NAVSHIPS 900171

ELECTRONIC INSTALLATION PRACTICES MANUAL

CHAPTER 11

RIGID RF TRANSMISSION LINES

BUREAU OF SHIPS NAVY DEPARTMENT

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NAVSHIPS 900,171

ELECTRONIC INSTALLATION PRACTICES MANUAL

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

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

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

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SECTION 11-1

GENERAL DESCRIPTION

1. INTRODUCTION.

Rigid RF transmission lines include waveguides (rigid and flexible), bead-supported coax (Teflon and Steatite), stub-supported coax and Pyrotenax cable.

Rigid waveguides are both round and rectangular in shape but the use of round waveguide is limited to special applications, such as rotating joints. Rectangular waveguides are widely used, particularly in the radar field.

Rigid waveguides will be referred to by size rather than by frequency and the more common type sizes are:

6-1/2 inches x 3-1/4 inches, "L" band.

3 inches x 1-1/2 inches, "S" band.

1-1/4 inches x 5/8 inches, "X" band.

1 inch x 1/2 inch, small "X" band.

5/8 inches x 5/16 inches, "K" band.

Section 11-2 deals with rigid waveguides in detail.

On applications where either flexible waveguide or rigid waveguide can be used, the flexible waveguide is not to be used because of greater power loss. The use of small sections is sometimes unavoidable, Flexible waveguide can also be used for emergency repair of battle damage.

Section 11-3 discusses flexible waveguides.

Bead-supported coax (consisting of both Teflon and Steatite beads) was used on early radar equipment installations and is still necessary in certain types of installations. Details for the UHF Teflon bead-supported coax and the Steatite bead-supported coax are discussed in sections 11-4A and 11-4B respectively.

Stub-supported coax was more widely used on early radar equipment installations and short runs are still found in late equipments, usually within the antenna pedestal.

Section 11-5 discusses stub-supported coax.

Pyrotenax cable is being installed to meet a specific need on submarines. Complete information on Pyrotenax cable is included in Section 11-6.

SECTION 11-2

RIGID WAVEGUIDE

1. INTRODUCTION.

In certain frequency ranges, waveguides are the most efficient means of carrying RF energy from a transmitter to an antenna. Before the use of ultra-high frequencies, waveguide was not considered because it would have taken a very large type to transfer power at the lower frequencies. At radar frequencies, however, the size and weight are reduced and the installation of waveguide becomes practical.

a. STORAGE. - When bulk guide is stored, the following precautions should be observed: It should be stored in a horizontal position to prevent buckling and bowing. It should be kept dry and cool to reduce oxidation and corrosion. It should be stored clear of heavy and hard articles which may dent the guide walls.

Prefabricated sections of guide which are supplied as ready spares for certain equipments should be stored separately, in appropriately marked bins. The ends of each section should be covered with paper caps or stuffed with clean lintless cloth to keep dust out. Flange faces should be carefully protected to avoid bowing or denting which would prevent proper assembly later. Edges of the choke couplings should receive special attention, since serious electrical disturbances can be set up if these edges lose their original finish. Stamped chokes and flanges, made from sheet metal are easily deformed and should receive special attention in storing to prevent even minor changes in physical dimensions caused by mishandling.

In transportation, the same precautions should be observed; also taking special care to prevent shifting of parts.

2. GENERAL DESCRIPTION.

The proper type and size of waveguide is determined by the equipment designer and any change to another type should not be made, unless approved by the Bureau of Ships and issued as a modification of the equipment.

On installations of waveguide, the runs should be made as short as possible. Avoid making horizontal runs by locating the radar transmitter-receiver close to the base of the mast. This must be one of the primary considerations on planning any new radar installation.

Lay out all waveguide installations so that there are no low points or places where moisture can gather. If such a condition must be tolerated, always be sure that there is a small drainage hole at the lowest point on the waveguide run. Dust and dirt settle in waveguides rather easily when they are open during a long repair period. A quick way to remove the undesirable matter uses a blower converted into a vacuum cleaner by reversal of the motor rotation. A length of rubber hose inserted into the guide at elbows, particularly the lowest one in the line, will remove almost all dust in a few seconds.

If it is considered necessary to blow the line clear, never use the ship's compressed air line; it usually contains some water, rust, scale and oil.

Arcing in a waveguide may be caused by dust, salt water, grit, copper filings, brass dust, loose corroded products, poorly fitted flanges, etc. To clean the guide, pull a clean rag soaked with clean carbon tetrachloride through the guide by suspending it between two lengths of plumber's tapes, steel wire "snakes", or lintless string until successive clean cloths show no dirt marks. Then repeat once again with a clean cloth soaked with chemically pure carbon tetrachloride. If part of this operation is done inside a compartment, be sure it has good ventilation. (Observe safety precautions of BuShips Manual, Chapter 67.)

While the presence of moist air inside a waveguide is not usually hazardous, it should be avoided. The reason for this is that at night, when radar visibility should be tops, the temperature usually drops, causing moisture to condense on the inner surfaces of the guide. The moisture acts like a layer of poor conductor on and through the very area which the electro-magnetic currents are traveling. The losses increase rapidly, and the range goes down. Make sure that a drain hole is drilled and deburred in the bottom of the guide at its lowest level as described later in paragraph 3h.

The loss in a pair of couplings can be far greater than in an equal length of guide. Use a minimum number of couplings in any run. A good bend has less electrical loss than a coupling. Also, there is one less point for dirt to enter. However, if the ability to make a good bend is lacking, use prefabricated bends. When mating the flange faces, be sure that they have clean, flat, butting surfaces which contact each other at all points, or that there is a uniform and proper space clearance between a choke flange and mating flange. Choke cover combinations are preferred for field use. Any variations will result in loss of power or arcing.

When tightening the nuts around the flanges, apply uniform tension around the edges; tightening opposing nuts in pairs until all are down.

It is a useful and time saving operation to have several lengths of guide already annealed and filled with rosin or alloy so that quick bends may be made without taking time out for the preliminary operations. Store these in a safe place.

3. PLANNING THE WAVEGUIDE INSTALLATION.

Proper installation of waveguide is important. Unless the run is laid out, fabricated, and installed in exact accordance with approved procedures, severe RF disturbances may result, causing poor performance.

a. LENGTH OF RUNS.—All waveguide runs should be made as short as possible. Always use as few bends and twists as possible. A gradual bend is preferred over a manufactured elbow. When cast or prefabricated elbows are used, do not use more than 10 for any waveguide run. The 1-1/4 inch x 5/8 inch and smaller size waveguide runs must not exceed 50 feet in length and horizontal runs should not be used.

b. LOCATING ANTENNAS FED BY SMALL SIZE WAVEGUIDE, – When deciding on the location of antennas for these installations, a compromise must be made between the following two considerations:

(1) The range of the equipment depends upon the height of the antenna.

(2) Attenuation of energy is materially affected by small changes in waveguide length. Over 1/2 the power is lost in a 50 ft run.)

In consideration of these factors, the following table shows the maximum length of waveguide which may be used to gain additional height without defeating its own purpose:

Increase in height (percent)	Max. extra wave-guide run (feet)
5	12.5
10	24
15	35
20	46
25	55
30	65
40	83
50	100

The following paragraphs explain the use of the table in determining which of two mounting positions will give the greater range.

Position 1: A position is available for mounting the antenna 65 feet above the water line. The transmitter-receiver may be so mounted that only a 15-foot waveguide run will be required.

Position 2: A second position is available for the antenna on another mast, 80 feet above the water line. This will require a waveguide run of 55 feet, which is 40 feet more than the run required in Position 1.

Which is the better position? The solution is found as follows: The percentage of increase in height equals:

$$\frac{80-65}{65} = 23\% \text{ (approx.)}$$

Using the table and interpolating between 20% and 25%, it is found that a 23% increase in height permits a maximum of 53 feet of waveguide. Since this is 13 feet higher than the 40 feet allowed by Position 1, it is obvious that Position 2 will give the better range.

Positioning the antenna as high as possible without loss of range gives better performance with large or high targets. In certain cases, however, the installation of the extra waveguide length will not provide enough increase in range to be worthwhile. Regardless of the outcome, the location must in every case be chosen with due consideration of the principle target to be observed.

c. SUPPORTS.–The weight of the waveguide must not be supported from the antenna. As a waveguide installation usually begins at the top of the mast, a support must be provided directly below the lower section of the antenna waveguide flange. If this is difficult, a welded hanger (Figure 11-1) should be used.

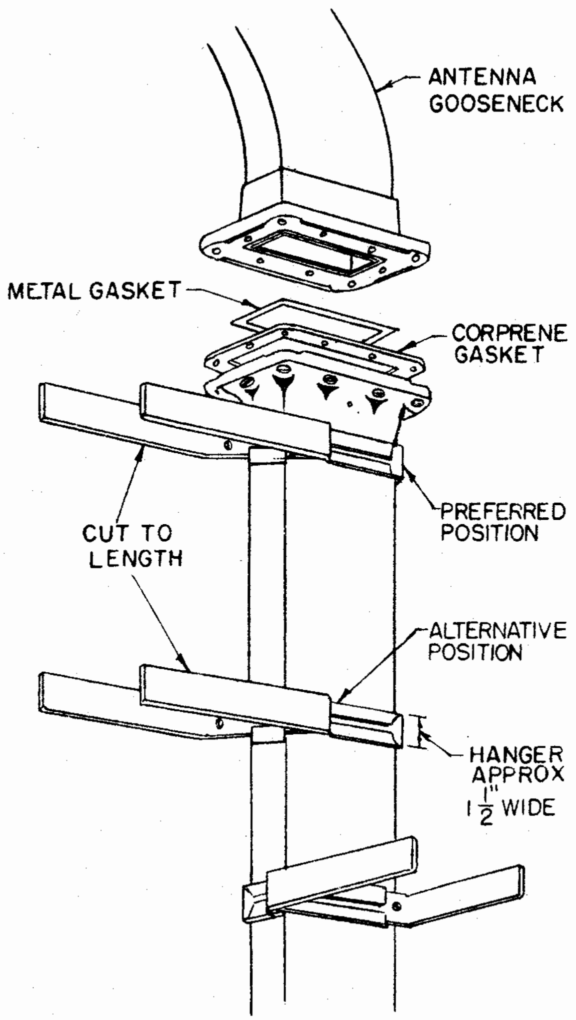


Figure 11-1. Support of the Waveguide at the Antenna

d. EXPANSION JOINTS. – When these are used, the spacing between the two faces must not exceed 1/2 inch. To prevent the two halves of the joint from vibrating, the guide must be supported so as to permit only longitudinal motion. The two faces must be parallel and exactly aligned.

When the expansion joint is not mounted horizontally, the open end of the protecting shoe must face downward to prevent the entrance of water.

e. BENDS AND TWISTS. – Waveguide is supplied in straight lengths of from six to fourteen feet, but usually the length is ten feet. The number of joints or couplings in a run should be kept to a minimum in order to obtain the most efficient electrical transmission. In a shipboard installation, there will be a need for bends, twists, and off-sets. Since all conditions cannot be met with standard fittings, it is desirable to be able to form bends and twists in the straight sections of the waveguide. These can be formed in the full straight lengths by the methods described in this chapter. The stainless steel "L" band guide is an exception to this.

To properly identify bends in waveguide, they will be referred to as follows:

E plane bend = Easy bend = Flat side bend.
H plane bend = Hard bend = Edgewise bend.

WAVEGUIDE BEND CHART

WAVEGUIDE	SPECIFICATIONS
3-1/4 inch x 6-1/2 inch	Bending not permissible when using RG-127/U or NT-14ACM stainless steel waveguide. Use manufactured elbows. Never more than 10.
1-1/2 inch x 3 inch	Minimum bending radius, E or H - 18 inches Minimum length for 90° twist - 18 inches Maximum inside wall variance - ± 1/16 inch
5/8 inch x 1-1/4 inch	Minimum bending radius. E - 6 inches; H-12 inches. No prefabricated elbows. Minimum length for 90° twist - 18 inches Maximum inside wall variance - ± 1/32 inch
EXCEPTIONS	
1 inch x 3 inch (RG-109/U Waveguide)	Minimum bending radius, E bend - 12 inches Minimum length for 90° twist - 30 inches POSITIVELY NO H BENDS ON RG - 109/U WAVEGUIDE.
1/2 inch x 1-1/2 inch (RG-110/U Waveguide)	Minimum bending radius, E bend - 12 inches Minimum length for 90° twist - 15 inches POSITIVELY NO H BENDS ON RG - 110/U WAVEGUIDE.

All bends will be referred to as E or Easy bend, and H or Hard bend.

Ordinarily, bends and twists should not be sharper than those given in the specifications.

It is possible to make sharper bends and twists than specified above, without causing excessive attenuation, provided that reflections are avoided. This is done by forming the bend so that its electrical length ("mean L" in Figure 11-2) is any exact multiple of half wavelengths. This will cause the reflections at either end of the bend to cancel out. Similarly, twists may be so designed that their length is any exact multiple of half wavelengths.

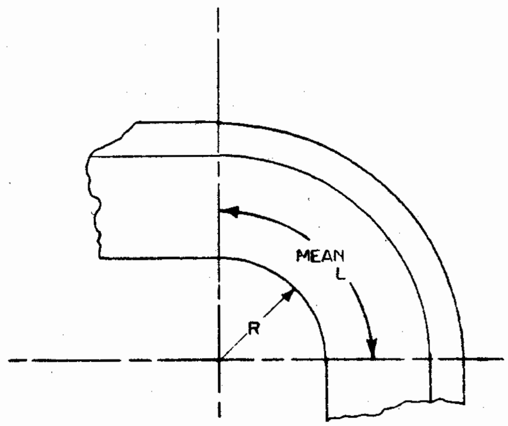
Never make a bend or twist sharper than the specified minimums, unless conditions make it absolutely necessary. Under no conditions should the radius of a bend or twist be less than one full wavelength of the center frequency for any waveguide.

The reflections caused by poorly matched bends can result in a high standing wave ratio.

Detailed procedures for bending and twisting are given later.

f. CONNECTING BENDS.–The important points listed below must be followed in the installation of waveguide elbows for the 6-1/2 inch x 3-1/4 inch waveguides as used on certain air search radar:

(1) Two "E" bends or two "H" bends should not be connected directly together unless separated by an odd multiple of 1/4 wavelength of straight waveguide.



1. R= 18 INCHES FOR 3" X 1½"
WAVEGUIDE (S BAND)

2. R=12 INCHES FOR 1" X ½"
WAVEGUIDE (X BAND)

Figure 11-2. Electrical Length of Bends

(1/4 wavelength equals 3.19 inches at mid-frequency.) The length of straight waveguide run necessary in inches between any two of these identical bends can be determined from the formula 3.19 x odd No's. ± 1/16 inches, i.e., 1-3-5-7 etc.

(2) An "E" and "H" bend may be connected directly together with small loss. However, if a straight waveguide is run between these bends, the length is determined from the following formula:

3.19 x even No's. ± 1/16 inches, i.e., 0-2-4-6-8, etc.

The following table shows the proper amount of straight waveguide that should be inserted between bends, not directly connected.

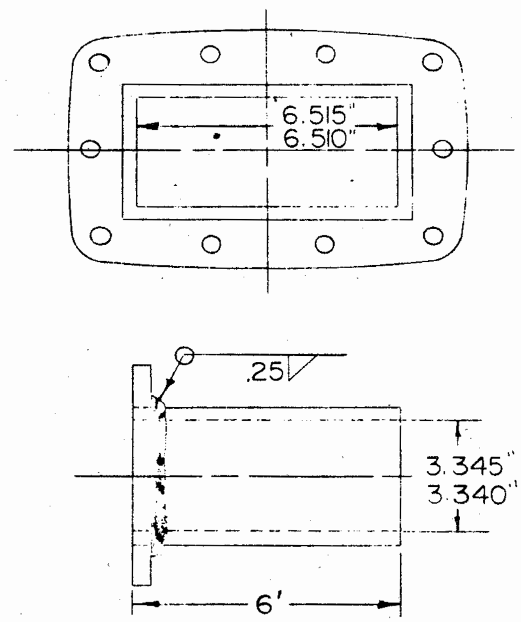
TABLE OF DISTANCES BETWEEN SIMILAR AND DISSIMILAR BENDS FOR 6-1/2 x 3-1/4 INCH WAVEGUIDE

STRAIGHT DISTANCES BETWEEN SIMILAR BENDS E to E or H to H In Inches	STRAIGHT DISTANCES BETWEEN DISSIMILAR BENDS H to E or E to H In Inches
3-3/16	0
9-9/16	6-3/8
15-15/16	12-3/4
22-5/16	19-1/8
28-11/16	25-1/2
35-1/16	31-7/8
41-1/2	38-1/4
47-7/8	44-11/16
54-1/4	51-1/16
60-5/8	57-7/16
67	63-13/16
74-3/8	70-3/16
80-3/4	76-9/16
87-1/8	82-15/16
93-1/2	89-5/16
99-7/8	95-11/16
105-1/4	102-1/16
111-5/8	108-7/16
118	114-13/16
	121-1/4

NOTE

These distances should not be changed by more than ± 1/16 inch.

g. PASSAGE THROUGH BULKHEADS AND DECKS. -Where a waveguide passes through a deck or bulkhead, the fitting used must be watertight. Fig.11-3 to 11-6 illustrates a method of passing RG-127/U or Navy Type 14ACM waveguide through a bulkhead or deck. This method uses a special steel sleeve as shown in Figure 11-3.



OPTIONAL SLEEVE CONSTRUCTION
4 SECTIONS FLAT .25 STOCK
2 SECTIONS RIGHT ANGLE .25 STOCK

FLANGE MATERIAL: .25 MILD STEEL
SLEEVE MATERIAL: STEEL

FOR FLANGE INFORMATION REFER TO FIG 11-4

Figure 11-3, Special Sleeve for Passing RG-127/U or NT-14ACM Waveguide through Bulkhead or Deck

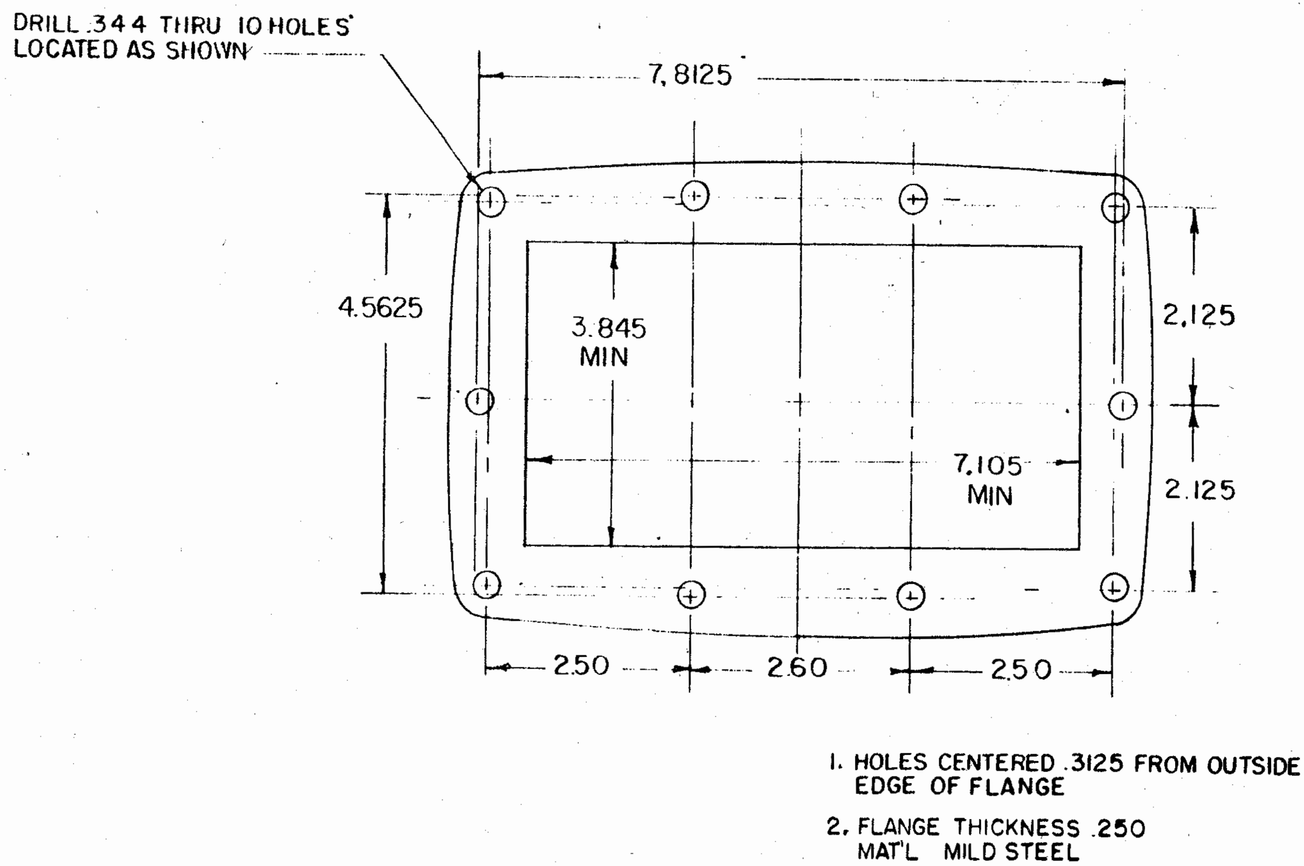


Figure 11-4. Special Flange for Sleeve used in Passing RG-127/U or NT-14ACM Waveguide Thru Deck or Bulkhead

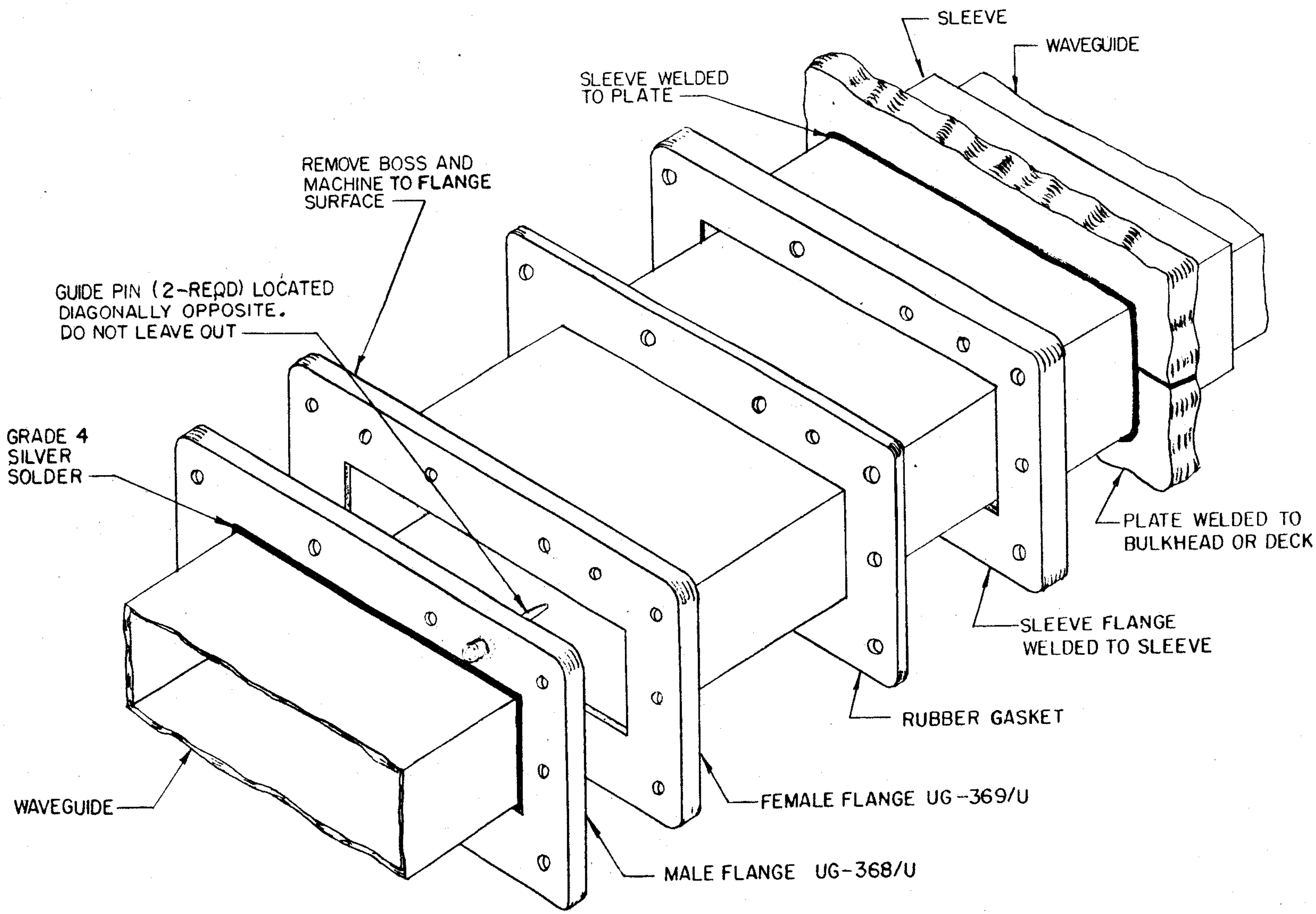


Figure 11-5. Method of Installing RG-127/U or NT-14ACM Waveguide Thru Bulkhead or Deck

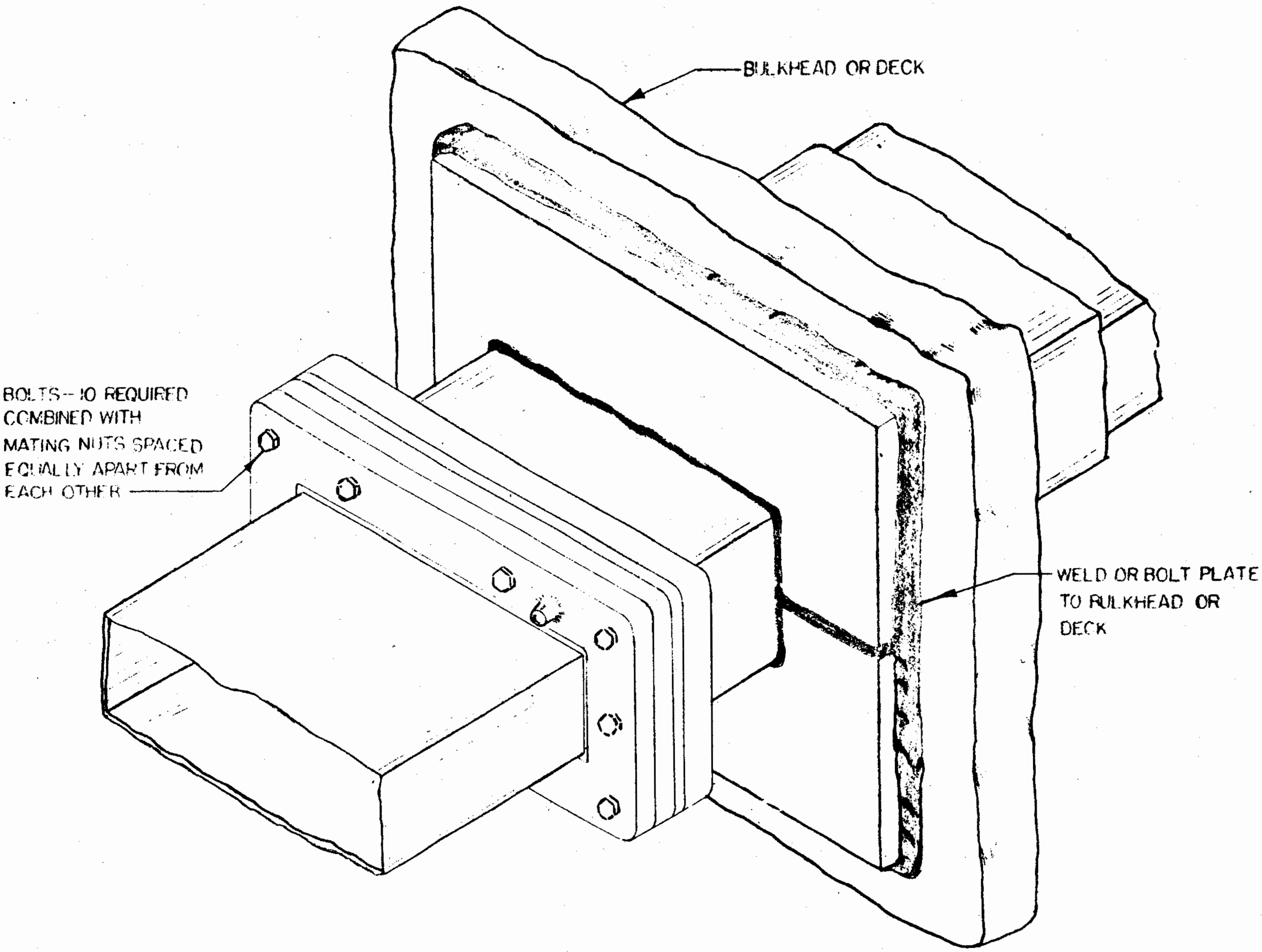


Figure 11-6. RG-127/U or NT-14ACM Waveguide Installed Thru Bulkhead or Deck.

