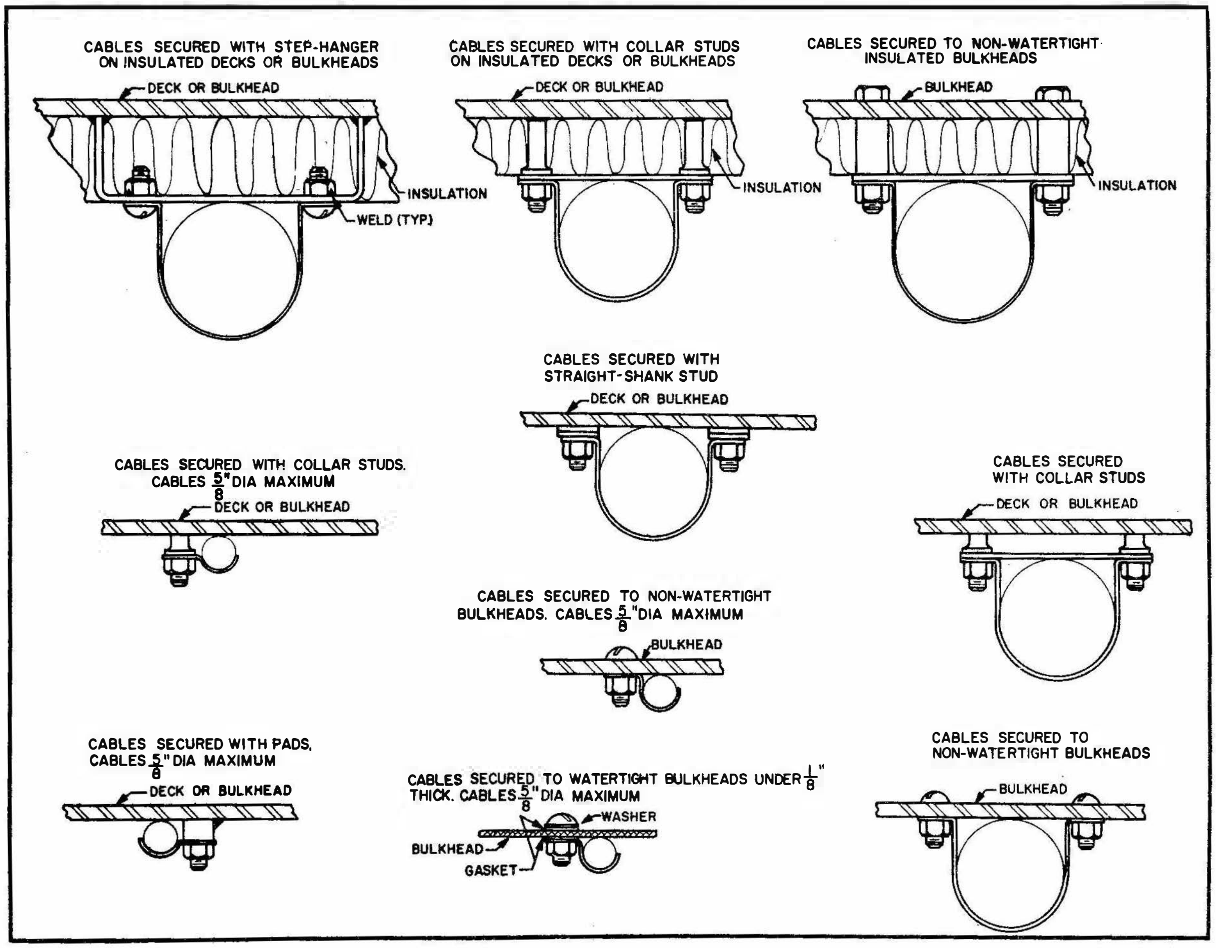



Figure 9-2. Single Semi-Solid Coaxial Cables on Aluminum or Steel, Decks or Bulkheads

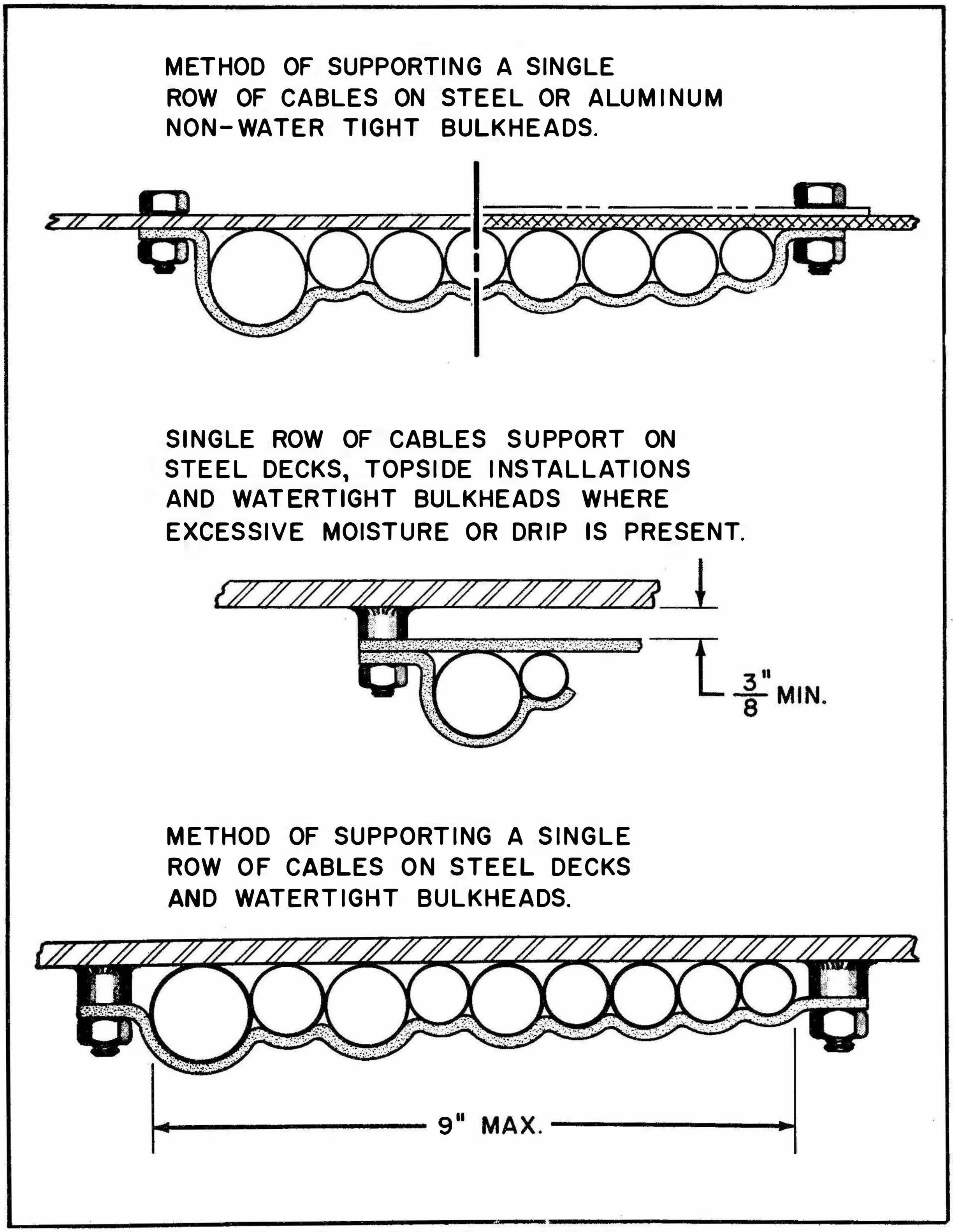



**Figure 9-3.** Single Row Semi-Solid Coaxial Cables on Aluminum or Steel, Decks or Bulkheads

Contour straps may be supported by welding studs, stud pads, tapped pads; or by bolts or screws and nuts. In some locations where the bulkhead or deck is subject to moisture condensation it may be advisable to use hangers to support contour straps, in other locations long welding studs or pads may suffice. Stud pads, tapped pads, and welding studs are illustrated in Figures 9-4 and 9-5.

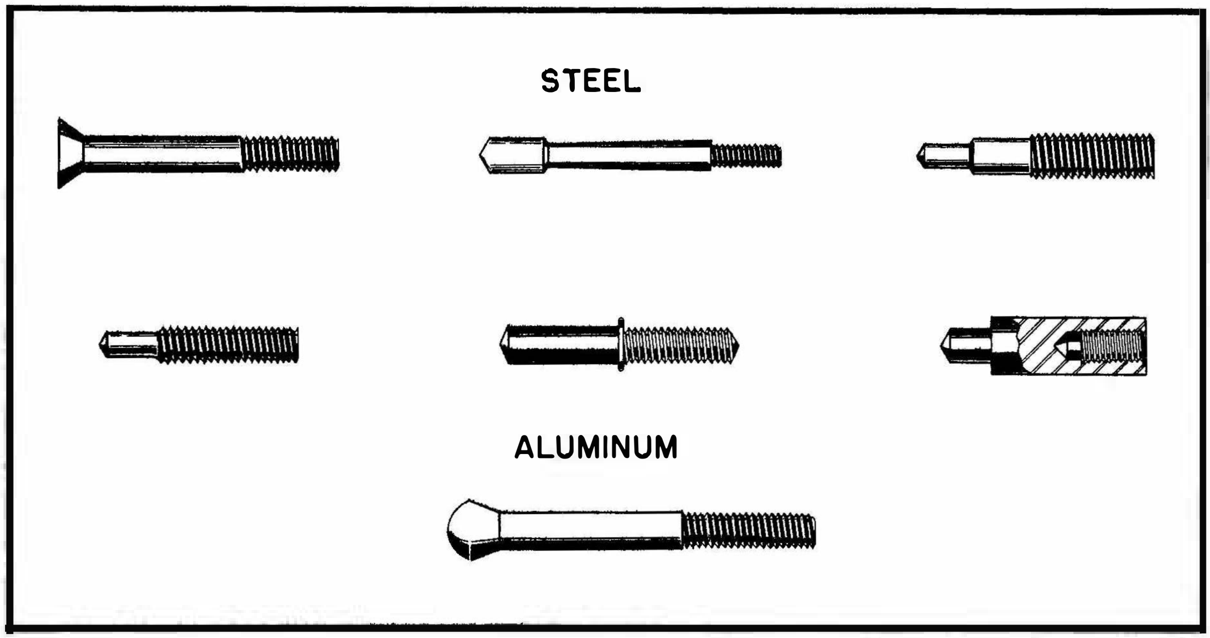



**Figure 9-4. Welding Studs**

Studs may be welded to bulkheads and decks either manually or with an electric-arc-stud-welding gun. The latter method is preferable in most instances, particularly where studs are to be welded to an insulated bulkhead or deck. The electric-arc-stud-welding gun is a simple and dependable tool designed to end-weld studs to steel or aluminum plate. It does not require exceptional welding skill to use this tool. An ordinary 400 ampere direct current electric-welding generator furnishes the current for welding. The operating principles of the electric-arc-stud-welder are to initiate and control the arc between the end of the stud and the plate. The device is so designed that when the trigger is pulled the current is turned on and the stud is lifted a given distance from the plate. The timing device which controls the duration of the arc also trips the gun and forces the stud into the molten crater. The gun is spring operated, and the cocking operation is automatic. When operating the tool, pull the trigger quickly and hold it until the weld is completed, the trigger should not be pulled slowly. Most welding studs contain a flux material capped in the end of the stud, which eliminates the need for loose-powered flux.

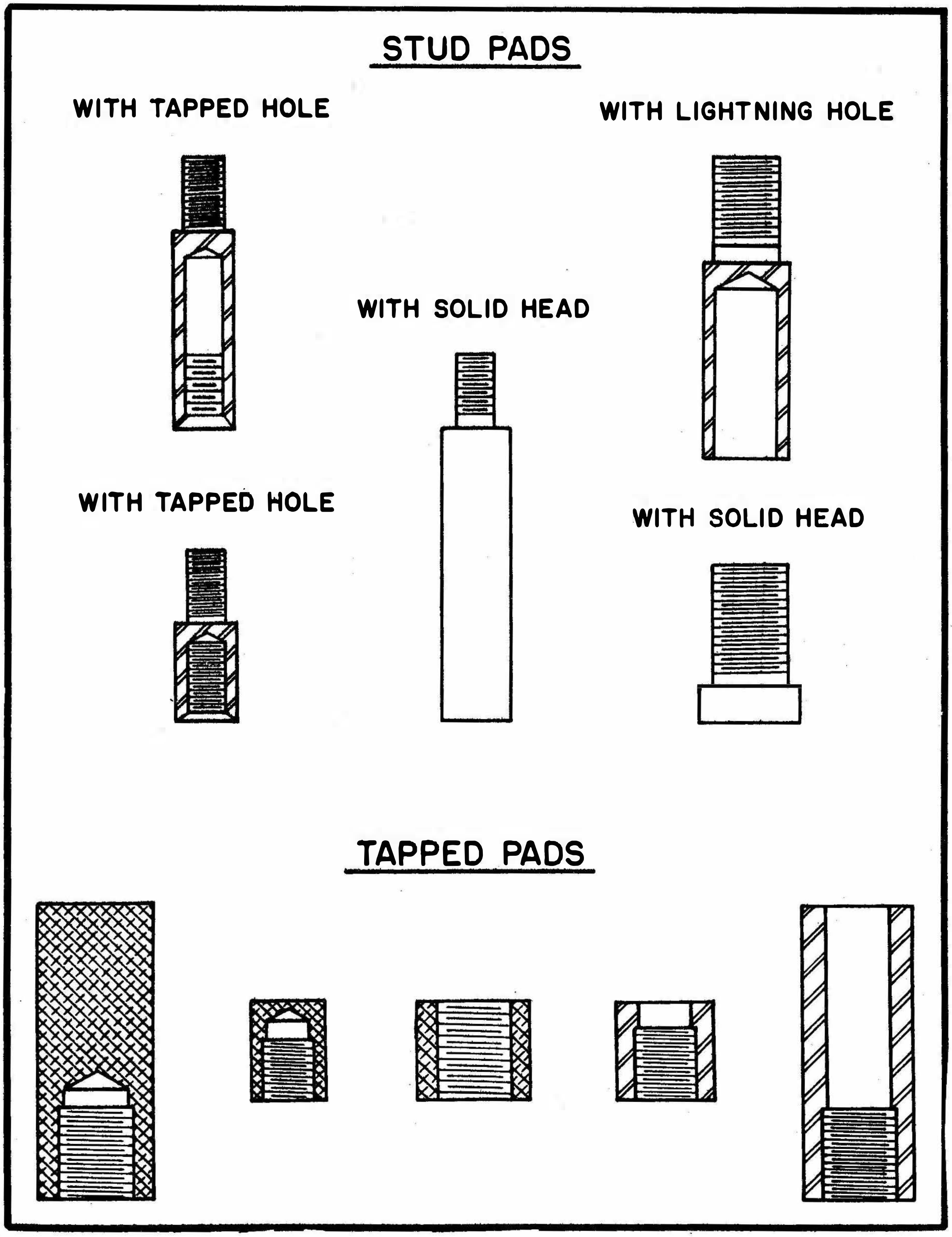



Figure 9-5. Stud Pads and Tapped Pads

**4-10. GENERAL PURPOSE METAL STUFFING TUBES.**-This sub-section covers the types of general purpose metal stuffing tubes used for preservation of airtight or watertight integrity when interconnection cables are installed for electronic systems. It includes special fittings, types of packing and the proper installation methods.

a. STUFFING TUBE TYPES.- Metal stuffing tube types and descriptions are listed below:

(1) TYPE 30-2A.-Steel. Direct weld to bulkhead (see figure 10-1b).

(2) TYPE 48-5.-Steel. Body same as type 30-2A with addition of a bottom section with female pipe thread. Used with kickpipes for cable protection in deck penetration and with pipe sections for bulkhead penetration (see figure 10-1a).

(3) TYPE 48-6.-Brass. Construction identical to type 48-5.

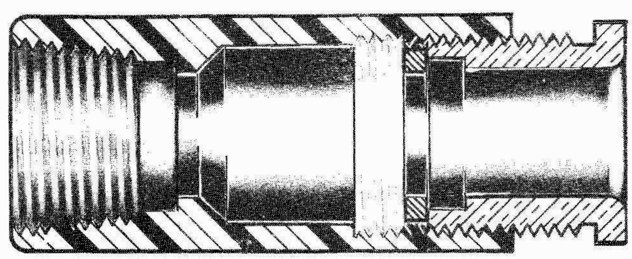
(4) TYPE 21.-Aluminum. Body same as type 30-2A with addition of a bottom section with male pipe thread. Used for cable entry to cast enclosures.

(5) TYPE 22-B.-Brass. Construction identical to type 21.

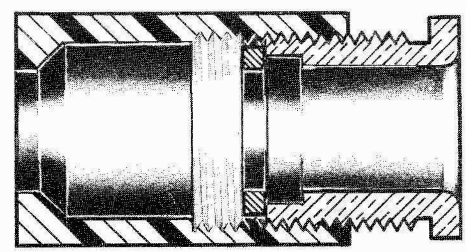
(6) TYPE 22-S.-Steel. Construction identical to type 21.

(7) TYPE 47.-Aluminum. 90 degree elbow with male pipe thread at enclosure entry end.

(8) TYPE 48.-Aluminum. 45 degree elbow with male pipe thread at enclosure entry end.



a. Type 48-5 & 48-6

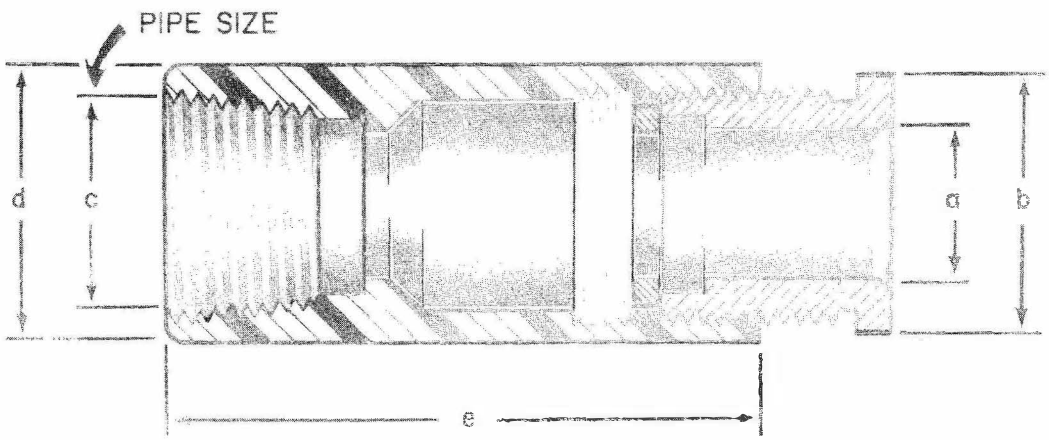


b. Type 30-2A

**Figure 10-1. Metal Stuffing Tubes.**

b. METAL COMBINATIONS.- When stuffing tubes are selected and installed, care must be taken not to install two different metals together, and electrolytic action may be set up. Table 10-2 shows the metals which may be used together without the danger of electrolytic action.

**TABLE 10-1 STUFFING TUBE GENERAL DIMENSIONS.**




| TUBE SIZE | DIMENSIONS IN INCHES "a" | "b" | "c" | "d" | "e" |
|---|---|---|---|---|---|
| A | 0.406 | 1-1/32 | 3/8 | 1-1/8 | 2-3/8 |
| B | 0.515 | 1-1/8 | 1/2 | 1-1/4 | 2-7/16 |
| C | 0.640 | 1-1/4 | 3/4 | 1-3/8 | 2-1/2 |
| D | 0.750 | 1-3/8 | 3/4 | 1-1/2 | 2-1/2 |
| E | 0.812 | 1-3/8 | 1 | 1-5/8 | 2-5/8 |
| F | 0.843 | 1-7/16 | 1 | 1-5/8 | 2-5/8 |
| G | 0.953 | 1-21/32 | 1 | 1-13/16 | 2-11/16 |
| J | 1.062 | 1-25/32 | 1-1/4 | 2 | 2-3/4 |
| K | 1.171 | 1-7/8 | 1-1/4 | 2-1/16 | 4-1/16 |
| L | 1.265 | 1-15/16 | 1-1/4 | 2-1/8 | 4-1/16 |
| M | 1.406 | 2-3/16 | 1-1/2 | 2-5/16 | 4-1/16 |
| N | 1.315 | 2-1/4 | 1-1/2 | 2-7/16 | 4-1/8 |
| P | 1.625 | 2-11/32 | 2 | 2-3/4 | 4-1/8 |
| R | 1.750 | 2-15/32 | 2 | 2-3/4 | 4-1/8 |
| S | 1.873 | 2-13/16 | 2 | 3-1/16 | 6-1/8 |
| T | 2.062 | 2-31/32 | 2-1/2 | 3-1/4 | 6-5/16 |
| V | 2.187 | 3-3/32 | 2-1/2 | 3-3/8 | 6-5/16 |
| W | 2.312 | 3-9/32 | 2-1/2 | 3-1/2 | 6-5/16 |
| X | 2.500 | 3-7/16 | 3 | 3-7/8 | 6-3/8 |
| Y | 2.609 | 3-9/16 | 3 | 3-7/8 | 6-3/8 |
| Z | 2.781 | 3-3/4 | 3 | 3-15/16 | 6-3/8 |
| AA | 2.875 | 3-7/8 | 3 | 4-1/8 | 8-1/8 |
| BB | 3.125 | 4-1/8 | 3-1/2 | 4-1/2 | 8-1/8 |

TABLE 10-2. METAL COMBINATIONS

| ENCLOSURE, DECK OR BULKHEAD MATERIAL | STUFFING TUBE MATERIAL |
|---|---|
| Steel | Steel and Brass |
| Brass | Steel and Brass |
| Aluminum | Steel and Aluminum |
| Zinc | Steel |

c. STUFFING TUBE USE. – In order to penetrate airtight and watertight decks, bulkheads, and enclosures with interconnecting cables and; maintain tightness in the compartment, stuffing tubes will be used in the following locations:

(1) WATERTIGHT BULKHEADS AND DECKS (BELOW MAIN DECK).

(a) Watertight decks.

(b) Watertight bulkheads and watertight portions of bulkheads specified to be watertight to a certain height.

(2) WATERTIGHT BULKHEADS AND DECKS (ABOVE MAIN DECK).

(a) Watertight or airtight boundaries.

(b) Bulkheads designed to withstand a water head.

(c) Bulkheads below the height of a sill or coaming which gives access to the compartment.

(d) Flametight, gastight, or watertight bulkheads, decks, or wiring trunks within turrets or gun mounts.

(e) Portions of bulkheads below the level to which main transverse subdivision tightness is required.

(f) Structure subject to sprinkling.

(3) AIRTIGHT BULKHEADS. – Stuffing tubes shall be used for penetration below the height of sills or coamings of the compartment access. Above this, Bureau standard methods for non-tight installations may be used instead of stuffing tubes if satisfactory airtightness can be maintained by using close fitting construction and plastic sealer.

(4) OTHER SPACES. – Stuffing tubes shall be used in the following spaces:

(a) Air conditioned spaces.

(b) Garbage disposal room.

(c) Spaces where light-tightness is required.

(d) Storage battery rooms.

(e) Surgery, wards and isolation wards.

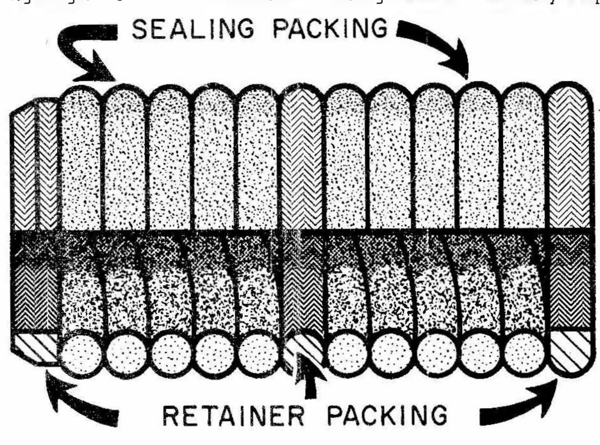
**NOTE**

Nylon stuffing tubes may be used when required in airtight and fumetight bulkheads 3/16 inch thick or less.

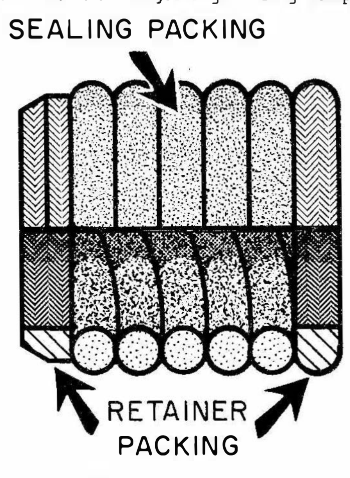
d. PREFORMED PACKING. – Preformed packing is made up in sets to fit all sizes of stuffing tubes. These sets are assembled from combinations of two different types of packing material. Packing sets are illustrated in figure 10-2, and the sizes are tabulated in table 10-3.

(1) RETAINER PACKING. – The retainer packing is composed of asbestos rovings, either braid over braid, or braided square and treated with a waterproof compound.

(2) SEALING PACKING. – The sealing packing is a material in a plastic condition, coil formed and enclosed in a cotton lattice jacket. It may be in one continuous piece in the form of a tight helix or may be cut into individual rings. If it is made up of individual rings, the cuts shall be displaced approximately 90 degrees from the cuts of the adjoining rings. The cut in each retainer ring shall be similarly displaced from the cut in the adjoining sealing component.




a. Type I, K to Z




b. Type I, A to J

Figure 10-2. Preformed Packing.

(3) PACKING TYPES. – The preformed packing is made up in three different types which differ in overall length of the packing in order to fit the different types of stuffing tubes. The packing types and associated stuffing tubes are listed below:

(a) TYPE I. – This packing is used with the following stuffing tubes.

1. TYPE 30-2A. – BUSHIPS plan 9-S-5166-L Alt. 10 and later.
2. TYPE 48-5 and 6. – BUSHIPS plan 9-S-5166-L Alt. 10 and later.
3. SPLIT STUFFING TUBES. – BUSHIPS plan 9-C-4436-L Alt. 9 and later.

**TABLE 10-3. PREFORMED PACKING SIZES.**

| SIZE | OD | ID | TYPE I | TYPE II | TYPE IA |
|---|---|---|---|---|---|
| A | 0.750 | 0.375 | 1-3/8 ± 1/16 | 1-1/8 ± 1/16 | 1-3/8 ± 1/16 |
| B | 0.875 | 0.480 | | | |
| C | 1.000 | 0.610 | | | |
| D | 1.125 | 0.719 | | | |
| E | 1.125 | 0.778 | | | |
| F | 1.187 | 0.812 | | | |
| G | 1.375 | 0.911 | | | |
| J | 1.500 | 1.037 | | | |
| K | 1.625 | 1.120 | 2-5/8 ± 3/32 | 1-3/8 ± 1/16 | 1-11/16 ± 1/16 |
| L | 1.687 | 1.232 | | | |
| M | 1.875 | 1.375 | | | |
| N | 1.937 | 1.474 | | | |
| P | 2.062 | 1.586 | | | |
| R | 2.187 | 1.681 | | | |
| S | 2.562 | 1.820 | 4-5/8 ± 1/8 | 2-1/8 ± 3/32 | 2-9/16 ± 3/32 |
| T | 2.750 | 2.030 | | | |
| V | 2.875 | 2.142 | | | |
| W | 3.000 | 2.280 | | | |
| X | 3.125 | 2.427 | | | |
| Y | 3.250 | 2.545 | | | |
| Z | 3.437 | 2.673 | | | |

(b) TYPE I. A. – This packing is for use with the following stuffing tubes.

1. TYPE 47. –90 degree elbow aluminum. BUSHIPS plan, 9-S-5111-L.
2. TYPE 48. – 45 degree elbow aluminum. BUSHIPS plan, 9-S-5111-L.
3. TYPES 30-1, 48-1, 48-6, 49-1. – Short length obsolescent tubes. BUSHIPS plans 9-S-4860-L and 9-S-5166-L Alt. 9 and earlier.

(c) TYPE II. – This packing is for use with the following stuffing tubes:

1. TYPES 21, 22-S and 22B. –BUSHIPS plan 9-S-5010-L.
2. TYPES, 51, 51-B, 52 and 52-B. –BUSHIPS plan 9-S-5235-L.
3. TYPE 53. – BUSHIPS plan 9-S-5342-L.
4. TYPES 54, 56, and 57. –BUSHIPS plan 9-S-5355-L.
5. TYPE 55. – BUSHIPS plan 9-S-5343-L.
6. TYPES 59 and 59-B. – BUSHIPS plan 9-S-5457-L.
7. NAVY STANDARD PLUGS WITH PACKING GLANDS.

(4) PACKING INSTALLATION. – Preformed packing should be installed in the stuffing tubes prior to the installation of the cables. The gland nut and ring should be in place and not applying pressure to the packing when the cable is pulled through the stuffing tube. If it is necessary to install the packing after the cable has been installed, the packing shall be carefully disassembled and installed around the cable in the same sequence as in the original assembly. When the cable is installed and packing is in place, tighten the gland nut until the pressure deforms the packing

and holds the cable snugly in the stuffing tube. If the gland nut bottoms before the packing is properly tightened on the cable, it will be necessary to add extra turns of retainer packing to assure a good seal on the cable. A stuffing tube with packing installed is illustrated in figure 10–3.

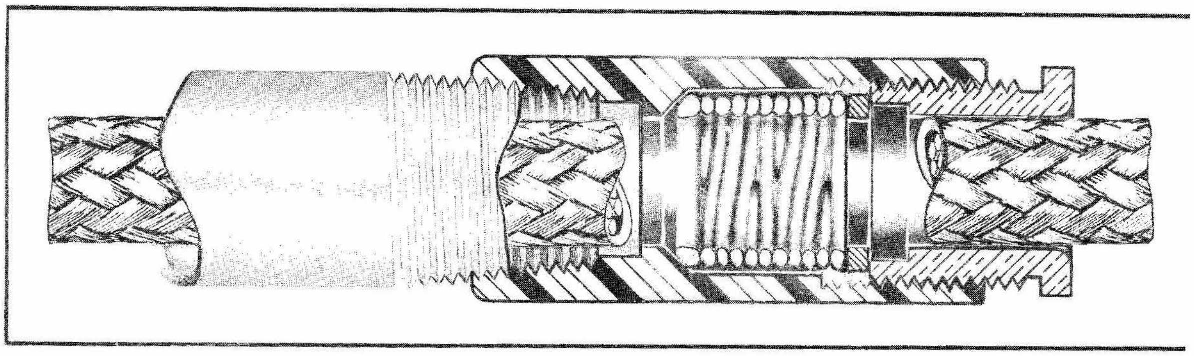


**Figure 10-3. Completed Packing Installations.**

e. PLASTIC SEALER. – The use of plastic sealer in stuffing tubes is no longer required. It is used only in cable clamps and bushings entering the top of an electrical enclosure and in bushings or drilled holes used for passing cables through light tight and fume tight bulkheads.

f. ALTERED STUFFING TUBES. – In some cases, stuffing tubes already installed in bulkheads or decks maybe altered or modified to fit smaller sizes of cables. This may be accomplished by the following two methods:

(1) SPECIAL GLAND RINGS. – This method of utilizing existing stuffing tubes shall be limited to cables normally assigned to stuffing tubes one, two or three letter sizes smaller. The existing gland ring shall be removed and two special gland rings installed, one below and one above the packing (see figure 10-4). Additional sealing packing shall be added to the preformed packing as required to assure a watertight seal on the cable. The special gland ring sizes are listed in table 10-4.

(2) WELDED STUFFING TUBES. –In some cases, where burning out unused tubes and welding of new tubes within existing tube areas would cause possible damage to existing cable, the stuffing tubes can be modified to suit new cable installations by welding additional tubes in place as shown in figure 10-5.

g. SEALING UNUSED STUFFING TUBES. – Unused stuffing tubes may be sealed by use of plugs and preformed packing (see figure 10-6a). This should be limited to locations where removal of a few tubes from group is not practical. Large groups of unused stuffing tubes should be burned out and the hole in the plate patched.

h. SEALING UNUSED KICKPIPES. – In cases where the stuffing tube is removeable from the kickpipe or bulkhead penetrating pipe, the pipe may be sealed with a brass pipe cap as shown in figure 10-6b.

i. KICKPIPE AND STUFFING TUBE SPACING. – The location and spacing of kickpipes and stuffing tubes must be carefully planned to eliminate structural weakness and to allow space for proper tightening of the stuffing tube gland nuts. Table 10-6 lists the minimum hole spacing for stuffing tubes and kickpipes in decks or bulkheads.

(1) PLATE THICKNESS. – Table 10-6 may be used for all plate thicknesses not exceeding three inches.

(2) NONFERROUS STRUCTURE. – Table 10-6 may also be used for aluminum and brass decks and bulkheads where installation of stuffing tubes is required.

(3) EXCEPTIONS. – Table 10-6 is applicable to the great majority of installations, however, exceptions to to the table are recognized when it is expedient to mount stuffing tubes on alternate sides of the plate being pierced, and when special fittings are required tin passing cables through the pressure hull of submarines into conning tower trunks or as otherwise noted in this section.

(4) STRENGTH PRESERVATION. – For strength preservation of both medium and special treatment steel platings, stuffing tube hole spacings shall in no case be less than 1.9 mean diameters of any two adjacent holes. For medium steel calculations, (for the hole diameters) use the internal diameters of the extra strong kickpipes. For special treatment steel, use the actual hole diameters given in column three of table 10-6.

(5) HOLE LOCATION. –When locating a hole from a boundary structural member or cable support, the distance shall not be less than half the center to center spacing given in table 10-6 for two stuffing tubes of the required size.

(6) HOLE ARRANGEMENT. – Table 10-6 does not impose any restrictions on how the holes shall be arranged as long as the restriction regarding the minimum allowable spacing is not violated.

(7) GLAND NUT ACCESSIBILITY. – The spacings for stuffing tube sizes "A" through "Z" are sufficient for the use of the standard open ratchet wrenches (GG-W-646) in tightening the gland nut. The spacings for tube sizes "AA" and "BB" are sufficient for the use of 32 point box type crowfoot wrenches suitable for the purpose.

Figure 10-4. Special Gland Ring Use.

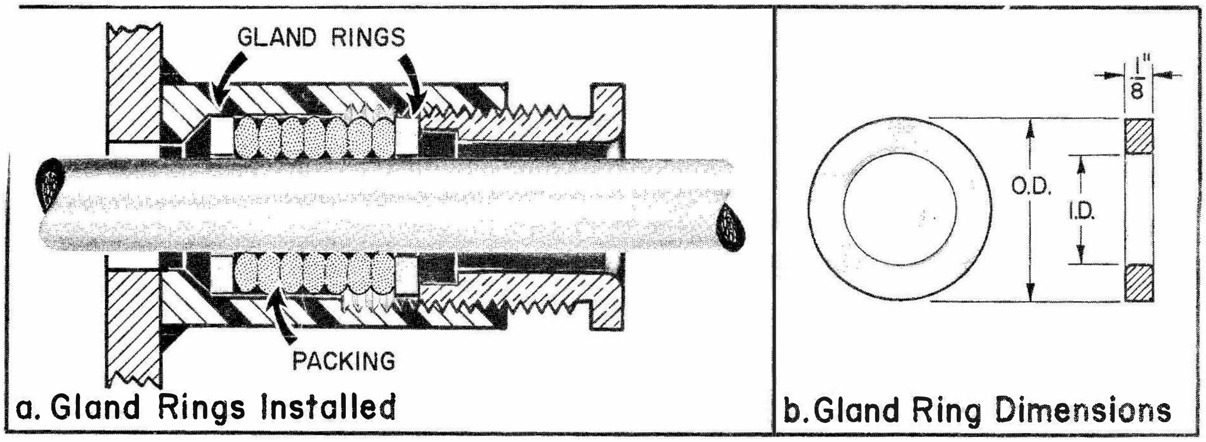



Figure 10-5. Stuffing Tube Modification.

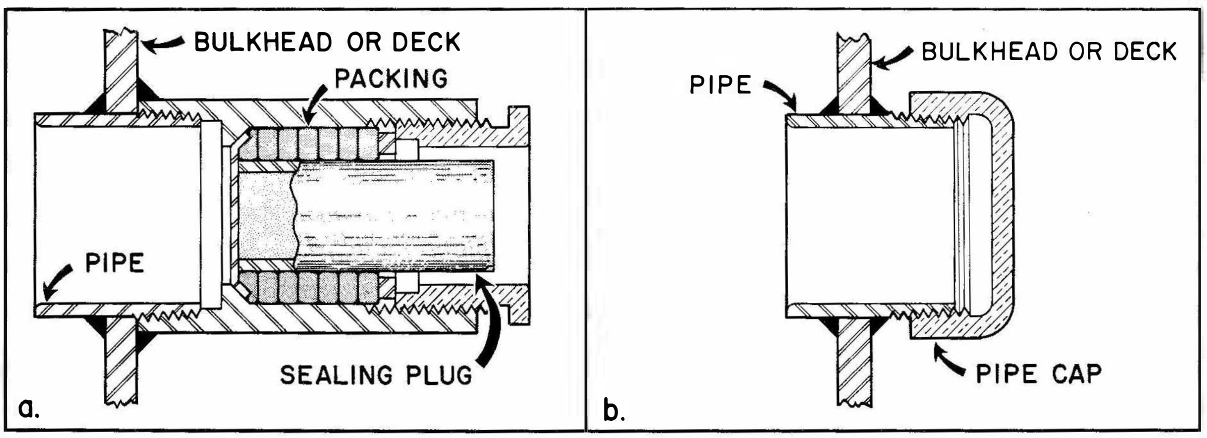



Figure 10-6. Sealing Unused Stuffing Tubes and Kickpipes.

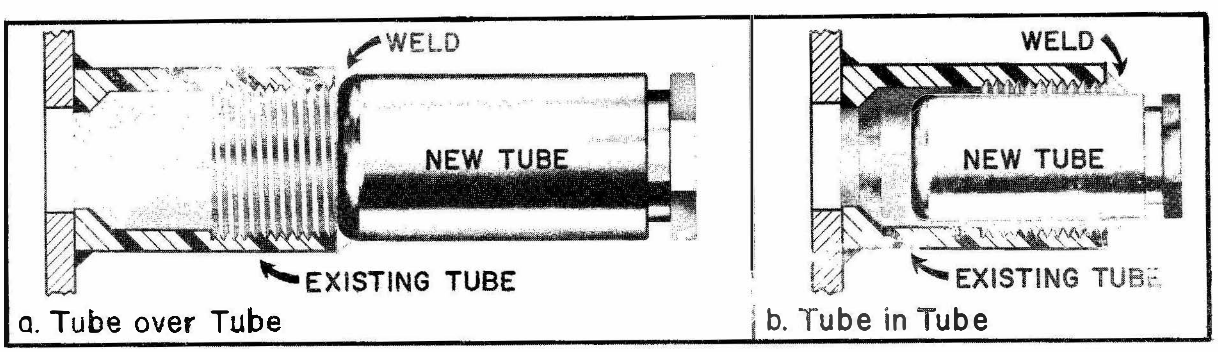
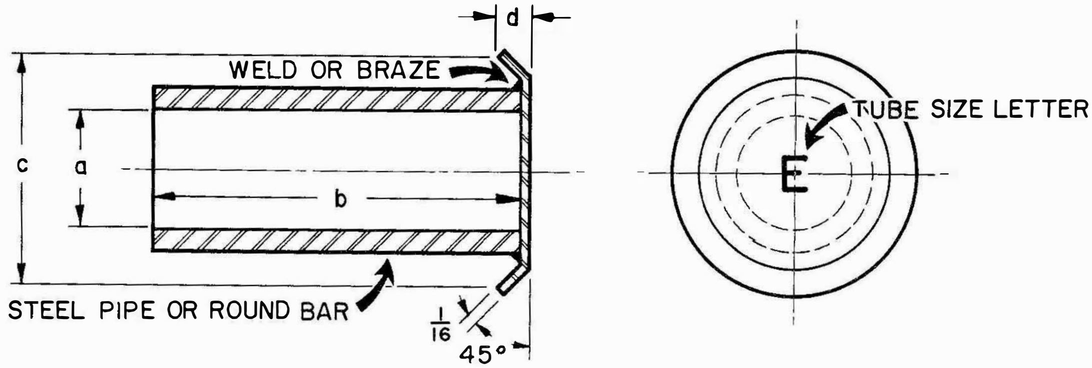


TABLE 10-4. SPECIAL GLAND RING SIZES

| OUTSIDE DIA. SIZES | | INSIDE DIAMETER SIZES—ALL DIMENSIONS IN INCHES | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | J | K | L | M | N | P | R | S | T | V | W | X | Y | Z | AA | BB |
| A | 3/4 | | | | | | | | | | | | | | | | | | | | | | | |
| B | 7/8 | 25/64 | | | | | | | | | | | | | | | | | | | | | | |
| C | 1 | 25/64 | 33/64 | | | | | | | | | | | | | | | | | | | | | |
| D | 1 1/8 | 25/64 | 33/64 | 5/8 | | | | | | | | | | | | | | | | | | | | |
| E | 1 1/8 | | 33/64 | 5/8 | 47/64 | | | | | | | | | | | | | | | | | | | |
| F | 1 3/16 | | | 5/8 | 47/64 | 13/16 | | | | | | | | | | | | | | | | | | |
| G | 1 3/8 | | | | 47/64 | 13/16 | 27/32 | | | | | | | | | | | | | | | | | |
| J | 1 1/2 | | | | | 13/16 | 27/32 | 61/64 | | | | | | | | | | | | | | | | |
| K | 1 5/8 | | | | | | 27/32 | 61/64 | 1 3/64 | | | | | | | | | | | | | | | |
| L | 1 11/16 | | | | | | | 61/64 | 1 3/64 | 1 5/32 | | | | | | | | | | | | | | |
| M | 1 7/8 | | | | | | | | 1 3/64 | 1 5/32 | 1 1/4 | | | | | | | | | | | | | |
| N | 1 15/16 | | | | | | | | | 1 5/32 | 1 1/4 | 1 25/64 | | | | | | | | | | | | |
| P | 2 1/16 | | | | | | | | | | 1 1/4 | 1 25/64 | 1 1/2 | | | | | | | | | | | |
| R | 2 3/16 | | | | | | | | | | | 1 25/64 | 1 1/2 | 1 39/64 | | | | | | | | | | |
| S | 2 9/16 | | | | | | | | | | | | 1 1/2 | 1 39/64 | 1 47/64 | | | | | | | | | |
| T | 2 3/4 | | | | | | | | | | | | | 1 39/64 | 1 47/64 | 1 7/8 | | | | | | | | |
| V | 2 7/8 | | | | | | | | | | | | | | 1 47/64 | 1 7/8 | 2 3/64 | | | | | | | |
| W | 3 | | | | | | | | | | | | | | | 1 7/8 | 2 3/64 | 2 11/64 | | | | | | |
| X | 3 1/8 | | | | | | | | | | | | | | | | 2 3/64 | 2 11/64 | 2 9/32 | | | | | |
| Y | 3 1/4 | | | | | | | | | | | | | | | | | 2 11/64 | 2 9/32 | 2 15/32 | | | | |
| Z | 3 7/16 | | | | | | | | | | | | | | | | | | 2 9/32 | 2 15/32 | 2 37/64 | | | |
| AA | 3 5/8 | | | | | | | | | | | | | | | | | | | 2 15/32 | 2 37/64 | 2 25/32 | | |
| BB | 3 7/8 | | | | | | | | | | | | | | | | | | | | 2 37/64 | 2 25/32 | 2 7/8 | |

TABLE 10-5. STUFFING TUBE SEALING PLUGS.




| TUBE SIZE | COMMON DIMENSIONS IN INCHES "a" | "b" | "c" | "d" |
|---|---|---|---|---|
| A | 3/8* | 1-5/8 | 5/8 | 1/8 |
| B | 1/2* | 1-5/8 | 3/4 | 1/8 |
| C | 1/4 | 1-5/8 | 7/8 | 1/8 |
| D | 3/8 | 1-5/8 | 31/32 | 1/8 |
| E | 3/8 | 1-5/8 | 1-1/32 | 1/8 |
| F | 3/8 | 1-5/8 | 1-1/16 | 1/8 |
| G | 1/2 | 1-5/8 | 1-3/16 | 1/8 |
| J | 3/4 | 1-5/8 | 1-3/8 | 3/16 |
| K | 3/4 | 3 | 1-1/2 | 3/16 |
| L | 3/4 | 3 | 1-19/32 | 3/16 |
| M | 1 | 3 | 1-3/4 | 3/16 |
| N | 1 | 3 | 1-27/32 | 3/16 |
| P | 1 | 3 | 1-15/16 | 3/16 |
| R | 1-1/4 | 3 | 2-1/16 | 3/16 |
| S | 1-1/4 | 5 | 2-3/16 | 3/16 |
| T | 1-1/2 | 5 | 2-3/8 | 3/16 |
| V | 1-1/2 | 5 | 2-1/2 | 3/16 |
| W | 1-1/2 | 5 | 2-5/8 | 3/16 |
| X | 2 | 5 | 2-13/16 | 3/16 |
| Y | 2 | 5 | 2-15/16 | 3/16 |
| Z | 2 | 5 | 3-3/32 | 3/16 |
| AA | 2 | 3-5/16 | 3-3/16 | 3/16 |
| BB | | | | |

* These two dimensions are for round bar. All others in column "a" are for inside pipe size.

TABLE 10-6. KICKPIPE AND STUFFING TUBE HOLE SPACING

## SPACING OF HOLES FOR STUFFING TUBES AND KICKPIPES

THIS TABLE DOES NOT APPLY TO ARMOR PLATE

NOTE: ALL DIMENSIONS ARE IN INCHES

| NOMINAL DIA. OF KICKPIPE | DRILL FOR PIPE (MEDIUM STEEL ONLY) | DRILL FOR PIPE SPECIAL (TREAT. STEEL) | TUBE SIZE | A | B | C | D | E | F | G | J | K | L | M | N | P | R | S | T | V | W | X | Y | Z | AA | BB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3/8 | 23/32 | .406 | A | 1 15/16 | | | | | | | | | | | | | | | | | | | | | | |
| 1/2 | 7/8 | .515 | B | 2 | 2 | | | | | | | | | | | | | | | | | | | | | |
| 3/4 | 1 3/32 | .640 | C | 2 1/16 | 2 1/16 | 2 1/16 | | | | | | | | | | | | | | | | | | | | |
| 3/4 | 1 3/32 | .750 | D | 2 1/4 | 2 5/16 | 2 3/8 | 2 7/16 | | | | | | | | | | | | | | | | | | | |
| 1 | 1 21/64 | .812 | E | 2 1/4 | 2 5/16 | 2 3/8 | 2 1/2 | 2 1/2 | | | | | | | | | | | | | | | | | | |
| 1 | 1 21/64 | .843 | F | 2 1/4 | 2 5/16 | 2 3/8 | 2 1/2 | 2 1/2 | 2 1/2 | | | | | | | | | | | | | | | | | |
| 1 | 1 21/64 | .953 | G | 2 3/4 | 2 13/16 | 2 7/8 | 2 15/16 | 3 | 3 | 3 1/16 | | | | | | | | | | | | | | | | |
| 1 1/4 | 1 45/64 | 1.062 | J | 2 3/4 | 2 3/16 | 2 7/8 | 2 15/16 | 3 | 3 | 3 3/16 | 3 3/16 | | | | | | | | | | | | | | | |
| 1 1/4 | 1 45/64 | 1.171 | K | 2 3/4 | 2 13/16 | 2 7/8 | 2 15/16 | 3 | 3 | 3 3/16 | 3 3/16 | 3 3/16 | | | | | | | | | | | | | | |
| 1 1/4 | 1 45/64 | 1.265 | L | 2 3/4 | 2 13/16 | 2 7/8 | 2 15/16 | 3 | 3 | 3 1/4 | 3 1/4 | 3 1/4 | 3 1/4 | | | | | | | | | | | | | |
| 1 1/2 | 1 15/16 | 1.406 | M | 2 3/4 | 2 13/16 | 2 7/8 | 2 15/16 | 3 | 3 | 3 3/8 | 3 3/8 | 3 3/8 | 3 3/8 | 3 3/8 | | | | | | | | | | | | |
| 1 1/2 | 1 15/16 | 1.515 | N | 3 5/16 | 3 3/8 | 3 7/16 | 3 1/2 | 3 9/16 | 3 9/16 | 3 11/16 | 3 3/4 | 3 13/16 | 3 13/16 | 3 15/16 | 4 | | | | | | | | | | | |
| 2 | 2 13/32 | 1.625 | P | 3 5/16 | 3 3/8 | 3 7/16 | 3 1/2 | 3 9/16 | 3 9/16 | 3 11/16 | 3 3/4 | 3 13/16 | 3 13/16 | 3 15/16 | 4 1/8 | 4 1/8 | | | | | | | | | | |
| 2 | 2 13/32 | 1.750 | R | 3 5/16 | 3 3/8 | 3 7/16 | 3 1/2 | 3 9/16 | 3 9/16 | 3 11/16 | 3 3/4 | 3 13/16 | 3 13/16 | 3 15/16 | 4 1/8 | 4 1/8 | 4 1/8 | | | | | | | | | |
| 2 | 2 13/32 | 1.875 | S | 3 5/16 | 3 3/8 | 3 7/16 | 3 1/2 | 3 9/16 | 3 9/16 | 3 11/16 | 3 3/4 | 3 13/16 | 3 13/16 | 3 15/16 | 4 5/16 | 4 5/16 | 4 5/16 | 4 5/16 | | | | | | | | |
| 2 1/2 | 2 29/32 | 2.062 | T | 3 5/16 | 3 3/8 | 3 7/16 | 3 1/2 | 3 9/16 | 3 9/16 | 3 13/16 | 3 13/16 | 3 13/16 | 3 13/16 | 3 15/16 | 4 7/16 | 4 7/16 | 4 7/16 | 4 7/16 | 4 7/16 | | | | | | | |
| 2 1/2 | 2 29/32 | 2.187 | V | 3 11/16 | 3 3/4 | 3 13/16 | 3 7/8 | 3 15/16 | 3 15/16 | 4 1/16 | 4 1/8 | 4 3/16 | 4 1/4 | 4 5/16 | 4 7/16 | 4 1/2 | 4 1/2 | 4 11/16 | 4 3/4 | 4 13/16 | | | | | | |
| 2 1/2 | 2 29/32 | 2.312 | W | 3 11/16 | 3 3/4 | 3 13/16 | 3 7/8 | 3 15/16 | 3 15/16 | 4 1/16 | 4 1/8 | 4 3/16 | 4 1/4 | 4 5/16 | 4 1/2 | 4 1/2 | 4 1/2 | 4 11/16 | 4 3/4 | 4 7/8 | 4 7/8 | | | | | |
| 3 | 3 17/32 | 2.500 | X | 3 11/16 | 3 3/4 | 3 13/16 | 3 7/8 | 3 15/16 | 3 15/16 | 4 1/8 | 4 1/8 | 4 3/16 | 4 1/4 | 4 5/16 | 4 11/16 | 4 11/16 | 4 11/16 | 4 11/16 | 4 3/4 | 5 1/16 | 5 1/16 | 5 1/16 | | | | |
| 3 | 3 17/32 | 2.609 | Y | 3 11/16 | 3 3/4 | 3 13/16 | 3 7/8 | 3 15/16 | 3 15/16 | 4 1/8 | 4 1/8 | 4 3/16 | 4 1/4 | 4 5/16 | 4 11/16 | 4 11/16 | 4 11/16 | 4 11/16 | 4 3/4 | 5 1/16 | 5 1/16 | 5 1/16 | 5 1/16 | | | |
| 3 | 3 17/32 | 2.781 | Z | 3 11/16 | 3 3/4 | 3 13/16 | 3 7/8 | 3 15/16 | 3 15/16 | 4 1/8 | 4 1/8 | 4 3/16 | 4 1/4 | 4 5/16 | 4 3/4 | 4 3/4 | 4 3/4 | 4 3/4 | 4 3/4 | 5 1/8 | 5 1/8 | 5 1/8 | 5 1/8 | 5 5/16 | | |
| 3 | 3 17/32 | 2.875 | AA | 3 13/16 | 3 7/8 | 3 15/16 | 4 | 4 | 4 1/32 | 4 5/32 | 4 1/4 | 4 9/32 | 4 5/16 | 4 7/16 | 4 15/32 | 4 5/8 | 4 19/32 | 4 25/32 | 4 31/32 | 4 31/32 | 5 1/16 | 5 9/16 | 5 9/16 | 5 9/16 | 5 17/32 | |
| 3 1/2 | 4 1/32 | 3.156 | BB | 4 | 4 1/16 | 4 1/8 | 4 3/16 | 4 3/16 | 4 7/32 | 4 11/32 | 4 7/16 | 4 15/32 | 4 1/2 | 4 5/8 | 4 21/32 | 5 1/16 | 5 1/16 | 5 1/16 | 5 13/32 | 5 13/32 | 5 13/32 | 5 31/32 | 5 31/32 | 5 31/32 | 5 31/32 | 6 13/32 |

**4.12- NYLON STUFFING TUBES. –** Nylon stuffing tubes, manufactured in accordance with MIL-S-19622, shall be used where authorized in shipboard electronic cable installations. These stuffing tubes, when properly installed, will provide a sealed cable entry to equipment enclosures and a sealed passage through bulkheads.

a. AUTHORIZED INSTALLATION USE. – Nylon stuffing tubes shall be used in the following locations:

(1) ENCLOSURE ENTRY. – Splashproof, spraytight, watertight, submersible and explosion proof enclosures. If a cable must enter the top of other enclosures (NWT etc.) the nylon stuffing tube shall be used. Cables entering molded insulated enclosures will be passed through nylon stuffing tubes.

(2) BULKHEADS. – Nylon stuffing tubes may be used for passage of cables through airtight or fume tight bulkheads up to and including a thickness of 3/16 inch.

b. TYPES AND SIZES. –The types of nylon stuffing tubes are illustrated in figure 12-1 and the available sizes are listed in table 12-1 on page 4-12-8.

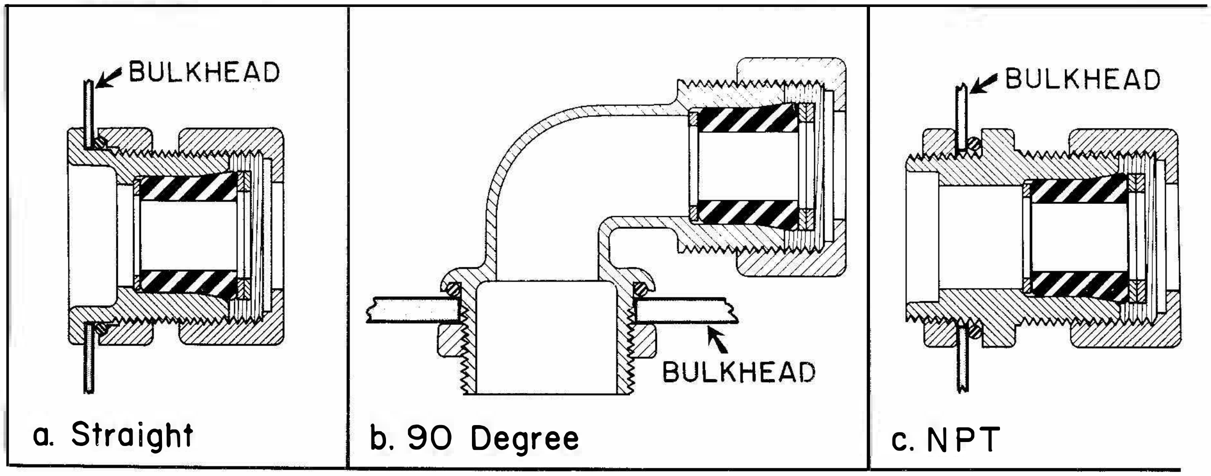



**Figure 12-1. Nylon Stuffing Tubes Types**

(1) STRAIGHT. – This stuffing tube is used for passing cables through bulkheads and into equipment enclosures that do not restrict installation of the stuffing tube body from the inside of the enclosure (see figure 12-1a).

(2) 90 DEGREE. – In cases where space limitations will not allow the cable to be bent for a straight stuffing tube entr y to the enclosure, the 90 degree stuffing tube shall be used (see figure 12-1b.)

**NOTE**

The 90 degree type is available in sizes one, two, four, five and six.

(3) NPT. – This type can be used with the locknut for cable entry into equipment enclosures where internal congestion prevents the use of a "straight" type stuffing tube. It may also be used by direct installation in cast enclosures equipped with entry holes tapped with a pipe thread. When used in this manner the threads in the cast enclosure entry hole and on the stuffing tube body shall be treated with a pipe thread sealing compound before the tube is installed.

c. PACKING ASSEMBLIES. – The packing assemblies used with nylon stuffing tubes are made up in sets consisting of one neoprene bushing, one nylon retainer washer and two nylon slip washers. If the stuffing tube is no longer used and it is impractical to remove the tube and patch the hole, the tube can be sealed by use of neoprene sealing plugs.

(1) BUSHINGS. – The bushings are available with various inside diameters for each size of stuffing tube. This allows each tube size to accommodate several cables within a given range of diameter. Tabel 12-2, on page 4-12-9, lists the MS16174 dash number, inside diameter of the bushing and the stuffing tube size with which it is used.

(2) WASHERS. – The proper size of washers must be selected and used with each bushing size. Table 12-3, on page 4-12-10, lists the MS16171 dash number, inside diameter of the slip washer and the stuffing tube size with which it is used. Table 12-4, on page 4-12-10, lists MS16172 dash number, inside diameter of the retainer washer and the stuffing tube size with which it is used.

(3) SEALING PLUGS. – If a sealing plug is required to seal off an unused stuffing tube, the proper size can be selected from table 12-5, on page 4-12-11, which lists the MS16173 dash numbers. When installing the plugs, the cable bushing shall be discarded but the nylon washers shall be retained and installed in the proper location in respect to the plug. A bonding agent is required when the stuffing tube is sealed with a plug (see figure 12-6a).

d. "O" RINGS. – The "O" rings used to maintain a tight seal between the stuffing tube body and the enclosure or bulkhead are not furnished as a part of the stuffing tube assembly. These "O" rings must conform to MIL-P-5514. Table 12-6, on page 4-12-11, lists the "O" rings required for each type and size of stuffing tube.

e. NYLON STUFFING TUBE INSTALLATION. – These stuffing tubes are installed in bulkheads and enclosures as follows:

(1) TUBE SELECTION. – Generally, the stuffing tube size is the same as that assigned for the cables in section 4-2 (Cable Types and Selection) both when end sealing is applied or is not applied. In those cases where the addition of the required synthetic resin tubing increases the diameter of the wire group larger than the throat diameter of the assigned tube, the next larger tube shall be used.

(a) BUSHING MODIFICATION. – If the wire group cannot be accommodated in a standard bushing, use the sealing plug assigned to the stuffing tube. Freeze the plug to minus 40 degrees F. and drill a hole to the dimension required for the wire group diameter thus making a new bushing.

(2) HOLE PREPARATION. – When the stuffing tube size has been selected and the hole has been drilled or punched to the required clearance size, carefully inspect the hole and remove any burrs or irregularities.

(a) STEEL ENCLOSURES. – When the stuffing tube is to be installed in steel enclosures, remove the paint and roughen the surface with sand paper (do not use emery paper in or around electronic equipments) in the area 1/2 inch wide around the hole on the exterior of the equipment. Apply one coat of primer (Gates Eng. Co. N-10 or equivalent) and allow to set. Dust the primer coated surface with talc (soapstone).

**NOTE**

This process is not required on brass or aluminum enclosures.

(b) THREADED HOLES. – If the hole in the enclosure is threaded with standard pipe threads, a fitting of the NPT type shall be used and the engaging threads coated with a pipe thread sealing compound before the stuffing tube is installed.

(3) CABLE PREPARATION. – Prepare the cable for termination and installation in the stuffing tube as shown in section 4-15 (Cable Termination).

(4) STUFFING TUBE AND CABLE INSTALLATION. – When the requirements above have been met proceed with the installation as follows:

STEP 1. – Insert the body of the stuffing tube in the enclosure hole. The straight type is installed from the inside of the enclosure and the 90 degree and NPT types are installed from the outside.

**NOTE**

The "O" ring is installed on the 90 degree and NPT type before the tube body is installed and on the straight type after the tube body installation.

STEP 2. – Screw the locknut on the tube body until finger-tight. Complete the tightening by use of two spanner wrenches until a good metal to plastic contact of the stuffing tube and enclosure is obtained and the "O" ring is sufficiently compressed for a tight seal.

STEP 3. –Slide the cap and slip washers over the wire group, jacket, and up on the armor. Slide the bushing and retainer washer over the wire group up to the jacket termination (all parts installed in the order listed). Pull the wire group through the stuffing tube until the bushing is approximately six inches from the stuffing tube.

STEP 4. – For an ungrounded installation, slip the bushing over the terminated jacket until it butts against the taped armor termination. For a grounded installation, slide the second slip washer back to the bushing, flare the armor at the termination point, install the grounding strip under the first washer and press the slip washers tightly up on each side of the flared armor. Trim the flared armor to the outside dimension of the slip washers. Slide the bushing over the terminated jacket until it butts against the second slip washer.

**NOTE**

For tube sizes six, seven, eight and nine, the cable jacket beyond the flared armor (in grounded installations) or the jacket and armor securing tape (in grounded installations) and the inner surface of the bushing shall be coated with Gates Eng. Co. bonding agent N-29 (accelerated with N-39) or equal before the bushing is installed in the final position.

STEP 5. – Position the retainer washer against the bushing and insert the cable and packing assembly into the stuffing tube. Screw the cap on the stuffing tube until it is finger-tight. Complete the installation by tightening the cap with a spanner wrench while holding the body of the tube immoveable by use of a second spanner wrench. Tighten sufficiently to compress the bushing into a tight seal between the cable and stuffing tube.

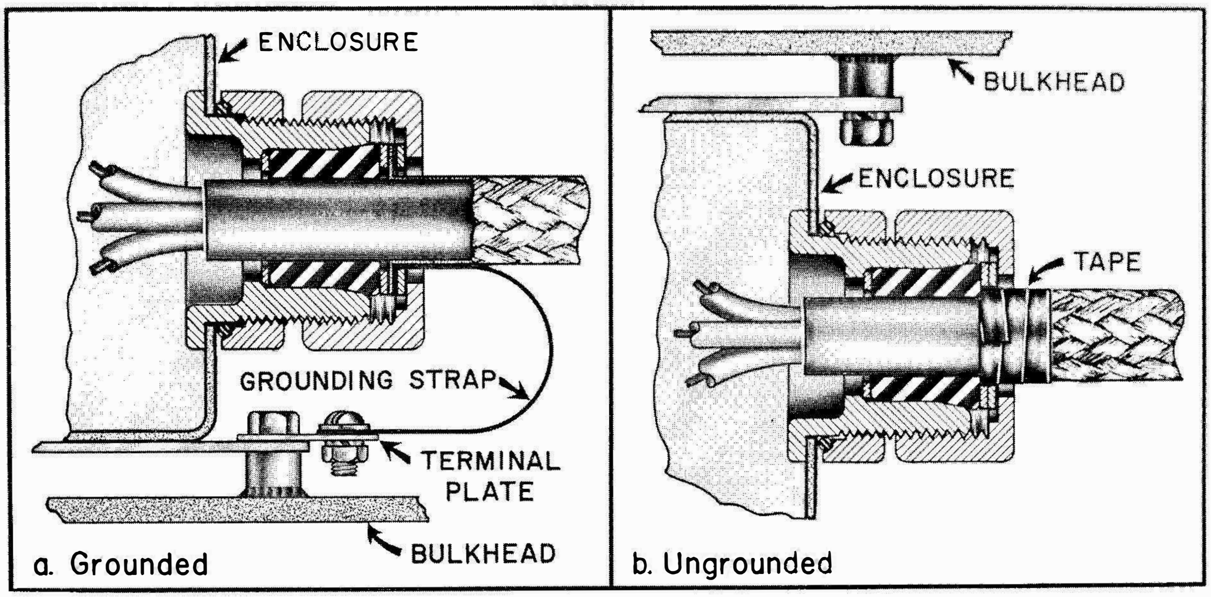



**Figure 12-2. Stuffing Tube Installation**

(5) BULKHEAD INSTALLATION.— When the straight type stuffing tube is used for a bulkhead installation, it is assembled and tightened in the hole complete with all parts except the neoprene bushing. After the cable is pulled through the stuffing tube, the cap is unscrewed and, along with the two slip washers, positioned at a point on the cable to allow installation of the bushing. The bushing is slit on one side at an angle of approximately 30 degrees and installed around the cable. Brush the inside of the stuffing tube body and the section of cable over which the bushing will fit with neoprene cement (MIL-C-5540). Slip the bushing into place in the stuffing tube, reinstall the slip washers and cap and tighten until the seal is tight (use two spanner wrenches).

**CAUTION**

Use extreme care when pulling the cable through the stuffing tube. Do not damage or break the retainer and slip washers.

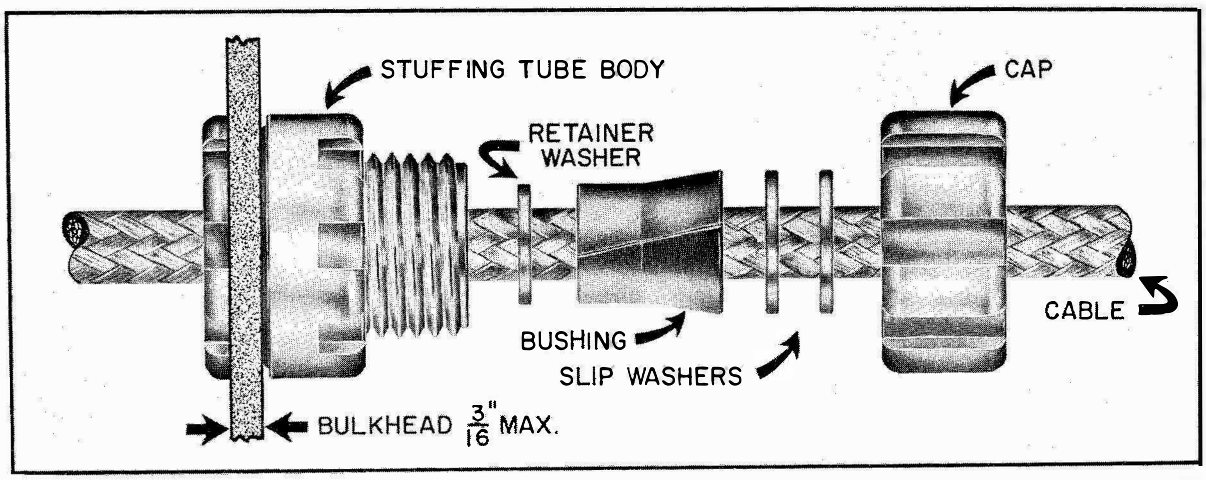



**Figure 12-3. Bulkhead Installation.**

f. GROUNDING. – An installation where the cable armor is grounded at the termination in the stuffing tube shall be provided only where bonding of the cable armor to the equipment is required in electronic spaces. The grounding straps shall be attached to the terminal plate at the enclosure mounting stud as shown in figure 12-4a and b.

(1) GROUND STRAP MATERIAL. – The grounding straps or braid in general shall be of the same material as the cable armor. Steel straps, zinc plated, shall be used for bonding aluminum cable armor to brass enclosures.

(2) GROUND STRAP SIZE. – All ground straps shall be 0.031 inch thick and of the following widths:

(a) Cables less than 3/8 inch diameter shall use a 1/4 inch wide strap.
(b) Cables 3/8 inch diameter through one inch diameter shall use a 3/8 inch wide strap.
(c) Cables above one inch diameter shall use a 1/2 inch wide strap.

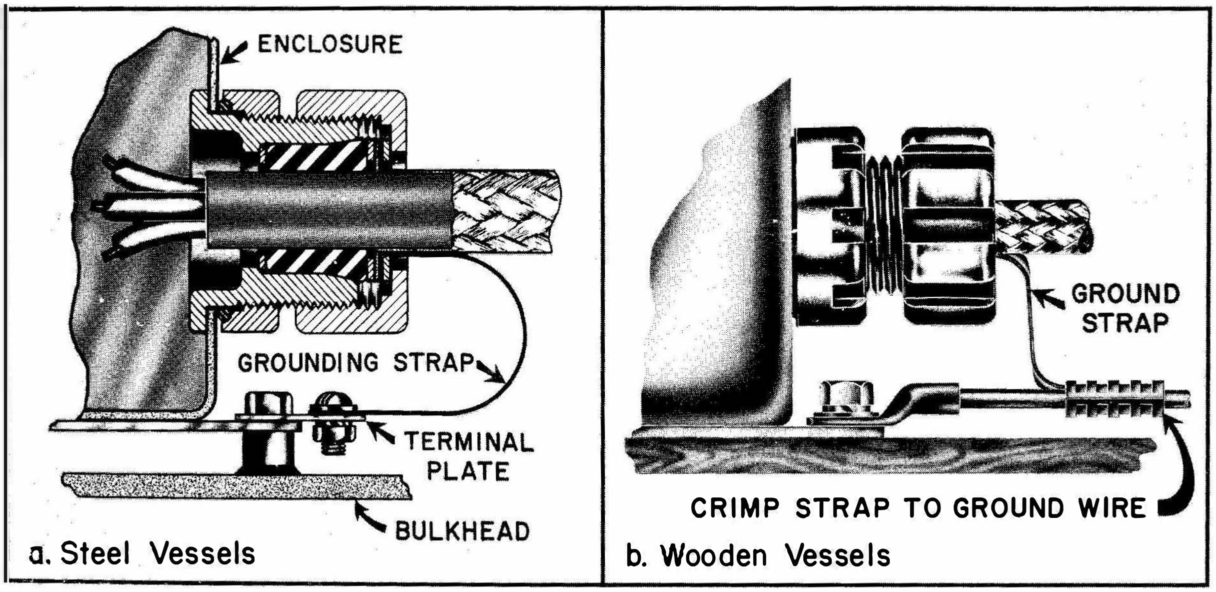



**Figure 12-4. Grounded Installations.**

**NOTE**

In the smaller sizes of stuffing tubes, where a smaller size strap may be desirable due to the limited clearance between the cable and the nylon cap, a thinner strap may be used provided a maximum resistance of 0.01 ohm is maintained at the bond between the cable armor and the grounding terminal.

(3) GROUNDING ARMOR INSIDE ENCLOSURE. – In some cases it may be necessary or desirable to ground the cable armor inside the enclosure after passing through the stuffing tube.

(a) BRAIDED ARMOR. – The cable is prepared by combing the armor to form a pigtail or by a separate pigtail soldered or crimped to the armor. If the pigtail is attached by soldering, the armor should be pulled clear of the cable to prevent damage to the jacket or wires during the soldering operation. Crimp Type connectors are allowed in any circuit application where the frequency does not exceed 100 megacycles per second. This method of grounding is illustrated in figure 12-5a.

(b) BSP CABLES. – The copper tape on this type of cable can be grounded by constructing a phosphor bronze grounding clip which is inserted between the impervious cable sheath and the copper tape. The clip is connected to ground by a pigtail that is crimp connected or soldered to the square end of the grounding clip. This method is illustrated in figure 12-5b.

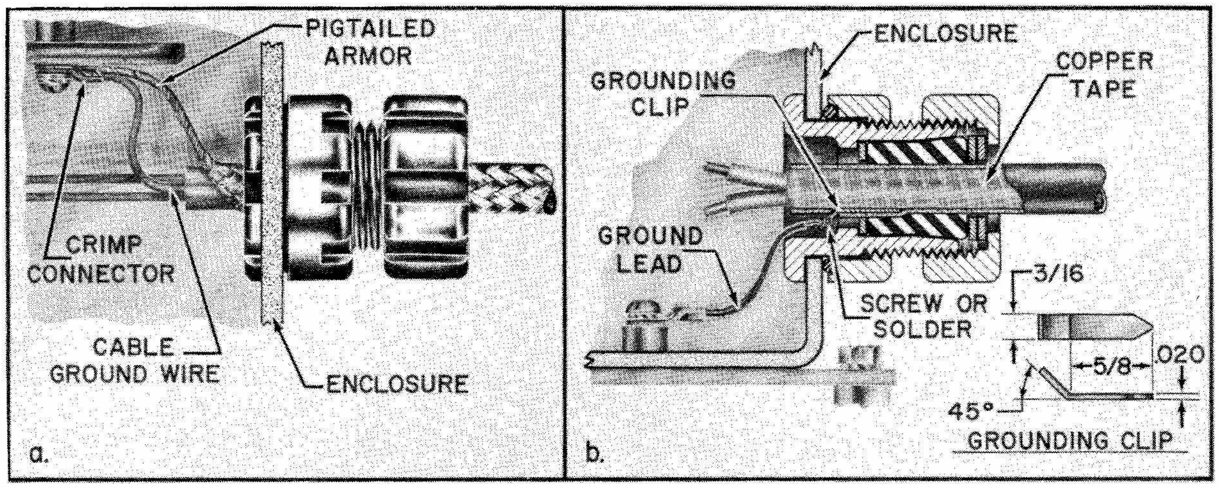



**Figure 12-5. Grounding Armor Inside Enclosure.**

g. STUFFING TUBE EXTENSION.—In cases where the stuffing tube must be extended to pass through bulkhead insulation, this may be done by use of a suitable length and diameter of nylon tubing. Select the proper size tubing to fit the stuffing tube (see dimension "d" in table 12-1.

STEP 1.—Dip or brush the end of the sleeve to be joined in an 85% aqueous phenol solution (carbolic acid) Brush the inside surface of the stuffing tube where the sleeve joins in a like manner. When the parts become tacky, join togeter.

STEP 2.—Dip the joined parts in hot water approximately 150 degrees F. for two or three minutes.

STEP 3.—Remove the parts from the water and allow to cool. The assembly is then ready for use.

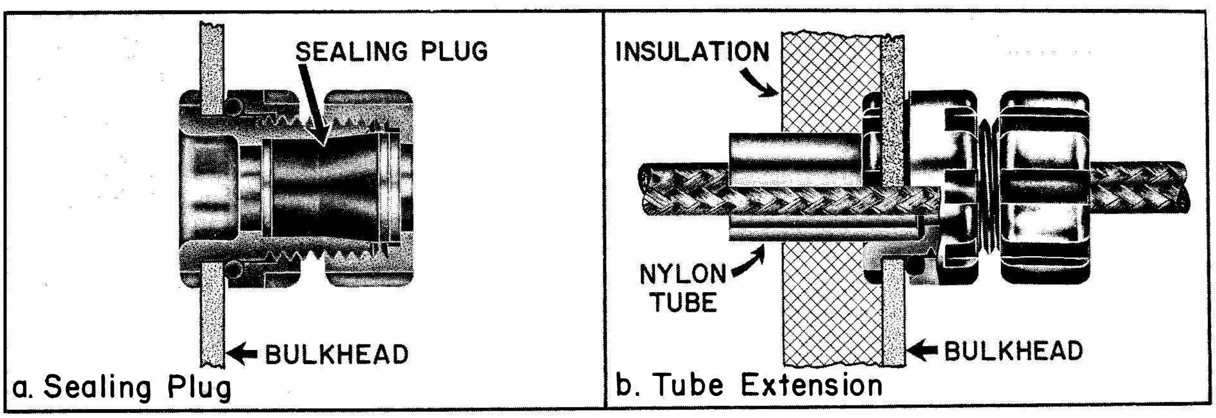



**Figure 12-6. Sealing Plugs and Tube Extension.**

TABLE 12-1. NYLON STUFFING TUBE DIMENSIONS.

| TUBE SIZE | STRAIGHT TYPE-GENERAL DIMENSIONS | | | |
|---|---|---|---|---|
| | "a" | "b" | "c" | "d" |
| 1 | 0.350 | 0.875 | 1.250 | 0.625 |
| 2 | 0.564 | 1.000 | 1.375 | 0.750 |
| 4 | 0.825 | 1.250 | 1.625 | 1.000 |
| 5 | 1.187 | 2.000 | 2.500 | 1.625 |
| 6 | 1.505 | 2.500 | 3.000 | 2.125 |
| 7 | 1.689 | 2.750 | 3.375 | 2.375 |
| 8 | 2.089 | 3.250 | 3.875 | 2.875 |
| 9 | 2.842 | 4.000 | 4.750 | 3.625 |
| TUBE SIZE | NPT TYPE-GENERAL DIMENSIONS | | | |
| | "a" | "b" | "c" | "d" |
| 1 | 0.350 | 0.840 | 1.250 | 0.500 |
| 2 | 0.563 | 1.050 | 1.375 | 0.750 |
| 4 | 0.825 | 1.315 | 1.625 | 1.000 |
| 5 | 1.187 | 1.900 | 2.500 | 1.500 |
| 6 | 1.505 | 2.375 | 3.000 | 1.875 |
| 7 | 1.688 | 2.875 | 3.375 | 2.375 |
| 8 | 2.094 | 3.500 | 3.875 | 2.875 |
| 9 | 2.844 | 4.000 | 4.750 | 3.250 |
| TUBE SIZE | 90 DEGREE TYPE-GENERAL DIMENSIONS | | | |
| | "a" | "b" | "c" | "d" |
| 1 | 0.350 | 0.875 | 1.312 | 0.562 |
| 2 | 0.564 | 0.875 | 1.312 | 0.564 |
| 4 | 0.825 | 1.250 | 1.687 | 0.825 |
| 5 | 1.187 | 2.000 | 2.437 | 1.625 |
| 6 | 1.505 | 2.500 | 2.937 | 2.125 |

**NOTE**

The dimensions shown in the table above are: "a" the throat or passage diameter of the tube body, "b" the minimum hole diameter required for installation of the stuffing tube, "c" the over-all diameter of the stuffing tube and "d" the diameter required if an extension tube is used with the stuffing tube.

TABLE 12-2. BUSHING SIZES—INSIDE DIAMETER (INCHES)

| MS16174 DASH# | TUBE SIZE | INSIDE DIA. | MS16174 DASH# | TUBE SIZE | INSIDE DIA. |
|---|---|---|---|---|---|
| 102 | 1 | 0.187 | 125A | 6 | 1.159 |
| 102A | 1 | 0.127 | 125B | 6 | 1.167 |
| 102B | 1 | 0.150 | 125 | 6 | 1.200 |
| 103 | 1 | 0.234 | 125C | 6 | 1.244 |
| 103A | 1 | 0.278 | 126 | 6 | 1.305 |
| 104 | 1 | 0.296 | 126A | 6 | 1.350 |
| 105 | 2 | 0.325 | 127 | 6 | 1.390 |
| 106 | 2 | 0.367 | 129A | 7 | 1.458 |
| 107 | 2 | 0.390 | 129 | 7 | 1.500 |
| 108 | 2 | 0.425 | 130 | 7 | 1.566 |
| 109 | 2 | 0.472 | 130A | 7 | 1.614 |
| 110 | 4 | 0.500 | 132 | 8 | 1.641 |
| 111 | 4 | 0.547 | 132A | 8 | 1.688 |
| 112 | 4 | 0.584 | 132B | 8 | 1.735 |
| 113 | 4 | 0.609 | 133 | 8 | 1.812 |
| 114 | 4 | 0.665 | 133A | 8 | 1.859 |
| 114A | 4 | 0.700 | 133B | 8 | 1.906 |
| 115 | 4 | 0.719 | 133C | 8 | 1.953 |
| 115A | 4 | 0.760 | 133D | 8 | 2.000 |
| 116 | 4 | 0.777 | 134 | 9 | 2.046 |
| 117 | 5 | 0.812 | 134A | 9 | 2.093 |
| 118 | 5 | 0.853 | 134B | 9 | 2.140 |
| 119 | 5 | 0.889 | 135 | 9 | 2.285 |
| 120 | 5 | 0.937 | 136 | 9 | 2.364 |
| 121 | 5 | 0.980 | 137 | 9 | 2.418 |
| 121A | 5 | 1.021 | 137A | 9 | 2.540 |
| 122 | 5 | 1.042 | 138 | 9 | 2.700 |
| 123 | 5 | 1.073 | | | |
| 124 | 5 | 1.113 | | | |

## TABLE 12-3. SLIP WASHERS

| MS16171 DASH# | TUBE SIZE | INSIDE DIA. | MS16171 DASH# | TUBE SIZE | INSIDE DIA. |
|---|---|---|---|---|---|
| 28 | 1 | 0.298 | 47 | 5 | 1.087 |
| 29 | 1 | 0.355 | 48 | 5 | 1.166 |
| 30 | 1 | 0.412 | 49 | 5 | 1.200 |
| 31 | 2 | 0.451 | 50 | 5 | 1.250 |
| 32 | 2 | 0.485 | 51 | 6 | 1.348 |
| 33 | 2 | 0.517 | 52 | 6 | 1.453 |
| 34 | 2 | 0.557 | 53 | 6 | 1.511 |
| 35 | 2 | 0.595 | 54 | 6 | 1.562 |
| 36 | 4 | 0.626 | 55 | 7 | 1.597 |
| 37 | 4 | 0.662 | 56 | 7 | 1.665 |
| 38 | 4 | 0.698 | 57 | 7 | 1.750 |
| 39 | 4 | 0.752 | 58 | 8 | 1.912 |
| 40 | 4 | 0.797 | 59 | 8 | 2.151 |
| 41 | 4 | 0.844 | 60 | 9 | 2.187 |
| 42 | 4 | 0.887 | 61 | 9 | 2.373 |
| 43 | 5 | 0.937 | 62 | 9 | 2.623 |
| 44 | 5 | 0.975 | 63 | 9 | 2.748 |
| 45 | 5 | 1.000 | 64 | 9 | 2.904 |
| 46 | 5 | 1.063 | | | |

## TABLE 12-4. RETAINER WASHERS

| MS16172 DASH# | TUBE SIZE | INSIDE DIA. | MS16172 DASH# | TUBE SIZE | INSIDE DIA. |
|---|---|---|---|---|---|
| 65 | 1 | 0.216 | 84 | 5 | 1.005 |
| 66 | 1 | 0.273 | 85 | 5 | 1.084 |
| 67 | 1 | 0.330 | 86 | 5 | 1.118 |
| 68 | 2 | 0.369 | 87 | 5 | 1.180 |
| 69 | 2 | 0.403 | 88 | 6 | 1.266 |
| 70 | 2 | 0.435 | 89 | 6 | 1.371 |
| 71 | 2 | 0.475 | 90 | 6 | 1.429 |
| 72 | 2 | 0.513 | 91 | 6 | 1.485 |
| 73 | 4 | 0.544 | 92 | 7 | 1.515 |
| 74 | 4 | 0.580 | 93 | 7 | 1.583 |
| 75 | 4 | 0.616 | 94 | 7 | 1.669 |
| 76 | 4 | 0.670 | 94A | 7 | 1.680 |
| 77 | 4 | 0.715 | 95 | 8 | 1.830 |
| 78 | 4 | 0.762 | 96 | 8 | 2.069 |
| 79 | 4 | 0.805 | 97 | 9 | 2.147 |
| 80 | 5 | 0.855 | 98 | 9 | 2.441 |
| 81 | 5 | 0.893 | 99 | 9 | 2.541 |
| 82 | 5 | 0.919 | 100 | 9 | 2.666 |
| 83 | 5 | 0.981 | 101 | 9 | 2.822 |

TABLE 12-5. SEALING PLUGS

| TUBE SIZE | MS16173 | TUBE SIZE | MS16173 |
|---|---|---|---|
| 1 | -150 | 6 | -154 |
| 2 | -151 | 7 | -155 |
| 4 | -152 | 8 | -156 |
| 5 | -153 | 9 | -157 |

TABLE 12-6. "O" RING SIZES

| TUBE SIZE | "O" RING "AN" SIZES | | |
|---|---|---|---|
| | STRAIGHT | NPT | 90 DEGREE |
| 1 | 6227-17 | 6227-16 | 6227-17 |
| 2 | 6227-19 | 6227-19 | 6227-17 |
| 4 | 6227-23 | 6227-23 | 6227-23 |
| 5 | 6230-4 | 6230-3 | 6230-4 |
| 6 | 6230-8 | 6230-7 | 6230-8 |
| 7 | 6230-10 | 6230-11 | ------- |
| 8 | 6230-14 | 6230-15 | ------- |
| 9 | 6230-20 | 6230-20 | ------- |

**4-13. 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:

a. TYPE I AND II. – These box connectors (manufactured in accordance with MIL-C-17277) are available in steel, brass or aluminum.

(1) TYPE I. – The type I box connector has the cable clamping member secured with two machine screws as shown in figure 13-1.

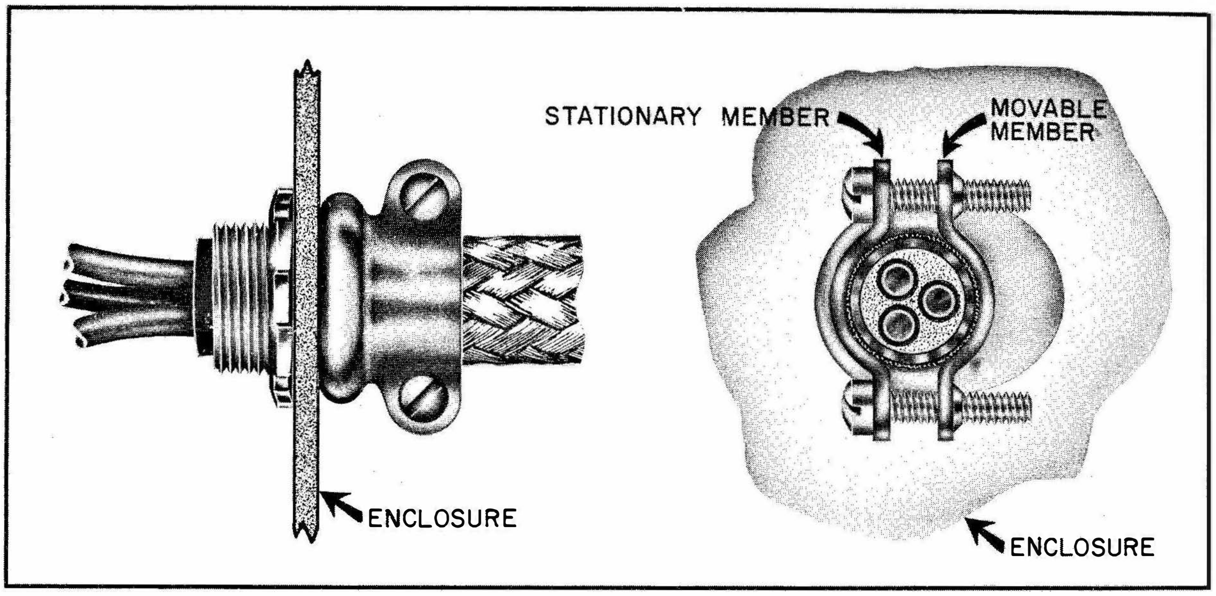



**Figure 13-1. Type I Box Connector.**

(2) 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 13-2.

(3) CONNECTOR SIZES. – The three sizes available in this type connector are listed in table 13-1. The body of the connector is furnished with American standard pipe threads conforming to the connector size in inches.

(4) 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 13-2.

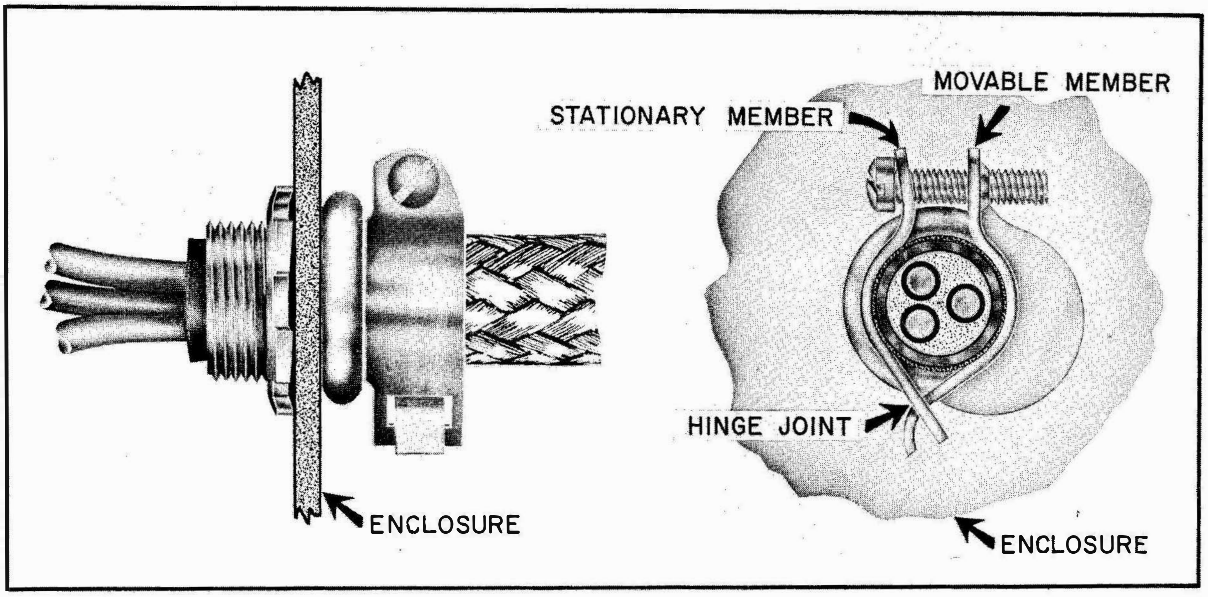



Figure 13-2. Type II Box Connector.

TABLE 13-1. TYPE I AND II CONNECTOR SIZES.

| NAVY SIZE | TRADE AND K. O. SIZE | THROAT DIA. | 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 |

TABLE 13-2. CABLE RECESS DEPTH.

| CONNECTOR SIZE | | DEPTH OF RECESS |
|---|---|---|
| A-C | 3/8 | 13/16 inch |
| CD | 3/4 | 1 inch |
| D-J | 1 | 1 inch |

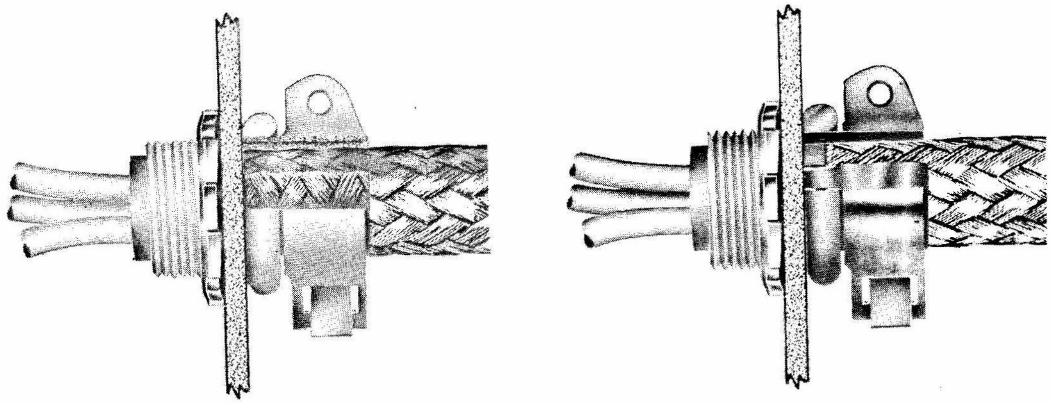
(5) INSTALLATION. – When the point of cable termination has been determined and the cable end prepared for termination as shown in section 4-15, proceed with the connector and cable installation as follows:

STEP 1. – Install the threaded 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 of 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 13-3 shows a typical grounded and ungrounded armor installation.

**NOTE**

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 termin ation point under the connector clamp.



a. Grounded

**Figure 13-3. Cable and Clamp Installation.**

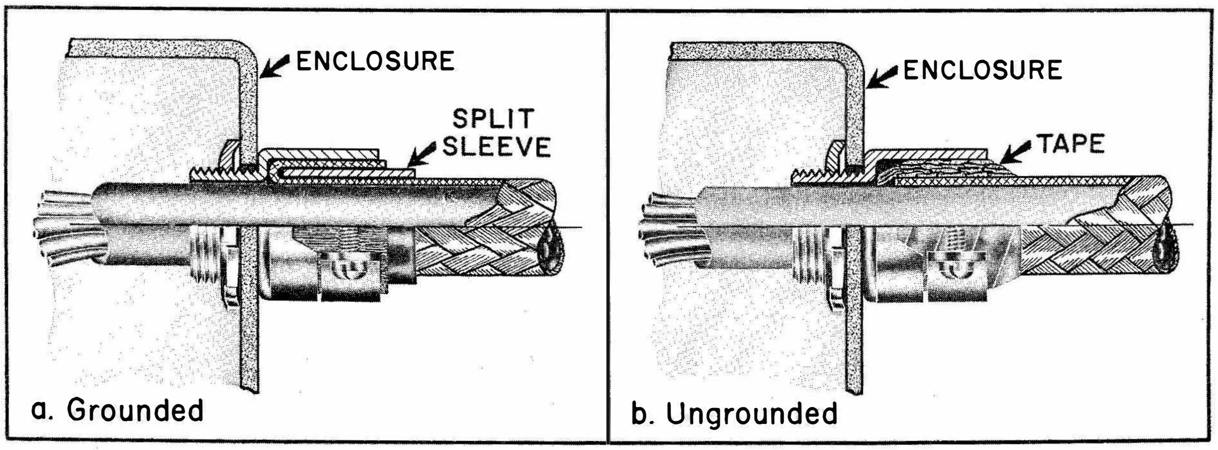



**Figure 13-4. Greenfield Clamp and Cable Installation.**

b. GREENFIELD 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.

(1) 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 13-3 lists the sizes and approximate dimensions of a typical straight type connector. Figure 13-4 shows typical installations.

TABLE 13-3. 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.

TABLE 13-4. 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 |

(2) 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 removeable for ease in installation of the cable. Table 13-4 lists the sizes and approximate dimensions of a typical 90 degree angle type connector.

(3) 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 removeable. Table 13-5 lists the sizes and approximate dimensions of a typical 45 degree angle type connector.

TABLE 13-5. 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 |

c. 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 cable diameters ranging from 0.250 inch through 2.375 inches. These connectors are best suited for grounded armor cable termination using the split metal sleeve method or can be used for ungrounded installations by use of the AN3420 insulating bushings. Table 13-6 lists the AN3064 box connectors with the mating MS3057 cable clamps and the general dimensions.

TABLE 13-6. MS3057 CLAMP SIZES.

| MS 3057 | AN 3057 | THROAT DIAMETER | CLAMP DIAMETER OPEN | CLAMP DIAMETER CLOSED |
|---|---|---|---|---|
| -3A | -3 | 0.250 | 0.250 | 0.156 |
| -4A | -4 | 0.312 | 0.312 | 0.188 |
| -6A | -6 | 0.438 | 0.438 | 0.282 |
| -8A | -8 | 0.562 | 0.562 | 0.344 |
| -10A | -10 | 0.625 | 0.625 | 0.375 |
| -12A | -12 | 0.750 | 0.750 | 0.438 |
| -16A | -16 | 0.938 | 0.938 | 0.562 |
| -20A | -20 | 1.250 | 1.250 | 0.750 |
| -24A | -24 | 1.375 | 1.375 | 0.781 |
| -28A | -28 | 1.625 | 1.625 | 0.969 |
| -32A | -32 | 1.875 | 1.875 | 1.125 |
| -40A | -40 | 2.375 | 2.375 | 1.469 |

(1) AN3064 BOX CONNECTOR. - These box connectors were originally designed as conduit box connectors when used with the AN3054 conduit coupling nut. In some cases, cable or wires are installed in conduit for protection or shielding purposes. Table 13-7 lists the mating sizes of the box connectors and coupling nuts.

TABLE 13-7. AN3064 BOX CONNECTOR.

| AN 3064 | AN 3064 | THROAT DIAMETER | CONDUIT SIZE | INSTALLATION HOLE SIZE |
|---|---|---|---|---|
| -3 | -3 | 0.167 | 3/16 | 1/2 |
| -4 | -4 | 0.229 | 1/4 | 5/8 |
| -6 | -6 | 0.354 | 3/8 | 3/4 |
| -8 | -8 | 0.479 | 1/2 | 7/8 |
| -10 | -10 | 0.604 | 5/8 | 1 |
| -12 | -12 | 0.729 | 3/4 | 1-3/16 |
| -16 | -16 | 0.979 | 1 | 1-7/16 |
| -20 | -20 | 1.229 | 1-1/4 | 1-3/4 |
| -24 | -24 | 1.479 | 1-1/2 | 2 |
| -28 | -28 | 1.729 | 1-3/4 | 2-1/4 |
| -32 | -32 | 1.979 | 2 | 2-1/2 |
| -40 | -40 | 2.479 | 2-1/2 | 3 |

**NOTE**

The installation hole size listed in table 13-7 is the exact thread diameter of the box connector and does not include any tolerance for clearance.

(2) AN3420 BUSHING. - This molded polychloroprene bushing is available in telescoping sizes and can be used with the MS3057 cable clamps for ungrounded armor cable installations. The bushings may be telescoped when necessary for reduction of clamp throat diameter. Table 13-8 lists the available sizes and general dimensions.

TABLE 13-8. AN3420 BUSHING SIZES.

| AN 3420 | THROAT DIAMETER | BARREL OUTER DIAMETER | OVER-ALL LENGTH |
|---|---|---|---|
| -3 | 0.130 | 0.210 | 2-7/8 |
| -4 | 0.220 | 0.302 | 2-3/4 |
| -6 | 0.312 | 0.427 | 2-5/8 |
| -8 | 0.437 | 0.552 | 2-1/2 |
| -10 | 0.562 | 0.615 | 2-3/8 |
| -12 | 0.625 | 0.740 | 2-1/4 |
| -16 | 0.750 | 0.927 | 2-1/8 |
| -20 | 0.937 | 1.240 | 2 |
| -24 | 1.250 | 1.365 | 1-7/8 |
| -28 | 1.375 | 1.614 | 1-3/4 |
| -32 | 1.624 | 1.864 | 1-5/8 |
| -40 | 1.874 | 2.364 | 1-1/2 |

(3) FITTING INSTALLATION.– When the proper size entry hole has been drilled or punched in the enclosure and prepared for installation of the fitting, insert the box connector into the hole from the inside of the enclosure. Install the clamp on the box connector (finger-tight). Hold the box connector with a wrench of proper size and by use of a strap wrench (or equivalent tool which will not mar the fitting) tighten the assembly until it is rigidly connected to the enclosure. If the fitting is installed in restricted space or in proximity to other fittings and cables, the clamp and connector assembly must be positioned to allow access to the clamp tightening screws after the assembly is rigidly installed.

**NOTE**

When the AN3420 bushing is used with the clamp for an ungrounded cable installation, the bushing is installed in the clamp (flared end inside) before the clamp is joined to the box connector.

(4) CABLE INSTALLATION.– When the cable end has been prepared for termination (see section 9-4-15), install in the clamp as shown in figure 13-5. Figure 13-5a shows a grounded armor installation using a split metal sleeve with the armor over the sleeve and figure 13-5b shows an ungrounded armor installation using the synthetic rubber bushing.

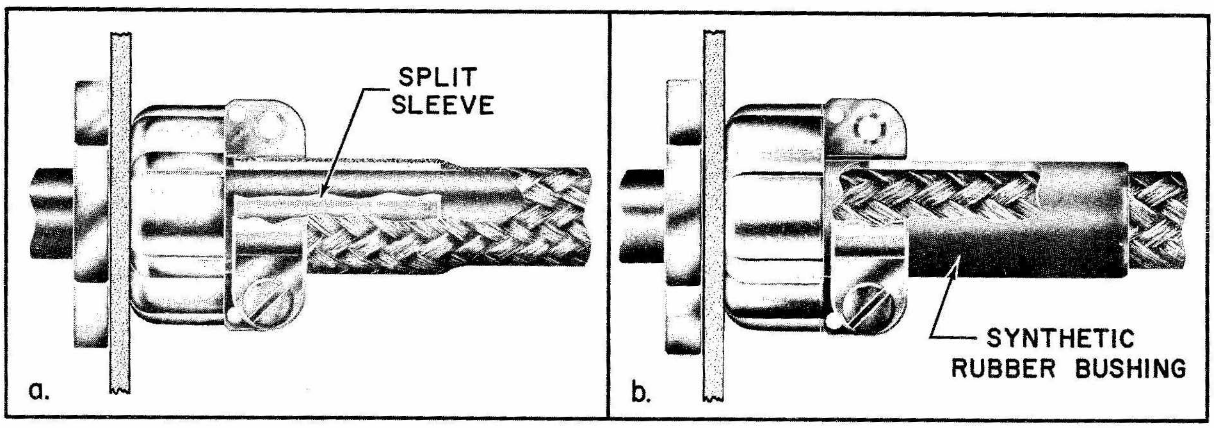



**Figure 13-5. MS3057 Cable Installation.**

**4-15. CABLE TERMINATION.** – This sub-section describes and illustrates the methods to be used to prepare the wires of interconnection cables for termination within an enclosure or equipment. It includes the removal of cable armor, jacket, and binding materials on all types of cables used in the installation of electronic equipment.

a. PROTECTIVE MATERIAL REMOVAL. – When the protective materials are removed from the cable, the following precautions shall be observed:

(1) CABLE STRIPPING TOOLS. – When cable stripping tools are used, the proper blade adjustment must be used. The cutting blade should be adjusted for a cut slightly less than the cable jacket thickness. Test the cable stripperblade adjustment on a spare piece of similar cable, or on the extreme end of the cable to be installed.

**NOTE**

The thickness of the cable jacket will vary from cable to cable and the stripper blade adjustment must be checked often enough to assure a consistently correct depth of cut in the cable jacket.

(2) INSULATION DAMAGE. – Do not nick or otherwise damage the wire insulation.

(3) WIRE BENDING. – Avoid sharp bends in the wires while removing the cable protective materials.

b. STRIPPING LENGTH. – Before the cable end is stripped, the following should be observed:

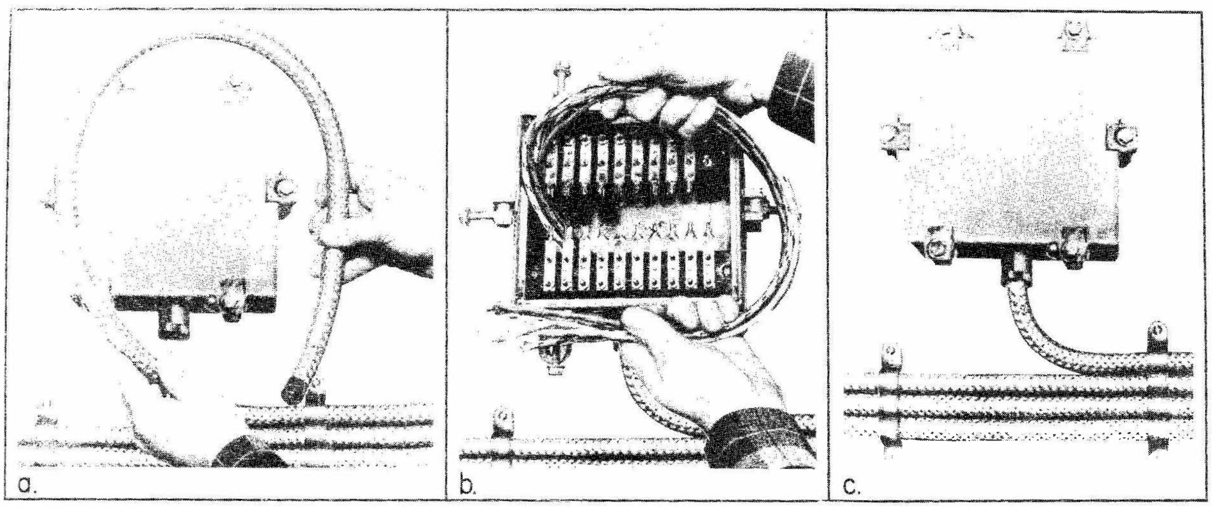
(1) CABLE ENTRY INTO ENCLOSURE. – The cable length from the last point of securing on the ship's structure to the point of entry into the equipment enclosure should be carefully judged to allow a neat installation of the cable. Excessive bends or slack in the cable shall be avoided. (See figure 15-1a).

(2) WIRE LENGTH. – Sufficient cable must be stripped for proper routing and termination of the wires in the equipment or enclosure. The wires shall be routed around the enclosure in the approved manner with sufficient extra length to allow re-termination of the wires at least three times. (See figure 15-1b).

(3) ENCLOSURE ENTRY FITTING. – The methods of finishing the cable stripping at the point of contact with the enclosure entry fitting will vary with different fittings and cables. The proper method for use with the particular cable and fitting shall be used.

**NOTE**

These methods of finishing are illustrated in figures 15-2 and 15-3 and are explained in the text following the figures. Particular attention must be paid to the type of fitting used and the method of armor termination. In grounded installations, the armor may be terminated and grounded in the clamp or pressure part of the fitting by direct contact to the armor or by the use of split sleeves installed between the armor and jacket. In some cases the armor will be combed and folded back over the sleeve. Some installations will call for termination of the armor inside the enclosure by combed pigtail or other methods. In all cases, the fitting and the method of termination used will govern the length of armor required for proper termination. For more detailed instructions, refer to the section describing the particular fitting that is being used.



a. b. c.

**Figure 15-1. Cable Termination Length.**

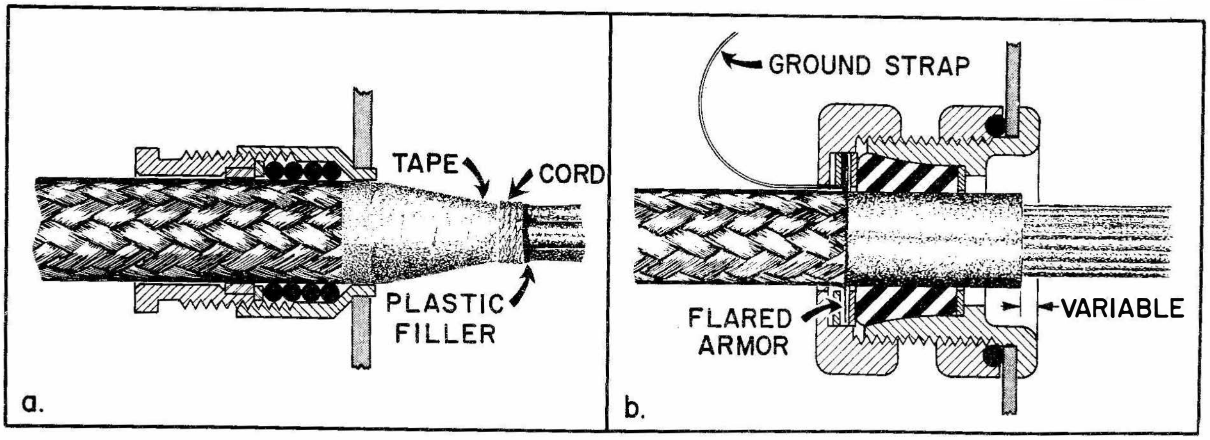



**Figure 15-2. Cable Termination in Metal and Nylon Stuffing Tubes.**

(a) METAL STUFFING TUBE. – When a cable is terminated in an enclosed equipment through a metal stuffing tube, the jacket shall be tapered, and the cable crotch filled with plastic sealer (MIL-I-3064). The tapered section is then wrapped with synthetic resin tape (MIL-I-15126), and the end of the tape served with treated glass cord (MIL-I-3158) as shown in figure 15-2a.

(b) NYLON STUFFING TUBE. –A cable terminated in an enclosed equipment through a nylon stuffing tube shall be finished as shown in figure 15-2b. The cable jacket is finished square and protrudes through the grommet as indicated.

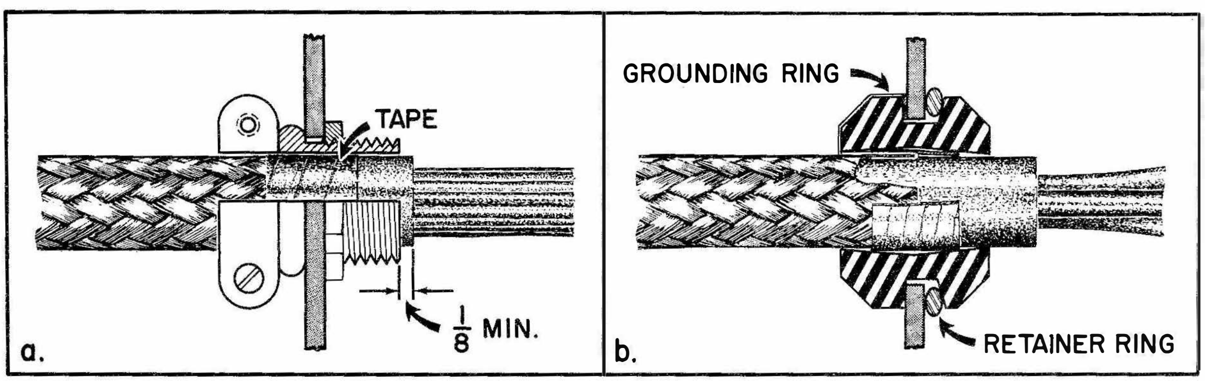



**Figure 15-3. Cable Termination in Box Connectors and Rubber Grommets.**

(c) BOX CONNECTOR. – When a Box Connector is used for cable termination, the armor shall be cut back, taped, and the cable installed with the jacket protruding through the connector as shown in figure 15-3a.

(d) RUBBER GROMMET. – Termination of a cable in a synthetic rubber grommet is shown in figure 15-3b.

c. REDUCED DIAMETER CABLES. – Reduced diameter cables of the SGA and MSCA types require very careful handling so as not to damage the insulating materials used in the construction of the cable. The conductors are insulated with a silicone rubber covered with a woven glass braid. These insulating materials have a very low tensile strength and are easily damaged by small nicks or cuts and light abrasions. The following additional precautions shall be taken when installing cables of this type:

(1) JACKET SLITTING TOOL. – Accidental damage to the wires can be greatly reduced by use of the cable jacket slitting tool illustrated in figure 15-11.

(2) WIRE ABRASION. – Do not allow the wires to rub against any sharp or rough surface, corner, or ridge in any of the spaces through which the wires are installed.

(3) WIRE FORCING. – Do not force the wires through fittings or spaces. If force is required to install the wires in congested spaces, provide temporary protection by installation of flexible synthetic resin sleeving over the group of wires.

(4) PUTTY REMOVAL.– Use extreme care in removing the water sealing putty from the wires. Any small damage or defects in the wire insulation will be greatly increased by rough treatment during the process of putty removal.

(5) CABLE CLAMPS.–Do not use cable clamps equipped with jacket butting lips for cable entry fittings.

(6) STUFFING TUBES.–Use nylon stuffing tubes in preference to metal stuffing tubes and clamps for entering fifteen–foot submersible, watertight or totally enclosed (NWT) equipments.

(7) OIL CONTACT.– Do not allow the wires to come in contact with any type of oil (oil will cause the silicone rubber to swell and weaken). If the wires are installed where the possibility of contact with spilled or leaking oil exists, protect as outlined in Section 4-19, Protection of Wire Forms.

(8) INSULATION DAMAGE.– If the wire insulation is damaged during the installation process, repair should be effected by the most economical of the following correctives:

(a) CABLE REPLACEMENT. – The damaged cable may be replaced with a new cable when approved by the Supervising Naval Activity.

(b) DAMAGED CABLE SECTIONS. – Damaged sections of the cable may be renewed by splicing when it has been determined by the Supervising Naval Activity that time and replacement cost for new cable is excessive and where the cable is otherwise in good mechanical and electrical conditions.

(c) DAMAGED WIRES. – Damaged single wires may be protected by synthetic resin flexible sleeving or by wrapping the damaged section of wire with a polyethylene base self-fusing insulation tape.

(9) CLEANING.– The excess water sealing compound should be carefully removed from each wire by wiping with a soft cloth or cotton waste. Do not use any solvent that will damage the silicone rubber insulation of the wire. The use of rough material for wiping would damage the glass braid.

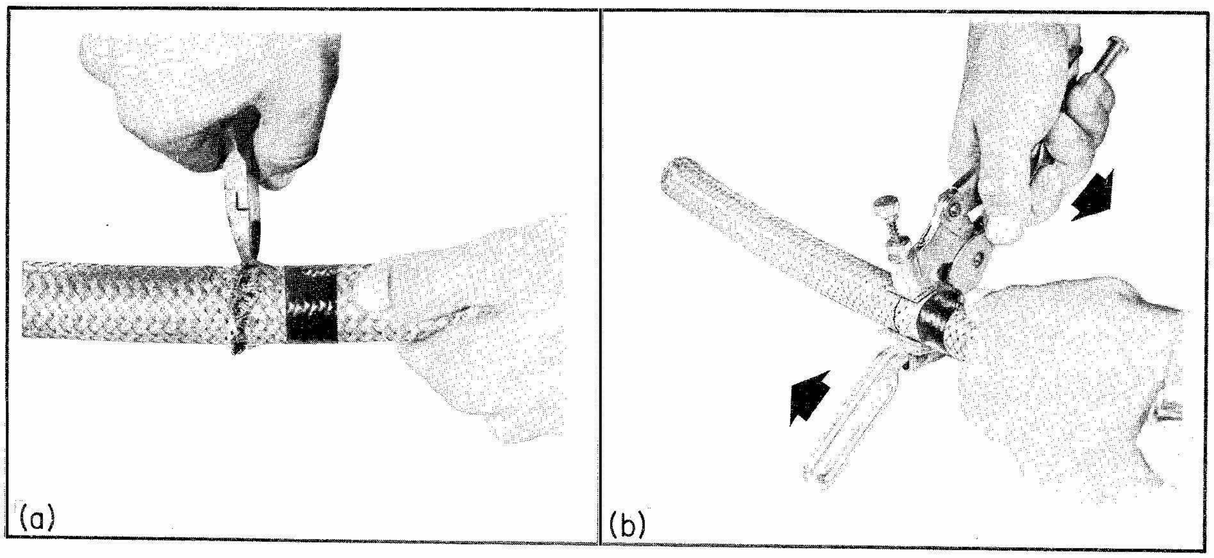
d. ARMOR REMOVAL. – The length of armor to be removed from the cable end prior to installation is determined by the length of cable required for a neat entry into the enclosure and the length of wires required for proper termination and connection to the equipment. Mark the cable at the proper spot for removal of the armor by the use of a wrap of electrical insulating tape.

STEP 1. –Make a circumferential cut through the cable armor close to the tape marker. Use Jones cable strippers or equivalent for this operation (see figure 15-4b).

**CAUTION**

Make certain that the cutting blade is in the proper position for a circumferential cut and set to the proper depth for cutting only the armor. If in doubt, try a test cut on a piece of scrap cable.

If a cable stripping tool is not available, the circumferential cut may be made by use of diagonal cutting pliers as shown in figure 15-4a.



(a) (b)

**Figure 15-4. Cutting Armor.**

STEP 2.- Flare the armor slightly on the cable end of the circumferential cut, grip with the hand at the flare and pull towards the cable end. Due to the diagonal lay of the armor strands, it will usually expand for easy removal.

If armor is too tight for removal in this manner, a longitudinal cut must be made from the circumferential cut to the cable end. The armor may then be peeled from the cable. (See figure 15-5).

e. JACKET LENGTH. – The length of jacket left between the end of the armor and the bared wires will depend on the type of cable termination to be used. Different types of terminations are as follows:

(1) OPEN EQUIPMENT, TAPE METHOD. –When the cable is to be terminated by the tape method in open equipment, a jacket length of approximately one and one-half times the cable diameter should be left protruding from the armor for tapering, taping, and serving. (See figure 15-6a).

(2) NYLON STUFFING TUBE. – When the cable is terminated in a nylon stuffing tube, a jacket length of approximately the cable diameter plus the grommet length should be left protruding from the armor (See figure 15-6b).

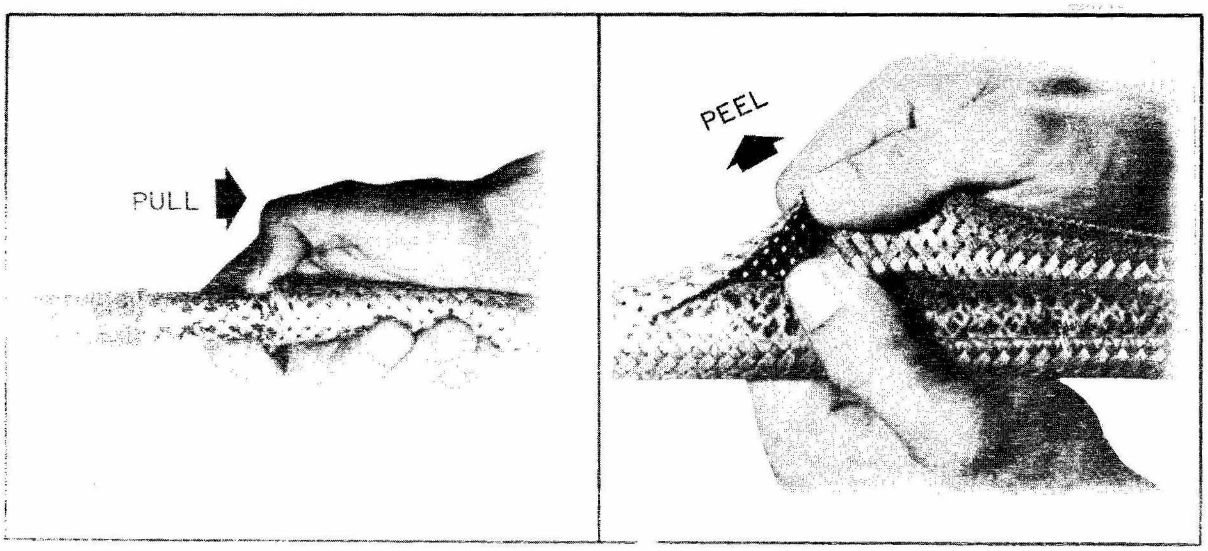



Figure 15-5. Armor Removal.

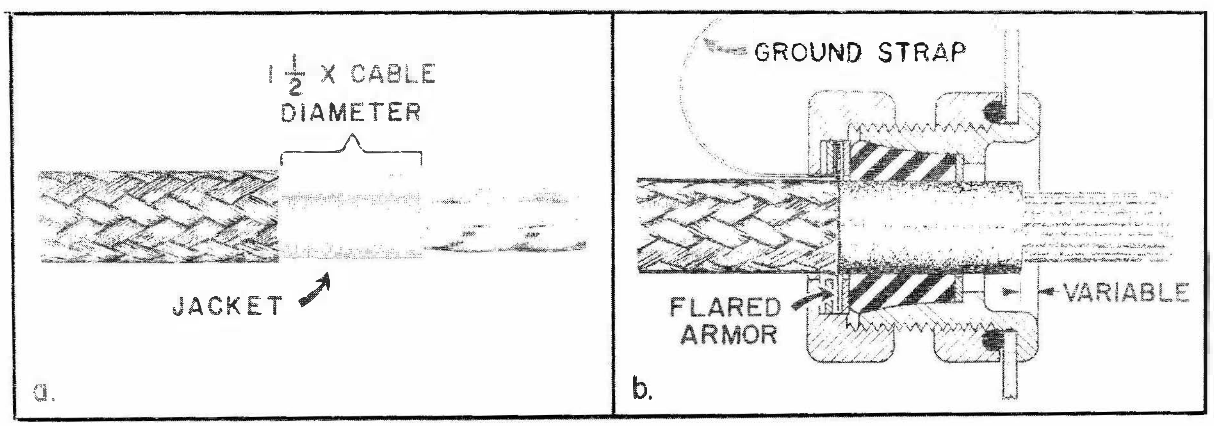



Figure 15-6. Jacket Length.

(3) METAL STUFFING TUBE OR BOX CONNECTOR. – When the cable is terminated in a metal stuffing tube or box connector, a jacket length of approximately one-half the cable diameter should be left protruding from the armor (see figure 15-7a).

(4) SYNTHETIC RUBBER GROMMET. – When the cable is terminated in a synthetic rubber grommet, a jacket length of approximately the length of the grommet should be left protruding from the armor (see figure 15-7b).

f. JACKET REMOVAL. – When the jacket length, which is to be left protruding from the armor, has been determined by the type of termination to be used, proceed with the jacket removal as follows:

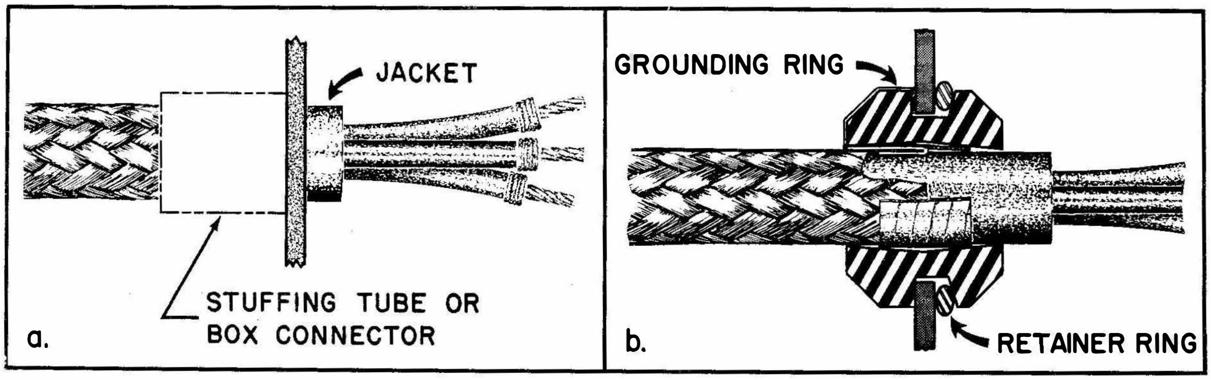



Figure 15-7. Jacket Length

STEP 1.–Set the cable stripping tool cutter blade in the position for a circumferential cut. Adjust the cutter blade for a depth of cut approximately three-fourths of the jacket thickness. Close the tool on the cable and cut once around the jacket. If a cable stripping tool is not available this cut may be made by careful use of a sharp knife.

**CAUTION**

Do not cut completely through the jacket as this will injure the insulation on the wires. The jacket thickness will vary from cable to cable and the cutting blade depth must be frequently checked to insure the proper depth of cut consistent with the jacket thickness.

STEP 2.–Set the cable stripping tool cutter blade for a longitudinal cut. Close the tool on the cable and cut from the circumferential cut to the cable end (see figure 15-8).

STEP 3.–Separate the jacket at the cable end by use of diagonal pliers and peel apart until sufficient wire length has been exposed to allow a good hand grip (see figure 15-9).

STEP 4.–Grip the wires in one hand and the jacket in the other. Pull the wires and the jacket in opposite directions, tearing the jacket along the longitudinal cut until the circumferential cut is reached. Carefully continue pulling and the jacket should separate from the cable.

**CAUTION**

Cables of reduced diameter types such as SGA and MSCA are manufactured with a conductor insulation of silicone rubber covered with a woven glass braid. This type of wire is very susceptible to damage. It is not recommended to pull on the wires and jacket as illustrated in figure 15-9, Step 4. Continue the method shown in figure 15-9, Step 3, until the jacket is entirely removed.

STEP 5.–Separate any filling material and binders from the wires and cut them from the cable at the termination of the jacket.

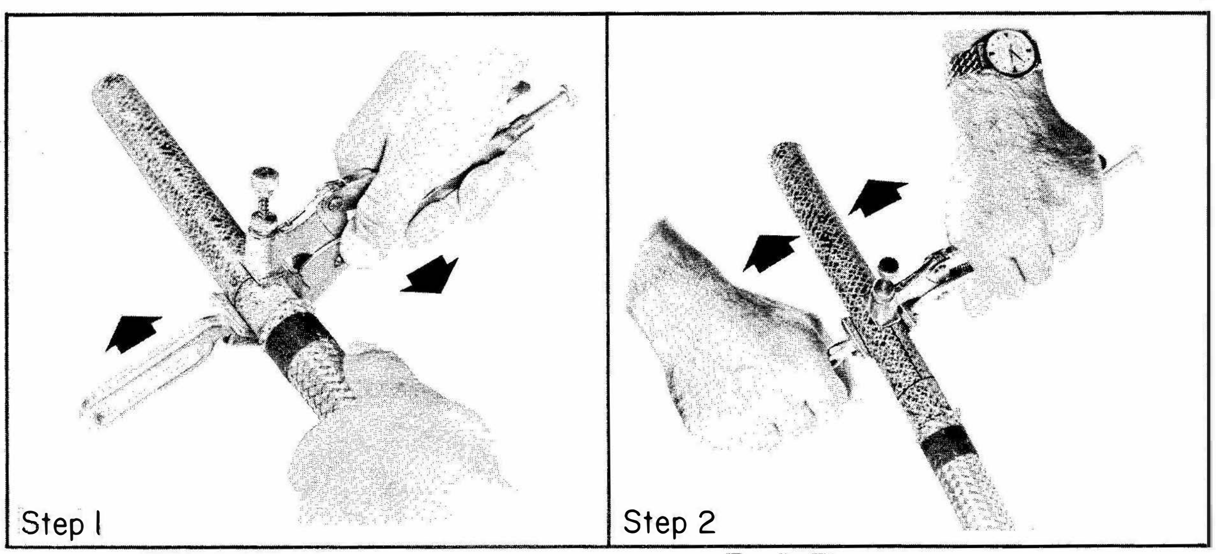



Figure 15-8. Jacket Cutting.

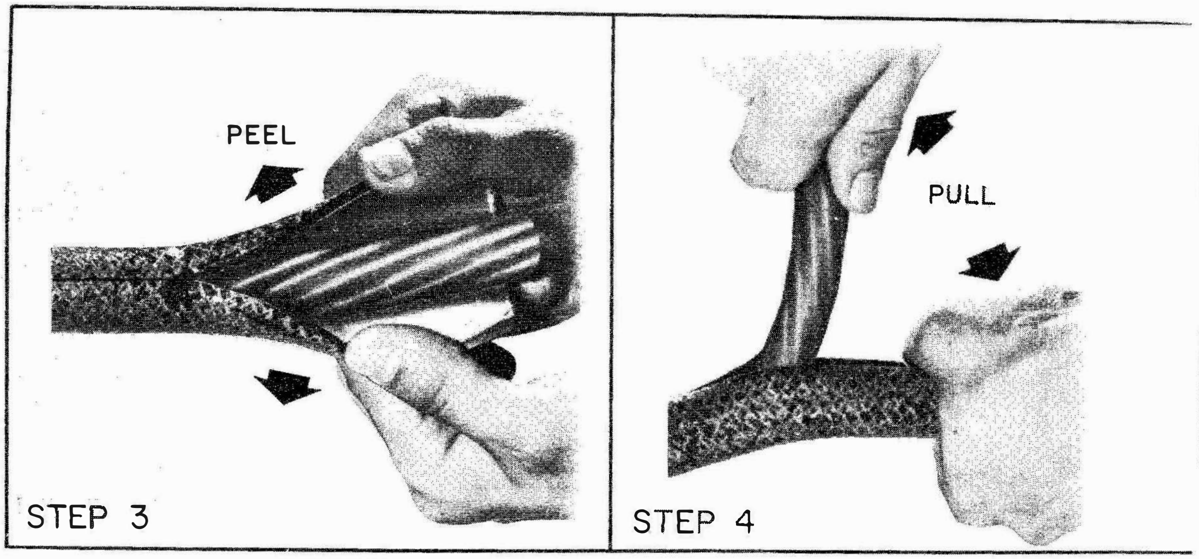



Figure 15-9. Jacket Removal.

g. JACKET REMOVAL – REDUCED DIAMETER CABLES. – Damage of wires in reduced diameter types of cables can be greatly reduced by using a special jacket slitting knife. Unlike the conventional cable stripper, this tool presents no sharp surface that may contact the wires in the process of jacket slitting. This tool can be fabricated locally by making the blade (see figure 15-10) and attaching it to a commercially available wood handle as shown in figure 15-11.

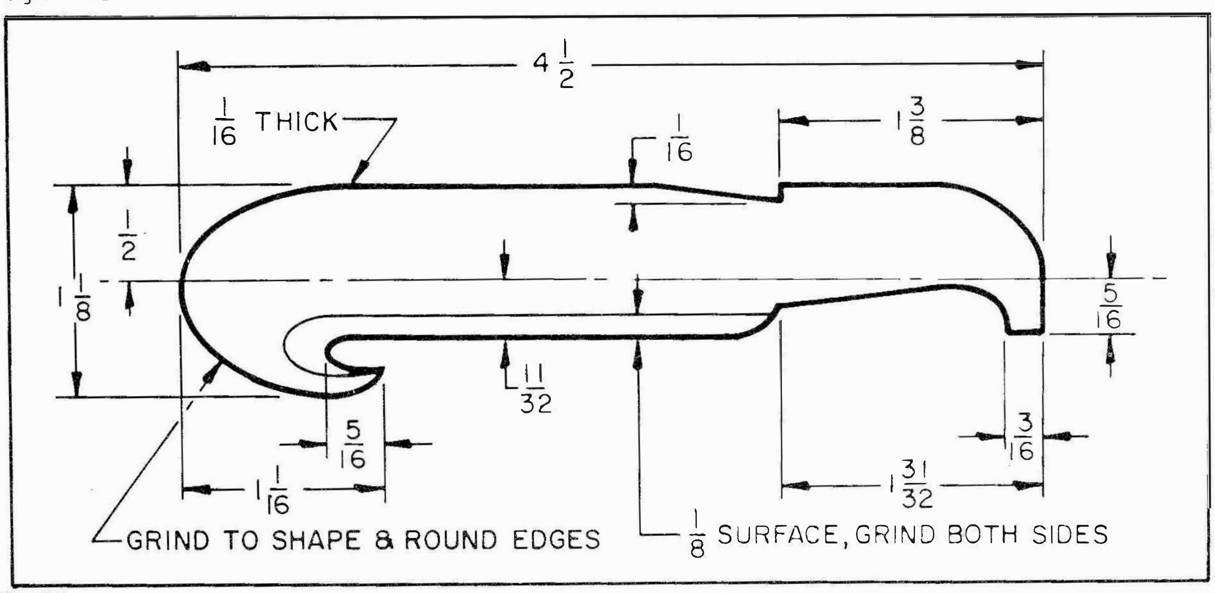



Figure 15-10. Stripping Tool Blade.

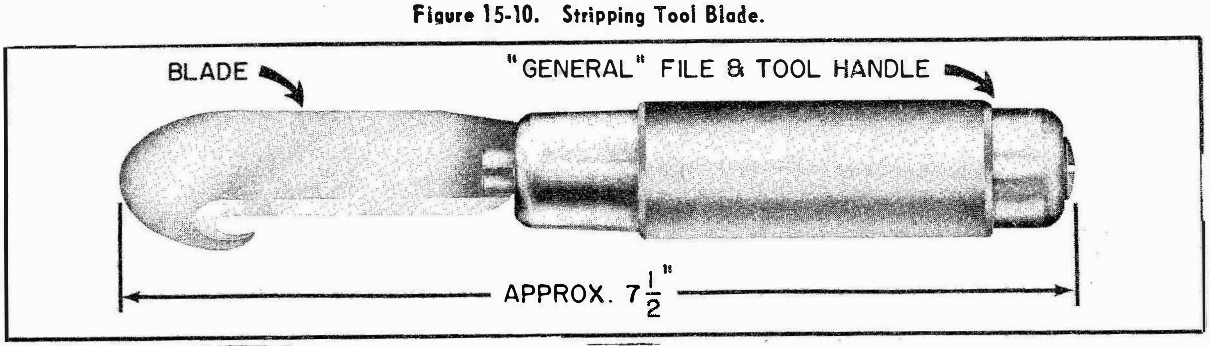



Figure 15-11. Cable Jacket Stripping Tool.

(1) JACKET SLITTING.– The cable jacket is slit for removal with this tool as follows:

STEP 1. – Carefully insert the hooked cutting edge of the tool under the cable jacket at the approximate angle shown in figure 15-12, and make the cut in a a direction away from the cable end.

STEP 2. – Continue the cut along the jacket, maintaining the same cutting angle, until the circumferential cut in the jacket is reached. The jacket and wires can now be easily separated.

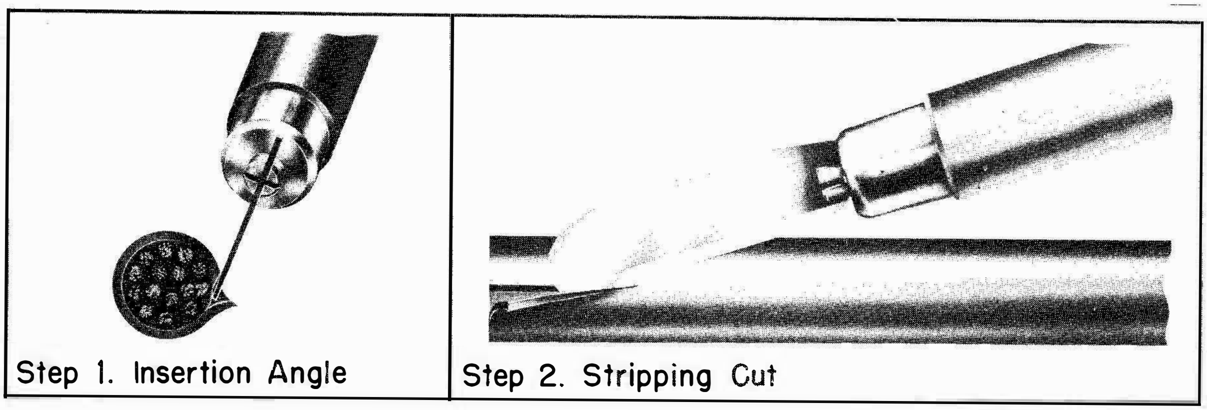



**Figure 15-12. Jacket Slitting.**

**CAUTION**

This tool will produce good results in jacket slitting, but mustbe used with extreme caution and not allowed to slip.

h. JACKET TAPERING AND FINISHING. – Cables terminated in open equipment and in certain types of enclosure entry fittings shall be finished by tapering the jacket, serving with tape to secure the armor, and finished with a cord serving to produce a neat and effective termination. Proceed with this method as follows:

STEP 1. –Bend a thin piece of sheet metal around the wires and insert one end between the jacket and the wires. This piece of metal should be wide enough to protect approximately half of the wire group circumference and should have smooth rounded corners and edges. Using a sharp knife with extreme care, start the taper as shown in figure 15-13. Make many small cuts rather than a few large cuts and keep the taper even. The metal guard is slipped around the wire group as the tapering progresses.

**CAUTION**

Extreme care must be used in the tapering operation. Keep the cutting hand in contact with, and supported by, the thumb on the protected wires. Use only the finger action of this hand to complete the tapering cuts. Do not cut through the jacket and into the unprotected portion of the wires.

STEP 2. –Start the tape serving with a full lap over the end of the cable armor. Pull the tape tight, continue with a half lap serving down the taper and one-half inch out over the wire group as shown in figure 15-14.

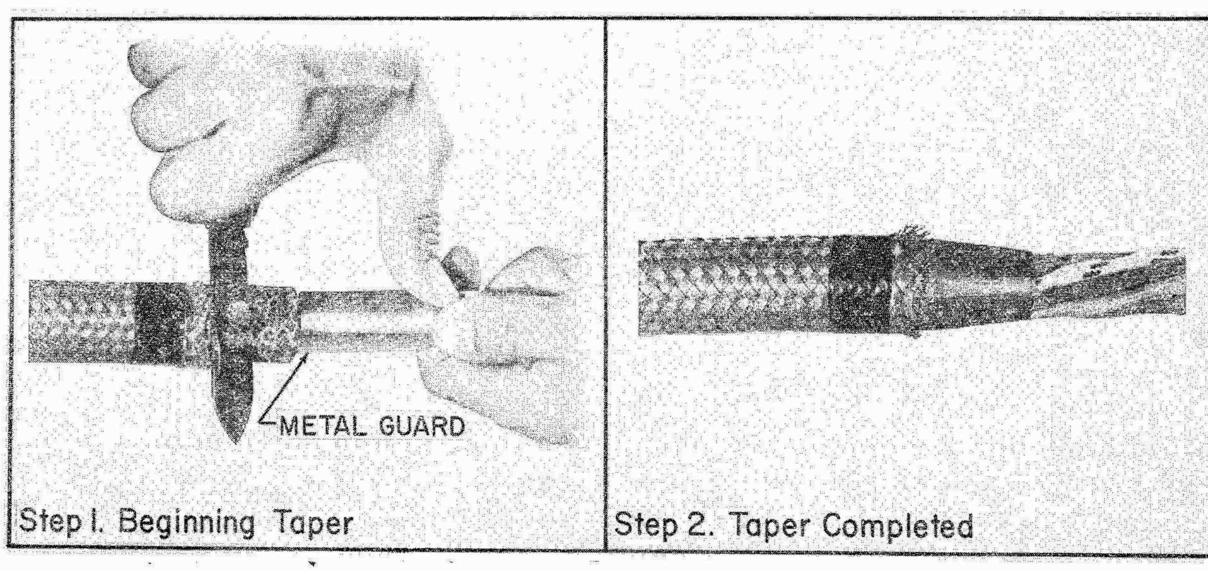



**Figure 15-13. Tapering Jacket.**

STEP 3.—Using treated glass cord, double the end to form a loop. Lay the loop lengthwise on the portion of cable to be served as shown in figure 15-15.

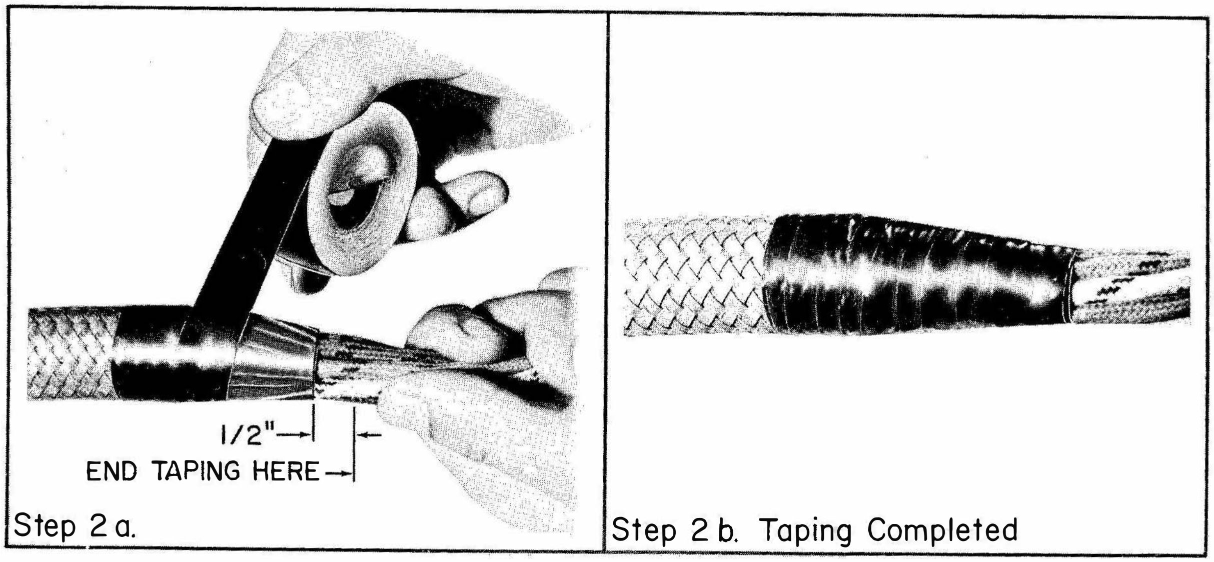



**Figure 15-14. Taping Cable End.**

STEP 4.—Wind the cord tightly around the cable and loop approximately 10 turns. Pass the free end of the cord (A) through the loop and hold the serving tightly in place.

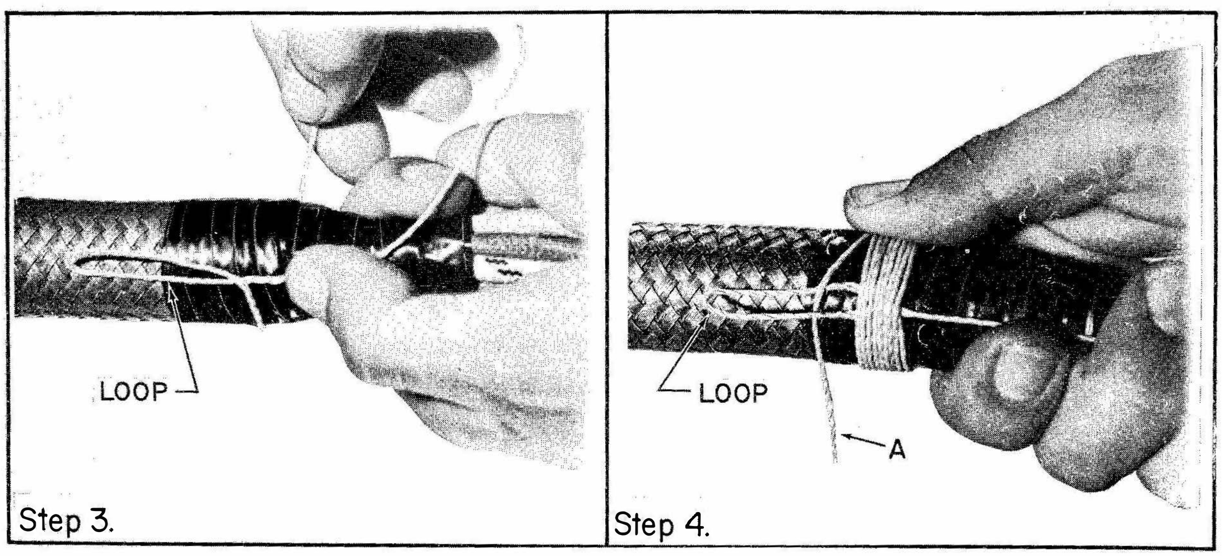



**Figure 15-15. Cord Serving.**

STEP 5.—Pull the free end of the loop (B) until the loop and cord end (A) are approximately halfway under the cord serving. If the serving is tight and this step properly performed, the ends of the cord will be locked under the serving and it will not slip or come undone. Trim the free ends (A and B).

STEP 6.—Coat the tapered cable termination with insulating varnish and allow the finish to dry.

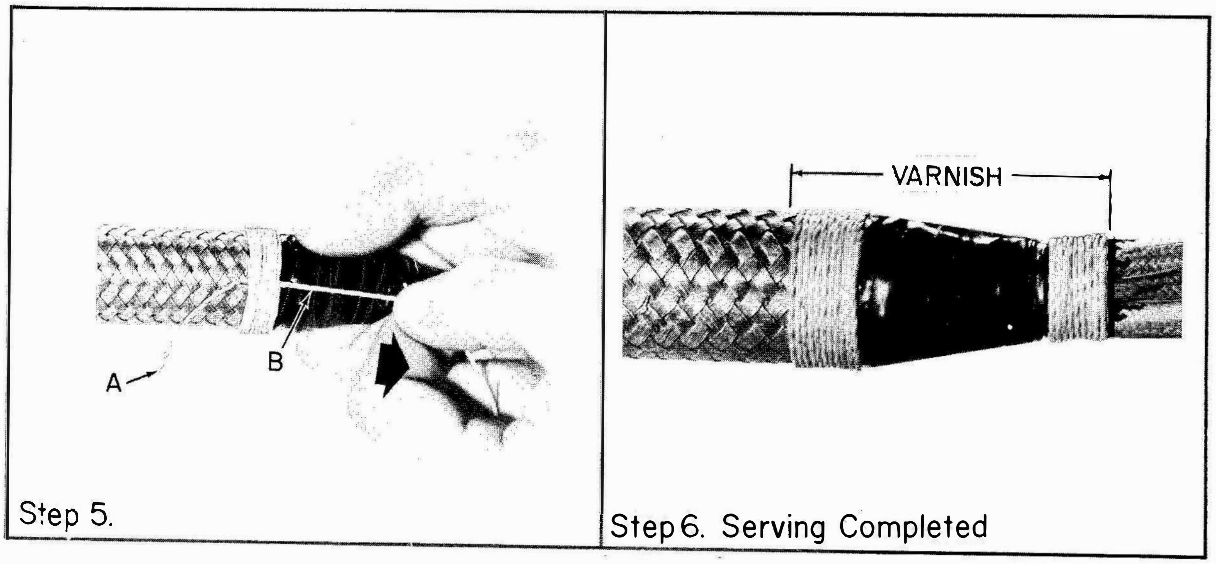



Figure 15-16. Taper Finishing.

**4-16. CABLE MARKING.**—This sub-section describes the approved methods of marking electronic system cables for identification.

a. TAGGING. – All permanently installed cables shall be tagged as close as practicable to each point of connection. They shall also be tagged on both sides of bulkheads, decks, and other barriers, and at intervals, such that the length of cable between tags does not exceed 50 feet. Where cable runs are short and straight (such as vertical runs between decks) and where a second set of tags serves no useful purpose a single set within a compartment will be considered adequate. Cables that are located wholly within a compartment in such a manner that they can be readily traced need not be tagged. Wherever possible tags should be attached to a straight portion of cable; bends should be avoided. Tags should be placed so that they are easily read.

b. CABLE IDENTIFICATION. – All cables used for electronics equipment interconnection service shall be identified by the letter "R" followed by a dash, the letters designating the system, and the system cable number. If two or more identical systems are installed, they will be identified by numbers in sequence beginning with "1". This number will precede the electronic identification letter "R".

(1) CABLE SEGREGATION MARKING.–If a cable is classed as active or susceptible, the designating letter of the particular class will follow the electronic identification letter "R".

(2) SYSTEM DESIGNATION MARKING. – The two letters used for system designations are given in table 16-1.

(3) SYSTEM CABLE NUMBERING. – The system cables are numbered consecutively from "1", beginning at the unit where the ship service power connects, or at the focal point of the system.

(4) SYSTEM INTERCONNECTING CABLES. – Electronic system cables interconnecting through panels, switchboards, or similar items, are considered a part of one integrated system and carry the same system identification.

(5) POWER CABLES. – Cables supplying power to electronic equipment systems will carry the designation specified for power and lighting systems. This applies only to the supply cable up to the first electronic unit of the system or to the power receptacle to which the unit connects. Interconnection power cables between electronic system units will carry the electronic identification letter "R".

c. CABLE SEGREGATION. – Shipboard cables are segregated in the following classes:

(1) ACTIVE CABLES. – (High level).
- (a) RADAR modulator pulse cables.
- (b) RADIO transmitter antenna cables or transmission lines (except UHF and VHF).
- (c) SONAR transducer cables (when transmitting).

(2) SUSCEPTIBLE CABLES. – (Low level).
- (a) RADIO receiving antenna cables including LORAN, ECM and AEW.
- (b) SONAR transducer cables (when receiving).
- (c) SONAR hydrophone cables.
- (d) TRANSCEIVER cables (including IFF).

(3) PASSIVE CABLES. – (Medium level).
- (a) POWER and LIGHTING cables.
- (b) IC and FC cables.
- (c) CONTROL cables.
- (d) ELECTRONIC cables other than those designated as either active or susceptible.

d. CABLE SEGREGATION MARKING. – The classes of cable segregation are marked as follows:

(1) ACTIVE CABLES. – Mark with the letter "A".
(2) SUSCEPTIBLE CABLES. – Mark with the letter "S".
(3) PASSIVE CABLES. – No additional designation.

e. CABLE MARKING EXAMPLES

EXAMPLE 1. – "2RS-RR3" The number two indicates that this cable is a part of which there are two or more systems with identical designating letters. "R" indicates an electronic system and the "S" indicates a low level susceptible cable. The "RR" indicates a radio receiver system and the "3" shows that this cable is the 3rd cable of the system.

EXAMPLE 2. – "R-RT7" The first "R" indicates an electronics system and the "RT7" shows that this cable is the 7th cable of a radio transmitter circuit.

**NOTE**

In this example, the absence of a number preceeding the initial letter "R" indicates that there is only one system of this type in the installation. The absence of a letter suffix to "R" identifies the cable in the passive classification.

f. CABLE TAGGING. – Tags for marking cable shall be of gray soft aluminum tape (MIL-A-2877) except where used with cables having bronze armor. In this case, sheet brass of commercial quality shall be used. Tags are secured to cables with aluminum strip 5/16 inch wide and 0.014 inch .o 0.16 inch thick. Table 16-1 lists the standard circuit or system designations.

(1) SECURING TAGS TO CABLES. – Identification tags are secured to cables as follows:

STEP 1. – Cut two pieces of aluminum strip of a length sufficient to go around the cable once plus 1-1/2 inches.

STEP 2. – Pass 1/2 inch of one end of one strip through one of the slots in the cable tag and bend back.

STEP 3. – Repeat STEP 2 with the other strip through the other slot on the same side of the cable tag.

STEP 4. – Place the cable tag on the cable in its correct position and bend the two strips around the cable.

STEP 5. – Pass the free ends of the strips through the opposite slots in the cable tag. Pull the strips tight and bend back.

STEP 6. – Trim the ends of the strips to 1/2 inch of the slots and press the ends of the strips to the cable.

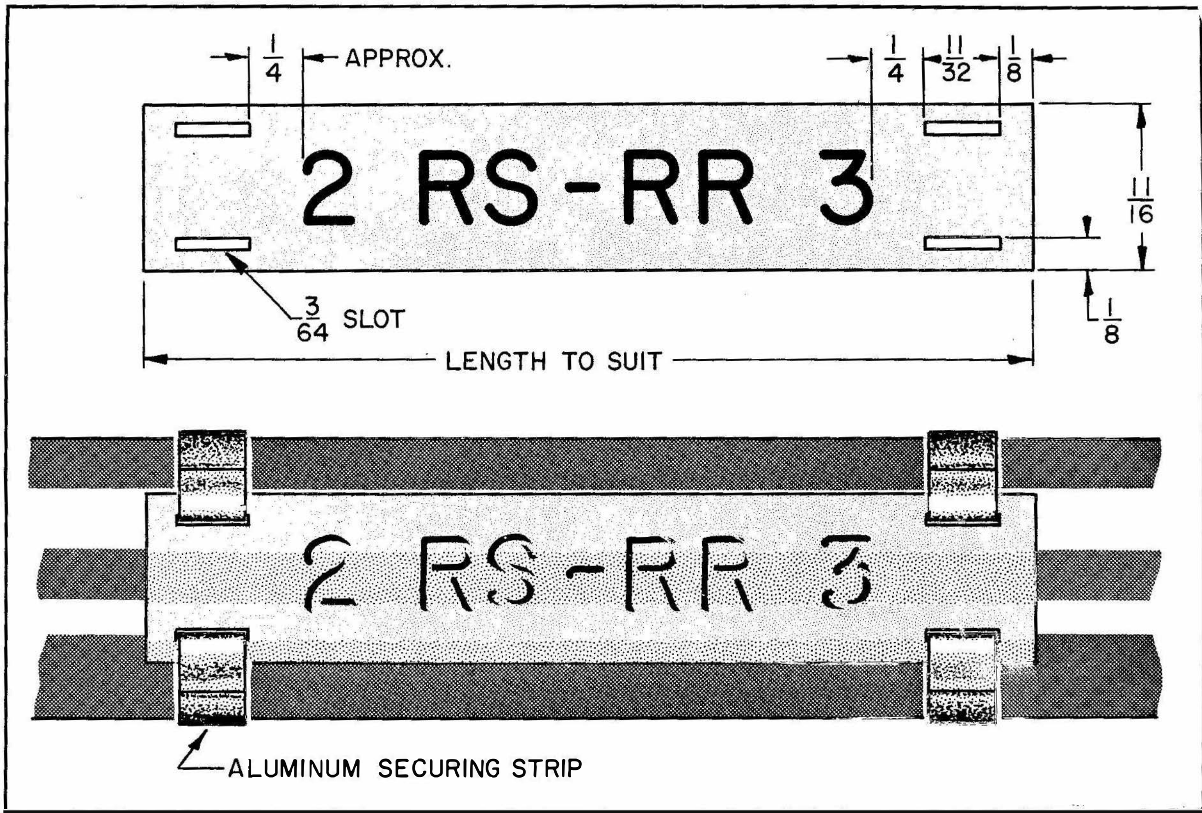



Figure 16-1. Cable Marking

NOTE

In cases where cables are subjected to rough handling, the aluminum securing strip should be reinforced with a wrap of insulation tape.