The sleeve is made up with a special flange welded to the sleeve. Figure 11-4 shows flange dimensions. All fabrication can be done in the shop except for welding sleeve to bulkhead or deck. If flange type UG-369/U is being used, the embossment as well as any irregularities should be ground or filed flat on the outside. This will insure a watertight connection between the waveguide flange and the sleeve flange. A large rubber gasket as shown in Figure 11-5 completes the material needed for passing this type of waveguide through a deck or bulkhead. These parts can be made up ahead of time and carried in stock. This will save installation time in future requirements. This method may also be used for aluminum and silver or silver-plate waveguides.

For passing 3 x 1-1/2 inch or 1-1/4 x 5/8 inch waveguide through a deck or bulkhead, a steel sleeve, as shown in Figure 11-7, can be hard soldered or silver soldered directly to the brass waveguide. The installation can then be made as shown in Figure 11-7.

Both of the above methods properly done will insure a watertight job.

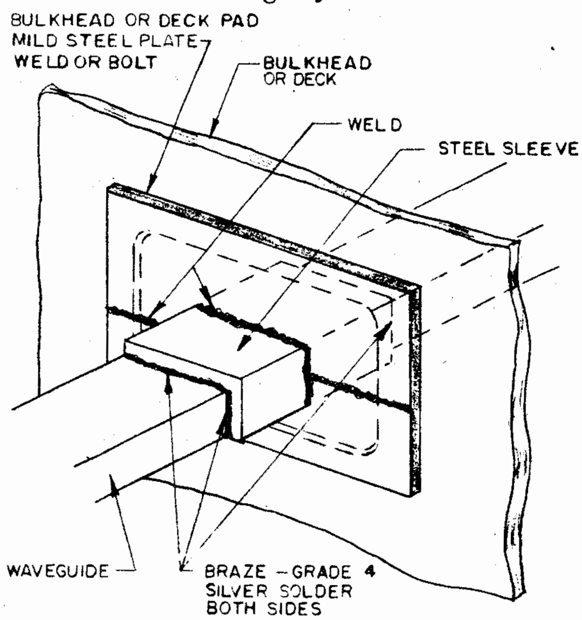
h. DRAINAGE.—Horizontal runs should slope toward the transmitter. If this is impossible, make use of drainage holes bored at the water trap (low point) as specified below.

(1) On 3-1/4 inch x 6-1/2 inch waveguide or 1-1/2 inch x 3 inch waveguide a 1/8 inch hole may be drilled in the center of the wide side. It is not good practice to drill on the narrow side.

(2) On 5/8 inch x 1-1/4 inch waveguide a 1/32 inch or 3/64 inch hole may be drilled on the center of the wide side, or two such holes may be drilled one inch apart along the guide. If preferred, a slot not greater than three inches in length may be cut along the guide, 3/64 inch each side of center (total width of slot 3/32 inch).

4. WAVEGUIDE FABRICATION.

a. TEMPLATE.— The first step in fabricating a waveguide is to go aboard the ship and make a full scale template (see Figures 11-8 and 11-9). The purpose of the template is to provide the shop with accurate information as to the shape, radius, and angle of all bends and twists



STEP 1. CUT HOLE IN BULKHEAD OR DECK WITH CUTTING TORCH

STEP 2. SILVER SOLDER SLEEVE TO WAVEGUIDE AT PROPER POINT (DO NOT USE TOO MUCH HEAT)

STEP 3. WELD PL. TE TO SLEEVE

STEP 4. WELD OR BOLT PLATE TO BULKHEAD OR DECK

Figure 11-7. Method of Passing Brass Waveguide Through a Bulkhead or Deck

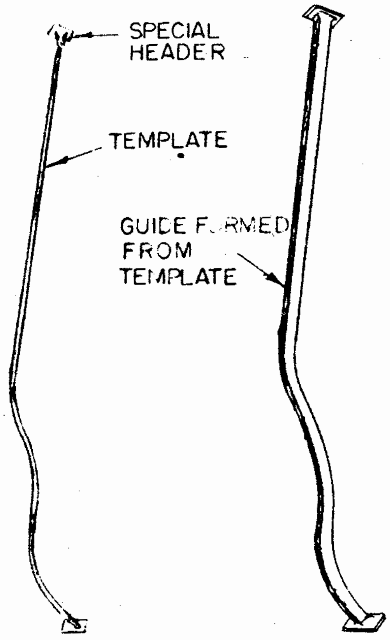


Figure 11-8. Guide Showing Template and Waveguide Formed from It

in the waveguide, as well as the position of bulkhead connections, flange holes and the over-all length of the run.

The template can be made of 1/2 inch mild steel wire or wood. If the template is made of wood, choose its size to approximate the size of the waveguide to be installed. The flange can be made with wood to the exact dimensions including hole spacings. By using a wood saw, hammer, nails and wood screws, the templete can be made aboard ship and brought back to the shop for waveguide fabrication. The advantages of using wooden templates include:

(1) Rigidity of template when carried from ship to shore.

(2) More exact size of wood to waveguide.

(3) Ease of marking wood to note proper clearances for bends.

One disadvantage in using wooden templates is that a gradual radius cannot easily be shown.

A method of using a wrought metal wire template is shown in Figure 11-8, and the method of using a wooden template is shown in Figure 11-9. When the template is brought back to the shop, it can be laid out on a wooden bench or table and the opposite flange can then be fastened

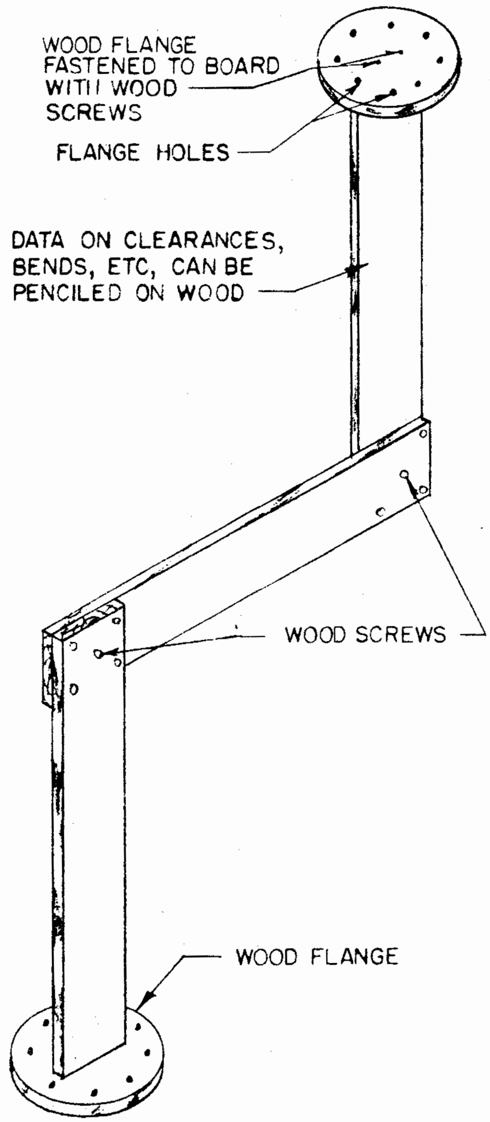


Figure 11-9. Wooden Waveguide Template

securely to the table in the proper position. The waveguide to be fabricated can then be made up until it sets between these flanges and conforms to the shape of the template.

For making a twist in waveguide where no H or E bends are required, a template, as shown in Figure 11-10, can be used.

In starting any waveguide run, it is usually best to start at the antenna and work down the mast to the deck. Then start at the transmitter and work up to the deck leaving the method of going through the deck for the last operation.

5. ANNEALING

Annealing is always necessary if the waveguide is to be formed in any way.

If the guide is to be filled with sand for forming, annealing can be done either before or after the waveguide has been filled. If the guide is filled with rosin or alloy, filling is done after annealing.

a. BRASS WAVEGUIDE.—Commercial brass waveguide is 90% copper and 10% zinc. To properly anneal this waveguide, it should be heated to a temperature of between 427°C (800°F) and 788°C (1,450F), depending on the degree of softness desired. Estimated times at temperatures for typical tubes would be eight minutes for the .040 inch gauge wall tubing and 15 minutes for the .080 inch wall tubing. The waveguide should then be cooled in air.

NOTE

> The higher temperature will result in softer waveguide but should only be used for making real sharp radius bends.

A good average temperature for the majority of bends is 650°C (1200°F). If temperature control is not possible,

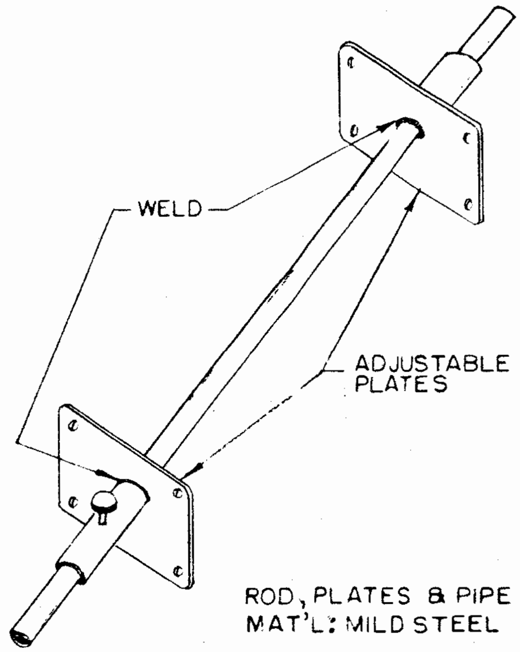


Figure 11-10. Template for Measuring Twist of Waveguide

650°C is approximately cherry-red on brass. As an emergency, waveguide can be annealed using two torches. The torch tip should be selected to give a large, soft or spread-out flame to avoid hot spots.

Move the flame over both sides of the waveguide continually until the brass is cherry-red.

CAUTION

> If only one torch is used, the waveguide will bow when heated.

Anneal only the portion of waveguide that is to be bent or twisted and then allow the waveguide to cool naturally in air. The waveguide is now ready for bending or twisting.

b. ALUMINUM WAVEGUIDE. -Aluminum waveguide is made of 2S alloy. The proper annealing for 2S alloy of aluminum is as follows: Heat to a temperature of 343°C-427°C (650°F-800°F). The amount of time in the furnace should only be long enough to insure that temperature is the same throughout the metal. The alloy is then cooled in air to room temperature.

Too high a temperature or too much time in the furnace will result in large grain size.

Too rapid cooling will result in warping.

c. STAINLESS STEEL WAVEGUIDE.- Never anneal stainless steel waveguide since excess heat blisters the inlay of silver inside the guide and also tends to ruin the stainless properties of the steel. This type of waveguide is not intended for bending but is installed with elbows.

d. FILLING WITH GAS BEFORE ANNEALING (OPTIONAL). - To prevent the oxidation which is usually brought on by heating, the shipyards are now filling the waveguide sections with carbon dioxide gas (CO_2) before annealing. As air is thus eliminated, there is no oxidation, and the guide remains clean, smooth, and free from discoloration. The yards find that this procedure saves them time and much effort in cleaning out the oxidation. Other inert gases have been tried, but CO_2 has given the best result and is the least expensive. One tank of gas will last four to six months in a small yard which bends about 300 feet of guide per week.

The gas filling procedure follows:

(1) Provide wooden plugs for the two ends of the waveguide section. These should fit smoothly.

CAUTION

If the plugs fit too tightly when cold, they will expand and distort the waveguide when heated.

(2) In one of the plugs, insert a hose connection and an escape valve.

(3) Close up the waveguide section with the wooden plugs and attach a carbon dioxide tank to the hose connection.

(4) Fill the section with carbon dioxide until no air is left inside. When the guide is properly filled, a match will go out when placed in front of the escape valve.

(5) Now anneal the section in the usual way, as outlined before.

6. FILLING.

To prevent deformation, waveguide must be filled with some solid material before bending, unless a Wallace Bending Machine with mandrel is used. Before twisting, the guide must always be filled. Filling may be done with alloy, rosin, sand, or thin metallic shims; separate procedures are given below for each of these methods.

a. ALLOY METHOD. - When the alloy method is used for filling, the guide should first be thoroughly annealed as outlined in this section, and allowed to cool. The guide should then be filled as follows:

(1) Tightly plug the guide at one end with a wooden plug.

(2) Melt the required quantity of bending alloy in a welded stainless steel container suspended in boiling water or in a stainless steel tank jacketed with hot water. (The alloy melts at 71°C to 82°C (160°F to 180°F).

(3) Pour a gallon of light oil (such as SAE-10) into the guide, cover the top end, and move the guide about so as to splash the oil on all interior surfaces. Then pour out the oil, leaving an inch or two in the bottom of the guide. (If de-

sired, fill the guide completely with oil and leave it filled. The oil will be displaced when the heavy alloy is added in the next step.)

CAUTION

Careful attention to oiling is necessary to prevent the alloy from tinning the guide, making cleaning very difficult.

NOTE

The bending alloy is a type of Wood's metal -- a mixture of bismuth, lead, tin, and cadmium. The trade names are Cerobend and Bendaloy.

(4) Fill the guide with the melted alloy, allowing the alloy to run down the side of the guide in order to avoid air pockets.

(5) Immediately lower the filled guide into a quench-tank containing rapidly circulating cold water, leaving it there long enough for the guide and alloy to reach room temperature throughout.

(6) Remove the filled guide and rewarm it in hot water to about body temperature. Remove the wooden plug from the bottom of the guide. The guide is now ready for bending and twisting. IMPORTANT: Good results with alloy fillers depend entirely on rapid quenching, adequate cooling, and RE-WARMING BEFORE BENDING.

NOTE

Rust-resistant iron or stainless steel are required for tank construction. Plain steel will rust when in constant contact with boiling water and steam (formed during initial contact of hot guide). Copper, aluminum, and galvanized iron tanks will contaminate the alloy.

b. ROSIN METHOD.—When rosin is used as a filler, the guide must first be annealed, after which it should be filled as follows:

(1) Estimate how much rosin is needed to fill the guide and melt. Melting is usually done in a vat by means of steam coils.

WARNING

If other means of heating are used, be sure to heat the sides of the container first. Too much heat applied at the bottom will cause an explosion.

(2) When the guide has cooled (after annealing) just enough so that it will not burn wood, drive a wooden plug in one end, place the guide in an upright position with the plugged end down, and fill with melted rosin.

CAUTION

If the guide is cold, the rosin will congeal when poured; forming air pockets which will cause the guide to cave in during bending or twisting.

(3) Allow the guide to cool naturally, then look for a cone-shaped hole caused by contraction of the rosin cooling at the top end of the guide. If the hole is deep, add melted rosin and allow to cool; if not very deep, fill with loose rosin.

(4) Plug the top end of the guide with a wooden plug. The guide is now ready for bending and twisting.

NOTE

Wrinkles may be hammered out before removing the filling, because rosin, when powdered by hammer blows, expands and occupies more space than solid filling.

c. SAND METHOD.-When sand is used as a filler, filling can be done either before or after annealing. If filling is done before annealing, most of the oxidation scale caused by heating will come out with the sand when the guide is emptied. Unless a temperature controlled oven is used, it is very hard to get perfect annealing with the sand in the waveguide. When using hand torches or gas ovens with no temperature control, anneal the waveguide before filling with sand. The type sand can be any fine beach sand but it should be screened to remove large particles. Before the sand is used, be sure that it is perfectly dry even if it is necessary to use heat.

CAUTION

Do not use wet sand, as it may cause an explosion when the guide is heated for annealing.

The following steps should be followed when using sand as a filler:

(1) Seal the waveguide by silver soldering a brass or copper plate over one end. Fill the guide with a high grade dry sand and tamp well.

(2) Pack the guide solidly with sand as follows: With the guide in a vertical position, add sand a little at a time, tapping the guide with a wooden mallet or block after each addition. Do the tapping on the corners of the guide to avoid denting in the flat areas. Continue until the guide is filled and the sand level remains constant after tapping.

CAUTION

If the sand is not packed solidly, serious wrinkles will form when the guide is bent.

(3) Plug the upper end of the guide with a steel plug. (Wooden plugs may be used but are not recommended when sand is used as a filler or when the guide is to be bent near the end.)

d. METAL SHIMS. — Thin metallic shims can be used as a filler particularly for small radius bends on small waveguide. The metal shims should be flexible, smooth and have the same width as the smaller size ID of the waveguide. Apply grease to both sides of each shim as they are inserted into the waveguide. The shims should be long enough to leave at least 2 or 3 inches outside the waveguide as a means of withdrawing them after the bending is completed. To withdraw the shims from the waveguide, a vise, clamp and hydraulic jack can be rigged up to exert the necessary pressure for removal. Heat may also be applied to help removal of the shims.

7. BENDING.

Bending can be done by using a Wallace Bending Machine, an ordinary hydraulic push press, a portable pipe-bending machine, or a block and tackle.

a. WALLACE BENDING MACHINE. - The Wallace Bending Machine involves a long set-up time and can be used to advantage only where several sections of waveguide with the same type of bend are being done at once.

The advantage of using the Wallace Bending Machine is that the waveguide can be bent without using a filler inside the guide. The waveguide, however, must still be annealed on the portion that is to be bent. Some of the special forms that are used with the Wallace Bending Machine are shown in Figure 11-11 to Figure 11-15.

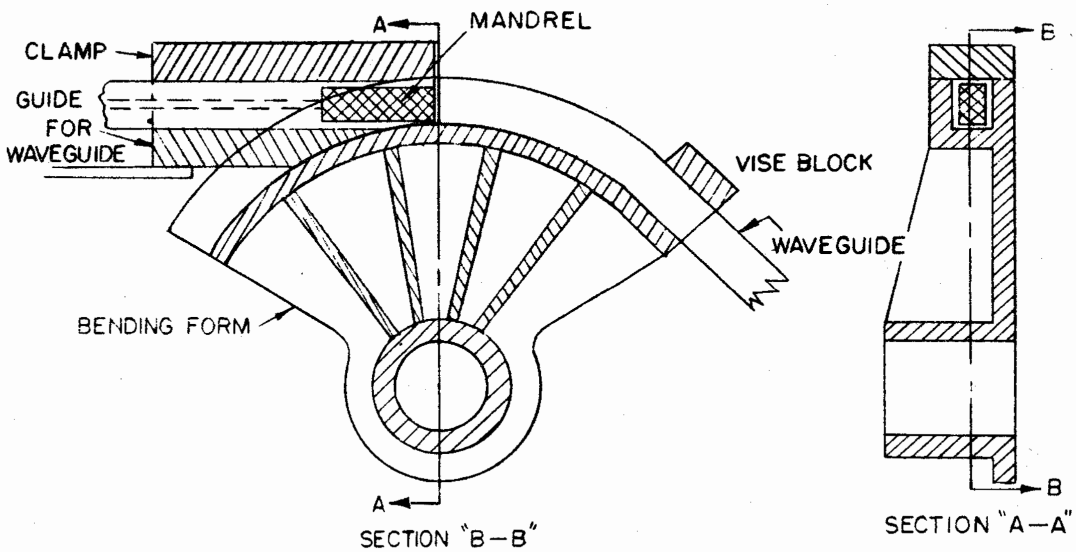


Figure 11-11. Details of Bending Forms for Wallace Bending Machine

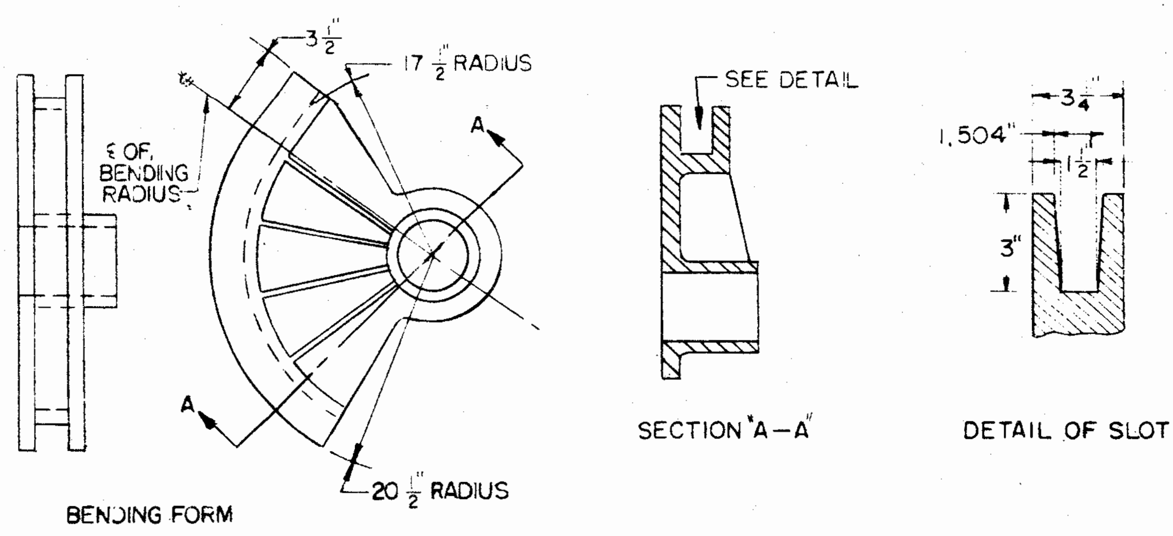


Figure 11-12. Bending Forms for Edgewise Bend

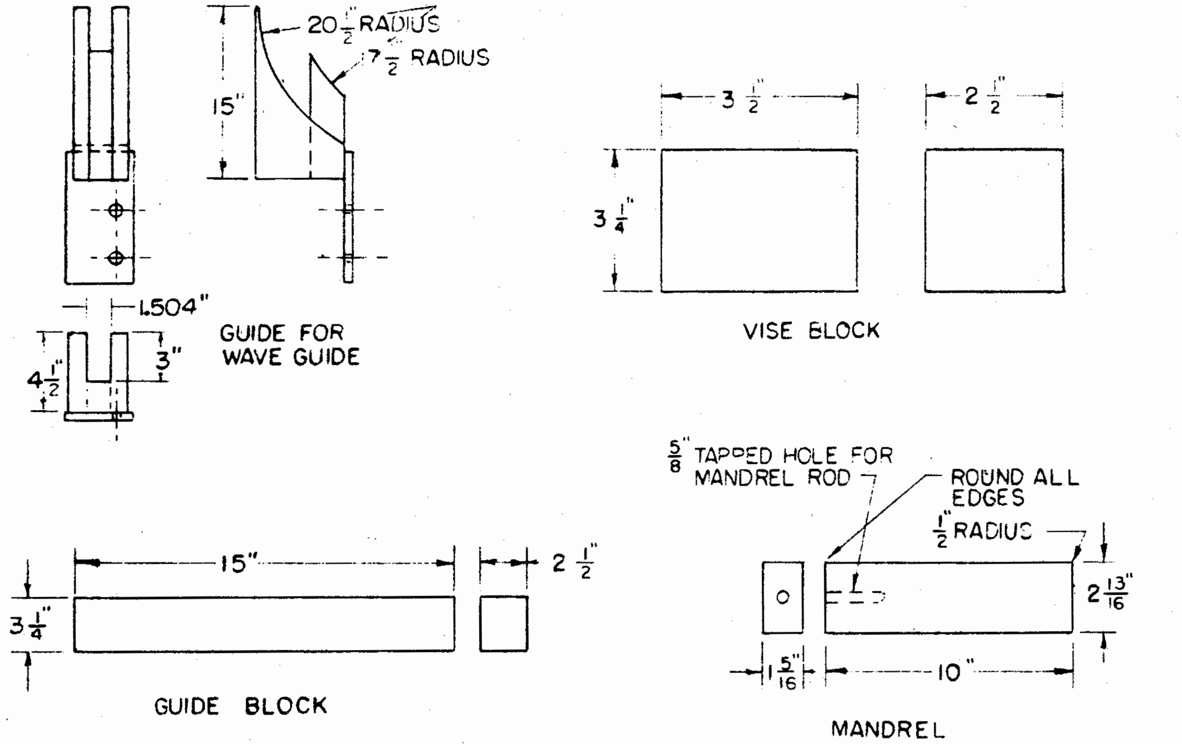


Figure 11-13. Detail of Bending Forms for Edgewise Bends

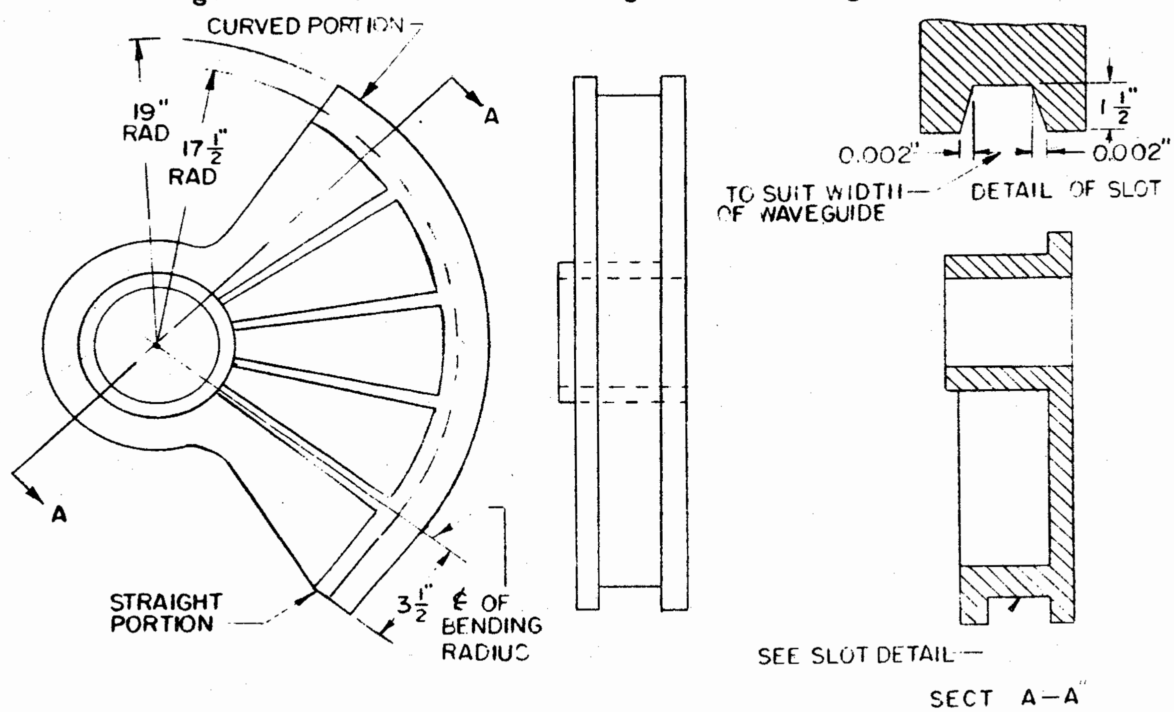


Figure 11-14. Bending Form for Sideways Bend.

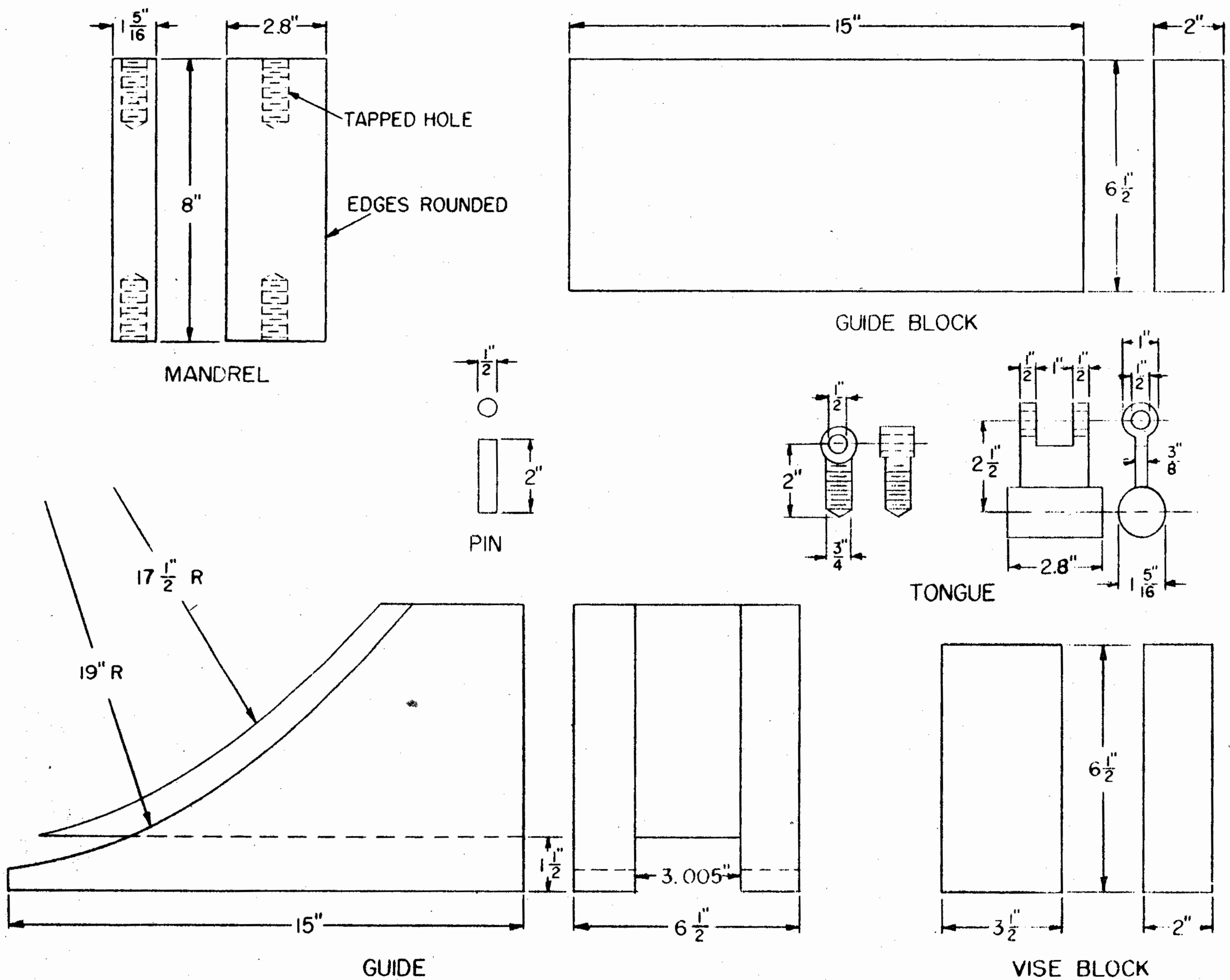


Figure 11-15. Detail of Forms for Sideways Bend

b. HYDRAULIC PUSH PRESS AND PORTABLE HYDRAULIC BENDER METHOD.—This method has a disadvantage in that the waveguide must be filled for bending, but it is the preferred method when doing different bends where no two bends are alike. It is also the most convenient to use at a forward area or advanced base.