TABLE 16-1. CIRCUIT OR SYSTEM DESIGNATION AND TITLE

| DESIGNATION | TITLE |
|---|---|
| R-AM | Radiation monitoring |
| R-AW | Aerological sounding and tracking |
| R-BC | Radio beacon |
| R-BN | Infrared beacon |
| R-BR | Radar beacon |
| R-BS | Sonar beacon |
| R-CI | Electronic countermeasures-intercept |
| R-CT | Electronic countermeasures-jamming |
| R-EA | Air search radar |
| R-EC | Carrier controlled approach-radar |
| R-ED | Electronics data system |
| R-EE | Air search radar with height determining capabilities |
| R-EF | Height determining radar |
| R-EG | Guided missile radar |
| R-EM | Mortar locator radar |
| R-ER | Radar remote indicator |
| R-ES | Surface search radar |
| R-ET | Radar trainer |
| R-EW | Aircraft early warning |
| R-EZ | Hemispheric scanning |
| R-FB | Guided missile fire control radar |
| R-FG | Heavy machine gun battery fire control radar |
| R-FM | Surface battery fire control radar |
| R-FS | Double purpose battery fire control radar |
| R-GM | Electronic guidance remote control or telemetering |
| R-IA | IFF used with air search radar |
| R-IC | Radar recognition |
| R-IF | IFF used with fire control radar |
| R-IM | IFF test equipment |
| R-IR | IFF used with radar remote indicators |
| R-IS | IFF used with surface search radar |
| R-IT | Radar identification |
| R-IU | IFF used with sonar |
| R-NC | Infrared communication |
| R-ND | Infrared detection |
| R-RA | Radio antenna (incl. freq. meter extension circuits) |
| R-RC | Radio channel selection |
| R-RD | Radio direction finder |
| R-RN | Radio navigation |
| R-RQ | Combined radio receiver and transmitter control circuits |
| R-RR | Radio receiving circuits (incl. unit interconnection) |

TABLE 16-1. CIRCUIT OR SYSTEM DESIGNATION AND TITLE (con)

| DESIGNATION | TITLE |
|---|---|
| R-RS | Radio Synchronization |
| R-RT | Radio transmitter control (incl. unit interconnection) |
| R-RX | Radio facsimile |
| R-RY | Radio teletype |
| R-SA | Azimuth echo ranging sonar |
| R-SB | Underwater telephone |
| R-SC | Sonar computing |
| R-SD | Depth determining sonar |
| R-SE | Depth charge direction indicator and range estimator |
| R-SH | Sonar hoist-lower control |
| R-SI | Sonar identification equipment |
| R-SK | Scanning sonar |
| R-SL | Listening sonar |
| R-SM | Sonar monitoring |
| R-SO | Bathythermograph |
| R-SP | Attack aid and auxiliary |
| R-SQ | Combination depth-azimuth sonar |
| R-SR | Sonar remote indicator |
| R-SS | Sounding sonar |
| R-ST | Attack teacher or sonar trainer |
| R-SU | Underwater object locator |
| R-SV | Variable depth sonar |
| R-SX | Doppler sonar |

## 4-17 CABLE BONDING AND GROUNDING*

**a. GENERAL** - Bonding is defined as the connecting of two or more elements or electrical conductors through a low resistance or impedance path. Grounding equipment is a low resistance or impedance bus between equipment framework, the ships hull, the ships ground system, or earth which are at sero potential or reference point from which measurements are made.

Mechanically and electrically connecting all parts of a system prevents an accumulation of charges which may create a difference of potential causing a personnel hazard and arcs or sparks which are a serious electronic interference problem.

Bonding to ground will provide a low resistance or impedance path to drain away any radio frequency currents which may exist on cables, equipments, and frameworks, thereby reducing or eliminating electronic interference.

**b. PURPOSE FOR BONDING AND GROUNDING** - Bonding and grounding provide the following measures:

(1) Prevention of personnel hazards from radio frequency potentials, or lighting.

(2) A return path to ground of all currents including interference currents.

(3) Prevention of a difference of potential from building up along the system.

(4) Prevention of shock hazard to personnel or the creation of interference by internal breakdowns of equipments through circuit shorts.

(5) Prevention of static charges which create electronic interference and personnel shock hazards.

(6) Prevention of the accumulation of charges on objects or structures to transmitting equipment.

**c. REQUIREMENTS FOR BONDING** - The metal structure that supports cable normally provides adequate grounding of cable armor without additional grounding circuits. The methods used shall be governed by the materials on hand and the policy of the installing activity. Electronic cables requiring special shielding or grounding will be indicated on plans furnished by the Bureau of Ships or the Bureau of Naval Weapons.

Bonds or joints in ground circuits that are exposed to the weather or corrosive agents shall be given a protective coat of paint, or other preservative. Topside cables shall be routed to keep their exposed length to a minimum consistant with obtaining maximum practicable separation from antennas circuits. Wherever possible, avoid runs paralleling anttenna circuits. Take advantage of shielding afforded by adjacent ship structures.

All shielded connections and bonding surfaces must make a clean, tight electrical contact. Remove all paint and foreign matter from mating areas to ensure a good electrical bond, otherwise the contact may become a source of trouble. When the bond has been completed paint the area with a water resistant paint of good quality.

**d. METHODS OF BONDING** - Several of the approved methods of bonding are illustrated in figures 17-1 through 17-6, additional methods conforming to good engineering practices are illustrated in Sub-Section 10-3.

**e. ADDITIONAL GROUNDING** - All equipment requiring additional grounding, as indicated by a radio interference test, shall be grounded by straps as follows:

(1) On units that require vibration isolation, the straps shall be copper braid, not less then 1/2 inch wide.

(2) On other units, the strap shall be sheet copper or brass not less than 0.020 inch thick by 1/2 inch wide.

(3) The contacting surface of, strap to case and strap to ground, shall be throughly cleaned to ensure unimpaired metal to metal contact.

(4) Straps shall be as short as possible. Where shock or vibration mounts are used, the strap shall have only enough loop to permit unrestricted movement of the equipment on the mounts.

(5) Straps shall be secured in such a manner as to prevent working loose because of vibrations.

(6) Only one strap shall be installed on each unit unless tests indicate that more are required.

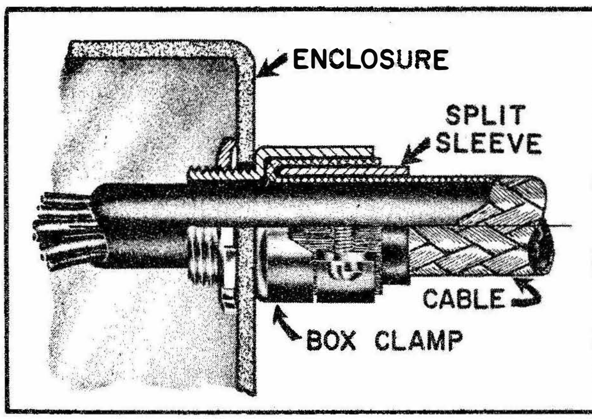



**Figure 17-1. Box Clamp.**

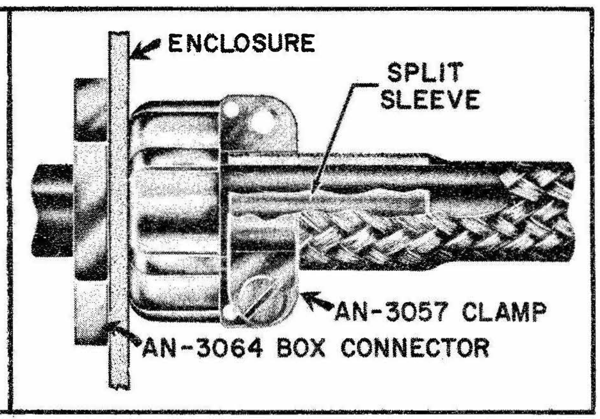



**Figure 17-2. AN-3064 Box Conn and AN-3057 Clamp.**

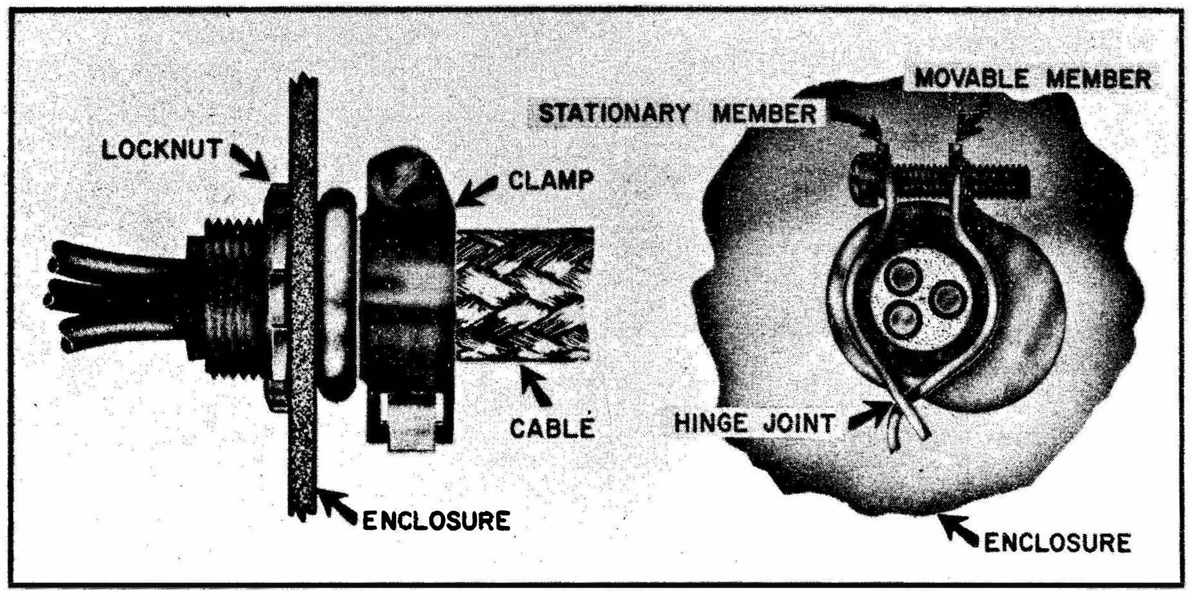



Figure 17-3. Clamp and Locknut.

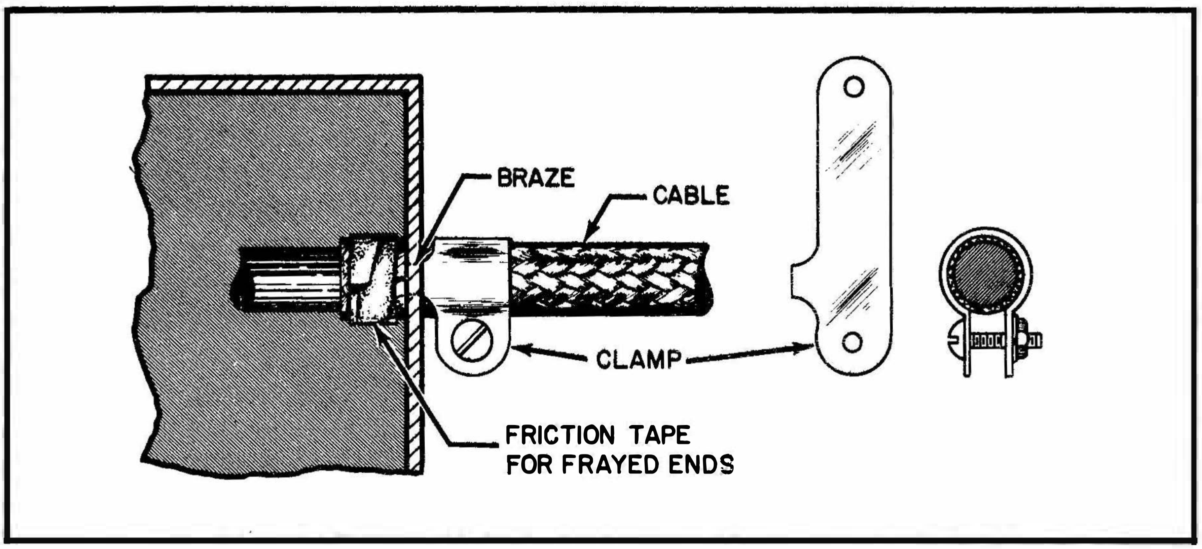



Figure 17-4. Clamps Brazed to Enclosures (Method a).

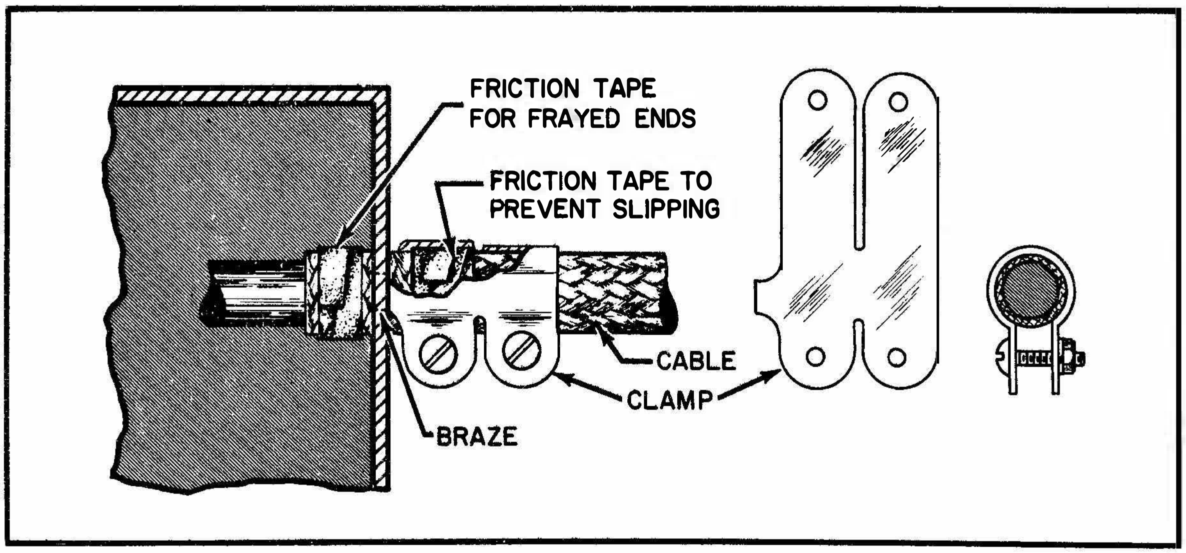



Figure 17-5. Clamps Brazed to Enclosures (Method b).

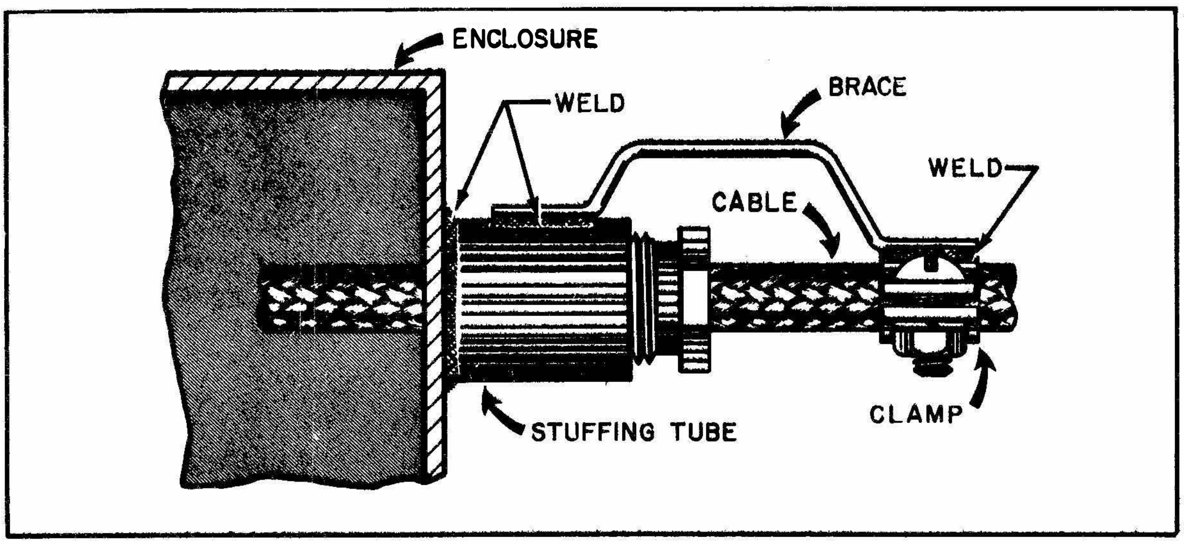



Figure 17-6. Clamp and Braces

**4-18. ROUTING AND FORMING OF WIRING.**–This sub-section describes and illustrates the recommended methods for routing and forming wires, and wire groups within an enclosure such as an electronic unit or junction box.

a. WIRE LENGTH. – Do not cut wires to length until the group has been shaped and fastened up to its terminating point. Wires should be long enough to reach the farthest terminal served.

b. TWISTED PAIRS. – Do not separate the individual wires of telephone type cable pairs until the termination point has been reached.

c. INDIVIDUAL WIRES. – Arrange individual wires straight and parallel to each other before forming and tying. This will eliminate unsightly and bulky wire groups caused by twists and crossovers.

d. CABLE GROUPS. – When two or more multiconductor cables enter an enclosure each cable wire group will be laced, tied or otherwise bound together and in place while the group is being shaped.

e. TEMPORARY TIES. – Temporary ties are used to hold a wire group together and in place while the group is being shaped. Colored cord should be used for this purpose in order that the temporary ties may be easily identified. They are removed when the forming is completed.

f. ROUTING. – Particular care should be taken in choosing the route for wire groups and forms. No group should be routed in such a manner as to cross a terminal block or in any way obstruct access to the terminals. From the point of entry a wire group should not always be routed direct to its designated terminals. Where the terminals are close to the point of entry a direct route would make too rigid a form. It is better practice to route the group around the enclosure and approach the terminals from the side farthest from the point of entry.

g. HINGE PROTECTION. – Where one or more groups are terminated on a piece of equipment that is hinged, care must be taken in routing the group across the hinge. If the group crosses the hinge directly, the wires of the group will be subject to bending that would ultimately result in broken wires. To avoid this, the group must be routed for as great a distance as possible in a direction parallel and close to the hinge. The wires will not be subjected to a twisting, rather than bending motion, over a greater length of wire and are less likely to fracture.

h. SUPPORT. – When deciding the route for a wire group, consideration must be given to possible points of support on the framework. Routing should be such that fastening to these support points can be accomplished without distorting the form. Where two or more wire groups follow the same route they must be formed so that they fit closely to each other and will not be deformed when tied together.

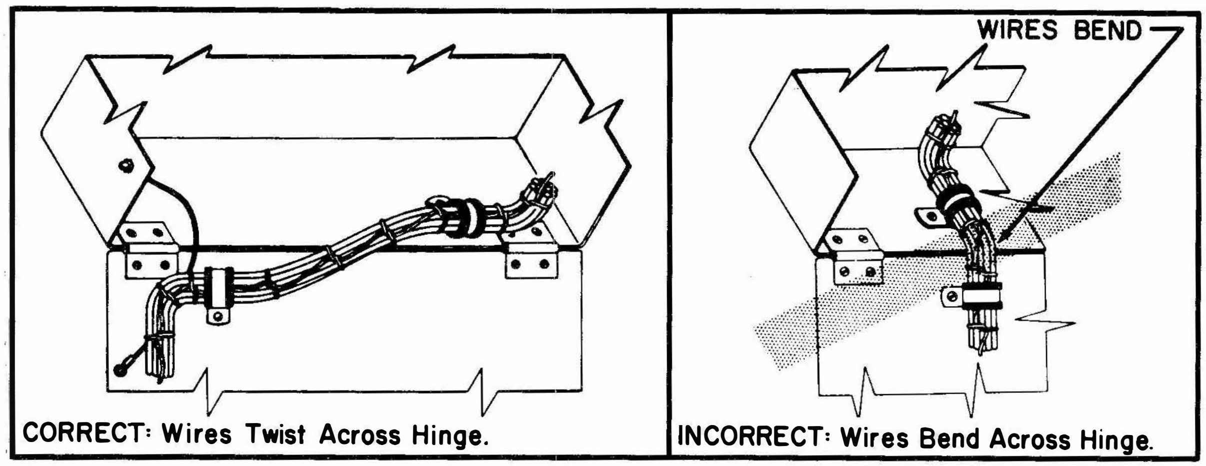



**Figure 18-1. Routing Wiring Over a Hinge**

i. ROUTING AND FORMING A GROUP. – When a route has been decided after consideration of paragraph a. through h., proceed as follows:

STEP 1.–Comb out the wires of the groups so that they are straight and parallel.

STEP 2.–Separate the spares from the group and bend back out of the way to be dealt with later.

STEP 3.–Put a temporary tie around the active wires at a point near where the wires leave the cable jacket.

STEP 4.–Bunch the wire group together with the hands and run the group in the direction intended. Put in temporary ties at intervals sufficient to hold the wires together. Maintain the wires straight and parallel.

STEP 5.–Where a bend occurs in the route, bend the wire group to the desired shape. Put a temporary tie in the angle of the bend.

STEP 6.–Where a branch-off occurs, put a temporary tie immediately before the branch-off. Select the wires from the group that are to go into the branch-off and bend away from the group and in the correct direction for the branch-off. Bunch the wires of the branch-off together and put a temporary tie near the point where they leave the group.

STEP 7.–Continue forming and installing the temporary ties until the group is run along its entire route. The permanent form of fastening may now be carried out.

j. DISPOSITION OF SPARES.–Spares should be cut to a length that will enable any wire to reach the farthest terminal when routed with the group. The wire ends should be insulated in the approved manner and laced, tied or otherwise bound together by the same method as used for the active wire groups. They should be routed along with the other groups and folded back on themselves as near as possible to the point of entry and then tied to the form.

k. COMPLETING THE FORM.–A group routed and shaped with temporary ties in place is shown in figure 18–2. This is a typical example and intended to serve as a guide. For the sake of clarity only one group is illustrated, other groups would be routed in the same manner and then tied together in a completed form.

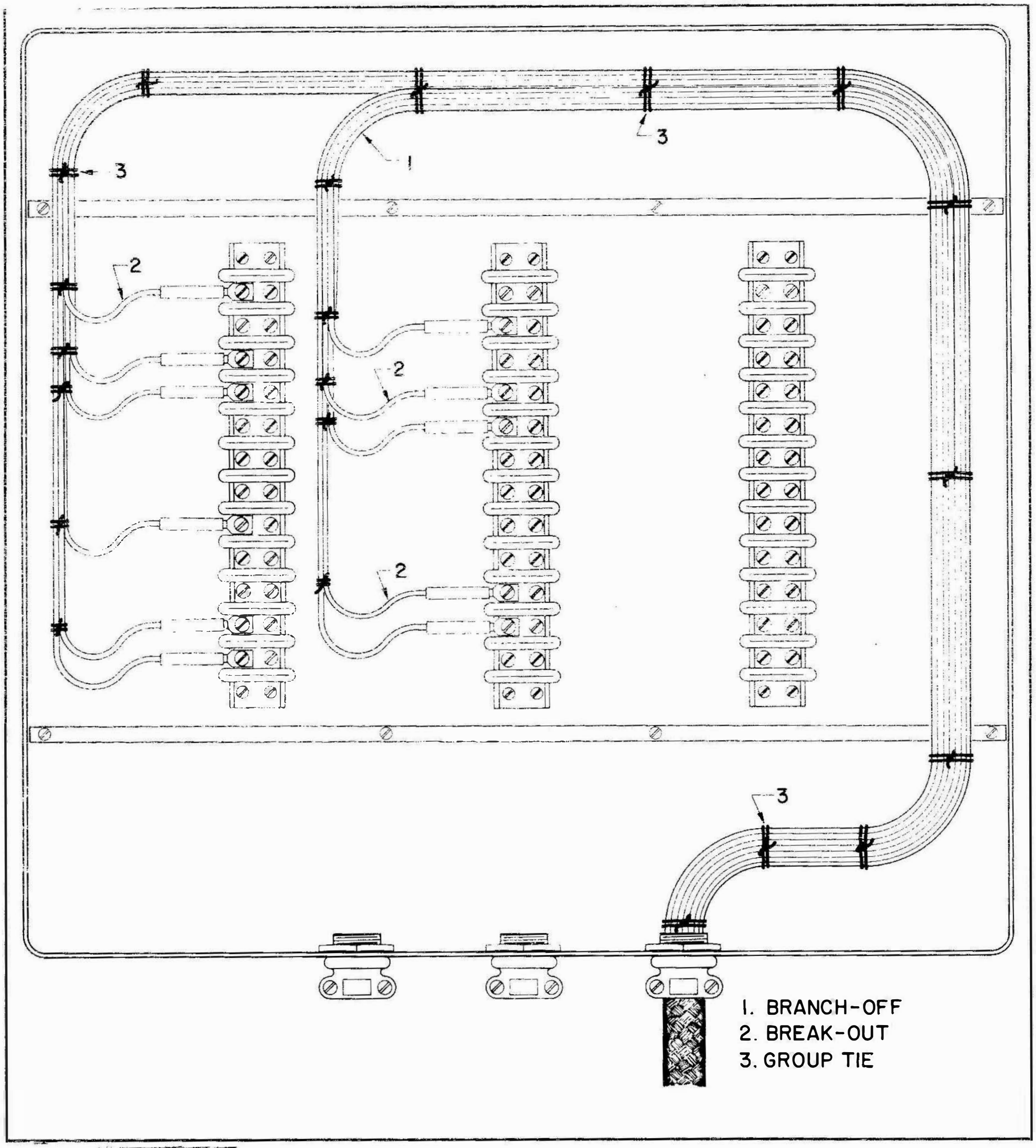



FIGURE 18–2 Group Routing, Forming and Tying

**4-19. PROTECTION OF WIRE FORMS.**–This sub-section describes the methods for protecting wires, wire groups and forms when installed within electronics equipment units or junction boxes.

a. PROTECTIVE TAPE.–The form shall be wrapped with protective tape at all points of possible abrasion. This includes sections of the frame, screws, protrusions or sharp edges. The wrapping should be sufficient to protect the form but should not be excessive so as to make the form bulky. It should also be confined to the area requiring protection.

b. SLEEVING SIZE.–If sleeving is used for wire protection, the correct size must be used for the particular conductor or wire being sleeved. Select a sleeving size with an inside diameter slightly larger than the wire on which the sleeving is to be installed. The standard AWG sleeving sizes are listed in Table 19–1.

c. BARE CONDUCTORS.–All bare conductors such as ground wires and shielded conductors with unprotected shield must be sleeved.

d. HFA WIRES.–Sleeve DHFA, THFA, AND FHFA wires when the voltage is above 125 volts and whenever the the wire insulation is damaged.

e. SLEEVING.–In cases where wires are to be sleeved from the point of cable entry to the termination end proceed as follows:

STEP 1.–Select and cut to length sleeving of the proper size to fit the wire (see table 19–1).

STEP 2.–Apply a coating of insulating varnish (MIL–1137) to the wires at the crotch of the cable.

STEP 3.–Install the sleeving immediately after varnishing the cable crotch. Push the sleeving ends into the cable crotch and under the cable jacket.

STEP 4.–Serve the termination end of the sleeving with treated glass cord (MIL–I–3158), colored for phase identification if the circuit carries AC (single phase wires do not require phase identification). The finished sleeving installation for cables entering through stuffing tubes or box connectors is illustrated in figure 19–1a. Figure 19–1b illustrates sleeving installation on a cable terminating in open equipment. The sleeving is installed as in steps 1 through 4 above before the cable jacket taper is taped and served.

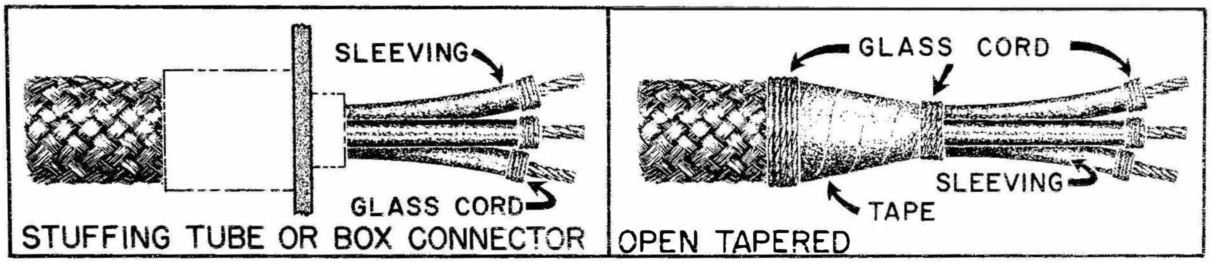



**FIGURE 19–1 Wire Sleeving Installation**

f. MOVEABLE WIRE PROTECTION.–Wires and wire groups connected to moving parts such as equipment doors or draw–out chassis, should be protected with sleeving where the wires are subject to abrasion. This protection is illustrated in figures 19–2a and b.

g. PROTECTION FROM OIL.–Cables of the reduced diameter types, such as SGA and MSCA, require additional protection of the wires in locations where the possibility of exposure to oil exists. The wires shall be protected by one of the following methods:

(1) ACRYLIC RESIN SPRAY.–The wires may be sprayed with a plastic sealer compound (MIL–I–12599). Separate the individual wires in order to completely cover the wire insulation with the compound.

(2) FLEXIBLE SLEEVING.–The wire groups may be protected from oil contact by the use of flexible plastic tubing (MIL–I–631). Plastic zipper type tubing such as ALPHLEX or equivalent may be installed after the wires have been connected. The seam is permanently sealed by application of a sealing compound on the zipper tracks before closing the tubing. Secure the ends of the tubing with insulating tape (MIL–I–3825). The use of zipper tubing is illustrated in figure 19–3.

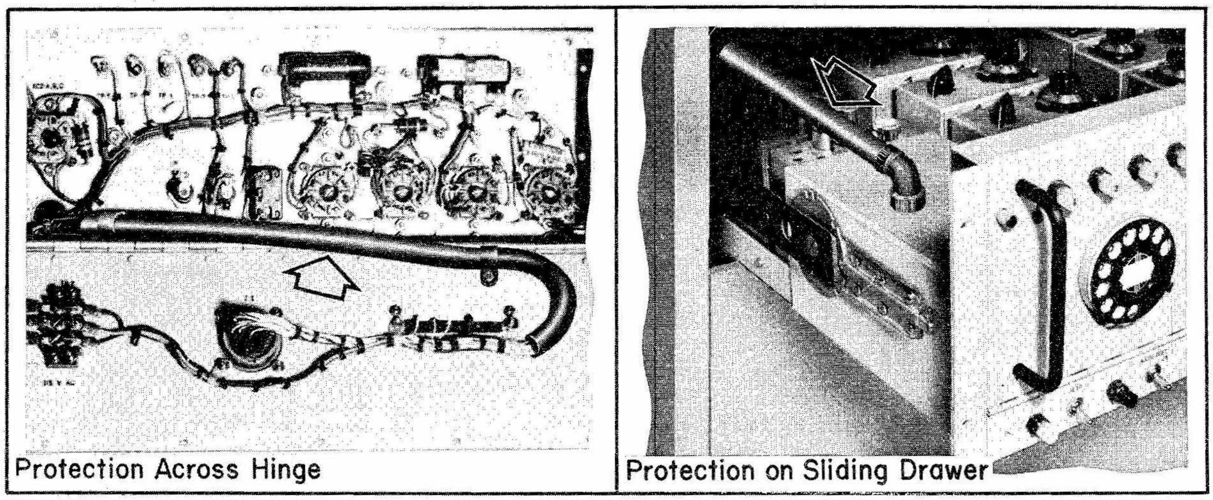



**FIGURE 19-2** Moveable Wire Protection.

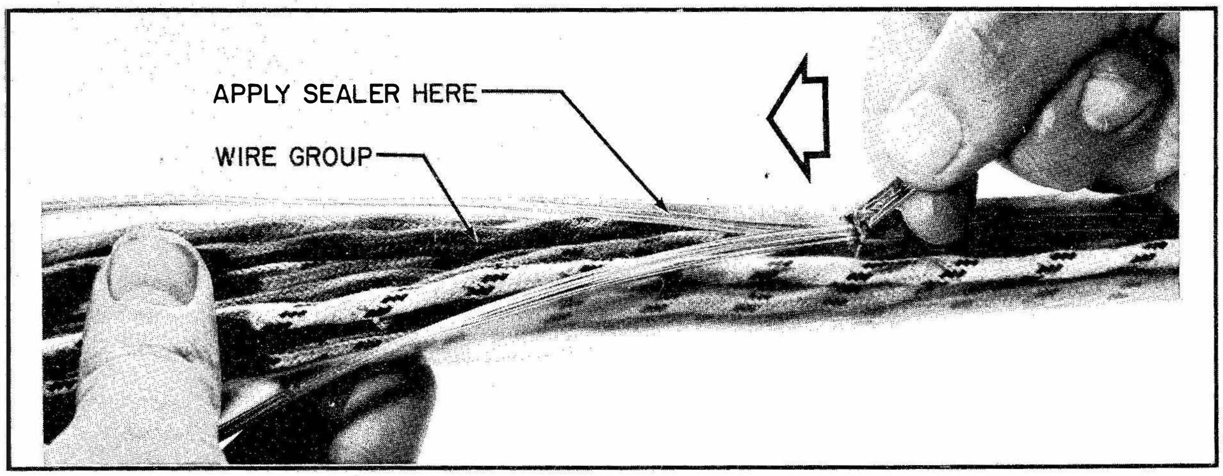



FIGURE 19-3 Installation of Zipper Tubing.

TABLE 19-1. SLEEVING SIZES.

| AWG # | INSIDE DIAMETER | AWG # | INSIDE DIAMETER |
|---|---|---|---|
| 20 | 0.032 | 3 | 0.229 |
| 19 | 0.036 | 2 | 0.258 |
| 18 | 0.040 | 1 | 0.289 |
| 17 | 0.045 | 0 | 0.325 |
| 16 | 0.051 | 5/16 | 0.313 |
| 15 | 0.057 | 3/8 | 0.375 |
| 14 | 0.064 | 7/16 | 0.438 |
| 13 | 0.072 | 1/2 | 0.500 |
| 12 | 0.081 | 5/8 | 0.625 |
| 11 | 0.091 | 3/4 | 0.750 |
| 10 | 0.102 | 7/8 | 0.875 |
| 9 | 0.114 | 1 | 1.000 |
| 8 | 0.129 | 1-1/4 | 1.250 |
| 7 | 0.144 | 1-1/2 | 1.500 |
| 6 | 0.162 | 1-3/4 | 1.750 |
| 5 | 0.182 | 2 | 2.000 |
| 4 | 0.204 | | |

## 4-20 WIRE STRIPPING*

a. **GENERAL** - In preparation of wires for terminations and connections, the removal of insulation without damage to the conductor is of prime importance. It has been established by experience that the only practical way of preventing damage to conductors when removing insulation from wires is by using tools especially designed for this purpose. A variety of wire stripping tools are available through normal supply channels and commercial sources. Except for the Hot Blade type illustrated in figure 28-1, stripping tools are of mechanical design. The cutters are adjustable in some types of mechanical strippers and in others they have a fixed setting. Proper usage of either type of stripper will insure an insulation cut of uniform depth, without contact between cutter and conductor, but deep enough for easy removal of the insulation. It is not the purpose or intent of this publication to attempt a listing or description of the many strippers which are available, only three of the most commonly used will be described herein.

b. **JONES CABLE STRIPPER** - The Jones Cable Stripper illustrated in Figure 20- 1, consists of a forged steel frame, clamping lever and an adjustable hinged cutting mechanism. This tool is capable of cutting woven armor, lead sheathing, and insulation of various types. The cutting mechanism consists of a blade and indexing head. The tool may be adjusted to the diameter of the wire involved, and to the depth of the cut desired. It may be adjusted to use either edge of the double edged cutting blade. The cutting blade and indexing head are replaceable. Operation of the Jones Stripper is as follows:

(1) Withdraw the cutting clade (4) completely by means of blade depth adjustment (5).

(2) Depress clamping lever (1) and fit cable into saddle (3). By means of the cable size adjusting screw (2), adjust the tool so that it moves easily along the wire with the cutting blade barely touching the insulation. Lift the clamping lever and remove the tool from the wire.

(3) Adjust the cutting blade to a depth just under the thickness of the insulation.

(4) To make a longitudinal cut along the cable, adjust the blade so that it is positioned parallel to the "V" of the saddle. The position of the blade is changed by depressing and turning the knob (6). Secure the tool over the wire by depressing the clamping lever, pulling the tool along the cable will then make a clean cut of desired depth. To make a circumferential cut, remove the tool and position the cutting blade at an angle of 90° to the wire. After ascertaining that the cutting blade depth adjustment is unchanged, clamp the tool on the wire at the point where the cut is desired. Rotate the tool around the wire. With the tool removed from the wire, the insulation may now be removed easily.

To remove the cutting blade for replacement, unscrew the depressing knob and allow the blade to drop out of the blade channel. Do not remove the blade depth adjusting screw (5) or the tension spring behind it. The cutting blade is aligned by unscrewing the recessed lock screw and turning the flat-headed eccentric pin.

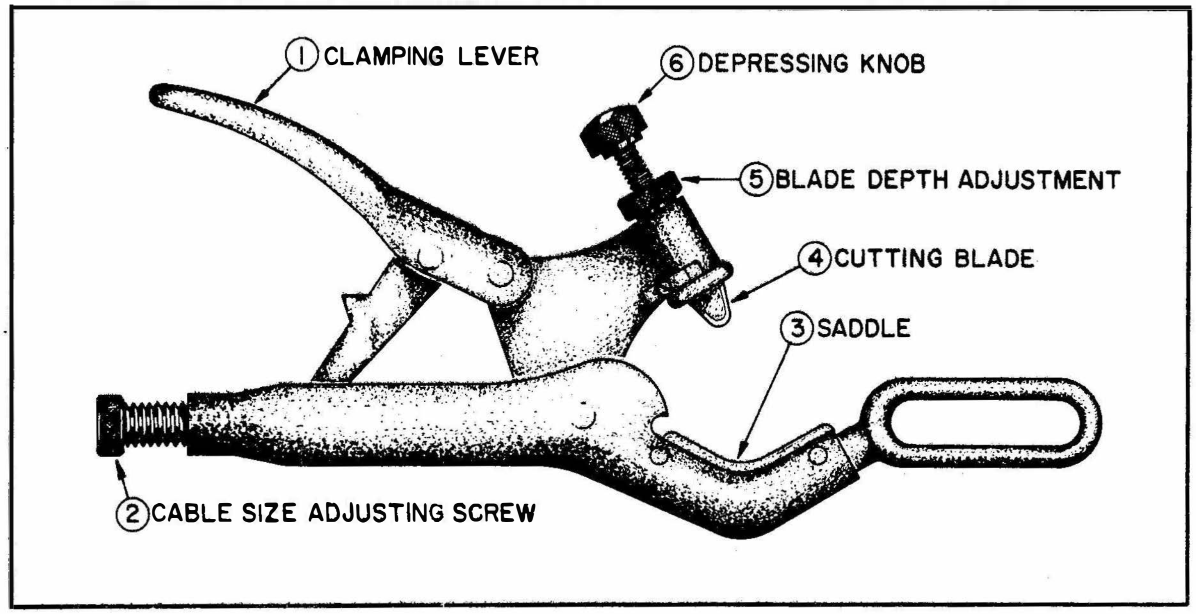



Figure 20-1. Jones Cable Stripper

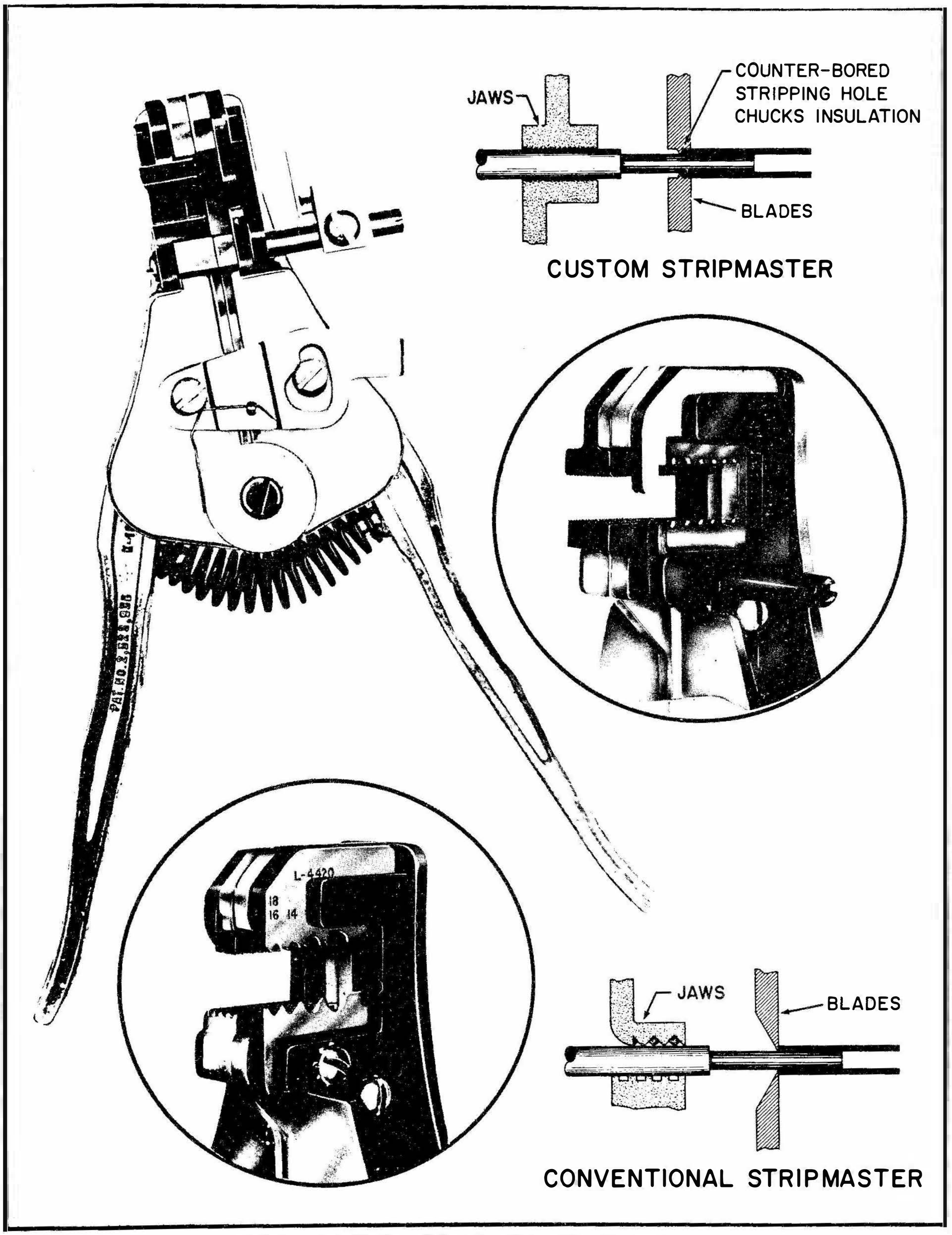



Figure 20-2. Ideal Wire Stripper

c. **IDEAL WIRE STRIPPERS** - The Ideal Custom Stripmaster is widely used in stripping wires from 10 to 30 gauge (see figure 20-2). Operation of the Stripmaster is simple; the wire is inserted between the jaws and held in the bottom half of the correct size stripping hole, squeezing the handle cuts and strips the insulation. The concentric hole stripping blades and knurled jaws make teflon and similar insulations easy to strip. The counter-bored stripping hole chucks the insulation, thereby preventing nicking and scraping the conductor. Optional features of the Custom Stripmaster are the Short-Stop latch and the transparent Wire Stop. The Short-Stop latch protects wire strands by limiting the stripping stroke to approximately 5/32 of an inch. The latch disengages without removal to allow a full 7/8 of an inch stripping stroke. The Transparent Wire Stop adjusts to desired stripping length. To cover the range of 10 to 30 gauge wire, three sets of cutting blades are required. These sets are easily removed or installed in the stripper.

Ideal strippers are also available with jaws and stripping blades for stripping rubber and similar insulations, however, this type is not recommended for stripping Polytetrafluoroethylene (teflon) insulation.

d. **HUFF CABLE STRIPPER** - The Huff Cable Stripper (see figure 20-3) consists of a tubular body with adjustable, hinged flaps to accommodate cables and wires of various diameters. A hood shaped arm is provided for a good grip. The cutter has an indexed head for setting the blade to the depth of cut desired, and a locking screw to retain the setting. In using this stripping tool; the blade is set for the depth of cut desired, the wire placed in the tubular body and the flaps closed. By squeezing the body and moving the tool along the wire a longitudinal cut is made in the wire insulation.

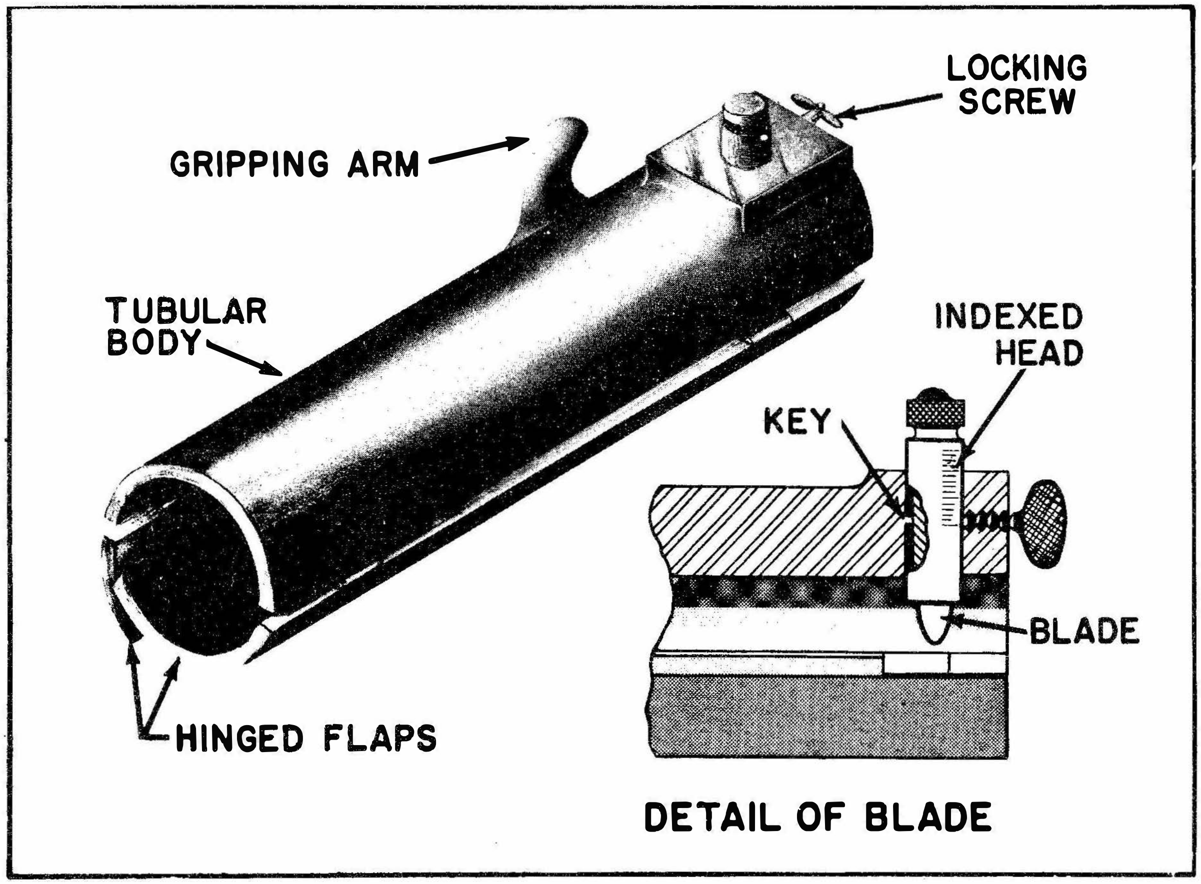



Figure 20-3. Huff Cable Stripper

**4–21. LACING AND TYING WIRE FORMS.**–This sub–section describes and illustrates the recommended methods for lacing and tying wires, wire groups and forms to provide a neat, efficient and serviceable installation of interconnection cables.

a. GENERAL PROCEDURES.–The following general procedures must be observed:

(1) WIRE FORMING.–Bends must be made before lacing. If an attempt is made to bend a group after lacing, the wires on the inner radius of the bend will kink and the bend will not retain the desired shape. Wires in a group must be kept straight and parallel with each other, except twisted pairs. Twisted pairs should retain their original twist but the pairs should run parallel to each other.

(2) TEMPORARY TIES.–Temporary ties may be used to hold the wires of a group together in the required shape. These ties should be made with colored cord for easy identification and are removed when the lacing is complete. Care must be taken not to cut or damage insulation, wires, or lacing, when removing temporary ties.

(3) WIRE LACING.- All lacing must be tight enough to hold the wires firmly together and prevent slipping of the stitches. It must not, however, be so tight as to damage or deform the insulation. Single or double cord lacing may be used. Single cord is used for groups of five–eighths inch or less in diameter. Double cord is used for groups over five–eighths inch in diameter. Lacing must be started at the thickest part of the group, at the point where the wires leave the cable jacket. Stitches must be evenly spaced and the running part of the stitch kept straight and parallel with the wires of the group. The stitch spacing on groups five–eighths inch or smaller in diameter shall be one–half to three–fourths inch. Stitch spacing on groups larger than five–eighths inch in diameter shall be one–half to one inch.

(4) SPARE WIRES.–Spares must be laced separately, folded back and tied to the group. They should be of sufficient length to reach the furthermost terminal served by the group to which they belong.

(5) GROUP TYING.–Where two or more groups run parallel they should be tied together at intervals with a telephone hitch and a square knot, and all knots must be secured with GE7031 Glyptal or equivalent (see figure 21–1).

(6) BRANCH–OFF AND BREAK–OUT.–Where a branch–off occurs the lacing should be continued on the main group and the lacing of the branch–off is to be completed separately. The spacing of the stitches at break–outs must conform with the spacing of the terminals to which the wires will be connected.

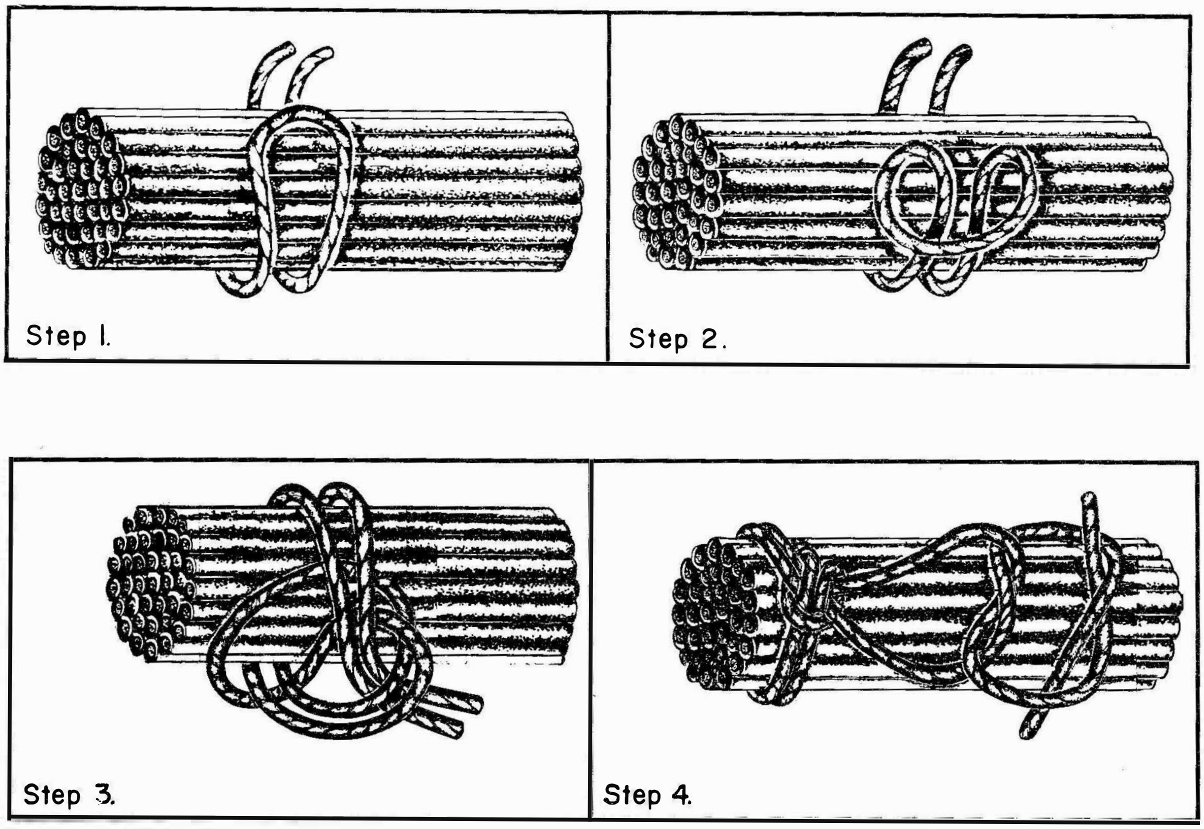



FIGURE 21-1 Telephone Hitch

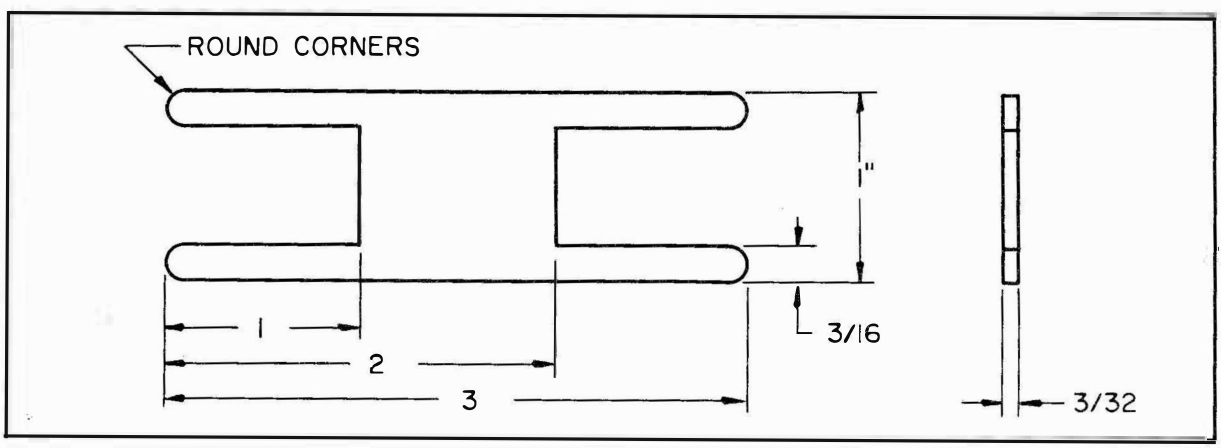



FIGURE 21-2 Lacing Shuttle

b. LACING SHUTTLE.—To assist in handling long lengths of lacing cord a shuttle may be used. A suggested shape for the shuttle is given in figure 21—2. It should be made of a non—ferrous material such as brass,aluminum or plastic. The required length of cord is wound on the shuttle and after the starting knot is tied the shuttle can be passed through the stitches thus avoiding the pulling of long lengths of cord through each stitch. When double cord is used the required length is spooled off and doubled. Start the two loose ends onto the shuttle first so as to leave the loop for the starting end.

c. SINGLE CORD LACING.—To lace with a single cord proceed as follows:

STEP 1.—Wrap the cord around the group to form a clove hitch, slide it into position and pull tight.

STEP 2.—Complete the knot with a square knot or extra loop.

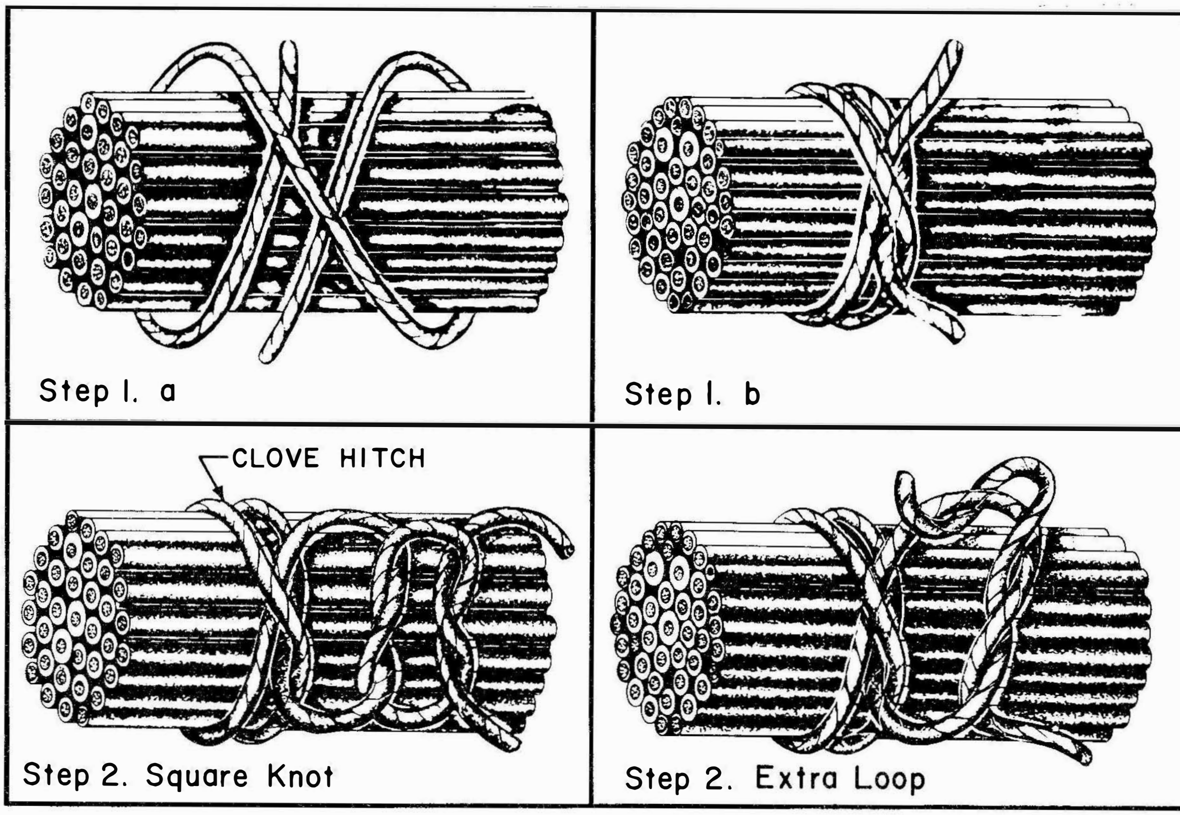



FIGURE 21-3 Clove Hitch

STEP 3.— Cut off surplus cord from the short end to about 3/8 inch of the knot.

STEP 4.—Pass the cord around the group and bring the end over and under to form a lock stitch.

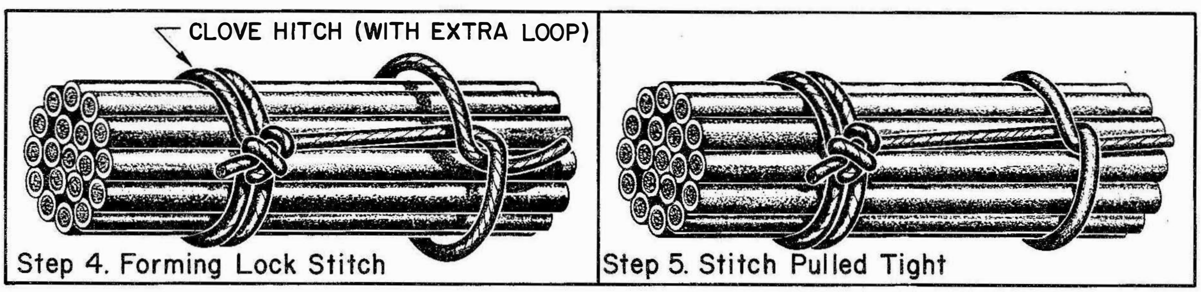
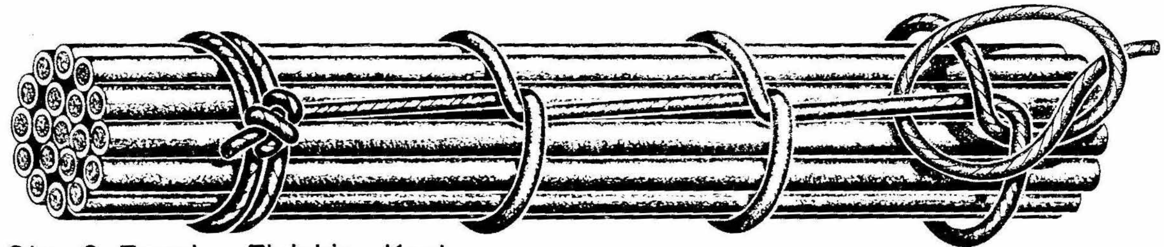



FIGURE 21-4 Single Cord Lacing

STEP 5.—Adjust the stitch to the required position and pull tight. Repeat steps 4 and 5 for each subsequent stitch.

STEP 6. – When the last stitch is formed and before it is pulled tight, pass the end of the cord behind the running part of the stitch and back through the loop thus formed.



Step 6. Forming Finishing Knot

**FIGURE 21-5 Single Cord Lacing**

STEP 7.–Pull the lock stitch tight and complete the finishing knot by pulling on the end of the cord. Secure the knot with Glyptal.

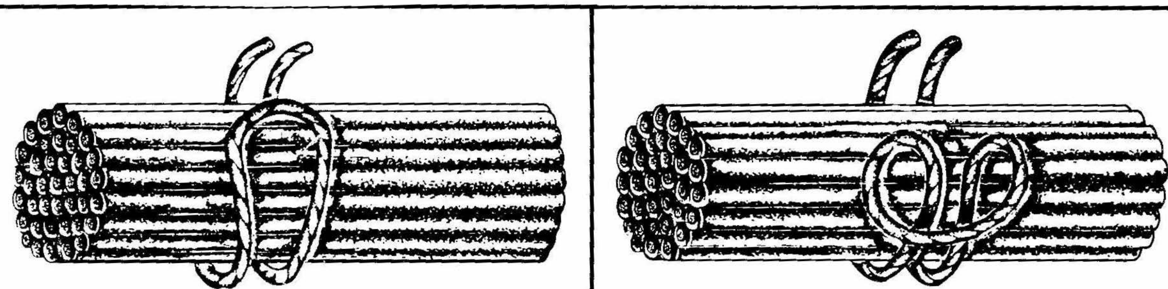
**NOTE**

A much more durable but time consuming lockstitch may be made by using the finishing stitch and knot (as shown in figure 21–5) at each stitch location. This will provide securely fastened lock stitches which will not loosen or slip. This procedure may also be used with double cord lacing.

d. DOUBLE CORD LACING.–To lace with double cord proceed as follows:

STEP 1.–Pass the doubled end of the cord around the group to be laced.

STEP 2.–Turn the loop back to form two loops.

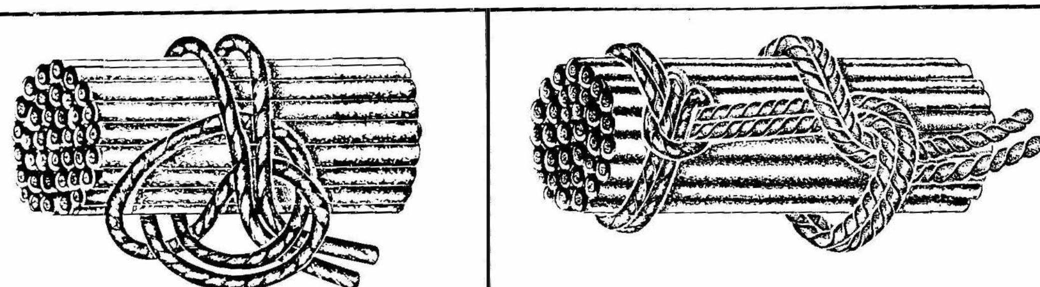


Step I. | Step 2.

**FIGURE 21–6 Start of Double Cord Lacing**

STEP 3.–Pass free ends through the loops and pull tight.

STEP 4.–Pass the free ends around the group and over and under to form a lock stitch. Pull lock stitch tight. Repeat step 4 for each subsequent lock stitch.



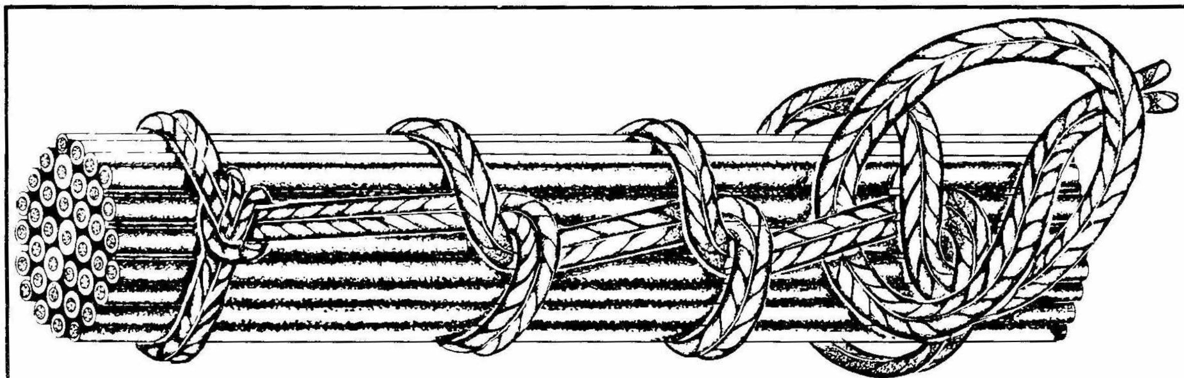
Step 3. Starting Knot. | Step 4. Starting Knot Tightened and First Lockstitch Formed.

**FIGURE 21–7 Double Cord Lacing**

STEP 5.–When the last stitch is formed and before it is pulled tight, pass the ends of the lace behind the running part of the stitch and back through the loop thus formed.

STEP 6.–Pull the lock stitch tight and pull the ends of the cord. Separate the two ends and tie a square knot.

STEP 7.–Cut off the surplus cord 3/8 inch from the knot, and secure the knot with Glyptal.



Step 5. Forming Finishing Knot

**FIGURE 21–8 Double Cord Lacing (Finishing)**

e. BRANCH–OFF LACING.–Where a branch–off is to be laced the starting knot must be made on the group at a point as close as possible to the branch–off. The type of starting know used depends on whether single or double lacing is used. In either case lacing is continued along the branch–off in exactly the same manner as shown for single or double cord lacing of a group.

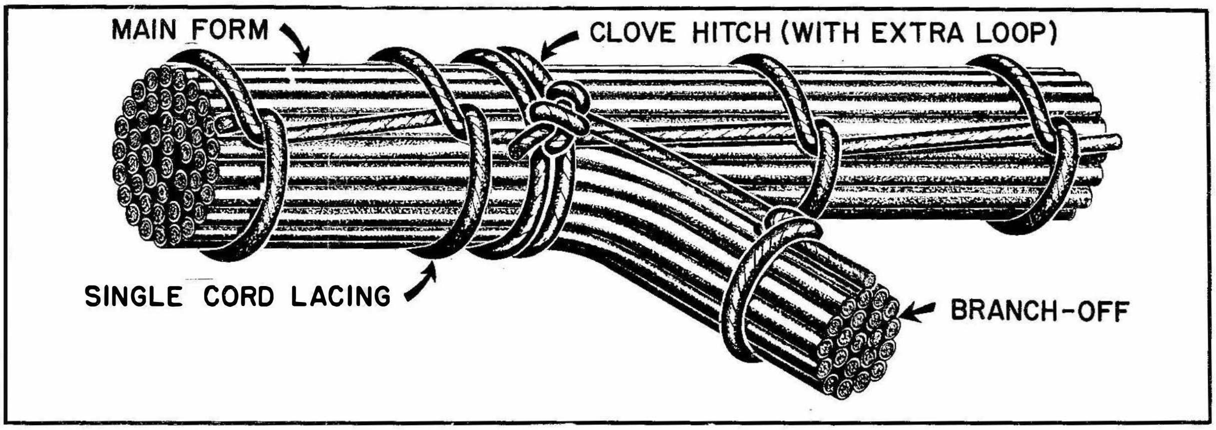



**FIGURE 21–9 Branch–off Lacing**

f. BREAK–OUT LACING.–The lacing of a group or branch–off where break–outs occur should be arranged so that a lock stitch is placed immediately before the break–out. Each break–out must be supported by a lock stitch.

g. MULTIPLE GROUP TYING.–Where two or more groups run together they must be tied into forms. Ties should be made as frequent as necessary to hold the groups together in a compact form, but should not be more than 12 inches apart. These ties may be either the telephone hitch or the clove hitch as illustrated in figures 21–1 and 21–3.

h. SPLICING OF LACING CORD.–Splicing of lacing cord should be avoided if possible but where a splice must be made the following technique should be used. Make the splice at a point where the knot will not interfere with the lock stitch. Pull the splice very tight before trimming the loose ends.

(1) SINGLE.–To make a splice in single cord proceed as follows:

STEP 1.–Make a half hitch in the old length of cord.

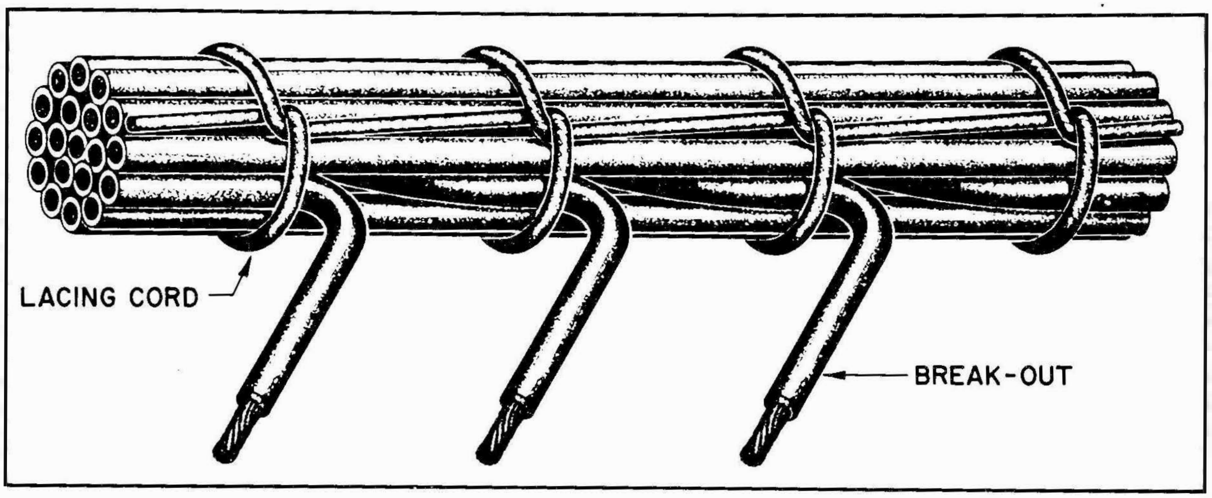



FIGURE 21-10 Break-out Lacing

STEP 2.–Pass the end of the new length of cord through the half hitch of step 1 and make a half hitch around the old length of cord.

STEP 3.–Pull tight and trim loose ends to 3/8 inch of the knot.

(2) DOUBLE.–To splice double cord proceed as follows:

STEP 1.–Wrap the ends of the old length of cord and the loop end of the new length of cord around each other.

STEP 2.–Pass the ends of the old length through the loop of the new length.

STEP 3.–Hold the ends of the old length and pull on the new length until the knot is tight.

STEP 4.–Trim the loose ends to 3/8 inch of the knot.

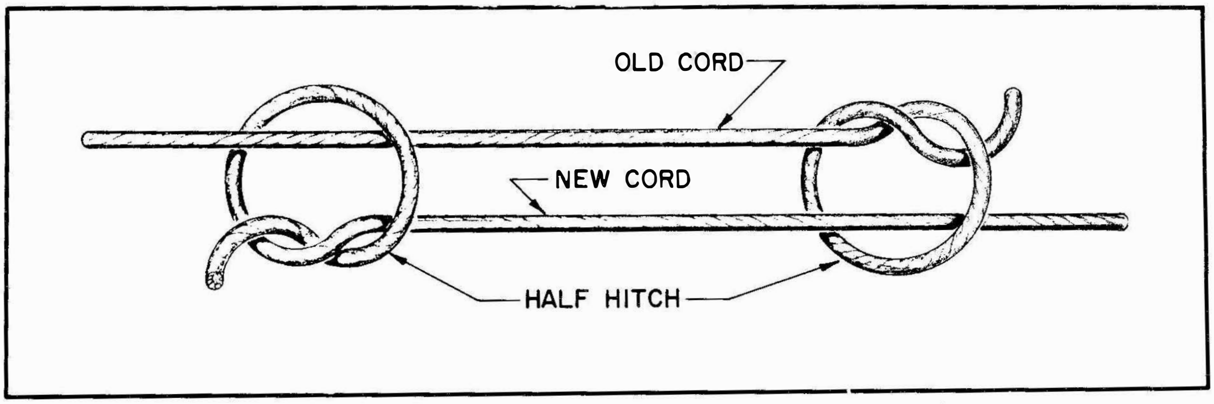



FIGURE 21-11 Splicing Single Cord

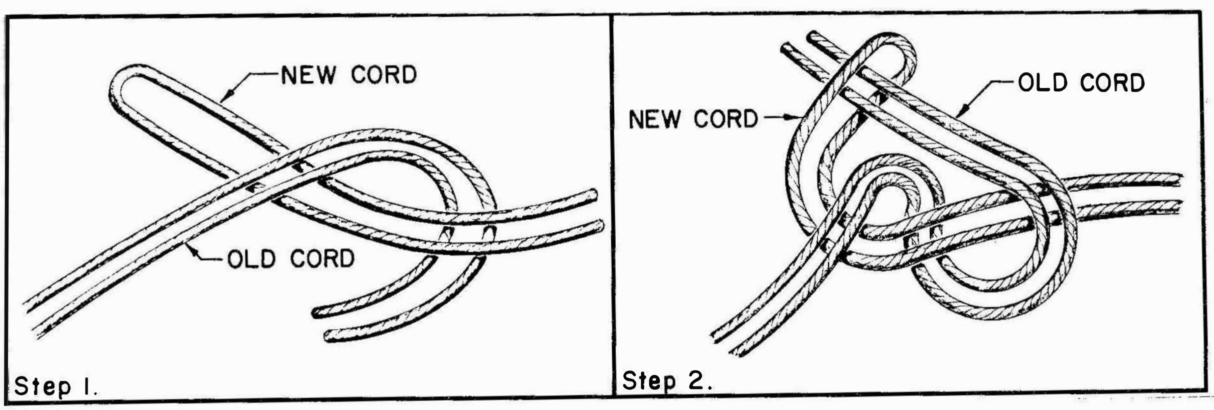



FIGURE 21-12 Splicing Double Cord

i. COMPLETE LACED INSTALLATION.–Figure 21–13 shows a typical example of a wiring form correctly laced.

j. WIRE TYING.–In many cases, wire forms may be secured by the use of cord ties in sufficient number to properly hold and support the wire form. The ties are not required to be evenly spaced and are used only where necessary for securing the wires. This method is much faster than lacing and if used judiciously will produce a satisfactory wire form. The general procedures used in lacing also apply for this method. The telephone hitch illustrated in figure 21–1 or the clove hitch illustrated in figure 21–3 may be used for group ties.