Another disadvantage to this method is that puckers or wrinkles that usually form as a result of the bending operation must be removed. This is done using a rolling machine or by hammering.

A typical hydraulic push press and a portable press is shown in Figures 11-16 to 11-18.

The procedure for using this method is as follows:

(1) Anneal and fill the waveguide.

(2) Insert the waveguide between two bending pins or dies (with suitable protective slabs in place). A bending form, curved to suit the desired radius of the waveguide, contacts the waveguide as the hydraulic hammer moves forward. For

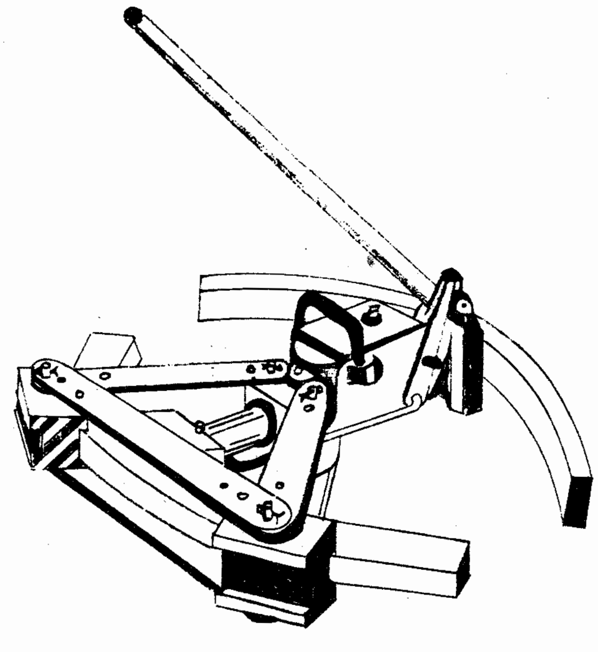


Figure 11-16. Greenlee Hydraulic Bender, Model 775

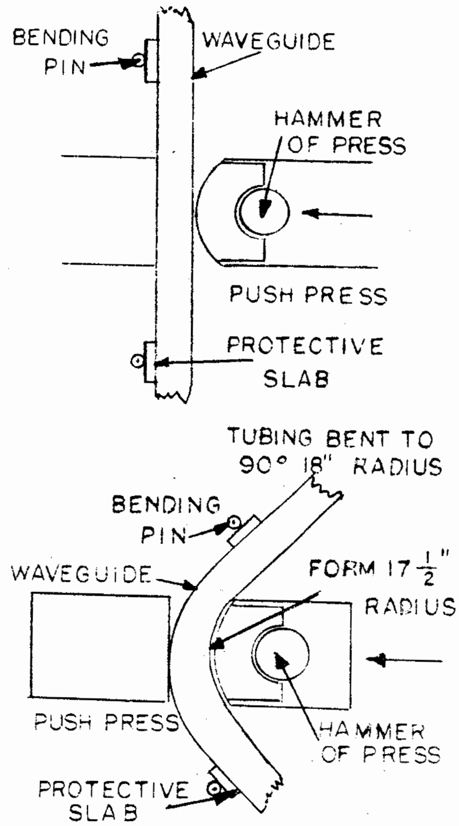


Figure 11-17. Bending Waveguide in Simple Hydraulic Press

the desired 18-inch radius bend in the waveguide, the radius of the curve of the bending form should be 17-1/2 inches. This compensates for the spring of the waveguide. A complete bend is done by bending the waveguide in short sections along the radius distance. The bend will not be smooth but will have "puckers" or hills and valleys in the surface; these will have to be hammered out. Keep shifting the points of pressure of the ram. Force ram surface against the "puckers".

(3) A complete 18-inch radius, 90° bend can be made in the waveguide sideways (wide side as the throat and back) with one rosin filling. However, if the waveguide is bent edgewise (narrow side as the back and throat) two rosin fillings are necessary.

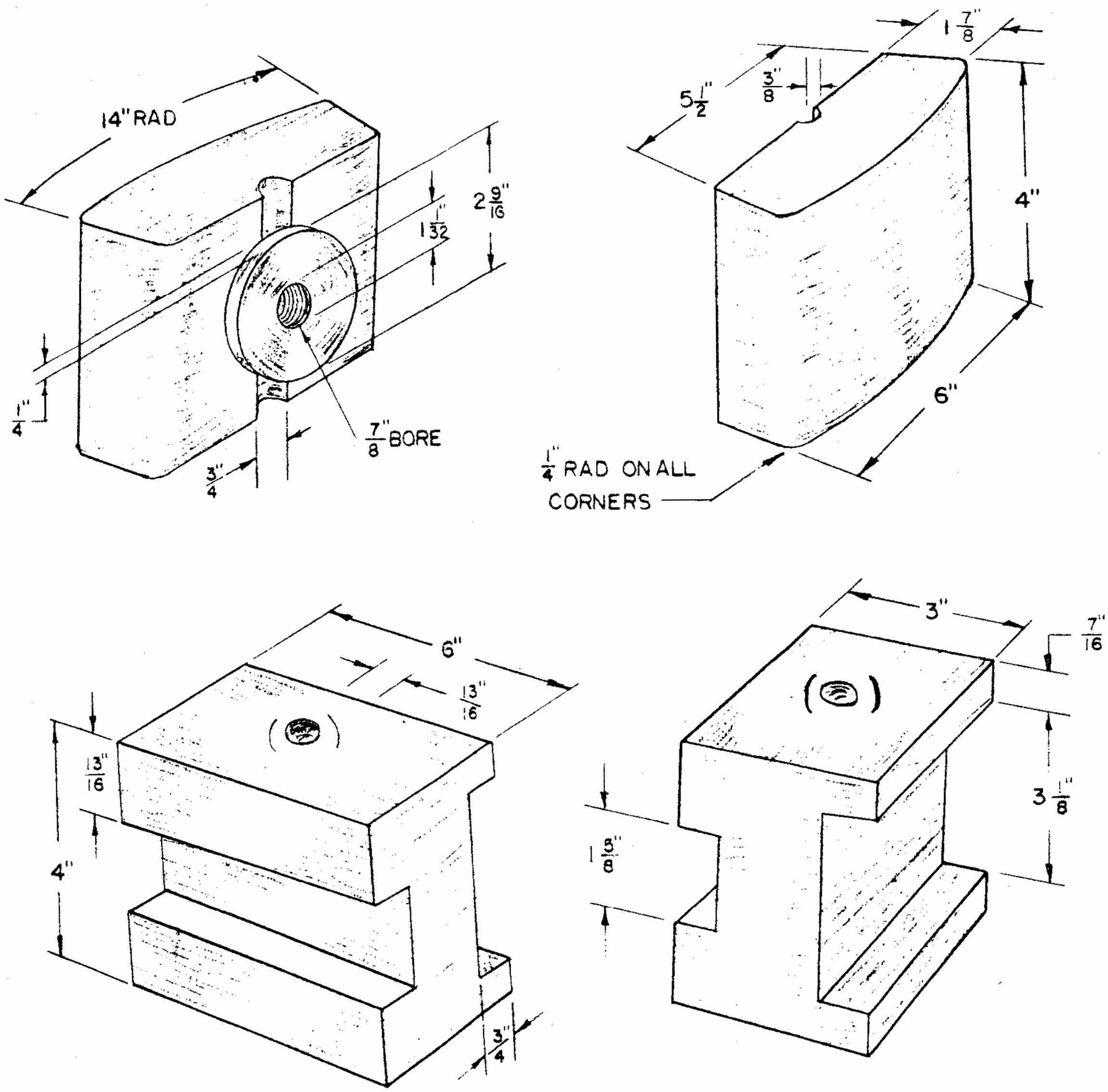


Figure 11-18. Waveguide Dies Used with Greenlee Bender

(4) Bending the waveguide sideways: The waveguide is bent until it has the desired angle and a true radius. The puckers in the throat of the bend are hammered smooth with a properly shaped hammer. The radius of the face of the hammer must be as nearly like the radius of the throat as is practically possible.

(5) Bending the waveguide edgewise: The waveguide is bent approximately half way to the desired angle until visible distortions appear in the form of puckers in the throat and bulges in the side walls. The puckers are hammered smooth as explained before, and the walls are dressed by a 3-1/2 inch square-faced blacksmith's flatter with a suitable hammer supplying a proper blow. Another method is to insert the guide in a hand roller and roll the guide through several times with increasing pressure. After all distortion has been removed, the filler is removed and the waveguide is re-annealed and refilled. The waveguide is bent again until it has the desired angle and a true radius. The puckers in the throat are again removed as before and the increase in the thickness of the waveguide at the throat is reduced to normal by applying light blows to the flatter while it is being held firmly against the throat area of the side walls. Waveguide can be bent very satisfactorily with rosin to within five to ten percent of perfection. This result may be obtained by a properly trained coppersmith using the previously described tools and methods.

c. HAND BENDING MACHINE.– If none of the previously described methods are available for bending waveguide, it is possible to make up a Hand Bending Machine as shown in Figure 11-20. This type of bending machine does not require very many parts and it is capable of making satisfactory bends in most cases, provided the operator uses sufficient time and care.

d. HOT BENDS.– All waveguide bends that have been described are made with the guide at room temperature. The use of heat when making a bend will allow the bend to be made with less leverage or force. This applies only when making bends where sand has been used as a filler. In Figure 11-19, a special torch tip can be made which will produce a large spread-out flame when used as an acetylene torch tip. This flame can be played over the area that is to be bent or twisted and when the waveguide comes up to a temperature just below annealing (dull-red), it will bend with very little pressure. Wrinkles and puckers will still appear as the waveguide is being bent and it will usually be necessary to smooth these out two to three times before the final bend is completed.

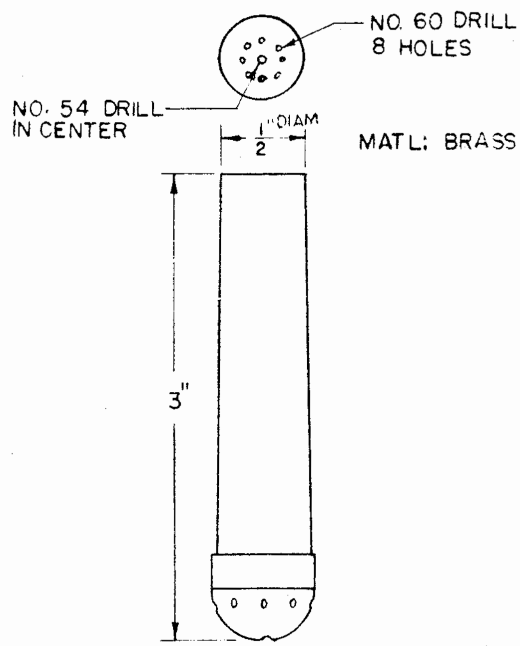


Figure 11-19. Special Torch Tip
for Bending Waveguide

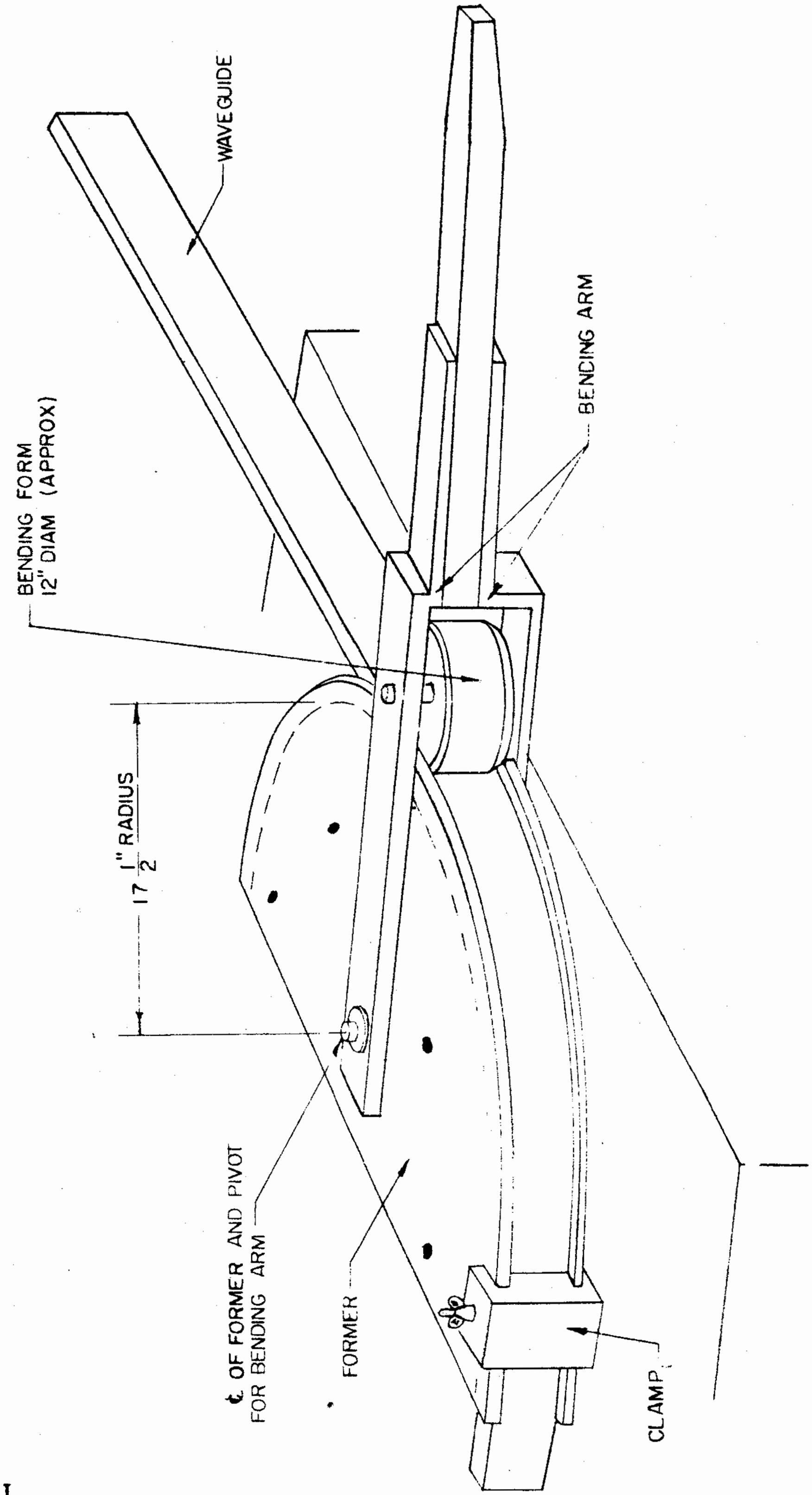


Figure 11-20. Waveguide Hand Bending Tool

CAUTION

Never try to make a hot bend when the waveguide contains rosin or an alloy as a filler.

8. TWISTING THE WAVEGUIDE.

The twisting of the waveguide is accomplished by the use of equipment whose essential features are shown in Figures 11-21 to 11-25.

The method of twisting is as follows:

a. The waveguide is annealed along the portion of the length where the twist is to be made.

b. The waveguide section is plugged at one end, filled, allowed to cool, and then "topped off".

c. The waveguide is then inserted in the equipment as shown in Figure 11-22 and is twisted to the desired degree.

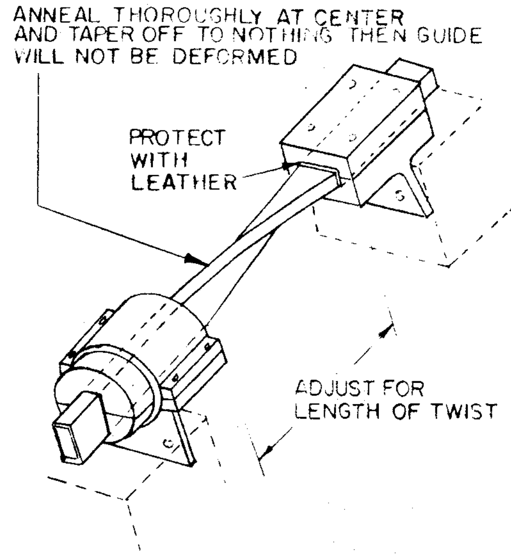


Figure 11-22. Twisting Machine Detail

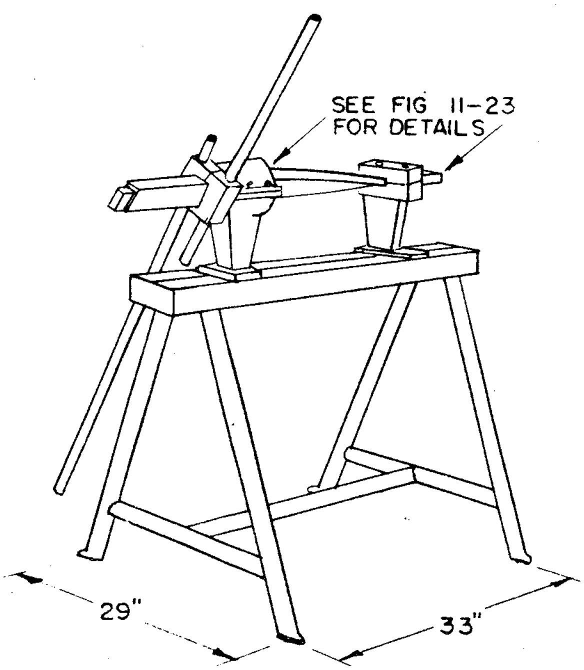


Figure 11-21. Twisting Machine for 1-1/2 x 3 inch Waveguide

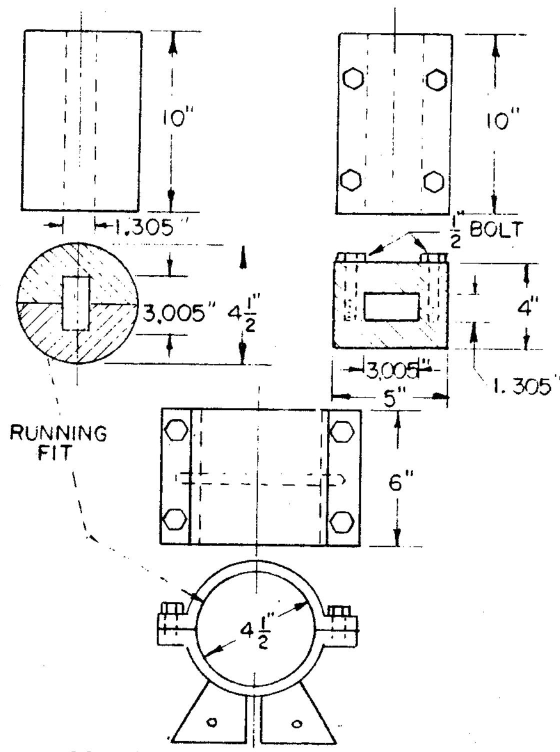


Figure 11-23. Cross Section of Clamps for Waveguide Twisting Machine

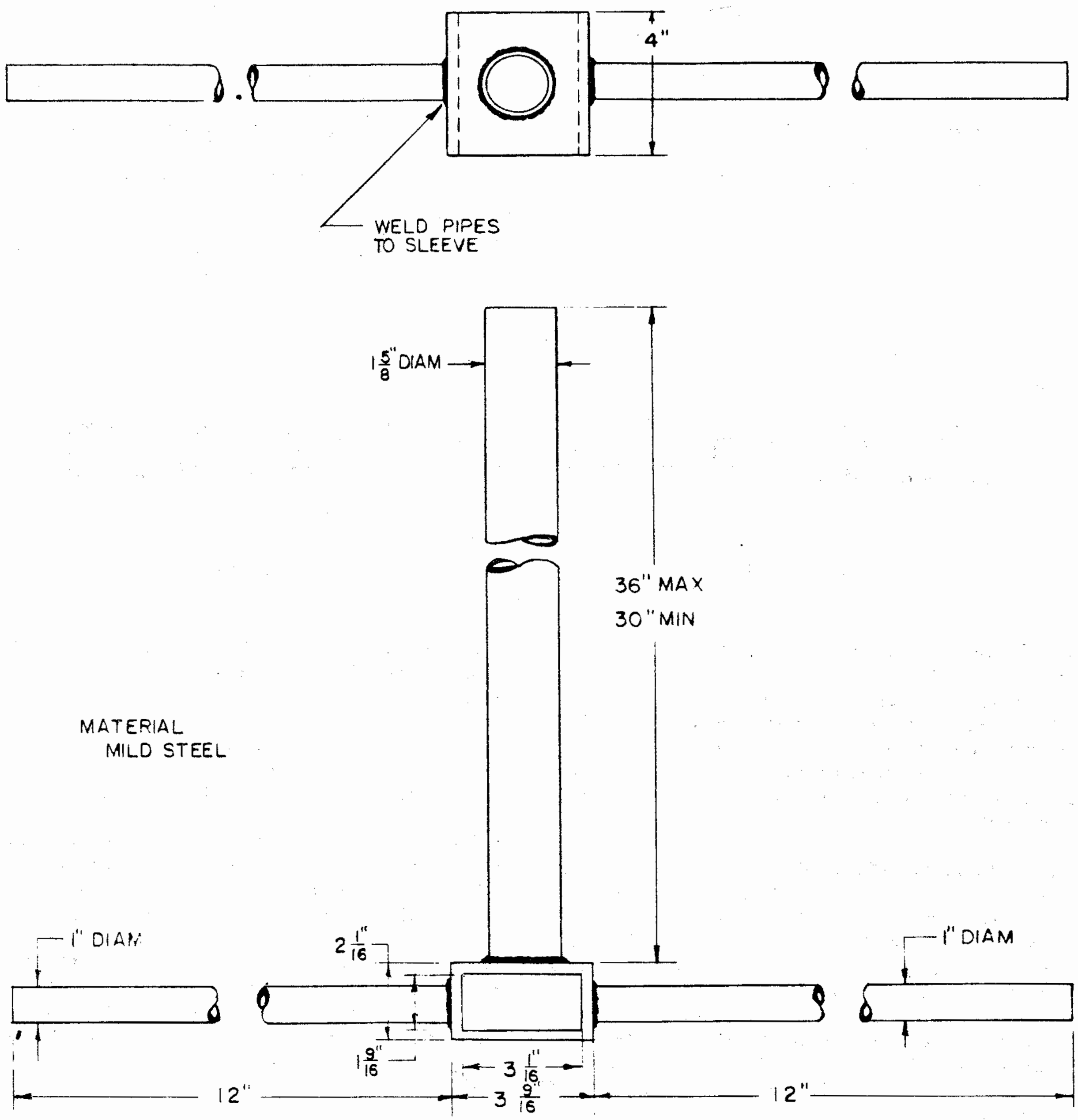


Figure 11-24. Waveguide Twisting Tool

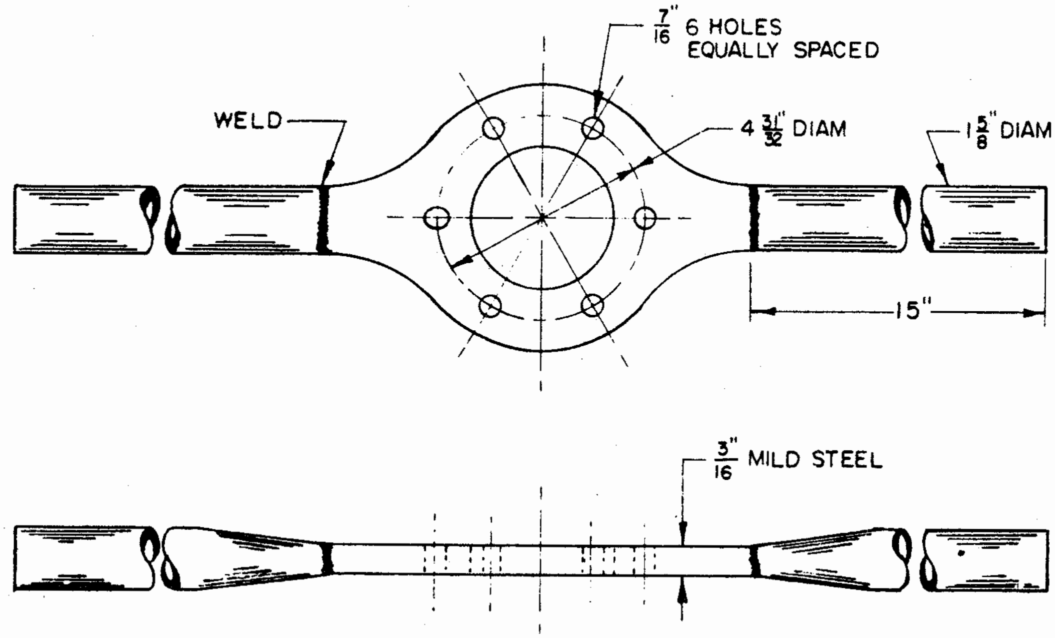


Figure 11-25. Tool for Use with Twisting Machine

9. REMOVAL OF FILLING.

If rosin is used for filling, dents and wrinkles should be removed while the filler is still in the guide, but not otherwise. Use a flatting hammer with curvature corresponding to the shape being formed.

a. ALLOY METHOD.— After bending and twisting, immerse the guide in a tank of hot water at 82°C-93°C(180°F-200°F), (stainless steel tank preferred), and allow the alloy to run out. Do not use a torch. Tilt and shake the guide to remove the alloy as completely as possible.

Plunge the emptied guide (while still hot) into cold water for two minutes to solidify any small drops of alloy retained in the oil film.

To remove the oil film and remaining solid particles of alloy, flush the guide with a cold grease solvent (such as Oakite No. 23) or blow it out with a blast of steam. Then use a tight-fitting pull-through.

b. ROSIN METHOD.— Remove both plugs and tilt the guide, using a chain hoist if desired.

CAUTION

Always remove both plugs before melting out the rosin.

Using a torch adjusted for moderate heat, apply heat to the bottom end of the guide until the rosin begins to flow, then gradually raise the torch along the guide. After the guide is clear, direct the flame through the interior to remove remaining particles of rosin. It is not necessary to melt all the rosin. The tendency is for the surface of the rosin to melt, permitting chunks to slide out of the guide.

WARNING

Never apply heat to the middle of a guide that is filled with rosin, or an explosion will result.

c. SAND METHOD. -Remove the filling by pulling out the steel plug and pouring out the sand. Remove soldered end plate.

10. CUTTING.

In cutting stainless steel waveguide, RG-127/U or NT-14ACM, it is necessary to use special hacksaw blades due to the hardness of the stainless steel. When a hacksaw is used, a recommended type is the Blumol Blade No. 1224M or equivalent (Stock No. G41-B-1173-500). This blade is 12 inches long and has twenty-four teeth to the inch. It is possible with this blade to make two separate and complete cuts of the waveguide before the blade is worn out. For power saws, a recommended type of blade is the Kuta 1 special Alloy High-speed Steel (Manufactured by Sparton Saw Workers, Inc., Springfield, Massachusetts) or equivalent. When cutting brass waveguide, a recommended type for a power saw is the Simmonds T-11 Steel Blade or equivalent. This saw blade is round and has a twelve inch diameter with 188 teeth. It is 1/16 inch thick and should be driven at approximately 1,200 rpm.

When cutting all types of waveguide, the cut should be made at right angles and the edges filed before inserting the coupling.

11. ATTACHMENT OF FLANGE COUPLING.

a. FLANGES ON STAINLESS STEEL WAVEGUIDE. - When installing UG-319/U or UG-320/U flanges on RG-127/U or NT-14ACM stainless steel waveguide, the following step-by-step method can be used:

(1) Use fine sandpaper and clean outer surface of guide to one inch back from the edge to be soldered.

(2) Clean inside surface of cast brass flange.

(3) Flux inside of flange and outside of guide with Handy Flux or equivalent (Stock No.G51-F-640).

(4) Install flange on waveguide by method shown in Figure 11-27 or as shown in Figure 11-28. Leave 1/32 to 1/16 inches of waveguide extending out of flange. If method shown in Figure 11-27 is used, a mandrel as shown in Figure 11-26 must be inserted inside the waveguide. Either of these methods can be used but the method shown in Figure 11-26 and 11-27 is preferred as being both faster and doing the better job.

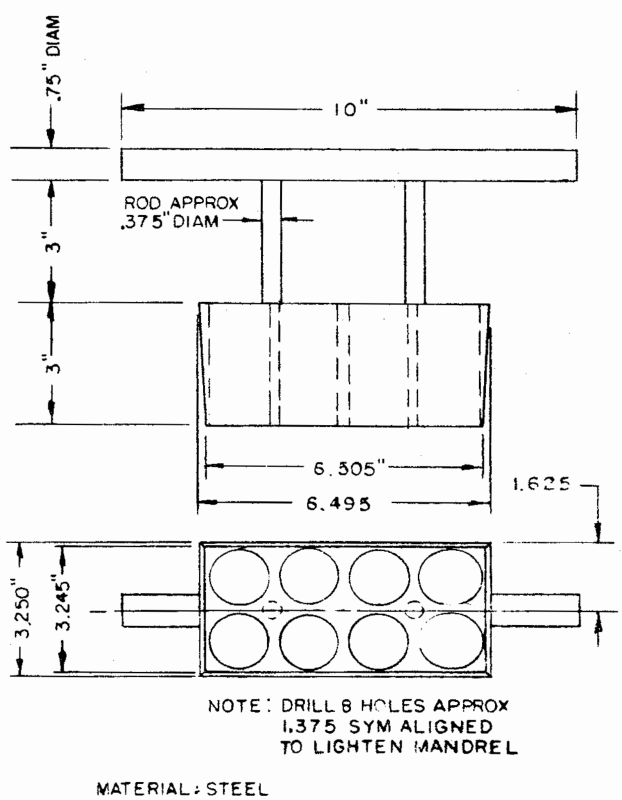


Figure 11-26. Mandrel for RG-127/U or NT-14ACM Waveguide

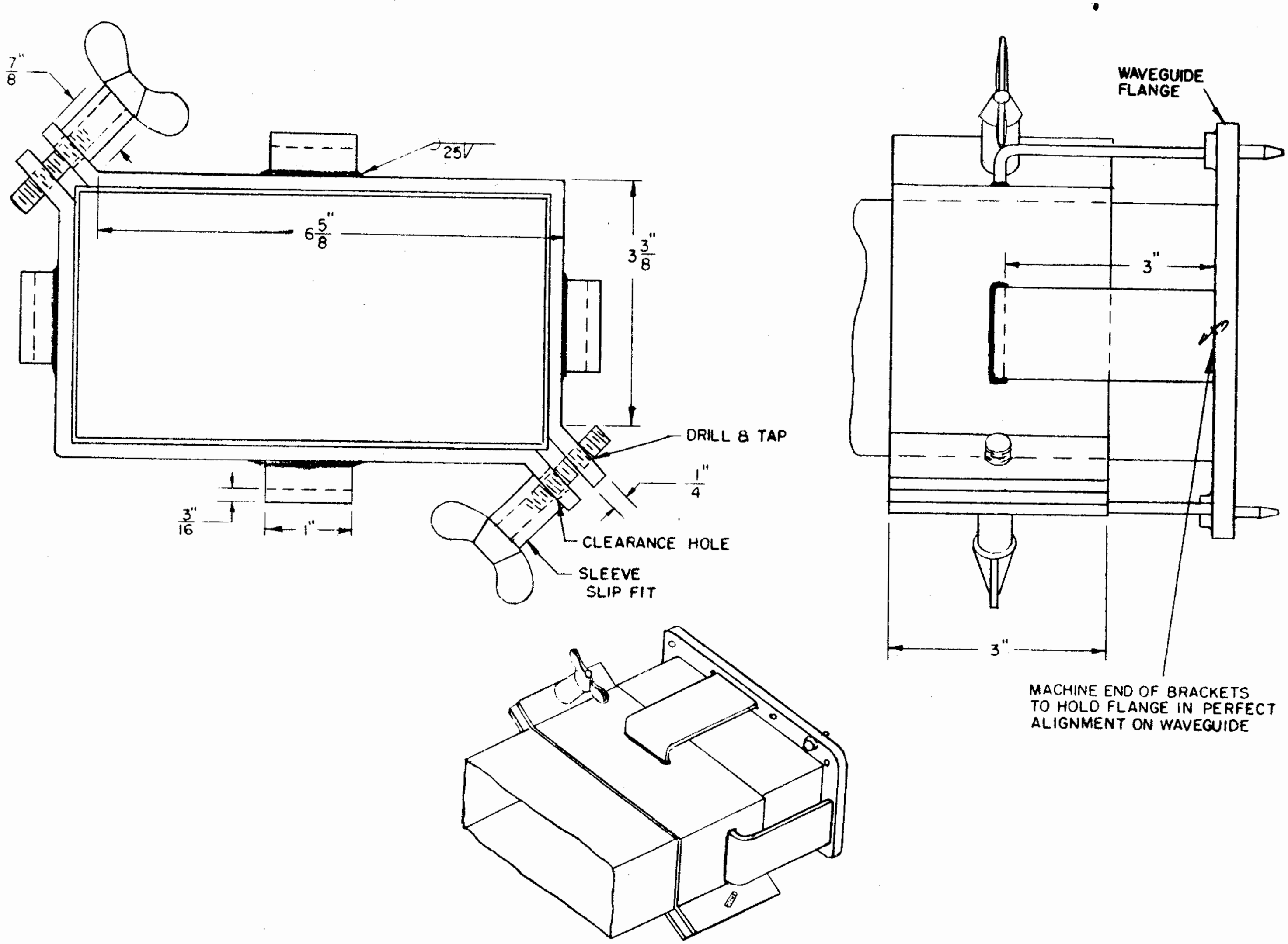


Figure 11-27. Jig for Squaring RG-127/U or NT-14ACM with UG-368/U Flange When Soldering Flange to Waveguide

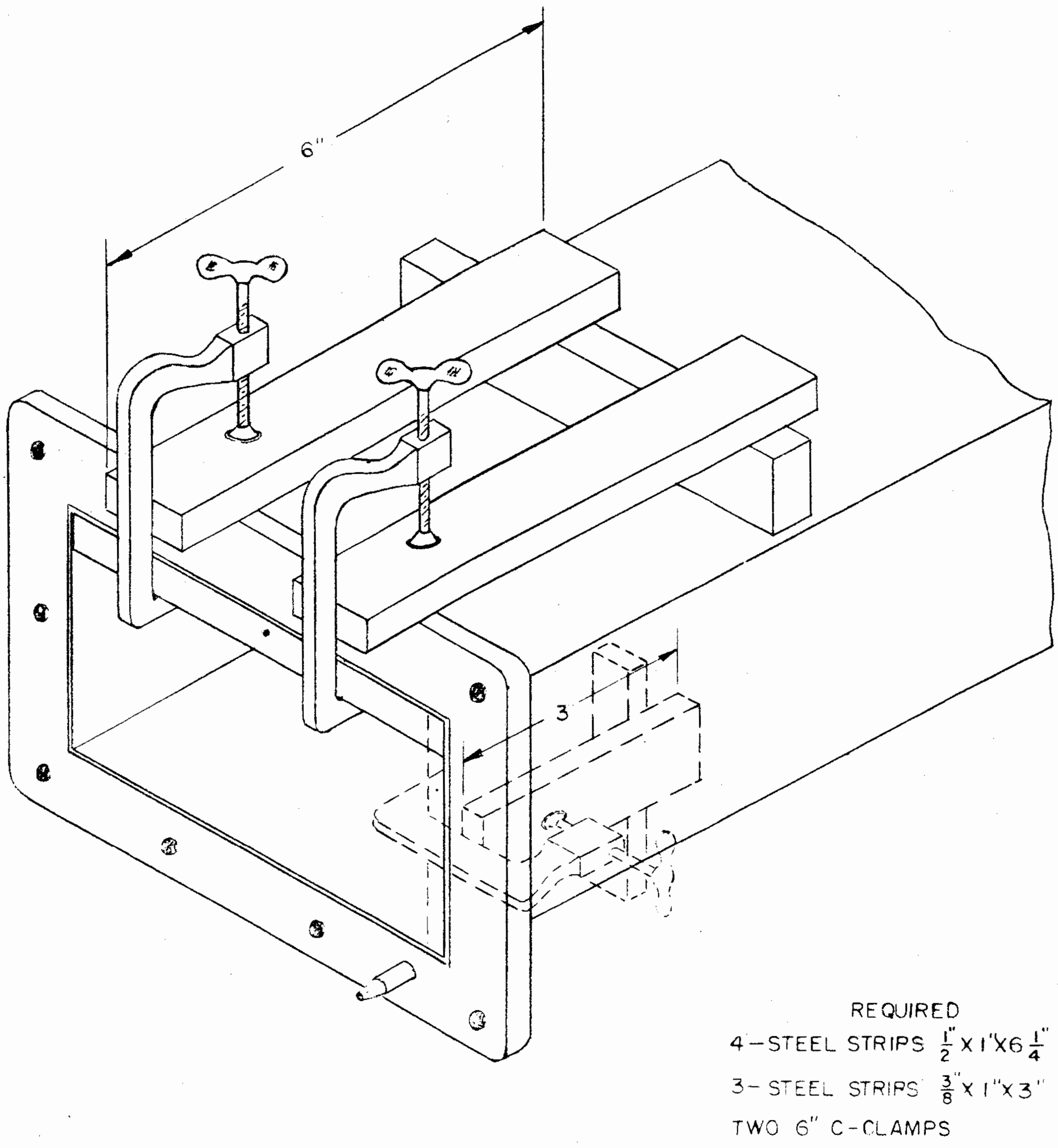


Figure 11-28. Method of Soldering Flange to 6-1/2 x 3-1/4 " Waveguide

(5) Use a number six tip on the acetylene welding torch and preheat the base of the flange.

(6) Use 1/16 inch, grade 4, silver-solder and first put a few drops of solder on the outside of the flange to the waveguide; then feed solder from the back of the flange until the entire assembly has a good hard solder connection.

(7) File or power grind the mounting surface of the flange and the end of the waveguide until it is smooth.

b. FLANGES ON BRASS WAVEGUIDES.- When installing flanges to brass waveguide, the following method can be used:

(1) Thoroughly clean the contact surfaces to be brazed, using fine emery paper or crocus cloth.

(2) Square up the edges of the guide.

(3) Insert the guide in the flange coupling and leave .002 inch to .008 inch of guide outside of the coupling. This clearance is needed to insure a perfect face-to-face butting with the two flanges without any interference to the guide and assures a positive electrical connection between sections. See Figure 11-29.

(4) Apply silver-solder flux (Stock No.G51-F-640) or borax using a brush.

CAUTION

The flux is poisonous. Avoid inhaling.

This type of flux flows at 627°C (1,160°F); Borax flows at 716°C (1,300°F). Braze the waveguide to the flange coupling using grade 4 silver solder (Stock No. G46-S-657). Apply heat to the collar end, as shown in Figure 11-30. This will bring the coupling and guide up to an even

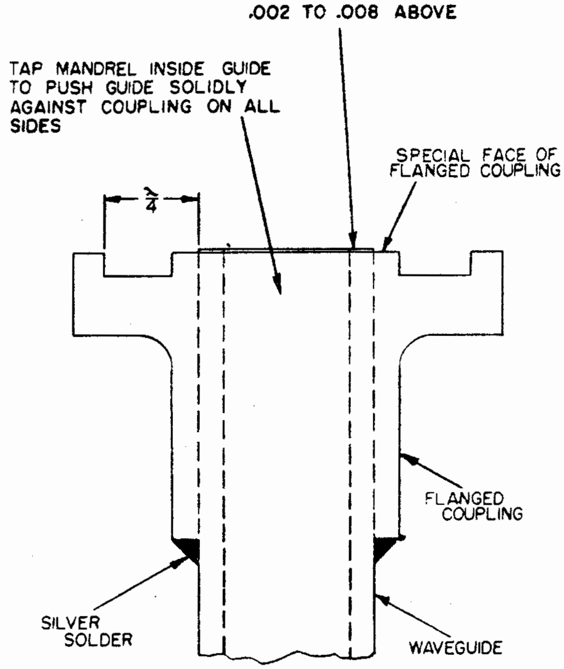


Figure 11-29. Attachment of Flange Coupling to Waveguide

welding heat. Insufficient heat will result in a weak point.
Overheating will burn away the flux and cause oxidation.

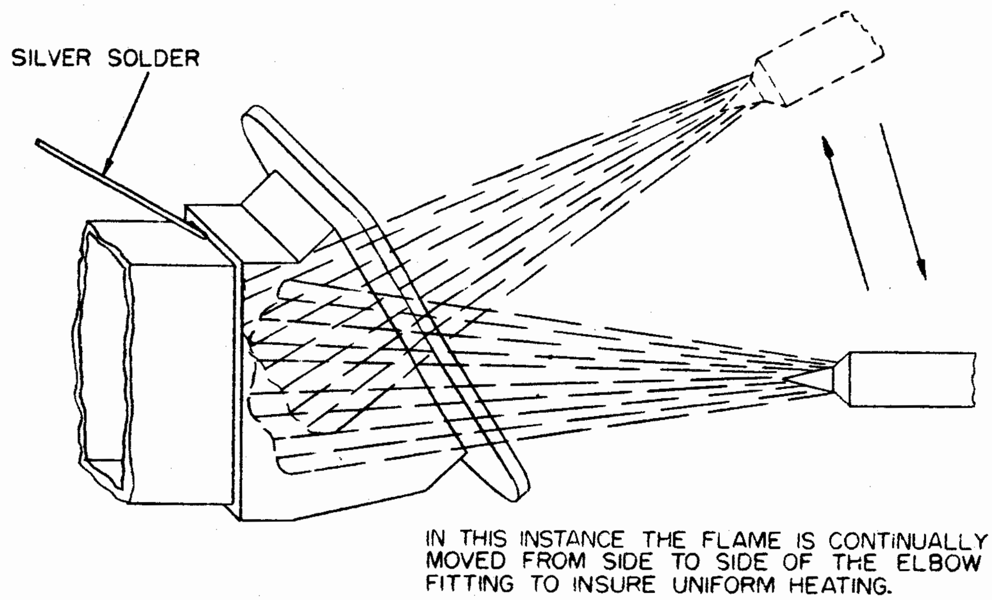
(5) Silver solder the gas escape vents in the wide sides of the coupling flange.

(6) Remove all traces of flux by flushing the end in boiling hot water.

(7) Tap the mandrel shown in Figure 11-31 into the guide. This will push the guide against the coupling at all points.

CAUTION

Do not use soft solder on the face of the coupling as soft solder oxidizes with age and may cause a high resistance joint.



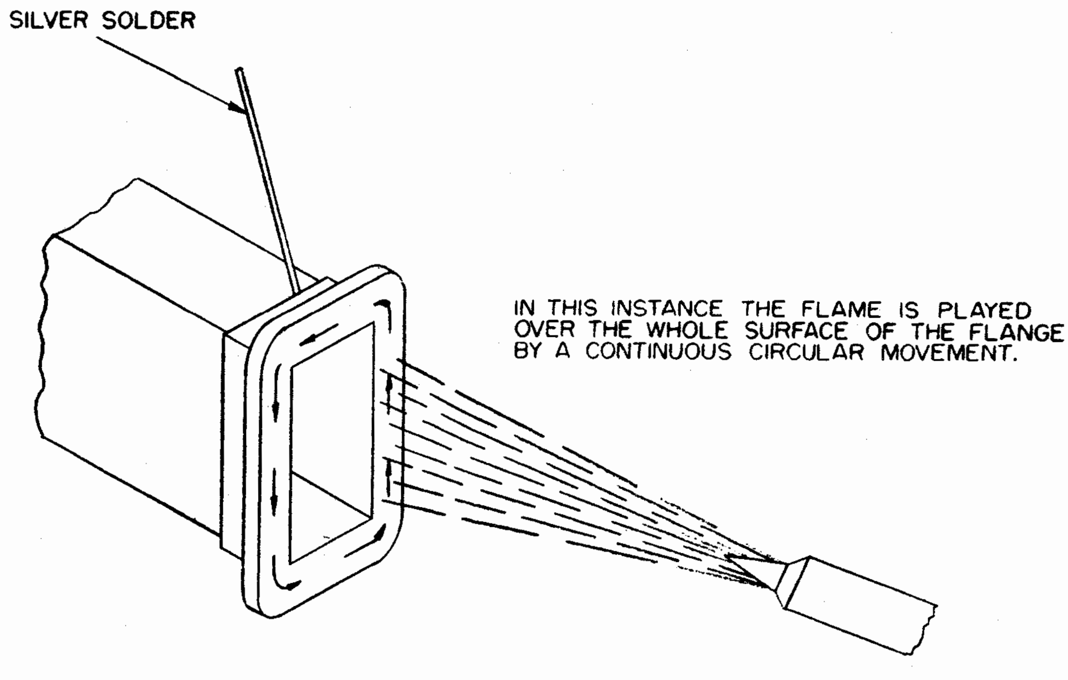


Figure 11-30. Directing a Flame on Socket and Flange

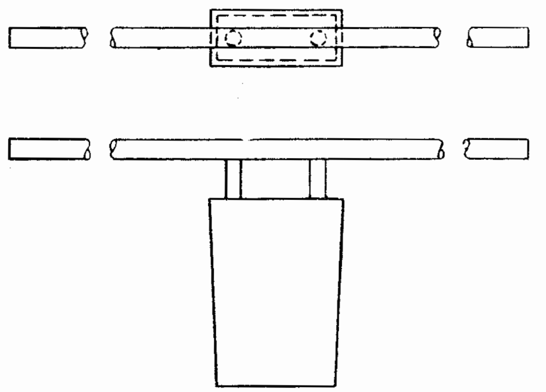


Figure 11-31. Waveguide Mandrel

The fitting for an echo box probe may be installed as shown in Figure 11-32. Remove inside burrs before soldering.

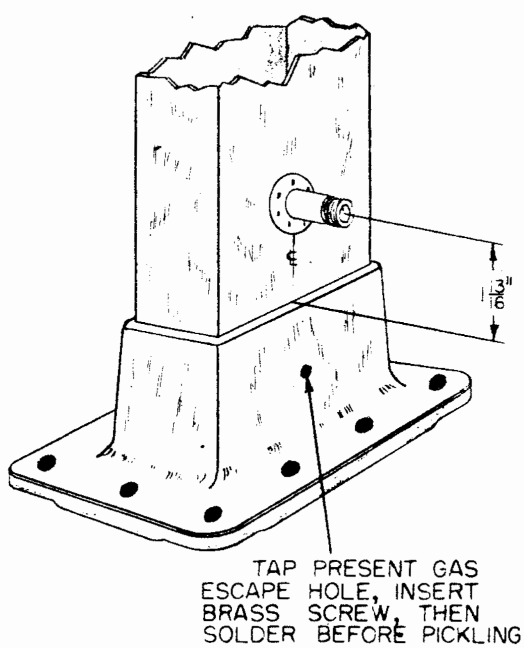


Figure 11-32. Installing Pick-up Probe in Waveguide

c. FLANGES ON ALUMINUM WAVEGUIDES. -The basic equipment and methods required for brazing flanges on aluminum waveguides are as follows:

(1) EQUIPMENT REQUIRED.

(a) TORCH TIPS No. 1-5. -The use of various size torch tips are determined by the thickness and the size of the area of aluminum to be brazed. The tips (No. 1-5) vary according to their openings. It is generally suggested that a No.3 tip be used for waveguide brazing.

(b) BRAZING ROD. -The main requirement for a good brazing alloy is that it have a sufficiently low melting temperature to provide a practicable range at which brazing can be done. Specifically recommended is Alcoa No. 716 brazing rod, 1/16 inches thick or equivalent (Stock No. G46-S-567-345). Brazing range is 521°-595°C (970°-1085°F).

(c) BRAZING FLUX. -The brazing flux is used as a guide to produce a flow of filler metal. Specifically recommended is Alcoa brazing flux No. 33 or equivalent (Stock No. G51-F-635-2500). This is the flux having the lowest melting point (approximately 593°C (1100°F), and the most active, chemically, producing maximum flow of filler metal.

(d) CAUSTIC SODA. -Caustic Soda is used as a cleaner. One-half pound of caustic soda is dissolved in two gallons of boiling water.

(e) CONCENTRATED NITRIC ACID. Concentrated Nitric Acid is used to restore aluminum parts to their natural color after dipping in caustic soda. (Caustic Soda turns aluminum black).

(2) BRAZING METHOD. -The brazing operation of aluminum flanges consists of three major steps:

(a) PRE-CLEANING. - For best results, the aluminum parts to be brazed must be absolutely clean. They must be free of all dirt, grit, grease, oil film, etc. If necessary, de-grease the work to be brazed by submerging the work for approximately 10 to 15 seconds in a hot solution of caustic soda (proportion: one half pound of caustic soda to two gallons of boiling water). The aluminum will then turn black. Remove the work from the caustic soda solution and rinse well in clean, cold water. Remove the work from the cold water, rinse and then submerge into a heavy glass, stainless steel or stone receptacle filled with concentrated nitric acid. This will restore the aluminum to its natural color in approximately ten seconds. Remove the work from the nitric acid and submerge the parts into clear, cool water. RINSE WELL SO THAT ALL ACID IS REMOVED.

(b) BRAZING. -Install the coupling on the guide so that 1/32 of an inch of guide extends beyond the face of the coupling. This will insure that the solder does not enter into the guide. Place the guide upright with the flange to be soldered on the bottom. Keep the flange off a flat surface by means of a suitable jig, such as four bolts threaded into the flange.

Apply the flux to the areas of the aluminum to be brazed and to several inches of the brazing rod.

Use a No. 3 torch tip and adjust for "reducing" flame (oxygen starved flame).

Apply heat to the parts to be brazed. Keep the torch in constant motion at all times so that the parts will receive an even distribution of heat for proper fusion.

When flux dissolves into a liquid and becomes transparent, apply brazing rod to the area to be brazed. The rod is applied at one point only, and will, of its own course, flow around and seal the joint. This will happen only if the heat is properly distributed.

(c) FINAL CLEANING. - The final cleaning of work follows exactly the procedure of pre-cleaning. This is important as it removes the residue flux and prevents corrosive attack.

12. REMOVAL OF DENTS AND WRINKLES FROM WAVEGUIDE.

This should be done after the filler has been removed. (If the filler is rosin, imperfections may be removed from the wide side of 1-1/2 inches x 3 inches waveguide while the rosin is still in place.) Dents are removed from an empty guide as follows:

a. Seal the guide in the usual way at both ends and fit one end with a valve.

b. Fill the guide with air at a pressure of about 28 psi (pounds-per-square-inch).

CAUTION

The air pressure must be closely watched, as pressure exceeding 30 psi will bulge the guide.

c. Heat the area around the dent with a torch and remove the dent by means of a flatter.

Another way of removing a wrinkle or dent would be to use water pressure instead of air pressure. This requires a special jig as shown in Figure 11-33. The jig for the opposite end of the waveguide should be as shown in Figure 11-33, except for the valve. Connect the jig, without a valve, to a water pipe and let the water enter the guide. Open the valve on jig at opposite end until all the air is out of the guide, then close valve. If the dent or wrinkle is not too deep, water pressure will force it outward.

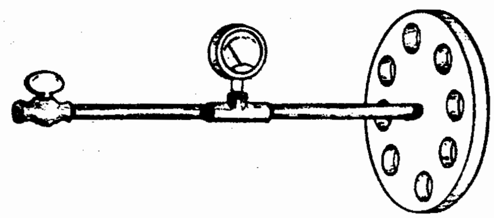


Figure 11-33. Jig for Getting Water-Pressure into Waveguide

13. CLEANING WAVEGUIDE.

When fabrication is completed, each waveguide section must be carefully cleaned. This is essential, as the inner surfaces of the entire run must form an electrical mirror to allow proper transmission of RF energy. Coppersmiths, etc., must be impressed with the importance of this operation.

a. BRASS WAVEGUIDE, - For inside surfaces of brass waveguide, it is necessary to use an acid pickle and a bright dip as follows:

(1) First remove all oil or grease from the guide by washing it in a hot solution of Oakite No. 23 at 82°C (180°F) and then rinsing in hot water. (Acid will not remove oil or grease.)

(2) After removing oil or grease, and while the guide is still warm, immerse it in the acid pickle.

(a) A pickle commonly used, consists of the following:

Sulphuric acid	1 gallon
Water	9 gallons
Temperature of bath	Room temperature to 66°C (150°F)

The heavier the oxide scale, the more concentrated and hotter the pickle used.

(b) Sometimes it is desirable to add an oxidizing agent for the removal of the red stain or cuprous oxide. This red stain is not easily affected by sulphuric acid pickling. In such cases, either sodium bichromate or ferric sulphate are added to the acid in quantities that vary depending on the work. A typical solution would be:

Sulphuric acid	12 ounces
Sodium bichromate	4 ounces
Water	1 gallon
Temperature of bath	Room to 49°C (120°F)

The length of time for cleaning or pickling depends upon the surface condition of the waveguide.

(3) For bright dipping, nitric acid is added to the sulphuric acid bath as follows:

Sulphuric acid	2 gallons
Nitric acid	1 gallon
Water.............	1 to 2 quarts
Hydrochloric acid..	1/2 fluid ounce
Temperature of bath	Room temperature

(4) After the guide has been thoroughly cleaned with acid, immerse it in hot water. The guide should then be immersed in one of the following neutralizing baths:

(a) Potash, 1-1/2 pounds and water, 1-1/2 gallons.

(b) Soda ash, 1 pound and water, 7 gallons.

(c) Magnus, diluted as directed on the package.

(5) Again, wash the guide in hot water making sure that no alkali remains on the inner corners of the flange.

CAUTION

Avoid contact with pickling or neutralizing solutions. If some gets on the skin, wash the area well with cold water and then with soap and warm water.

b. ALUMINUM WAVEGUIDE. - The above methods apply to cleaning brass waveguide only. For cleaning aluminum waveguides, use the cleaning procedure outlined in Paragraph 11c.

c. STAINLESS STEEL WAVEGUIDE. - Stainless steel waveguide, RG-127/U, or NT-14ACM, should never require cleaning with acid. It should, however, be degreased before painting.

d. OUTSIDE SURFACES. - The outside surfaces of most brass and aluminum waveguides can be cleaned by sandblasting. Use a light sand blast and apply evenly, otherwise the waveguide may be distorted. Never sand blast RG-127/U (stainless steel) or RG-132/U (brass) as the wall thickness is .040" instead of .080".

14. PAINTING WAVEGUIDE.

After cleaning the waveguide, the inside and outside surfaces should be painted. While painting the inside surface will introduce a slight loss of RF power, the attenuation will remain more constant over longer periods of time.

a. INTERIOR. - After the flanges have been installed and the waveguide cleaned, both inside and outside surfaces should be painted.

(1) BRASS AND STAINLESS STEEL WAVEGUIDE. - For painting the inside surfaces on the waveguide, expansion plugs as shown in Figure 11-34 can be used. Install the expansion plug on one end of the guide and tilt the guide so this end is down. Pour zinc chromate paint into top end of guide until approximately one-quarter full and install top expansion plug. Turn guide up and down so paint can cover interior. Remove plugs and pour paint back into container. Dry the guide by hanging in a vertical position.