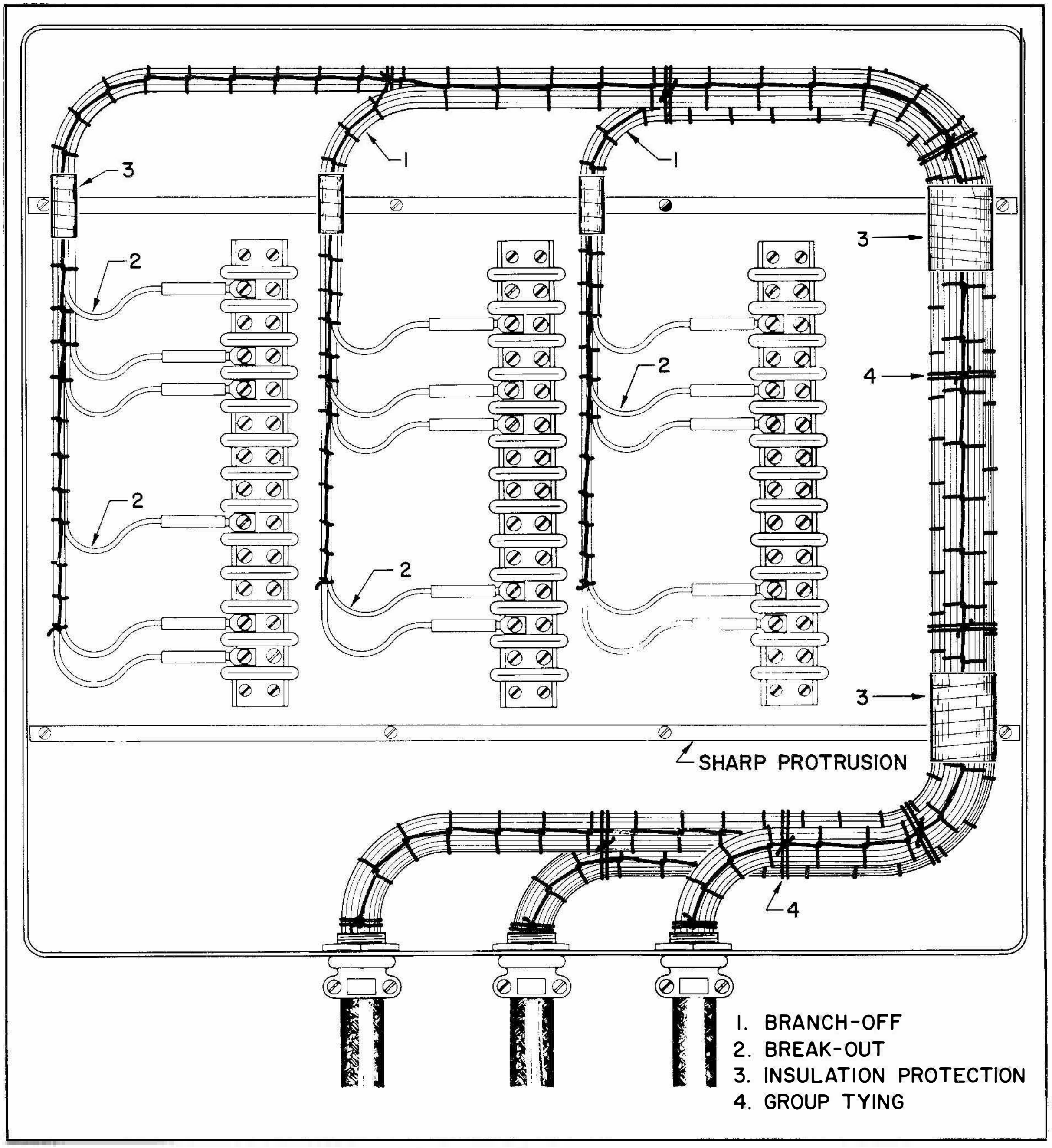



FIGURE 21–13 Laced Form

(1) BRANCH-OFF TYING.-Where a branch-off leaves the form a tie will be placed around the form immediately before the branch-off.

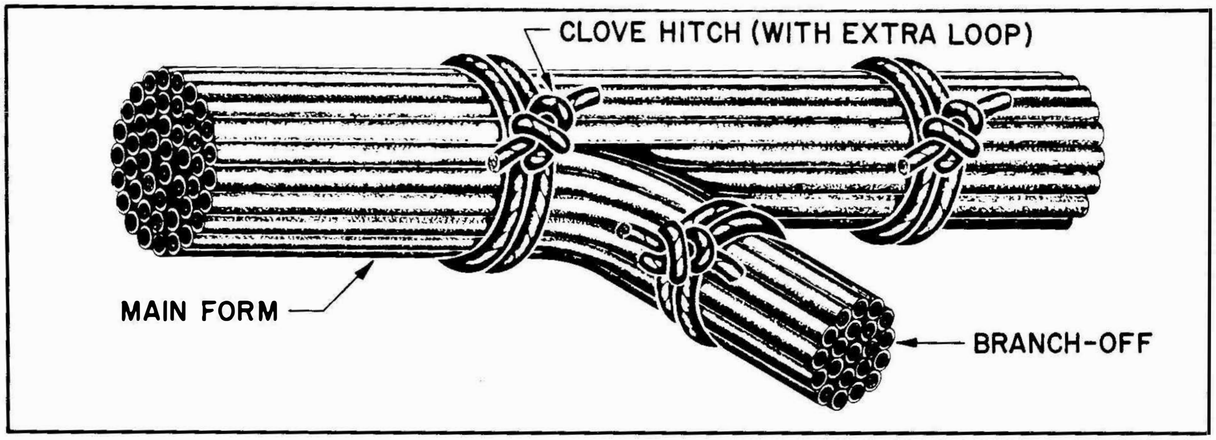



FIGURE 21-14 Branch-off Tying

(2) BREAK-OUT TYING.-A tie will be placed immediately before each break-out.

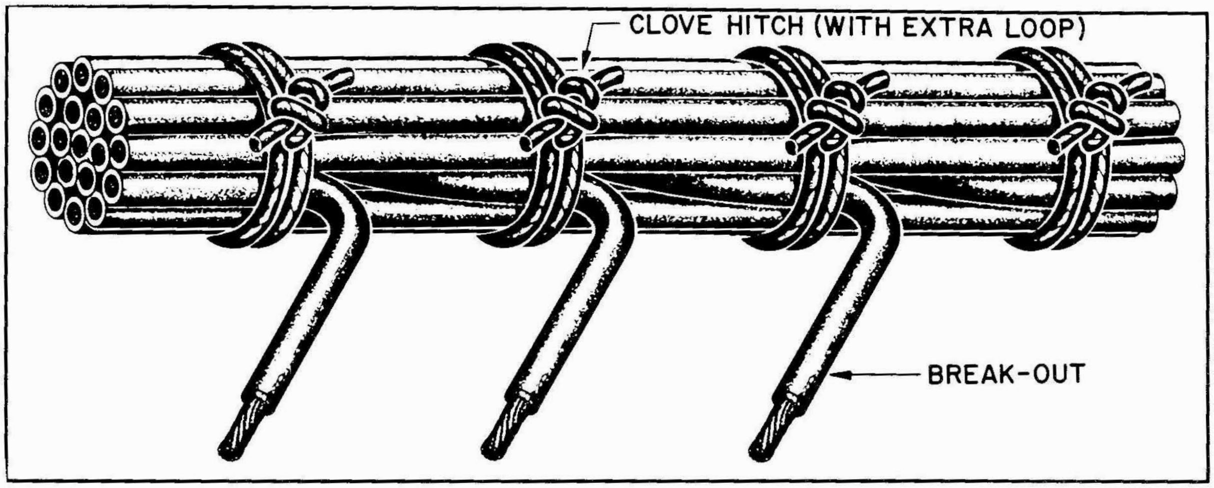



FIGURE 21-15 Break-out Tying

(3) COMPLETED TIED FORM.-The completely tied form including the tying of separate groups into the form, branch-off tying and break-out tying is illustrated in figure 21-16.

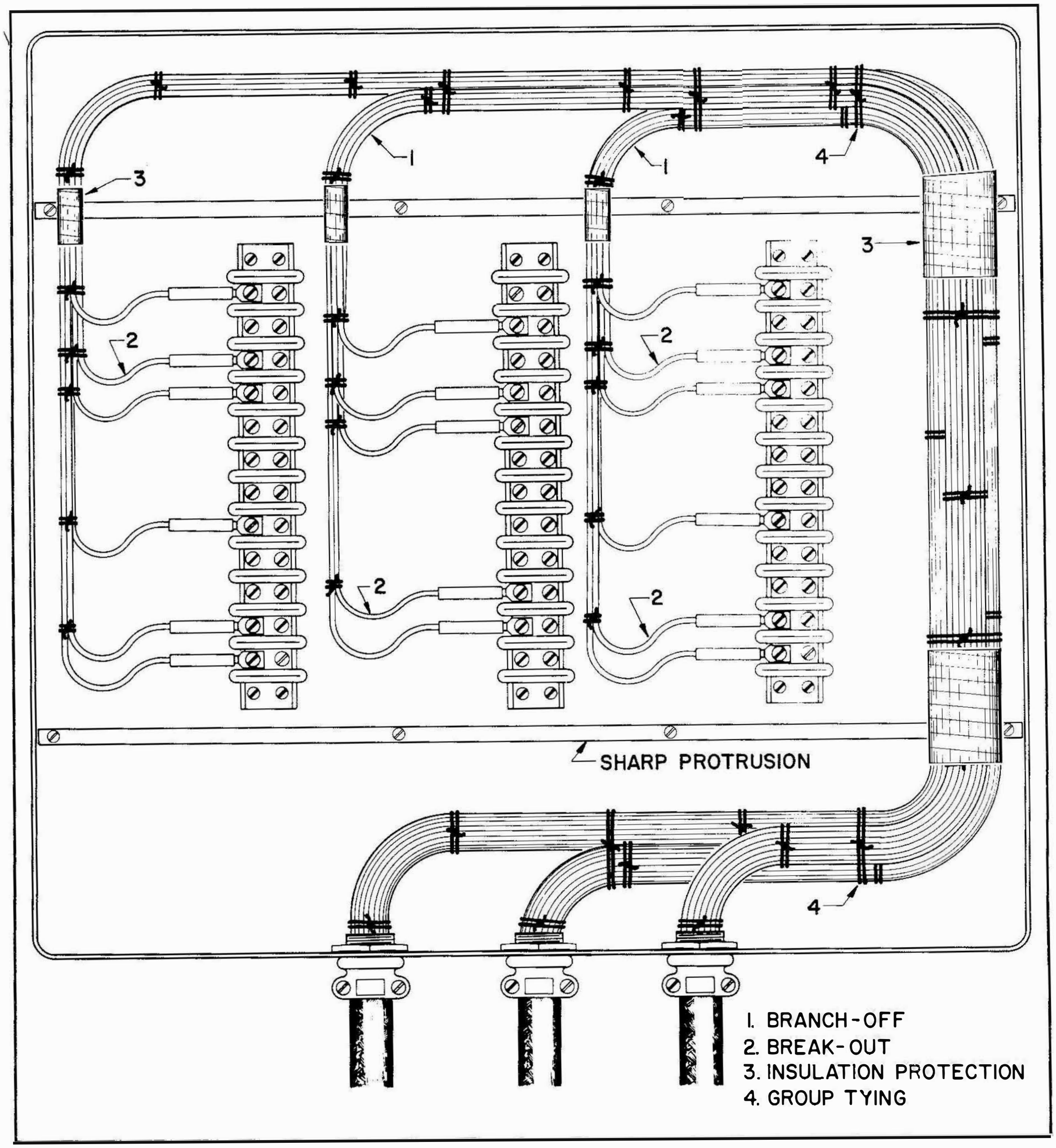



FIGURE 21-16 Tied Form

## 4-22 WIRE CLAMPS*

**a. GENERAL** - The clamps described below are intended for use in making wire or cable entrances into electrical and electronic enclosures below the degree of watertight.

**b. REQUIREMENTS** - The requirements for wire or cable clamps are as follows:

(1) **MATERIAL** - The clamp shall be made of malleable iron or sheet steel. It shall be sufficiently strong to adequately hold the cable or conduit with which it is used so that it will withstand a steady pull of 100 pounds for 5 minutes.

(2) **CABLE FIT** - Clamps shall be designed for use on wires and cables conforming to Specifications MIL-C-915 and MIL-C-2194. The clamps shall cover a cable range as shown in table 22-1.

### TABLE 22-1 - CABLE RANGE

| Navy size designation | Nominal trade size | Cable range covered | |
|---|---|---|---|
| | | Minimum | Maximum |
| A-C | 3/8 | 1/4 inch | 5/8 inch |
| CD | 3/4 | 7/16 inch | 3/4 inch |
| D-J | 1 | 9/16 inch | 1-1/16 inches |

### NOTE

Cable range covered refers to overall outer diameter of cable.

(3) **SHAKEPROOFNESS** - The clamps shall be so designed that after being initially tightened they will not become loose under constant strain, vibration, or such changes in temperatures as may be encountered in service.

(4) **THREADS** - Screw threads shall be in accordance with Handbook H28.

Clamping screws shall be fillisterhead not less than the following sizes with the maximum number of threads per inch for the sizes given:

| Nominal size | |
|---|---|
| 3/8-inch connector | Number 8/32 screw |
| 3/4-inch connector | Number 10/32 screw |
| 1-inch connector | Number 10/32 screw |

Threaded lugs for clamping screws shall be of sufficient thickness to insure two full clean cut threads.

Wire clamps shall have at least five full, clean cut, American standard straight pipe threads on the throat with the end of the threaded portion rounded and smooth to prevent damage to the wires.

(5) **IDENTIFICATION MARKING** - Each cable clamp shall have molded or stamped on its surface the manufacturer's name or trademark and the Navy cable size for which it is designed (see table 22-1).

(6) **CABLE RECESS** - The depth of cable recess or socket inside the cable clamp, measured from armored cable stop to outer end, shall not be less than the following:

| Nominal size | Depth (inches) |
|---|---|
| 3/8 inch connectors | 13/16 |
| 3/4 inch connectors | 1 |
| 1-inch connectors | 1 |

Protective coatings of zinc on surfaces of sheet steel shall be of such thickness and uniformity as to withstand a minimum of 50 seconds application of the Hull-Strausser test (see MIL-C-17277A).

(7) **ELECTRICAL GROUNDING** - Clamps shall be so designed as to provide an effective electrical bond between the cable armor and the box or other fitting with which they may be used.

**c. CABLE CLAMP TYPES.**

(1) **TYPE I, TWO SCREW** - The clamps shall be complete with lockout (see figure 22-1). The clamps shall have an adjustable saddle clamp and be designed for shipboard cable having basket-weave metallic armor and nonmetallic impervious cable sheath. The saddle shall be 3/8 ± 1/32 inch wide and be provided with a flange which butts against the body of the clamp completely covering that portion of the throat not required for cable entrance. The lock nut shall be designed that it will exert a uniform pressure against the surface it contacts.

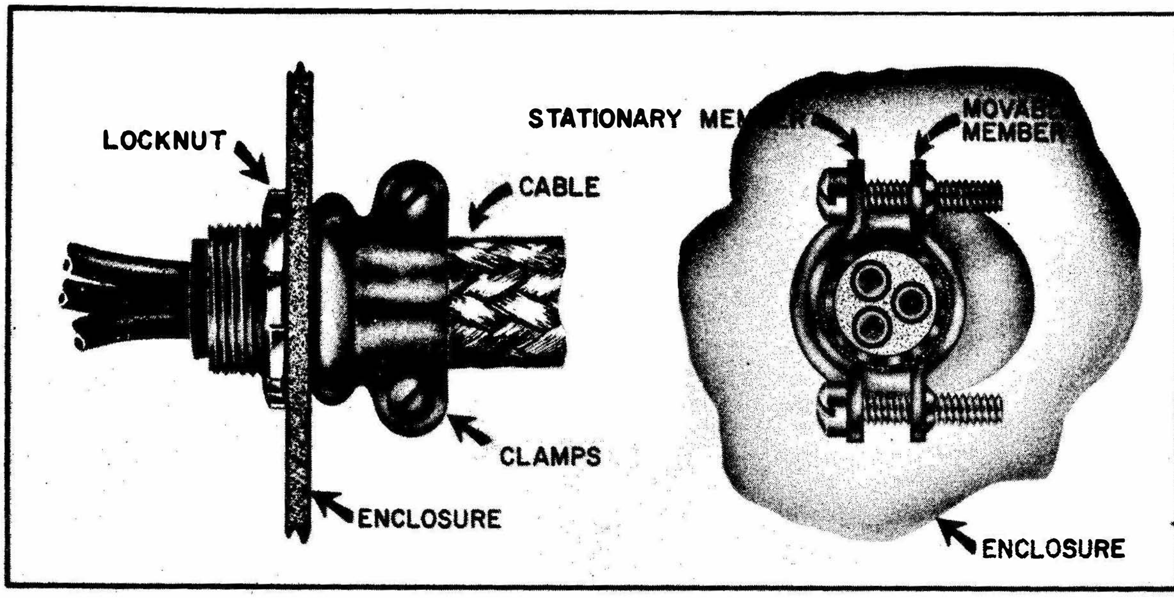



Figure 22-1. TYPE I WIRE CLAMP

(2) TYPE II, SINGLE SCREW, HINGED – The cable clamp shall be complete with locknut (see figure 22-2). The cable clamp shall have an adjustable saddle tightened by a single screw at one end. The other end shall be secured by means of a tongue extending through a slot in the stationary portion, forming a hinge action at that point. It shall be designed for use with shipboard cable with a basket weave metallic armor and nonmetallic impervious sheath. The saddle shall be 3/8 ± 1/32 inch wide and be provided with a flange which butts against the body of the cable clamp completely covering that portion of the throat not required for cable entrance. The lock nut shall be so designed that it will exert a uniform pressure against the surface it contacts.

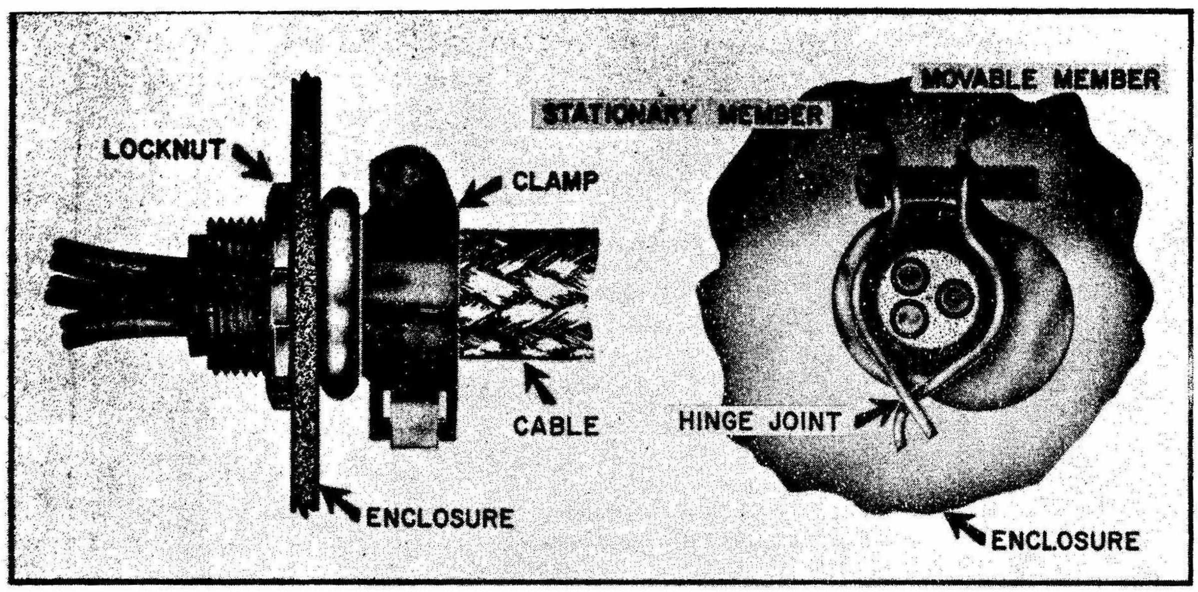



Figure 22-2. TYPE II WIRE CLAMP

d. **LOCK NUTS** - Locks nuts shall conform to the thickness shown in table 22-2.

**TABLE 22-2 - THICKNESS OF LOCK NUTS**

| Nominal size | Minimum thickness |
|---|---|
| 3/8 inch | 0.125 inch |
| 3/4 inch | 0.140 inch |
| 1 inch | 0.170 inch |

**4-23. NYLON BANDS AND SPIRAL WRAP.**—Several types of nylon bands are available for use in securing wires and wire groups in electronic equipment enclosures. A nylon "spiral wrap" is also available for the same purpose. The use of these materials for binding or securing wires and wire groups is much faster than tying or lacing with cord and provides a neat and well supported wire installation (figure 23-16, on page 4-23-11, illustrates a completed form using nylon bands.) The following precautions shall be observed when these materials are used:

a. BAND MATERIAL.—The bands or wraps shall be made of a material that is non-toxic, self extinguishing, and resistant to acids, alkalies and organic solvents.

b. BAND CONSTRUCTION.—The band shall not have any sharp edges which might cut the wire insulation. The locking eye of the band shall furnish a positive lock when the band is installed.

c. BAND TIGHTNESS.—The band shall be set-up tight enough to provide a rigid wire form but not so tight as to cut or deform the wire insulation.

d. DETAILED PROCEDURES.—The various types of banding, the tools required for installation, and the methods of installation are as follows:

(1) THOMAS AND BETTS TYRAP.—These bands are of a one piece nylon molded construction having a chordal cross section, two small raised longitudinal ribs and a rectangular eye at one end. In use, the convex ribbed side is applied toward the wire group, the free tapered end is threaded through the eye, tightened and locked. These bands will accommodate a wire group ranging in size from one sixteenth to one and three quarters inches in diameter.

(a) BAND TYPES.—The T & B bands are available in various colors and in the following four types:

1. TY-5.—TOOL APPLIED.—This band is equipped with locking recesses in the eye boss at right angles to the eye. When the band is installed and tightened, the free end is twisted until the locking recesses engage the band.

2. TY-25.—SELF LOCKING.—This band is identical to the TY-5 except for a metal locking clip built into the eye end. The band is tightened and the clip prevents the band from backing out of the eye.

3. TY-15.—CABLE STRAP.—This band is identical to the TY-5 except for the addition of a mounting bolt hole in the band above the locking eye. This allows the band to be used for a wire group tie and also as a clamp to secure the wire group to the equipment.

4. TY-35.—CABLE STRAP.—This is identical to the TY-15 except for incorporation of the metal locking clip as used in the TY-25.

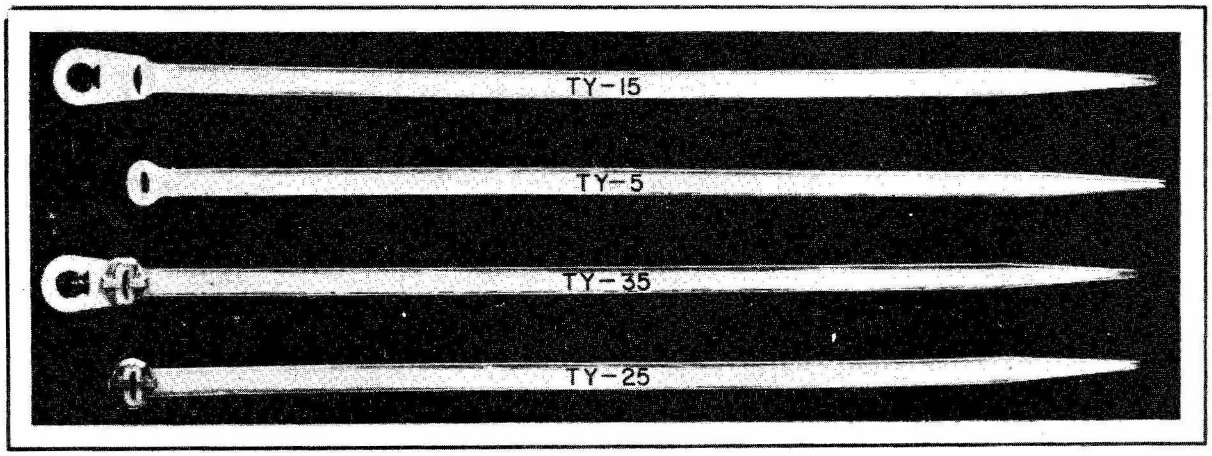



**FIGURE 23-1 TY-RAP Band Types.**

(b) INSTALLATION TOOLS.—Two special types of tools are available for use in installation of the TY-RAP.

1. TOOL TYPE WT183.—This is a plier type of tool equipped with a band positioning plate, a spring loaded snubber and a cut-off blade.

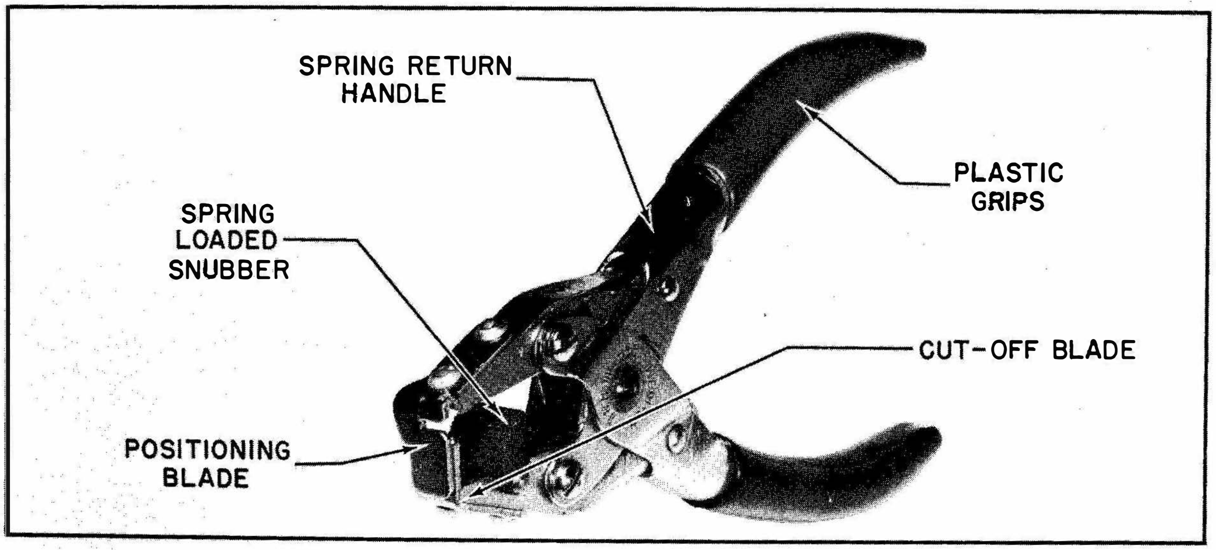



**FIGURE 23-2 Type WT183 Tool.**

2. TOOL TYPE WT184. –This is a "shoehorn" type of tool designed to slip between and under wire groups and used to aid installation of the bands in close quarters. The recessed channel guides the band around the wire group.

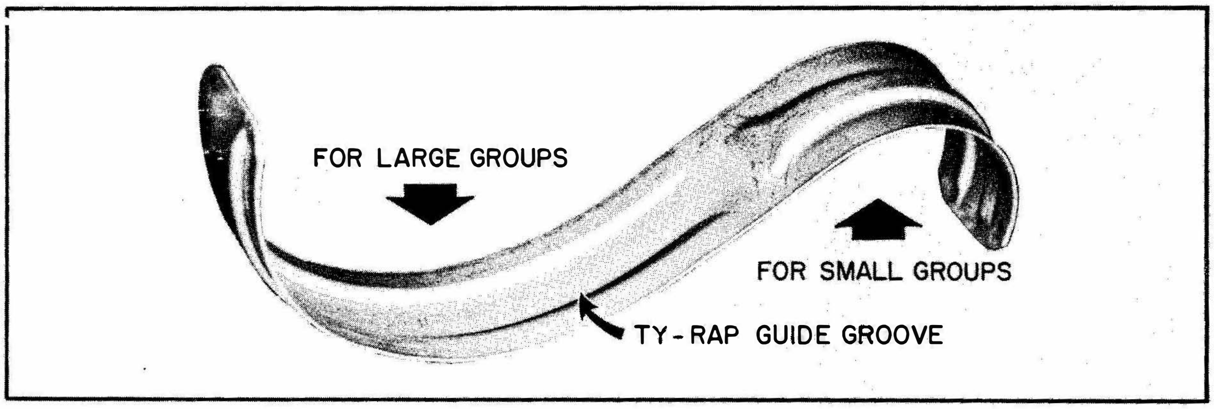



**FIGURE 23-3 Type WT184 Tool.**

(c) BAND INSTALLATION.–The bands can be installed with the type WT183 tool and may also be installed with ordinary long or short nose side cutting pliers.

1. TYPE WT183 TOOL. –Install bands with this tool as follows:

STEP 1. –Pass the band around the wire group with the ribbed side next to the group. Thread the tip into the eye and draw-up snug.

STEP 2. –Pass the free end of the band through the slot in the positioning plate and up over the snubber tip.

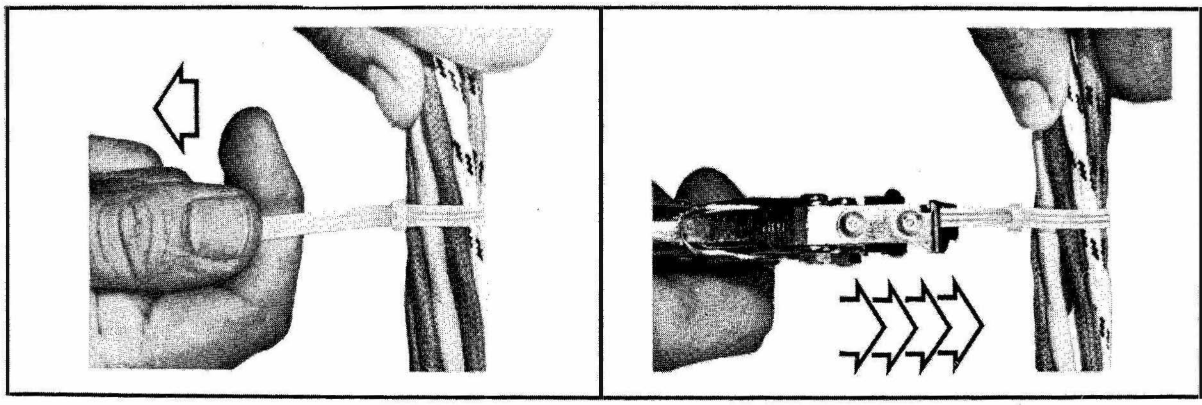


FIGURE 23-4 Band Positioning.

STEP 3.–With the positioning plate in contact with the band eye boss, tighten the band to the desired tension by gently pumping the tool handles.

STEP 4.–When the band is tightened to the desired tension, the tool is twisted in either direction, about 120 degrees, and then the tool handles are closed completely. This locks the band in the locking recess and severs the unused portion of the band.

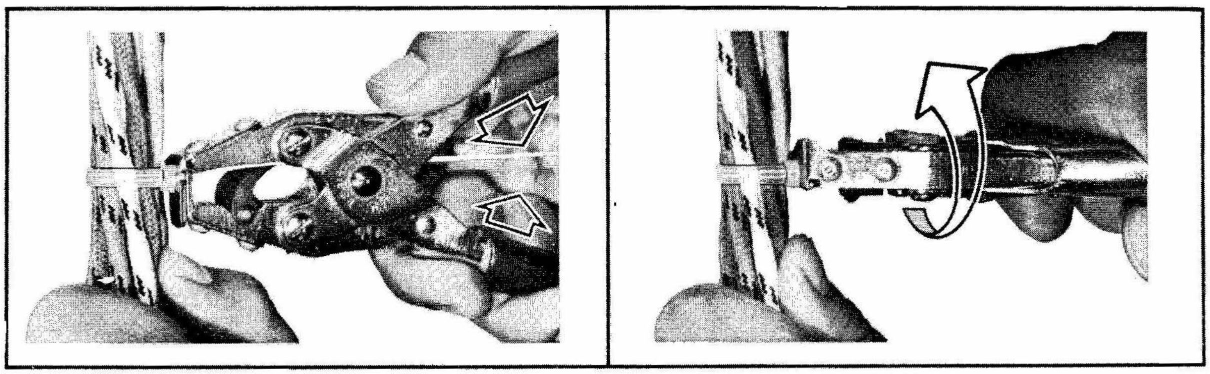


FIGURE 23-5 Band Locking and Trimming.

2. STANDARD PLIERS.–Install the bands with ordinary long or short nose side cutting pliers as follows:

STEP 1.–Pass the band around the wire group with the ribbed side next to the group. Thread the tip into the eye and draw-up snug.

STEP 2.–Pass the free end of the band through the loose flat jaws of the pliers and, with hand tension still on the free end, press the eye boss tightly against the wire group. Tighten the plier jaws and twist the band approximately 120 degrees in either direction until the band is locked in the locking recess. The unused portion of the band can be trimmed with the cutting jaws of the pliers.

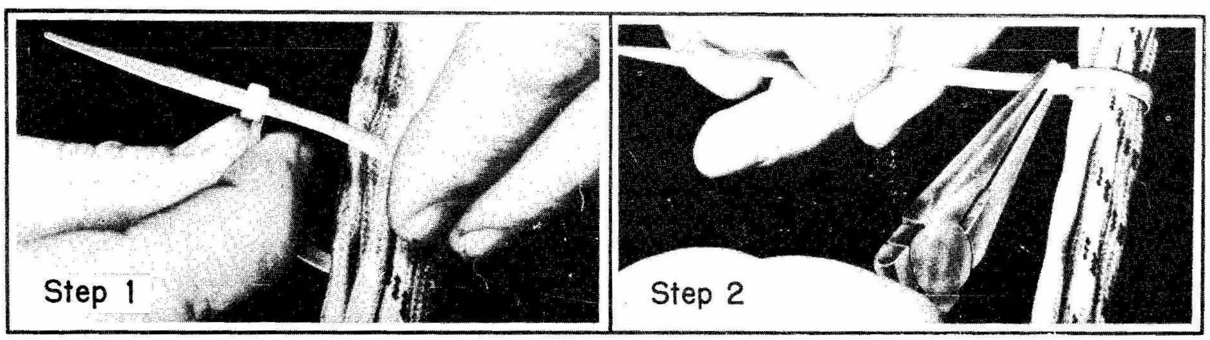



FIGURE 23-6 Plier Installation of Bands.

3. TYPE WT184 TOOL.—If this tool is available and difficulty is experienced in passing the band around the wire group, the procedure can be made easier by guiding the band around the group as shown in figure 23-7.

4. SELF LOCKING BANDS.—The self locking type of band is installed as in paragraph, 2.—but the twisting action is not required. The metal clip automatically locks the band as it is tightened.

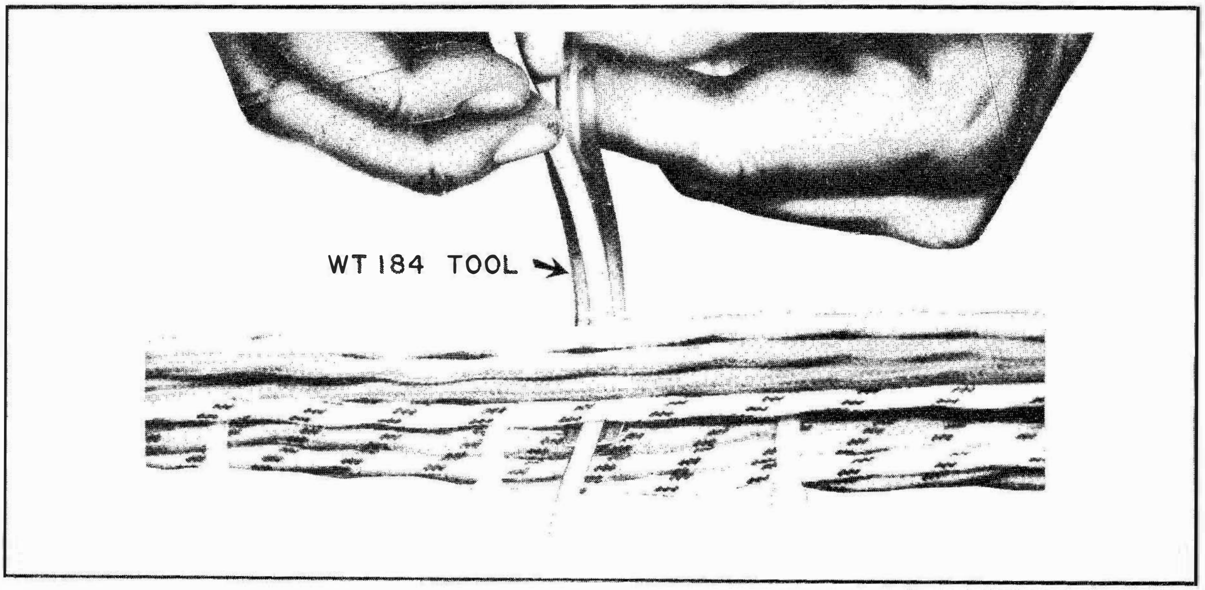



**FIGURE 23–7** Use of WT184 Tool.

5. REUSABLE BANDS.—The TY-15 band may be used as a temporary reusable tie by threading the tip through the eye, pulling up snug, and returning through the key slot in the bolt eye. If desired, this tie may be secured to the equipment by a machine screw which will lock the free end of the band.. This assembly may be loosened at any time for removal or addition of wires in the group.

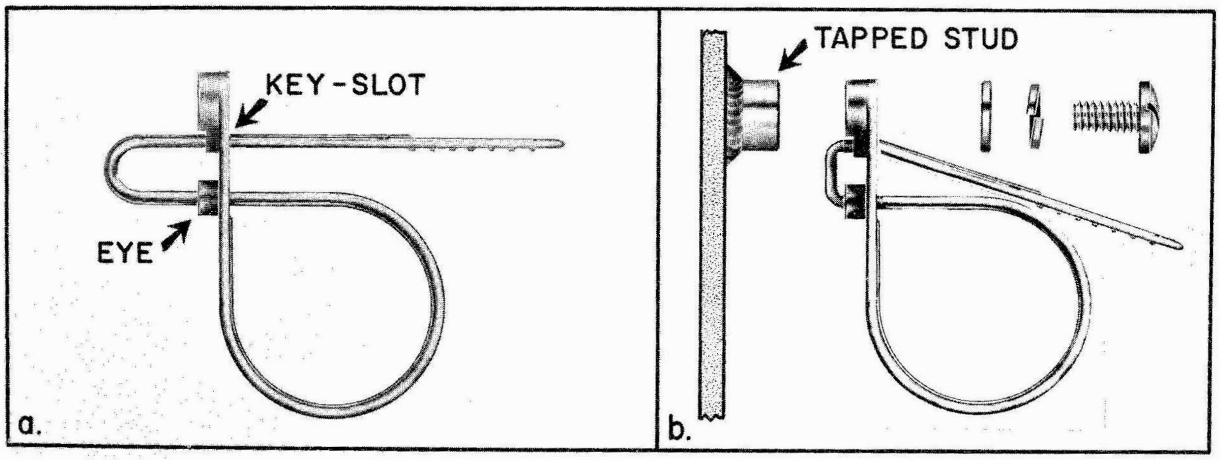



**FIGURE 23–8** Reusable Bands.

**NOTE**

The self locking type band cannot be used for this purpose. Once the self locking type is installed, it can be removed only by cutting.

(2) WECKESSER WEDGE LOCK BAND.—This type of band is constructed of nylon and has no metal parts. One size will fit wire group diameters from one eighth inch up to one and three quarters inches.

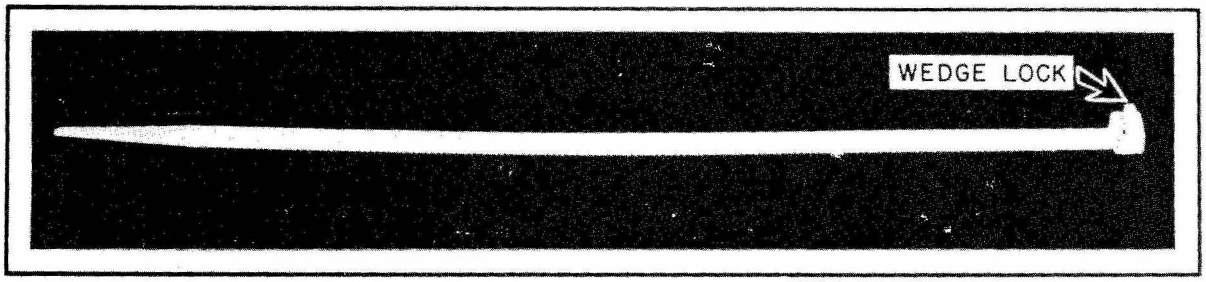



FIGURE 23–9 Weckesser Wedge Lock Band.

(a) INSTALLATION TOOL.–A simple and inexpensive tool is available for use in the installation of these bands. The bent forked end is used to set the wedge lock and to sever the unused portion of the band.

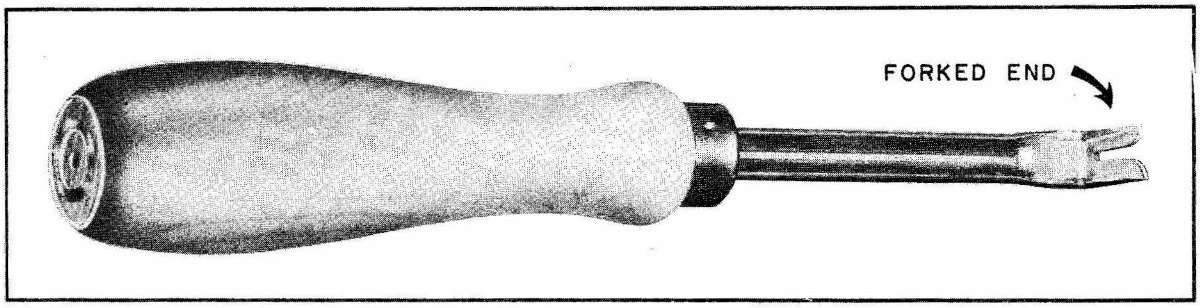



FIGURE 23–10 Weckesser Installation Tool.

(b) BAND INSTALLATION.–These bands are installed as follows:

STEP 1.–Pass the band around the wire group, ratchet teeth inside, and insert the end of the band through the loop end above the locking wedge.

STEP 2.–Grasp the end of the band, by hand or pliers, and place the fork of the tool next to the loop end with the free end of the band protruding through the fork slot.

STEP 3.–Pull tight, applying pressure against the wedge, until the band is tight around the wire group and the top of the wedge is flush with the loop. The wedge is now in the locked position.

**CAUTION**

Do not set the band so tight as to cut the wire insulation or to deform the wire group.

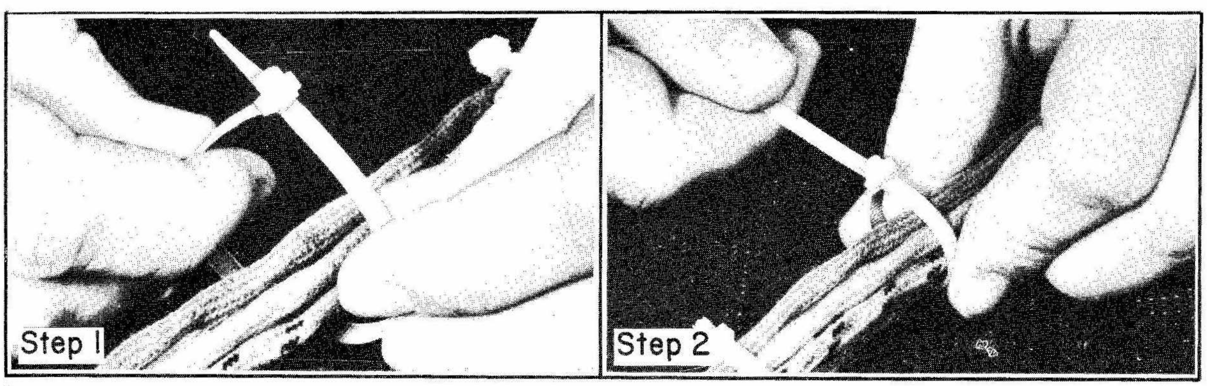



FIGURE 23–11 Band Positioning.

STEP 4.–The unused portion of the band may be removed by twisting it off with the forked tool or by cutting with diagonal cutting pliers.

**NOTE**

If the forked tool is not available for use in band installation, the band may be tightened and the wedge lock set by use of slightly open side cutting plier jaws.

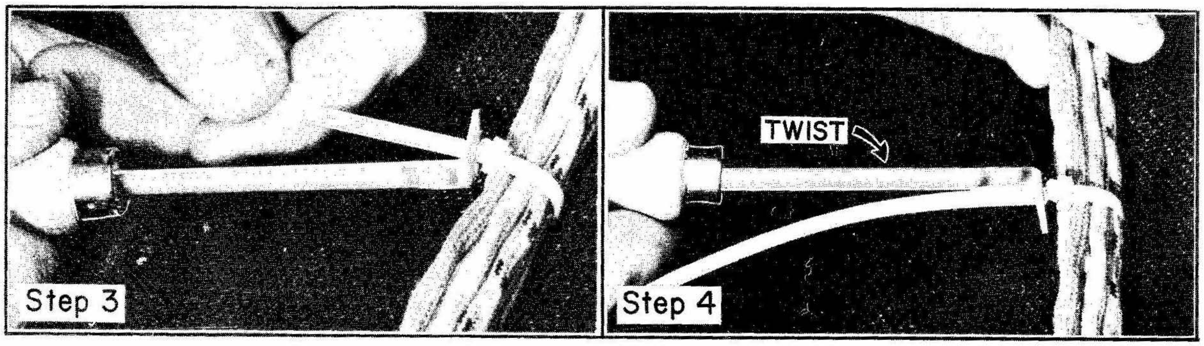



**FIGURE 23–12 Band Locking and Trimming.**

(3) AMP SPIRAL WRAP.–This material is a spiral cut nylon wrapping which may be applied to wire groups from one sixteenth inch to four inches in diameter. It permits the breakout of single wires at any point in the form and may be unwound for removal, addition, or relocation of wires. The spiral wrap holds the wires tightly together, allows flexibility of the form and provides mechanical protection for the form.

(a) SPIRAL WRAP SIZES.–The spiral wrap is available in three sizes to accommodate wire groups as shown in tables 23–1.

(b) LENGTH REQUIRED.–The length of spiral wrap required for various wire group sizes is shown in table 23–2.

TABLE 23-1. SPIRAL WRAP SIZES.

| SIZE | MAXIMUM GROUP RANGE |
|---|---|
| 1/8 inch | 1/16 to 1/2 inch |
| 1/4 inch | 3/16 to 2 inches |
| 1/2 inch | 3/8 to 4 inches |

**NOTE**

Tabl‹ 23–2 shows the length of spiral wrap required for each 12 inch length of the wire group.

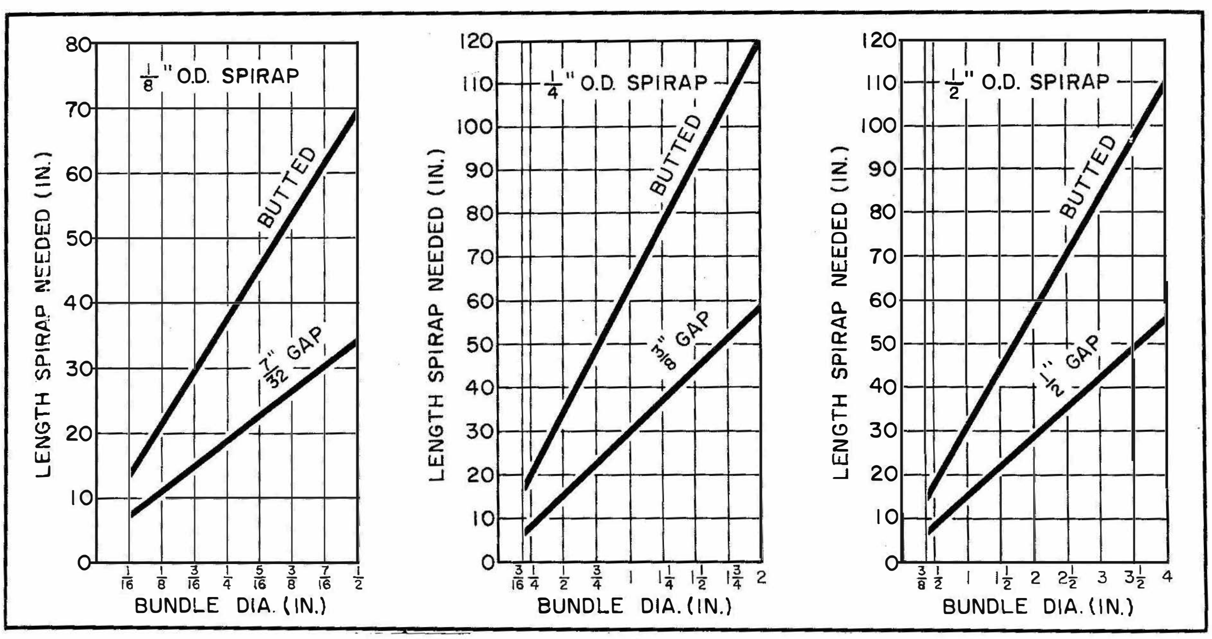



**TABLE 23–2. SPIRAL WRAP LENGTH.**

(c) INSTALLATION TOOL.–A special tool is available for installation of the spiral wrapping. It consists of a fiber or plastic strip, slotted for each size of spiral wrap and simplifies unwinding the spiral wrap for installation on the wire group.

(d) SPIRAL WRAP INSTALLATION.–Select the proper size of spiral wrap from table 23–1 and proceed with the installation as follows:

STEP 1.–Cut the length of spiral wrap required for the wire group. (see table 23–2). If the total length required is greater than 24 inches, the spiral wrap should be cut in 24 inch lengths for ease and speed in installing. The ends should be cut diagonally to aid in locking the ends into the wire group. Straighten out the first two to four inches.

STEP 2.–Hook the end of the spiral wrap into the wire group so that the tip curls around an inner wire.

STEP 3.–Wind the straightened portion of spiral wrap around the wire group (close or spaced as desired), straighten another two to four inches and wind. Continue this process until the entire length of spiral wrap is installed on the wire group.

STEP 4.–Lock the finishing end of the spiral wrap into the wire group. If a tighter wrap is desired, the wire group end should be twisted in the opposite direction from the lay of the spiral wrap. Repeat the above process with additional lengths of spiral wrap until the wire group is completely wrapped.

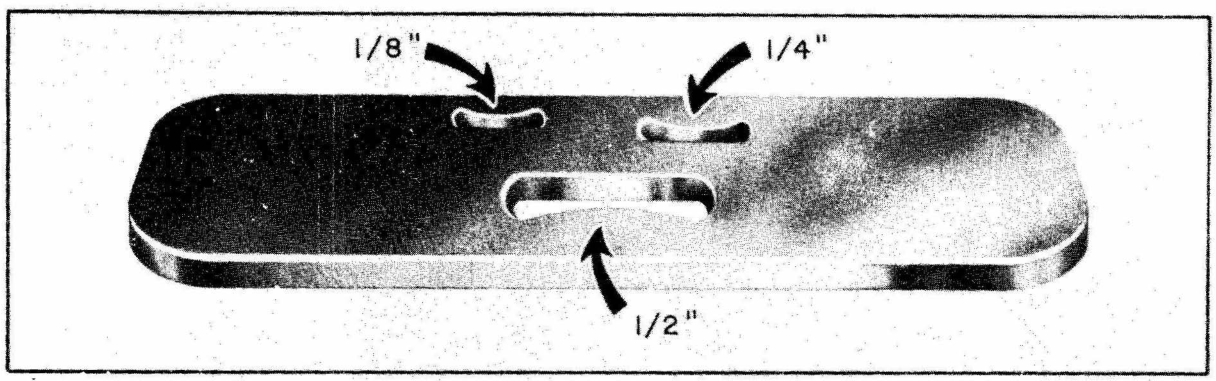



FIGURE 23–13 Spiral Wrap Tool.

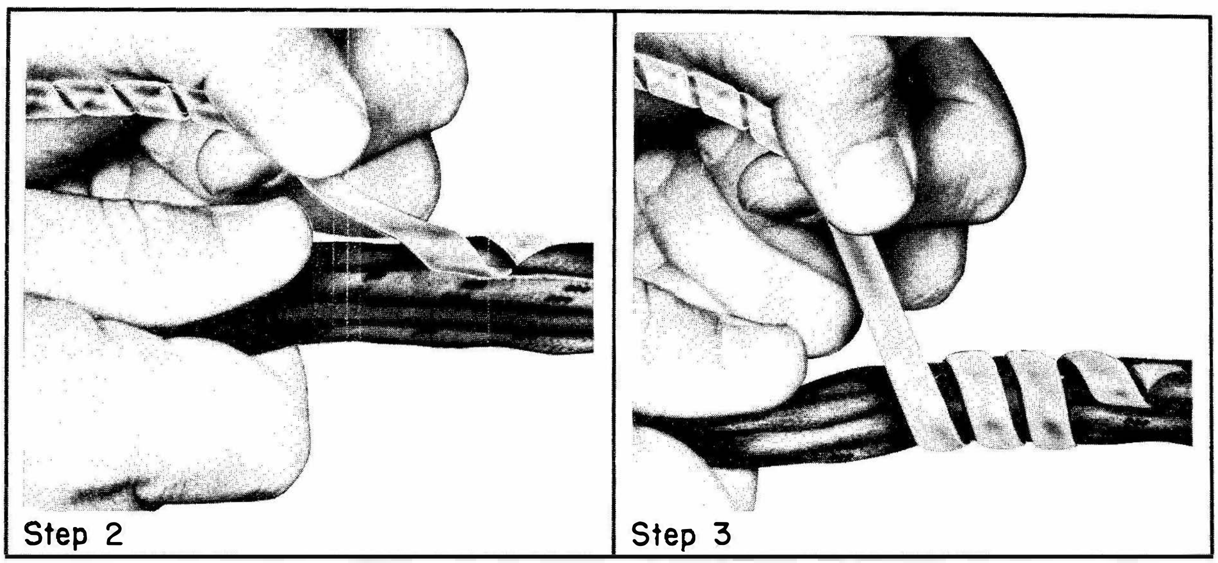



FIGURE 23–14 Starting Spiral Wrap.

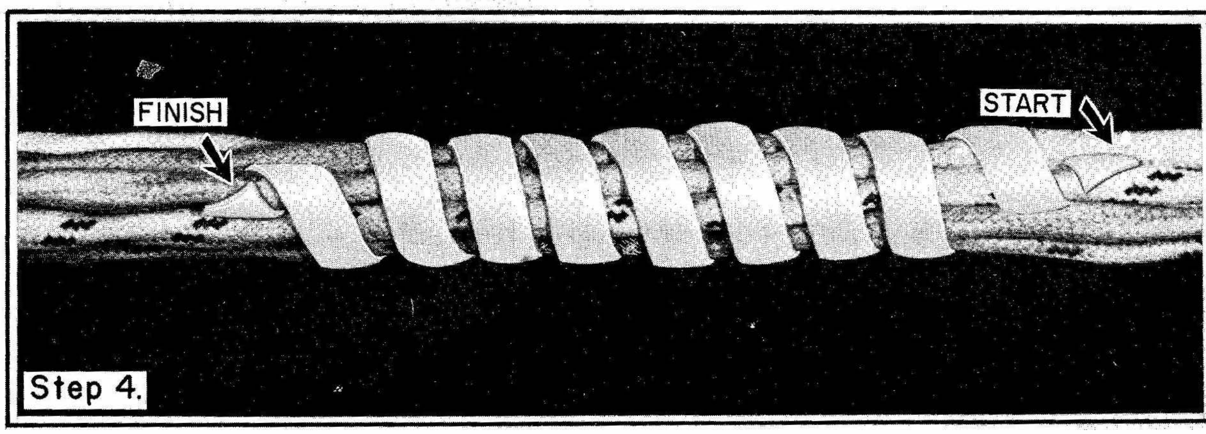



FIGURE 23–15 Finishing Spiral Wrap.

(e) WIRE BREAKOUT.—A wire breakout may be made at any point along the form while installing the spiral wrap. A typical completed form is shown in figure 23–17, on page 4–23–12.

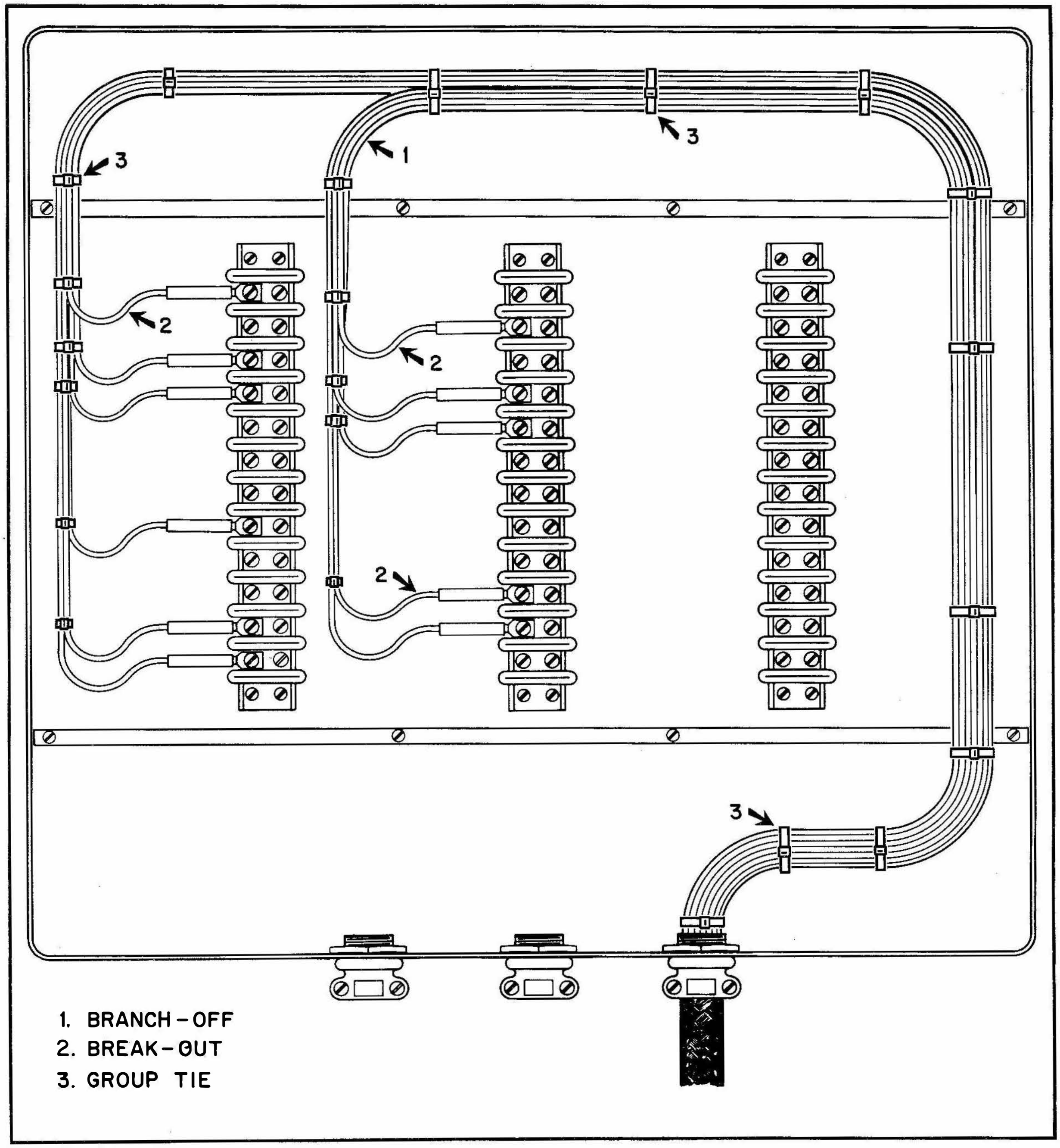



FIGURE 23–16 Completed Form (Nylon Bands).

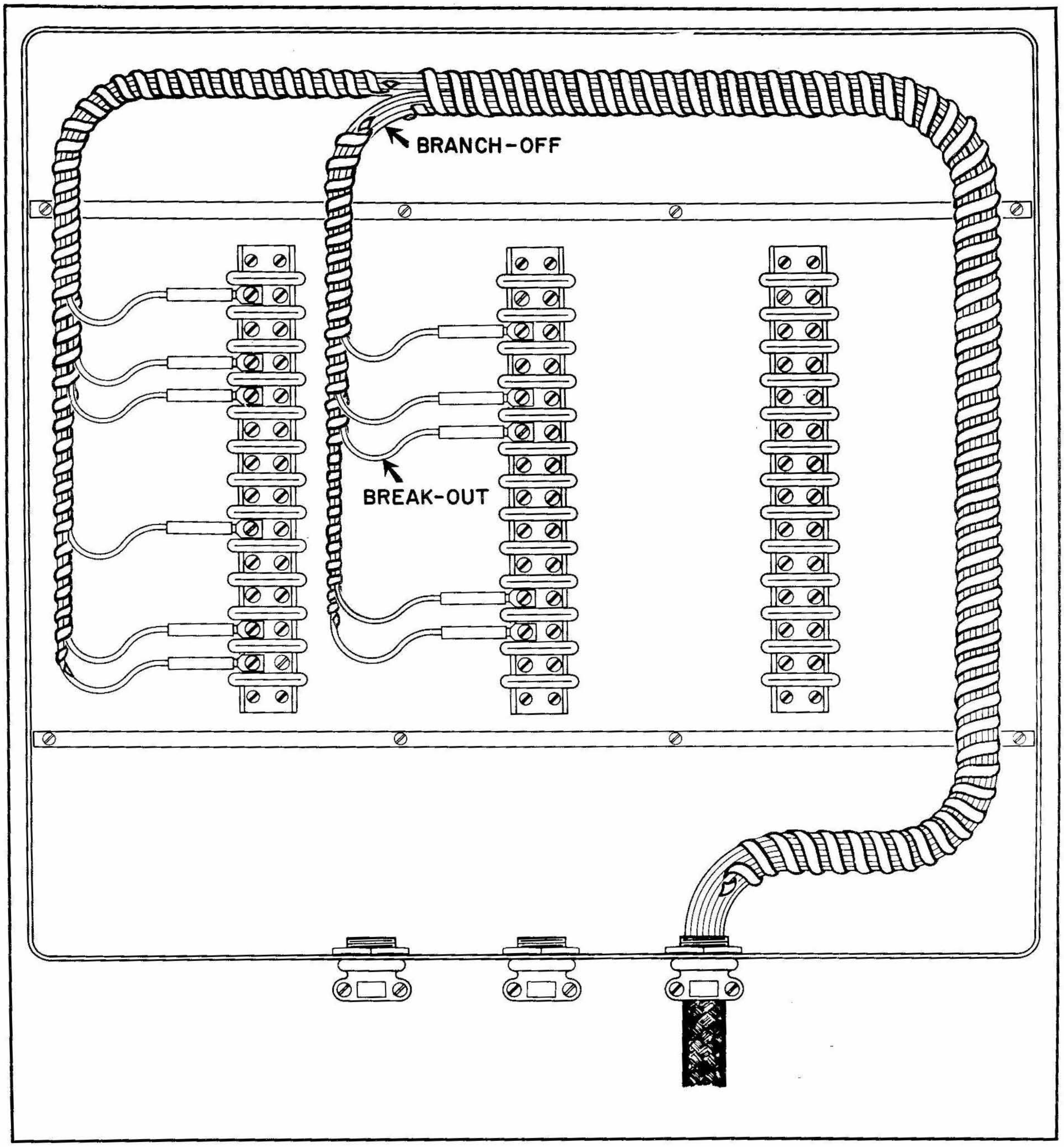



FIGURE 23-17 Completed Form (Spiral Wrap).

**4–24. WIRE COLOR CODES.**–This sub–section lists, and describes the use of, the standard wire color codes for multi–conductor cable used for shipboard electronic installations. It covers the color codes used for power cables, control circuit cables and telephone type twisted pair cables. Wires in cables for use in shipboard electrical and electronic installations, manufactured in accordance with Military Specifications, are marked by standard color codes for identification. This color coding enables the installer to complete the installation with a minimum of effort expended in tracing the individual wires. The use of standard color coding in the installation of interconnection cable wiring will produce a finished job in the minimum amount of time and will be of valuable aid to personnel servicing the equipment if interconnection wiring failures are encountered.

a. COLOR CODE METHODS.–Wires are color coded by means of the following four methods:

(1) INSULATION.–Colored insulation over the individual conductor.
(2) THREAD.–Colored thread winds over the outer periphery of the wire insulation.
(3) TAPE.–Colored tape incorporated in the wire insulation.
(4) BRAID.–Colored braid over the individual conductor insulation.

b. COLOR SEQUENCE.–Where wires are color coded through the use of colored insulation, the following sequence of solid colors is employed: one black, two white, three red, four green, five orange, six blue, seven brown, eight gray, nine yellow, ten purple, eleven tan and twelve pink.

c. POWER CABLES.–Shipboard cables used in electronic installations to conduct electrical power to the equipment will usually be on the one, two or three conductor types of cable. Single conductor cables are used for permanent service installations that do not require flexibility of cables. Two conductor cables are installed for two wire DC or single phase AC circuits. Three conductor cables are installed for three wire DC or three phase AC circuits. The cable types and color codes for various power system supplies are shown in table 24–1 and illustrated in figure 24–1.

**NOTE**

The ground conductor in flexible cables connected to portable tools, lights, vent sets, pumps, and other portable equipment shall be the green wire in three and four conductor cables (see figure 24–1).

**NOTE**

The ± or neutral, when it exists, shall be the white wire.

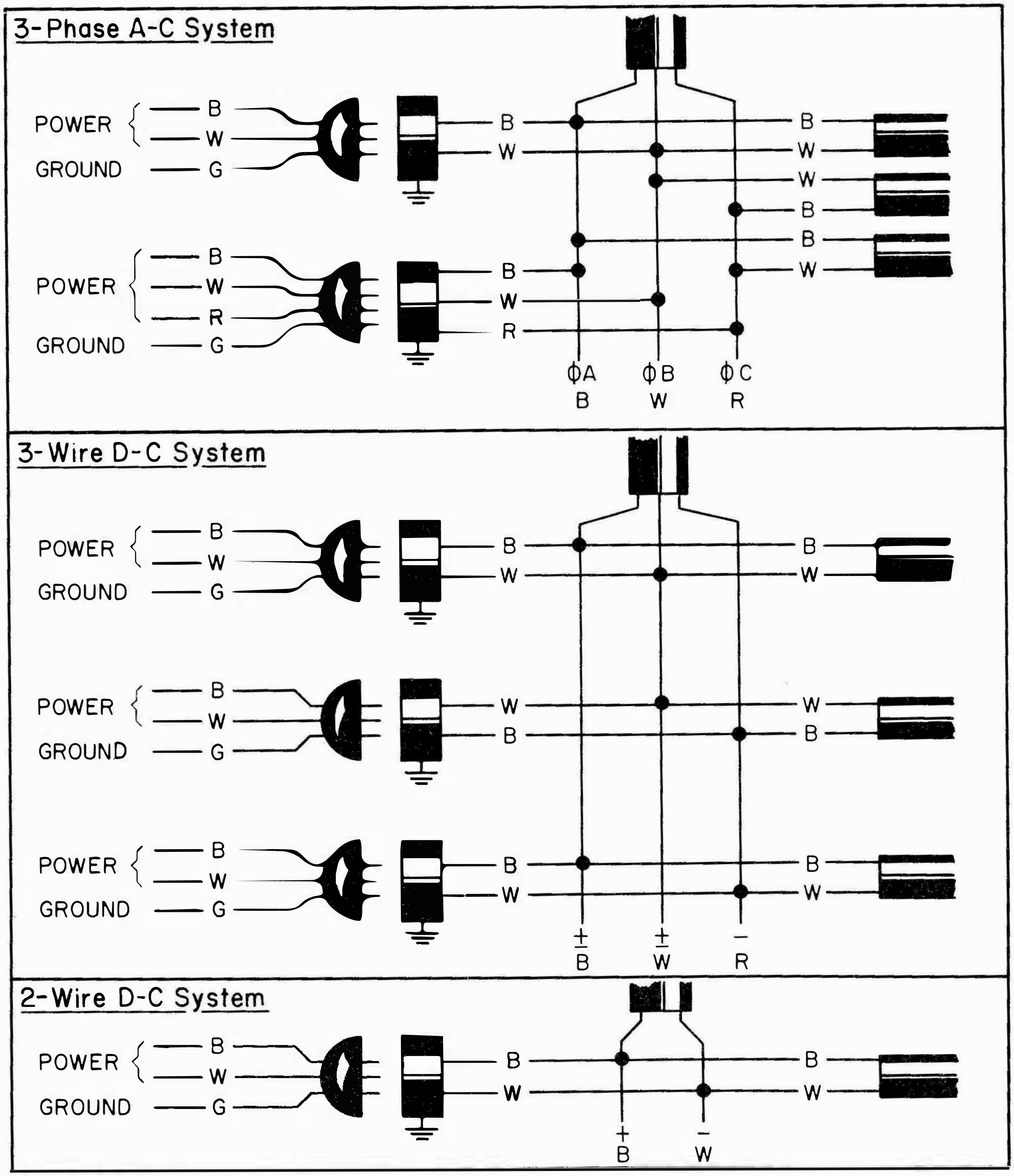



FIGURE 24–1 Standard Color Code Connection for Power Cables

TABLE 24-1 POWER SYSTEM CABLE COLOR CODES

| POWER SYSTEM | CABLE TYPE | PHASE OR POLARITY | COLOR CODE |
|---|---|---|---|
| 3 Phase AC | 3 Cond. | A | Black |
| | | B | White |
| | | C | Red |
| | 2 Cond. | AB | Black-A |
| | | | White-B |
| | | BC | White-B |
| | | | Black-C |
| | | AC | Black-A |
| | | | White-C |
| 3 Wire DC | 3 Cond. | + | Black |
| | | ± | White |
| | | – | Red |
| | 2 Cond. | + and ± | Black + |
| | | | White ± |
| | | ± and – | White ± |
| | | | Black – |
| | | + and – | Black + |
| 2 Wire DC | 2 Cond. | | White – |
| | | + | Black |
| | | – | White |

d. MULTIPLE CONDUCTOR CABLE.–The color code shown in table 24–2 will apply to all multiple conductor (except twisted pair) cables having from two to forty–four individual wires within a common protective sheath.

e. TWISTED PAIR TELEPHONE CABLE.–Individual conductors and pairs in twisted pair telephone cables will be color coded by pairing the solid colors in sequence. This system of color coding is shown in table 24–3.

**NOTE**

This color code is not applicable to discontinued and obsolete types of telephone cables having textile wrap or enamel insulation on the individual conductors.

TABLE 24-2 COLOR CODE OF MULTIPLE CONDUCTOR CABLE

| WIRE NO. | BASE COLOR | FIRST TRACER | SECOND TRACER | WIRE NO. | BASE COLOR | FIRST TRACER | SECOND TRACER |
|---|---|---|---|---|---|---|---|
| 1 | Black | - | - | 23 | White | Black | Red |
| 2 | White | - | - | 24 | Red | Black | White |
| 3 | Red | - | - | 25 | Green | Black | White |
| 4 | Green | - | - | 26 | Orange | Black | White |
| 5 | Orange | - | - | 27 | Blue | Black | White |
| 6 | Blue | - | - | 28 | Black | Red | Green |
| 7 | White | Black | - | 29 | White | Red | Green |
| 8 | Red | Black | - | 30 | Red | Black | Green |
| 9 | Green | Black | - | 31 | Green | Black | Orange |
| 10 | Orange | Black | - | 32 | Orange | Black | Green |
| 11 | Blue | Black | - | 33 | Blue | White | Orange |
| 12 | Black | White | - | 34 | Black | White | Orange |
| 13 | Red | White | - | 35 | White | Red | Orange |
| 14 | Green | White | - | 36 | Orange | White | Blue |
| 15 | Blue | White | - | 37 | White | Red | Blue |
| 16 | Black | Red | - | 38 | Brown | - | - |
| 17 | White | Red | - | 39 | Brown | Black | - |
| 18 | Orange | Red | - | 40 | Brown | White | - |
| 19 | Blue | Red | - | 41 | Brown | Red | - |
| 20 | Red | Green | - | 42 | Brown | Green | - |
| 21 | Orange | Green | - | 43 | Brown | Orange | - |
| 22 | Black | White | Red | 44 | Brown | Blue | - |

TABLE 24-3 COLOR CODE OF TWISTED PAIR TELEPHONE CABLE

| TELEPHONE PAIR | ONE WIRE | OTHER WIRE | TELEPHONE PAIR | ONE WIRE | OTHER WIRE |
|---|---|---|---|---|---|
| 1 | White | Black | 31 | Orange | Green |
| 2 | Red | Black | 32 | Blue | Green |
| 3 | Green | Black | 33 | Brown | Green |
| 4 | Orange | Black | 34 | Gray | Green |
| 5 | Blue | Black | 35 | Yellow | Green |
| 6 | Brown | Black | 36 | Purple | Green |
| 7 | Gray | Black | 37 | Tan | Green |
| 8 | Yellow | Black | 38 | Pink | Green |
| 9 | Purple | Black | 39 | Blue | Orange |
| 10 | Tan | Black | 40 | Brown | Orange |
| 11 | Pink | Black | 41 | Gray | Orange |
| 12 | Red | White | 42 | Yellow | Orange |
| 13 | Green | White | 43 | Purple | Orange |
| 14 | Orange | White | 44 | Tan | Orange |
| 15 | Blue | White | 45 | Pink | Orange |
| 16 | Brown | White | 46 | Brown | Blue |
| 17 | Gray | White | 47 | Gray | Blue |
| 18 | Yellow | White | 48 | Yellow | Blue |
| 19 | Purple | White | 49 | Purple | Blue |
| 20 | Tan | White | 50 | Tan | Blue |
| 21 | Pink | White | 51 | Pink | Blue |
| 22 | Green | Red | 52 | Gray | Brown |
| 23 | Orange | Red | 53 | Yellow | Brown |
| 24 | Blue | Red | 54 | Purple | Brown |
| 25 | Brown | Red | 55 | Tan | Brown |
| 26 | Gray | Red | 56 | Pink | Brown |
| 27 | Yellow | Red | 57 | Yellow | Gray |
| 28 | Purple | Red | 58 | Purple | Gray |
| 29 | Tan | Red | 59 | Tan | Gray |
| 30 | Pink | Red | 60 | Pink | Gray |

f. SPECIAL PURPOSE CABLE.—Polyethylene jacket type multiconductor shielded cables and polyethylene insulated conductors used in shore communication stations and facilities for telephone and telegraph signal cables are color coded as shown in tables 24–4 and 24–5. The 104–pair cable is formed in two 52–pair concentric units, or four 26–pair units. These units are separated by a special binder and the color coding is repeated for the additional 52 pairs.