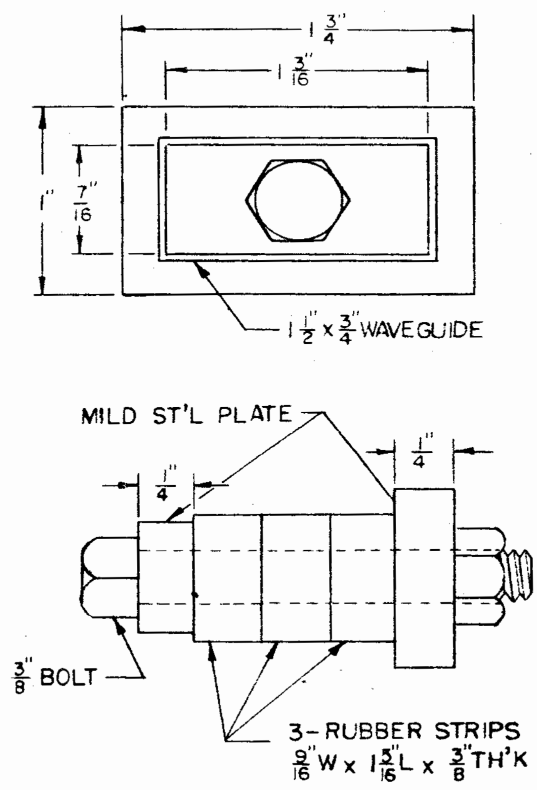


Figure 11-34. Expansion Plug for Painting 1-1/2 x 3/4 inch Waveguide

In painting waveguide, follow the standard practices for painting. Screen the paint each time it is to be used. Reduce with thinner to the proper thickness. (It is better to have the paint too thin and have to apply two to three coats than have it too thick.) Waveguide, paint, and room temperature should not be less than 21°C (70°F).

YELLOW ZINC CHROMATE PRIMER
5 Gallon Pail . . . . SNSN G52-P-20635
Set to touch . . . . .2 hours max
Dry hard . . . . 8 hours max
USE UNTIL STOCK EXHAUSTED
5 Gallon Pail. SNSN G 52-P-20635-2
Set to touch . . . . 2 hours max
Dry hard. . . . . 6 hours max
WILL SUPERSEDE FIRST ITEM

THINNER	
Container	Stock Number
5 Gallon Pail	G52-T-725-5
55 Gallon Drum	G52-T-725-55

(2) ALUMINUM WAVEGUIDE. – Before painting aluminum waveguide, it should be anodized. Anodizing will provide a protective coating that is considerably harder than the base aluminum and will prevent corrosion for long periods of time.

(a) CHROMIC ACID PROCESS. – This method is preferred for marine applications in preventing corrosion due to salt spray. Chromic acid anodizing is generally done in a steel tank containing a chromic acid solution of from five to ten percent concentration. Heating and cooling coils are needed to maintain temperature of the bath at 35°C (95°F) plus or minus 5°F. Gentle agitation with compressed air is advisable and suitable exhaust ducts are required to remove spray and mist. Before the aluminum is put in the anodizing tank, it should be thoroughly cleaned by immersion in hot water (71 to 82°C – 160 to 180°F) that has a suitable cleansing compound for removing grease, oil and dirt. DO NOT USE SOAP. It is then rinsed in clear hot water. After anodizing, the aluminum parts are again rinsed in clear hot water and dried.

The aluminum parts to be anodized are made the anode, and the tank is the cathode with the chromic acid and water the electrolyte. A low DC voltage is used at first and then increased to 40 volts as rapidly as possible without overloading the generator, or burning the clamps or aluminum parts being anodized. Starting at zero volts, an increase of five volts per minute is normal. After reaching 40 volts, the anodizing is continued for 30 minutes. Depending on the amount of work done each day, additions of chromic acid are made to replace drag-out and spray losses, and the bath is finally discarded when it no longer produces satisfactory results.

In anodizing aluminum waveguide, an auxiliary cathode should be placed inside the waveguide and insulated so that the cathode is centered inside the waveguide. Do not use solid insulators as the electrolyte must flow freely through the inside of the guide. An aluminum rod or wire may be used for the inside cathode. Place the waveguide in an upright or inclined position when anodizing as this allows movement of the electrolyte within the waveguide due to thermal agitation. Bubbles will also rise to the surface faster with the waveguide vertical when anodizing. Figure 11-35 is the outline of a tank for anodizing aluminum.

CAUTION

FUMES FROM CHROMIC ACID ANODIZING ARE HARMFUL AND SHOULD BE AVOIDED.

The first indication of harmful effects from chromic acid fumes is bleeding from the nose.

After anodizing and cleaning, the aluminum waveguide interior should be zinc chromated as outlined under brass and stainless steel.

Another method for preventing corrosion is to use a plastic coating for the interior. National Products Co., type 741 or equivalent may be used for this purpose. (SNSN). Use Xylol for thinning to proper consistency. (SNSN G52-X-1400-100.)

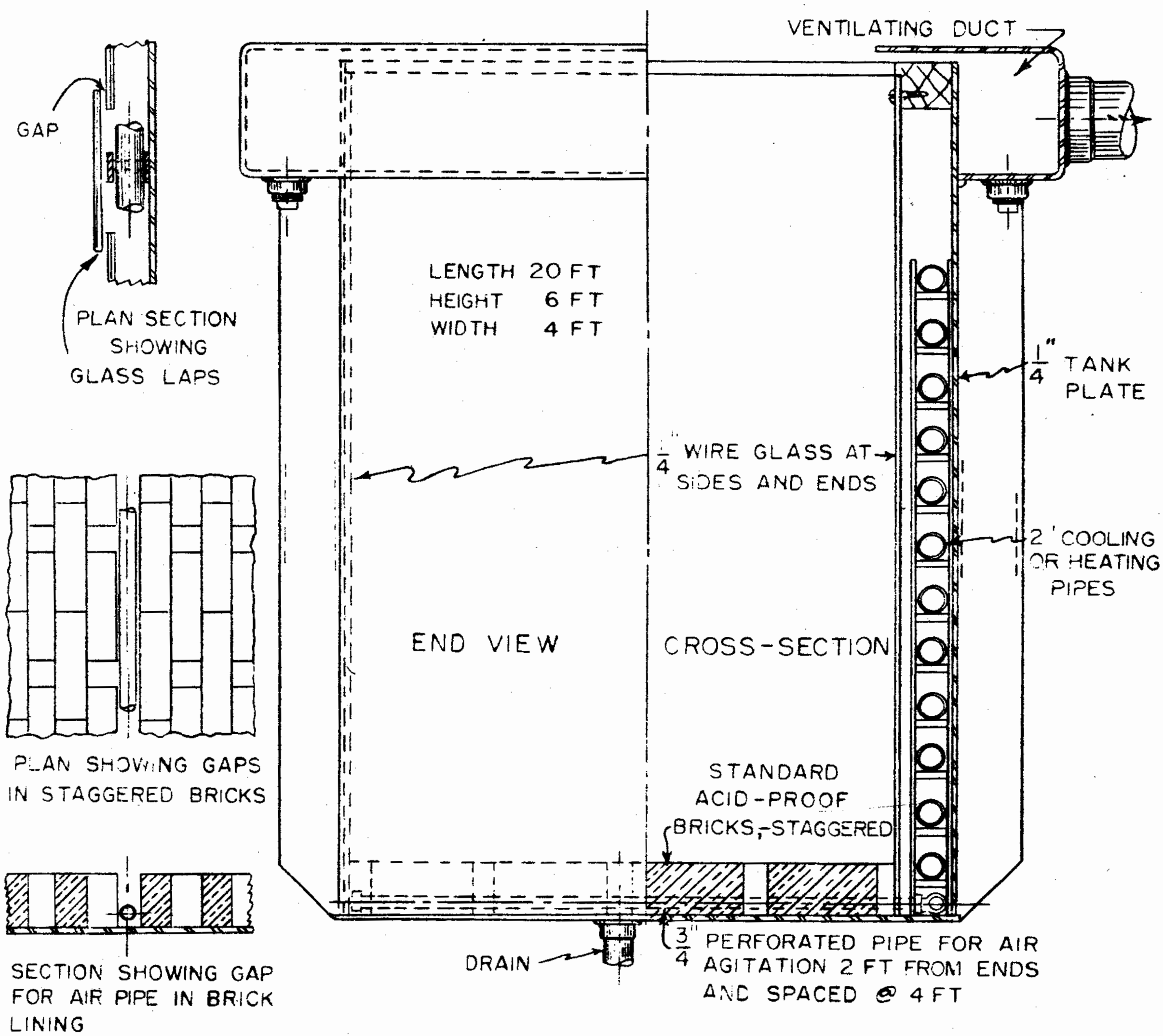


Figure 11-35. Anodizing Tank

After paint or lacquer is dry, remove any traces on the mounting surfaces of the flanges.

b. EXTERIOR.

(1) Apply one coat of air dry zinc chromate primer.

(2) Air dry 12 to 16 hours.

(3) Apply one coat of air dry haze gray enamel.SNSN G52-P-961.

(4) Air dry 12 to 16 hours.

(5) Apply second coat of air dry haze gray enamel.

(6) Air dry parts until completely dry.

15. INSTALLATION PRACTICES.

The installation of the waveguide should begin at the antenna when the transmitter location is such as to require passage through the deck. The waveguide should then be installed down the mast without actually reaching the deck. Then the waveguide run should be started at the transmitter and installed up through the deck to the previous run. The method used when installing waveguides is as follows:

a. Take the first section of waveguide (adjacent to the antenna), remove the pieces of plywood from each end, and inspect the interior of the guide. Make sure that the contact surfaces of the flange are clean and straight. Position the guide beneath the antenna.

b. Place the first hanger on the mast at the proper point to support the waveguide just below the antenna waveguide flange. Mark this position and weld the hanger support to the mast. Details of hanger construction are given in Figure 11-36A and 36B.

NOTE

Since the waveguide must not be supported by the antenna, the first hanger must be as close to the antenna as possible.

c. Starting at a point five feet below the first hanger, install hanger number two. Then install hangers every five feet for the rest of the waveguide run. Do not allow the weight of any part of a vertical run to be supported by an elbow or a transverse run of waveguide. Always make sure that the contact surfaces of flanges are bright and clean. If necessary, use a fine emery paper or crocus cloth to remove any tarnish.

IF A SECTION OF WAVEGUIDE HAS A CHOKE FLANGE ON ONE END, INSTALL THE GUIDE SO THAT THE CHOKE END FACES THE TRANSMITTER.

d. Place a corprene or rubber gasket on the upper waveguide flange, seating it within the recess.

e. Carefully raise the waveguide into contact with the flange above and fasten the flange bolts loosely. Tighten the inside bolts as tight as possible with a wrench, leaving the four corner bolts to be tightened last. This will insure the best electrical contact of the flanges.

f. Continue to install the waveguide in this manner until the deck is reached.

NOTE

All hangers must hold the guide firmly without distorting its cross section. All hangers except the top one should have a lead sheath to allow for normal expansion and contraction.

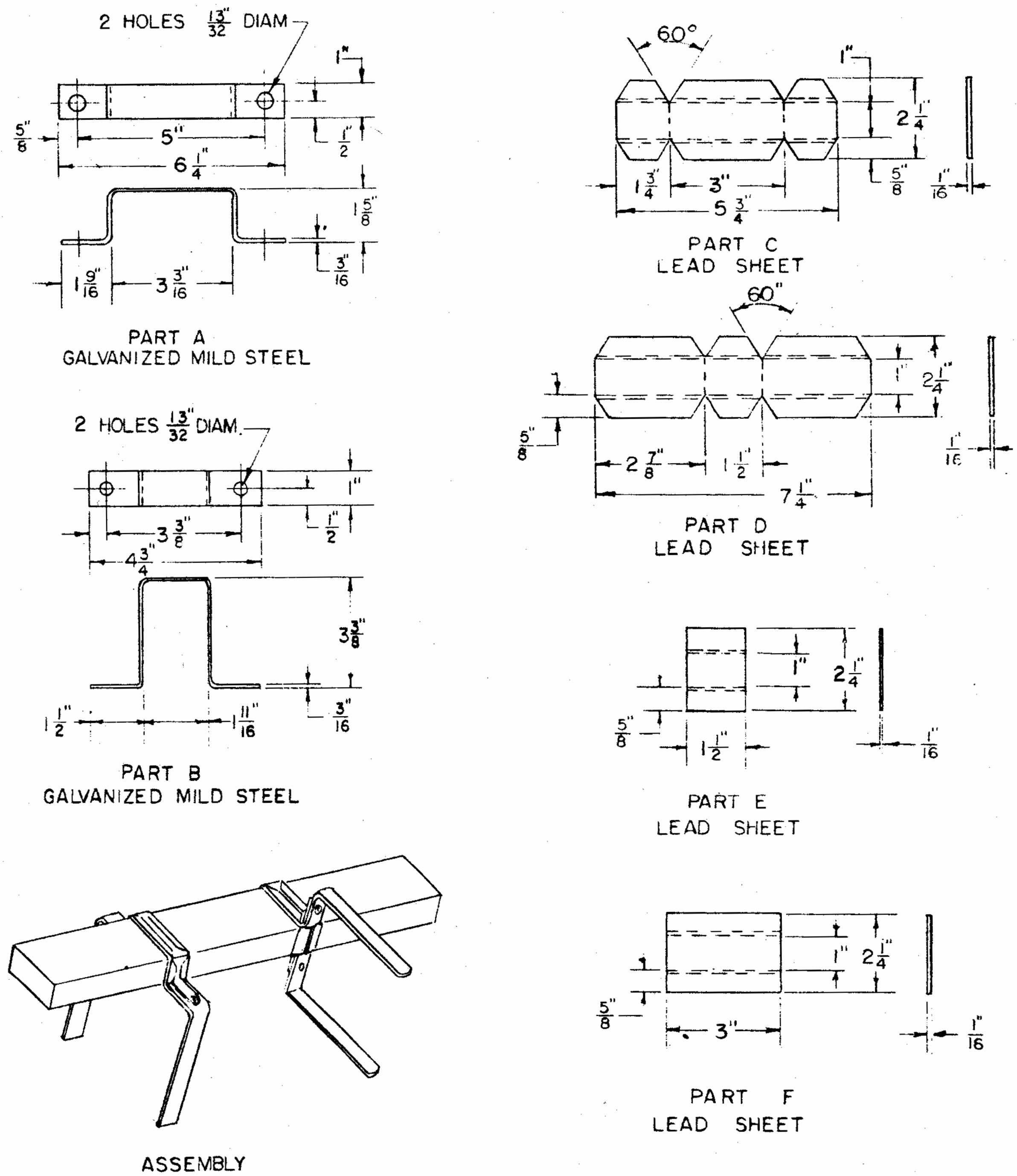


Figure 11-36A, "S" Band Waveguide Hangers (Improved Type)

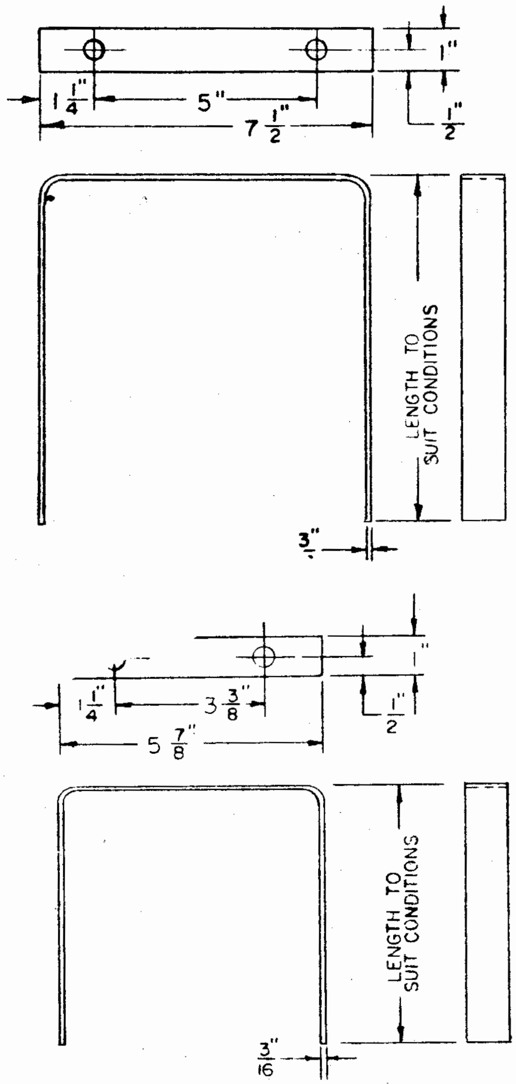


Figure 11-36B. "S" Band Waveguide Hangers (Improved Type)

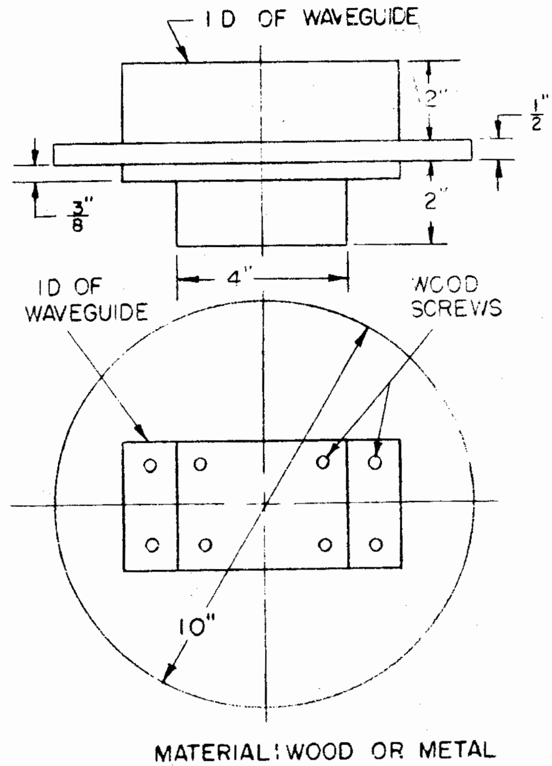


Figure 11-37. Alignment Jig for 6-1/2 x 3-1/4 inch Waveguide

g. Start the waveguide run at the transmitter and continue to the deck. On installations of 6-1/2 inch by 3-1/4 inch waveguide, a jig as shown in Figure 11-37 should be used at the transmitter. This jig will insure proper alignment between the first section (which contains a choke flange) and the transmitter. After the waveguide run has been started, the first section can be removed and the jig taken out.

h. The waveguide can be brought through the deck as shown in Figures 11-3, 11-4, 11-5, 11-6 and 11-7. Cut a hole in the deck considerably larger than the dimensions of the waveguide. The waveguide section above deck should be in perfect alignment with waveguide section below deck. A long straight edge or a long section of waveguide may be used to obtain this alignment.

i. The last section of waveguide can then be bolted together and the deck pad welded to the deck as the last operation.

16. GENERAL NOTES.

Alignment pins as shown in Figure 11-38 will come in handy when making a waveguide run.

A special Allen wrench as shown in Figure 11-39 is useful for tightening flanges.

AFTER THE RADAR IS OPERATING, INSPECT EVERY FLANGE WITH A NEON BULB(SNSN G17-L-6806-120). IF THE NEON BULB CAN BE LIGHTED ON ANY JOINT, REMAKE THE JOINT.

ALWAYS PROTECT EXPOSED PARTS OF A WAVEGUIDE RUN BY A SHIELD. THE SHIELD SHOULD BE MADE REMOVABLE TO AID IN FUTURE MAINTENANCE.

Always use the shortest possible waveguide run to the antenna with the least number of bends and twists. A gradual bend or twist is better than a series of elbows. Never make more than 10 changes of direction in any waveguide run. This number applies to gradual and abrupt changes. Do not use flexible waveguide when it is possible to use rigid guide.

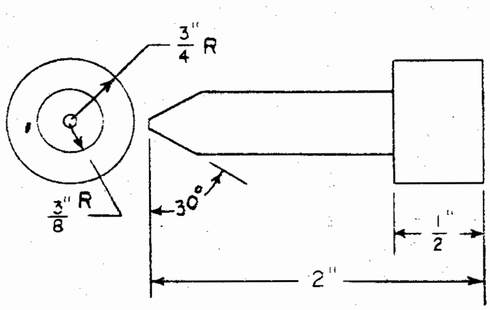


Figure 11-38. Alignment Pin for Couplings (4 Required)

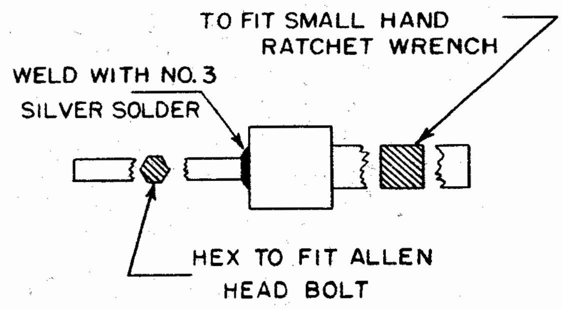


Figure 11-39. Special Allen Wrench To Tighten Couplings

Maximum lengths of waveguide run should be 100 feet on 6-1/2 inches by 3-1/4 inches and 3 by 1-1/2 inches. Maximum length runs on smaller sizes of waveguide should be 50 feet.

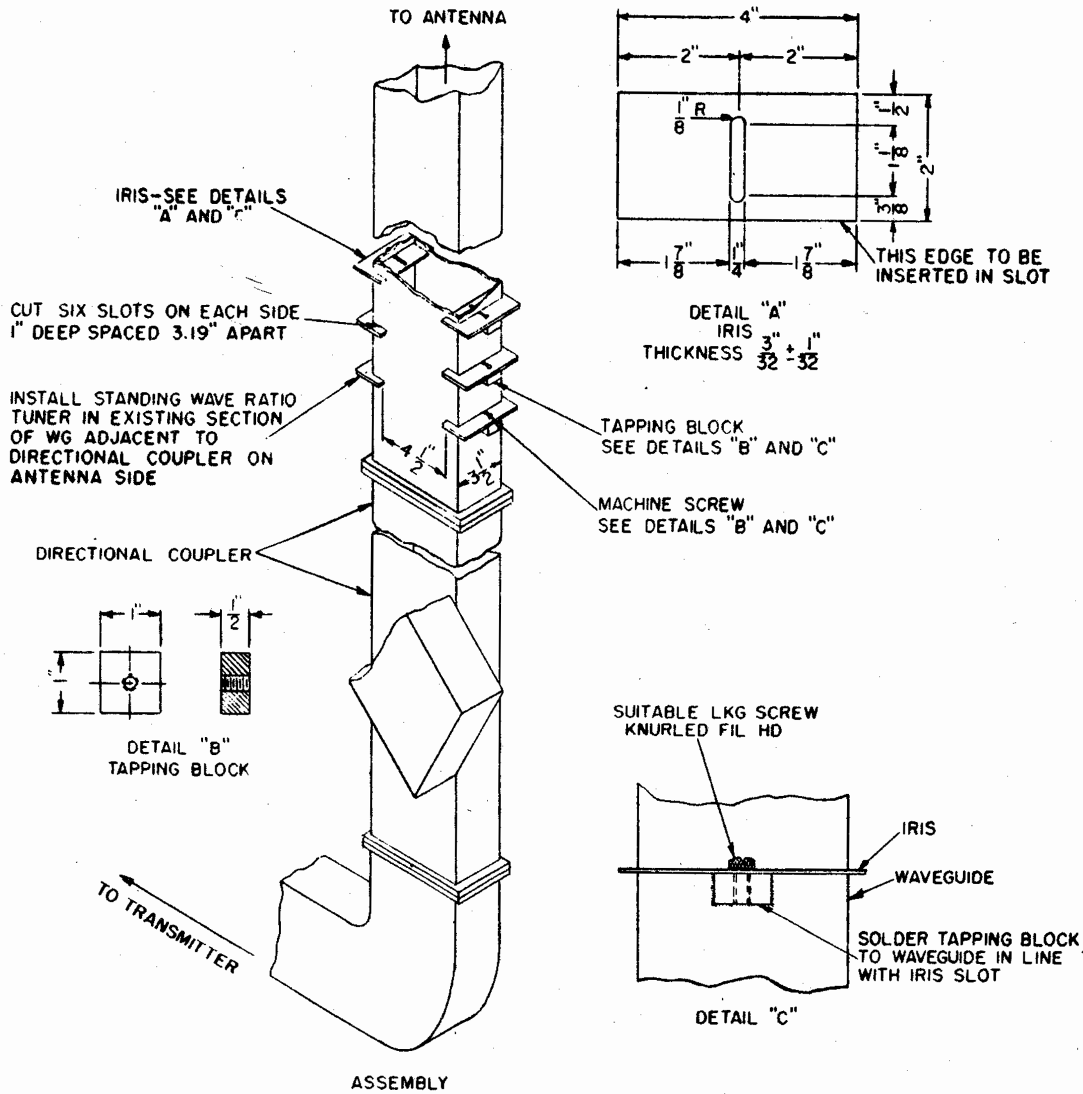
On some installations of 6-1/2 by 3-1/4 inch waveguide, it may be necessary to use a standing wave ratio tuner. Details of this tuner assembly are given in Figure 11-40. THIS TUNER IS ONLY NECESSARY IF THE STANDING WAVE RATIO IS GREATER THAN 1-1/2 TO 1.

17. SUBMARINE PRACTICES.

Installation of radar equipments on submarines require some special practices. One of the reasons for this is the space limitations on most subs.

On waveguide installations, it is sometimes necessary to make sharper bends than is possible with bending equipment. Figure 11-41, shows a way of doing this by joining a manufactured elbow to a straight section of guide. Another method is shown in Figure 11-42. This method uses a large, steel plate jig and the waveguide shape is made as follows:

a. Take a flat sheet of brass (0.080 inches thick) and cut two pieces to the exact



NOTE

CHECK STANDING WAVE RATIO OF TRANSMISSION LINE (WAVEGUIDE) IN USUAL MANNER. TO COMPENSATE FOR STANDING WAVE RATIO GREATER THAN 1.5 TO 1 (MAX ALLOWED) THE STANDING WAVE RATIO SHOULD BE ADJUSTED AS FOLLOWS:–

WITH ALL IRISES AS FAR OUT AS POSSIBLE, ADJUST EACH IRIS (PUSH IN) A SMALL EQUAL DISTANCE. THE IRIS SHOULD BE HELD IN THIS POSITION BY MEANS OF A LOCKING SCREW. AFTER EACH IRIS IS ADJUSTED, THE STANDING WAVE RATIO SHOULD BE CHECKED. THIS PROCESS SHOULD BE REPEATED UNTIL THE STANDING WAVE RATIO IS NOT GREATER THAN 1.5 TO 1. ATTEMPT SHOULD BE MADE TO REDUCE THE STANDING WAVE RATIO AS FAR BELOW 1.5 TO 1 AS POSSIBLE.

BUSHIPS DWG RE10F627C

Figure 11-40. Standing Wave Ratio Tuner Assembly and Details

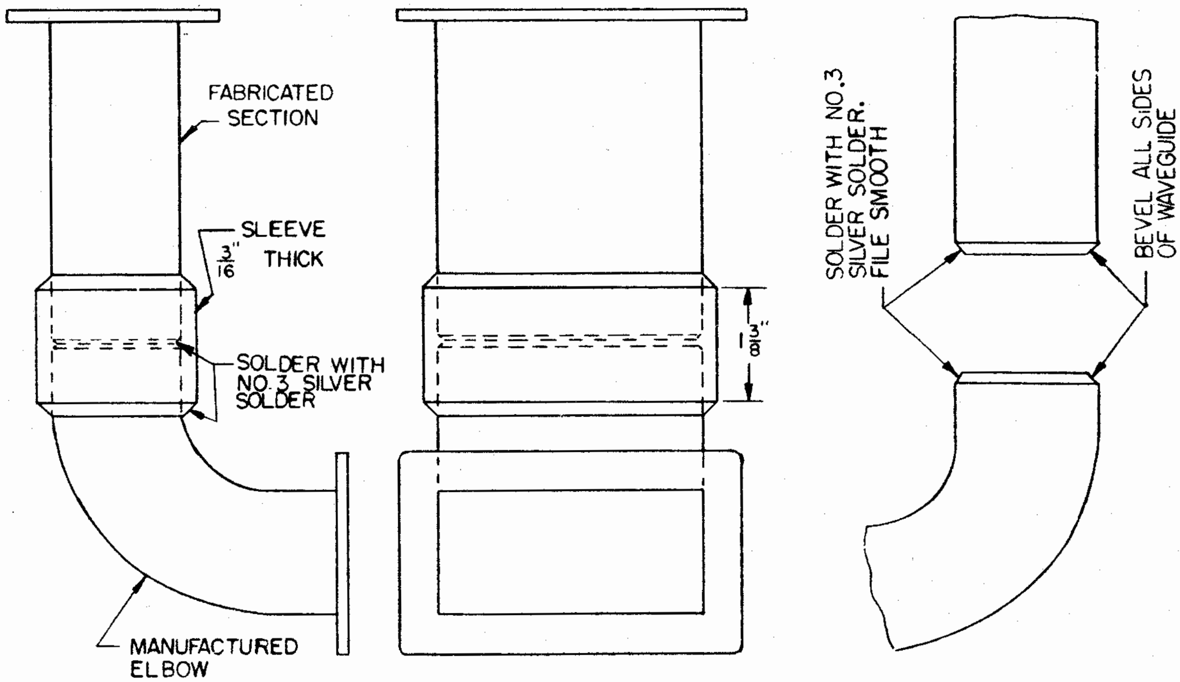


Figure 11-41. Method of Joining Manufactured Elbow to Fabricated Section on 3 x 1-1/2 inch Waveguide

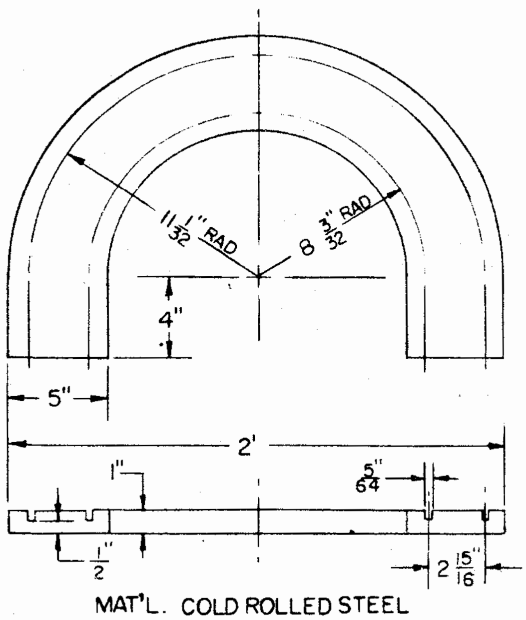


Figure 11-42. Sharp Radius U Bend Jig for SV-1 Waveguide

size of the jig. These U shape pieces should be 2-27/32 inches wide.

b. Cut two pieces 1-1/2 inches wide and long enough to fit around the U shape. Lay these two pieces in the jig and fit the first piece inside and flush with the two side pieces.

c. Silver solder these three pieces together on their entire length. Use care not to let the solder run down on the inside surface.

d. Remove the piece from the jig and place upside down on a metal table. Remove any silver solder that may be on the inside.

e. Place the other U shape piece inside and flush with the outside pieces.

f. Silver solder this piece on the entire length.

The result is a U shape waveguide with the exact dimensions needed for SV radar installations.

A spacer jig as shown in Figure 11-43 is required for making installations of SU radar. This jig is needed when aligning the mast section of waveguide with the hull section.

Figure 11-44 shows a jig for measuring the point to cut the waveguide on the SS mast.

Special sections of waveguides that are mounted outside the sub are sometimes required. Figure 11-45 shows a section as used for installation of SV-2. Figures 11-46, 11-47 and 11-48 show the parts that make up the jig and Figure 11-49 shows the method of using these parts to make the section of waveguide.

18. TOOLS AND EQUIPMENT.

The following tools and equipment are required for doing waveguide fabrication:

- Bending Machine
- Twisting Machine
- Power Grinder
- Acetylene Welding Equipment
- Two Wheel Hand Roller
- Power Hacksaw
- Square
- Bevel Square
- Hand Jig Saw
- Power Jig Saw
- Monkey Wrench, 14 Inch
- Hammers:
  - Flat Spanker
  - Planishing and Bumper
  - Half Round
- Wooden Mallet, 2 Inch
- Set of Files
- Goggles for Brazing
- Goggles for Welding
- Ratchet Wrenches
- Set of Screwdrivers
- Set of Straight Wrenches
- Dividers
- Scribers
- Fire Brick
- Asbestos
- Pickling Acids
- Paint (Zinc Chromate)
- Thinner
- Large Vise
- Large Wooden Bench
- Flat Steel Plate (2 ft x 2 ft x 1 in.)
- Small Air Grinder
- Lead and Mild Steel for Hangers
- Silver Solder No. 3 & 4, 1/16 in. size
- Flux
- Soldering Iron
- Soft Solder
- Brass Flat Stock, 1/16 and 3/16 in.

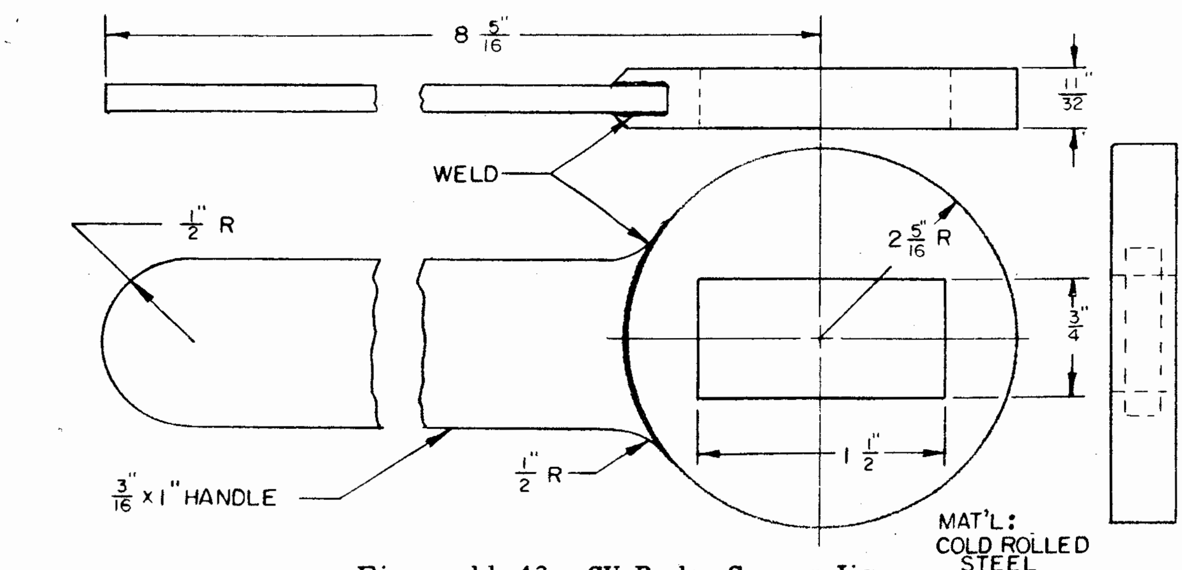


Figure 11-43. SU Radar Spacer Jig

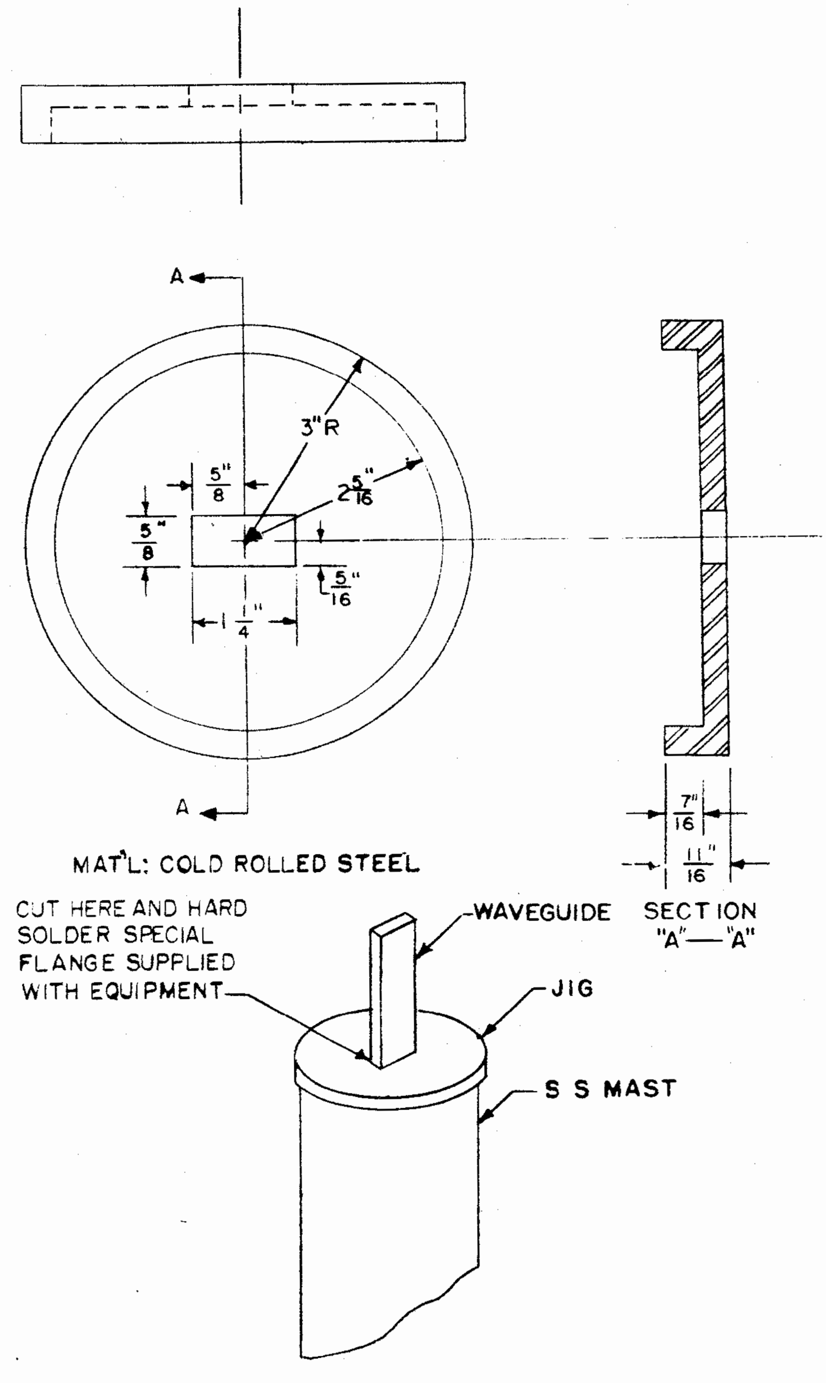


Figure 11-44. Jig for Measuring Waveguide on SS Mast

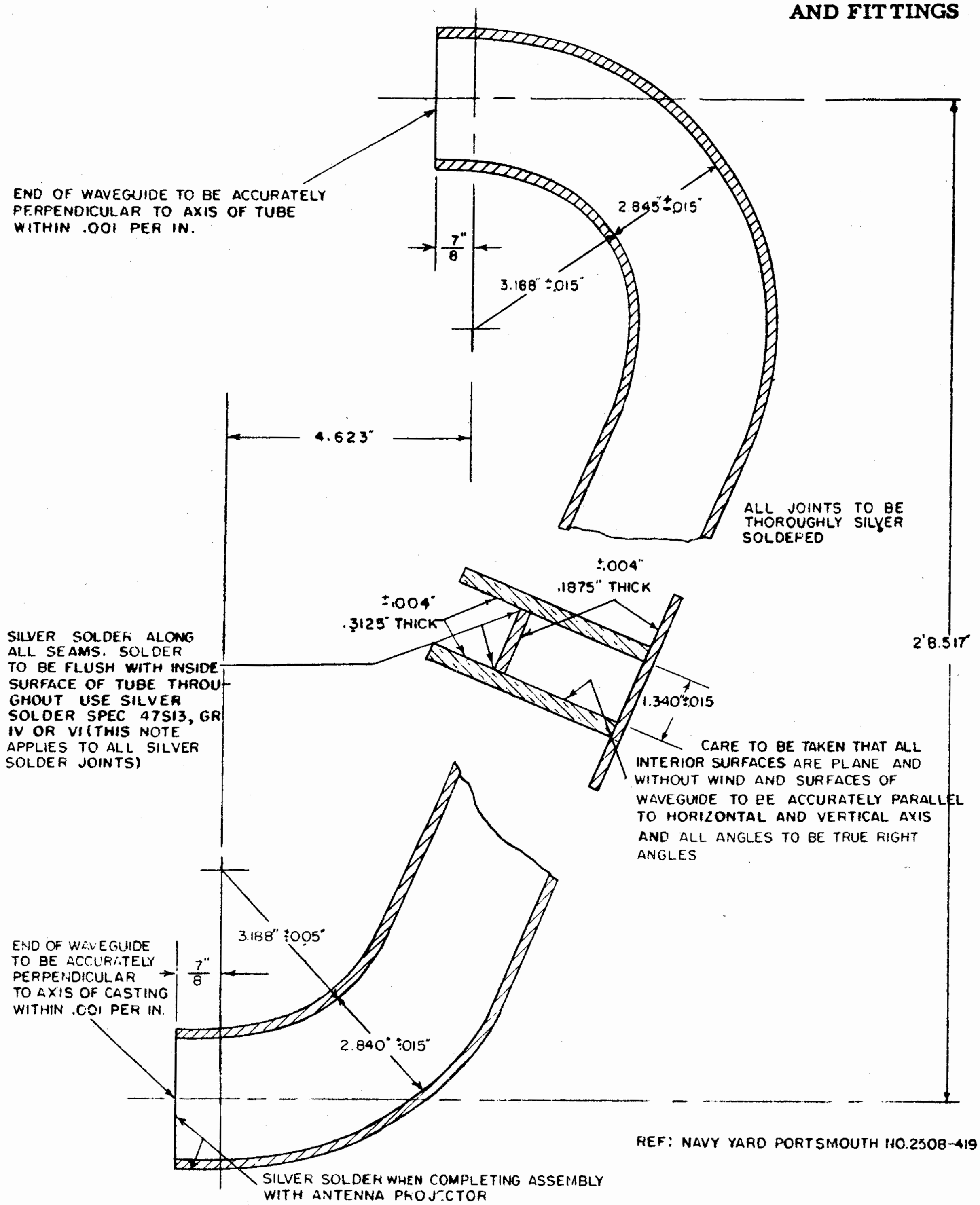


Figure 11-45. SV-2 Antenna Waveguide

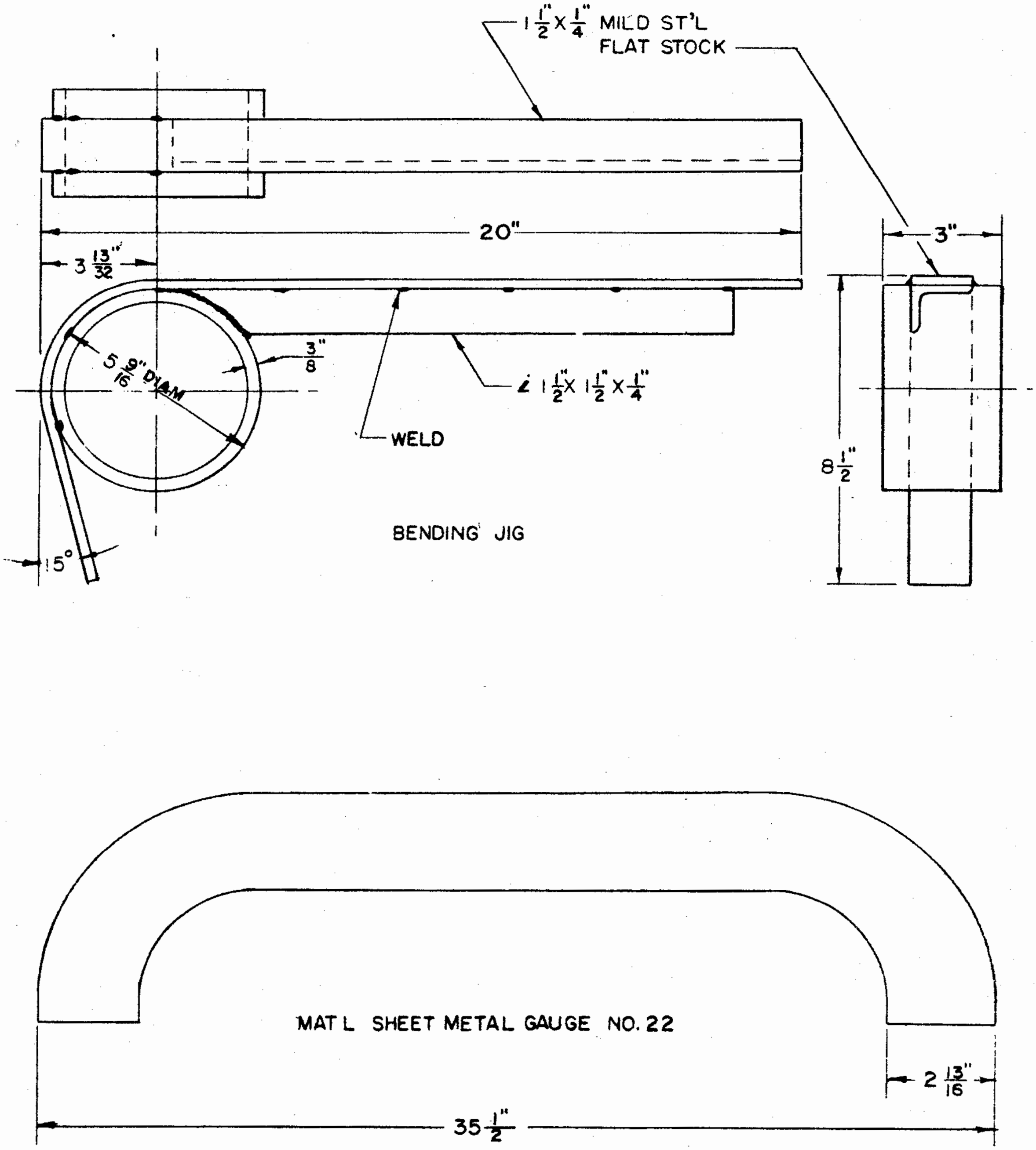


Figure 11-46. Bending Jig and Template

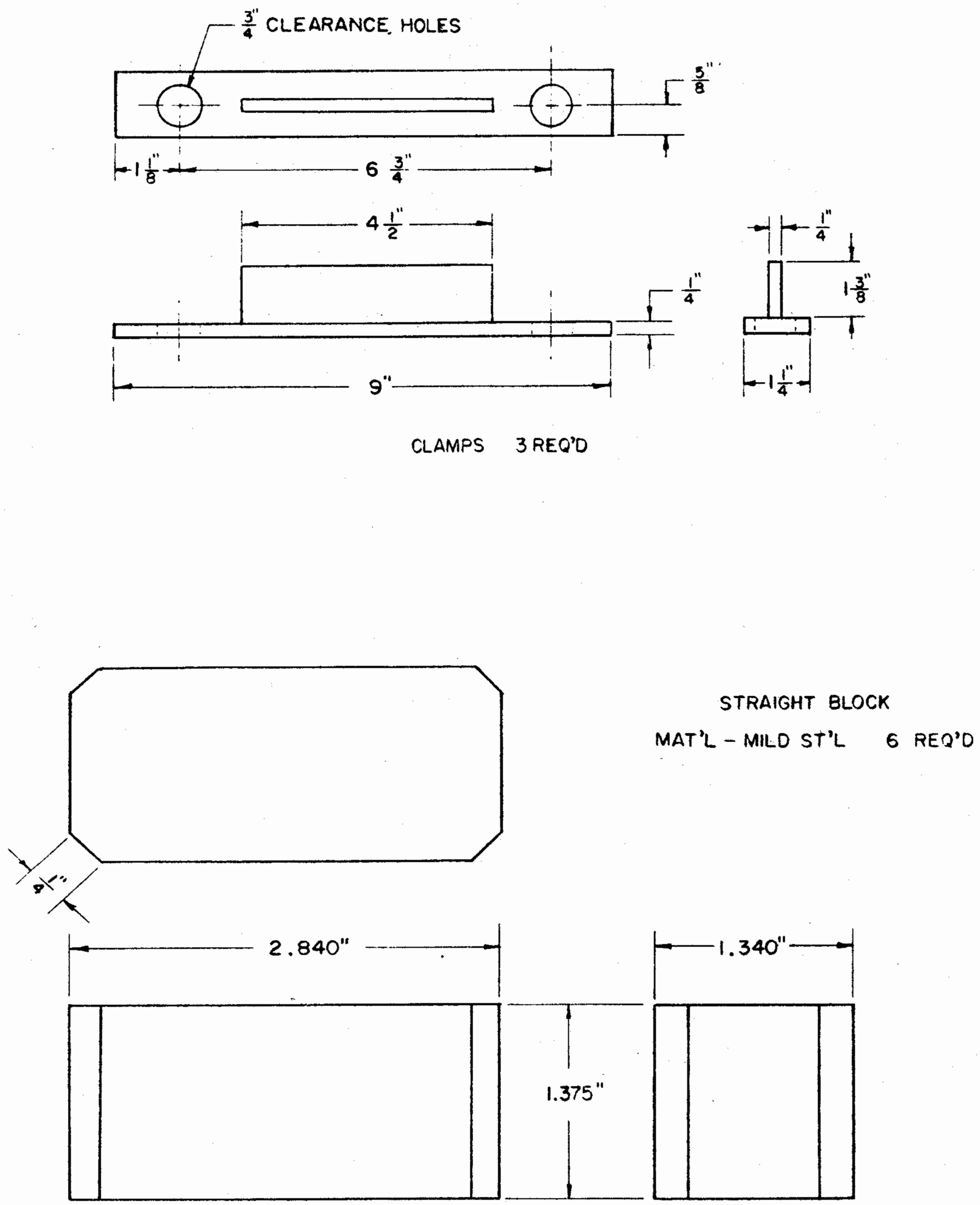


Figure 11-47. Clamps and Straight Block

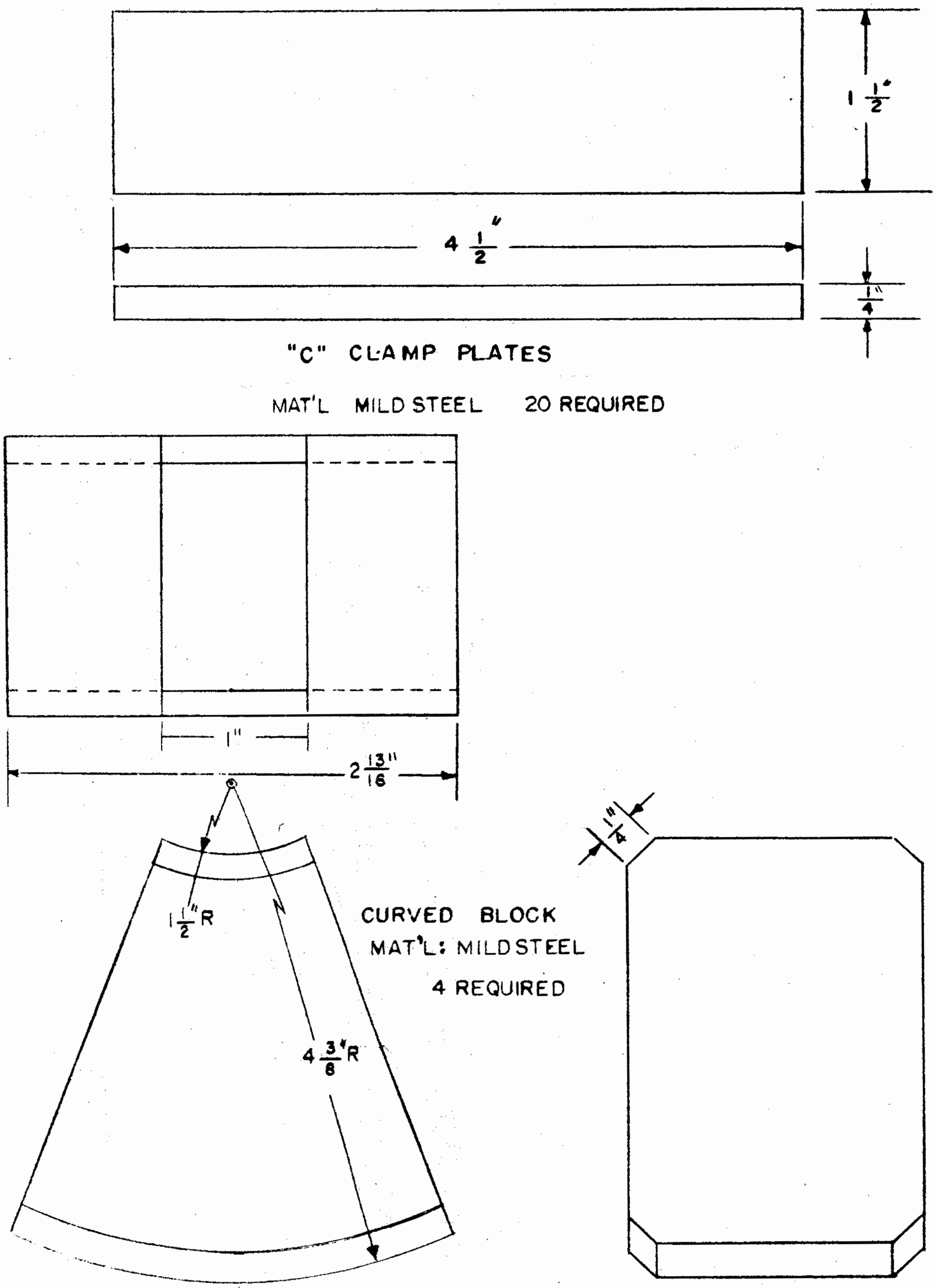


Figure 11-48. "C" Clamp Plates and Curved Block

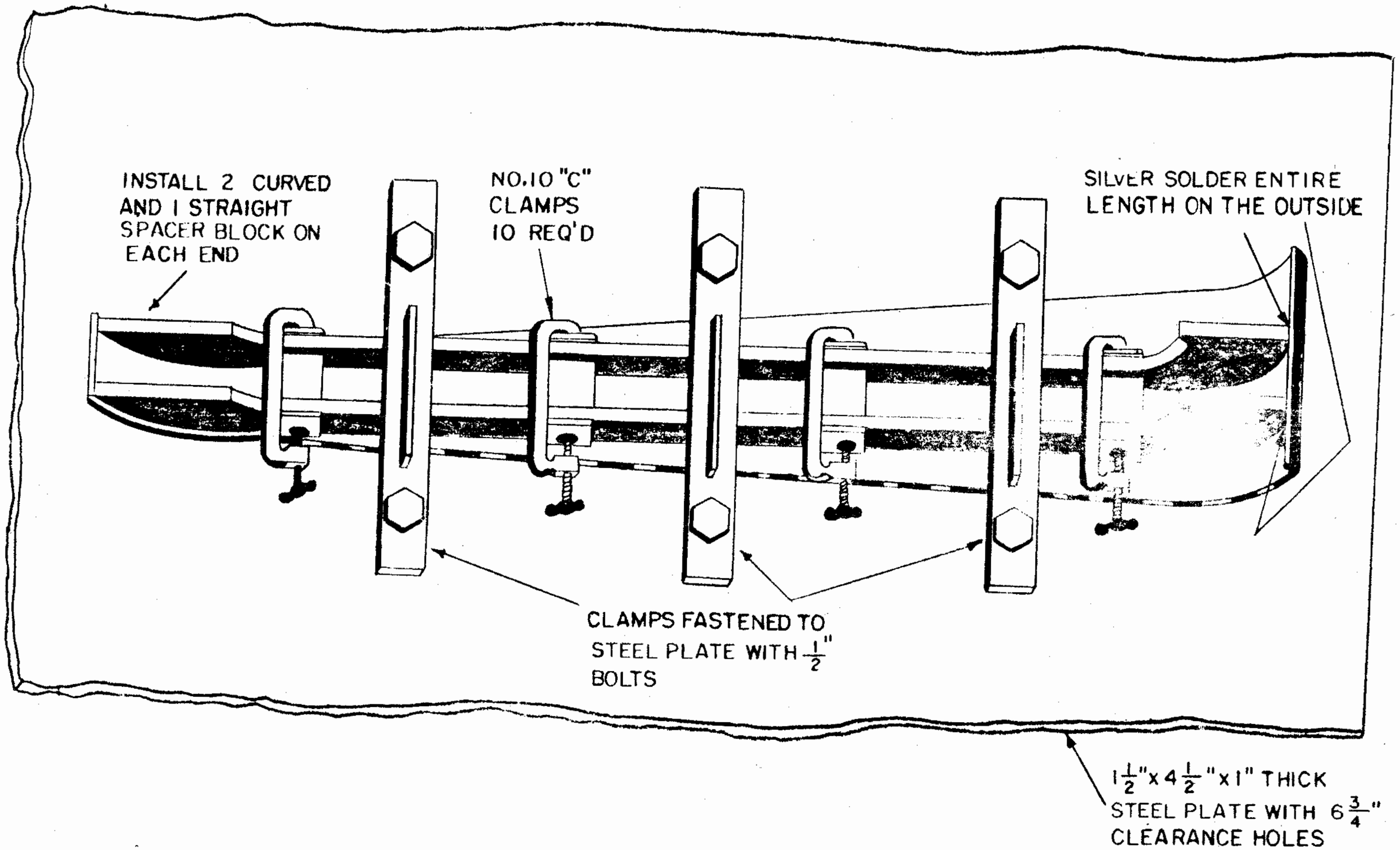
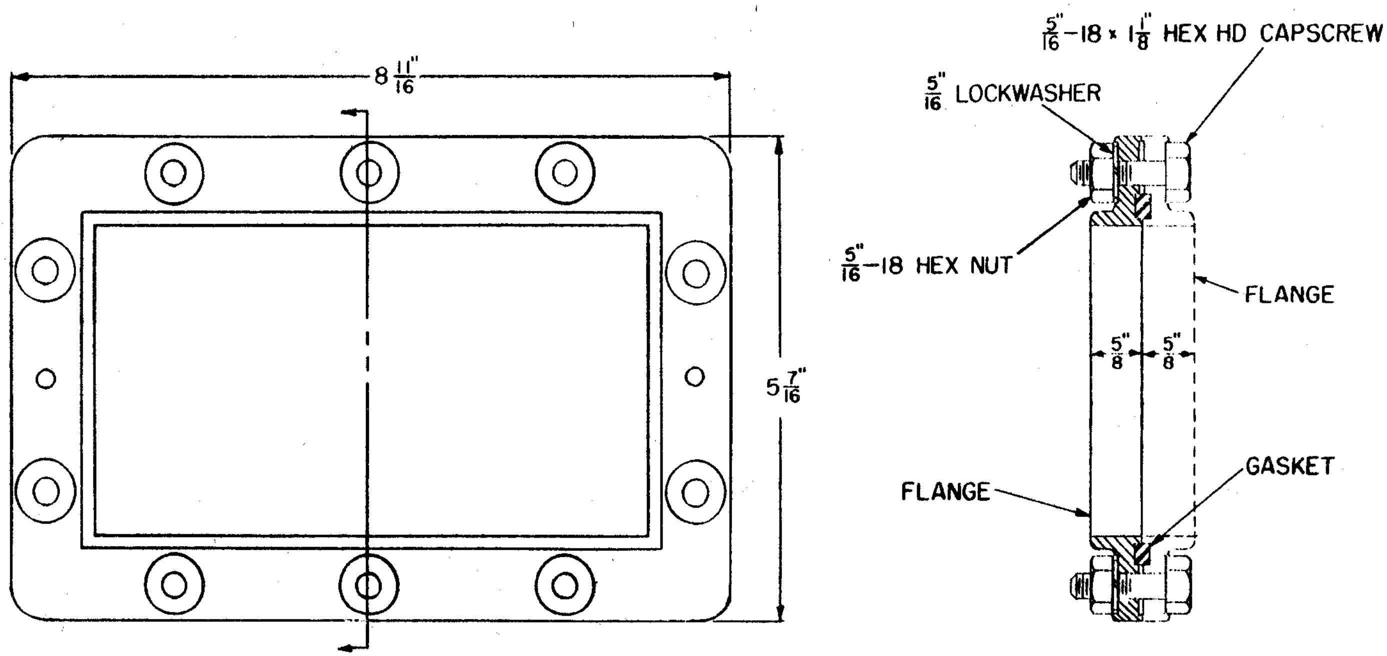