TABLE 24–4 SPECIAL PURPOSE CABLE COLOR CODING

| PAIR NUMBER | WIRE COLORS |
|---|---|
| 1 & 53 | Blue and White (or natural) |
| 2 & 54 | Orange and White (or natural) |
| 3 & 55 | Green and White (or natural) |
| 4 & 56 | Brown and White (or natural) |
| 5 & 57 | Slate and White (or natural) |
| 6 & 58 | Blue and Red |
| 7 & 59 | Orange and Red |
| 8 & 60 | Green and Red |
| 9 & 61 | Brown and Red |
| 10 & 62 | Slate and Red |
| 11 & 63 | Blue and Black |
| 12 & 64 | Orange and Black |
| 13 & 65 | Green and Black |
| 14 & 66 | Brown and Black |
| 15 & 67 | Slate and Black |
| 16 & 68 | Blue and Yellow |
| 17 & 69 | Orange and Yellow |
| 18 & 70 | Green and Yellow |
| 19 & 71 | Brown and Yellow |
| 20 & 72 | Slate and Yellow |
| 21 & 73 | Blue and Violet |
| 22 & 74 | Orange and Violet |
| 23 & 75 | Green and Violet |
| 24 & 76 | Brown and Violet |
| 25 & 77 | Slate and Violet |
| 26 & 78 | Blue-White(tracer) and White (or natural) |
| 27 & 79 | Orange-White(tracer) and White (or natural) |
| 28 & 80 | Green-White(tracer) and White (or natural) |

(Continued on page 9-4-24-7)

TABLE 24-4 SPECIAL PURPOSE CABLE COLOR CODING (cont'd)

| PAIR NUMBER | WIRE COLORS |
|---|---|
| 29 & 81 | Brown-White(tracer) and White (or natural) |
| 30 & 82 | Slate-White(tracer) and White (or natural) |
| 31 & 83 | Blue-White(tracer) and Red |
| 32 & 84 | Orange-White(tracer) and Red |
| 33 & 85 | Green-White(tracer) and Red |
| 34 & 86 | Brown-White(tracer) and Red |
| 35 & 87 | Slate-White(tracer) and Red |
| 36 & 88 | Blue-White(tracer) and Black |
| 37 & 89 | Orange-White(tracer) and Black |
| 38 & 90 | Green-White(tracer) and Black |
| 39 & 91 | Brown-White(tracer) and Black |
| 40 & 92 | Slate-White(tracer) and Black |
| 41 & 93 | Blue-White(tracer) and Yellow |
| 42 & 94 | Orange-White(tracer) and Yellow |
| 43 & 95 | Green-White(tracer) and Yellow |
| 44 & 96 | Brown-White(tracer) and Yellow |
| 45 & 97 | Slate-White(tracer) and Yellow |
| 46 & 98 | Blue-White(tracer) and Violet |
| 47 & 99 | Orange-White(tracer) and Violet |
| 48 & 100 | Green-White(tracer) and Violet |
| 49 & 101 | Brown-White(tracer) and Violet |
| 50 & 102 | Slate-White(tracer) and Violet |
| 51 & 103 | Red and White (or natural) |
| 52 & 104 | Red-White(tracer) and White (or natural) |
| Spare | (104 pair cable) Red and Black |

**4-25. WIRE MARKING.** – This sub-section describes and illustrates the approved methods of marking the terminal ends of interconnection cable wiring. It covers the materials and methods used in marking wires between the following electronic equipment interconnection points: (1) equipment units with interconnection between "like" terminals which have the same designation in each unit, (2) equipment units with interconnections between "unlike" terminals which have different designations in each unit, (3) equipment units with interconnections to junction box terminals, and (4) equipment units with interconnections to power sources.

a. MARKING METHOD. – Interconnection cable wires are marked at each end near the point of connection to the designated equipment terminal. These markers are manufactured from flexible vinyl sleeving, either clear or white opaque, and of a selected size to properly fit the wire being marked. The marking is applied to the sleeve by a special marking machine using an indelible ink that will penetrate the vinyl sleeving and make a permanent marking. The various sizes of sleeving are listed in table 25-1 and the recommended sizes of marking type for use in manufacturing wire markers are listed in table 25-2.

TABLE 25-1. SLEEVING SIZES FOR WIRE MARKING

| SLEEVING SIZE AWG | INSIDE DIAMETER | SLEEVING SIZE AWG | INSIDE DIAMETER |
|---|---|---|---|
| 20 | 0.032 | 3 | 0.229 |
| 19 | 0.036 | 2 | 0.258 |
| 18 | 0.040 | 1 | 0.289 |
| 17 | 0.045 | 0 | 0.325 |
| 16 | 0.051 | 5/16 inch | 0.313 |
| 15 | 0.057 | 3/8 inch | 0.375 |
| 14 | 0.064 | 7/16 inch | 0.438 |
| 13 | 0.072 | 1/2 inch | 0.500 |
| 12 | 0.081 | 5/8 inch | 0.625 |
| 11 | 0.091 | 3/4 inch | 0.750 |
| 10 | 0.102 | 7/8 inch | 0.875 |
| 9 | 0.114 | 1 inch | 1.000 |
| 8 | 0.129 | 1-1/4 inch | 1.250 |
| 7 | 0.144 | 1-1/2 inch | 1.500 |
| 6 | 0.162 | 1-3/4 inch | 1.750 |
| 5 | 0.182 | 2 inch | 2.000 |
| 4 | 0.204 | | |

TABLE 25-2. RECOMMENDED SIZES OF MARKING TYPE

| SLEEVING SIZE (AWG) | HEIGHT OF LETTERS (IN.) |
|---|---|
| 3/4 inch thru 3/8 inch & 0 thru 6 | 7/64 inch |
| 7 thru 10 | 5/64 inch |
| 11 and smaller | 1/16 inch |

(1) MARKER INFORMATION. – The marker on each wire will furnish the following identification: (1) the terminal to which the wire will be connected, (2) the unit and terminal board to which the wire is connected on the opposite end, and (3) the terminal to which the wire is connected on the opposite end. Each of these designations will be separated by a dash. The order of marking is such that the first appearing set of numbers and letters reading from left to right will be the designation corresponding to the terminal to which the wire will be connected. The center marking will indicate the unit and terminal board on the opposite end of the wire and the third group indicates the terminal to which the wire is connected on the opposite end. The wire marker will always be installed with the left hand identification group next to the lug or connection.

(2) WIRE MARKER TAGS. – Prior to the actual termination of the wires, a card or tag should be made up, showing the cable identification, type, color code of wires, terminal information, and wire marker designations for each end of the cable. This will expedite the installation by eliminating constant reference to interconnection wiring diagrams.

(3) WIRE MARKER JIG. – When the wire markers are received by the installer, they are usually furnished in uncut lengths or in cut bundles. This necessitates sorting the markers each time a particular one is required for installation on the wire. A simple jig may be constructed of scrap plyboard or cardboard as shown in figure 25-1. The

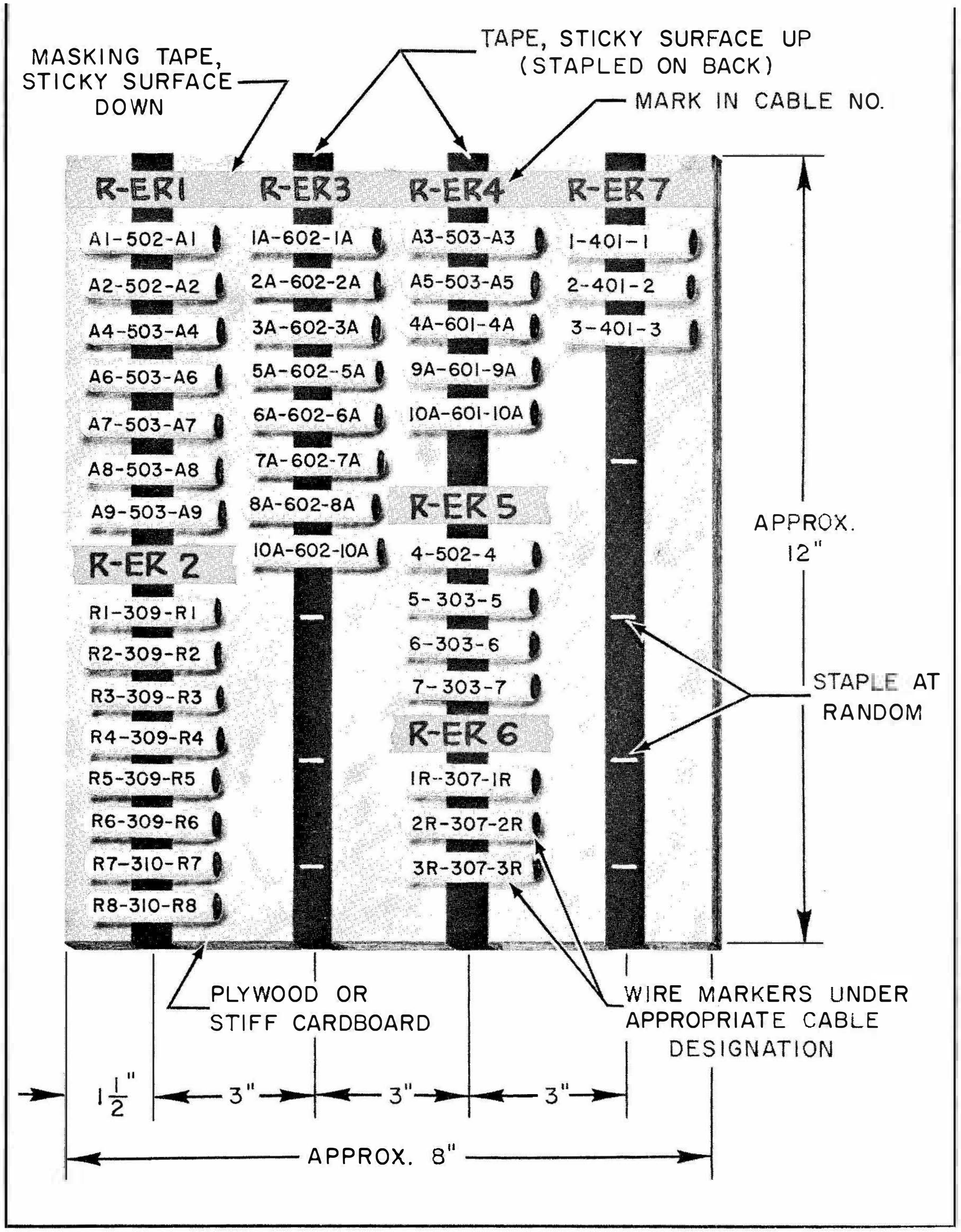



Figure 25-1. Wire Marker Jig

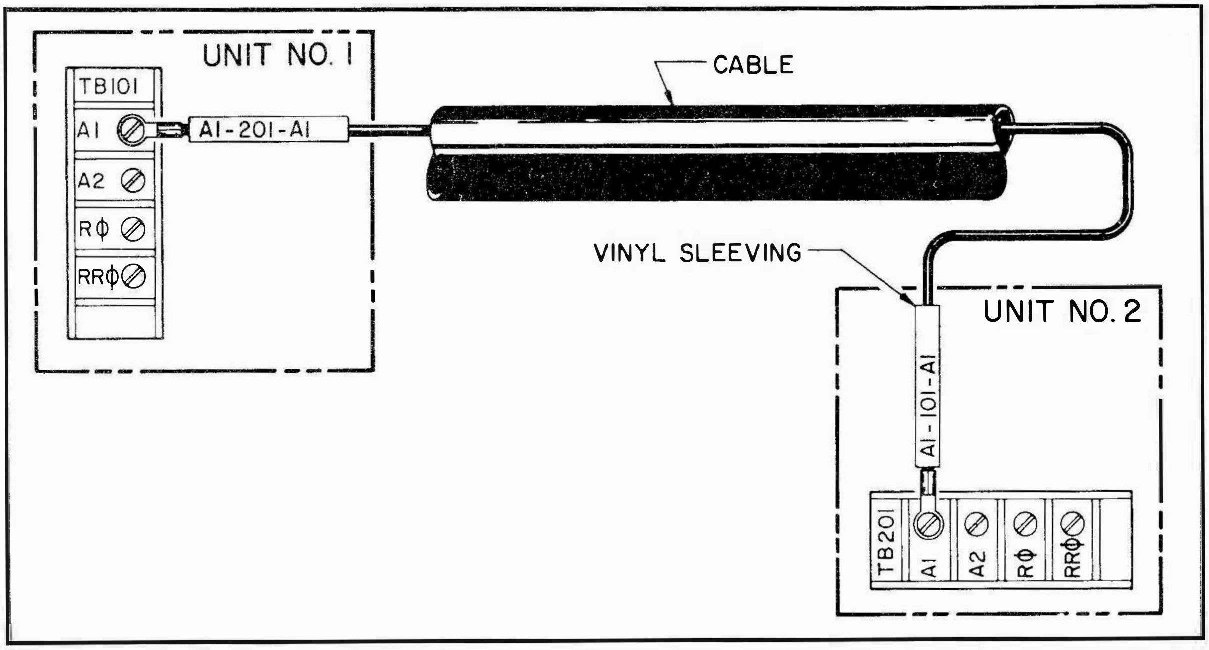



Figure 25-2. Wire Marking Between "Like" Terminals

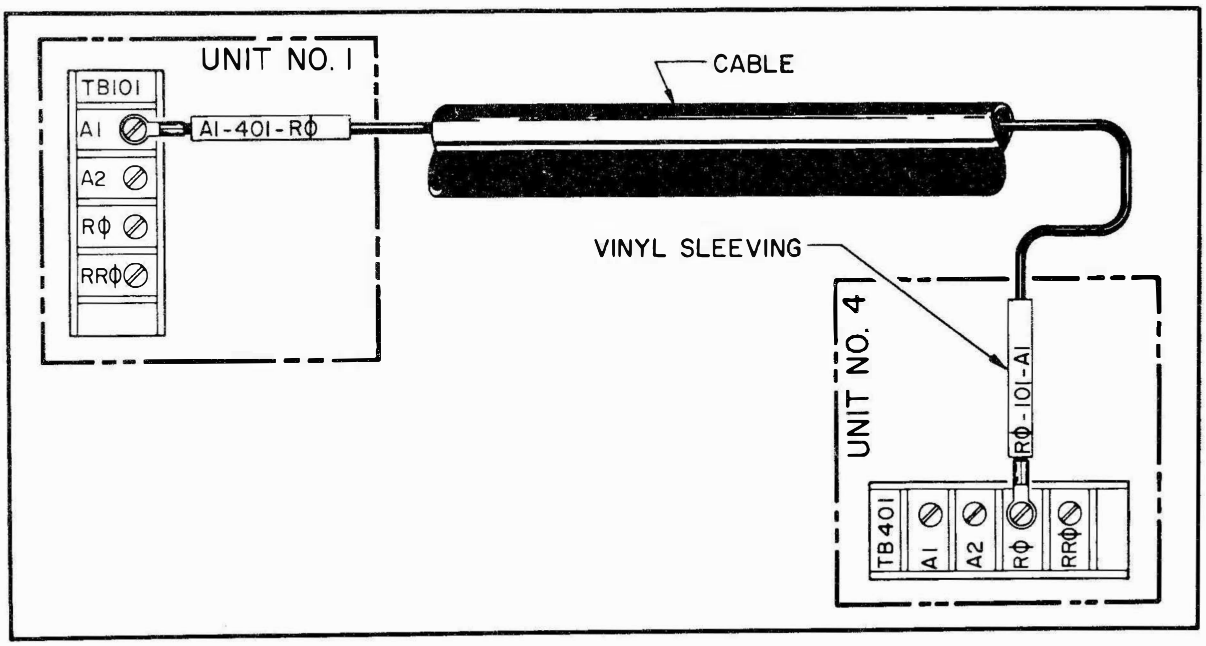



Figure 25-3. Wire Marking Between "Unlike" Terminals

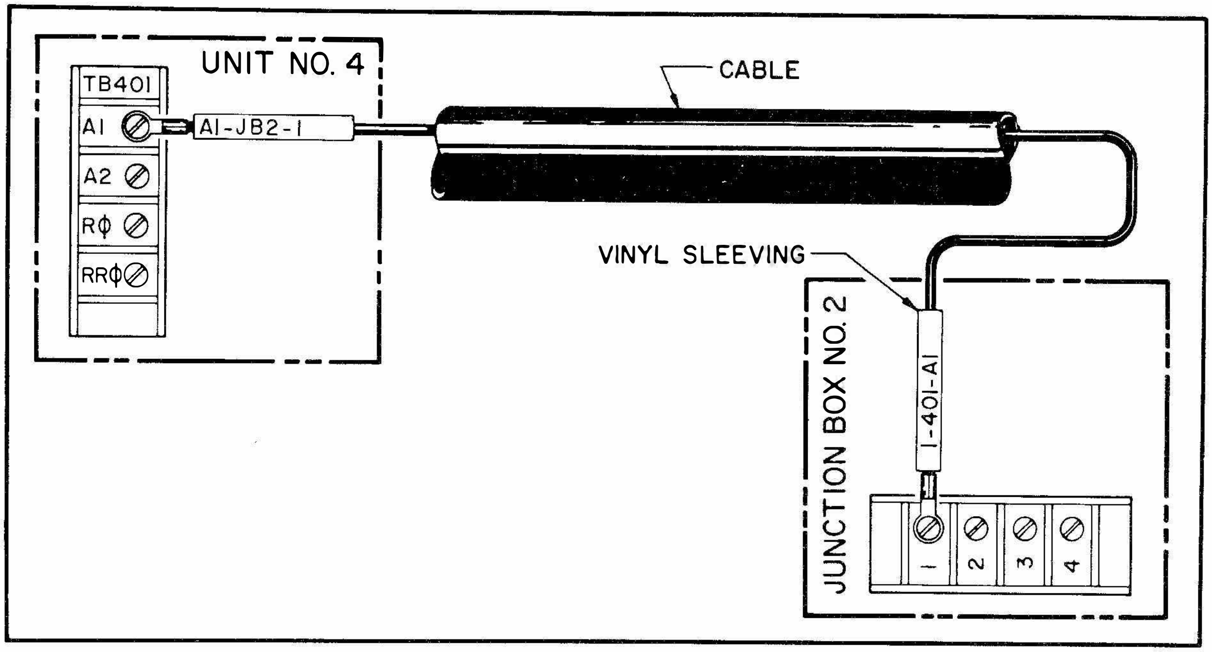



Figure 25-4. Wire Marking Between Equipment Unit and Junction Box

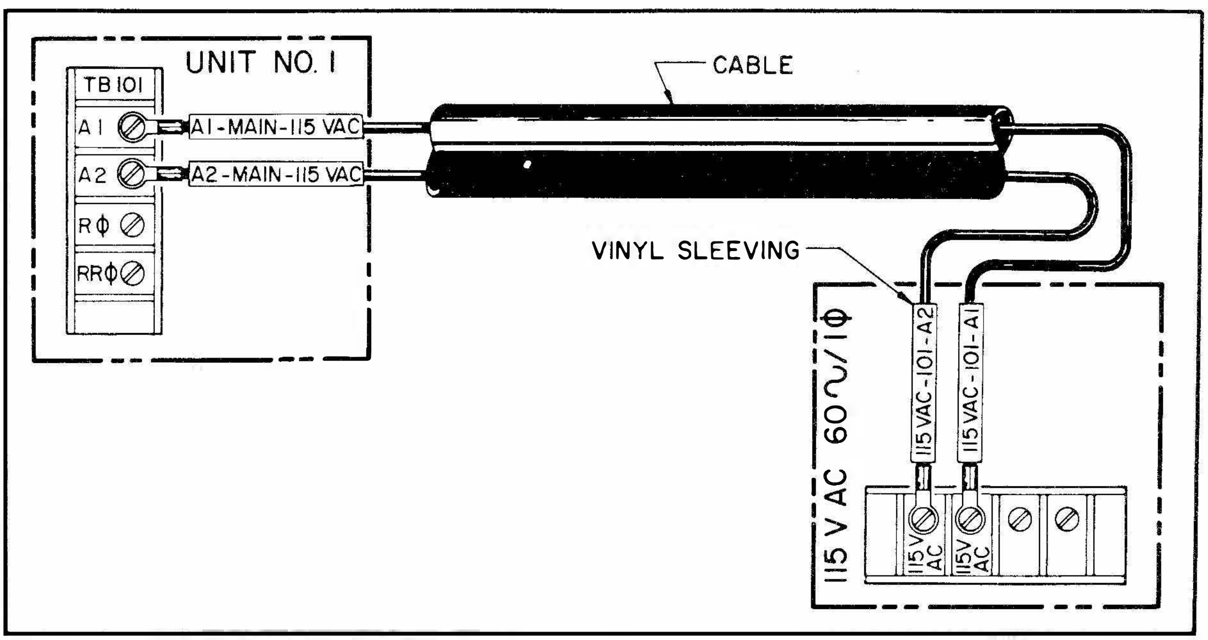



Figure 25-5. Wire Marking Between Equipment Unit and Power Source

markers can be assembled on the jig and, when required for installation on the wire, can be selected and easily removed for instant use.

b. MARKING BETWEEN "LIKE" TERMINALS. – An example of a wire connected between units 1 and 2 of an equipment is illustrated in figure 25-2. The connection is to "like" terminals on TB101 and unit 1 and TB201 in unit 2.

c. MARKING BETWEEN "UNLIKE" TERMINALS. – When the wire is connected between equipment units and to "unlike" terminals it will be marked as shown in figure 25-3.

d. MARKING BETWEEN EQUIPMENT UNIT AND JUNCTION BOX. – If the wire is connected between an equipment unit and a junction box it will be marked as shown in figure 25-4.

e. MARKING BETWEEN EQUIPMENT UNIT AND POWER SOURCE. – In the case of wires connected between an equipment unit and a power source they will be marked as shown in figure 25-5.

f. SONAR SYSTEM WIRE MARKING. – SONAR system interconnection cable wires shall be marked in accordance with the following method. Each wire in the system shall be designated by function as derived from the key dictionary for sonar wire numbers. Only wires that are always conductively coupled bear identical numbers, and these without exception. A wire that is used for more than one function shall have a number assigned that designates the function existing when the system is in the most advanced mode of operation. Wire numbers for synchro busses shall be assigned in the proper sequence for standard CCW rotation (see figure 25-6).

Jumpers will not require wire numbers. Braids or shields for cables will not have wire numbers in most cases; the word "Braid" will be used instead. A common number for systems ground shall be assigned and used throughout the system for grounds of different functions, where feasible.

(1) DEFINITIONS OF SONAR FUNCTIONS. – The following are definitions of abbreviations used in the key dictionary for SONAR interconnection wire numbers:

(a) Ba. – RELATIVE TARGET BEARING. – The angle between the vertical plane through own ship centerline, and the vertical plane through the line of sight, measured in the horizontal plane. Positive angles measured clockwise from own ship centerline.

(b) Bda. – SONAR TRAIN. – The angle between the fore and after axis of own ship and the plane perpendicular to the deck through the axis of the sound beam at the transducer, measured in the deck plane clockwise from the bow.

(c) Bts. – TARGET ANGLE. – The angle between the vertical plane through the target speed vector, and the vertical plane through the line of sight, measured in the horizontal plane clockwise from the target speed vector.

(d) Bya. – TRUE TARGET BEARING. – The angle between the North-South vertical plane, and the vertical plane through the line of sight, measured in the horizontal plane. Positive angles measured clockwise from North.

(e) Co. – OWN SHIPS COURSE. – The angle between the North-South vertical plane and the vertical plane through own ship speed vector, measured in the horizontal plane clockwise from North.

(f) CT. – TARGET COURSE. – The angle between the North-South vertical plane and the vertical plane through target speed vector, measured in the horizontal plane clockwise from North.

(g) DB. – BEARING RATE. – The time rate of change of Sonar Bearing.

(h) DMho. – OWN SHIP SPEED. – Speed of own ship in knots.

(i) DMht. – TARGET SPEED. – Speed of the target in knots.

(j) DR. – SONAR RANGE RATE. – The time rate of change of sonar range.

(k) Edua'. – SONAR DEPRESSION FROM DECK. – The angle between the deck plane of the axis of the sound beam at the transducer and the line of sound measured in the vertical plane through the axis of the sound beam: positive angles measured downward from the deck plane.

(l) Ei. – LEVEL ANGLE. – The angle between the horizontal plane and the deck plane, measured in the vertical plane through the sonar line of sight. Positive angles measured downward from the horizontal plane on the target side of the ship.

(m) Eio. – PITCH. – Angle between the horizontal plane and the deck plane, measured in the vertical plane through own ship centerline. Positive angles measured downward from the horizontal plane.

(n) Eua. – SONAR DEPRESSION. – The angle between horizontal plane of the axis of the sound beam at the transducer and the line of sound measured in the vertical plane through the axis of the sound beam; positive angles measured downward from the horizontal plane.

(o) jstp(Eua). – REFRACTED DEPRESSION ANGLE. – The angle between the horizontal plane, which is parallel to the horizontal plane of the axis of the transducer, at the point of refraction of the sound beam and the line of sound, due to (jt) temperature, (js) salinity, or (jp) pressure measured in the vertical plane through the axis of the refracted sound beam.

(p) Hvs. – SONAR TRANSDUCER DEPTH. – The depth of the transducer measured in a vertical plane from the surface of the ocean to the horizontal plane of the axis of the transducer.

(q) Mhox. – OWN SHIP DISTANCE (E-W). – The linear rate in the horizontal plane and in the East-West vertical plane due to own ship motion.

(r) Mhoy. — OWN SHIP DISTANCE (N-S). — The linear rate in the horizontal plane and in the North-South vertical plane due to own ship motion.

(s) Ra. — SONAR RANGE. — The measured distance from the transducer to the target along the path of the sound beam.

(t) Rha. — HORIZONTAL SONAR RANGE. — The projection on a horizontal plane of sonar range (Ra).

(u) Rvua'. — RELATIVE TARGET DEPTH. — The target depth measured in a vertical plane from the horizontal plane of the axis of the transducer to the center of the target.

(v) Rvua. — TRUE TARGET DEPTH. — Target depth measured in a vertical plane from the surface of the ocean to the center of the target.

(w) Zd. — CROSS LEVEL. — Angle between the vertical plane through sonar line of sight, and the normal plane through the intersection of the vertical plane through the sonar line of sight and the deck plane, measured about the axis which is the intersection of the vertical plane through the line of sight and the deck plane. Positive direction is clockwise when viewed along axis inward from target.

(x) Zo. — ROLL. — Angle between the vertical plane through own ship centerline, and the normal plane through the intersection of the vertical plane through own ship centerline and deck plane, measured about the axis which is the intersection of the vertical plane through own ship centerline and the deck plane. Positive direction is clockwise when viewed inward from own ship bow.

(y) MODIFIERS. — The following definitions for modifiers shall apply when used prior to the above functions:

c = Computed quantity.
i = Increments of a quantity.
q = A manual correction to a quantity.
a = When used as part of the basic symbol it shall relate to the apparent target position.

(2) KEY DICTIONARY FOR SONAR WIRE NUMBERS. — Basic wiring information will be determined from the following system:

| | | | | | | |
|---|---|---|---|---|---|---|
| Sample: | R | 24 | SK | 03 | 2 | 04 |
| Parts: | (a) | (b) | (c) | (d) | (e) | (f) |
| Possibilities: | R | 1-99 | SA-SX | 00-99 | 0-9 | 0-99 |

(a) R designated electronics (letter "R" is omitted in figure 25-6).

(b) Number 1 — Primary Ships AC power.
2 — Secondary AC power (primary power modified by transformers, simple circuit elements, etc.).
3 — DC supplies.
4 — Circuit control signals (trigger pulses, sweep signals, TVG, RCG, blanking signals).
5 — RF Signals, normal plane.
6 — Output signals (audio, video).
7 — RF Signals, variable plane.
8 — Unassigned.
9 — Miscellaneous
10 — through 20 — unassigned.
21 — Synchro order Bya.
22 — Synchro order unassigned.
23 — Synchro order q(Bya), i(Bya), ic(Bya),
24 — Synchro order Ba.
25 — Synchro order Bda.
26 — Synchro order ic(Ba).
27 — Synchro DB.
28 — 30 — Synchro order unassigned.
31 — Synchro order Ra.
32 — Synchro order unassigned.
33 — Synchro order q(Ra), DR.
34 — Synchro order Rha.
35 — Synchro order unassigned.
36 — Synchro order c(Rha).
37 — 40 — Synchro order unassigned.
41 — Synchro order Eua.
42 — Synchro order Eua — Ei, Edua.
43 — Synchro order Etua, i(Eua), ic(Eua).
44 — Synchro order jt(Eua), jp(Eua), js(Eua), Ep.
45 — Synchro order Eua-Edua.
46 — 47 — Synchro order unassigned.

48 – 50 – Synchro order unassigned.
51 – Synchro order Rvua.
52 – Synchro order Rvua'.
53 – Synchro order c(Rvua).
54 – 55 – Synchro order unassigned.
56 – Synchro order Bts.
57 – 58 Synchro order unassigned.
59 – Synchro order Zo.
60 – Synchro order Eio.
61 – Synchro order unassigned.
62 – Synchro order Zd.
63 – 70 – Synchro order unassigned.
71 – Synchro order Co.
72 – Synchro order DMho.
73 – Synchro order Mhoy.
74 – Synchro order Mhox.
75 – Synchro order DMho cos Ba.
76 – 77 – Synchro order unassigned.
78 – Zero order.
79 – 99 – Unassigned.

(c) The "S" series of letters indicate specific sonar equipments:

| | | | |
|---|---|---|---|
| SA | Azimuth searchlight. | SM | Monitoring system, test. |
| SB | Underwater communication. | SN | Passive ranging. |
| SC | Computing equipment. | SO | Bathythermograph systems. |
| SD | Depth determining. | SP | Auxiliary, attack aids. |
| SE | Depth charge indicators. | SQ | Combination azimuth/depth. |
| SF | | SR | Remote indicator. |
| SG | | SS | Sounding. |
| SH | Sonar hoist/lower systems. | ST | Trainer. |
| SI | Sonar identification. | SU | Object locater. |
| SJ | | SV | Variable depth. |
| SK | Azimuth scanning equipment. | SW | Classification. |
| SL | Listening. | SX | Doppler sonar. |

(d) Digits from 1 to 99 indicate that the wire function has been modified by an "open circuit/closed circuit" circuit element (switches, fuses, relay contacts).

(e) Digits from 0-9 to differentiate between similar but not identical functions (different sources, functions modified by amplifiers, etc.).

(f) Digits from 0 to 99 to identify specific wire functions:

Power functions:

| | | |
|---|---|---|
| 110 VAC power circuits | 1SZ1 | A phase |
| | 1SZ2 | B phase |
| | 1SZ3 | C phase |
| 440 VAC power circuits | | |
| | 1SZ4 | A phase |
| | 1SZ5 | B phase |
| | 1SZ6 | C phase |
| 220 VAC and all other power circuits | | |
| | 1SZ7 | A phase |
| | 1SZ8 | B phase |
| | 1SZ9 | C phase |

(g) A final digit of "0" indicates a ground connection, the basic ground being indicated by "10". (Single "0" not used)

(h) Synchro functions:

Low speed stator leads are:

| | | |
|---|---|---|
| | 21SZ1 | S1 lead |
| | 21SZ2 | S2 lead |
| | 21SZ3 | S3 lead |

High speed stator leads are:

| | |
|---|---|
| 21SZ4 | S1 lead |
| 21SZ5 | S2 lead |
| 21SZ6 | S3 lead |

Any other stator leads are:

| | |
|---|---|
| 21SZ7 | S1 lead |
| 21SZ8 | S2 lead |
| 21SZ9 | S3 lead |

Rotor excitation is:

| | |
|---|---|
| 21SZ10 | R1 |
| 21SZZ10 | R2 |

NOTE

This is not confused with the ground notation because the part (b) indicates a synchro function.

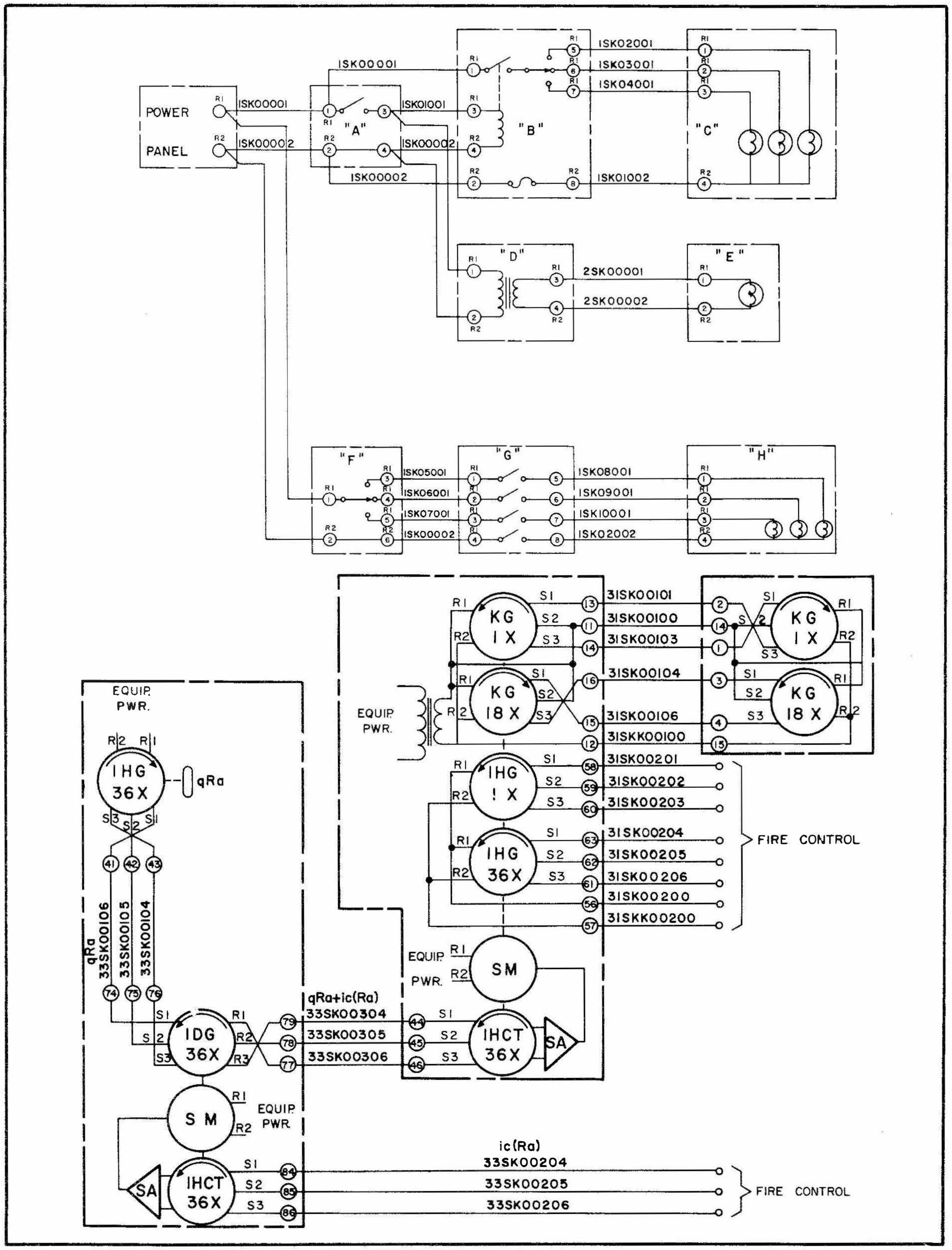



Figure 25-6. Wire Designation Examples.

**4-26. SOLDER LUG TERMINALS.**—This sub-section describes and illustrates the method of soldering lug terminals in cases where the soldered type lug terminals are used in lieu of crimp type lug terminals.

a. LUG TERMINAL SELECTION.—Lug terminals, of the solder type, used for termination of wires in electronic installation shall be of the approved types. The two hole types will be used where there is the possibility of a short or ground caused by twisting or shifting of the lug terminal. The type of lug terminal used in the installation shall properly fit the terminals. Selection of the proper type and size of lug terminal required is governed by the following information:

(1) CONDUCTOR SIZE.—A lug terminal used for termination of a wire must fit the conductor in order to provide the proper mechanical and electrical termination.

(2) TONGUE SHAPE.—The terminal or stud to which the lug terminal is connected and physical location of this connection will govern the selection of the proper tongue shape required for each particular case.

(3) STUD SIZE.—The lug terminal shall be of the proper size to fit the terminal stud in order to provide the proper mechanical and electrical termination.

(4) STUD TYPE.—The type and location of the terminal stud will govern the shape of the required lug terminal. When the above information is available, the proper lug terminal can be selected from the tables and illustrations shown in figures 26—5 through 26—10.

b. WIRE PREPARATION.—The wire ends must be properly prepared before soldering the lug terminal in place. The wire end is prepared as follows:

STEP 1.—Slip the vinyl wire marker over the wire end and position it where it will not interfere with the stripping operation. This will identify the wire with the associated terminal.

STEP 2.—Cut the wire to the proper length for termination and connection to the terminal (allow sufficient length to reterminate three times).

STEP 3.—Remove the insulation from the conductor (using approved type wire strippers). The length of insulation to be removed will vary with the diffierent types of lug terminals in use. The stripped length should equal the length of the soldering area of the lug terminal except when a solder barrel type lug terminal is used. In this case, an additional 1/16 inch of insulation shall be removed to permit inspection of the soldered connection.

**CAUTION**

Do not nick or otherwise damage the conductor during the stripping operation. Any damage at this time will weaken the conductor and introduce the possibility of conductor breakage during handling.

STEP 4.—Clean and tin the exposed conductor if not already tinned. Tin only the length necessary to complete the soldered connection.

c. LUG TERMINAL SOLDERING.—The soldering iron or other heating apparatus shall be of sufficient size or capacity to quickly heat the lug terminal and conductor to the melting point of the solder. Overheating the conductor will damage the wire insulation and insufficient heat will produce a poor soldered connection.

(1) LUG TERMINAL TYPES.—The lugs illustrated in figures 26—5 through 26—10 are the 28 types of solder lug terminals approved for use in electrical installations. There are only three basic methods of soldering required to cover the installation of all 28 types of lug terminals. These methods of soldering are as follows:

(a) FOLDOVER LUG TERMINAL.—The foldover type of lug terminal is installed on the conductor as follows (see figure 26—1 and 26—2):

STEP 1.—Place the tinned conductor under the tabs and, using a pair of pliers, press the tabs against the conductor to make a firm mechanical connection.

STEP 2.—Heat the lug terminal and conductor until they will melt the solder. Flow enough solder to completely cover the conductor and fill the space around it. Do not use an excessive amount of solder.

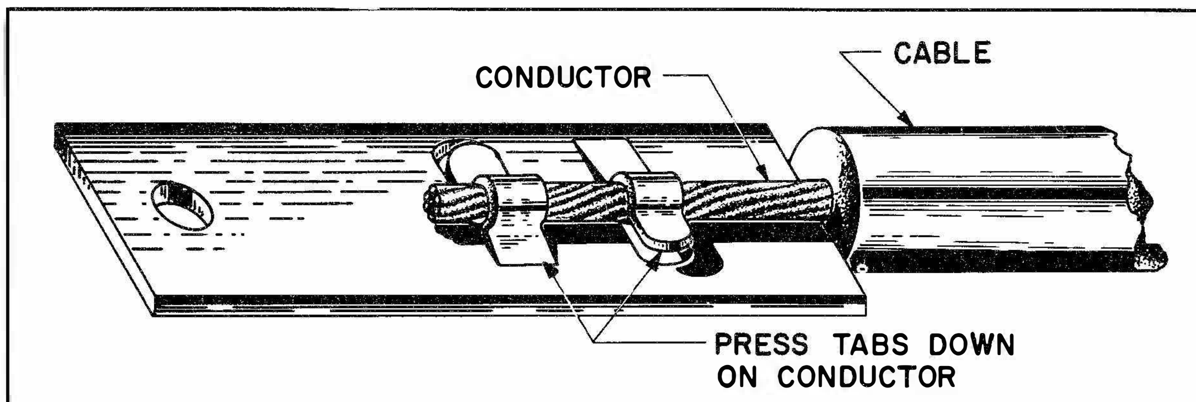



**FIGURE 26—1 Foldover Lug Terminal**

**CAUTION**

Do not use excessive pressure to complete the mechanical bond. Excessive pressure will deform and weaken the the conductor and lug terminal.

(b) EYELET LUG TERMINAL.—The eyelet type of lug terminal is installed on the conductor as follows (see figure 26–3).

STEP 1.—Pass the conductor through the eye and bend back at least 1/2 and not more than 3/4 of a turn.

STEP 2.—Apply pressure (with pliers) to the conductor on both sides of the lug terminal until the conductor and lug terminal are joined in a firm mechanical bond.

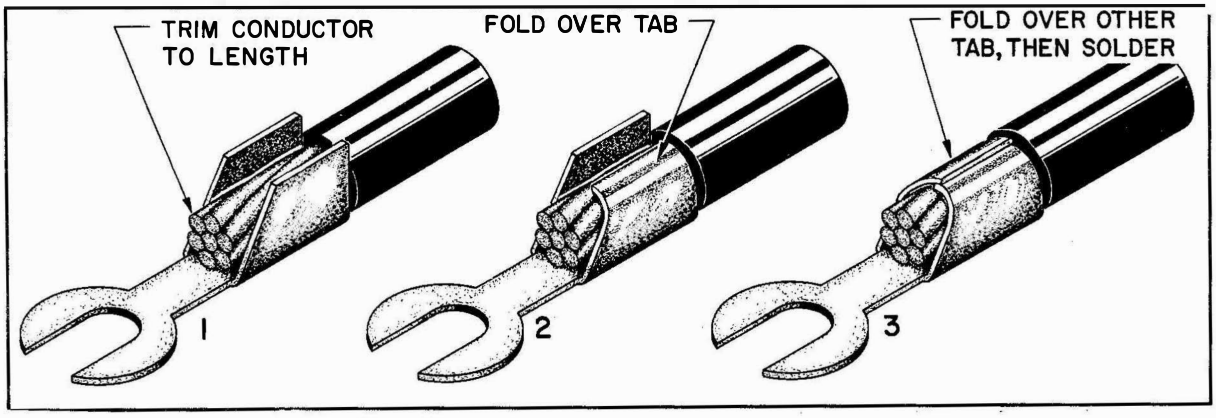



**FIGURE 26–2 Foldover Lug Terminal**

STEP 3.—Heat the lug terminal and conductor until they will melt the solder. Flow enough solder to completely cover the conductor and the space around it. Do not use an excessive amount of solder.

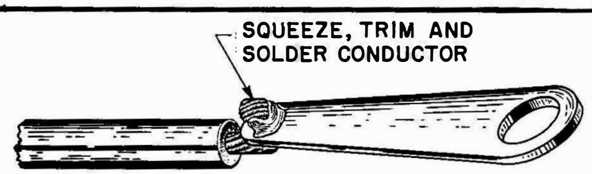



**FIGURE 26-3 One Hole Flat Lug Terminal**

(c) TUBULAR LUG TERMINAL.—The tubular type terminal is installed on the conductor as follows (see figure 26–4):

STEP 1.—Apply heat to the side of the lug terminal barrel and melt sufficient solder to fill the barrel approximately 1/4 full.

STEP 2.—Insert the tinned end of the conductor carefully into the barrel (with heat still applied) until the conductor bottoms in the barrel. Continue the heat application until the conductor has reached the temperature required to melt solder.

**CAUTION**

Do not use excessive heat for the soldering operation. Excessive heat will char or otherwise damage the wire insulation.

STEP 3.—Inspect the junction between the lug terminal barrel and the conductor. If solder is not visible add a sufficient amount to bring the solder level up to the top of the barrel.

**NOTE**

Do not add excessive solder to the connection. This will cause wicking of the solder along the conductor with a resultant stiffening of the conductor which will increase the possibility of breakage when subject to vibration.

STEP 4.—Remove the heat and hold the joint steady until it has cooled sufficiently to allow the solder to solidify.

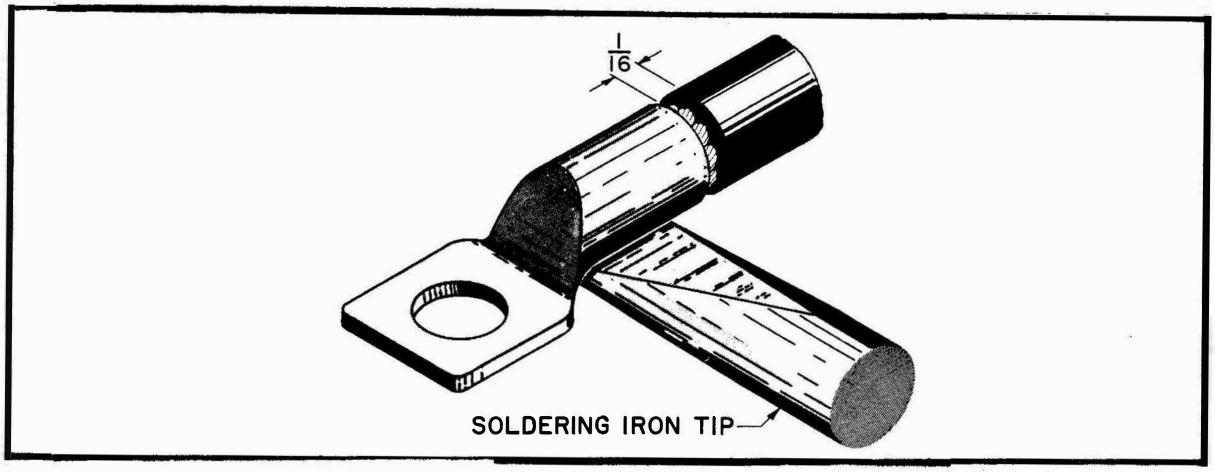



**FIGURE 26–4 Soldering Tubular Lug Terminals**

d. INSPECTION.–Every soldered connection shall be examined for proper completion as follows:

(1) The soldered connection shall be clean, shiny and smooth.

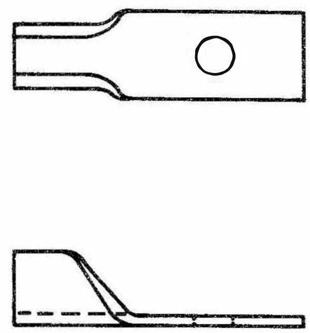
(2) The outline of the conductor and lug terminal shall be visible in the connection.

(3) There shall be no evidence of charring, burning or other damage caused by application of heat during the soldering operation.

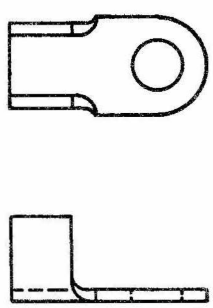
(4) There shall be no excessive solder or flux on the connection or any splattered solder or flux on adjacent connections or parts.

(5) There shall be no evidence of wicking in stranded conductors.

| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 14-20 | 2 |
| | 4 |
| | 6 |
| | 8 |
| | 10 |
| 10-12 | 4 |
| | 6 |
| | 8 |
| | 10 |
| 6-8 | 6 |
| | 8 |
| | 10 |
| 14-20 | 6 |

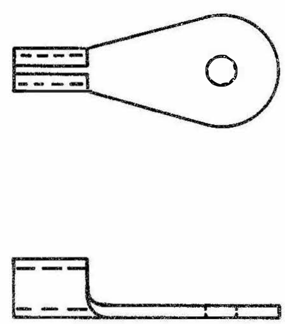


| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 6 |
| | |
| | 10 |



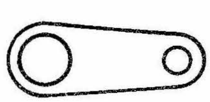
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 1-2 | 1/4 |
| | 5/16 |
| | 3/8 |
| 0-00 | 5/16 |
| | 3/8 |
| 10 | 10 |

Copper Stamping, One Hole



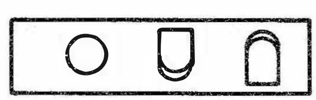
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 4 |
| | 10 |

Copper Stamping, One Hole



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 12 | 4 |
| | 6 |
| | 8 |
| | 10 |

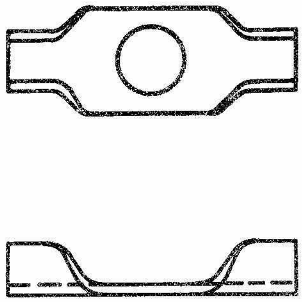
Copper Stamping, One Hole, Flat



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 6 | 6 |

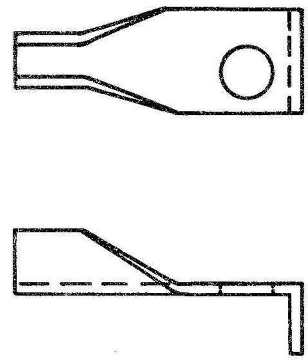
Copper Stamping, One Hole, Flat, Slitted

FIGURE 26-5 Solder Type Lug Terminals



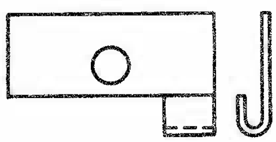
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 8 | 10 |

Stamping, One Hole, Center Mounting

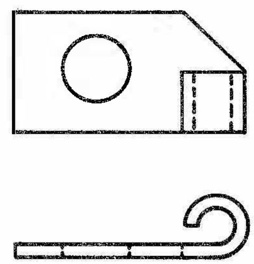


| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 4 |
| 12 | 6 |

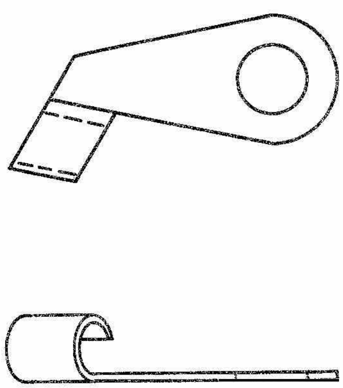
Stamping, One Hole, Locating Lip



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 6 |

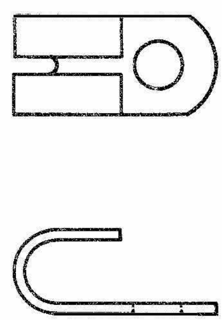


| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 10 |



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 8 | 10 |

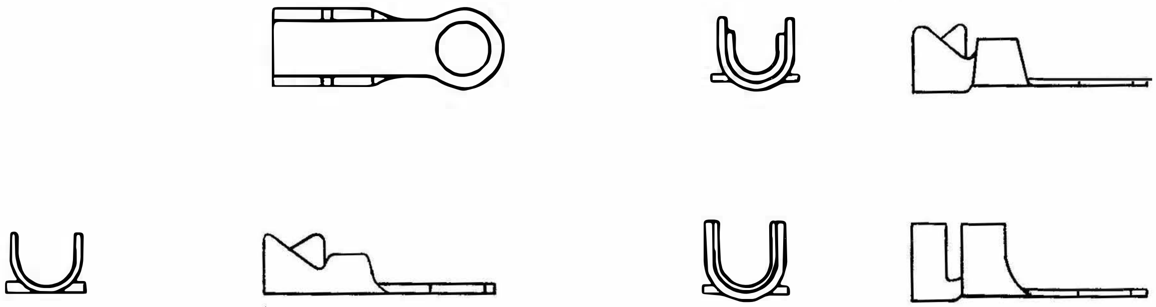
Copper Stamping, One Hole, Flag



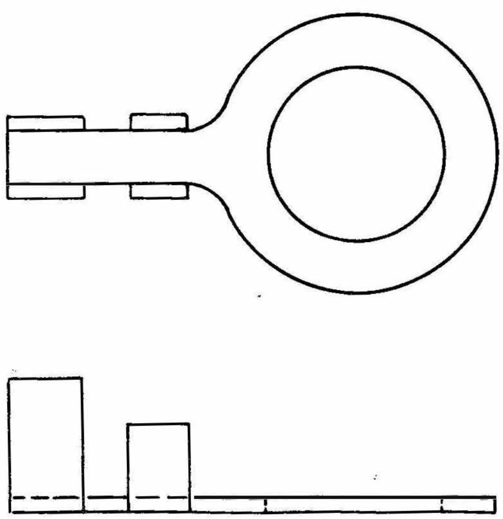
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 12-16 | 8 |
| | 10 |
| | 12 |
| 8-10 | 10 |
| | 1/4 |
| 1 | 3/8 |
| | 1/2 |
| 0-00 | 3/8 |
| | 1/2 |

Copper Stamping, One Hole, Flag

FIGURE 26-6 Solder Type Lug Terminals (con.)



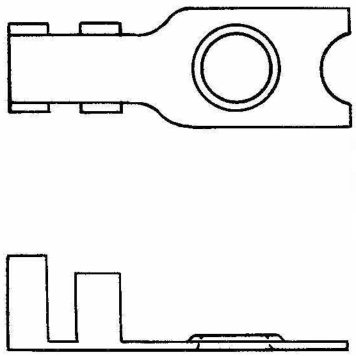
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STUD SIZE | 1/4 | 5/16 | 4 | 6 | 8 | 10 | 1/4 | 5/16 | 3/8 | 8 | 10 | 1/4 | 5/16 | 3/8 | 7/16 | 1/2 | 10 | 1/4 | 5/16 | 3/8 | 7/16 | 10 | 1/4 | 5/16 | 3/8 | 7/16 | 1/2 | 3/8 | 1/2 |
| WIRE SIZE AWG NOM | 18-20 | | 14-16 | | | | | | | 10-12 | | | | | | | 8 | | | | | 4-6 | | | | | | 0-1 | |



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 6 |
| 8 | 8 |
| | 10 |
| | 3/8 |
| 6 | 6 |
| | 8 |
| | 10 |
| | 1/4 |
| 4 | 6 |
| | 8 |
| | 10 |
| | 1/4 |

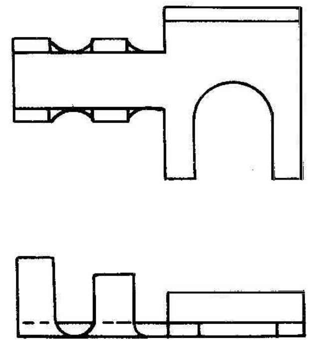
Copper Stamping, Insulation Grip, One Hole

FIGURE 26-7 Solder Type Lug Terminals (con.)



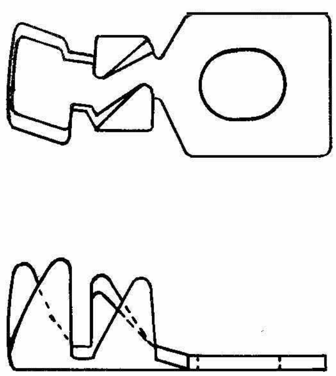
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 6 |
| | 8 |
| 8 | 6 |

Insulation Grip, One Hole, Locating



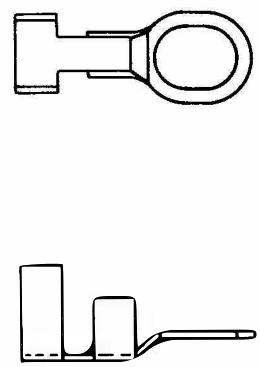
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 8 |

Insulation Grip, Slotted, Flag



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 20 | 2 |
| 18 | 6 |

Insulation Grip, Elongated Hole



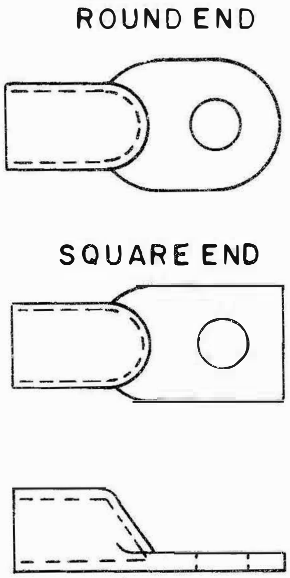
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 12 | 6 |

Insulation Grip, Elongated Hole


| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 16 | 6 |
| 14–16 | 8, 10, 1/4, 5/16, 3/8 |
| 12-14 | 8, 10 |
| 10-12 | 1/4, 5/16 |
| 8 | 10, 3/8, 1/2 |
| 6–8 | 10, 12, 1/4, 5/16, 3/8 |
| 2 | 1/4, 3/8, 5/16, 1/2 |
| 1 | 3/8 |

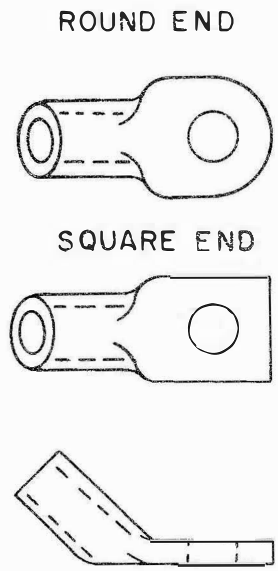
Insulation Grip, One Hole, Flag

FIGURE 26–8 Solder Type Lug Terminals (con.)



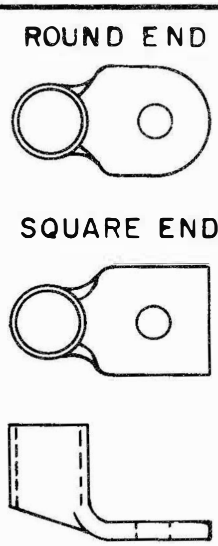

| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 8 |
| 8 | 10 |
| 6 | |
| 4 | 1/4 |
| 2 | |
| 0 | 5/16 |
| 00 | 3/8 |
| 000 | |
| 0000 | |
| 250MCM | |

Copper Tubing, One Hole



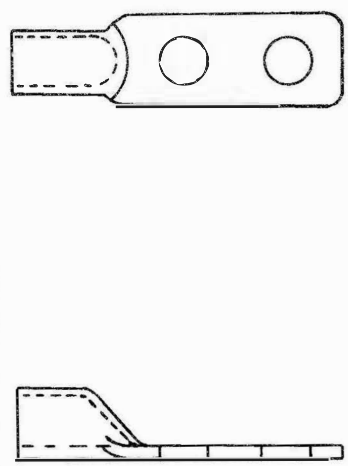

| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 8 |
| 8 | 10 |
| 6 | |
| 4 | 1/4 |
| 2 | |
| 0 | 5/16 |
| 00 | 3/8 |
| 000 | |
| 0000 | |
| 250MCM | |

Copper Tubing, One Hole, 45°




| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 8 |
| 8 | 10 |
| 6 | |
| 4 | 1/4 |
| 2 | |
| 0 | 5/16 |
| 00 | 3/8 |
| 000 | |
| 0000 | |
| 250MCM | |

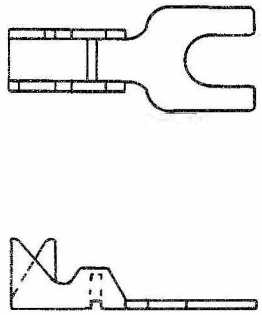
Copper Tubing, One Hole, 90°



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 6 |
| 8 | 8 |
| 6 | 10 |
| 4 | 12 |
| 2 | 1/4 |
| 0 | 5/16 |
| 00 | 3/8 |
| 000 | |
| 0000 | |
| 250MCM | 1/2 |

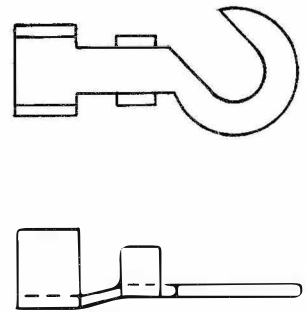
Copper Tubing, Two Hole

FIGURE 26-9 Solder Type Lug Terminals (con.)



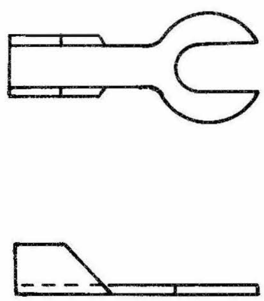
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 12 | 10 |
| 10 | 6 |
| 8 | 10 |

Insulation Grip, Slotted



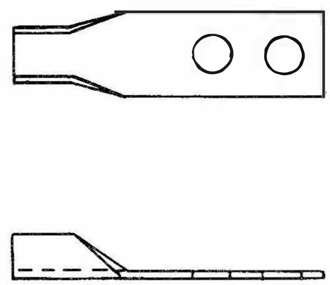
| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 4 | 5/16 |

Insulation Grip, Slotted 45°



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 12 | 4 |

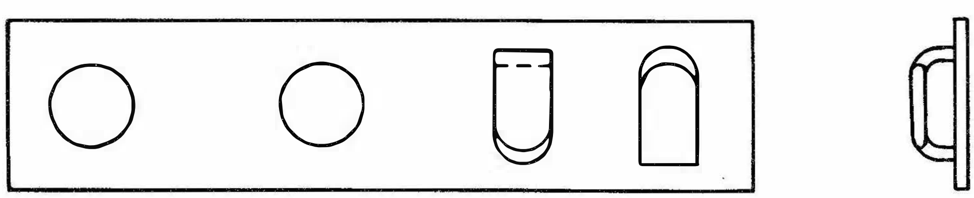
Copper Stamping, Slotted



| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 10 | 8 |
| | 10 |

Copper Stamping, Two Hole

| WIRE SIZE AWG NOM | STUD SIZE |
|---|---|
| 6 | 8 |
| | 10 |



Copper Stamping, Two Hole, Flat, Slitted

FIGURE 26-10 Solder Type Lug Terminals (con.)

**4-27. CRIMP LUG TERMINALS.**-This sub-section describes and illustrates the types of approved crimp lug terminals, the methods of installation and the crimping tools used for termination of interconnection cable wiring. It covers the crimping tools and types of lug terminals required for termination of wires with conductor sizes ranging from #26 AWG to #10 AWG.

a. LUG TERMINALS, CRIMP TYPE.-Lug terminals approved for use in electronic installations are available in the types listed as follows:

(1) WT AND WTG.-These two types of lug terminals are uninsulated and identical in sizes and tongue shapes. The WTG type has an insulation grip added to the closed end barrel to water seal the wire when the lug terminal is crimped.

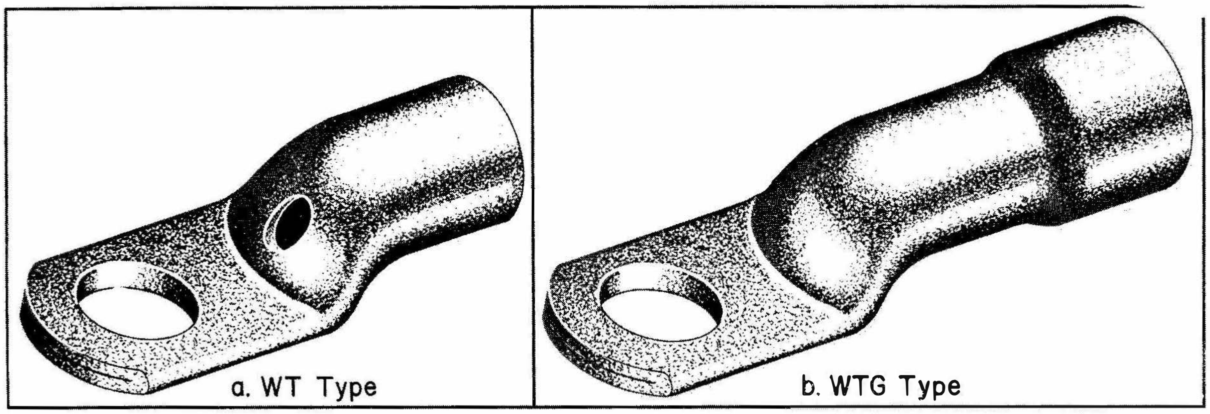



Figure 27-1. Lug Terminals, WT and WTG

The WT and WTG lug terminals are available in the following tongue shapes:

(a) SQUARE TONGUE WITH ONE BOLT HOLE.-The various square tongue shapes are shown in figure 27-2 and the sizes are tabulated in table 27-1.

(b) SQUARE TONGUE WITH BOSS REINFORCING AT THE BOLT HOLE (See table II).

(c) TONGUE FOR FLAG TERMINAL (See table 27-3).

(d) ROUND OR ROUNDED TONGUE, ONE BOLT HOLE (See table 27-4).

(e) SQUARE TONGUE, SPECIAL APPLICATION (See table 27-5).

(f) SQUARE TONGUE, TWO BOLT HOLES (See table 27-6).

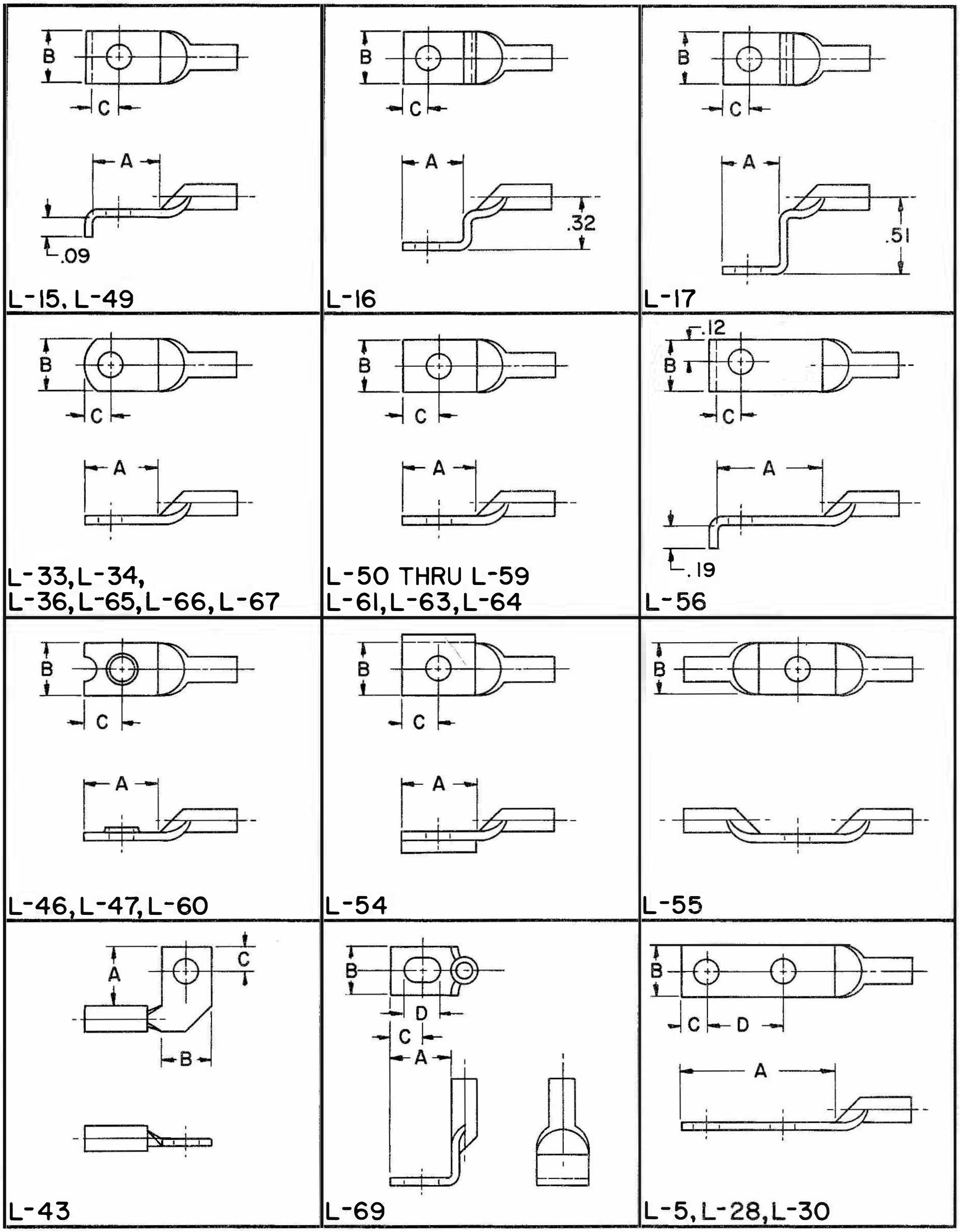



FIGURE 2 WT and WTG Lug Terminal Tongue Shapes

TABLE 27-1. WT AND WTG, SQUARE TONGUE, ONE BOLT HOLE.

| TONGUE SHAPE | A | B | C | HOLE SIZE | STUD SIZE | SEE NOTE # |
|---|---|---|---|---|---|---|
| L-15 | 15/32 | 5/16 | 5/32 | 0.169 | 8 | 1,2 |
| L-16 | 13/32 | 5/16 | 5/32 | 0.169 | 8 | 2 |
| L-17 | 11/32 | 5/16 | 5/32 | 0.169 | 8 | 2 |
| L-49 | 3/8 | 1/4 | 0.183 | 13x.2 | 5 | 3 |
| L-50 | 21/32 | 15/32 | 21/64 | 0.255 | 1/4 | -- |
| L-51 | 21/32 | 7/16 | 21/64 | 0.221 | 12 | -- |
| L-52 | 31/32 | 3/8 | 9/32 | 0.169 | 8 | -- |
| L-53 | 7/16 | 5/16 | 7/32 | 0.143 | 6 | -- |
| L-54 | 11/32 | 5/16 | 1/8 | 0.143 | 6 | 4 |
| L-55 | ----- | 5/16 | ---- | 0.143 | 6 | 5 |
| L-56 | 21/32 | 5/16 | 1/8 | 0.143 | 6 | 6 |
| L-57 | 5/16 | 0.234 | 0.117 | 0.128 | 5 | -- |
| L-58 | 1/4 | 0.218 | 0.117 | 0.117 | 4 | -- |
| L-59 | 3/8 | 1/4 | 3/16 | 0.143 | 6 | -- |
| L-61 | 1/2 | 5/16 | 1/4 | 0.169 | 8 | -- |
| L-63 | 1/2 | 5/16 | 1/4 | 0.195 | 10 | -- |
| L-64 | 21/32 | 3/8 | 21/64 | 0.221 | 12 | -- |

NOTE 1.

L-15 has a 3/32 inch lip at the tongue end.

NOTE 2.

L-15, 16 and 17 can be mounted on the same stud with a distance between axes of barrels 9/64 inch minimum, 15/64 inch maximum.

NOTE 3.

L-49 has a 3/32 inch lip at the tongue end for mounting three lug terminals to the same stud.

NOTE 4.

L-54 has a 3/32 inch lip on the left side looking over the tongue toward the barrel.

NOTE 5.

L-55 is the equivalent of two L-53 terminals with barrels at opposite ends and bolt hole concentric.

NOTE 6.

L-56 has a 3/16 inch lip on the end, with a stud hole 1/8 inch from the edge of the left side, looking over the tongue toward the barrel.

TABLE 27-2. WT AND WTG, SQUARE TONGUE, BOSS REINFORCED

| TONGUE SHAPE | A | B | C | D | E | F | HOLE SIZE | STUD SIZE |
|---|---|---|---|---|---|---|---|---|
| L-46 | 19/32 | 5/16 | 11/32 | 1/16 | 0.084 | 7/32 | 0.169 | 8 |
| L-47 | 7/16 | 1/4 | 3/16 | ---- | 3/64 | 0.148 | 0.148 | 6 |
| L-60 | 23/32 | 5/16 | 11/32 | ---- | 3/64 | ----- | 0.169 | 8 |

NOTE

L-60 has a 1/16 inch lip on the tongue end.

TABLE 27-3. WT AND WTG FOR FLAG TERMINAL

| TONGUE SHAPE | A | B | C | HOLE SIZE | STUD SIZE |
|---|---|---|---|---|---|
| L-43 | 1/2 | 3/8 | 1/4 | 0.169 | 8 |

NOTE

L-43 can be used either right or left hand by inverting the lug terminal.

TABLE 27-4. WT AND WTG, ROUND TONGUE, ONE BOLT HOLE

| TONGUE SHAPE | A | B | C | HOLE SIZE | STUD SIZE |
|---|---|---|---|---|---|
| L-33 | 5/16 | 1/4 | 1/8 | 0.149 | 6 |
| L-34 | 3/8 | 3/8 | 3/16 | 0.203 | 10 |
| L-36 | 11/32 | 5/16 | 5/32 | 0.192 | 10 |
| L-65 | 21/32 | 1/2 | 1/4 | 0.318 | 5/16 |
| L-66 | 3/4 | 19/32 | 19/64 | 0.380 | 3/8 |
| L-67 | 1.0 | 23/32 | 23/64 | 0.505 | 1/2 |

TABLE 27-5. WT AND WTG. SQUARE TONGUE, SPECIAL APPLICATION

| TONGUE SHAPE | A | B | C | D | STUD SIZE |
|---|---|---|---|---|---|
| L-69 | 1/4 | 7/32 | 7/64 | 0.152 | 8 |

TABLE 27-6. WT AND WTG, SQUARE TONGUE, TWO BOLT HOLES

| TONGUE SHAPE | A | B | C | D | HOLE SIZE | STUD SIZE |
|---|---|---|---|---|---|---|
| L-5 | 1-3/4 | 3/8 | 3/16 | 7/8 | 0.173 | 8 |
| L-28 | 7/8 | 3/8 | 3/16 | 5/16 | 0.187 | 8 |
| L-30 | 1-1/8 | 3/8 | 3/16 | 1/2 | 0.187 | 8 |

(2) TYPE I.-An uninsulated lug terminal similar to the WTG round tongue, one bolt hole type. The available sizes are listed in table 27-8.

(3) TYPE II.-A lug terminal of the same basic construction as Type I with the addition of a color coded insulation sleeve around the barrel. The available sizes are listed on table 27-9.

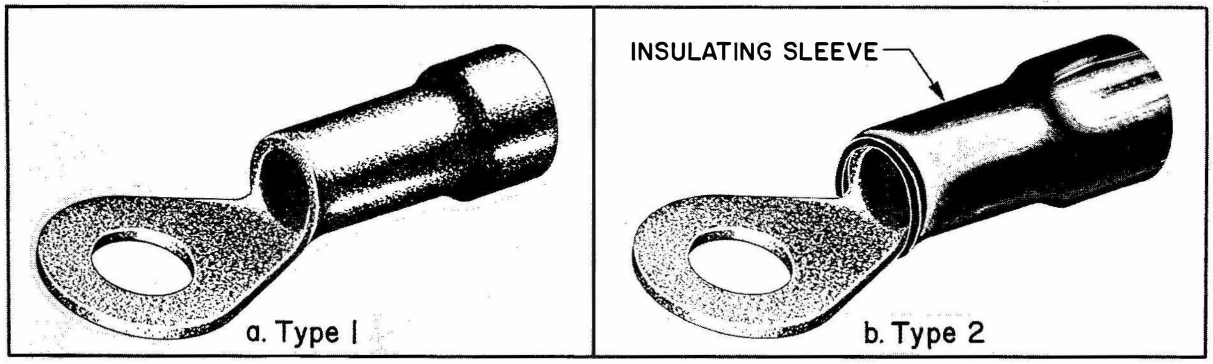



Figure 27-3. Lug Terminals, Type I and II

b. LUG SIZE IDENTIFICATION.- The crimp lug terminals are identified by a molded or stamped indication of the AN/MIL wire size, or range of wire sizes, that can be accommodated in the lug terminal. The manufacturer's trade mark is also included in this marking. The Type II lug terminals are further identified as to size or range by the color of the barrel insulation sleeve. Table 27-7 lists the installation data for the WT, WTG and WTT type lug terminals. Tables 27-8 and 27-9 list the data for Type I and II lug terminals. The standard size marking for lug terminals is indicated by the following two methods:

(1) ONE NUMERAL GROUP.-One group of numerals indicating the approximate size of the conductor, in thousands of circular mils, which the lug terminal will accommodate.

(2) TWO NUMERAL GROUPS.-Two groups of numerals (separated by a hyphen) indicating a range of conductor sizes, in thousands of circular mils, which the lug terminals will accommodate.

EXAMPLE 1.-"14." This would identify a lug terminal which would accommodate a conductor size of approximately 14,000 circular mils.

EXAMPLE 2.-"2-1/2-5." This would identify a lug terminal which would accommodate a range of conductor sizes from 2500 to 5000 circular mils.

c. WIRE SIZE IDENTIFICATION.-Standard Navy wire sizes are identified by a series of numbers which indicate the following information:

(1) CIRCULAR MIL AREA.-The approximate circular mil area of the conductor in thousands of circular mils.

(2) CONDUCTOR STRANDS.-The number of individual strands used to make up the conductor.

(3) AWG SIZE.-The approximate AWG size (This is used only in the smaller conductor sizes).

EXAMPLE 1.-"2/5 (1)-24". This would identify a conductor with an approximate circular mil area of 2/5 x 1000 or 400 circular mils, a one strand conductor and approximately number 24 AWG.

EXAMPLE 2.-"2-1/2 (26)". This would identify a conductor with an approximate circular mil area of 2-1/2 x 1000 or 2500 circular mils made up with 26 strands.

d. GENERAL PRECAUTIONS.-The crimping tools and crimp type lug terminals in general use are furnished by various manufacturers and the tools will not always complete a crimp on all types of lug terminals. The tool must be properly adjusted and the right size die set or nest used for crimping each size lug terminal.

(1) LUG TERMINAL SIZE.-The lug terminal must be selected to properly fit the conductor to which it will be attached.

(2) INSULATION LENGTH.-The wire insulation must be stripped to the correct length to insure that the conductor will bottom in the lug terminal and the insulation grip (if that type lug terminal is used) has the maximum length of grip on the insulation. The recommended insulation stripping lengths are listed in table 27-10. If the lug terminal is provided with an inspection hole at the bottom of the barrel, a visual inspection must be made to see whether the conductor is fully bottomed in the barrel before the crimp is completed.

TABLE 27-7. WTT, WT AND WTG LUG TERMINAL DATA

| LUG TYPE | IDENT. ON LUG TERM. | STD NAVY WIRE SIZE DESIG. | NOM. SIZE (CM) | DIA (IN.) OVER COPPER | NEAREST EQUIV. AWG. SIZE | NAVY CABLE TYPE |
|---|---|---|---|---|---|---|
| | | 1/5(1)-26 | 254 | 0.0159 | 26 | |
| | | 1/5(7)-26 | 280 | 0.0162 | 26 | |
| | | 2/5(1)-24 | 404 | 0.020 | 24 | |
| WTT | 1/2 | 2/5(7)-24 | 442 | 0.025 | 22 | |
| | | 1/2(21) | 525 | 0.028 | 21 | |
| | | 3/5(1) | 642 | 0.025 | 22 | |
| | | 3/5(7) | 700 | 0.030 | 20 | TTHFWA |
| | | 1 (1) | 1022 | 0.032 | 20 | |
| | | 1 (7) | 1020 | 0.039 | 18 | |
| | | 1 (10) | 1005 | 0.038 | 18 | TTRSA |
| WT | | 1 1/2 (1) | 1624 | 0.040 | 18 | |
| & | 1-2 | 1 1/2 (7) | 1624 | 0.049 | 16 | |
| WTG | | 1 1/2 (16) | 1608 | 0.049 | 16 | MCOS |
| | | 1 1/2 (41) | 1630 | 0.049 | 16 | |
| | | 2 (7) | 1779 | 0.048 | 16 | MSCA |
| | | 2 1/2 (1) | 2583 | 0.051 | 16 | |
| | | 2 1/2 (19) | 2407 | 0.060 | 15 | |
| | | 2 1/2 (26) | 2613 | 0.061 | 14 | MHFF |
| WT | 2 1/2-4 | 3 (7) | 2828 | 0.060 | 15 | MHFA |
| & | | 4 (1) | 4107 | 0.064 | 14 | |
| WTG | | 4 (19) | 3828 | 0.072 | 13 | |
| | | 4 (7) | 4497 | 0.076 | 12 | S, D, THFR |
| | | 4 (41) | 4121 | 0.077 | 12 | |
| | | 6 (7) | 6512 | 0.092 | 11 | |
| WT | 6-9 | 6 (19) | 6088 | 0.090 | 11 | |
| & | | 9 (7) | 9016 | 0.108 | 10 | |
| WTG | | 9 (37) | 9402 | 0.109 | 9 | |

TABLE 27-8. TYPE I LUG TERMINAL INSTALLATION DATA

| DASH # | WIRE SIZE (AN) | TONGUE WIDTH | OVERALL LENGTH | STUD SIZE |
|---|---|---|---|---|
| -38 | 22-20-18 | 0.256 | 0.893 | 4 |
| -1 | 22-20-18 | 0.281 | 0.906 | 6 |
| -2 | 22-20-18 | 0.343 | 0.969 | 10 |
| -25 | 22-20-18 | 0.687 | 1.312 | 3/8 |
| -39 | 17-14 | 0.256 | 0.969 | 4 |
| -3 | 16-14 | 0.343 | 0.969 | 6 |
| -26 | 16-14 | 0.256 | 0.969 | 6 |
| -4 | 16-14 | 0.343 | 0.969 | 10 |
| -27 | 16-14 | 0.687 | 1.312 | 3/8 |
| -5 | 12-10 | 0.406 | 0.969 | 10 |
| -6 | 12-10 | 0.562 | 1.125 | 5/16 |
| -25 | 12-10 | 0.598 | 1.281 | 3/8 |

NOTE

Lug terminals for the wire size #22 to #14 are furnished with an insulation grip. The lug terminal for the wire size range #12 to #10 is furnished with a straight barrel only.

(3) STRANDED CONDUCTORS.- All strands of stranded conductors must enter the barrel of the lug terminal before crimping.

(4) OVER-CRIMPING.- Do not over-crimp the lug terminal onto the conductor. Over-crimping will cause the metal of the conductor to flow out of the barrel of the lug terminal and will materially decrease the current carrying capacity of the connection.

(5) RATCHET TOOLS.- All approved types of crimping tools are equipped with a selflocking ratchet device which prevents the release of crimping pressure on the lug terminal until the crimp has been satisfactorily completed. If this ratchet device is disabled, the tool should not be used for the crimping operation.

e. CRIMP LUG TERMINAL INSTALLATIONS.- All of the crimping operation details are dependent on the types of crimping tools available and the type and size of lug terminals required for the termination of the interconnection wires. Most of the crimping tools require checks for correct adjustment of the dies before the crimp can be properly completed. Crimping tool adjustment checks, operation of crimping tools, and operational tests on the crimped connections are as follows:

(1) STANDARD TOOL MS 25037.- This crimping tool is identical to the Thomas and Betts WT-145 and was designed for use with the Type II lug terminals for wire sizes #22 through #10 AWG.

(a) DIE NESTS.- The standard tool (MS 25037) is equipped with a color coded double nest of dies. Lug terminals fitting conductor sizes #12 and #10 AWG are crimped in the yellow coded nest and those fitting conductor sizes #22 to #18 and #16 to #14 AWG are crimped in the die nest color coded red and blue.

(b) DIE CHECKS.- The crimping tool is properly adjusted for use when a #36 (0.106) drill cannot enter the smaller (red and blue) nest when the dies are completely closed.

(c) INSTALLATION.- All of the Type II preinsulated lug terminals in the #22 to #10 AWG conductor size range are crimped with the standard tool as follows:

STEP 1.- Strip the wire insulation from the conductor (see table 27-10).

STEP 2.- Insert the lug terminal, tongue first, into the crimping tool nest.

STEP 3.- Squeeze the crimping tool handles slightly together until the dies hold the lug terminal firmly by the barrel.

CAUTION

Do not close the crimping tool dies to the point where the lug terminal will be dented. Denting the lug terminal will prevent insertion of the wire into the barrel.

TABLE 27-9. TYPE II. LUG TERMINAL INSTALLATION DATA

| DASH # | WIRE SIZE (AN) | TONGUE WIDTH | OVERALL LENGTH | STUD SIZE | INSULATION COLOR |
|---|---|---|---|---|---|
| -43 | 26-24 | 0.191 | 0.618 | 2 | Yellow |
| -44 | 26-24 | 0.260 | 0.656 | 4 | Yellow |
| -45 | 26-24 | 0.260 | 0.656 | 6 | Yellow |
| -46 | 26-24 | 0.315 | 0.784 | 8 | Yellow |
| -47 | 26-24 | 0.315 | 0.784 | 10 | Yellow |
| -48 | 22-20-18 | 0.260 | 0.784 | 4 | Red |
| -1 | 22-20-18 | 0.238 | 0.875 | 6 | Red |
| -2 | 22-20-18 | 0.285 | 1.000 | 6 | Red |
| -49 | 22-20-18 | 0.337 | 0.910 | 8 | Red |
| -3 | 22-20-18 | 0.332 | 1.050 | 10 | Red |
| -50 | 22-20-18 | 0.485 | 1.080 | 1/4 | Red |
| -4 | 22-20-18 | 0.488 | 1.250 | 5/16 | Red |
| -5 | 22-20-18 | 0.633 | 1.375 | 3/8 | Red |
| -51 | 22-20-18 | 0.720 | 1.320 | 1/2 | Red |
| -52 | 16-14 | 0.270 | 0.800 | 4 | Blue |
| -6 | 16-14 | 0.270 | 0.875 | 6 | Blue |
| -7 | 16-14 | 0.348 | 1.000 | 6 | Blue |
| -53 | 16-14 | 0.348 | 0.910 | 8 | Blue |
| -8 | 16-14 | 0.348 | 1.050 | 10 | Blue |
| -54 | 16-14 | 0.480 | 1.080 | 1/4 | Blue |
| -9 | 16-14 | 0.488 | 1.250 | 5/16 | Blue |
| -10 | 16-14 | 0.633 | 1.375 | 3/8 | Blue |
| -55 | 16-14 | 0.720 | 1.320 | 1/2 | Blue |
| -11 | 12-10 | 0.395 | 1.172 | 6 | Yellow |
| -56 | 12-10 | 0.395 | 1.155 | 8 | Yellow |
| -12 | 12-10 | 0.395 | 1.172 | 10 | Yellow |
| -57 | 12-10 | 0.540 | 1.300 | 1/4 | Yellow |
| -13 | 12-10 | 0.551 | 1.390 | 5/16 | Yellow |
| -14 | 12-10 | 0.633 | 1.516 | 3/8 | Yellow |
| -58 | 12-10 | 0.720 | 1.415 | 1/2 | Yellow |

TABLE 27-10. WIRE INSULATION STRIPPING LENGTHS

| WIRE SIZE | STRIPPING LENGTH (INCHES) |
|---|---|
| #22 through #14 | 3/16 |
| #12 and #10 | 9/32 |

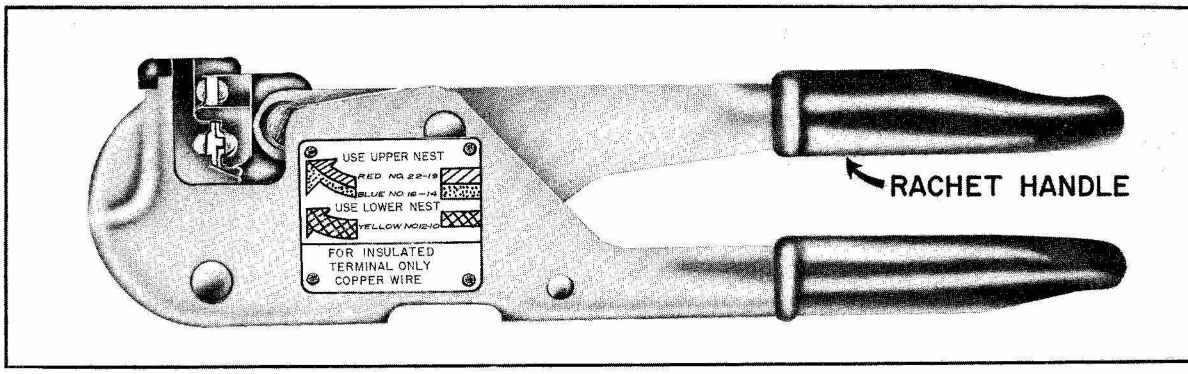



Figure 27-4. -Standard Crimping Tool-MS25037

TABLE 27-11. AMP HAND CRIMPING TOOLS

| WIRE SIZE AWG | UNINSULATED LUG TERMINAL | | PREINSULATED LUG TERMINAL | |
|---|---|---|---|---|
| | TYPE | TOOL# | TYPE | TOOL# |
| 22-16 | A | 49512 | A | 48430 |
| 16-14 | A | 49513 | A | 48431 |
| 12-10 | C | 59054 | C | 59239 |

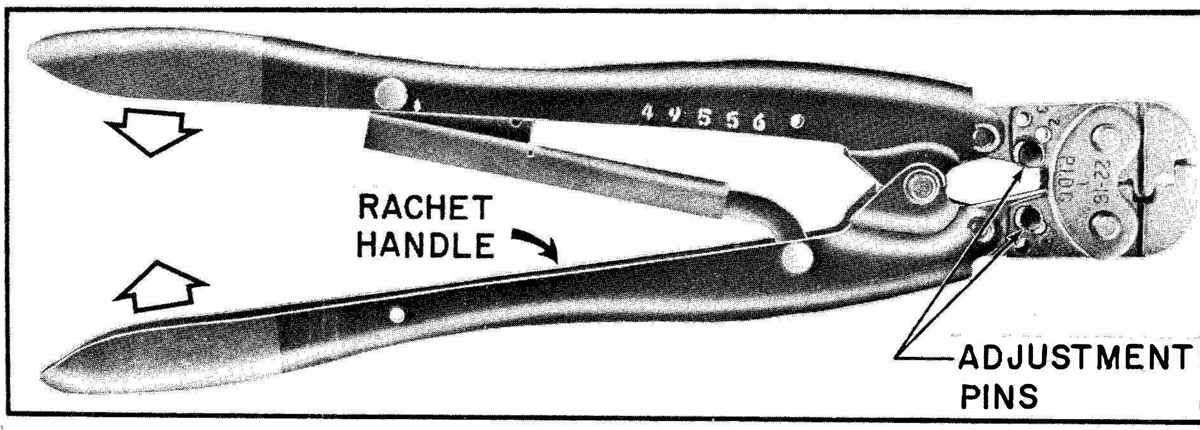



Figure 27-5. AMP Hand Crimping Tool-Type A

STEP 4.-Insert the stripped wire into the lug terminal barrel until the wire insulation is seated in the insulation grip and the conductor is bottomed in the barrel. Make visual check for conductor bottoming if the lug terminal is equipped with an inspection hole.

STEP 5.-Continue the crimping operation until the ratchet releases the pressure on the dies.

STEP 6.-Remove the terminated wire and examine it for proper completion of the crimp (see Crimp Inspection and Test).

(2) AIRCRAFT MARINE PRODUCTS.-The crimping tool available from AMP for installation of lug terminals on conductor sizes from #22 to #10 AWG are listed in table 27-11. The AMP hand crimping tool, Type A tool #49512 or #49513, is illustrated in figure 27-5.

(a) INSULATION GRIP ADJUSTMENT.-The AMP crimping tools are equipped with an insulation grip crimping adjustment. The amount of closing of the insulation grip crimping dies is adjustable by means of one or two pins for various wire insulation thicknesses (see table 27-12 and figure 27-5).

TABLE 27-12. AMP HAND TOOL ADJUSTMENT PIN POSITION

| SIZE OF INSULATION | POSITION OF PIN OR PINS |
|---|---|
| Small | #1 |
| Medium | #2 |
| Large | #3 |

(b) DIE CHECKS.-AMP crimping tools are checked for proper operation with the dies completely closed. The gap between the barrel crimping dies and the gap between the insulation grip crimping dies shall meet the requirements listed in table 27-13.

NOTE

The "GO" gages shall be able to enter between the dies and the "NO GO" gages shall be unable to enter.

TABLE 27-13. AMP HAND CRIMPING TOOL GAGING DIMENSIONS

| TOOL WIRE SIZE RANGE (AWG) | GAGING DIMENSIONS (INCHES) | | | |
|---|---|---|---|---|
| | BARREL GO | CRIMPING DIES NO GO | INSULATION GO | CRIMPING DIES NO GO |
| 22-16 | 0.098 | 0.104 | 0.030 | 0.090 |
| 16-14 | 0.108 | 0.114 | 0.040 | 0.100 |
| 12-10 | 0.139 | 0.145 | 0.064 | 0.139 |

NOTE

When tools are equipped with insulation grip crimping adjustment pins, the "GO" gaging is done with pins in position #1 and the "NO GO" gaging with pins in position #3.

(c) CRIMP SIZE CODE.-The AMP tools impress a code in the crimp area to certify the use of the proper tool for crimping a specific lug terminal size. Table 27-14 lists these codes.

TABLE 27-14. AMP CRIMP SIZE CODES

| LUG TERMINAL SIZE | COLOR | CRIMP SIZE CODE |
|---|---|---|
| 22-18 | Red | Single raised dot |
| 16-14 | Blue | Double raised dot |
| 12-10 | Yellow | Single raised dot |

NOTE

Red lug terminals will not be crimped if the yellow crimping tool is used and it is impossible to insert a yellow lug terminal in the red crimping tool.

(d) INSTALLATION.-When using AMP hand crimping tools, select the proper size tool for the lug terminal size being crimped and set the insulation grip crimp adjustment pins to the correct position in accordance with table 27-12. Be sure that the stop plate is in position for use with lug terminals. The lug terminals are crimped to the wire using the same procedure as used for the standard crimping tool MS 25037.

(3) BURNDY.- THE BURNDY M8ND hand operated crimping tool has an enclosed compact head using easily changed die sets to perform the crimping operation on lug terminals for conductor sizes #26 to #10 AWG. This tool is available in a small, light weight kit complete with die sets for many crimping operations.

(a) DIE SETS.- The die sets used in the Burndy M8ND crimping tool for crimping the WT, WTG and Types I and II lug terminals for conductor sizes ranging from #28 to #10 AWG are listed in table 27-15.

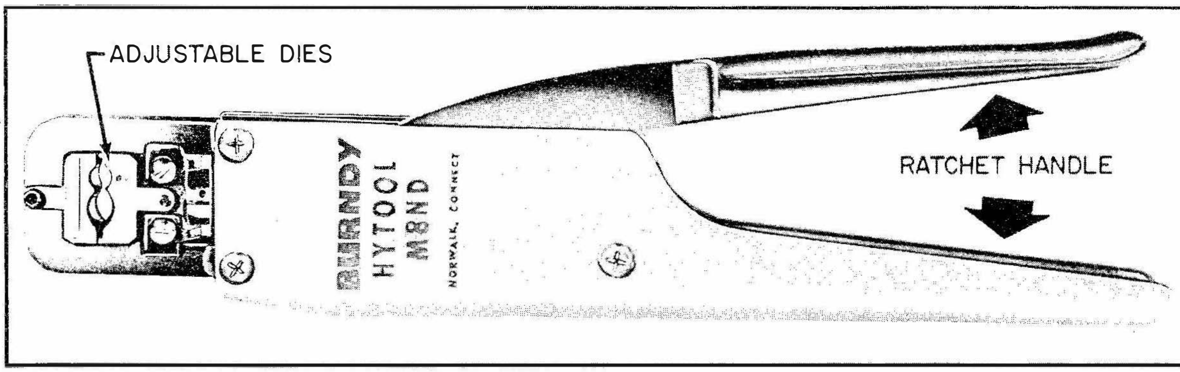



Figure 27-6. Burndy M8ND Hand Crimping Tool

TABLE 27-15. CRIMPING DIE SETS FOR BURNDY M8ND

| WIRE SIZE AWG | LUG TERMINAL TYPES WT | LUG TERMINAL TYPES WTG | LUG TERMINAL TYPES I AND II |
|---|---|---|---|
| 26-22 | ----- | -------- | N22HET -1 |
| 22-18 | N14HT | N14HT | N10ET - 17 |
| 18-16 | N14HT | N14HT | N10ET - 17 |
| 14-12 | N14HT | N14HT | N10ET - 17 |
| 12-10 | N10HT | N10HT | N10ET - 17 |

(b) DIE SET INSTALLATION AND ADJUSTMENT.- The die sets used in the Burndy M8ND are easily changed by the removal and replacement of two Allen head cap screws. The installation and adjustment is effected as follows:

STEP 1.- Select the proper die set matching the lug terminal to be installed on the wire.

STEP 2.- Loosen the Allen head die holder lock screw (use 3/32" Allen wrench) and turn the coupler bushing so that the ram die holder moves to the full open position.

STEP 3.- Place the dies in the tool (stamped lettering on the dies to the front) so that the holding prongs straddle the head and ram. Hand tighten the holding screws in each die.

STEP 4.- Close the tool handles and turn the coupler bushing until the dies are butted. Release the tool handles slightly and turn the coupler bushing 1/4 turn more (toward closing position).

STEP 5.- Remove the lower die and tighten the die holder lock screw. Replace lower die. Operate the tool and check the hand force.

NOTE

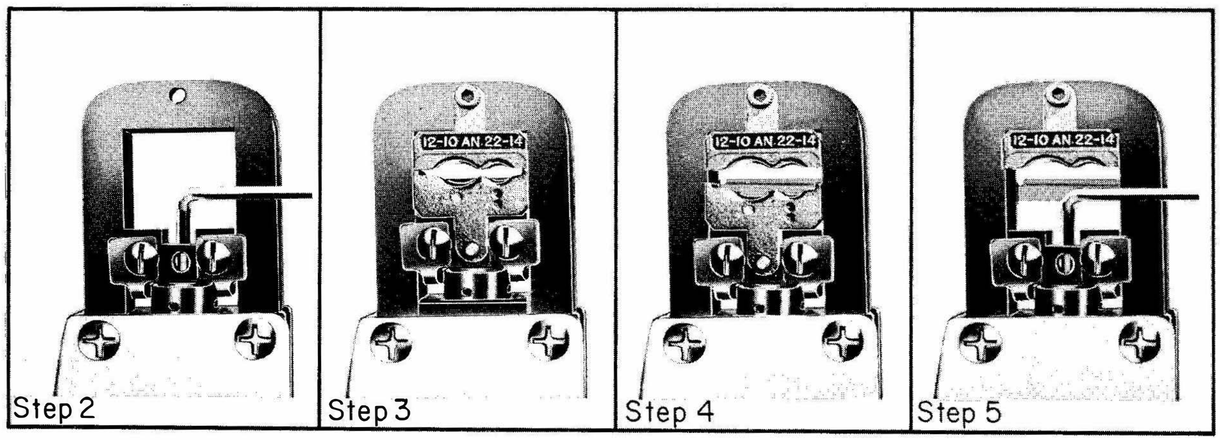
Keep the tool adjusted so that normal handforce (45 to 55 lbs) is required to butt the dies (no lug terminal in place) and release the ratchet.

(c) INSTALLATION.- WT, WTG and Types I and II lug terminals are crimped with the Burndy M8ND crimping tool as follows:

STEP 1.- Strip the wire insulation from the conductor (see table 27-10 for correct stripping lengths).

STEP 2.- Insert the lug terminal, tongue first, into the correct die nest until the barrel butts flush against the tool stop.

STEP 3.-Squeeze the crimping tool handles slowly until the dies hold the lug terminal firmly in place in the nest.




CAUTION

Do not close the crimping tool dies to the point where the lug terminal will be dented. Denting the lug terminal will prevent insertion of the wire into the barrel.

STEP 4.-Insert the stripped wire into the lug terminal barrel until the wire insulation is seated in the insulation grip and the conductor is bottomed in the barrel. Make visual check for conductor bottoming if the lug terminal is equipped with an inspection hole.

STEP 5.-Continue the crimping operation until the ratchet releases the pressure on the dies.

STEP 6.-Remove the terminated wire and examine it for the proper completion of the crimp (see Visual Inspection of Crimped Connections).

(4) VISUAL INSPECTION OF CRIMPED CONNECTIONS.-Examine the crimped connection carefully for the following:

(a) The indent must be centered on the lug terminal barrel.
(b) The indent must be in line with the barrel; not cocked.
(c) The lug terminal barrel must not be cracked.
(d) The lug terminal insulation must not be cracked.
(e) The insulation grip must be fully crimped.

(5) ELECTRICAL AND MECHANICAL TESTS FOR CRIMP TYPE LUG TERMINALS.-If there is any reason to doubt the proper completion of the crimp type connection the following tests may be made:

(a) WT AND WTG ELECTRICAL.-The electrical test shall be conducted on four specimens of the completed crimped connection. The test shall be made when operating at the rated current carrying capacity specified in table 27-16. The voltage drop will be the average readings on four specimens made at the following points:

1. CONDUCTOR TO LUG TERMINAL.-The voltage drop will be the average of several readings between the top of the barrel and several points on the conductor periphery.

2. LUG TERMINAL TO STUD.-This voltage drop will be the average of several readings between the stud and the top of the lug terminal barrel.

3. CONDUCTOR TO STUD.-This voltage drop will be the average of readings from several points on the stud and several points around the conductor periphery.

(b) TYPES I AND II ELECTRICAL.-The electrical test shall be conducted on two lug terminals crimped to two wires of the selected size. The lug terminals shall be securely bolted back to back and suspended in free air with a maximum clearance of 18 inches. Steel bolts, nuts and washers of the appropriate stud size shall be used. The test current, as listed in table 27-17, shall be passed through the assembly and when the temperature of the wire has stabilized, the millivolt drop shall be measured from the intersection of the lug terminal tongue and barrel to the following points on the conductor.

1. LUG TERMINALS, UNINSULATED, WITHOUT INSULATION GRIP.-A minimum of 1/4 inch from the open end of the barrel.

2. LUG TERMINALS, UNINSULATED, WITH INSULATION GRIP.- A minimum of 1/8 inch from the end of the insulation grip.

3. LUG TERMINALS, PREINSULATED.- A minimum of 1/8 inch from the end of the insulation.

(c) WT AND WTG MECHANICAL.- The mechanical test shall be conducted in a standard tensile testing machine. The specimens shall be placed in the machine and sufficient force applied to pull the conductor out of the lug terminal. The test shall be made at room temperature and with a speed of head travel of 1/2 inch per minute. The force, in pounds, required to pull the conductor out of the lug terminal, shall be taken as the pull-out strength of the connection.

(d) TYPES I AND II MECHANICAL.- These types of lug terminals shall be tested in the same manner as the WT and WTG Types except the speed of head travel will be one inch per minute.

TABLE 27-16. TEST DATA FOR WT AND WTG LUG TERMINALS

| LUG TERM. SIZE | NAVY STD. WIRE SIZE DESIG. | MILLIVOLT DROP | | | PULLOUT (MIN) POUNDS | COND. (MAX) AMPS. |
|---|---|---|---|---|---|---|
| | | COND. TO L. T. | L. T. TO STUD | COND. TO STUD | | |
| 1/2 | 1/5(1)-26 | 12 | 1 | 16 | 4 | 1.4 |
| | 1/5(7)-26 | 12 | 1 | 16 | 4 | 1.6 |
| | 2/5(1)-24 | 12 | 1 | 16 | 6 | 2.3 |
| | 2/5(7)-24 | 12 | 1 | 16 | 7 | 2.5 |
| | 1/2(21) | 12 | 1 | 16 | 8 | 3.0 |
| | 3/5(1) | 12 | 1 | 16 | 10 | 4.0 |
| | 3/5(7) | 12 | 1 | 16 | 10 | 4.0 |
| 1-2 | 1(1) | 12 | 1 | 16 | 15 | 7.0 |
| | 1(7) | 12 | 1 | 16 | 16 | 8.0 |
| | 1(10) | 12 | 1 | 16 | 15 | 8.0 |
| | 1-1/2(1) | 12 | 1 | 16 | 24 | 11.0 |
| | 1-1/2(7) | 12 | 1 | 16 | 24 | 11.0 |
| | 1-1/2(16) | 12 | 1 | 16 | 23 | 11.0 |
| | 1-1/2(41) | 12 | 1 | 16 | 24 | 11.0 |
| | 2(7) | 12 | 1 | 16 | 24 | 11.0 |
| 2-1/2-4 | 2-1/2(1) | 12 | 1 | 16 | 40 | 18.0 |
| | 2-1/2(19) | 12 | 1 | 16 | 38 | 17.0 |
| | 2-1/2(26) | 12 | 1 | 16 | 41 | 18.0 |
| | 3(7) | 12 | 1 | 16 | 43 | 21.0 |
| | 4(1) | 12 | 1 | 16 | 70 | 30.0 |
| | 4(19) | 12 | 1 | 16 | 70 | 29.0 |
| | 4(7) | 12 | 1 | 16 | 70 | 30.0 |
| | 4(41) | 12 | 1 | 16 | 70 | 30.0 |
| 6-9 | 6(7) | 12 | 1 | 16 | 105 | 48.0 |
| | 6(19) | 12 | 1 | 16 | 105 | 45.0 |
| | 9(7) | 12 | 1 | 16 | 140 | 66.0 |
| | 9(37) | 12 | 1 | 16 | 140 | 69.0 |

NOTE

If the maximum voltage drop values and the minimum pull-out values as listed in tables 27-15 and 27-16 are exceeded, the crimping tool or the lug terminals are faulty and shall not be used until corrective measures are taken and a good crimped connection obtained.

TABLE 27-17. TEST DATA FOR TYPE I AND II LUG TERMINALS

| WIRE SIZE (AN) | MILLIVOLT DROP (MAX) | PULL-OUT POUNDS (MIN) | CONDUCTOR AMPERES (MAX) |
|---|---|---|---|
| 26 | 8 | 7 | 3.0 |
| 24 | 8 | 10 | 4.5 |
| 22 | 8 | 15 | 9.0 |
| 20 | 7 | 19 | 11.0 |
| 18 | 7 | 38 | 16.0 |
| 16 | 7 | 50 | 22.0 |
| 14 | 6 | 70 | 32.0 |
| 12 | 5 | 110 | 41.0 |
| 10 | 5 | 180 | 55.0 |

f. LUG TERMINAL STANDARDIZATION.- Value Engineering studies have determined that out of a total of 537 lug terminals listed in FSC 5940, 327 of these could be eliminated. The lug terminals that will be retained in the Supply System are listed in table 27-18.

(1) TABULAR INFORMATION.- Table 27-18 contains the following information:

(a) COLUMN 1. - Federal Item Identification Number.

(b) COLUMN 2. - Wire Size in Thousands of Circular Mils.

(c) COLUMN 3. - Tongue Shape:

SQ - Square.
RD - Round.
FK - Fork.
SP - Spade.
RT - Ring or Rectangular.
L - Mil-E-16366 Shape.

(d) COLUMN 4. - Screw Size in Inches.

(e) COLUMN 5. - Lug Terminal Type:

WTT - Wire Lug Terminals, Telephone.
WT - Wire Lug Terminals.
WTG - Wire Lug Terminals with Insulation Grip.
CCBC - Cable Connector with Butt Crimp for Splicing Conductors.
CLC - Cable Lug Terminals, Crimp Type.
CLS - Cable Lug Terminals, Screw Clamp Type.
CCPS - Cable Clamp Conductor Splicer Parallel Screw Type.
CBCS - Electrical Cable Clamps, Bar Clamp Screw Type.
CCBS - Cable Clamp Conductor Splicer, Butt-Screw Type.
CCTS - Cable Clamp, Tee Screw Type.
CLCG - Cable Lug Terminals, Crimp Type with Insulation Grip.
IN - Insulated.
HYRIN - Hyring.
INVR - Inner Hyring, Red.
UN - Uniring, Uninsulated.
UNR - Uniring.
INLG - Insulug.
INLK - Insulink.

(f) COLUMN 6. - Joint Types:

CR - Crimp.
SO - Solder.
SC - Screw Clamp.

(g) COLUMN 7. - Commercial Order Number:

TB - Thomas and Betts.
AP - Aircraft Marine Products.
BE - Burndy.
GE - General Electric.

TABLE 27-18. LUG TERMINAL INDEX

| STOCK NUMBER | WIRE SIZE MIN | WIRE SIZE MAX | TONGUE SHAPE | SCREW SIZE | TYPE | JOINT | COMMERCIAL NUMBER |
|---|---|---|---|---|---|---|---|
| 5940-000-0010 | | | | | | | 1300C-LI |
| 5940-000-0774 | | | | | | CR | RB-1333-6-TB |
| 5940-003-0202 | | | | | | CR | 30202-AP |
| 5940-000-0687 | | | SQ | | | CR | 320657-AP |
| 5940-095-0882 | | | NONE | | HYRIN | CR | YOC -150-BE |
| 5940-095-0883 | | | NONE | | HYRIN | CR | YIC-156-BE |
| 5940-000-4616 | | | NONE | | INVR | CR | YEC-160-BE |
| 5940-000-4617 | | | NONE | | INVR | CR | YEC-180-BE |
| 5940-100-7158 | | | NONE | | INVR | CR | YEC-150-BE |
| 5940-100-7492 | | | NONE | | INVR | CR | YEC-[illegible]-BE |
| 5940-100-7734 | | | NONE | | INVR | CR | YEC-200-BE |
| 5940-067-0013 | | | NONE | | INVR | CR | YEC-160-BE |
| 5940-230-0553 | 5 | 10 | SQ | 0.1300 | WTT | CR | |
| 5940-197-8740 | 5 | 10 | SQ | 0.1430 | WTT | CR | |
| 5940-151-9385 | 5 | 10 | SQ | 0.1690 | WTT | CR | |
| 5940-197-8741 | 5 | 10 | SQ | 0.1950 | WTT | CR | |
| 5940-151-9354 | 7 | 16 | L-47 | 0.1480 | WTG | | |
| 5940-100-7165 | 7 | 16 | NONE | | INLK | CR | YSE-18H-BE |
| 5940-151-9333 | 7 | 16 | L-47 | 0.1480 | WT | CR | |
| 5940-001-1974 | 7 | 16 | RD | 0.1380 | | CR | A-18-6-GE |
| 5940-001-1977 | 7 | 16 | RD | 0.1900 | | CR | 18-10-GE |
| 5940-186-2878 | 7 | 18 | | | CCBC | CR | |
| 5940-000-0691 | 7 | 26 | SP | | | CR | 34070AP |
| 5940-001-7311 | 7 | 26 | | | IN-SP | CR | 320559AP |
| 5940-001-7300 | 7 | 26 | RD | 0.1190 | IN | CR | 31880-AP |
| 5940-000-0434 | 7 | 26 | RD | 0.1380 | | CR | RA853TB |
| 5940-000-0690 | 7 | 26 | SQ | 0.1450 | | CR | 320651-AP |
| 5940-000-5837 | 7 | 26 | SQ | 0.1450 | IN | CR | 33476-AP |
| 5940-001-7308 | 7 | 26 | FK | 0.1450 | IN | CR | 34080-AP |
| 5940-001-7301 | 7 | 26 | RD | 0.1450 | IN | CR | 31885-AP |
| 5940-067-0017 | 7 | 26 | RD | 0.1470 | IN | CR | YAE18G43-BE |
| 5940-000-7146 | 7 | 26 | RD | 0.1470 | INLG | CR | YAE18Z2-BE |
| 5940-000-7392 | 7 | 26 | RD | 0.1470 | INLG | CR | YAE18G43-BE |
| 5940-155-9666 | 7 | 26 | RD | 0.1640 | | CR | |
| 5940-001-7309 | 7 | 26 | FK | 0.1710 | IN | CR | 32053-AP |
| 5940-000-5836 | 7 | 26 | RD | 0.1710 | IN | CR | 31886-AP |
| 5940-000-7147 | 7 | 26 | RD | 0.1730 | INLG | CR | YAE18Z3-BE |
| 5940-067-0018 | 7 | 26 | RD | 0.1730 | IN | CR | YAE18N1-BE |
| 5940-000-0226 | 7 | 26 | RD | 0.1900 | | CR | RA873-TB |

TABLE 27-18. LUG TERMINAL INDEX. (CONTINUED)

| STOCK NUMBER | WIRE SIZE MIN | WIRE SIZE MAX | TONGUE SHAPE | SCREW SIZE | TYPE | JOINT | COMMERCIAL NUMBER |
|---|---|---|---|---|---|---|---|
| 5940-000-0436 | 7 | 26 | RD | 0.1900 | | CR | RB873-TB |
| 5940-000-0696 | 7 | 26 | SQ | 0.1970 | | CR | |
| 5940-001-7310 | 7 | 26 | FK | 0.1970 | IN | CR | 320654-AP |
| 5940-001-7303 | 7 | 26 | RD | 0.1970 | IN | CR | 32054-AP |
| 5940-001-7326 | 7 | 26 | RD | 0.1970 | IN | CR | 31889-AP |
| 5940-000-7148 | 7 | 26 | RD | 0.1980 | INLG | CR | YAE18Z4-BE |
| 5940-067-0019 | 7 | 26 | RD | 0.1980 | IN | CR | YAE18N-BE |
| 5940-001-7304 | 7 | 26 | RD | 0.2230 | IN | CR | 31894-AP |
| 5940-151-9359 | 7 | 45 | SQ | 0.1250 | CL1 | | |
| 5940-151-9379 | 7 | 45 | SQ | 0.1730 | CL1 | | |
| 5940-151-9362 | 7 | 45 | SQ | 0.1970 | CL1 | | |
| 5940-151-9375 | 7 | 45 | SQ | 0.1970 | CL1 | | |
| 5940-151-9376 | 7 | 45 | SQ | 0.1970 | CL1 | SO | |
| 5940-151-9377 | 7 | 45 | SQ | 0.1970 | CL1 | | |
| 5940-151-9380 | 7 | 45 | SQ | 0.1970 | CL1 | SO | |
| 5940-151-9360 | 7 | 45 | SQ | 0.1480 | CL1 | SO | |
| 5940-151-9361 | 7 | 45 | RD | 0.1570 | CL1 | SO | |
| 5940-151-9364 | 7 | 45 | RD | 0.1970 | CL1 | SO | |
| 5940-197-8693 | 10 | 16 | L-57 | 0.1280 | WT | | |
| 5940-197-8685 | 10 | 16 | L-53 | 0.1430 | WT | CR | |
| 5940-197-8694 | 10 | 16 | L-59 | 0.1430 | WT | CR | |
| 5940-259-7182 | 10 | 16 | L-69 | 0.1520 | WT | CR | |
| 5940-197-8683 | 10 | 16 | L-52 | 0.1690 | WT | | |
| 5940-197-8681 | 10 | 18 | L-49 | 0.1300 | WTG | CR | |
| 5940-197-8686 | 10 | 18 | L-53 | 0.1430 | WTG | CR | |
| 5940-197-8695 | 10 | 18 | L-59 | 0.1430 | WTG | CR | |
| 5940-197-8697 | 10 | 18 | L-61 | 0.1690 | WTG | CR | |
| 5940-151-9342 | 10 | 18 | L-05 | 0.1730 | WTG | CR | |
| 5940-151-9327 | 10 | 17 | L-36 | 0.1920 | WT | CR | |
| 5940-151-9325 | 10 | 18 | L-34 | 0.2030 | WT | CR | |
| 5940-230-0585 | 11 | 18 | L-65 | 0.3180 | WTG | CR | |
| 5940-230-0566 | 10 | 17 | L-66 | 0.3800 | WT | CR | |
| 5940-001-7001 | 11 | 41 | | | | | B55-TB |
| 5940-001-1973 | 11 | 41 | RD | 0.1380 | | CR | B-14-6-GE |
| 5940-001-2902 | 11 | 41 | RD | 0.1900 | | CR | B-14-10-TB |
| 5940-001-7020 | 16 | 41 | | | | | B-413-TB |
| 5940-258-3097 | 24 | 45 | L-15 | 0.1690 | WT | CR | |
| 5940-153-5708 | 24 | 45 | L-16 | 0.1690 | WT | | |
| 5940-152-0315 | 18 | 38 | L-05 | 0.1730 | WTG | CR | |
| 5940-153-5709 | 24 | 45 | L-17 | 0.1690 | WT | | |
| 5940-152-0320 | 18 | 38 | L-28 | 0.1870 | WTG | CR | |
| 5940-152-2975 | 24 | 45 | L-30 | 0.1870 | WT | | |
| 5940-155-7710 | 18 | 18 | RD | | | SO | |
| 5940-155-7662 | 18 | 18 | RD | 0.6250 | | SO | |
| 5940-259-7941 | 18 | 18 | RD | 0.1250 | | SO | |
| 5940-284-3235 | 18 | 18 | RD | 0.1562 | | SO | |
| 5940-156-7191 | 18 | 18 | SP | 0.1562 | | SO | |

TABLE 27-18. LUG TERMINAL INDEX. (CONTINUED)

| STOCK NUMBER | WIRE SIZE MIN | WIRE SIZE MAX | TONGUE SHAPE | SCREW SIZE | TYPE | JOINT | COMERCIAL NUMBER |
|---|---|---|---|---|---|---|---|
| 5940-156-7206 | 18 | 18 | RD | 0.2500 | | SO | |
| 5940-197-8704 | 24 | 45 | L-49 | 0.1300 | WTG | | |
| 5940-197-8712 | 24 | 45 | L-53 | 0.1430 | WTG | | |
| 5940-153-5729 | 24 | 45 | L-47 | 0.1480 | WTG | | |
| 5940-153-5723 | 24 | 45 | L-15 | 0.1690 | WTG | | |
| 5940-152-0318 | 24 | 45 | L-16 | 0.1690 | WTG | | |
| 5940-152-0319 | 24 | 45 | L-17 | 0.1690 | WTG | | |
| 5940-197-8710 | 24 | 45 | L-52 | 0.1690 | WTG | | |
| 5940-197-8708 | 24 | 45 | L-51 | 0.2210 | WTG | | |
| 5940-197-8706 | 24 | 45 | L-50 | 0.2750 | WTG | | |
| 5940-186-2877 | 24 | 45 | | | CCBC | | |
| 5940-230-0588 | 24 | 45 | L-58 | 0.1170 | WT | | |
| 5940-230-0551 | 24 | 50 | L-11 | 0.1250 | WT | | |
| 5940-186-8736 | 24 | 45 | L-49 | 0.1300 | WT | CR | |
| 5940-197-8711 | 24 | 45 | L-53 | 0.1430 | WT | CR | |
| 5940-197-8703 | 24 | 45 | L-56 | 0.1430 | WT | CR | |
| 5940-230-0550 | 24 | 45 | L-59 | 0.1430 | WT | | |
| 5940-230-0549 | 24 | 45 | L-59 | 0.1430 | WTG | | |
| 5940-152-0306 | 24 | 45 | L-47 | 0.1480 | WT | CR | |
| 5940-259-7181 | 24 | 45 | L-69 | 0.1520 | WT | | |
| 5940-197-8709 | 24 | 45 | L-52 | 0.1690 | WT | | |
| 5940-197-3349 | 24 | 45 | L-61 | 0.1690 | WT | | |
| 5940-197-3348 | 24 | 45 | L-61 | 0.1690 | WTG | | |
| 5940-153-5715 | 24 | 45 | L-36 | 0.1920 | WT | CR | |
| 5940-153-5721 | 24 | 45 | L-36 | 0.1920 | WTG | | |
| 5940-197-8739 | 24 | 45 | L-63 | 0.1950 | WT | CR | |
| 5940-197-8707 | 24 | 45 | L-51 | 0.2210 | WT | | |
| 5940-197-8751 | 24 | 45 | L-65 | 0.3180 | WT | | |
| 5940-197-8772 | 24 | 45 | L-64 | 0.2210 | WT | | |
| 5940-197-8750 | 24 | 45 | L-65 | 0.3180 | WTG | | |
| 5940-197-8705 | 24 | 45 | L-50 | 0.2250 | WT | | |
| 5940-197-8748 | 24 | 45 | L-66 | 0.3800 | WTG | | |
| 5940-153-5713 | 24 | 50 | L-33 | 0.1490 | WT | CR | |
| 5940-238-9595 | 25 | 25 | RD | 0.1562 | | SO | |
| 5940-001-7022 | 25 | 30 | | | | | YAV14G4-BE |
| 5940-001-7012 | 25 | 40 | | | | | B447-TB |
| 5940-001-7107 | 25 | 40 | | | | | B453-TB |
| 5940-100-7156 | 26 | 41 | NONE | | INLK | CR | YSE14H-BE |
| 5940-000-0222 | 26 | 41 | FK | 0.1380 | | CR | B-19-TB |
| 5940-000-0435 | 26 | 41 | RD | 0.1380 | | CR | RB853-TB |
| 5940-001-7036 | 26 | 41 | RD | 0.1380 | | CR | B133-TB |
| 5940-001-7314 | 26 | 41 | RD | 0.1450 | IN | CR | 32442-AP |
| 5940-067-0003 | 26 | 41 | RD | 0.1470 | IN | CR | YAE14N43-BE |
| 5940-000-2600 | 26 | 41 | SQ | 0.1640 | | CR | B94-TB |
| 5940-001-7029 | 26 | 41 | SQ | 0.1640 | | CR | B139-TB |
| 5940-001-7315 | 26 | 41 | RD | 0.1710 | IN | CR | 31902-AP |

TABLE 27-18. LUG TERMINAL INDEX, (CONTINUED)

| STOCK NUMBER | WIRE SIZE MIN | WIRE SIZE MAX | TONGUE SHAPE | SCREW SIZE | TYPE | JOINT | COMMERCIAL NUMBER |
|---|---|---|---|---|---|---|---|
| 5940-000-7446 | 26 | 41 | FK | 0.1730 | INLG | CR | YAE14Z3-BE |
| 5940-000-7138 | 26 | 41 | RD | 0.1730 | INLG | CR | YAE14NI-BE |
| 5940-636-7131 | 26 | 41 | SP | 0.1875 | | CR | |
| 5940-001-7002 | 26 | 41 | RD | 0.1900 | | CR | B87-TB |
| 5940-001-7316 | 26 | 41 | RD | 0.1970 | IN | CR | 31903-AP |
| 5940-000-7479 | 26 | 41 | FK | 0.1980 | INLG | CR | YAE14Z4-BE |
| 5940-000-7139 | 26 | 41 | RD | 0.1980 | INLG | CR | YAE14N-BE |
| 5940-000-0685 | 26 | 41 | RD | 0.2230 | IN | CR | 31904-AP |
| 5940-001-7317 | 26 | 41 | RD | 0.2230 | IN | CR | 31906-AP |
| 5940-067-0005 | 26 | 41 | RD | 0.2720 | IN | CR | YAE14N2-BE |
| 5940-001-7009 | 26 | 41 | RD | 0.3125 | | CR | B72-TB |
| 5940-001-1975 | 26 | 104 | RD | 0.1900 | | CR | C10-10-GE |
| 5940-001-1978 | 26 | 104 | RD | 0.2500 | | CR | 10-14-GE |
| 5940-155-9684 | 28 | 28 | RD | | | SO | |
| 5940-156-7425 | 28 | 28 | RD | 0.6250 | | SO | |
| 5940-159-1252 | 28 | 28 | RD | 0.1250 | | SO | |
| 5940-258-5144 | 28 | 28 | SP | 0.1562 | | SO | |
| 5940-155-7702 | 28 | 28 | RD | 0.1875 | | SO | |
| 5940-240-3439 | 45 | 45 | | | CCPS | CR | |
| 5940-151-9243 | 46 | 46 | RD | | CL2 | | |
| 5940-284-3267 | 45 | 45 | RD | 0.1875 | | SO | |
| 5940-197-8770 | 45 | 140 | | 0.2187 | CLS | CR | |
| 5940-197-8771 | 45 | 140 | | 0.2187 | CLS | CR | |
| 5940-186-2876 | 60 | 90 | | | CCBC | | |
| 5940-230-0564 | 65 | 90 | L-57 | 0.1280 | WT | CR | |
| 5940-197-8731 | 65 | 90 | L-53 | 0.1430 | WT | CR | |
| 5940-197-8733 | 65 | 90 | L-52 | 0.1690 | WT | CR | |
| 5940-230-0558 | 65 | 90 | L-61 | 0.1690 | WT | CR | |
| 5940-197-8734 | 65 | 90 | L-52 | 0.1690 | WTG | CR | |
| 5940-194-4864 | 65 | 90 | L-63 | 0.1950 | WT | CR | |
| 5940-230-0555 | 65 | 90 | L-64 | 0.2210 | WT | CR | |
| 5940-197-8737 | 65 | 90 | L-50 | 0.2550 | WT | CR | |
| 5940-197-8746 | 60 | 90 | L-65 | 0.3180 | WTG | | |
| 5940-197-8742 | 60 | 90 | L-67 | 0.5050 | WTG | | |
| 5940-100-7157 | 65 | 104 | NONE | | INLK | CR | YSE10-BE |
| 5940-000-0437 | 65 | 104 | RD | 0.1900 | | CR | RC363-TB |
| 5940-100-7140 | 65 | 104 | RT | 0.1980 | INLG | CR | YAEV10-BE |
| 5940-100-7160 | 65 | 104 | RT | 0.2720 | INLG | CR | YAEV10T3-BE |
| 5940-151-9244 | 90 | 90 | RD | | CL2 | | |
| 5940-240-3440 | 90 | 140 | | | CCPS | CR | |
| 5940-258-5891 | 140 | 140 | | | CCBC | | |
| 5940-151-9245 | 140 | 140 | RD | | CL2 | | |
| 5940-197-3350 | 140 | 140 | RECT | 0.1970 | CLC | CR | |
| 5940-197-3351 | 140 | 140 | RECT | 0.2500 | CLC | CR | |
| 5940-197-8764 | 140 | 140 | RECT | 0.3125 | CLC | CR | |
| 5940-197-8765 | 140 | 140 | RECT | 0.3750 | CLC | CR | |
| 5940-001-2813 | 165 | 165 | SQ | 0.1900 | | CR | 54104-TB |

TABLE 27-18. LUG TERMINAL INDEX. (CONTINUED)

| STOCK NUMBER | WIRE SIZE MIN | WIRE SIZE MAX | TONGUE SHAPE | SCREW SIZE | TYPE | JOINT | COMMERCIAL NUMBER |
|---|---|---|---|---|---|---|---|
| 5940-240-3437 | 230 | 230 | | | CCPS | CR | |
| 5940-151-9381 | 230 | 230 | RD | | CL2 | | |
| 5940-197-8766 | 230 | 230 | RECT | 0.1970 | CLC | CR | |
| 5940-197-8768 | 230 | 230 | RECT | 0.3125 | CLC | CR | |
| 5940-197-8674 | 230 | 400 | | 0.2812 | CLS | CR | |
| 5940-197-8675 | 230 | 400 | | 0.2812 | CLS | CR | |
| 5940-258-5893 | 300 | 300 | | | CCBC | | |
| 5940-230-0568 | 300 | 300 | RECT | 0.2500 | CLC | CR | |
| 5940-240-3438 | 300 | 400 | | | CCPS | CR | |
| 5940-258-5892 | 400 | 400 | | | CCBC | | |
| 5940-240-3445 | 400 | 500 | | | CCPS | CR | |
| 5940-001-2815 | 417 | 417 | SQ | 0.2500 | | CR | 5410-TB |
| 5940-151-9247 | 500 | 500 | RD | | CL2 | | |
| 5940-197-8676 | 500 | 750 | | 0.3437 | CLS | CR | |
| 5940-151-9248 | 600 | 600 | RD | | CL2 | | |
| 5940-240-3434 | 600 | 750 | | | CCPS | CR | |
| 5940-240-3435 | 750 | 1000 | | | CCPS | CR | |
| 5940-197-3346 | 1000 | 1250 | | 0.4062 | CLS | CR | |
| 5940-197-3345 | 1000 | 1250 | | 0.4375 | CLS | CR | |
| 5940-151-9251 | 1250 | 1250 | RD | | CL2 | | |
| 5940-240-3436 | 1250 | 1500 | | | CCPS | CR | |
| 5940-001-2829 | 1330 | 1330 | SP | | | CR | |
| 5940-001-2819 | 1330 | 1330 | SQ | 0.3750 | | CR | 54110-TB |
| 5940-151-9252 | 1500 | 1500 | RD | | CL2 | | |
| 5940-230-0543 | 1500 | 2000 | | 0.5625 | CLS | CR | |
| 5940-240-3446 | 2000 | 2000 | | | CCPS | CR | |
| 5940-151-9253 | 2000 | 2000 | RD | | CL2 | | |
| 5940-240-3447 | 2500 | 3000 | | | CCPS | CR | |
| 5940-186-8717 | 2500 | 3500 | | 0.5625 | CLS | CR | |
| 5940-240-3443 | 4000 | 5000 | | | CCPS | CR | |
| 5940-186-8720 | 4000 | 5000 | | 0.4375 | CLS | CR | |
| 5940-186-8721 | 4000 | 5000 | | 0.6875 | CLS | CR | |

**4–28. SHIELDED WIRES AND TWISTED PAIRS.**–This sub–section describes the techniques used for termination of the shields and conductors of shielded type wires, or wires in cables of the twisted pair type. Shielded wires and twisted pairs can be terminated by use of the pigtail method or by crimp type ferrules.

**NOTE**

The pigtail method of shield termination must be used on wires in electrical circuits where the frequency exceeds 100 megacycles per second.

a. FERRULE TERMINATION.–The crimping tools and crimp type ferrules now in general use are furnished by various manufacturers, and a specific tool will not complete a crimp on all manufacturer's ferrules. The only approved types of crimping tools are those with a self–locking ratchet device which prevents the release of crimping pressure until the crimp has been satisfactorily completed. If this ratchet device is disabled, the tool shall not be used for crimping. When terminating wires snd shields by the ferrule method, the following must be observed:

(1) FERRULE SIZE.–The ferrule shall be of the proper size to fit the wire.

(2) FERRULE FIT.–The ferrule must be constructed so as to properly accept and hold the wire shield. All strands of the shield must enter the ferrule before crimping.

(3) CRIMPING TOOLS.–Use crimping tools designed for specific ferrules. Proper termination of the shield depends on a perfectly completed crimp and the use of improperly mated tools and ferrules will not produce this result.

(4) OVERCRIMPING.–Do not over–crimp the ferrule. Over–crimping will cause the metal of the conductor to flow out of the ferrule and will materially decrease the current capacity and mechanical strength of the termination.

(5) CONDUCTOR SHORTING.–Do not allow shield strands to enter under the inner section of the ferrule. This is important because when the ferrule is crimped, these strands may penetrate the insulation and short the shield to the conductor.

(6) GROUNDING WIRE.–The grounding wire (when used) must be properly inserted in the ferrule before the crimp is started.

b. PREPARATION.–Shielded wires must be carefully prepared for the conductor termination. The shield is used as a barrier to confine electrical energy within certain circuits and to prevent circuit interaction and pickup of noise. The shield must be unbroken and extend to a point as near the conductor termination as practicable. Observe the following when preparing for termination:

(1) INSULATION DAMAGE.–Do not nick or otherwise damage the conductor insulation when removing the jacket or preparing the shield for termination.

(2) SHIELD TRIMMING.–The shield shall be clean-cut and neatly trimmed. Avoid jagged or frayed ends which could accidentally pierce the insulation.

(3) WOVEN JACKET PROTECTION.–If the shield is covered with a woven or braided fabric jacket, fraying can be prevented by slipping a 3/4 inch length of vinyl sleeving over the jacket before preparing the wire for termination. The sleeving must be a close fit over the wire jacket and when the termination is complete, slip the sleeving up against the ferrule.

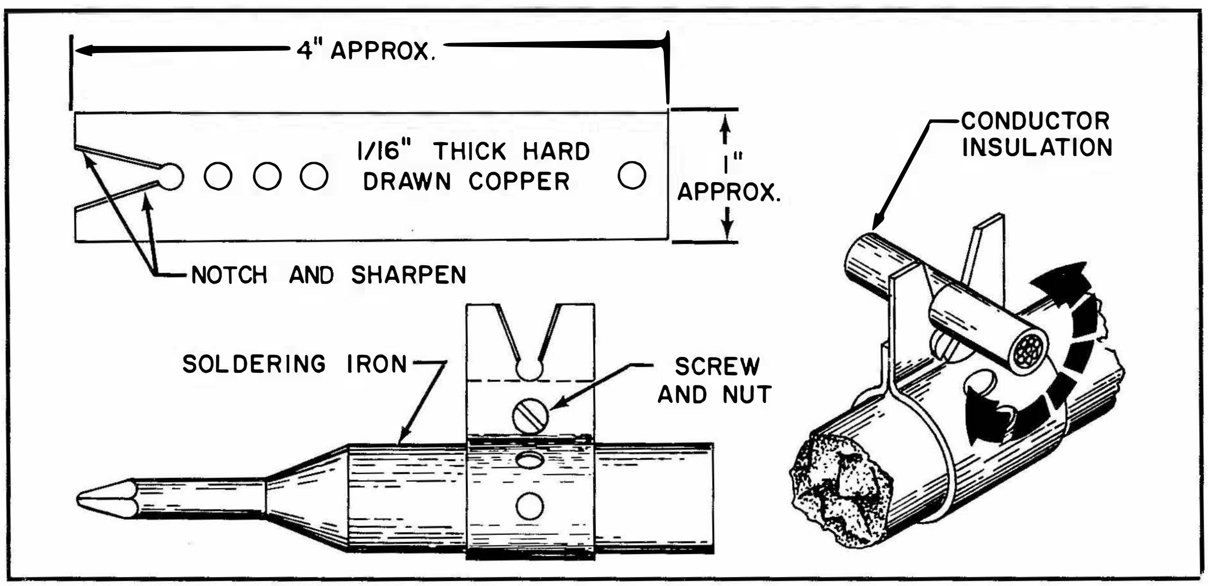



**FIGURE 28-1 Hot Blade Stripper.**


ORIGINAL

STEP 1.—Lay the wire to be stripped in the "V".

STEP 2.—Rotate the wire slowly and clean channel will be melted in the jacket.

STEP 3.—Remove the jacket by pulling the wire through the wire slot.

(2) ALTERNATE STRIPPING METHOD.—If a hot blade stripper is not available, the jacket may be removed by careful use of a pocket knife. This method of stripping is illustrated in figure 28–2.

**CAUTION**

The use of a knife for stripping insulation requires extreme caution while making the cuts. The shield strands must not be nicked or cut.

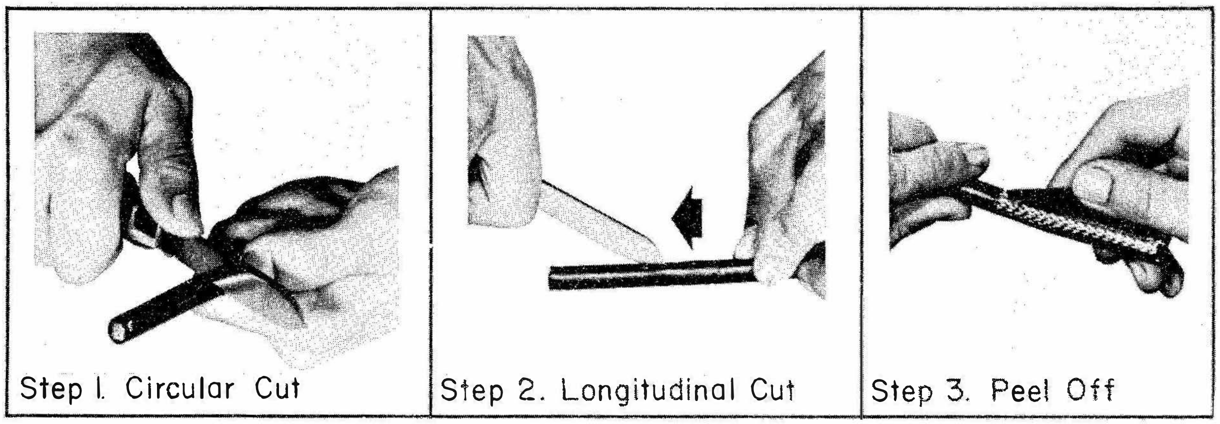



**FIGURE 28-2. Knife Stripping**

d. TERMINATION WITH FERRULES.—The use of ferrules for shield termination provides a fast, neat and good electrical connection to the shield. Some of the tools and ferrules in general use are described below:

(1) STANDARD FERRULE CRIMPING TOOL.—The standard MS25312 crimping tool is similar to tools of the BURNDY MR8 series. It is available with four different die nest sizes to crimp ferrules on wires with primary insulation diameters ranging from 0.040 inches to 9.202 inches. The standard tool is shown in figure 28–3. Table 28–1 lists the four tools with the associated die sizes.

(a) SHIELD TERMINATION FERRULES. The shield termination ferrules for use with the standard tool are listed in table 28–2. The ferrule is installed for shield termination as follows:

STEP 1.—Determine the outside diameter of the primary insulation and select the proper size ferrule from table 28–2. The "A" dimension of the ferrule should be a minimum of 0.005 inch larger than the diameter of the primary insulation.

STEP 2.—Strip the jacket and trim the shield, exposing the wire, then fan the shield by rotating the wire.

STEP 3.—Slip the ferrule in place over the wire to a point where the shield is bottomed in the ferrule.

STEP 4.—Insert the ground wire as shown in figure 28–5 (the ground wire may be inserted into either end of the ferrule).

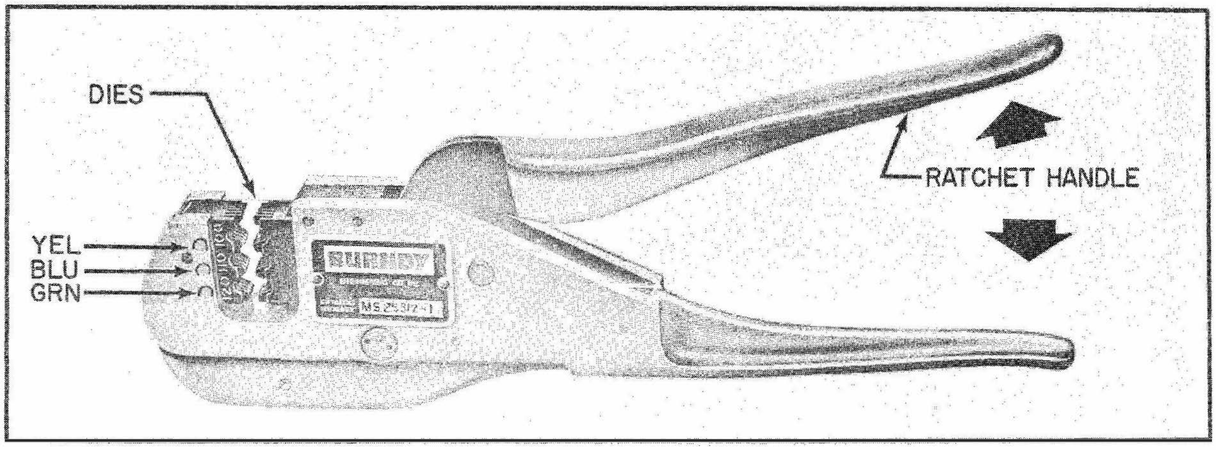



Figure 28-3. MS25312 Standard Tool.

TABLE 28-1. MS25312 STANDARD TOOLS AND DIE SIZES.

| TOOL # | DIE # | COLOR CODE | PRIMARY INSULATION SIZE (INCH) |
|---|---|---|---|
| MS25312-1 | 120 | GREEN | 0.101 |
| | 110 | BLUE | 0.080 |
| | 100 | YELLOW | 0.0631 |
| MS25312-2 | 130 | BLACK | 0.115 |
| | 90 | RED | 0.058 |
| MS25312-3 | 160 | RED | 0.156 |
| | 150 | GREEN | 0.134 |
| MS25312-4 | 200 | YELLOW | 0.210 |
| | 180 | BLUE | 0.179 |

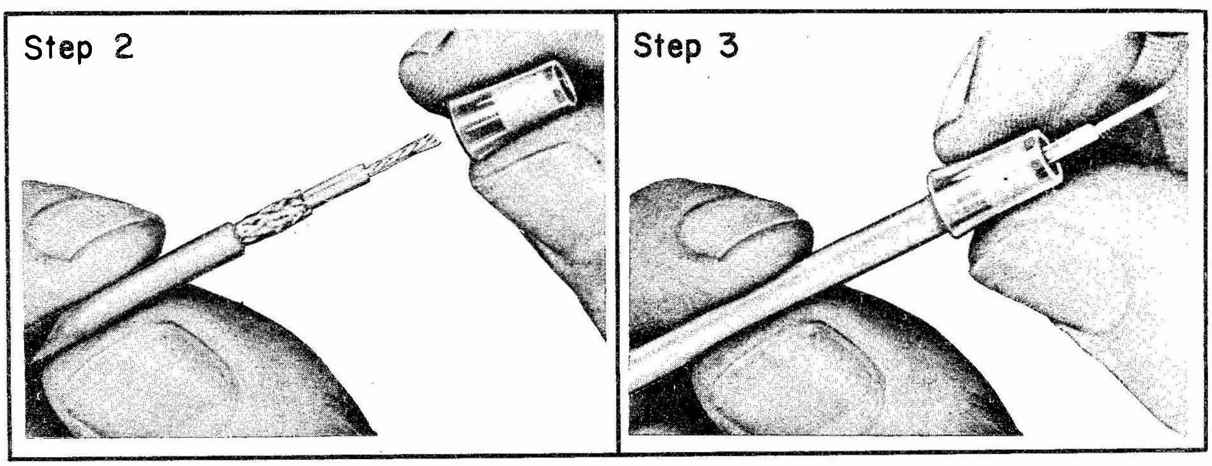
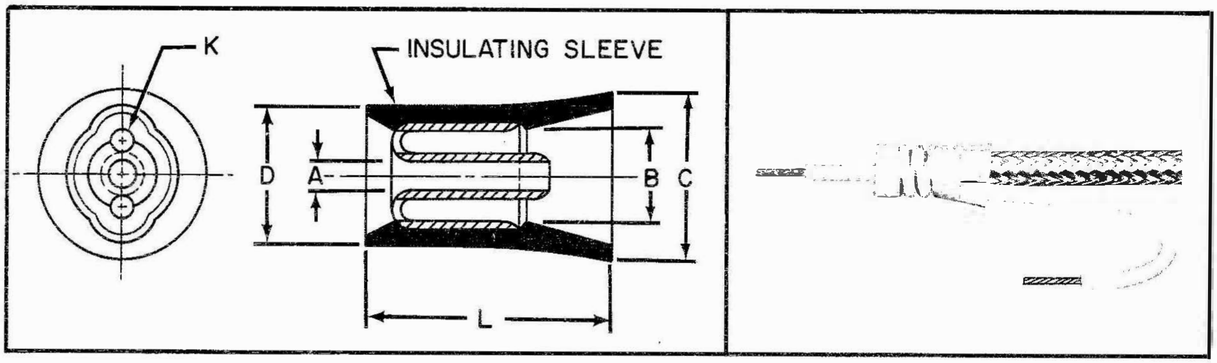



Figure 28-4. Preparation for Ferrule Installation.

TABLE 28-2. MS25311 SHIELD GROUNDING FERRULES.




| L = .46 | | DIMENSIONS (In Inches) | | | | | INSTALLATION TOOLS |
|---|---|---|---|---|---|---|---|
| DASH # | COLOR | "A" | "B" | "C" | "D" | "K" | MS25312 |
| -90 | Red | .058 | .145 | .25 | .21 | .043 | MS25312-2 |
| -100 | Yellow | .063 | .162 | .27 | .23 | .043 | MS25312-1 |
| -110 | Blue | .080 | .170 | .28 | .24 | .043 | MS25312-1 |
| -120 | Green | .101 | .193 | .30 | .26 | .043 | MS25312-1 |
| -130 | Black | .115 | .207 | .32 | .27 | .043 | MS25312-2 |
| -150 | Green | .134 | .230 | .34 | .29 | .043 | MS25312-3 |
| -160 | Red | .156 | .261 | .37 | .33 | .043 | MS25312-3 |
| -180 | Blue | .179 | .295 | .41 | .36 | .043 | MS25312-4 |
| -200 | Yellow | .210 | .326 | .44 | .40 | .043 | MS25312-4 |

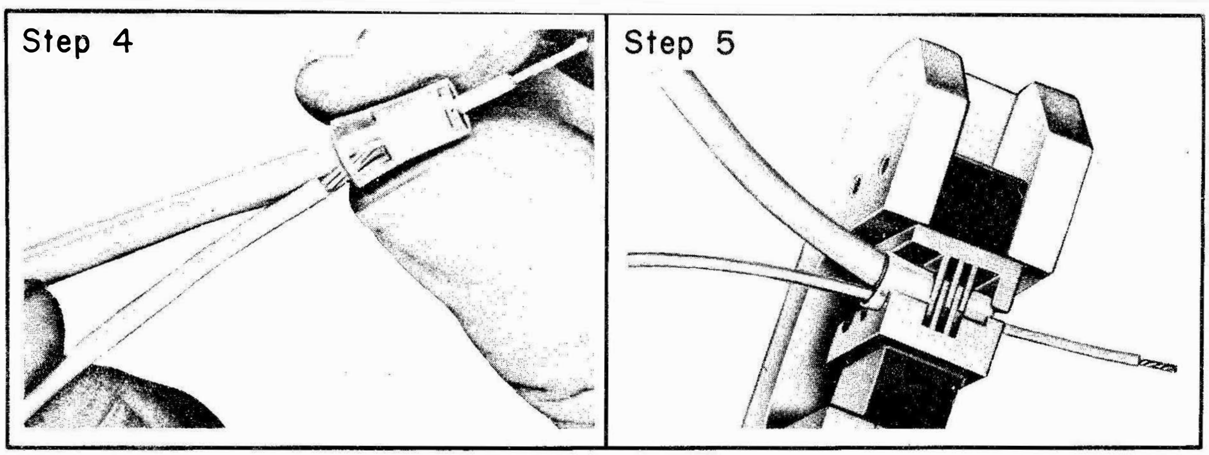
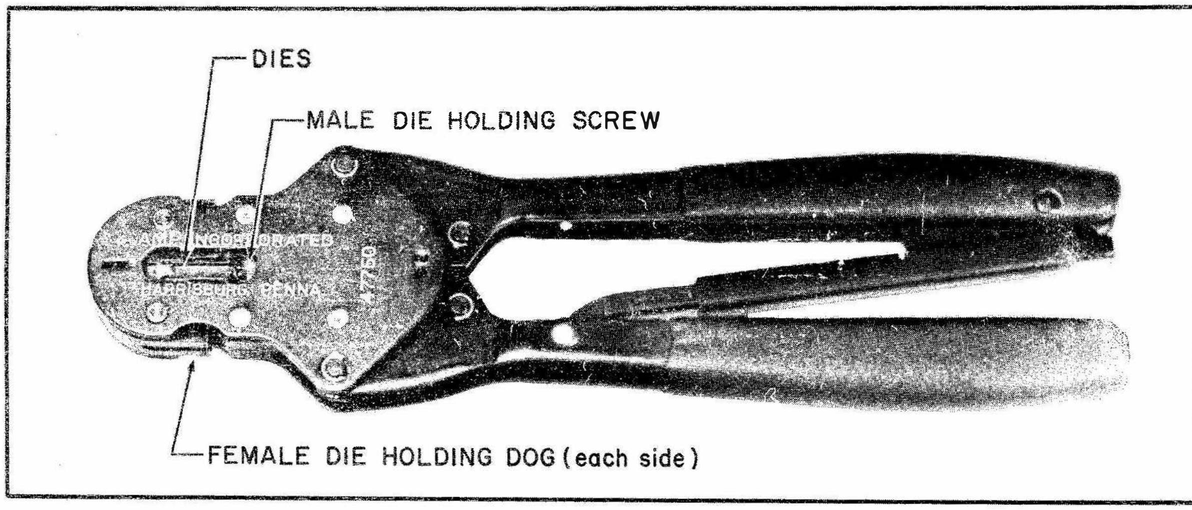



Figure 28-5. Ferrule Installation.

STEP 5.—Insert the ferrule and wire assembly into the proper size tool die nest (terminal end against the ferrule stop) and complete the crimp. Remove and examine the termination for proper completion of the crimp.

(2) AMP TERMA-SHIELD FERRULE CRIMPING TOOL #47750.–This hand tool is used to crimp AMP terma-shield ferrules on #22 through #14 shielded wire. The dies and ferrules used with this tool will depend on the diameter of the primary insulation of the conductor.




(a) DIE SETS AND FERRULES.–The five sets of dies, ferrules and insulating caps available for use with tool #47750 are color coded for use on wire diameters as shown in Table 28–3.

TABLE 28-3. #47750 DIE, FERRULE AND INSULATING CAP CODING.

| PRIMARY INS. DIA. | DIES | FERRULES | INSULATION CAPS |
|---|---|---|---|
| 0.045 - 0.065 inches | Violet | Violet | Violet |
| 0.065 - 0.085 inches | White | Tin | White |
| 0.085 - 0.105 inches | Brown | Brown | Brown |
| 0.105 - 0.125 inches | Orange | Orange | Orange |
| 0.125 - 0.145 inches | Green | Green | Green |

(b) DIE SET INSTALLATION.–The die sets in tool #47750 are easily changed as follows:
STEP 1.–Select the proper die set for the insulation size listed in table 28–3.
STEP 2.–Place the male and female dies together with the color coded grooves lined up.
STEP 3.–Squeeze the tool handles together until the male die holding screw is visible.

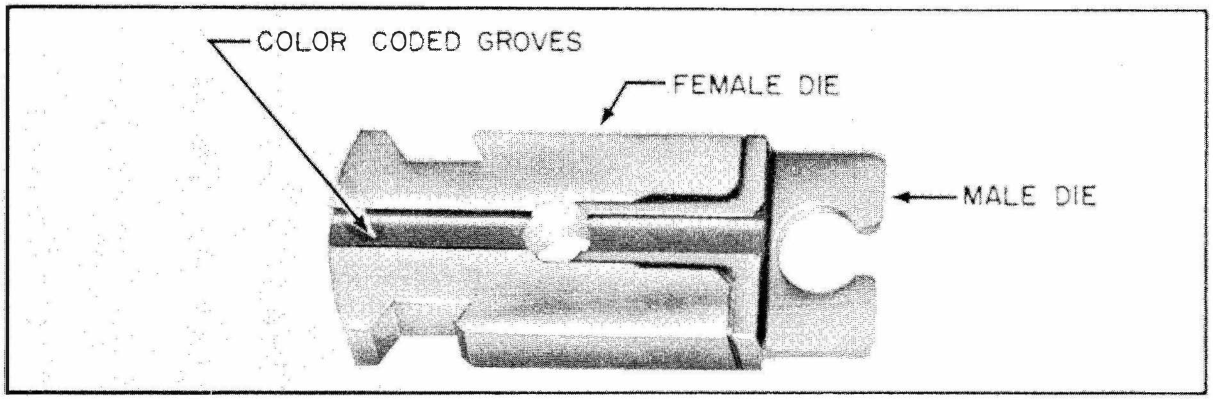



**FIGURE 28–7 Tool #47750 Dies.**

STEP 4.—Make sure that the screw slot is positioned as shown in figure 28–6.

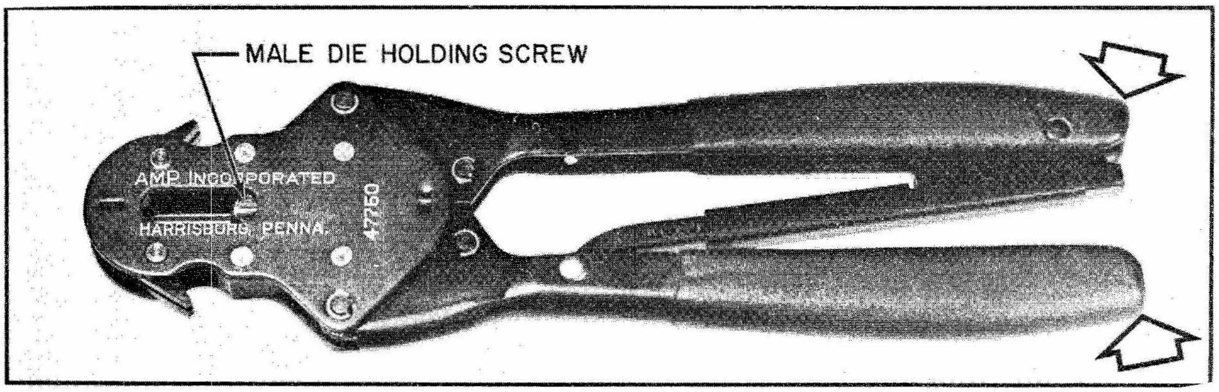



**FIGURE 28–8 Tool #47750 Die Installation**

STEP 5.—Press the die holding dogs inward on each side and push the dies, color coded grooves up, into the tool head as shown in figure 28–7.

STEP 6.—Release the die holding dogs and turn the male die holding screw 90 degrees to the right or left. If the dogs do not close after the dies have been inserted in the tool head, squeeze the tool handles together to engage the dogs in the female die. The tool is now ready for operation.

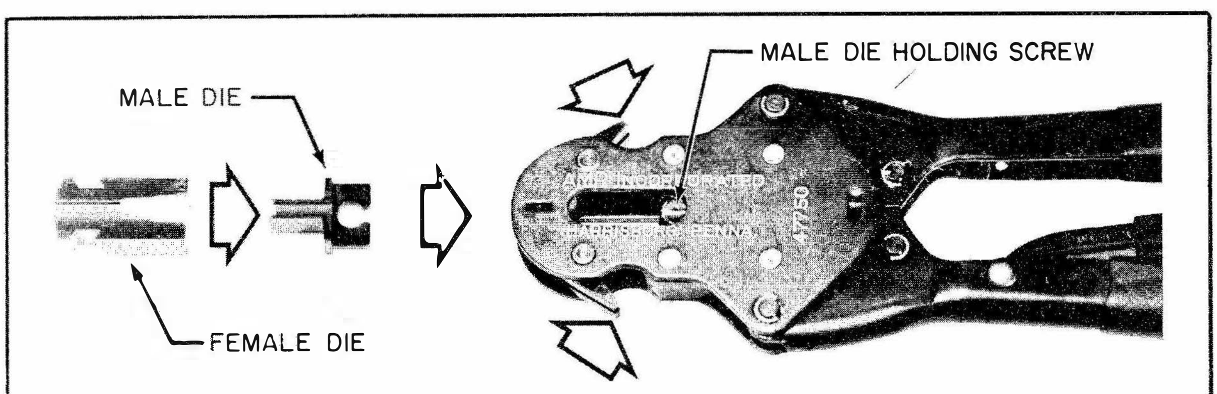



**FIGURE 28–9 Tool #47750 Die Insertion.**

c. TOOL #47750 CRIMPING PROCEDURE.—Wire shields are terminated with the AMP tool #47750 and ferrules as follows:

STEP 1.—Strip the shielded wire as indicated in figure 28—10.

STEP 2.—Strip the ground wire as indicated in figure 28—10.

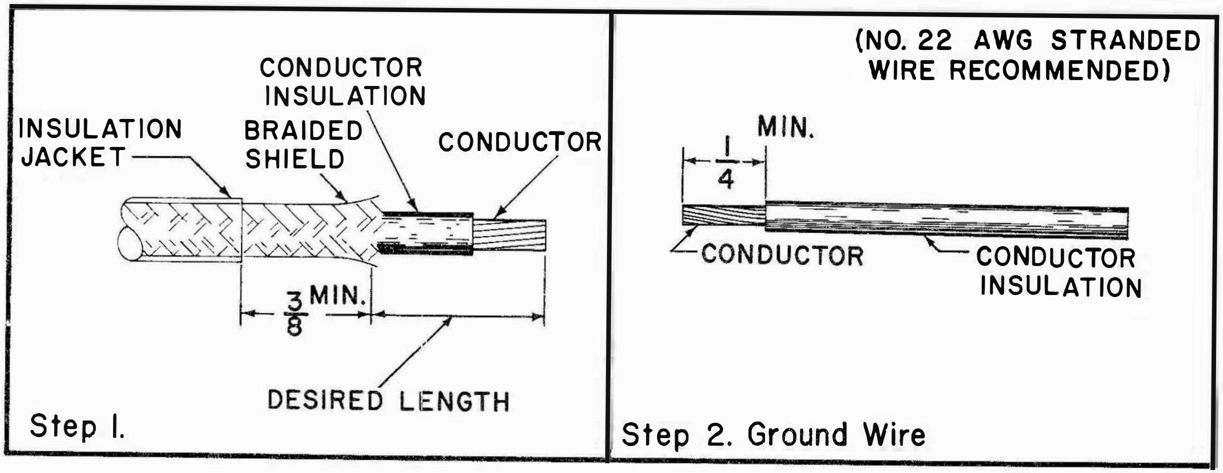



FIGURE 28—10 Wire Preparation.

STEP 3.—Flare the shield braid and slide the proper size ferrule along the wire until the shield braid enters braid enters and bottoms in the ferrule..

STEP 4.—Open the handles of the crimping tool and place the wire and ferrule in the lower die. Close the tool handles until the dies grip the ferrule.

**CAUTION**

Close the dies only enough to grip the ferrule. Do not start the actual crimping operation.

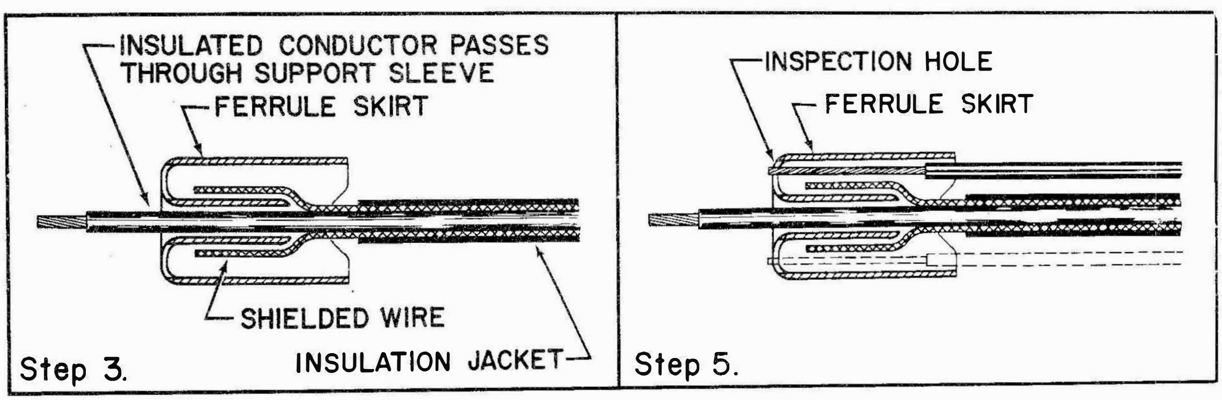



FIGURE 28—11 Ferrule.

STEP 5.—Insert the ground wire in the ferrule as shown in figure 28—11. The insulation on the ground wire should extend at least 1/16 inch under the ferrule skirt.

STEP 6.—Hold the shielded wire and ground wire in position in the ferrule and squeeze the tool handles until the ratchet allows opening of the tool handles. Remove and inspect for proper completion of the crimp.

STEP 7.—Slip a color coded insulation cap over the ferrule to the point where the locking teeth are engaged with the ferrule. The shield termination is now complete and the conductor ends may be terminated with approved terminations.

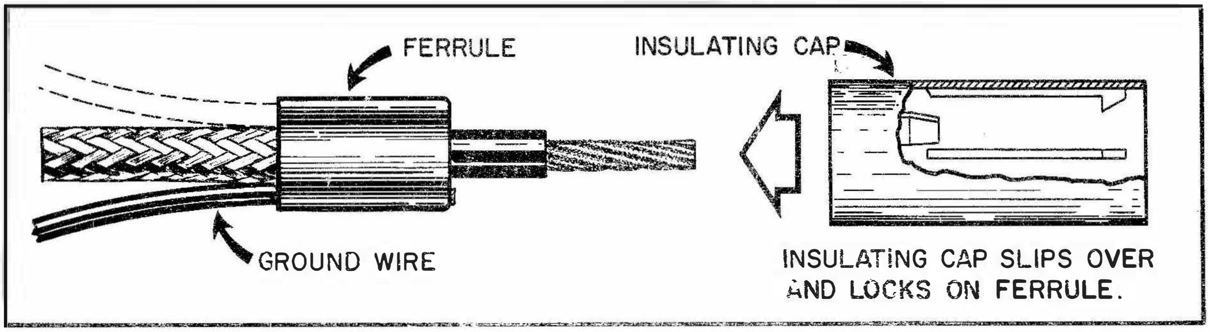



FIGURE 28-12 Completed Ferrule Installation

(3) BURNDY UNIRING AND HYRING SHIELD TERMINATION.—Wire shields may be terminated with a one piece UNIRING or with the two piece HYRING. These terminations are applied by pressure from circumferential interlocking tool dies which reduce the diameter of the soft outer ring and compress the shield and tap wire between the outer ring and the firm support of the inner ring. The hard inner ring does not distort and will not harm the wire insulation when the termination is crimped. The BURNDY crimping tools commonly used for shield termination are listed below:

(a) MR8—PV, —EC and —NC SERIES.—This series of tools is equipped with a die which is preset and permanently affixed to the tool. In most cases one size tool will handle two sizes of ferrules.

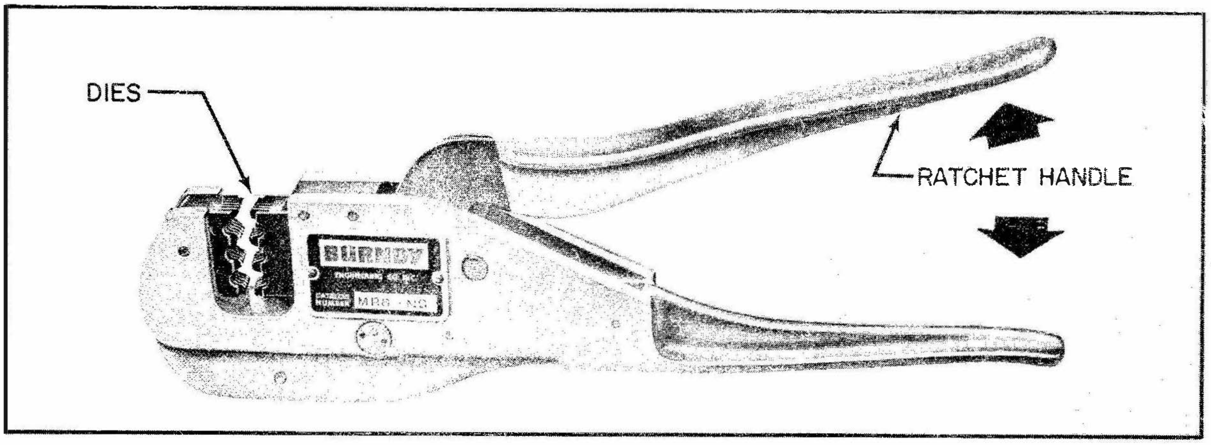



FIGURE 28-13 Crimping Tools MR8—PV, —EC and —NC.

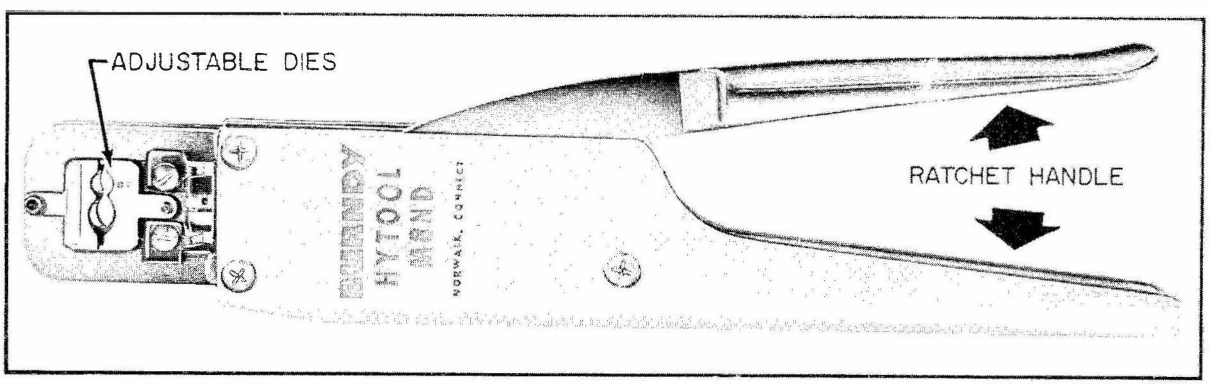



FIGURE 28-14 Crimping Tool M8ND.

(b) M8ND CRIMPING TOOL.—The M8ND hand crimping tool is equipped with interchangeable die sets to accommodate all sizes of ferrules. The die action is adjustable for control of indent depth and the dies are easily changed by removal and replacement of two Allen head cap screws.

(c) M8ND DIE CHANGE AND ADJUSTMENT.—The dies are installed and adjusted as follows:

STEP 1.—Select the proper size die set for the shield termination ferrule to be used.

STEP 2.—Loosen the Allen head die holder lock screw (use 3/32 inch Allen wrench) and turn the coupler bushing so that the ram die holder moves to the full open position.

STEP 3.—Place the dies in the tool (stamped lettering on the dies to the front) so that the holding prongs straddle the head and ram. Hand tighten the holding screws for each die.

STEP 4.—Close the tool handles and turn the coupler bushing until the dies are butted. Release the toll handles slightly and turn the coupler bushing 1/4 turn more toward the closing position.

STEP 5.—Remove the lower die and tighten the die holder locking screw. Replace the lower die. Operate the tool and check the hand force required to complete the operation of the tool.

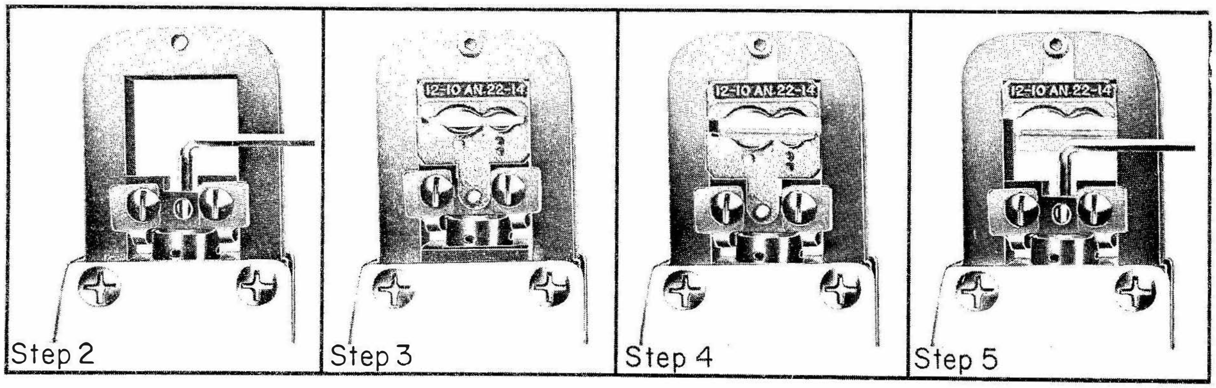



**FIGURE 28-15 M8ND Die Installation and Adjustment.**

**NOTE**

Keep the tool adjusted so that normal hand force of 45 to 55 lbs. is required to butt the dies (no ferrule in place) and release the ratchet.

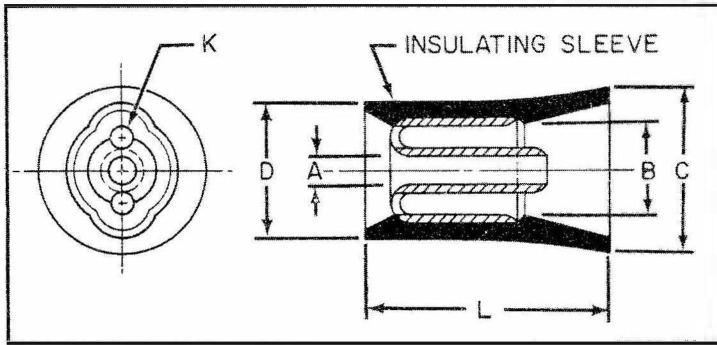
(d) UNIRING INSTALLATION.—There are two types of Unirings; the insulated type YEC (see table 28—4) and the uninsulated type UNC (see table 28—5). The construction and methods of installation are identical for both types. Install the Unirings as follows:

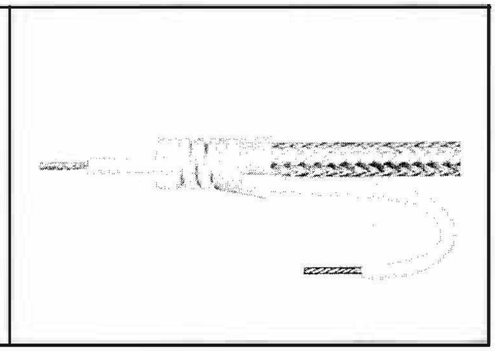
STEP 1.—Determine the outside diameter of the primary insulation and select the proper size Uniring from table 28—4 or 28—5. The "A" dimension of the Uniring should be slightly larger then the primary insulation diameter. The proper tool and die set may also be selected from these tables. The die sets are color coded to match the color code of the Uniring.

STEP 2.—Strip the jacket and trim the shield, exposing the wire, and fan the shield braid by rotating the wire.

STEP 3.—Slip the Uniring in place over the wire to a point where the shield is bottomed in the Uniring.

**TABLE 28-4. INSULATED UNIRING TYPE "YEC".**

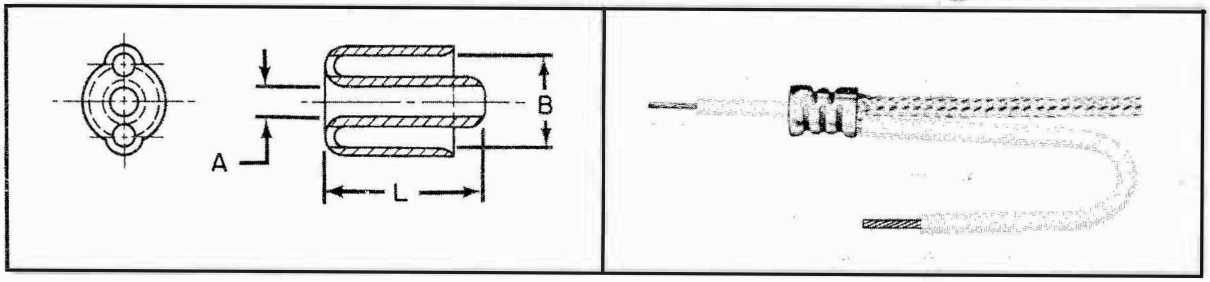


| L = .46 | | DIMENSIONS (In Inches) | | | | | INSTALLATION TOOLS | |
|---|---|---|---|---|---|---|---|---|
| CATALOG NUMBER | COLOR | "A" | "B" | "C" | "D" | "K" | MR8EC TYPE INCLUDES DIE | M8ND DIE SET |
| YEC90 | Red | .058 | .145 | .25 | .21 | .043 | MR8EC-2 | N10ECT |
| YEC100 | Yellow | .063 | .162 | .27 | .23 | .043 | MR8EC-1 | N10ECT |
| YEC110 | Blue | .080 | .170 | .28 | .24 | .043 | MR8EC-1* | N12ECT |
| YEC120 | Green | .101 | .193 | .30 | .26 | .043 | MR8EC-1* | N12ECT |
| YEC130 | Black | .115 | .207 | .32 | .27 | .043 | MR8EC-2* | N15ECT |
| YEC150 | Green | .134 | .230 | .34 | .29 | .043 | MR8EC-3 | N15ECT |
| YEC160 | Red | .156 | .261 | .37 | .33 | .043 | MR8EC-3 | N16ECT |
| YEC180 | Blue | .179 | .295 | .41 | .36 | .043 | MR8EC-4 | ..... |
| YEC200 | Yellow | .210 | .326 | .44 | .40 | .043 | MR8EC-4 | ..... |

*Also MR8EC-6

TABLE 28–5. UNINSULATED UNIRING TYPE "YNC".




| L = .46 | | DIMENSIONS (In Inches) | | INSTALLATION TOOLS | |
|---|---|---|---|---|---|
| CATALOG NUMBER | COLOR | "A" | "B" | MR8NC TYPE INCLUDES DIE | M8ND DIE SET |
| YNC90 | Red | .058 | .145 | MR8NC-2 | N10NCT |
| YNC100 | Yellow | .063 | .162 | MR8NC-1 | N10NCT |
| YNC110 | Blue | .080 | .170 | MR8NC-1 | N12NCT |
| YNC120 | Green | .101 | .193 | MR8NC-1 | N12NCT |
| YNC130 | Black | .115 | .207 | MR8NC-2 | N15NCT |
| YNC150 | Green | .134 | .230 | MR8NC-3 | N15NCT |
| YNC160 | Red | .156 | .261 | MR8NC-3 | N16NCT |
| YNC180 | Blue | .179 | .295 | MR8NC-4 | |
| YNC200 | Yellow | .210 | .326 | MR8NC-4 | |

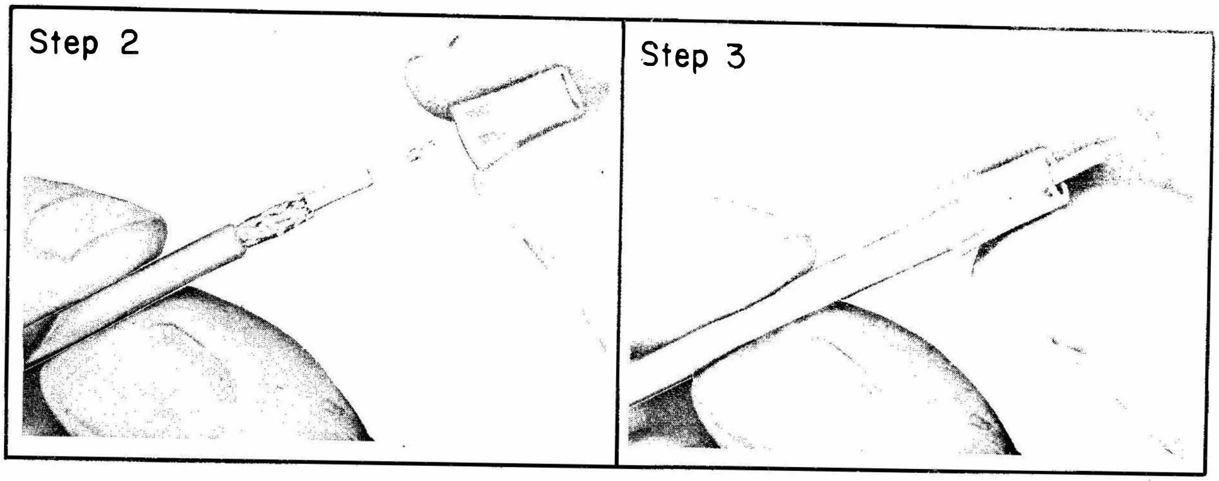



FIGURE 28–16 Preparation for Uniring Installation.

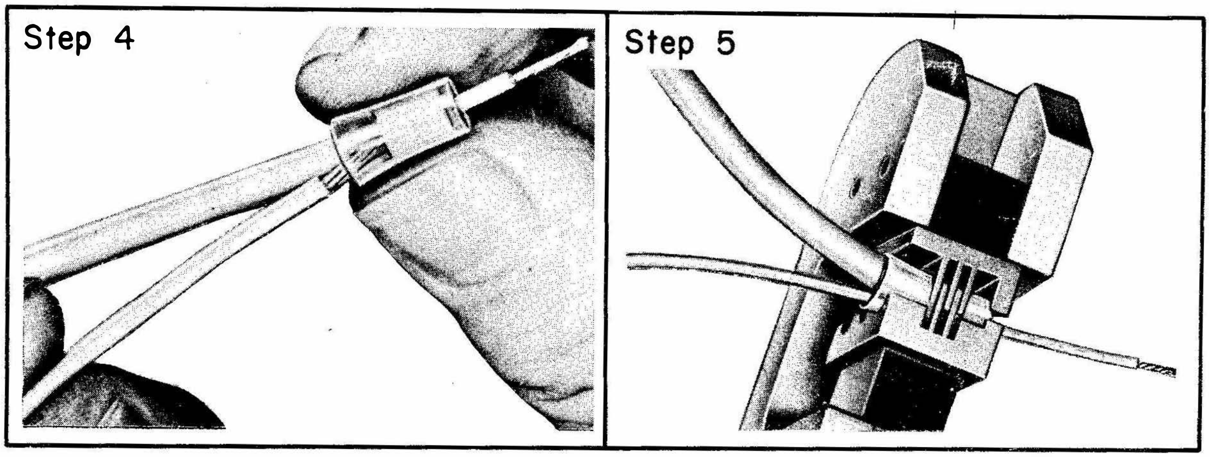



FIGURE 28–17 Uniring Installation.

STEP 4.–Insert ground or tap wire as shown in figure 28–17.

STEP 5.–Insert the Uniring and wire assembly into the crimping tool and complete the crimp. Remove and examine for proper completion of the crimp.

(e) HYRING INSTALLATION.–The Hyring is of two piece construction. The inner ring (type YIC) is inserted under the shield and the outer ring (types YOE and YOC) is installed over the shield. The different types of Hyrings and the tools required for installation are listed in tables 28–6, 28–7 and 28–8.

STEP 1.–Determine the outside diameter of the primary insulation. Select the inner Hyring from table 28–6. The inside diameter of the ring should be a minimum of 0.005 inch larger than the primary insulation diameter.

STEP 2.–Select the outer Hyring from table 28–7 or 28–8. The inside diameter of the outer ring should equal the outside diameter of the inner ring plus 0.025 inch (for single shield braid) plus 0.040 inch for the ground or tap wire (if used). The proper tool and dies are also selected from tables 28–7 and 28–8.

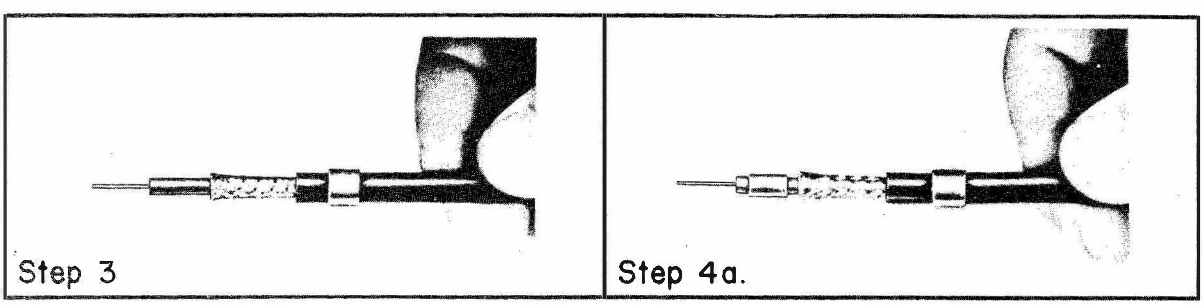
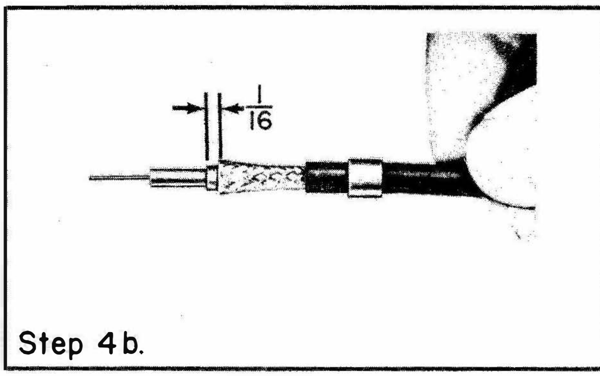



FIGURE 28–18 Preparation for Hyring Installation.

STEP 3.—Strip the jacket and trim the shield to the point of termination. Slip the outer Hyring over the shield.

STEP 4.—Flare the shield by rotating the wires and slide the inner Hyring under the shield. The Hyring should extend 1/16 inch beyond the end of the shield.



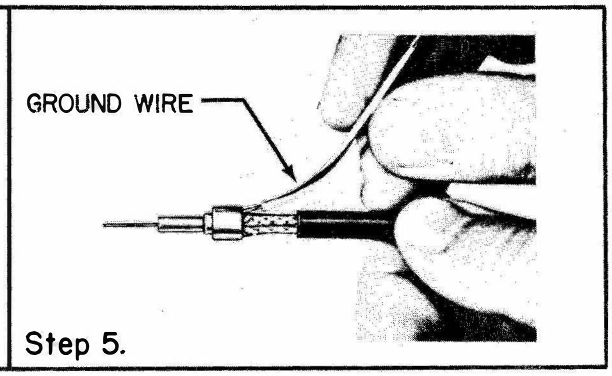




**FIGURE 28-19 Hyring Installation.**

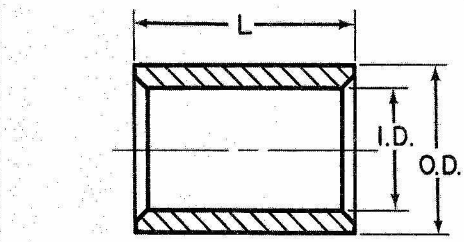
STEP 5.—Slip the outer Hyring back over the shield and inner Hyring. Insert the ground lead. No strands of the shield or ground lead should extend out of the terminal end of the Hyring.

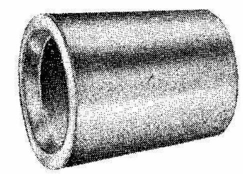
STEP 6.—Insert the assembled Hyring and wire in the tool and complete the crimp. Remove and examine for proper completion of the crimp.

**NOTE**

The shield braid is shown exposed in these pictures to clarify the installation procedure. In actual practice, the Hyring is installed flush against the insulating jacket.

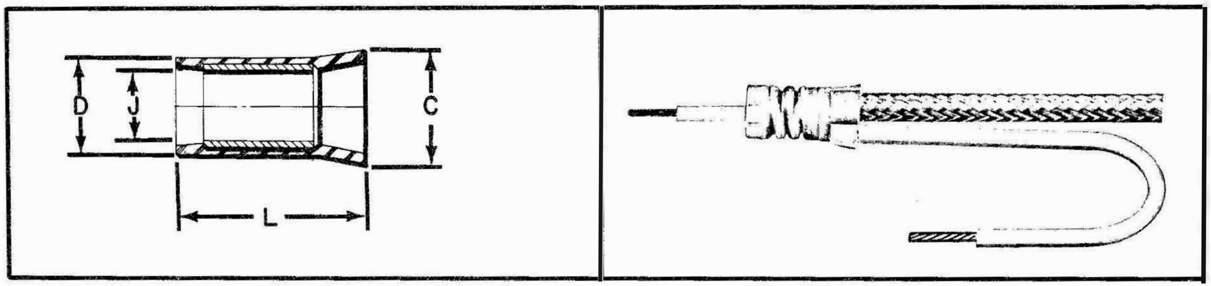
TABLE 28-6.- INNER HYRING TYPE "YIC".



| L = .31 | | DIAMETER (In Inches) | |
|---|---|---|---|
| CATALOG NUMBER | COLOR | I. D. | O. D. |
| YIC046 | Tin | .046 | .070 |
| YIC058 | Yellow | .058 | .083 |
| YIC063 | Red | .063 | .088 |
| YIC071 | Green | .071 | .096 |
| YIC080 | Blue | .080 | .104 |
| YIC090 | Orange | .090 | .114 |
| YIC101 | Yellow | .101 | .124 |
| YIC109 | Red | .109 | .131 |
| YIC115 | Tin | .115 | .146 |
| YIC124 | Green | .124 | .145 |
| YIC125 | Yellow | .125 | .156 |
| YIC134 | Orange | .134 | .156 |
| YIC150 | Blue | .150 | .181 |
| YIC156 | Red | .156 | .191 |
| YIC180 | Green | .180 | .204 |
| YIC194 | Blue | .194 | .225 |
| YIC219 | Tin | .219 | .243 |
| YIC261 | Blue | .261 | .297 |
| YIC297 | Red | .297 | .337 |

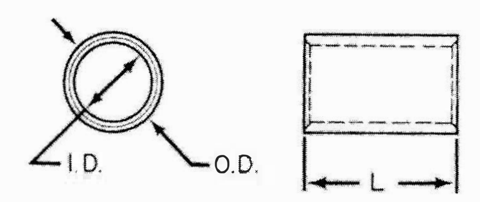
TABLE 28-7 OUTER HYRING, INSULATED TYPE "YOE".

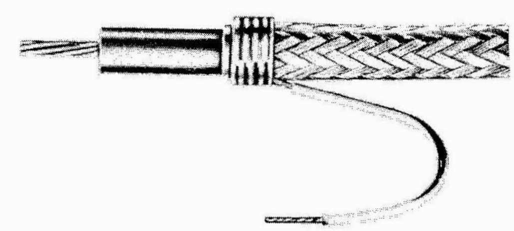



| L = .46 | | DIMENSIONS (In Inches) | | | INSTALLATION TOOLS | |
|---|---|---|---|---|---|---|
| CATALOG NUMBER | COLOR | "J" | "C" | "D" | MR8EC TYPE INCLUDES DIE | M8ND DIE SET |
| YOE90 | Red | .149 | .25 | .21 | MR8EC-2 | N10ECT |
| YOE100 | Yellow | .156 | .27 | .23 | MR8EC-1 | N10ECT |
| YOE110 | Blue | .180 | .28 | .24 | MR8EC-1* | N12ECT |
| YOE120 | Green | .187 | .30 | .26 | MR8EC-1* | N12ECT |
| YOE130 | Black | .207 | .32 | .27 | MR8EC-2* | N15ECT |
| YOE150 | Green | .235 | .34 | .29 | MR8EC-3 | N15ECT |
| YOE160 | Red | .261 | .37 | .33 | MR8EC-3 | N16ECT |
| YOE180 | Blue | .281 | .41 | .36 | MR8EC-4 | |
| YOE200 | Yellow | .312 | .44 | .40 | MR8EC-4 | |

*Also MR8EC-6

## TABLE 28-8. OUTER HYRING, UNINSULATED TYPE "YOC".



| L = .25 | | DIAMETER (In Inches) | | INSTALLATION TOOLS | |
|---|---|---|---|---|---|
| CATALOG NUMBER | COLOR | I.D. | O.D. | MR8PV TYPE INCLUDES DIE | M8ND DIE SET NUMBER |
| YOC70 | Tin | .101 | .124 | --------- | ------- |
| YOC80 | Blue | .125 | .156 | MR8PV-S | N8VST |
| YOC90 | Purple | .149 | .179 | MR8PV-S, MR8PV-1S | N10VST |
| YOC100 | Yellow | .156 | .196 | MR8PV-S, MR8PV-1S | N10VST |
| YOC110 | Blue | .180 | .204 | MR8PV-S, MR8PV-1S | N10VST |
| YOC112 | Blue | .175 | .215 | MR8PV-S, MR8PV-1S | N12VST |
| YOC120 | Orange | .187 | .227 | MR8PV-S, MR8PV-1S | N12VST |
| YOC128 | Tin | .199 | .235 | MR8PV-S, MR8PV-1S | N12VST |
| YOC130 | Yellow | .207 | .243 | MR8PV-S, MR8PV-1S | N12VST |
| YOC140 | Green | .219 | .250 | MR8PV-1S | N14VST |
| YOC150 | Orange | .235 | .266 | MR8PV-2 | N16VST |
| YOC160 | Yellow | .261 | .297 | MR8PV-2 | N16VT |
| YOC180 | Purple | .281 | .331 | MR8PV-2 | |
| YOC190 | Green | .300 | .335 | MR8PV-2 | |
| YOC200 | Yellow | .312 | .362 | MR8PV-3 | |
| YOC220 | Orange | .344 | .394 | MR8PV-4 | |
| YOC240 | Blue | .375 | .406 | --------- | |
| YOC250 | Red | .405 | .453 | --------- | |
| YOC370 | Tin | .705 | .755 | MD2-27 | |

(4) T&B GROUNDING SHEATH CONNECTORS.—T&B ferrules are of two piece construction with the hardened inner ferrules available in a straight and a flared—end type, and the outer ferrules available in insulated and uninsulated types. Tables 28—9 and 28—10 list the available sizes of sleeves. The ferrules are installed with the T&B "Shure Stake" hand tool.

(a) SHURE STAKE HAND TOOL.—The Shure Stake hand tools are available in three types and the only basic difference is the number or selection of dies that are installed in the tool. Table 28—11 lists the tools and the mating ferrules.

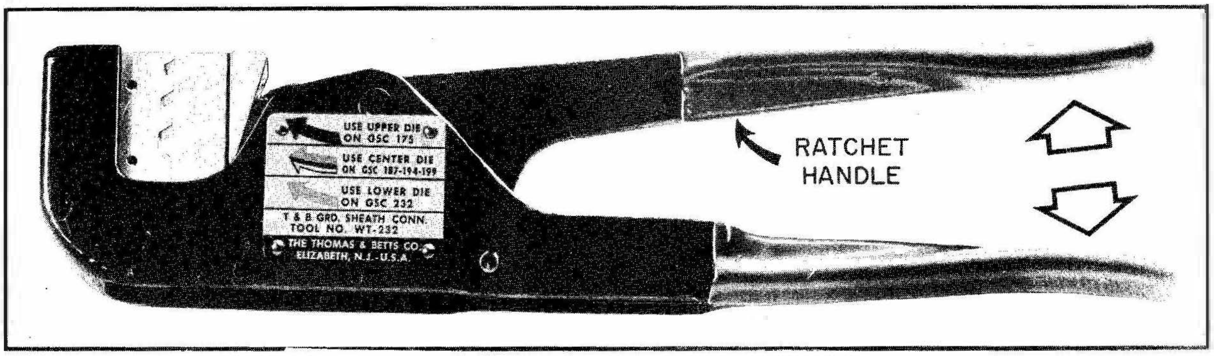



**FIGURE 28–20 T&B Shure Stake Tool Multiple Hex Type.**

(b) T&B GROUNDING SHEATH CONNECTOR INSTALLATION.—The T&B ferrules are installed on shielded wires as follows:

STEP 1.—Determine the outside diameter of the primary insulation, add 0.005 inch for minimum clearance, and select the inner ferrule from table 28–9.

STEP 2.—Determining from table 28–9 the outside diameter of the inner ferrule selected in STEP 1, then add to this dimension 0.025 inch (for thickness of single braid shield) and 0.040 inch (for ground wire #18). Using this total dimension, select on outer ferrule with the same or slightly larger inside diameter from table 28–9.

STEP 3.—Strip the jacket and trim the shield to the point of termination. Slip the outer ferrule over the shield.

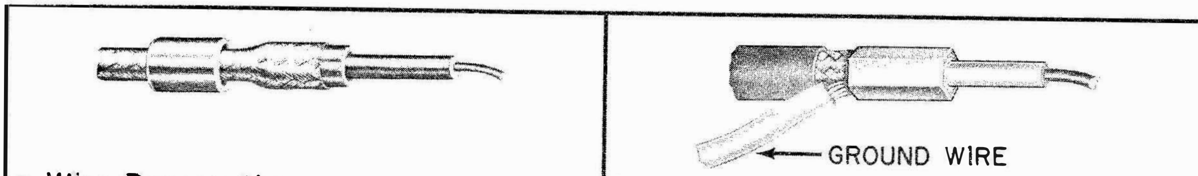
STEP 4.—Flare the shield by rotating the wire and slip the inner ferrule under the shield. Approximately 1/16 inch of the inner ferrule should protrude from the end of the shield.

**NOTE**

If the flared type of inner shield is used, the flared end should be installed facing the terminal end of the wire.

STEP 5.—Insert the ground wire between the outer ferrule and the shield. Slip the outer ferrule and ground wire back over the inner ferrule and align the terminal ends.

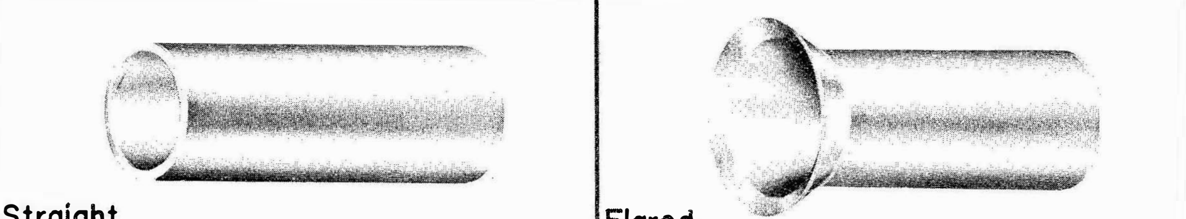
STEP 6. —Insert the ferrule and wire assembly in the correct size hand tool die and complete the crimping operation. Remove and inspect for proper completion of the crimp.



a. Wire Preparation
b. Completed Termination

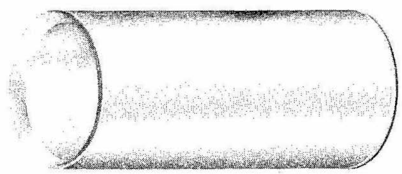
Figure 28-21. Crimping Procedure.

TABLE 28-9. T&B INNER FERRULES.

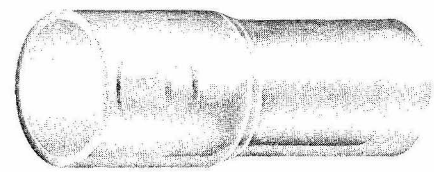

Straight
Flared

| CATALOG NUMBER | | COLOR CODE | DIMENSION | |
|---|---|---|---|---|
| STRAIGHT | FLARED | | INSIDE | OUTSIDE |
| GSB046 | GSB046X | Tin | 0.046 | 0.070 |
| GSB058 | GSB058X | Yellow | 0.058 | 0.083 |
| GSB063 | GSB063X | Red | 0.063 | 0.088 |
| GSB071 | GSB071X | Green | 0.071 | 0.096 |
| GSB080 | GSB080X | Blue | 0.080 | 0.1035 |
| GSB090 | GSB090X | Orange | 0.090 | 0.1135 |
| GSB096 | GSB096X | Purple | 0.096 | 0.119 |
| GSB101 | GSB101X | Yellow | 0.101 | 0.124 |
| GSB109 | GSB109X | Red | 0.109 | 0.131 |
| GSB124 | GSB124X | Green | 0.124 | 0.145 |
| GSB128 | GSB128X | Tin | 0.128 | 0.152 |
| GSB134 | GSB134X | Orange | 0.134 | 0.156 |
| GSB149 | GSB149X | Blue | 0.149 | 0.179 |
| GSB156 | GSB156X | Red | 0.156 | 0.193 |
| GSB165 | GSB165X | Tin | 0.165 | 0.194 |
| GSB175 | GSB175X | Green | 0.175 | 0.215 |
| GSB187 | GSB187X | Yellow | 0.187 | 0.227 |
| GSB194 | GSB194X | Blue | 0.194 | 0.236 |
| GSB205 | GSB205X | Orange | 0.205 | 0.245 |
| GSB219 | GSB219X | Tin | 0.219 | 0.250 |

TABLE 28-10. T&B OUTER FERRULES.



Uninsulated



Insulated

| CATALOG NUMBER | | COLOR CODE | INSIDE DIMENSION |
|---|---|---|---|
| UNINSULATED | INSULATED | | |
| GSC101 | GSR101 | Tin | 0.101 |
| GSC128 | GSR128 | Blue | 0.128 |
| GSC149 | GSR149 | Purple | 0.149 |
| GSC156 | GSR156 | Yellow | 0.156 |
| GSC175 | GSR175 | Blue | 0.175 |
| GSC187 | GSR187 | Orange | 0.187 |
| GSC194 | GSR194 | Red | 0.194 |
| GSC199 | GSR199 | Tin | 0.199 |
| GSC205 | GSR205 | Yellow | 0.205 |
| GSC219 | GSR219 | Green | 0.219 |
| GSC225 | GSR225X | Purple | 0.225 |
| GSC232 | GSR232 | Orange | 0.232 |
| GSC261 | GSR261 | Yellow | 0.261 |
| GSC275 | GSR275 | Tin | 0.275 |
| GSC281 | GSR281 | Purple | 0.281 |
| GSC287 | GSR287 | Blue | 0.287 |
| GSC297 | GSR297X | Green | 0.297 |
| GSC312 | GSR312X | Yellow | 0.312 |
| GSC327 | GSR327 | Tin | 0.327 |

## TABLE 28-11. T&B SHURE STAKE HAND TOOLS.

| OUTER FERRULE | | COLOR | SINGLE | MULTIPLE HEX | |
|---|---|---|---|---|---|
| UNINSULATED | INSULATED | CODE | HEX | TOOL # | DIES |
| GSC101 | | Tin | WT219 | | WT200 |
| GSC128 | GSR101 | Blue | WT200 | WT230 | WT202 |
| GSC149 | GSR128 | Purple | WT201 | | WT209 |
| GSC156 | | Yellow | WT202 | | |
| GSC175 | GSR149 | Blue | WT203 | | WT219 |
| GSC187 | GSR156 | Orange | WT206 | WT231 | WT201 |
| GSC194 | | Red | WT206 | | WT211 |
| GSC199 | | Tin | WT206 | | |
| GSC205 | GSR175 | Yellow | WT208 | | WT203 |
| GSC219 | | Green | WT208 | WT232 | WT206 |
| GSC225 | | Purple | WT209 | | WT210 |
| GSC232 | GSR187 | Orange | WT210 | | |
| | GSR194 | | | WT233 | WT208 |
| | GSR199 | | | | WT212 |
| GSC261 | GSR205 | Yellow | WT211 | | |
| | GSR219 | | | WT234 | WT214 |
| | GSR225 | | | | WT216 |
| GSC275 | GSR232 | Tin | WT212 | | |
| GSC281 | GSR261 | Purple | WT214 | WT235 | WT215 |
| GSC287 | | Blue | WT214 | | WT217 |
| GSC297 | | Green | WT214 | | |
| GSC312 | GSR275 | Yellow | WT215 | WT236 | WT216 |
| GSC327 | | Tin | WT216 | | WT218 |

**NOTE**

These tools are available in the following three types:

1. SINGLE HEX DIE.
2. MULTIPLE HEX DIES.–The multiple die tool numbers and the equivalent single die tool numbers are listed in the last two columns of the above table.
3. MULTIPLE HEX SELECTED DIES.–These tools may be ordered equipped with dies selected by the installer.

EXAMPLE.–A tool equipped with dies to install GSC128, GSC194 and GSC232 would have the catalog number WT202–09–09.

(e) PIGTAIL TERMINATION.–This method of shield termination is somewhat slower than the crimped ferrule method but can be used when ferrules and tools are not available.

**NOTE**

This method of shield termination must be used in circuits carrying electrical information with a frequency exceeding 100 megacycles per second.

(1) PIERCED SHIELD PIGTAIL.—Wire shields may be formed in pigtails for shield termination by separating the shield strands at the point of termination and pulling the terminal ends of the wires out of the shield through the hole formed in the shield. Proceed with this method as follows:

(a) SHIELD PICK METHOD.—A pointed tool such as an awl or scriber is used to make the hole in the shield (a mimeograph stencil stylus of the ball point type is an excellent tool for this purpose). If a sharp pointed tool is used, the point should be slightly rounded off in order to eliminate damage to the insulation.

STEP 1.—Determine the length of pigtail required for the termination. Cut and remove the outer jacket to this dimension.

STEP 2.—Push the shield back over the wire until a "bubble" forms at the jacket termination.

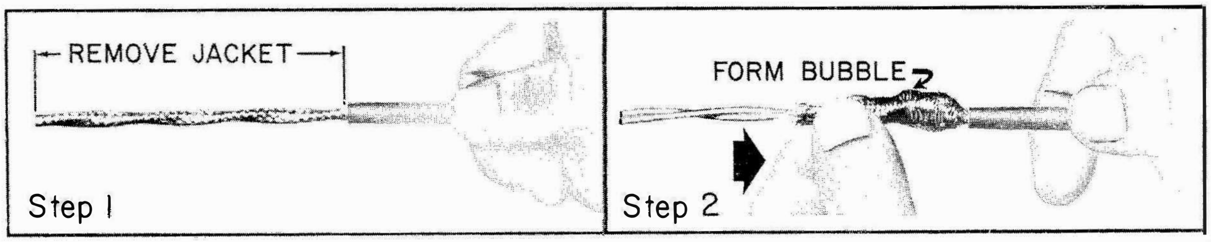



**Figure 28-22. Step 1 and 2.**

STEP 3.—Insert the pointed tool carefully into the braid "bubble" as close to the jacket termination as practicable. Move the tool with a circular motion until a hole large enough to pass the doubled wires is formed in the braid.

**CAUTION**

Do not break the shield strands or damage the wire insulation while forming the hole.

STEP 4.—Bend the wires and shield at the hole, carefully insert the tool between the wires and shield, then pull the terminal ends of the wires through the hole.

STEP 5.—Pull on the empty section of shield and form it into a compact braided conductor.

STEP 6.—Insulate the pigtail with a length of vinyl sleeving and tape the junction of the jacket and sleeving. The terminal ends of the pigtail and wires may now be terminated using approved methods.

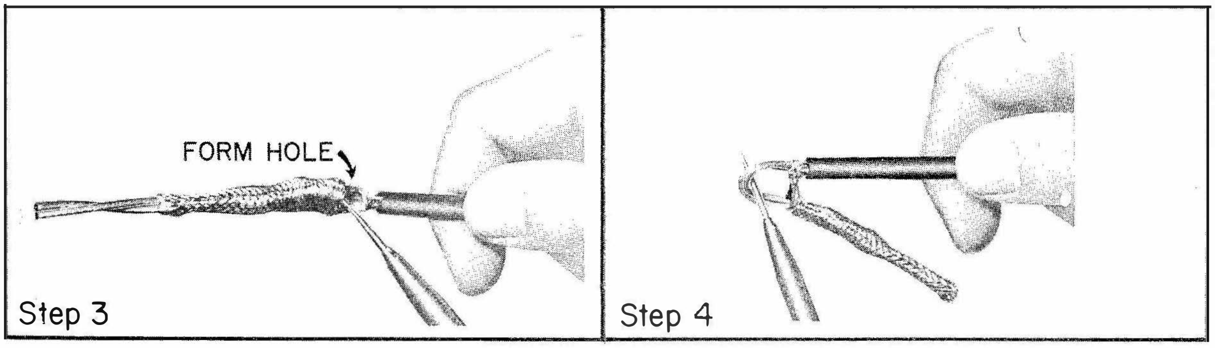



Figure 28-23. Step 3 and 4.

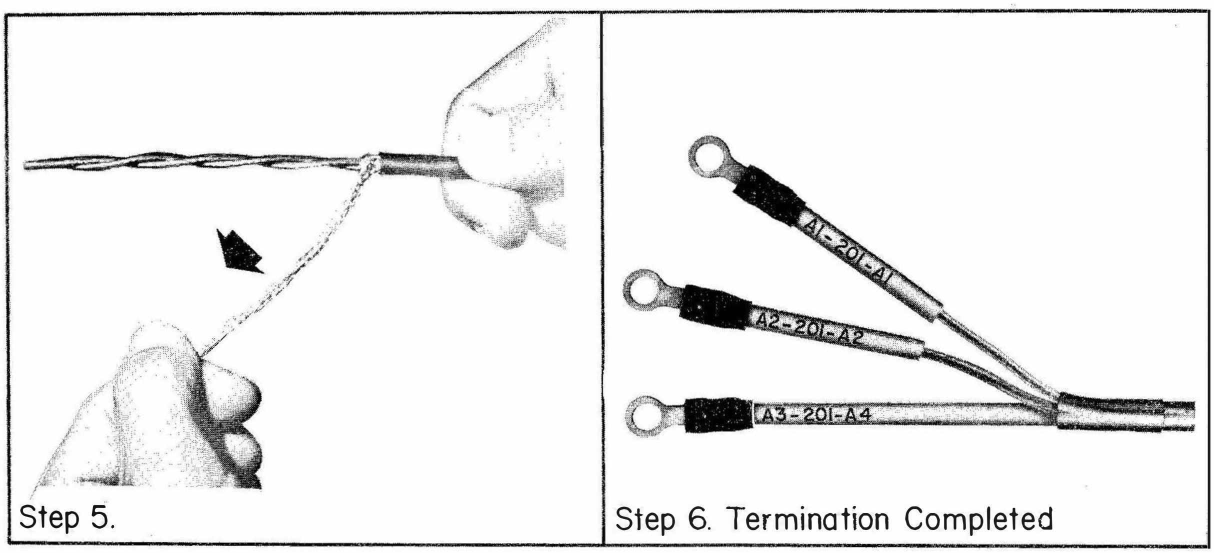



Figure 28-24. Completed Termination.

(b) SHIELD STRIPPING TOOL.—A special tool can be constructed to aid in the removal of the wire from the braid. This tool will only handle one specific size of shielded wire; however, if the installation warrents, additional tools of varying sizes can be constructed. The general construction of this tool is illustrated in figure 28-25.

**NOTE**

The pointed end of the tube on this tool should be finished with rounded edges. Sharp, unfinished edges will damage the insulation and cut the shield strands.

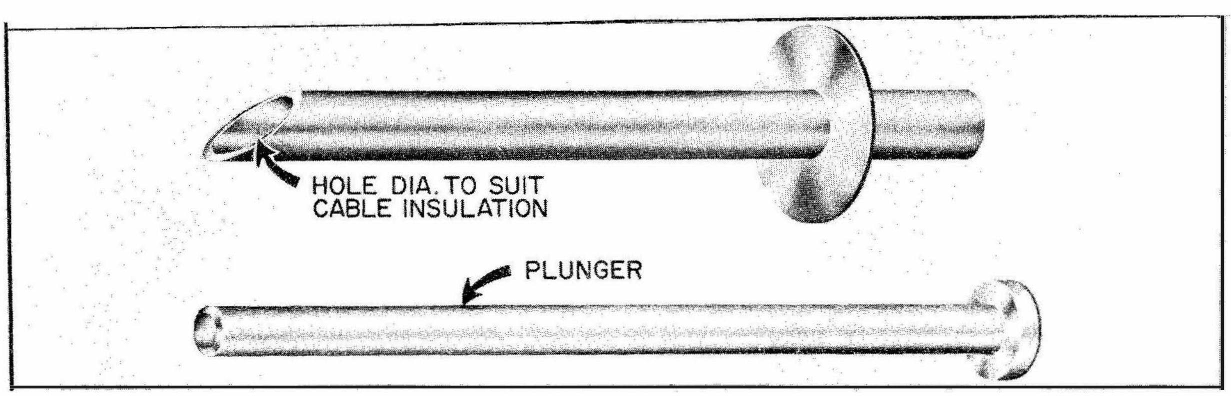



Figure 28-25. Shield Stripping Tool.

(c) SHIELD STRIPPING TOOL USE.–The method of using this tool is described in the following steps:

STEP 1.–Remove the insulating jacket to the point determined for termination of the shield.

STEP 2.–Slide the pointed tube between the shield and the wire insulation to the point of shield termination.

STEP 3.–Bend the shielded wire at right angles until the point of the tube protrudes through the shield and, by movement of the tool, enlarge the hole until it is of sufficient size to pass the doubled wire.

STEP 4.–Insert the plunger in the open end of the tube and push the wire back through the hole as illustrated in figure 28-26.

**CAUTION**

Use extreme care in operating this tool so as not to damage the insulation or cut the shield strands.

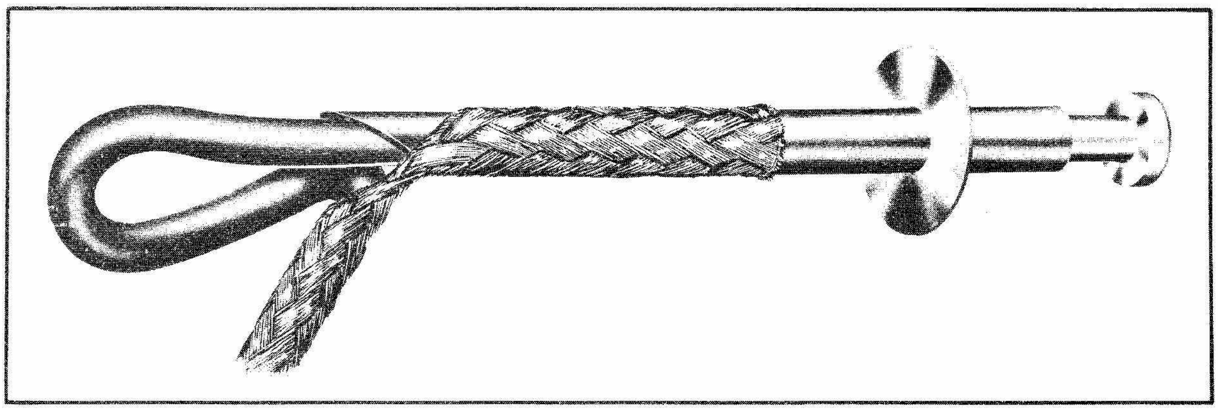


**Figure 28-26. Shield Stripping Tool Use.**

STEP 5.–Remove the tool from the shield, stretch and form into a compact braided conductor. Finish termination as described in STEP 6 under the "Shield Pick" method.

(2) COMBED SHIELD PIGTAIL.–Some shielded wires may be constructed in such a manner that the previous methods of making the pigtail will not be practicable. In these cases the shield strands must be separated or combed out with a pointed tool or by use of a specially constructed wire comb.

(a) POINTED TOOL METHOD.–The pointed tool should be constructed of a composition material so as not to damage the insulation or braid strands during the combing operation. If the tool is made of metal, the pointed end should be slightly rounded off to eliminate damage to the wire.

STEP 1.–Remove the wire jacket back to the predetermined shield termination point.

STEP 2.–Start combing out the shield at the terminal end of the shielded wire. Rotate the shielded wire and continue combing the shield, one braid section at a time, until the shield termination point is reached.

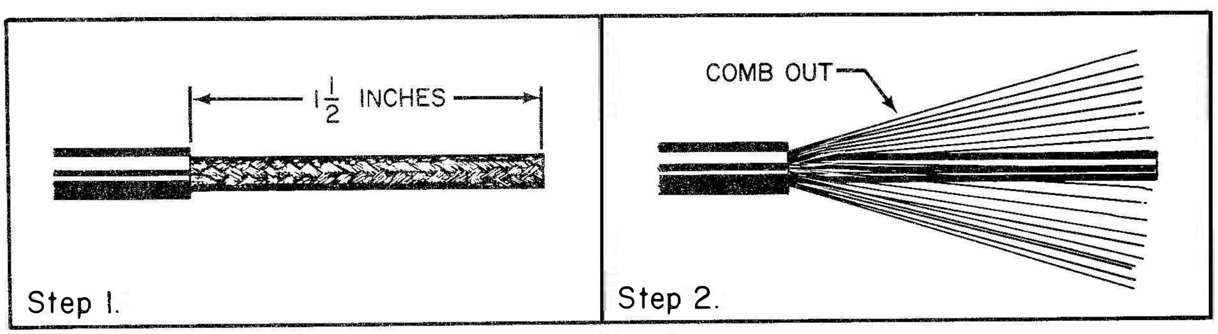



**Figure 28-27. Combed Shield Pigtail.**

STEP 3.–Twist the combed strands together into a compact conductor.

STEP 4.–Insulate the pigtail and finish termination as described in STEP 6 under the "Shield Pick" method.

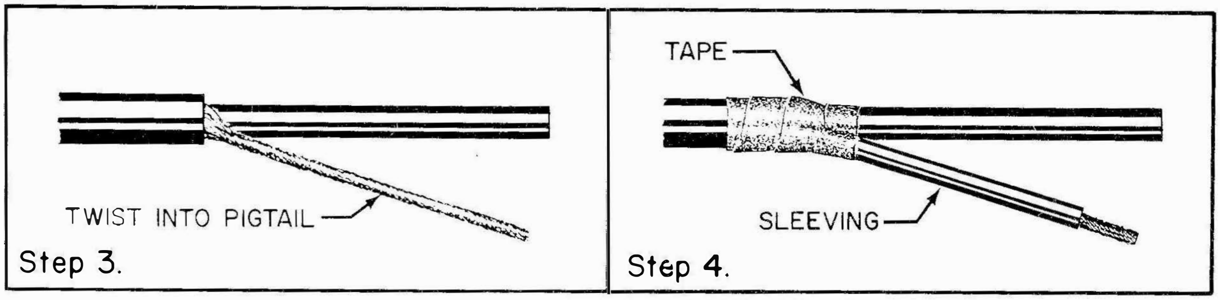



**Figure 28-28. Completed Shield Pigtail**

(b) SHIELD COMB METHOD.—A shield comb can be constructed using a section of wooden doweling and the wire comb pad from a file card. The shield combing procedure and termination is the same as that for the pointed tool method. Construction of the shield comb is illustrated in figure 28-29.

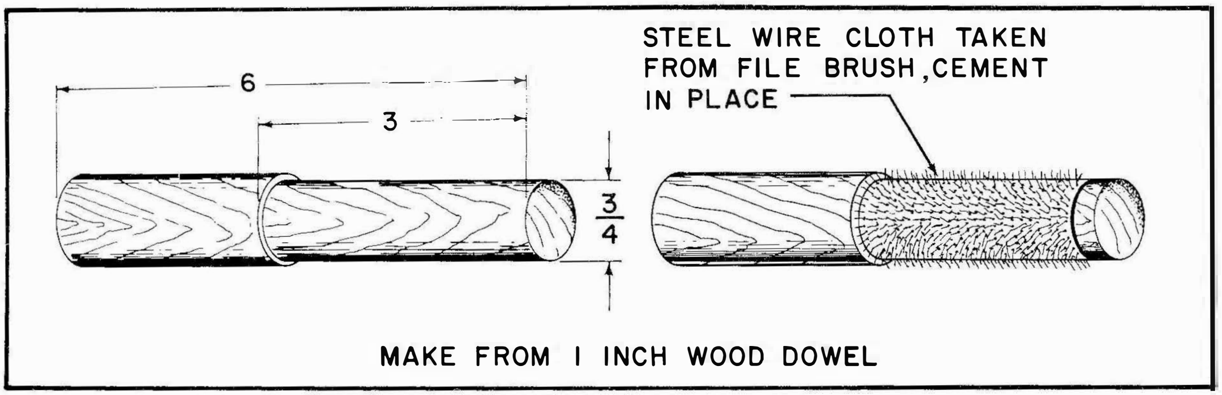



**Figure 28-29 . Shield Comb Construction .**

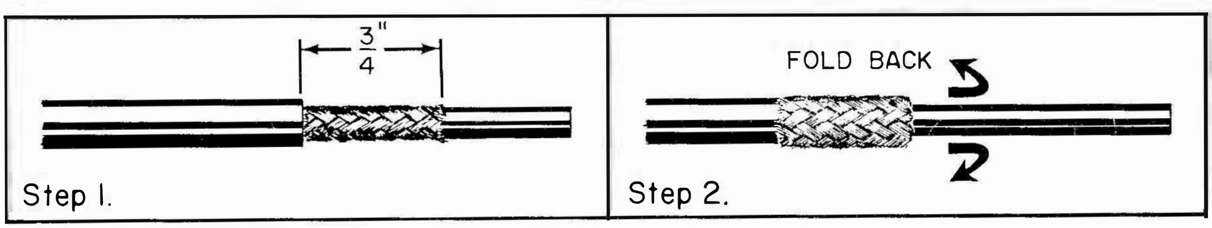
f. SHIELD DEAD ENDING.—In some cases of shielded wire termination, grounding the shield is not necessary or planned and the shield must be finished with a dead-end termination. This may be completed as follows:

(1) FERRULE TERMINATION.—The shield may be dead-ended by the use of ferrules (as previously described in this technique) with elimination of the ground wire. Insulated ferrules are preferred for dead-end shield termination.

(2) TAPE WRAP TERMINATION.—When ferrules and crimping tools are not available, the shield may be dead-end terminated as follows:

STEP 1.—Trim the shield approximately 3/4-inch forward of the shield termination point.

STEP 2.— Loosen the shield and roll back over the insulating jacket.




**STEP 3. Figure 28-30. Shield Dead Ending.**

STEP 3.—Wrap the rolled shield section with two layers of vinyl tape, covering all of the visible shield.

STEP 4.–Secure the tape with lacing cord using a clove hitch finished with a square knot.

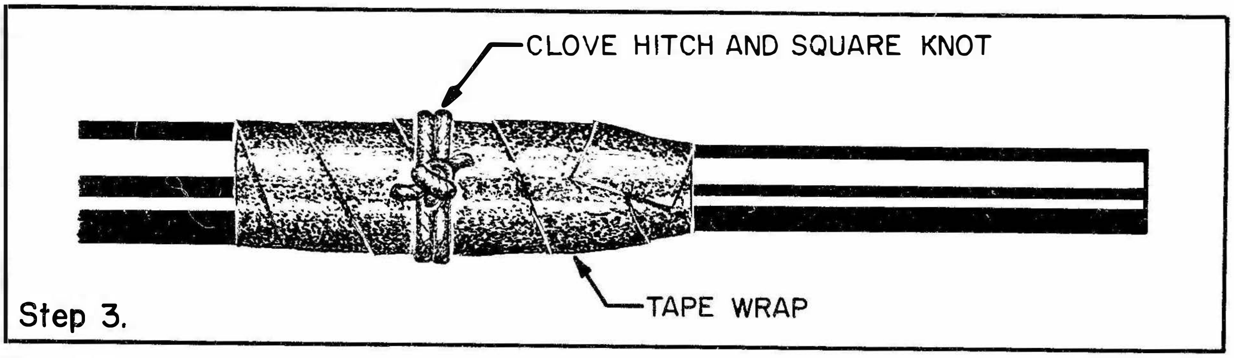



**Figure 28-31. Dead Ended Shield.**

g. VISUAL INSPECTION OF CRIMPED FERRULES.–The completed ferrule termination of wire shields shall be visually inspected after the crimping operation for any of the following defects:

(1) CRACKED FERRULES.–A cracked ferrule will not furnish a termination which is mechanically and electrically acceptable.

(2) CRACKED INSULATION.–If the ferrule insulation is defective, the purpose of the insulation is defeated and the termination is not acceptable.

(3) SHIELD END PROTRUSION.–If the shield ends are allowed to protrude beyond the ferrule (two piece types), the danger of insulation penetration exists and the wire should be properly re-terminated.

(4) CRIMP INDENT.–The crimp indent must be in the proper position and in line with the ferrule (not partially on the ferrule and not cocked).

(5) INSULATION DAMAGE.–The basic conductor insulation shall not be scratched, marred, compressed or otherwise distorted by the crimped ferrule shield termination.

h. ELECTRICAL TESTS.–If there is a reason to suspect improper electrical termination of the shield due to faulty ferrules or crimping tools, an electrical test should be conducted on samples of the wire shield ferrule termination in question. The millivolt drop of the ferrule splice shall be measured from the intersection of the tongue and barrel of the ground wire lug terminal to a point on the wire shield as shown in figure 28-32.

(1) ELECTRICAL TEST CONDITIONS.–The following conditions must be observed for the electrical test:

(a) TEST CURRENT.–A test current of one ampere shall be passed through the termination assembly for measurement of the voltage drop.

(b) ASSEMBLY TEMPERATURE.–The voltage drop measurement should not be made until the termination assembly has stabilized to an ambient room temperature of 20 to 30 degrees Centegrade.

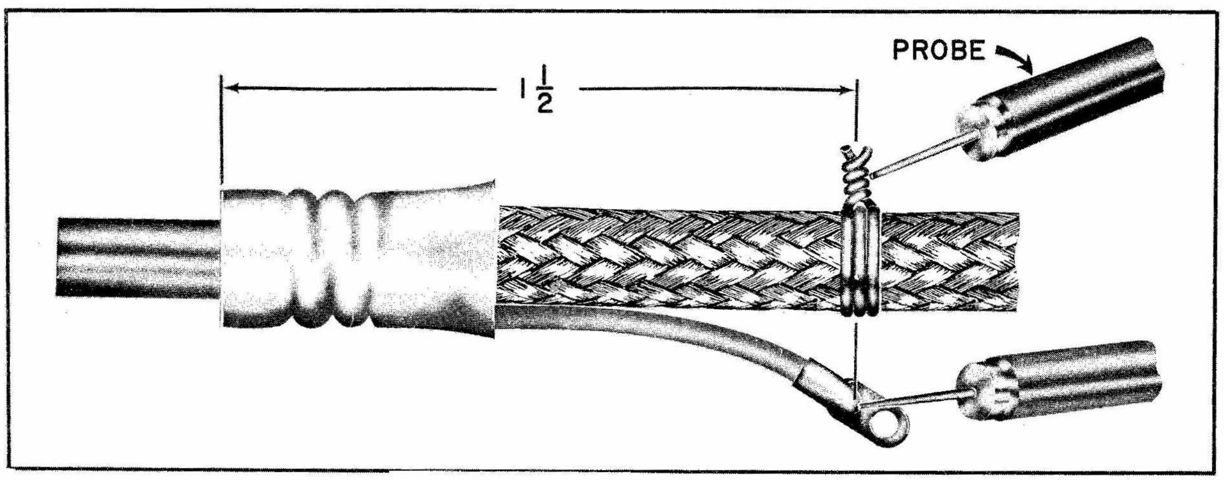



**Figure 28-32. Electrical Test Set-up.**

(c) SHIELD CONNECTION.—The test point connection to the shield shall be a #30 to #26 AWG copper wire wrapped tightly around the shield. A minimum of three turns shall be used and the ends shall be twisted together as shown in figure 28-32. A copper ring soldered to the shield can be used as an alternate test point connection.

(d) MAXIMUM VOLTAGE DROP.—The voltage drop, when passing a test current of one ampere through the test assembly, shall not exceed nine millivolts.

i. MECHANICAL TESTS.—When the shield termination is suspected to be mechanically defective, a sample assembly of the wire and ferrule should be checked for proper completion on the ferrule crimp by the following tests:

(1) TENSILE STRENGTH.—The sample assembly shall be tested in a standard tensile-testing machine as shown in figure 28-33. Conditions to be observed during the test are listed below following figure 28-33.

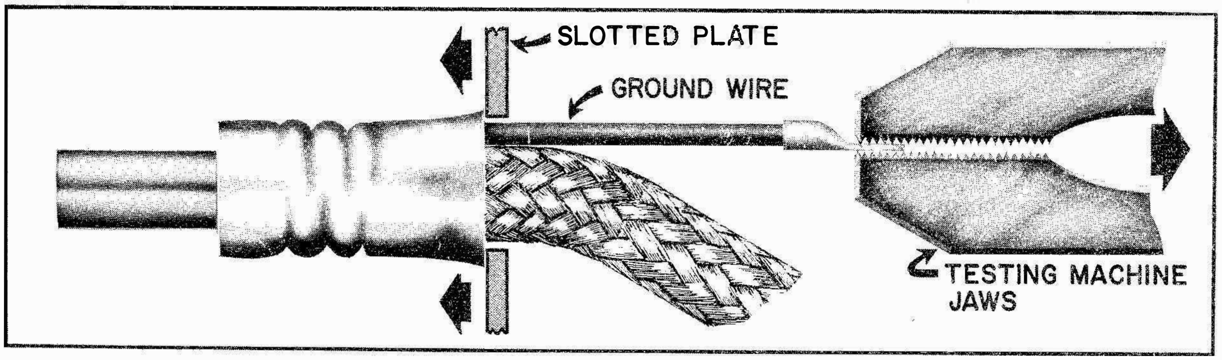



Figure 28-33. Tensile Strength Test.

(a) HEAD TRAVEL SPEED.—The test shall be conducted with a head travel speed of one inch per minute.

(b) TENSILE STRENGTH MINIMUM.—The mechanical connection between the ground wire and the crimped ferrule shall have a tensile strength of not less than 15 pounds for size AN-22 ground wire and not less than 19 pounds for size AN-20 ground wire.

(2) INSULATION DISTORTION.—Any distortion of the primary insulation can be checked by testing a sample assembly in a standard tensile-testing machine as shown in figure 28-34. The test conditions are listed below.

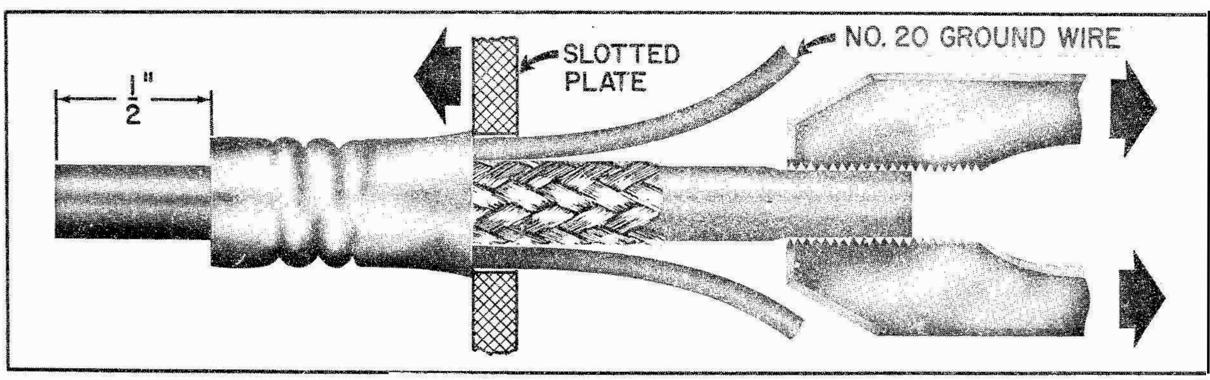



Figure 28-34. Insulation Distortion Test.

(a) HEAD TRAVEL SPEED.—The test shall be conducted with a head travel speed of one inch per minute.

(b) GROUND WIRES.—Two number 20 ground wires shall be crimped in the ferrule.

(c) SHIELD LENGTH.—The shield shall be stripped to within one-half inch of the ferrule.

(d) WIRE REMOVAL FORCE.—The force necessary to remove the wire from the crimped ferrule shall not exceed nine pounds.

4-29. CONNECTION TO TERMINALS.–This sub-section describes the approved methods and materials used for connection of wire terminating lug terminals to electronic equipment screw or stud type terminals.

a. SCREW OR STUD TERMINALS.–Screw or stud assemblies used for electronic equipment terminal connection points should be in perfect mechanical condition, clean, and meet the following requirements:

(1) FLAT WASHERS.–Suitable flat metal washers will be used to separate the wire lug terminals from the screw head or the stud nut. The outside diameter of the washer should equal the tongue width of the lug terminal.

(2) LOCK WASHERS.–A spring type lock washer will be used between the flat washer and the screw head or the stud nut.

(a) SERRATED LOCKWASHERS.–Serrated lockwashers are manufactured with the teeth located internally or externally on the washer. The lock washer with external teeth presents a larger gripping surface and is preferred for use on equipment terminals subjected to normal vibration. The diameter of the washer should not be larger than the diameter of the screw head or stud nut.

(b) SPLIT LOCKWASHERS.–Split lockwashers will withstand more vibration than the serrated type and may be used on any screw or stud terminal. They are preferred for use where excessive vibration will be present. The outside diameter of the split lockwasher should not exceed the diameter of the screw head or stud nut.

(3) THREAD LENGTH.–The thread length of screws or studs must be sufficient, after installation of the lug terminals and washers, to provide a secure engagement and fastening of the connection.

b. WIRE CONNECTION.–All wire connecting to a screw or stud equipment terminal shall be terminated with the correct type of lug terminal affixed to the wire. The connection to the equipment terminal shall be completed by use of the tongue section of the lug terminal.

c. SEQUENCE OF CONNECTION.–When two or more wires are connected to a single screw or stud equipment terminal, the heaviest wire shall be installed next to the terminal base. The lighter wires will be added progressively, one above the other, with the lightest wire at the top of the terminal (near the screw head or the stud nut).

d. CONNECTION TORQUE.–Sufficient torque should be applied to the terminal nut or screw to securely clamp the connection and hold it firmly in position. Do not apply excessive torque as this will result in stripped threads or broken studs or screws.

e. SCREW TERMINAL.–The assembly of materials required for the connection of a lug terminal to a screw type equipment terminal is illustrated in figure 29-1a.

f. STUD TERMINAL.–When the lug terminal connection is made to a stud type equipment terminal, use the sequence of materials as illustrated in figures 29-1b and c. If the equipment terminal stud is secured in position with a nut (see figure 29-1b), a flat washer is necessary immediately above the nut. If the equipment terminal stud is constructed with a flat bearing surface at the base, this additional washer is not required (see figure 29-1c).

g. COMPLETED CONNECTION.–The completed connection should be as illustrated in figure 29-2a, with the connection surfaces in flat contact and in the lug terminal barrel clear of the equipment terminal surface and surrounding materials.

h. PLACEMENT OF LUG TERMINALS.–The position of placement of the lug terminals, when installed on the terminal, shall be such that any normal pull on the wires shall exert torque in a direction that will promote tightening and not loosening of the connection assembly. The proper placement of a lug terminal, when connected to a screw type equipment terminal, is illustrated in figure 29-2b. If the lug terminal is positioned as illustrated (exaggerated for clarity in the illustration), any movement of the wire in the indicated direction will tend to tighten the connection. This system of lug terminal placement may also be used on the stud type of equipment terminal if the direction of probable wire movement can be predetermined.

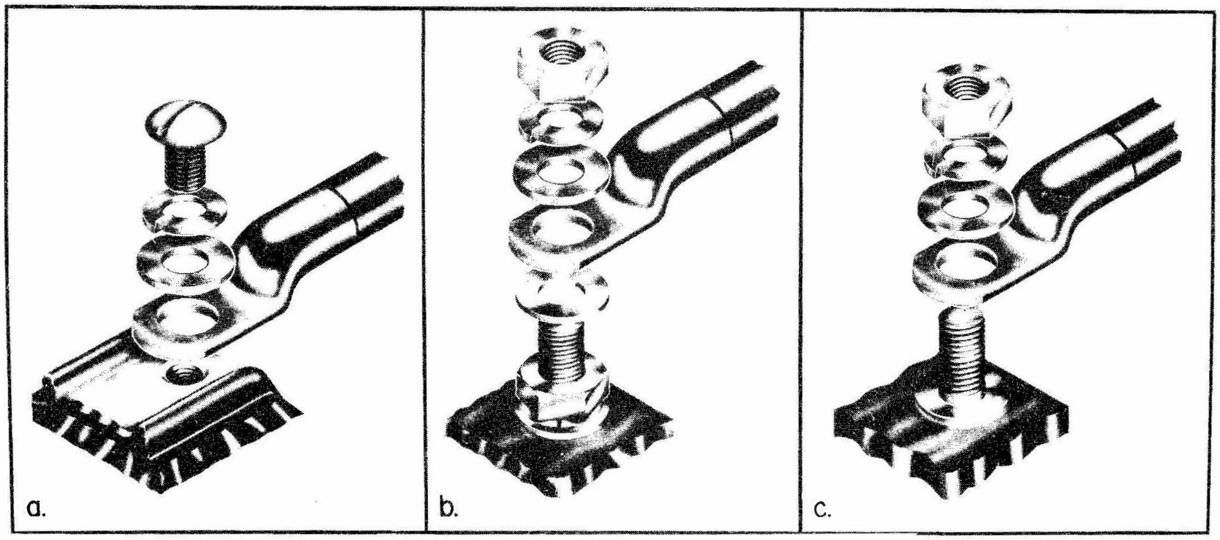



Figure 29-1. Equipment Terminal Connections

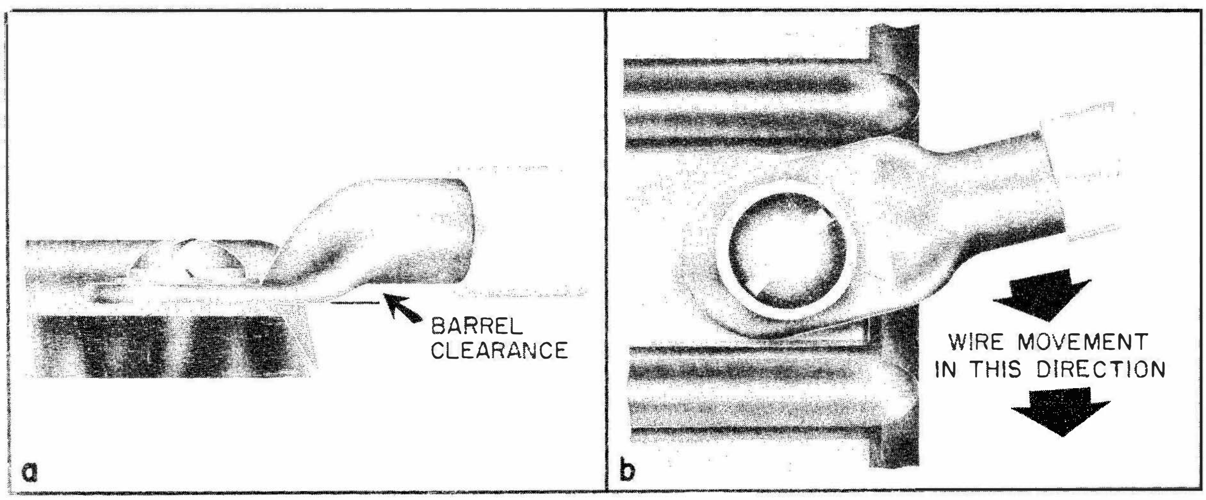



Figure 29-2. Completed Connections.

**4-30. PIGTAIL SPLICE CONNECTORS.** –These connectors may be used for making splice connections in lighting systems (fixtures, connection boxes, branch boxes, door switches etc.), small power appliances and motors (except IC and FC or electronics systems). They shall not be used in any case where the circuit voltage is greater than 600 volts.

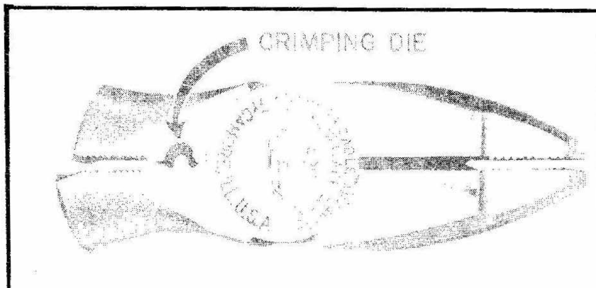
a. CONNECTOR TYPES.–The two distinct types of connectors that may be used for wire connections are listed below along with their advantages and disadvantages.

(1) REMOVEABLE TYPES.–The removeable types allow disconnection of the circuit wires for addition or deletion of wires or for circuit testing. If the connector is not tight or improperly installed, a high resistance connection may develop due to corrosion or vibration.

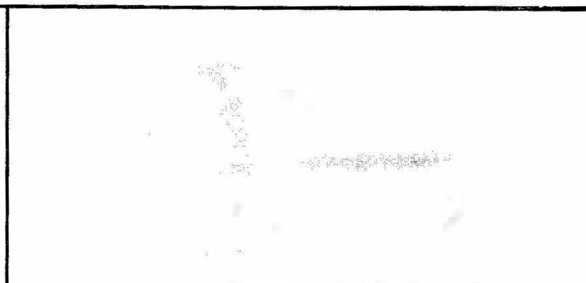
(2) CRIMP TYPES.–The crimp types, if installed with the proper tool, will provide a lasting low resistance connection. If the uninsulated type is used, and covered with a WRAP–CAP, or equivalent, the insulation may be removed at anytime for circuit testing. When the preinsulated type is used, the connector must be cut from the wires to allow alteration or testing of the circuit.

b. IDEAL CONNECTORS.–The types of IDEAL connectors, tool and methods of installation are as follows:

(1) #410 CRIMP CONNECTOR SLEEVE.–This sleeve may be used on wire size combinations with a maximum size of two #10 with two #14 and a minimum size not less than one #18 with one #14. The IDEAL electricians pliers equipped with crimping die will provide a properly crimped connection.




a. Crimping Pliers



b. Sleeve Connector (Enlarged)

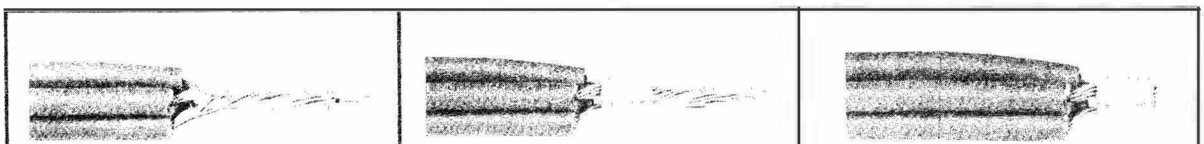
**FIGURE 30–1 IDEAL Crimping Pliers and Sleeve.**

(a) SLEEVE INSTALLATION.–Install and insulate the IDEAL sleeves as follows:

STEP 1.–Strip the wire insulation approximately one inch and twist the conductors together (combinations of conductors need not be twisted).

STEP 2.–Slip the sleeve over the conductors with the flared end toward the insulation, insert the assembly into the crimping tool and complete the crimp.

STEP 3.–Clip off the excess wire. The electrical connection is now completed.



Step 1 Step 2 Step 3

**FIGURE 30–2 Sleeve Installation.**

STEP 4.–Separate the wires and push the WRAP–CAP down over the crimped sleeve and the wires.

STEP 5.–Pull the tabbed cap between the wires and stretch up and over the insulated crimped connection. This completely insulates the connection and still allows easy removal of the insulation for circuit testing (see figure 30–3).

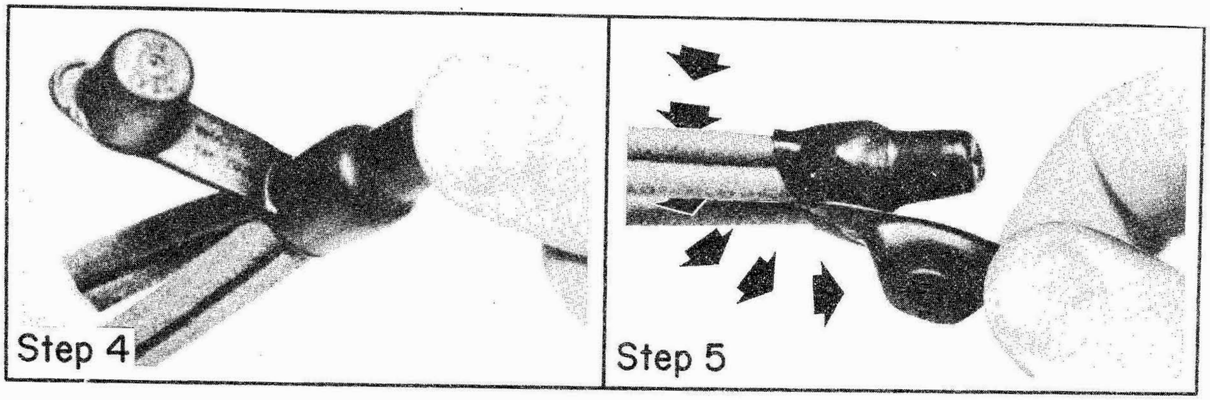



**FIGURE 30-3 Connection Insulation.**

(2) WING NUT CONNECTOR.–This is a nylon insulated connector of the "Wire Nut" type, manufactured in two sizes which connect a wide variety of wire combinations.

(a) WING NUT INSTALLATION.–Strip the wire insulation approximately one half inch for model 452 and three quarters inch for model 453. Bunch the wires together, slip the wing nut over the stripped ends, and twist the wing nut in a clockwise direction until it is tightly secured to the conductors.

**CAUTION**

The stripped portions of the wires must be completely inside the nut and the insulation of the wires must be inside the insulating flare of the wing nut.

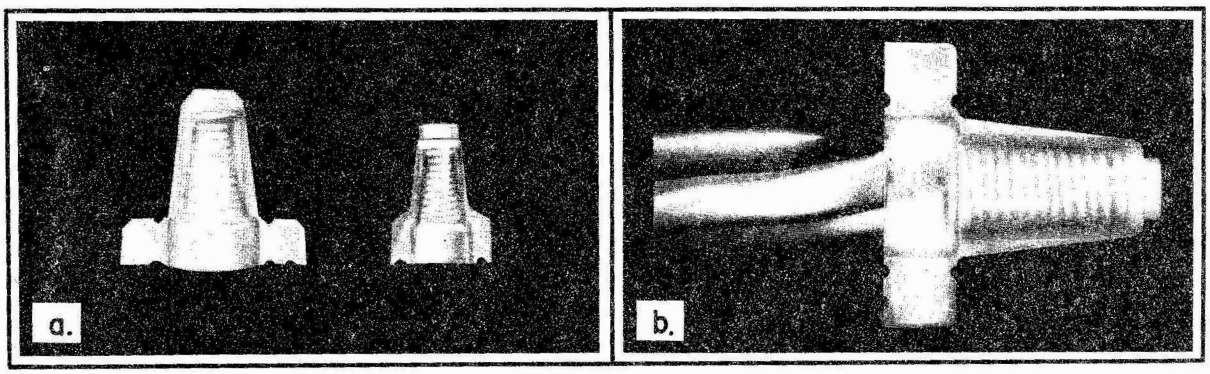



**Figure 30–4. Wing Nuts and Installation.**

c. BURNDY CONNECTORS.–The BURNDY BURCAP connectors are preinsulated and manufactured in two different sizes:

(1) YQE 91.–This connector will accommodate combinations of solid or stranded conductors in the AWG 14 to 12 range with a cross sectional area minimum of 4250 circular mils and maximum of 10,620 circular mils.

(2) DIE SETS.–The YQE-91 and YQE-150 are installed with the M8ND tool equipped with die set N150WT.

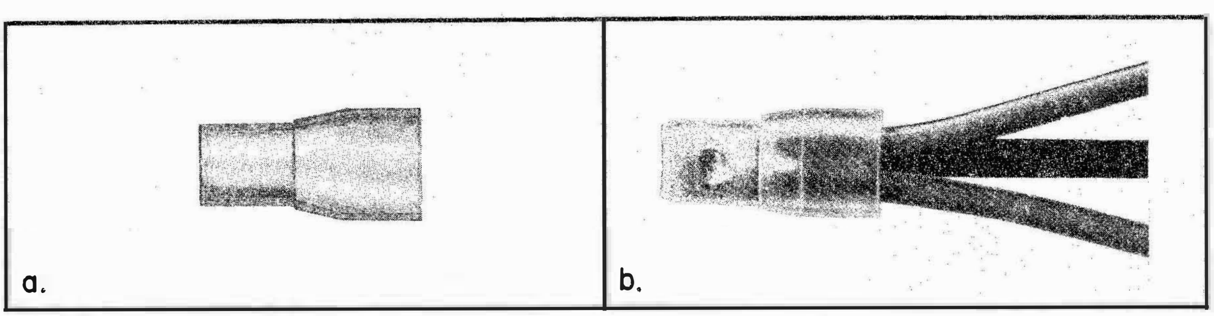



**Figure 30–5. BURCAP Installation.**

(3) BURCAP INSTALLATION.–These connectors are installed on combinations of conductors as follows:

STEP 1.–Select the proper size connector that will accommodate the combination of conductors to be connected. This may be done by combining the circular mil areas of the conductors or by using test specimens of the conductors to determine the size of connector required.

STEP 2.–Strip the ends of the wires to expose approximately 3/8 inch of the conductor. Group the conductors and slide the connector over the group until the conductor ends are visible at the open insulated end.

**CAUTION**

When the conductors are bottomed in the connector, the insulation of the wires should extend into, and be completely insulated by the connector insulating sleeve.

STEP 3.–Insert the wire and connector assembly into the tool die, complete the crimp, remove and visually examine for proper connection.

d. SCOTCHLOK CONNECTORS.–These connectors are of the uninsulated "wire nut" type with a notched winding stem which may be broken off after the connector is firmly positioned over the conductors.

(1) CONNECTOR SELECTION.–The number and size of wires permissible in a single connector is listed in table 30-1. The wire size designation indicates the circular mil area of a standard conductor in thousands of circular mils. A wire size of two would indicate a conductor with approximately 2000 circular mils area.

**TABLE 30-1**

| CONN. TYPE | WIRE SIZE | NO. OF WIRES | WIRE SIZE (MCM) | | |
|---|---|---|---|---|---|
| | | | 2 | 3 | 4 |
| S | 2 | 1 | 1-2-3-4 | 1-2-3 | 1-2 |
| S | | 2 | 2-3 | 1-2 | 1-2 |
| S | | 3 | --- | 1-2 | 1 |
| S | | 4 | --- | 1 | --- |
| S | 3 | 1 | 1-2-3 | 1-2-3 | 1-2 |
| S | | 2 | 1-2 | --- | 1 |
| S | | 3 | 1 | --- | --- |
| S | 4 | 1 | 1-2-3 | 1-2 | 1-2 |
| S | | 2 | 1-2 | 1 | --- |
| M | 3 | 1 | --- | 4 | 3 |
| M | | 2 | --- | 3-4 | 2-3 |
| M | | 3 | --- | 3 | 1-2 |
| M | | 4 | --- | --- | 1 |
| M | 4 | 1 | --- | 3 | 2-3 |
| M | | 2 | --- | 2-3 | 2-3 |
| M | | 3 | --- | 1-2 | --- |

EXAMPLE.–The numbers circled in table 30-1 indicate that a small connector will accommodate a wire combination of one 4000 circular mil conductor and one, two or three 2000 circular mil conductors.

(2) INSTALLATION.–The connectors are installed on the wire combinations as follows:

STEP 1.–Select the proper size connector to fit the wire combination from table 30–1.

STEP 2.–Strip the ends of the wires to expose the conductors slightly less than the length of the connector. Place the stripped ends parallel to each other (do not twist the ends together).

STEP 3.–Screw the connector on the parallel conductors until the conductor ends are flush with the small end of the connector.

STEP 4.–Break the winding stem away from the connector.

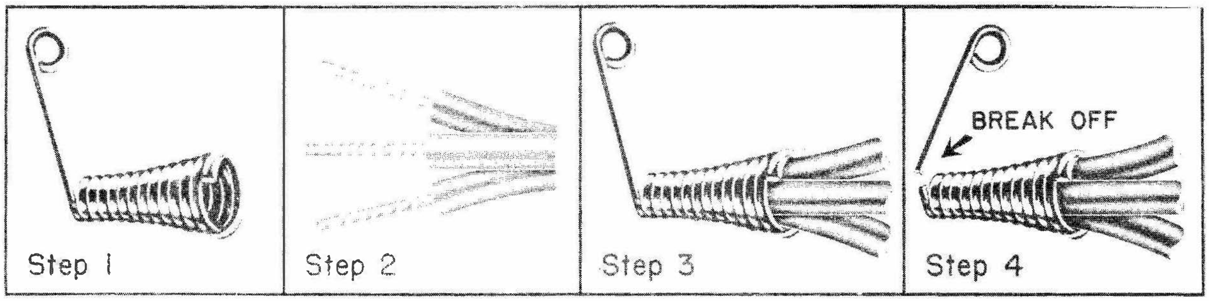



**FIGURE 30-6 Scotchlok Installation.**

(3) INSULATION.—When the connector has been installed it shall be insulated as described in steps four and five on page 4—30—2.

## 4-31 CABLE SPLICING*

a. **POLICY** - Cable splicing for new construction and conversion will be permitted only for approved changes and where it has been determined by the supervising Naval activity that time and replacement cost for a new cable is excessive and where the existing cable is in good mechanical and electrical condition. Cable splicing methods shall be in accordance with Bureau of Ships Plan 9000-S6202-73980, Section 4. However, splices of types MDGL and MDGY cable shall not be located on weather decks. Cables for repeated flexing service in rotating columns and radio frequency coaxial cables shall not be spliced. Except in emergencies, DSS, TSS, FSS and MSS cables shall not be spliced, where emergencies warrant the splicing of SS type cables, these splices shall be enclosed in a stuffing tube as illustrated in figure 31-1.

b. **METHODS APPROVED FOR SPLICING** - Where it has been determined by the supervising Naval activity that cable splices are to be made, the splices shall be in accordance with the current methods described and illustrated in Bureau of Ships Plan 9000-S6202-73980, Section 4. The current methods of splicing are:

| Method | Cable |
|---|---|
| 41181 | SHFA, DHFA, THFA, FHFA, SSGA, DSGA, TSGA, FSGA, SDGA |
| 41191 | MHFA, MSCA, MDGA |
| 41201 | MDGL |
| 41211 | MDGT |
| 41212 | MDGY |
| 41231 | TTHFWA |
| 41241 | TTRSA |
| 41251 | TSP |

c. **ADVANTAGES OF CABLE SPLICES** - The splicing materials and methods developed and tested at the Material Laboratory, New York Naval Shipyard, result in spliced cables that perform as well as unspliced cables and increase the diameter of the cable only slightly. They reduce the cost of new construction and conversions; and eliminate the considerable weight and cost of connection box splices.

d. **MATERIALS** - The materials used in splicing are listed in Bureau of Ships Plan 9000-S6202-73980. These materials should be requisitioned from the Military Industrial Supply Agency. They are dated and the length of shelf life is 12 months. Materials that have exceeded the 12 month period shall not be used. Materials other than those specified in Bureau of Ships Plan 9000-S6202-73980 are unacceptable for cable splicing.

e. **PERSONNEL ASSIGNED SPLICING** - It is considered essential that personnel assigned cable splicing be trained in selecting the precise materials and tools for and have practice in making each type of approved splice. Bureau of Ships Instruction 9620.33B outlines a suggested training course.

f. **REFERENCES.**

(1) BuShips Plan 9000-S6202-73980
(2) BuShips Instruction 9620.33B
(3) Bureau of Ships Technical Manual
(4) General Specifications for Ships

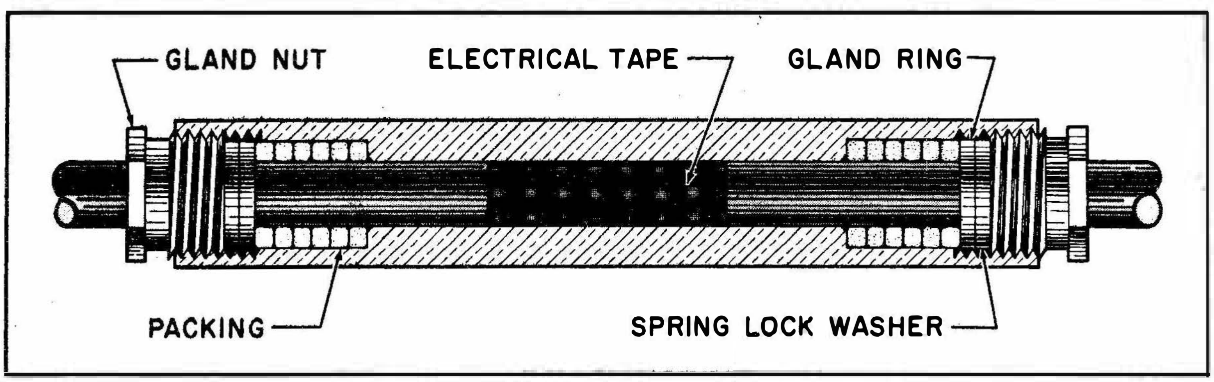



**Figure 31-1. Stuffing Tube**

**4-32. CABLE END SEALING.** - This sub-section describes and illustrates the approved methods of cable end sealing, including detailed instructions for each method.

a. PURPOSE. - The primary purpose of cable end sealing is to prevent the disruption of power to otherwise intact electrical circuits. In addition, cable end sealing on surface ships prevents water damage to otherwise intact electrical equipment and, in some measure, reduces the possibility of additional flooding from a flooded space to other parts of the ship. 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 on surface vessels must be retained. The introduction of even small amounts of water into electrical equipment via cables can jeopardize an entire system.

b. REQUIREMENTS.

(1) END SEALING REQUIRED. - The ends of cable as designated below shall be sealed in accordance with the methods given in following paragraphs. Cables terminating at the following equipment, when located below the watertight level shall be sealed:

(a) All power and lighting switchgear (includes ship service, emergency and load center switchgear).

(b) Manual and automatic bus transfer equipment (whether mounted on a switchboard or panel, or as an independent unit).

(c) Power Distribution and lighting panels that are supplied by two or more sources of power (i.e., normal, alternate or emergency).

(d) Automatic degaussing control panels.

(e) Degaussing switchboards and power supplies except where they supply power to only one degaussing coil.

(f) On minesweepers only, degaussing connections and through boxes that have connections for more than one degaussing coil.

(g) All watertight IC, FC and electronic equipment including switchboards and connections boxes, where water seepage into the unit would jeopardize undamaged operable portions of the system.

(h) Top entrance cables to IC, FC and electronic switchboards of other than watertight construction.

(2) END SEALING NOT REQUIRED. - Cables terminating at the equipment designated above shall not be sealed where one or more of the following conditions apply:

(a) Flexible cables to rotating structures.

(b) Cables which do not pass through a watertight deck or bulkhead.

(c) Cables which penetrate the tightness level without passing through a watertight deck or bulkhead below this tightness level.

(d) Where sealing the cable end would prevent bringing the armor of a cable containing low level amplifier circuits into the enclosure as required under shielding and grounding.

(e) Where water seepage into a unit of an IC, FC or electronic system through a damaged cable would result in no operational loss beyond that already sustained due to the cable casualty.

(f) Where used in IC, FC and electronic systems, type TTHFWA, MSCA, MHFA cable and all two, three, and four conductor cable, size nine and smaller.

(g) Where space is not available inside IC, FC or electronic units to accommodate the seal, the other end of the cable shall be sealed regardless of its location.

(h) Degaussing cables need not be end sealed under the following conditions:

1. Where the connection boxes or through boxes are required and have been approved by the Bureau of Ships to be completely filled with an approved compound because of their location in compartments subject to flooding or extreme moisture conditions such as bilge runs of A coils, etc.

2. Boxes may be filled with an approved compound in lieu of cable end sealing when approved by the Bureau of Ships where the designs of end sealing fittings are not available.

c. 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 lug terminals. The cable crotch shall then be end sealed by the use of approved methods. Table 32-1 lists thimble and tubing sizes for use with cables of the MIL-C-915 type. 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. In cases where the tubing is required, the proper sizes may be selected from table 32-2.

TABLE 32-1 THIMBLE AND TUBING DIMENSIONS.

| CABLE SIZE (CM) | THIMBLE LENGTH | THIMBLE ID | SYNTHETIC TUBING ID (IN.) | |
|---|---|---|---|---|
| | | | WIRE | JACKET |
| 3,000 | 1" | 0.069 | 0.162 | 0.430 |
| 4,000 | 1" | 0.084 | 0.250 | 0 430 |
| 9,000 | 1" | 0.116 | 0.280 | 0.630 |
| 14,000 | 1 1/2" | 0.144 | 0.320 | 0.630 |
| 23,000 | 1 1/2" | 0.179 | 0 360 | 0.680 |
| 30,000 | 1 1/2" | 0.210 | 0.400 | 0.680 |
| 40,000 | 1 1/2" | 0.234 | 0.430 | 0.760 |
| 50,000 | 2" | 0.262 | 0.450 | 0.760 |
| 60,000 | 2" | 0.290 | 0.520 | 0.760 |
| 75,000 | 2" | 0.325 | 0.570 | 0.820 |
| 100,000 | 2" | 0.371 | 0.630 | 0.890 |
| 125,000 | 2" | 0.415 | 0.680 | 0.890 |
| 150,000 | 2" | 0.465 | 0.760 | 0.960 |
| 200,000 | 2 1/2" | 0.522 | 0.820 | 1.030 |
| 250,000 | 2 1/2" | 0.585 | 0.890 | ----- |
| 300,000 | 2 1/2" | 0.636 | 0.960 | 1.100 |
| 350,000 | 2 1/2" | 0.693 | 1.030 | ----- |
| 400,000 | 2 1/2" | 0.750 | 1.100 | 1.285 |
| 500,000 | 2 3/4" | 0.841 | 1.165 | 1.365 |
| 650,000 | 2 3/4" | 0.944 | 1.225 | 1.470 |
| 800,000 | 2 3/4" | 1.059 | 1.365 | 1.585 |

TABLE 32-2. REDUCED DIAMETER CABLE DATA.

| CABLE SIZE (CM) | CONDUCTOR DIA. (IN.) | SYNTHETIC TUBING ID (IN.) | |
|---|---|---|---|
| | | WIRE | JACKET |
| 3,000 | 0.060 | 0.162 | 0.280 |
| 4,000 | 0.076 | 0.162 | 0.280 |
| 9,000 | 0.108 | 0.250 | 0.320 |
| 14,000 | 0.136 | 0.280 | 0.360 |
| 23,000 | 0.171 | 0.280 | 0.400 |
| 30,000 | 0.202 | 0.320 | 0.430 |
| 40,000 | 0.226 | 0.320 | 0.520 |
| 50,000 | 0.254 | 0.360 | 0.520 |
| 60,000 | 0.282 | 0.400 | 0.570 |
| 75,000 | 0.317 | 0.430 | 0.630 |
| 100,000 | 0.363 | 0.520 | 0.680 |
| 125,000 | 0.407 | 0.570 | 0.760 |
| 150,000 | 0.457 | 0.570 | 0.820 |
| 200,000 | 0.514 | 0.680 | 0.890 |
| 250,000 | 0.577 | 0.760 | ----- |
| 300,000 | 0.628 | 0.820 | 1.030 |
| 350,000 | 0.682 | 0.850 | ----- |
| 400,000 | 0.742 | 0.890 | 1.165 |
| 500,000 | 0.832 | 1.030 | 1.285 |
| 650,000 | 0.936 | 1.100 | 1.470 |
| 800,000 | 1.050 | 1.225 | 1.585 |

(1) NON-WATERTIGHT ENCLOSURES.

(a) SINGLE CONDUCTOR CABLE.-Methods "A" and "B" shall be used for end sealing single conductor cable where applicable.

1. METHOD "A". - This method is used where it is not desired to continue the cable armor up to the cable terminating point.

STEP 1.- Determine the length of un-armored cable desired in the enclosure and remove the armor at this point (see page 9-4-15-4 paragraph d. for armor removal).

STEP 2.- Remove the cable jacket starting at a point one inch forward of the removed armor (see figure 32-1).

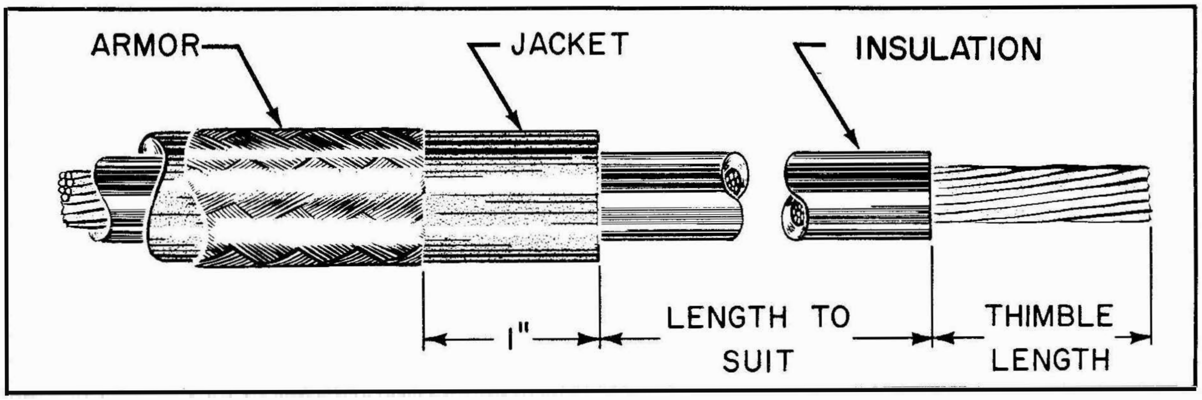



Figure 32-1. Preparation of Cable End (Method "A").

STEP 3.- Determine the circular mil size of the conductor and select an end seal thimble from table 32-1 that will fit the conductor.

STEP 4.-

NOTE

For CM size of conductors, see section 9-4-2, Cable Types and Selection.

STEP 5.- Install thimble over the conductor.

STEP 6.- Select the proper size lug terminal to be used.

CAUTION

Solderless lugs of the split-sleeve type which apply uniform pressure around the thimble covered conductor are not satisfactory because they cannot be crimped sufficiently to transmit the compression through the thimble wall and on to the conductor.

STEP 7.- Insert the thimble into the barrel of the lug terminal until it bottoms. The length of the thimble remaining outside of the lug terminal barrel must be built up to the inside diameter of the synthetic tubing, using synthetic resin tape and a bonding agent (see materials required in table 32-3).

NOTE

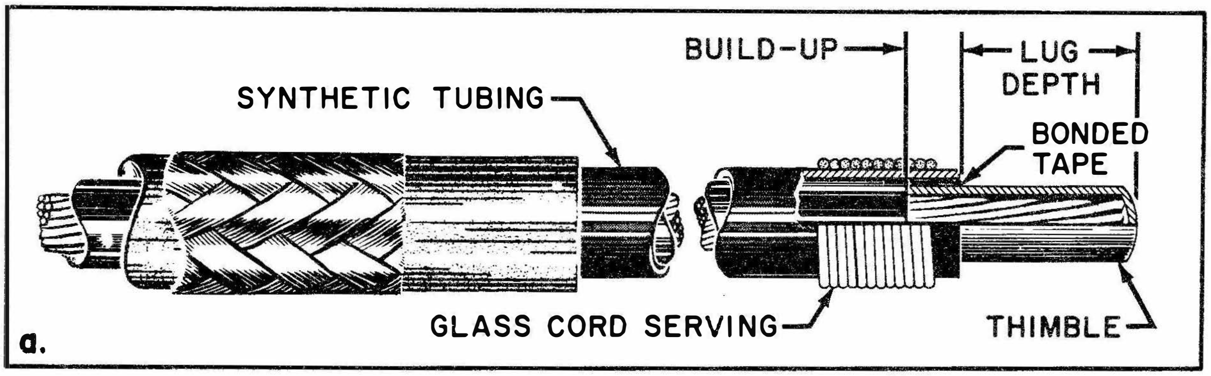
A satisfactory bonding agent can be made by dissolving battery sealing compound, (MIL-C02687) in trichloroethylene (O-T0634) to a light cream consistency. The bonding agent shall be applied to the area to be built up with tape and allowed to dry before application of the tape.

STEP 8.- Slide synthetic tubing over the built-up thimble area and conductor dielectric. Trim the tubing to size and serve the end with glass cord (see figure 32-2a).

TABLE 32-3. CABLE END SEALING MATERIALS.

| MATERIAL | MATERIAL SPECS. | REMARKS |
|---|---|---|
| Fiber Glass Tape | MIL-I-3158, Type SR-1 | |
| Friction Tape | HH-T-101 | |
| Fiberous Glass Cord | MIL-I-3158, Type SR-5 | For serving synthetic resin tubing. Colors-white, black, red, green gray |
| Synthetic Resin Tape | MIL-I-631, Type "F" GR. "a" | Form "T" 3/4" wide 0.010 Thick |
| Synthetic Resin Tubing | MIL-I-631, Type "F" GR. "a" | Form "U" |
| Plastic Sealer | MIL-I-3064, Type "HF" | Insulation Electrical |
| Insulating Varnish | MIL-V-1137 GR. "ca" | |
| Insulation Paper | MIL-I-695 Type "F" | Fish Paper |

STEP 8. - Slide synthetic tubing over the built-up thimble area and conductor dielectric. Trim the tubing to size and serve the end with glass cord (see figure 32-2a).



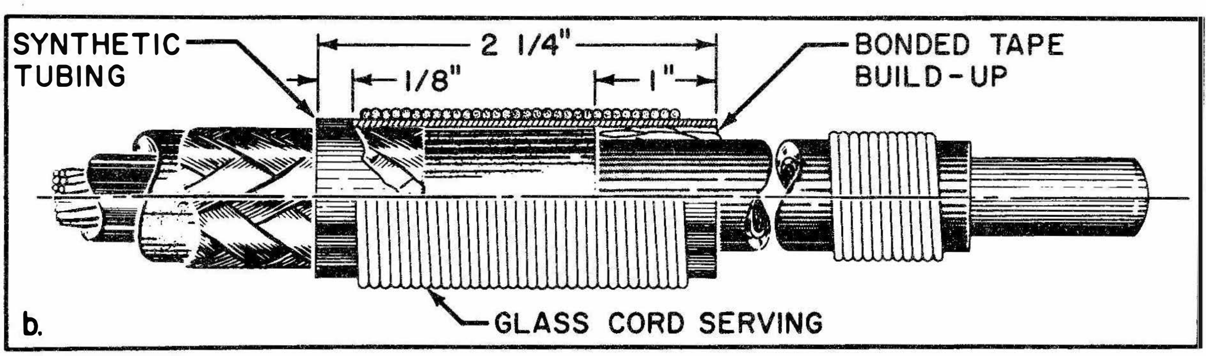




Figure 32-2. Finishing Cable End.

STEP 9.- The outside diameter of the synthetic tubing must be built up to the outside diameter of the jacket with synthetic resin tape and bonding agent as indicated in figure 32-2b.

STEP 10.- Slide synthetic tubing over the built-up area, jacket, and armor. Trim the tubing to length as shown in figure 32-2b.

STEP 11.- Serve the tubing where indicated in figure 32-2b with glass cord (for serving see page 4-15-11, steps three thru six).

2. METHOD "B".- This method is used when the cable armor is to terminate near the point of cable termination. (See figure 32-3).

STEP 1.- Determine the circular mil size of the conductor and select an end seal thimble from table 32-1 that will fit the conductor.

STEP 2.- Remove the armor as shown in figure 32-3 (3X conductor insulation diameter plus thimble length). This distance must be maintained to prevent electrical creepage between the armor and thimble or lug. The conductor insulation must be throughly cleaned of paint to prevent electrical creepage.

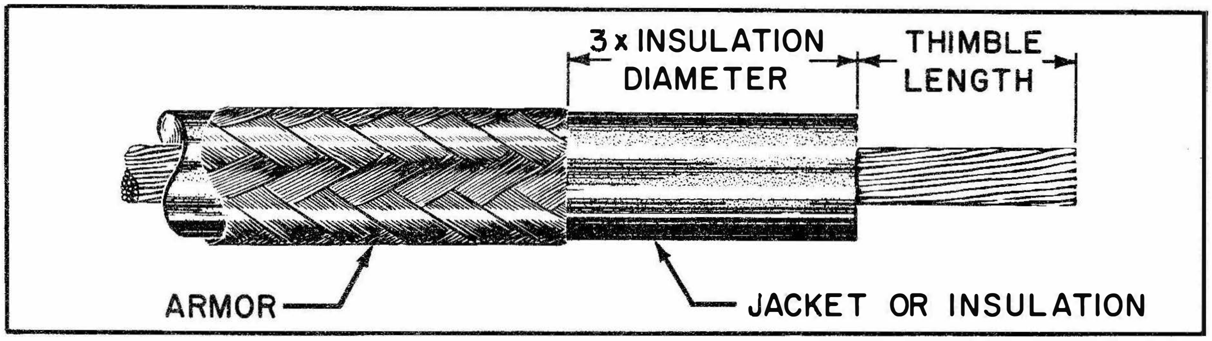



Figure 32-3. Preparation of Cable End.

STEP 3.- Remove the conductor insulation and the jacket as determined by the thimble length. The conductor shall extend to the extreme inside end of the thimble to prevent the possibility of the lug terminal clamping against the thimble only and not making good contact between the conductor and the lug terminal. Dress end of conductor with a file to prevent thimble end piercing. Make sure that the thimble also fits tightly up against the conductor insulation. No gap permitted.

STEP 4.- Install thimble over the conductor.

STEP 5.- Select the proper size lug terminal to be used.

CAUTION

Solderless lugs of the split-sleeve type which apply uniform pressure around the thimble covered conductor are not satisfactory because they cannot be crimped sufficiently to transmit the compression through the thimble wall and on to the conductor.

STEP 6.- Insert the thimble into the barrel of the lug terminal until it bottoms. The length of the thimble remaining outside of the lug terminal barrel must be built up to the outside diameter of the conductor dielectric using synthetic resin tape and a bonding agent (see materials required in table 32-2).

STEP 7.- Slide synthetic tubing over the built up thimble area and conductor dielectric. Trim the tubing to size and serve with glass cord (see figure 32-4).

**(b) MULTIPLE CONDUCTOR CABLE.-** The separate wires in multiple conductor cables are end sealed and protected as shown in method "A".

STEP 1.- Remove armor and insulation from cable as indicated in figure 32-5.

STEP 2.- Complete steps three thru seven of method "A" to prepare for end sealing of the individual wires.

STEP 3.- Synthetic tubing is slipped over entire length of individual wires, as shown in figure 32-5, making sure that the tubing is forced well into the cable crotch.

STEP 4.- Finish the wire ends as indicated by step eleven of method "A".

STEP 5.- Cable wires are to be separated just above the crotch by spreading the wires and inserting a 1/2 inch diameter metal ball against which the wires are to be tightly squeezed. The removal of the ball will leave a permanent pocket in the cable crotch which will serve as a receptacle for the plastic sealer (MIL-I-3064). This pocket and the entire area around the crotch is then to be coated with a bonding agent which insures positive adhesion of the plastic sealer to the cable. Allow sufficient time for the bonding agent to dry and apply plastic sealer as shown in figure 32-6.

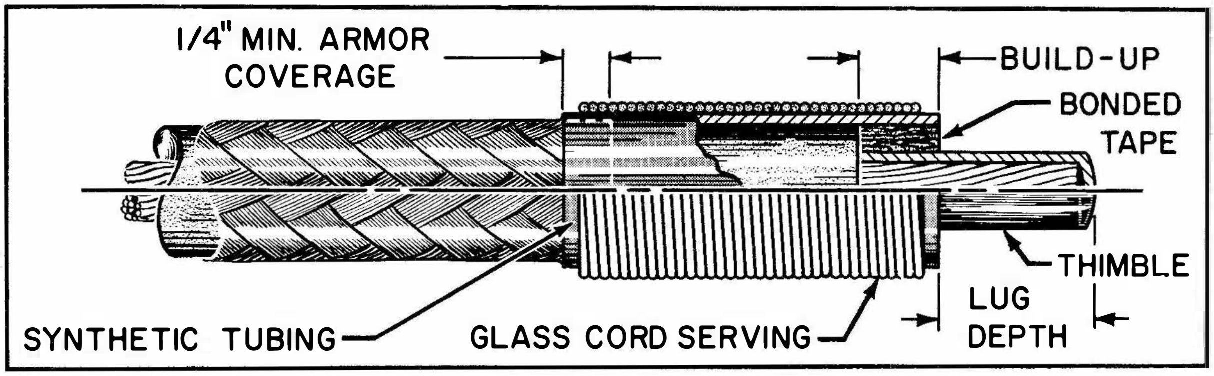



Figure 32-4. Finishing Cable End.

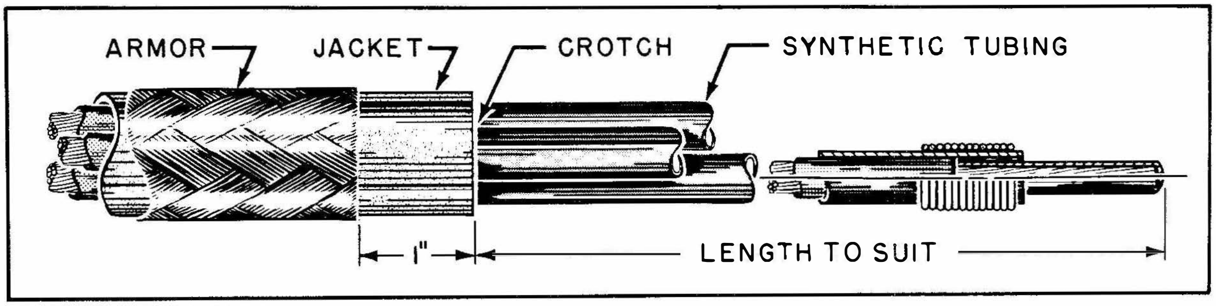



Figure 32-5. Preparation of Cable End.

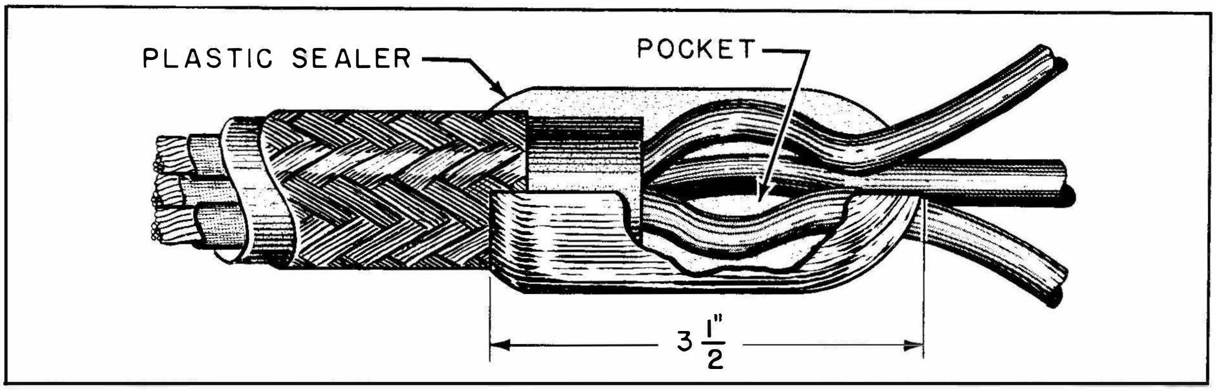



Figure 32-6. Application of Plastic Sealer.

NOTE

Check the insulation resistance of the cable before the plastic sealer is applied to make certain that no moisture is present in the cable. If a low megger reading is shown, treat the cable as shown in section 4-3, Cabling Inspection and Testing.

STEP 6.- Pull conductors together, apply bonding agent and cover with two layers plus one inch overlap of glass tape (MIL-I-3158).

NOTE

The fiber glass tape is available in widths of four, five, and six inches.

STEP 7.- Starting on the armor, 3/4 of an inch from the plastic sealer, serve tightly with fibrous glass cord as shown in figure 32-7.

STEP 8.- Starting on the individual wires, at a distance (dimension c) dependent on the cable size, serve tightly with fibrous glass cord as shown in figure 32-7 (dimensions are listed in table 32-4). The plastic sealer should be forced ahead of the serving (under the glass tape) to tightly seal the cable crotch.

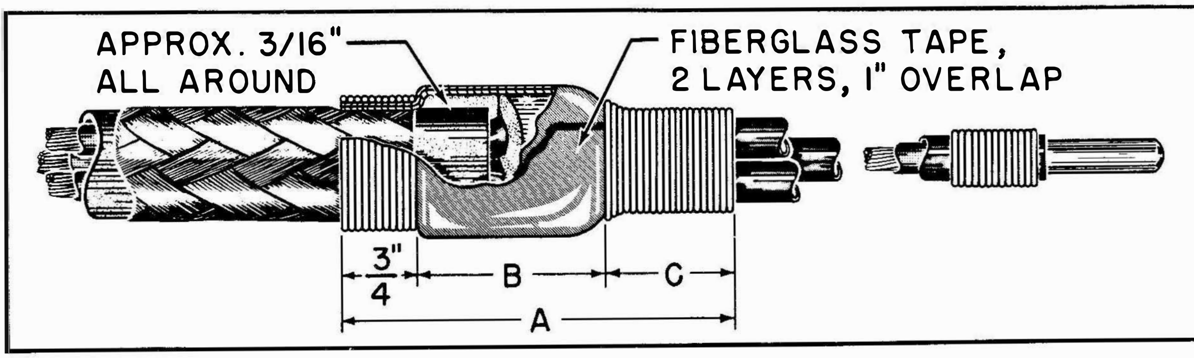



Figure 32-7. Finishing Cable End.

STEP 9.- When the serving has been completed, coat the cable crotch sealing assembly with insulating varnish (MIL-V-1137).

NOTE

The above method of sealing the cable crotch can be used for cable water-sealing at non-watertight equipment but the stuffing tube methods described later should be used except where insurmountable difficulties prevent its use.

(c) COMMERCIAL WATER SEAL THIMBLES.- The commercial water seal thimbles are of the same size as the standard thimbles except for a skirt that is to be compressed over the conductor sheath or dielectric to insure water tightness.

1. SINGLE CONDUCTOR CABLES.- Water sealing of single conductor cables with commercial types of waterseal thimbles is accomplished as follows:

STEP 1.- Follow the procedures outlined in method "B", steps one thru four (see figure 32-3) for cable preparation.

STEP 2.- Make certain that the jacket is inserted into the thimble the full length of the thimble skirt.

STEP 3.- The skirt of the water seal thimble shall be compressed over the impervious jacket by approved methods producing a watertight seal capable of withstanding 50 lbs. pressure per square inch without leakage.

STEP 4.- Sieze fraying end of armor with friction tape (HH-T-101) as shown in figure 32-8.

2. MULTIPLE CONDUCTOR CABLES.- The individual wires of multiple conductor cables are prepared for water sealing with commercial type thimbles as follows:

STEP 1.- Remove insulation from the conductor as determined by the thimble size. The conductor should be allowed to come just short of the thimble socket depth when the conductor is inserted. If necessary, dress end of conductor with a file to prevent thimble piercing.

STEP 2.- The outside diameter of the conductor insulation (in some cases) must be built up (with 3/4 inch synthetic resin tape) to fit the inside diameter of the synthetic tubing for a minimum distance equal to the thimble skirt length. Install synthetic tubing over the wire, extending from well into the cable crotch, to the end of the conductor insulation (see figure 32-9).

STEP 3.- Slip the thimble (as selected from table 32-1) over end of the conductor. Make certain the synthetic tubing is inserted into the thimble skirt the full length of the skirt.

STEP 4.- The skirt of the water-seal thimble shall be compressed over the synthetic tubing by approved methods to produce a watertight seal capable of withstanding 30 pounds pressure per square inch without leakage. The completed water seal is shown in figure 32-10.

TABLE 32-4. FINISHING DIMENSIONS

| CABLE SIZES (1000 C. M.) | DIMENSION (Inches) "A" | "B" | "C" |
|---|---|---|---|
| 3 to 9<br>M-7 to M-10<br>TT-1 to TT-25 | 4" | 2" | 1 1/4" |
| 14 to 100<br>M-14 to M-44<br>TT-30 to TT-60 | 5" | 2 1/4" | 2" |
| 125 to 400 | 6" | 2 1/4" | 3" |

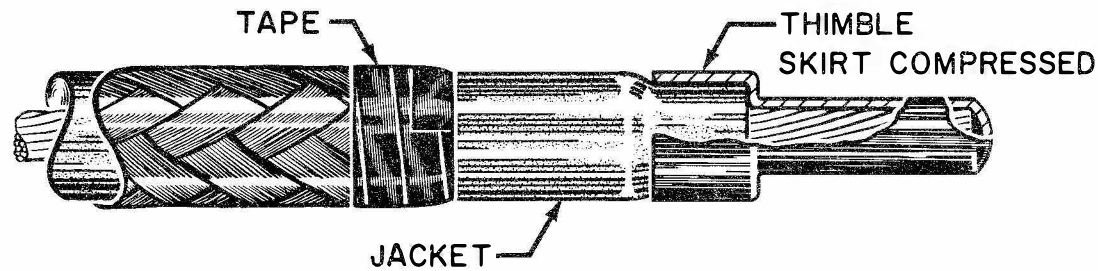



Figure 32-8. Finishing Cable End

(d) WATER SEAL CRIMP LUG TERMINALS.- This type of lug terminal (manufactured in accordance with MIL-E-16366) may be used for water sealing the ends of single conductor cables or the ends of the individual wires in multiple conductor cables by use of the same methods required for commercial type water seal thimbles.

NOTE

The crimp type lug terminal shall be secured to the conductor and insulation by approved methods and the lug skirt shall produce a water tight seal (on the wire or cable end) capable of withstanding 50 pounds pressure per square inch without leakage.

(2) WATERTIGHT AND DRIP-PROOF ENCLOSURES.- The preparation and water sealing of single and multiple conductor cables entering watertight and drip-proof enclosures is essentially the same as the procedures used for non-watertight enclosures. The only main difference in procedure is the use of the enclosure entry stuffing tube as a cable jacket and crotch sealing device in lieu of the method used for non-watertight equipment. This is accomplished by use of phenolic inserts used to restrain the plastic sealer within the stuffing tube body.

(a) PHENOLIC INSERTS.- These inserts are manufactured from 3/16 inch thick phenolic material, beveled on one edge to fit the inside contour of the stuffing tube. For lighting and power cables, the wire holes are drilled for clearance of the synthetic tube covered wires. For other cables, where it is not required to use the synthetic tubing on the wires, the holes are drilled just large enough to pull the wires through. The number of holes drilled in the phenolic insert shall match the number of wires in the cable. Figure 32-11 shows an insert for a single conductor cable (not required to be tubed) and an insert for a four conductor power or lighting cable. The outside diameter of the insert required for stuffing tubes one through nine (nylon) and "A" through "BB" (metal) is given in table 32-4.

(b) METAL STUFFING TUBES.- When a metal stuffing tube is used for end sealing a cable, proceed as follows:

STEP 1.- Determine the length of unarmored cable or wires desired inside the enclosure and remove the armor to this point.

STEP 2.- Table 32-6 lists the lengths of jacket to be left extending from the point of armor termination. Determine the right dimension for the size stuffing tube being used and remove the jacket to the selected point (see column "B" in table 32-6).

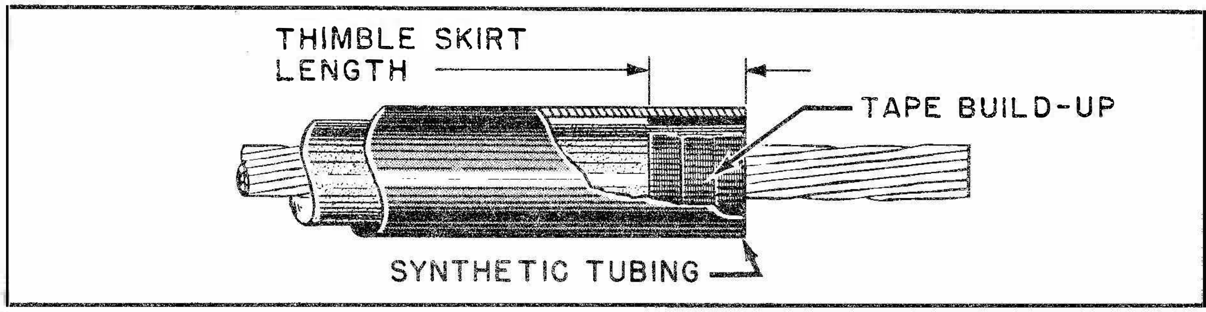



Figure 32-9. Preparation of Wire End.

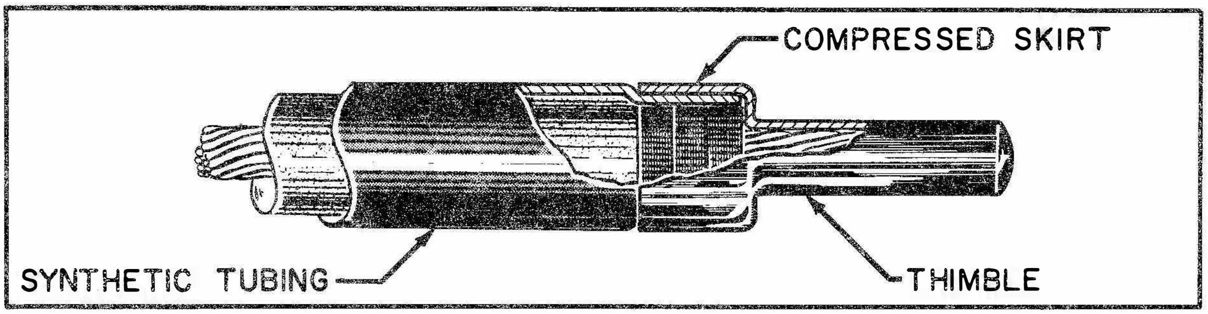



Figure 32-10. Finishing Wire End.

STEP 3.- Prepare the wires for water sealing by completing steps three through six of method "A".

STEP 4.- Install synthetic tubing tightly over the wires and into the cable crotch. Trim at the thimble allowing the thimble to protrude from the tubing a length equal to the lug terminal barrel depth (see figure 32-2a).

STEP 5.- Separate the wires just above the cable crotch, insert a 1/2 inch diameter steel ball and squeeze the wires tightly over the ball. Remove the ball and coat the entire area in and around the cable crotch with the bonding agent. Coat the exposed cable jacket and armor with the bonding agent to a point back on the armor approximately equal to the stuffing tube length. Allow the bonding agent to dry.

STEP 6.- Slide the stuffing tube gland nut over the wires and back on the cable armor.

STEP 7.- Install the phenolic insert on the tube covered wires and slide to a position where the distance between the jacket termination and the insert will be that indicated in table 32-6, column "A". Coat the entire insert with bonding agent and allow to dry.

STEP 8.- Force the synthetic tubing back on the wires far enough to expose the thimble. Apply bonding agent to the wire insulation end and that portion of the thimble which will not be covered by the lug terminal. When the bonding agent is dry, build up the thimble area with synthetic resin tape to a diameter equal to the inside diameter of the synthetic tubing. Pull the tubing back over the built up tape and serve tightly with fibrous glass cord (see figure 32-2a).

STEP 9.- Fill the cable crotch, between the jacket termination and the phenolic insert, with plastic sealer and work it tightly into this section. Apply more plastic sealer and build it up to the outside diameter of the phenolic insert and out over the cable jacket and armor to a point approximately equal to the inside depth of the stuffing tube (see figure 32-12).

STEP 10.- Feed the wires through the stuffing tube until the phenolic insert bottoms in the stuffing tube. Secure the cable tightly in place with the bulkhead or stuffing tube supported clamp stuffing tube gland nut up to the last thread (do not tighten beyond this point). The sealing compound should extrude slightly from the holes in the phenolic insert and through the gland nut around the cable. If no compound extrusion is evident, remove the gland nut, force more sealing compound into the stuffing tube and reinstall the gland nut. Figure 32-13 shows the completed end sealed cable installation.

1. SMALL CABLES.- When the small multiple conductor cables and the two, three and four conductor cables under 9000 CM are end sealed in metal stuffing tubes, the procedures are practically the same as those described in the preceeding paragraph. Exceptions to those procedures are: (1) the synthetic tubing is not used over the wires, (2) water-seal crimp type lug terminals are substituted for the thimbles, and (3) when the cable crotch has been treated with the bonding agent and before the phenolic insert is installed, serve the leads with two or three turns of fibrous glass cord as shown in figure 32-14.

TABLE 32-5. PHENOLIC INSERT DIMENSIONS

| STUFFING TUBE | | OD | STUFFING TUBE | | OD |
|---|---|---|---|---|---|
| NYLON | METAL | (IN.) | NYLON | METAL | (IN.) |
| 1 | | 0.550 | | M | 1.892 |
| 2 & 3 | | 0.615 | 7 | | 1.927 |
| | A | 0.767 | | N | 1.954 |
| | B | 0.892 | | P | 2.079 |
| 4 | | 0.896 | | R | 2.204 |
| | C | 1.017 | 8 | | 2.302 |
| | D | 1.142 | | S | 2.579 |
| | E | 1.142 | | T | 2.767 |
| | EE | 1.142 | | V | 2.892 |
| | F | 1.204 | | W | 3.017 |
| 5 | | 1.333 | | X | 3.142 |
| | G | 1.392 | 9 | | 3.240 |
| | J | 1.517 | | Y | 3.267 |
| | K | 1.642 | | Z | 3.454 |
| | L | 1.704 | | AA | 3.642 |
| 6 | | 1.740 | | BB | 3.892 |

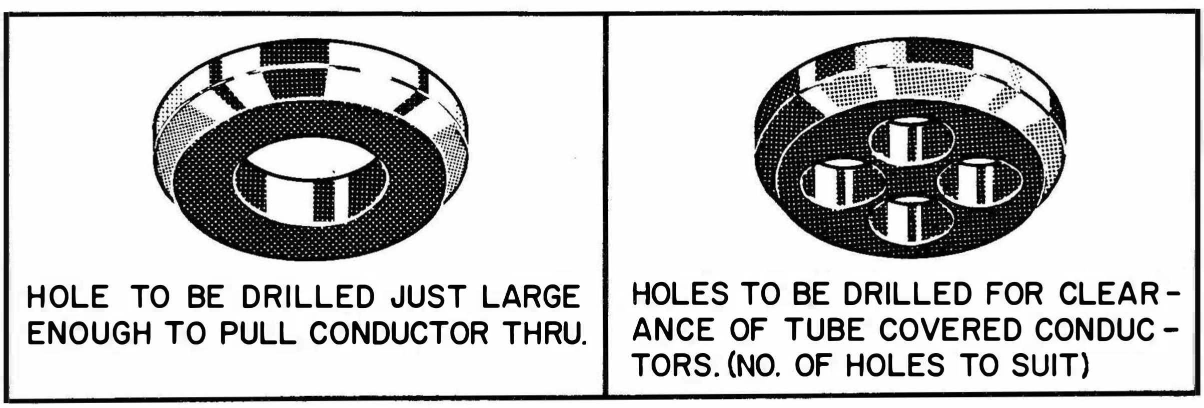



Figure 32-11. Phenolic Inserts

TABLE 32-6. CABLE PREPARATION DIMENSIONS

| STUFFING TUBE SIZE | CABLE POSITION "A" DIM. (IN.) | JACKET EXTENSION "B" DIM. (IN.) |
|---|---|---|
| A through J | 5/8 | 1/2 |
| K through R | 7/8 | 5/8 |
| S through BB | 1 1/2 | 7/8 |

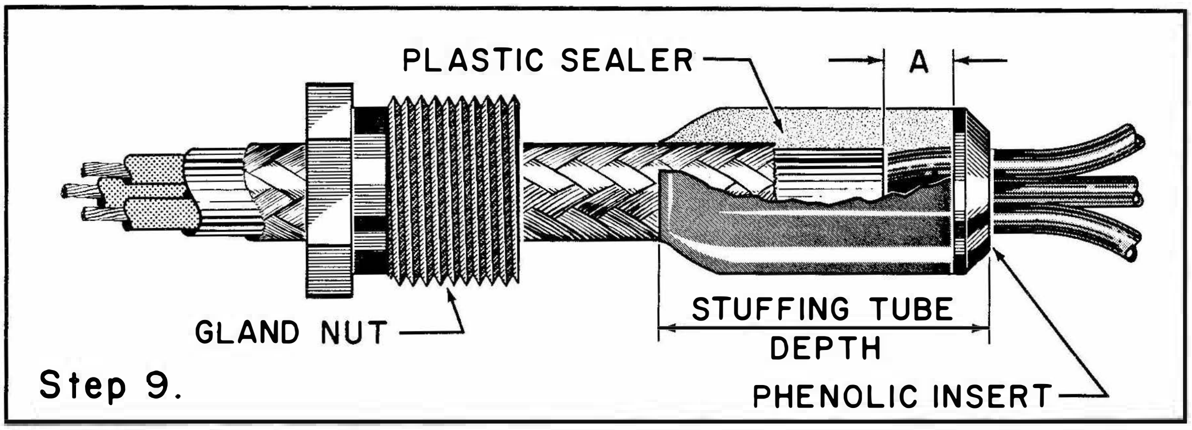



Figure 32-12. Insert and Sealer Application.

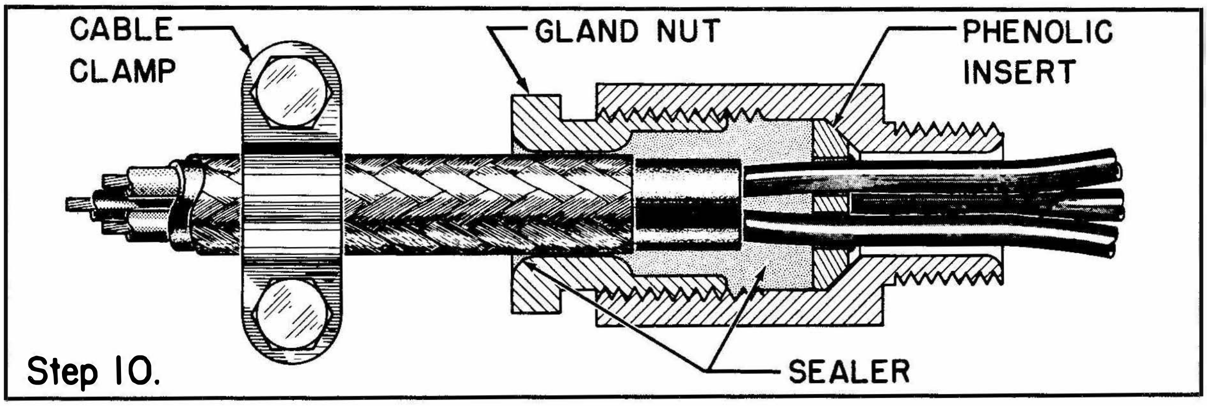



Figure 32-13. Metal Stuffing Tube End Seal.

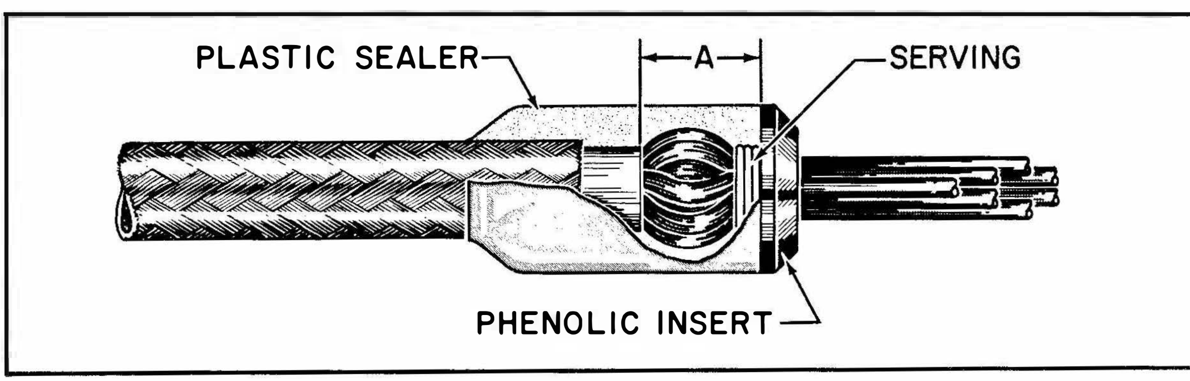



Figure 32-14. Small Cable Preparation.

(c) NYLON STUFFING TUBES.- When nylon stuffing tubes are used for cable end sealing the procedures are essentially the same as those used for metal tubes. Exceptions to these procedures are: (1) the cable armor is cut back to allow the cable jacket to enter approximately 2/3 of the way into grommet as shown in figure 32-15, and (2) the cable armor is flared and terminated in the usual method (see figure 32-15).

d. 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.

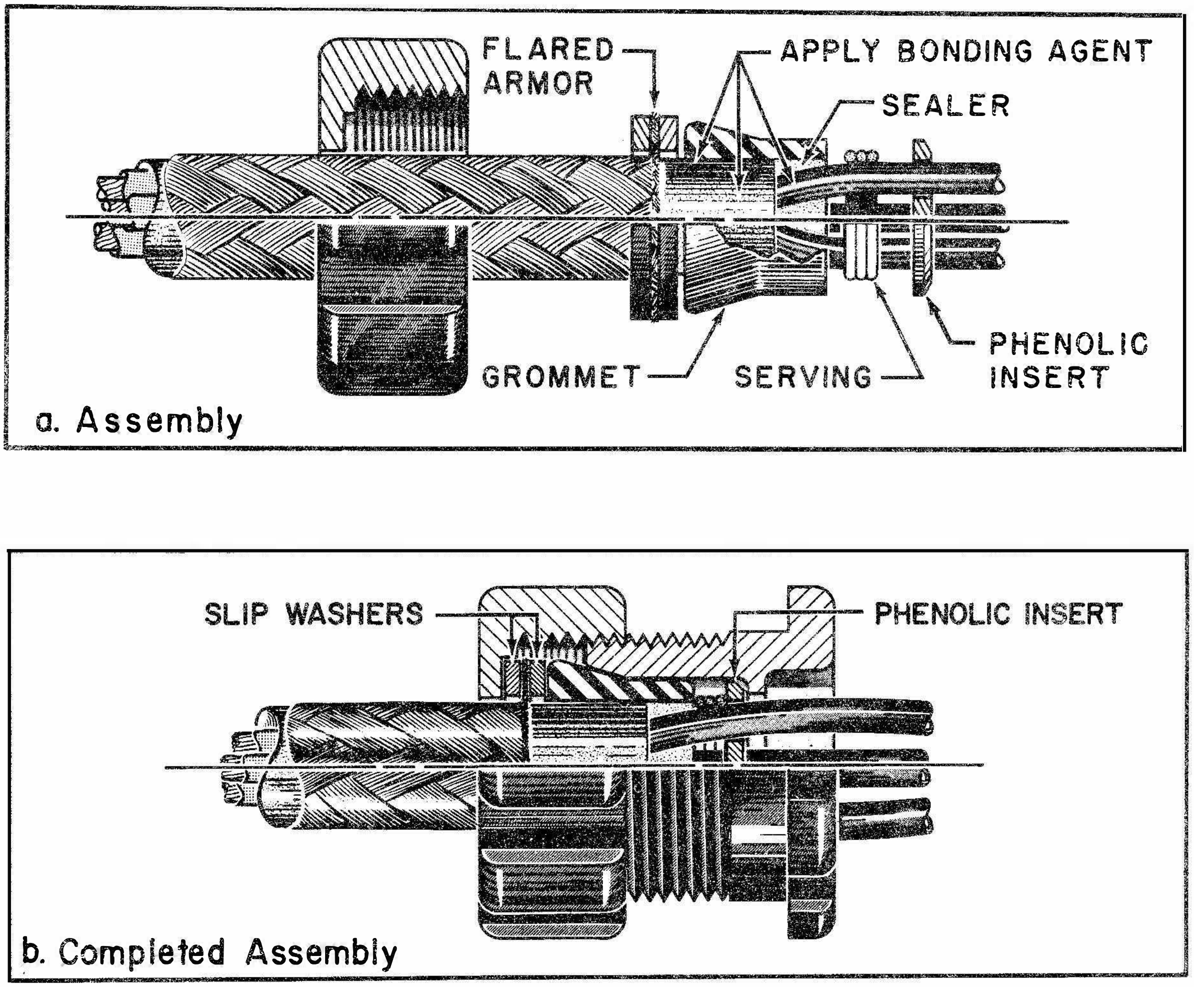



Figure 32-15. Nylon Tube End Seal.

(1) CABLE SUPPORT - NON-WATERTIGHT EQUIPMENT.- 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. In cases where more than one cable enters the enclosure, the end seal assemblies can be staggered and the cable armor covered with fish paper (MIL-I-695) to prevent abrasion of the fiber glass tape by the armor. Serve the fish paper at each end with fibrous glass cord to hold it securely in place. Figure 32-16 illustrates a typical installation of more than one cable in a non-watertight enclosure and figure 32-17 shows typical construction of cable straps (the strap material shall be 3/4 inch by 3/32 inch for cables of 100,000 CM and smaller; and 3/4 inch by 1/8 inch for cables of 125,000 CM and larger).

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.

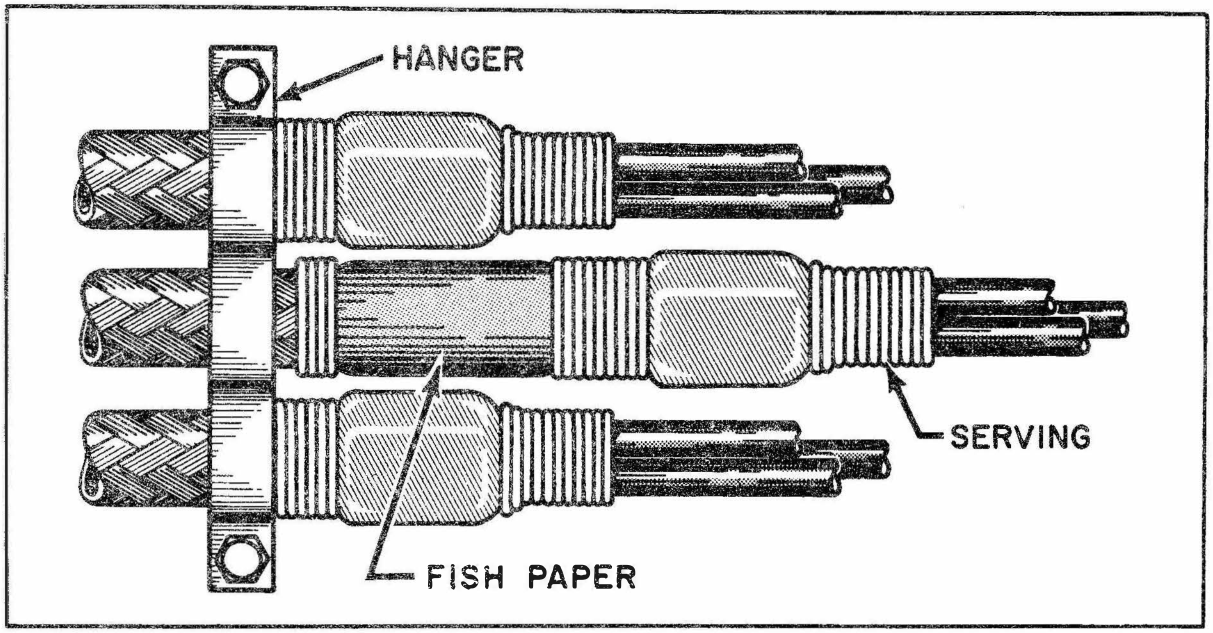



Figure 32-16. Cable Group Installation.

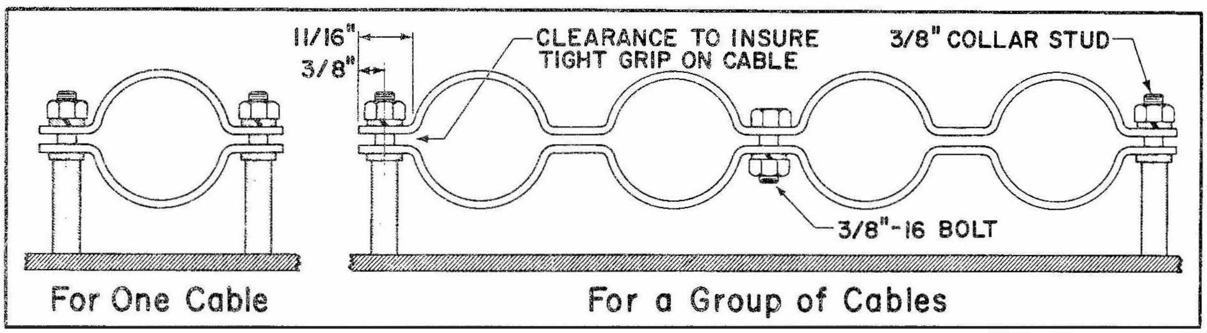



Figure 32-17. Cable Strap Construction.

(2) CABLE SUPPORT - WATERTIGHT AND DRIP-PROOF ENCLOSURES.- A cable that has been installed and end sealed in a metal stuffing tube is not mechanically secure due to substitution of the sealing compound for the pre-formed packing and the relatively small length of cable armor and jacket inserted in the stuffing tube. The cable or cables shall be made mechanically secure at the point of termination by use of properly designed supports and clamps.

(a) BULKHEAD SUPPORTED.- When the cable entry hole is so located that the cable can be clamped and secured to the same structure on which the equipment is mounted, cable straps and supports as shown in figure 32-17 can be used. The clamp shall fit to the cable at a point not more than three inches from the tightened-up gland nut of the stuffing tube.

(b) STUFFING TUBE SUPPORTED.- In cases where it is impractical to support the cable clamp on the bulkhead or other structure, supports can be constructed to weld or clamp to the stuffing tube body (see figure 32-18). The brace material shall be 3/4 inch by 3/32 inch steel for cables of 100,000 CM and smaller; and 3/4 inch by 1/8 inch steel for cables of 125,000 CM and larger. The clearance between the stuffing tube gland nut and the inside of the brace shall be a minimum of 1/2 inch to allow the use of proper tools for tightening the gland nut. The clearance between the stuffing tube body and the inside of the cable clamp shall be approximately twice the length of the gland nut. Construction of the cable clamp is illustrated in figure 32-17.

CAUTION

The brace must be securely fastened to the stuffing tube body and the cable held firmly by the cable clamp before the gland nut is tightened up.

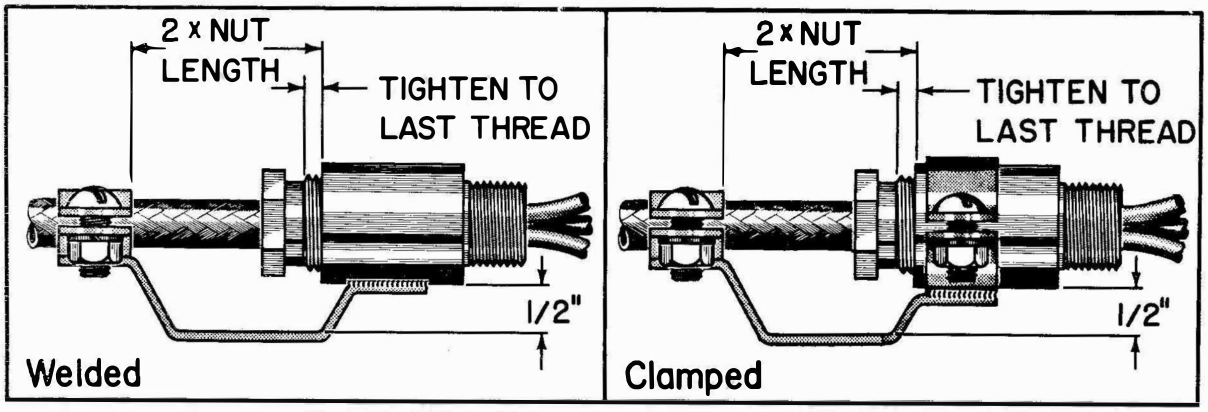



Figure 32-18. Stuffing Tube Cable Supports.