Figure 11-49. Jig Assembly for Soldering SV-2 Waveguide

TYPE	MATERIAL	NOMINAL OUTSIDE DIMENSIONS INCHES		WALL THICKNESS INCHES	WEIGHT (lbs/ft)	REFERENCE TO FLANGE FIG. NO.
RG-69/U	Brass	6.660	3.410	0.080	5.97	11-50
RG-103/U	Aluminum	6.660	3.410	0.080	1.91	11-50
RG-132/U	Brass	6.58	3.330	.040	2.93	11-50
RG-127/U or 14ACM	Stainless Steel	6.58	3.330	.040	2.70	11-50
RG-104/U	Brass	4.460	2.310	.080	4.02	11-51
RG-105/U	Aluminum	4.460	2.310	.080	1.29	11-51
RG-112/U	Brass	3.560	1.860	.080	3.23	11-52
RG-113/U	Aluminum	3.560	1.860	.080	1.03	11-52
RG-48/U	Brass	3.000	1.500	.080	2.67	11-53
RG-75/U	Aluminum	3.000	1.500	.080	.85	11-53
RG-109/U	Brass	3.00	1.164	.080	2.47	11-60
RG-49/U	Brass	2.000	1.000	.064	1.41	11-54
RG-95/U	Aluminum	2.000	1.000	.064	.45	11-54
RG-50/U	Brass	1.500	.750	.064	1.07	11.55
RG-106/U	Aluminum	1.500	.750	.064	.34	11.55
RG-110/U	Brass	1.5	0.615	.064	1.00	11-61
RG-51/U	Brass	1.250	.625	.064	.88	11-56
RG-68/U	Aluminum	1.250	.625	.064	.28	11-56
RG-52/U	Brass	1.000	.500	.050	.56	11-57
RG-67/U	Aluminum	1.000	.500	.050	.18	11-57
RG-91/U	Brass	.702	.391	.040	.32	11-58
RG-107/U	Aluminum	.702	.391	.040	.40	11-58
RG-53/U	Brass	.500	.250	.040	.22	11-59
RG-66/U	Silver	.500	.250	.040	.27	11-59
RG-96/U	Silver	.360	.220	.040	.21	11-59
RG-97/U	Silver	.304	.192	.040	.18	11-59
RG-98/U	Silver	.228	.154	.040	.14	11-59
RG-99/U	Silver	.202	.141	.040	.12	11-59

Table 11-1. Rigid Waveguide



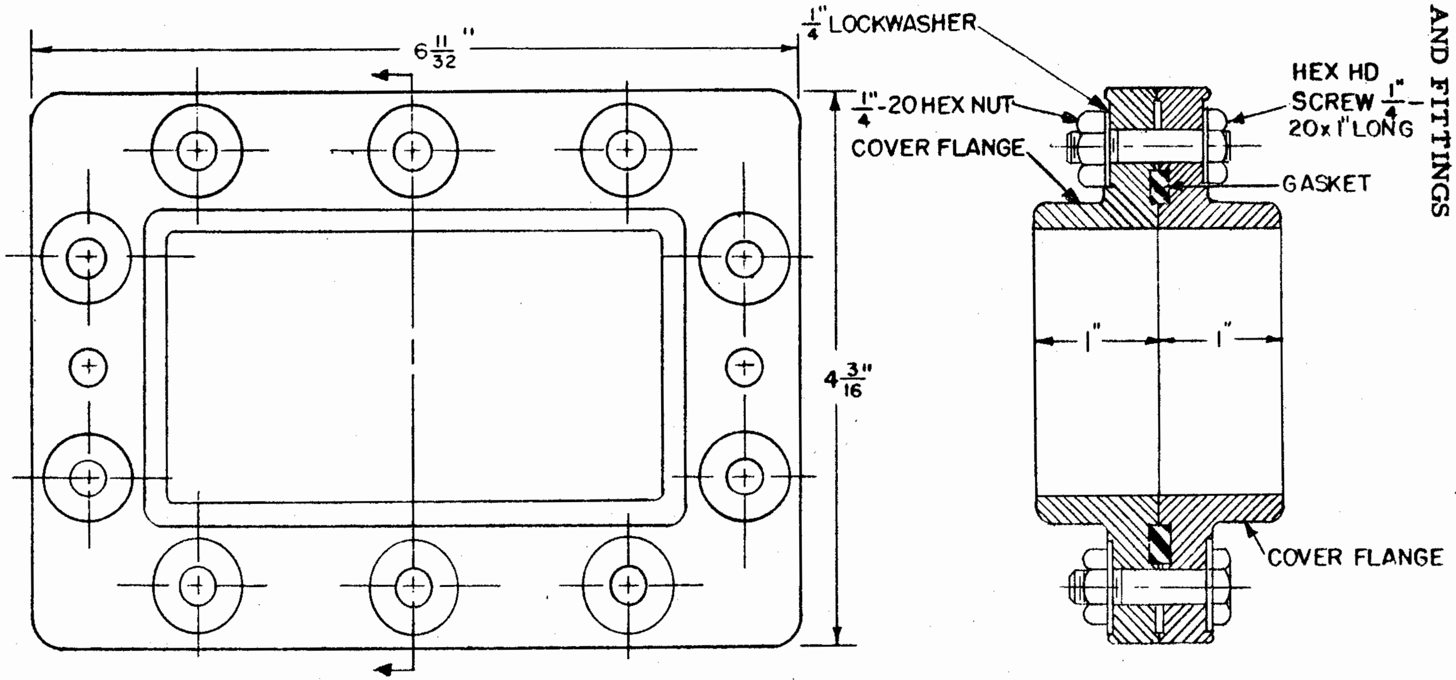
A. PREFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-417A/U	COVER	COPPER ALLOY	UG-417A/U
UG-418A/U	COVER	ALUMINUM	UG-418A/U
B. ALTERNATE FLANGES			
UG-417/U	COVER	COPPER ALLOY	UG-417/U
UG-418/U	COVER	ALUMINUM	UG-418/U
C. SUBSTITUTE FLANGES			
UG-319/U	COVER	COPPER ALLOY	UG-320/U
UG-320/U	COVER	COPPER ALLOY	UG-319/U
UG-322/U	CHOKE	COPPER ALLOY	UG-323/U
UG-323/U	COVER	COPPER ALLOY	UG-322/U
D. GASKET			
MX-1231/U	SPRING-FINGER METAL		UG-417A/U

HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
NUT	STAINLESS STEEL
CAPSCREW	STAINLESS STEEL

DRAWING REFERENCE:

A. AS-2006
B. RE49F496
C. WESTINGHOUSE T-7715587 & T-7715588; RE49F464

Figure 11-50. Flanges used with Waveguides RG-69/U, -103/U, -127/U, RG-132/U or NT-14ACM

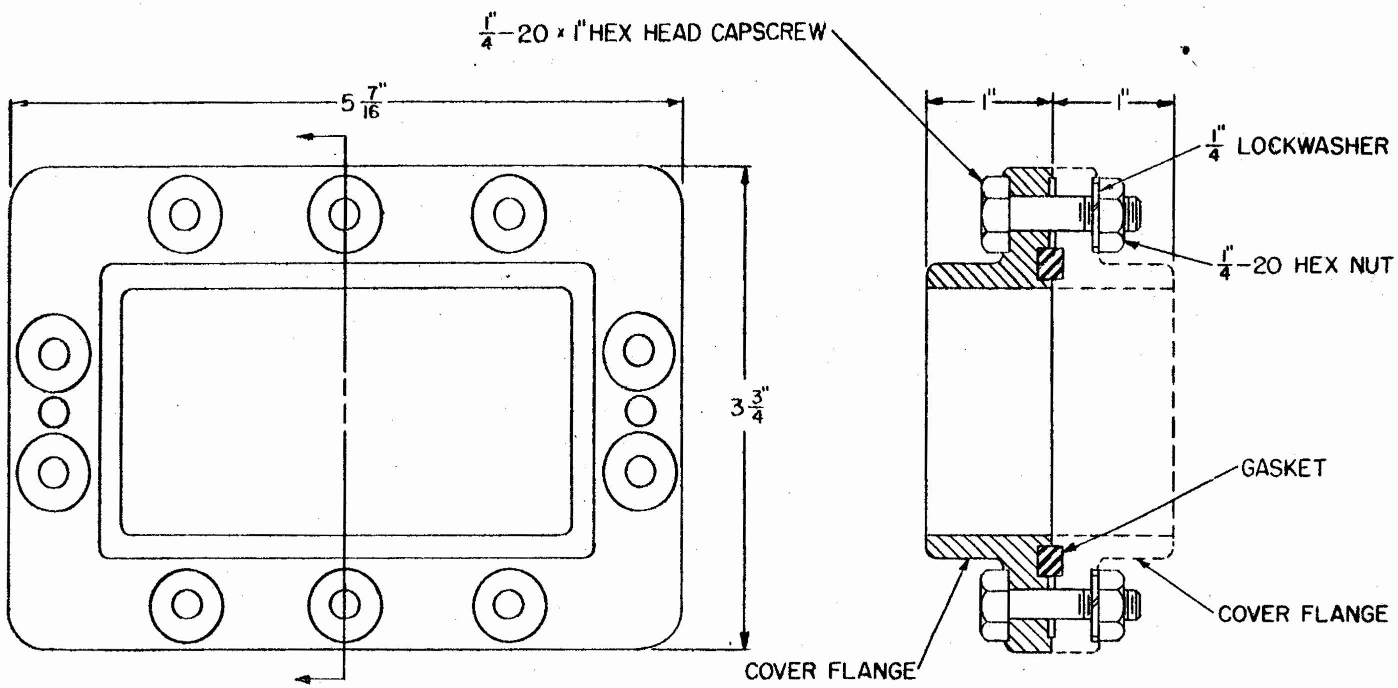


A. PREFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-435A/U	COVER	COPPER ALLOY	UG-435A/U
UG-437A/U	COVER	ALUMINUM	UG-437A/U
B. ALTERNATE FLANGES			
UG-435/U	COVER	COPPER ALLOY	UG-435/U
UG-437/U	COVER	ALUMINUM	UG-437/U
C. GASKET			
MX-1232/U	SPRING-FINGER METAL		UG-435/U

DRAWING REFERENCE:
A. AS-2007
B. RE-49F503

HARDWARE	
PART	MATERIAL
WASHER	S' STEEL
NUT	S' STEEL
CAPSCREW	S' STEEL
GASKET	SYN RUBBER

Figure 11-51. Flanges used with Waveguides RG-104/U and RG-105/U

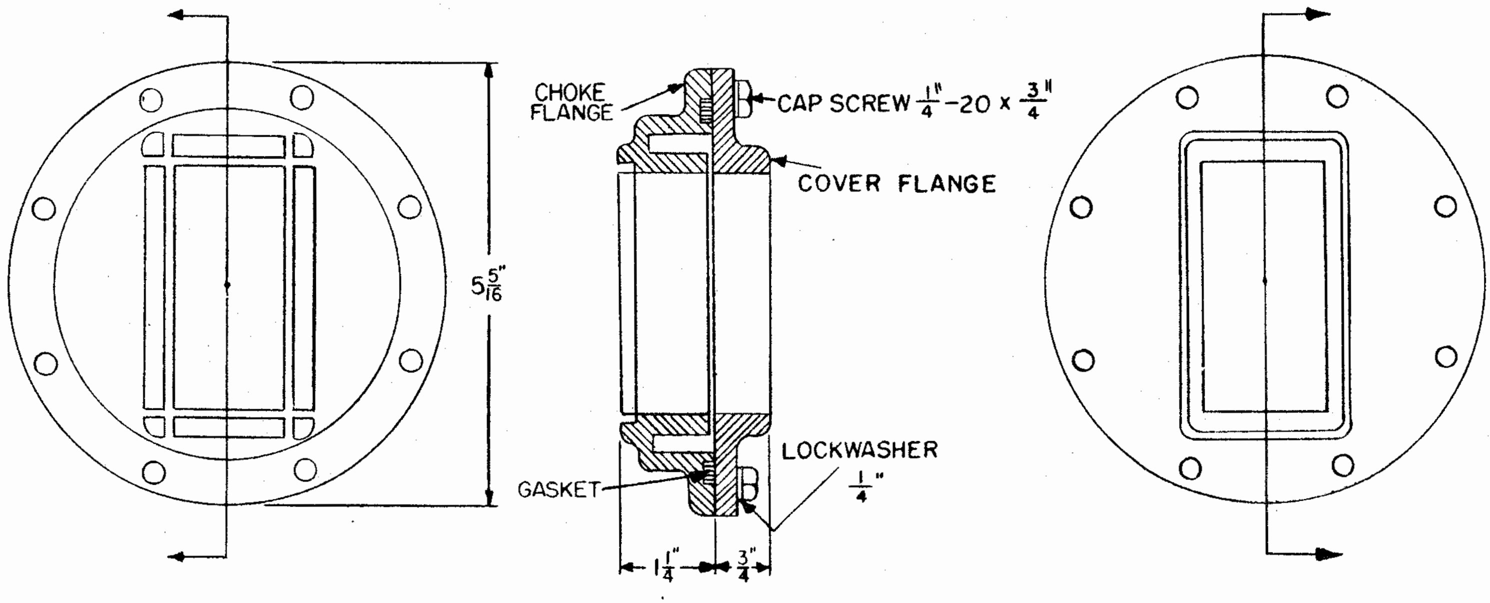


A. PREFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-553/U	COVER	COPPER ALLOY	UG-553/U
UG-554/U	COVER	ALUMINUM	UG-554/U
B. GASKET			
MX-1230/U	SPRING-FINGER METAL		UG-553/U

DRAWING REFERENCE
A. AS-2005

HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
NUT	STAINLESS STEEL
CAPSCREW	STAINLESS STEEL
GASKET	SYNTHETIC RUBBER

Figure 11-52. Flanges used with Waveguides RG-112/U and RG-113/U



FLANGE	TYPE	MATERIAL	MATES WITH
A. PREFERRED FLANGES			
UG-53/U	COVER	COPPER ALLOY	UG-54A/U
UG-54A/U	CHOKE	COPPER ALLOY	UG-53/U
UG-584/U	COVER	ALUMINUM	UG-585/U
UG-565/U	CHOKE	ALUMINUM	UG-584/U
B. ALTERNATE FLANGES			
UG-66/U	PLAIN	COPPER ALLOY	UG-66/U
UG-200/U	CHOKE	COPPER ALLOY	UG-214/U
UG-214/U	COVER	COPPER ALLOY	UG-200/U
UG-438/U	CHOKE	ALUMINUM	UG-439/U
UG-439/U	COVER	ALUMINUM	UG-438/U
C. SUBSTITUTE FLANGES			
UG-54/U	CHOKE	COPPER ALLOY	UG-53/U
UG-55/U	COVER(EXP)	COPPER ALLOY	UG-56/U
UG-56/U	CHOKE(EXP)	COPPER ALLOY	UG-55/U
UG-65/U	PLAIN	COPPER ALLOY	UG-65/U
UG-164/U	COVER	COPPER ALLOY	UG-165/U
UG-165/U	CHOKE	COPPER ALLOY	UG-164/U
D. GASKET			
MX-1109/U	SPRING —	FINGER METAL	UG-53/U

HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
CAPSCREW	STAINLESS STEEL
GASKET	SYNTHETIC RUBBER

DRAWING REFERENCE:

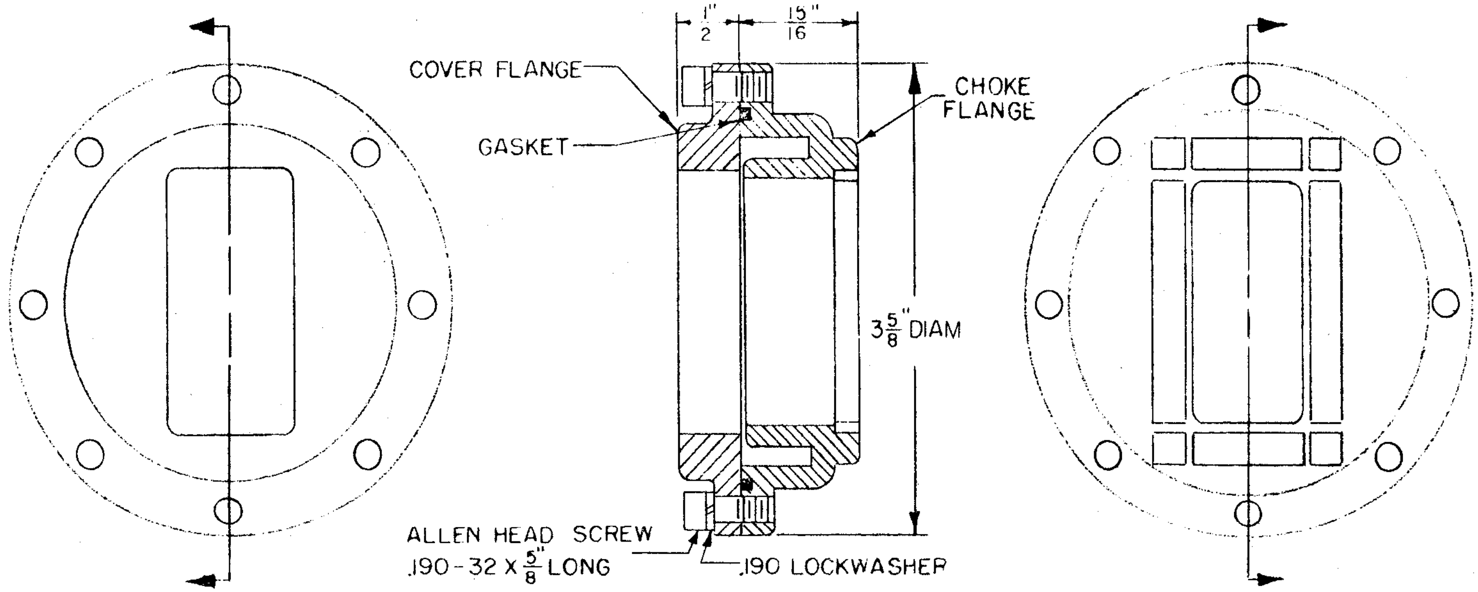
A. AS-2000

B. RE 49F213
RE 49F334

C. RE 49F204
RE 49Z 205
RE 49F213

D. RE 49F588

Figure 11-53. Flanges used with Waveguides RG-48/U and RG-75/U

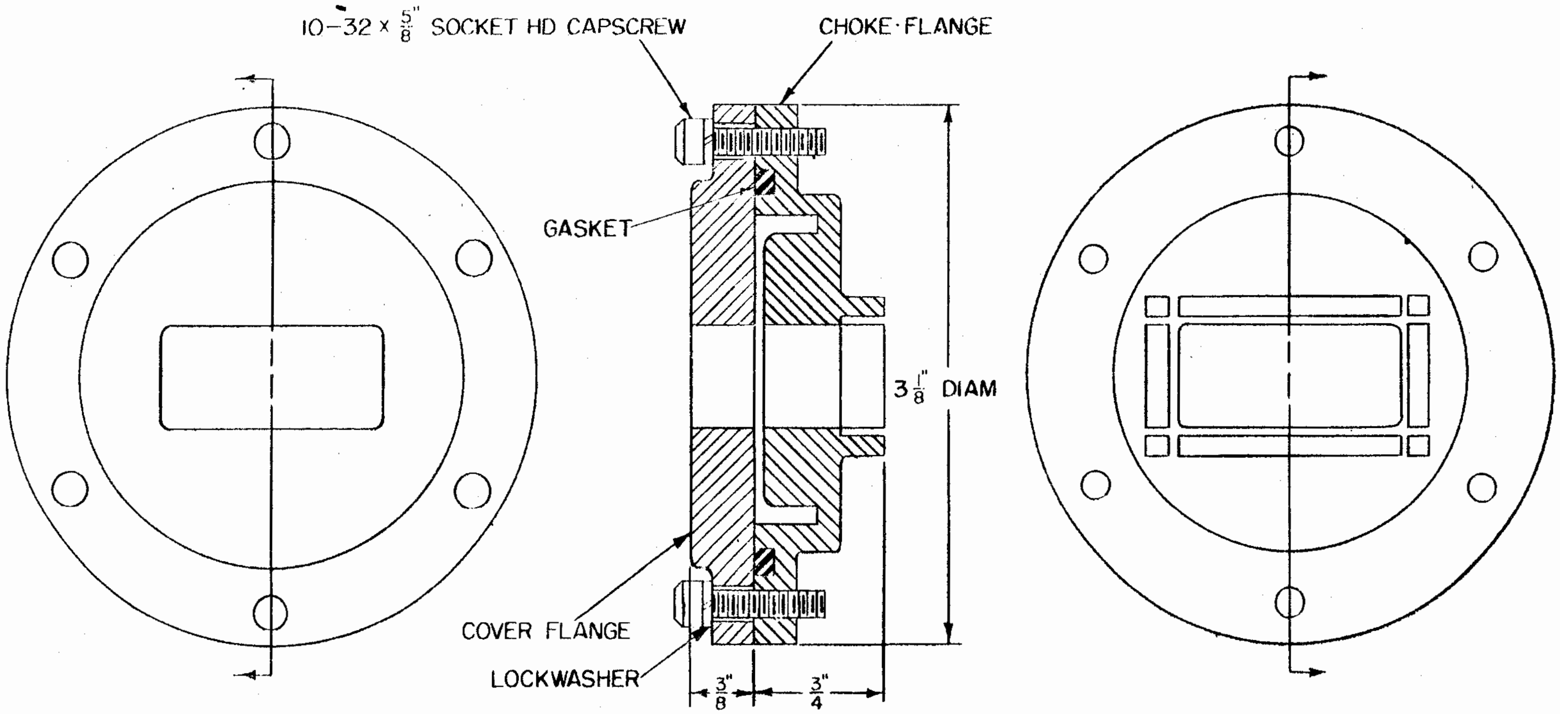


A. PREFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-148 B/U	CHOKE	COPPER ALLOY	UG-149 A/U
UG-149A/U	COVER	COPPER ALLOY	UG-148 B/U
UG-406A/U	CHOKE	ALUMINUM	UG-407/U
UG-407/U	COVER	ALUMINUM	UG-406A/U
B. ALTERNATE FLANGES			
UG-148A/U	CHOKE	COPPER ALLOY	UG-149 A/U
UG-406/U	CHOKE	ALUMINUM	UG-409/U
C GASKET			
MX-1110/U	SPRING — FINGER METAL		UG-149A/U

HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
ALLEN HEAD SCREW	STAINLESS STEEL
GASKET	SYNTHETIC RUBBER

DRAWING REFERENCE:
A. AS-2001
B. RE 49F279, RE49F492

Figure 11-54. Flanges used with Waveguides RG-49/U and RG-95/U



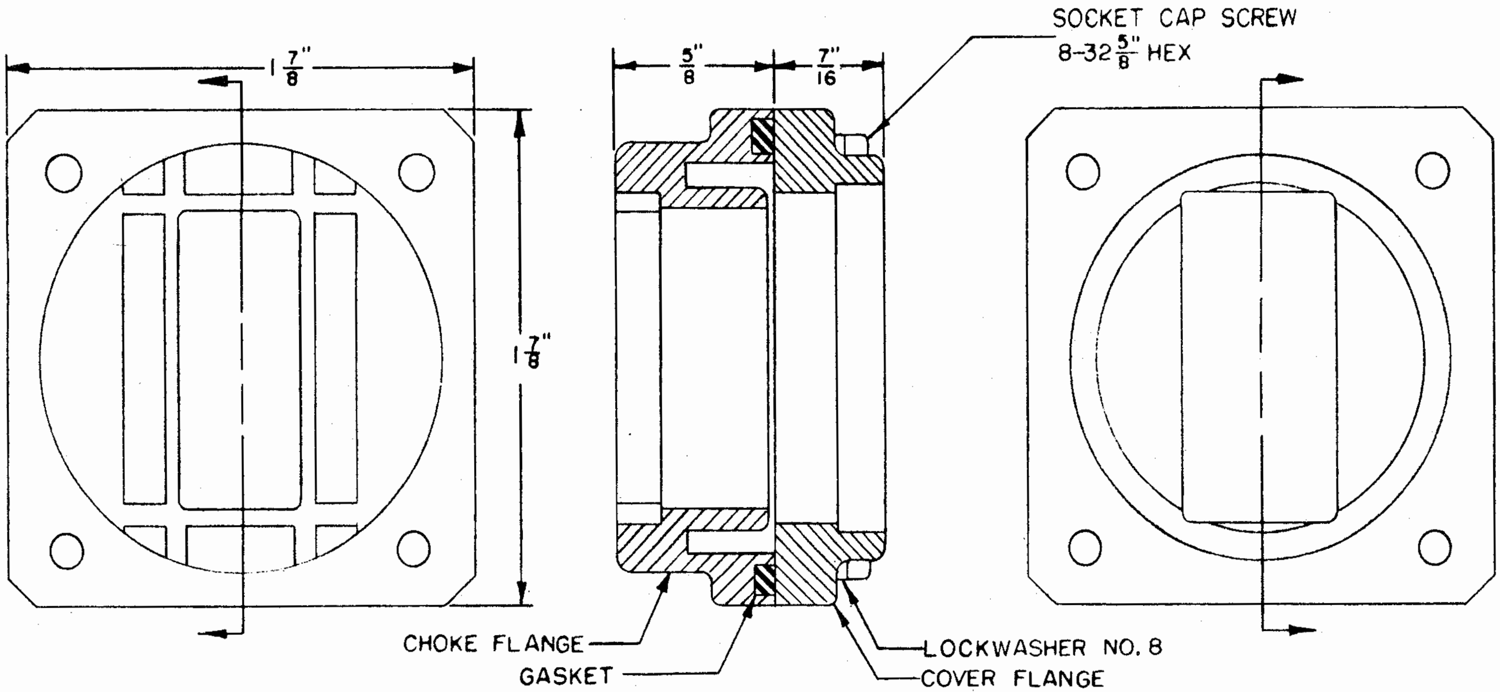
FLANGE	TYPE	MATERIAL	MATES WITH
A. PREFERRED FLANGES			
UG-343A/U	CHOKE	COPPER ALLOY	UG-344/U
UG-344/U	COVER	COPPER ALLOY	UG-343A/U
UG-440A/U	CHOKE	ALUMINUM	UG-441/U
UG-441/U	COVER	ALUMINUM	UG-440A/U
B. ALTERNATE FLANGES			
UG-150/U	PLAIN	COPPER ALLOY	UG-150/U
UG-343/U	CHOKE	COPPER ALLOY	UG-344/U
UG-440/U	CHOKE	ALUMINUM	UG-441/U
C. SUBSTITUTE FLANGES			
UG-247/U	COVER	COPPER ALLOY	UG-248/U
UG-248/U	CHOKE	COPPER ALLOY	UG-247/U
D. GASKET			
MX-1108/U	STRING FINGER METAL		UG-344/U

HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
SOCKET HD CAPSCREW	STAINLESS STEEL
GASKET	SYNTHETIC RUBBER

DRAWING REFERENCE:

A. AS 2002
B. RE49AA280, RE49F456
C. RA10A794

Figure 11-55. Flanges used with Waveguides RG-50/U and RG-106/U



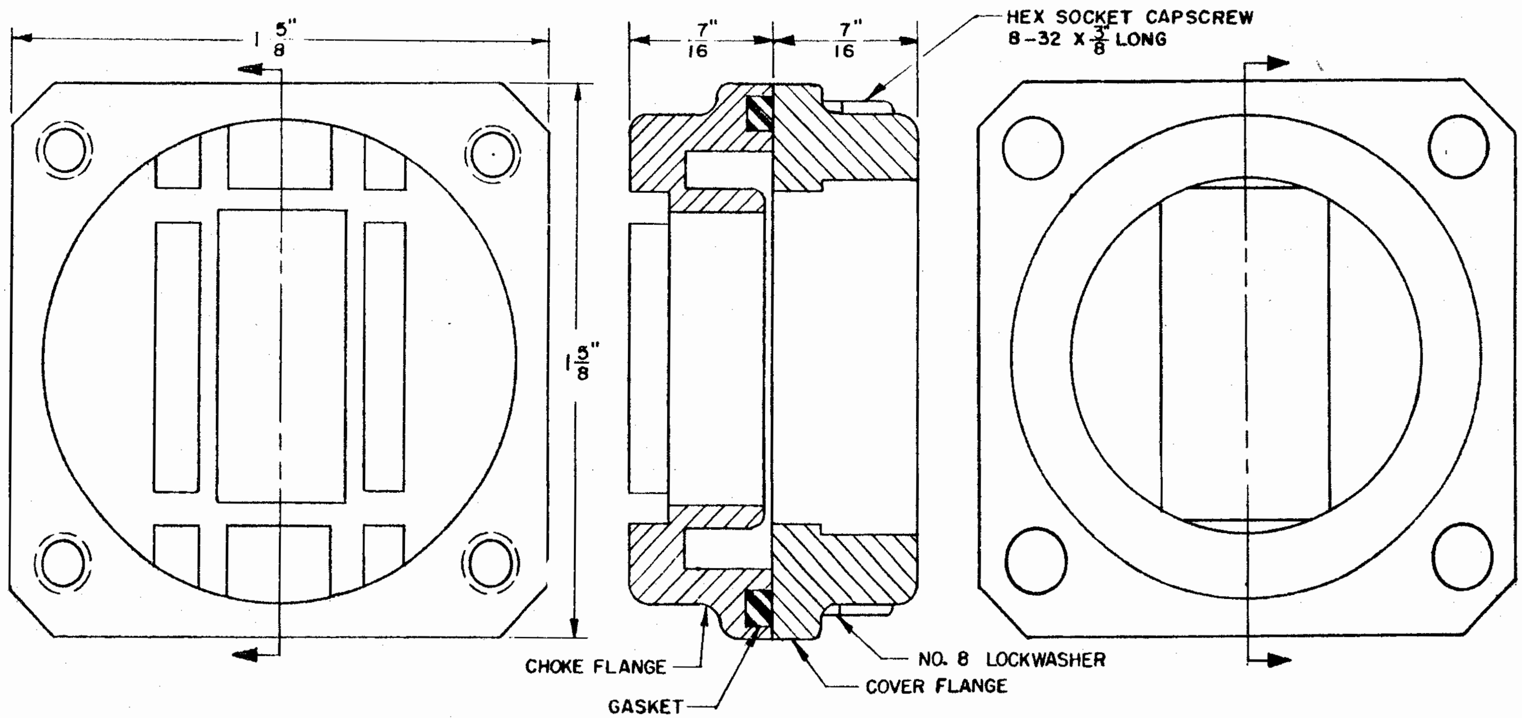
A. PREFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-51/U	COVER	COPPER ALLOY	UG-52A/U
UG-52A/U	CHOKE	COPPER ALLOY	UG-51/U
UG-137A/U	CHOKE	ALUMINUM	UG-138/U
UG-138/U	COVER	ALUMINUM	UG-137A/U
B. SUBSTITUTE FLANGES			
UG-42/U	CHOKE	COPPER ALLOY	UG-51/U
C. GASKET			
MX-1111/U	SPRING-FINGER METAL		UG-51/U

HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
SOCKET HEAD CAPSCREW	STAINLESS STEEL
GASKET	SYNTHETIC RUBBER

DRAWING REFERENCE:

A. AS-2021
B. RE 49F198

Figure 11-56. Flanges used with Waveguides RG-51/U and RG-68/U



A. PREFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-39/U	COVER	COPPER ALLOY	UG-40A/U
UG-40A/U	CHOKE	COPPER ALLOY	UG-39/U
UG-135/U	COVER	ALUMINUM	UG-136A/U
UG-136A/U	CHOKE	ALUMINUM	UG-135/U
B. ALTERNATE FLANGES			
UG-40/U	CHOKE	COPPER ALLOY	UG-39/U
UG-136/U	CHOKE	ALUMINUM	UG-135/U
C. GASKET			
MX-1106/U	SPRING-FINGER METAL		UG-39/U

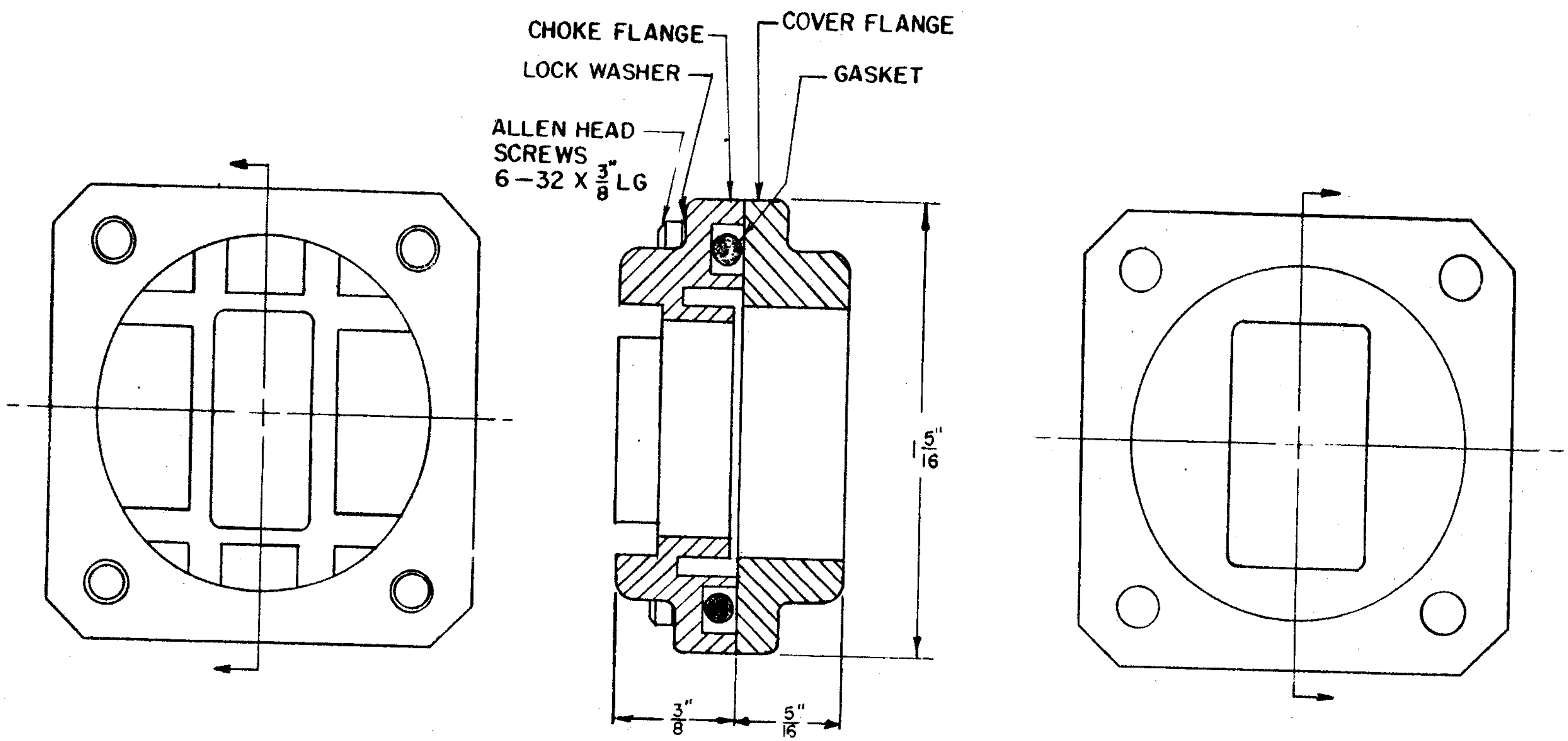
HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
HEX HD CAPSCREW	STAINLESS STEEL
GASKET	SYN RUBBER

DRAWING REFERENCE:

A. AS-2004

B. RE 49F197

Figure 11-57. Flanges used with Waveguides RG-52/U and RG-67/U



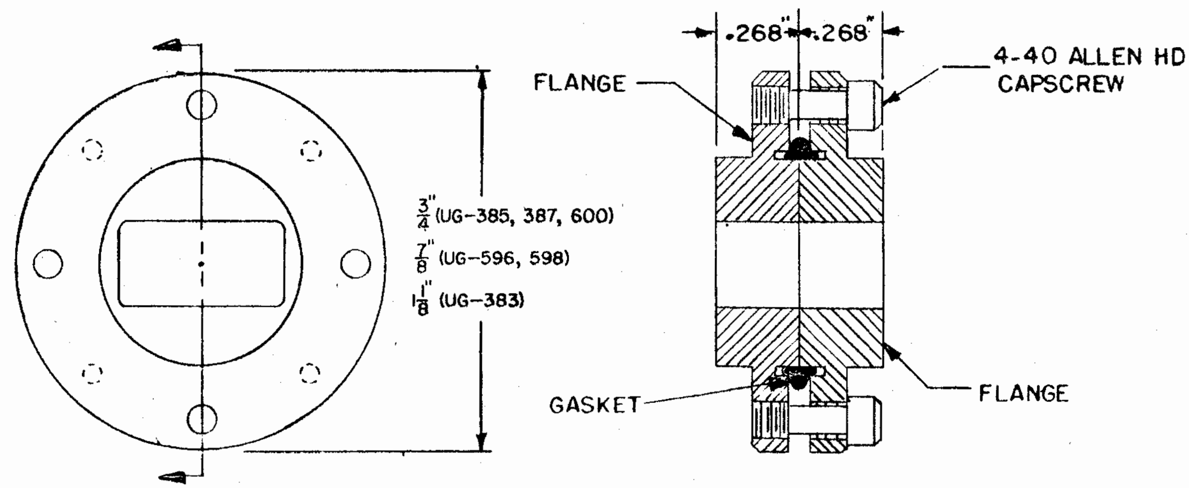
A. PREFFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-419/U	COVER	COPPER ALLOY	UG-541/U
UG-541/U	CHOKE	COPPER ALLOY	UG-419/U
B. ALTERENATE FLANGES			
UG-420/U	COVER	COPPER ALLOY	UG-419/U
C. GASKET			
MX-1107/U	SPRING — FINGER METAL		UG-419/U

NOTE: FLANGES ARE SILVER-PLATED AFTER ASSEMBLY WHEN USED WITH SILVER WAVEGUIDE

HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
ALLEN HD SCREW	STAINLESS STEEL
GASKET	SYN RUBBER

DRAWING REFERENCE:
A. AS-2003
B. RE 49F497

Figure 11-58. Flanges used with Waveguides RG-91/U and RG-107/U



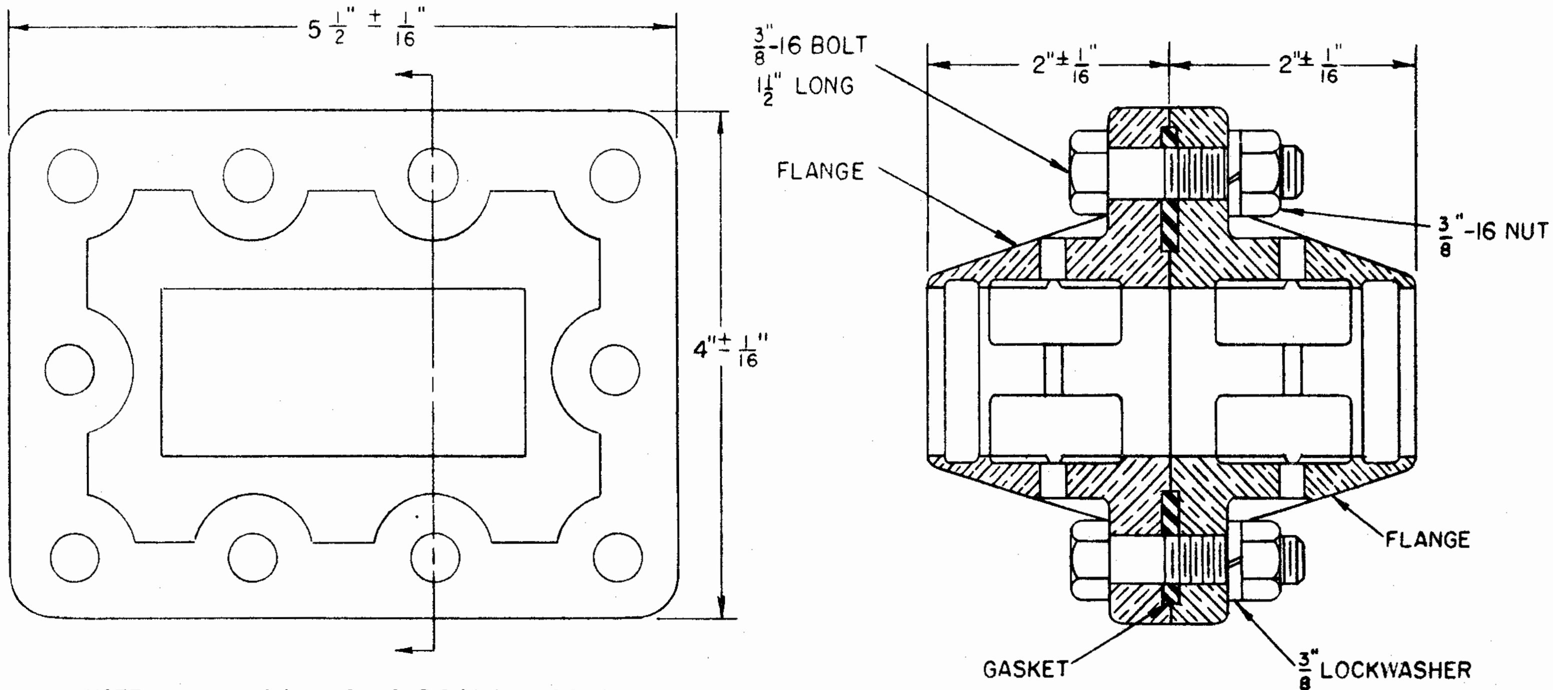
A. PREFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-383/U	COVER	COPPER ALLOY	UG-383/U
UG-385/U	COVER	COPPER ALLOY	UG-385/U
UG-387/U	COVER	COPPER ALLOY	UG-387/U
UG-595/U	COVER	COPPER ALLOY	UG-596/U
UG-596/U	CHOKE	COPPER ALLOY	UG-595/U
UG-597/U	COVER	ALUMINUM	UG-598/U
UG-598/U	CHOKE	ALUMINUM	UG-597/U
UG-599/U	COVER	COPPER ALLOY	UG-600/U
UG-600/U	CHOKE	COPPER ALLOY	UG-599/U
B. ALTERNATE FLANGES			
UG-381/U	COVER	COPPER ALLOY	UG-381/U
UG-425/U	COVER	COPPER ALLOY	UG-425/U
C. SUBSTITUTE FLANGES			
UG-116/U	COVER	COPPER ALLOY	UG-117/U
UG-117/U	CHOKE	COPPER ALLOY	UG-116/U
UG-210/U	CHOKE	COPPER ALLOY	UG-211/U
UG-211/U	COVER	COPPER ALLOY	UG-210/U
D GASKET			
MX-1105/U	SPRING — FINGER METAL		UG-425/U

HARDWARE	
PART	MATERIAL
DOWEL PIN	STAINLESS STEEL
CAPSCREW	STAINLESS STEEL
GASKET	SOFT SYNTHETIC

DRAWING REFERENCE:
A. AS-2072, AS-2092
B. RE 49F480G
C. RE49F281, RE49F493

NOTE: FLANGES ARE SILVERPLATED AFTER ASSEMBLY WHEN USED WITH SILVER WAVEGUIDES.

Figure 11-59. Flanges used with Waveguides RG-53/U, -66/U, -96/U, -97/U, -98/U, -99/U, and RG-121/U



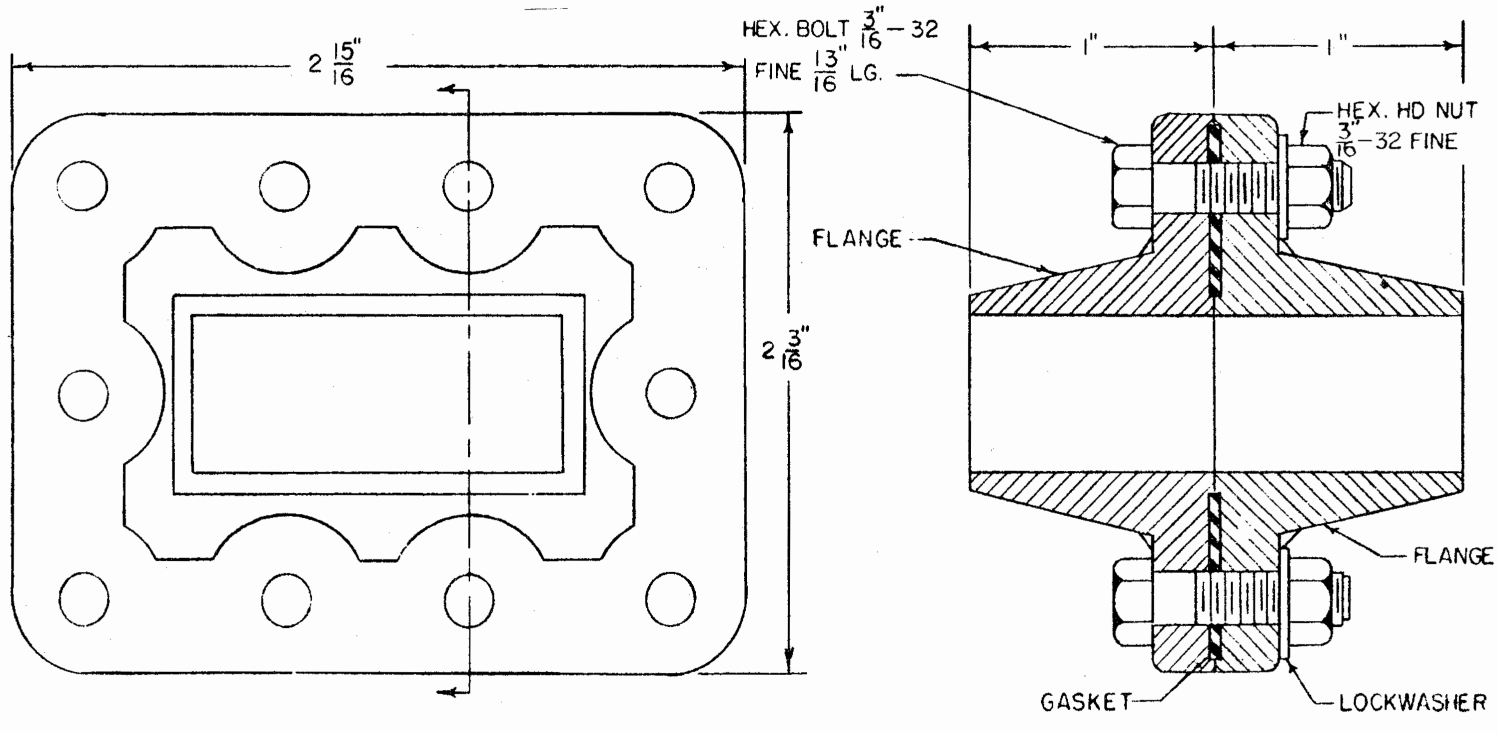
NOTE: UG-509/U AND UG-510/U ARE IDENTICAL FLANGES. THE GASKET COMES WITH UG-509/U ONLY. IF THE GASKET IS AVAILABLE, EITHER 2 UG-509/U'S OR 2 UG-510/U'S CAN BE USED.

A. PREFERRED FLANGES				
FLANGE	TYPE	MATERIAL	MATES WITH	
UG-509/U	COVER	COPPER ALLOY	UG-510/U	SEE
UG-510/U	COVER	COPPER ALLOY	UG-509/U	NOTE

DRAWING REFERENCE: A. RE 49F554B

HARDWARE	
PART	MATERIAL
LOCKWASHER	STAINLESS STEEL
NUT	STAINLESS STEEL
BOLT	STAINLESS STEEL
GASKET (UG-509/U)	SYNTHETIC CORPRENE

Figure 11-60. Flanges used with Waveguide RG-109/U



A. PREFERRED FLANGES			
FLANGE	TYPE	MATERIAL	MATES WITH
UG-511/U	COVER	COPPER ALLOY	UG – 512/U
UG-512/U	COVER	COPPER ALLOY	UG – 511/U

DRAWING REFERENCE
A. RE 49 F 555 B

HARDWARE	
PART	MATERIAL
LOCKWASHER	S'STEEL
NUT	S'STEEL
BOLT	S'STEEL
GASKET (UG-511/U)	0.0625 CORPRENE

Figure 11-61. Flanges used with Waveguide RG-110/U

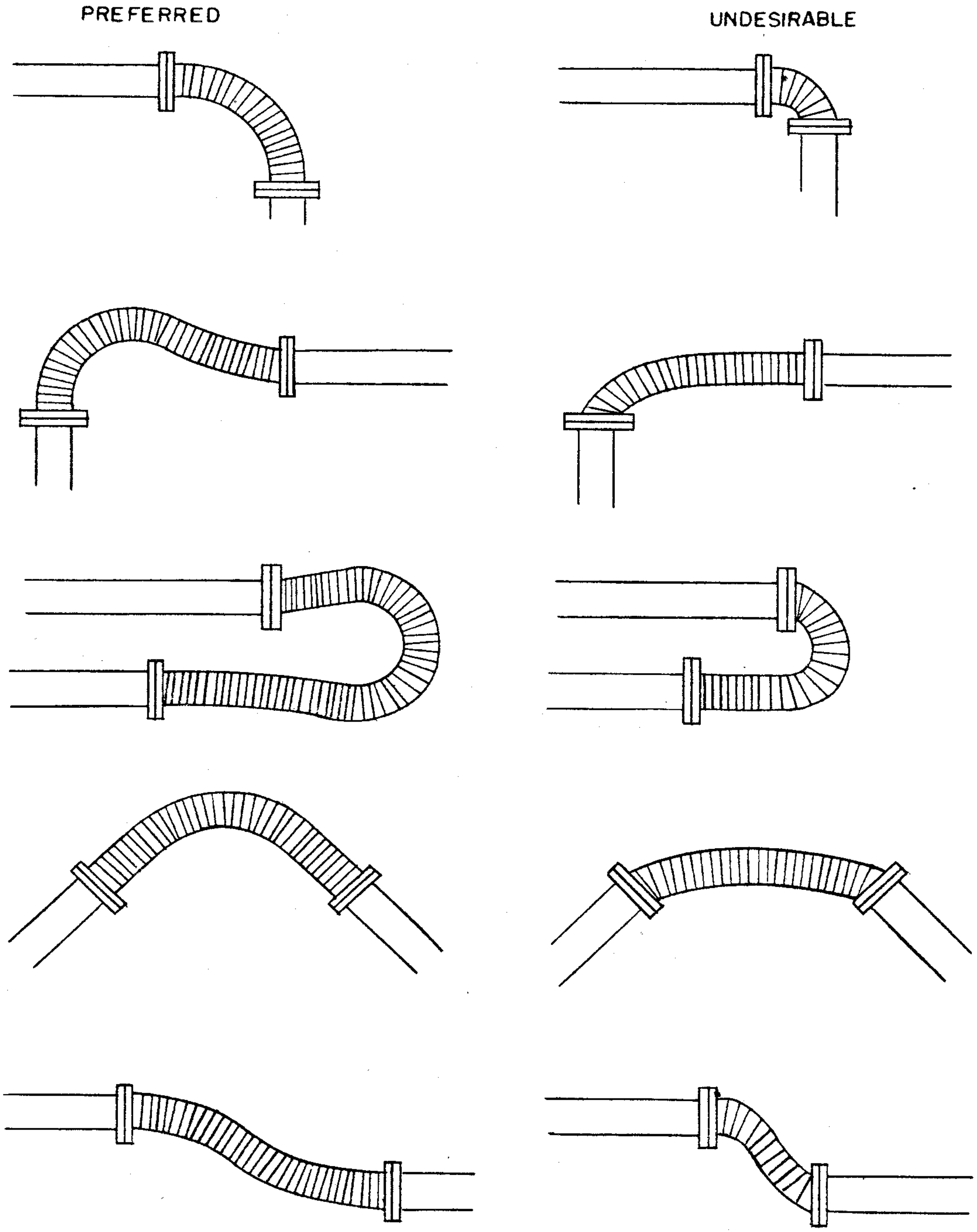


Figure 11-62. **Satisfactory and Unsatisfactory Installations of Flexible Waveguide Assemblies**

SECTION 11-3

FLEXIBLE WAVEGUIDES

1. INTRODUCTION.

Flexible waveguides are the same size as the corresponding rigid waveguide, and can be used with the same fittings. They look like BX conduit, except that they are rectangular instead of round. Because there is so much power loss, even in very short sections, flexible waveguides should not be used unless it is absolutely necessary.

The non-molded types are definitely inferior in flexing life to those molded over convolutions with Neoprene or equal jackets. The unjacketed types are used for emergency only.

In the event of battle damage or other casualty to waveguides, in which a short section, bend, or twist is cut out or otherwise made inoperative, a section of flexible waveguide may be used in order to keep the equipment operating.

2. GENERAL DESCRIPTION.

The guide is available in two general forms:

a. A continuous length of about 20 feet supplied without fittings, but with the ends tinned and ready for use.

b. Assemblies of six inches and longer in steps of six inches, complete with a flange coupling at each end to mate with a choke coupling on the guide sections to be connected. The longest length which is made up this way is 72 inches.

The assemblies listed in Table 11-2 are stock items.

3. INSTALLATION.

These flexible guides are quite sturdy, but they must be used with care. Figure 11-62 shows satisfactory and unsatisfactory methods of installing flexible waveguides. If a piece is installed on a mast run, make certain that it is not supporting the rest of the run below it. Some types of flexible waveguide may be stretched or shortened as much as 1/2 inch per foot of length, allowing its use as an emergency expansion section; however, it will break if stretched too far.

If standard ready-made angles or bending equipment are not available, or if time is lacking, these flexible sections may be used to form angles. A two-foot length can be formed into a right angle easily and quickly. Although the guides are flexible, they do have limits of bend. For electrical reason, do not exceed minimum bend radius or the maximum twist given in the tables.

Flexible guide is assembled to couplings or fittings as follows:

a. Cut the guide to the desired length making sure that the ends are cut square. Burr the ends inside and out and clean out chips. Use a dry air blast, if available.

b. Heat the fitting with a gas torch and tin the inside surface with rosin core solder. Avoid excess solder.

c. Tin the ends of the tubing uniformly, and insert the tinned end into the fitting. Keep edges and surfaces square.

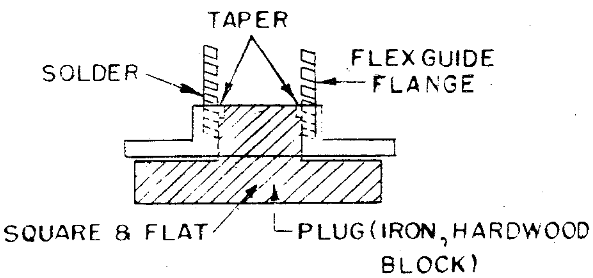


Figure 11-63. Block for Use in Soldering Coupling to Flexible Waveguide

NOTE

As an aid to this assembly operation, use the tapered block shown in Figure 11-63. To use this, seat the coupling over the block with just enough clearance on the taper to slide the guide in. This will prevent excess solder from collecting in the bottom of the fitting.

In soldering the guide to the coupling keep the tubing itself cool by wrapping wet rags around it. This prevents opening of the soldered joints of nearby turns. Keep the flame or direct heat away from the grooves; playing the flame only on the coupling.

CAUTION

Be sure that the solder flows evenly and smoothly into the first two grooves.

Use enough solder and flux to make an even joint. Chill the solder quickly, making certain that none of the parts are moved, to avoid a "cold" joint.

Reheat and add solder if necessary. Wipe off any excess flux from the surface of the work.

Remove grease with clean carbon tetrachloride and dry in air before assembly to the system.

Figures 11-64 and 11-65 show contact and choke couplings soldered to flexible waveguides.

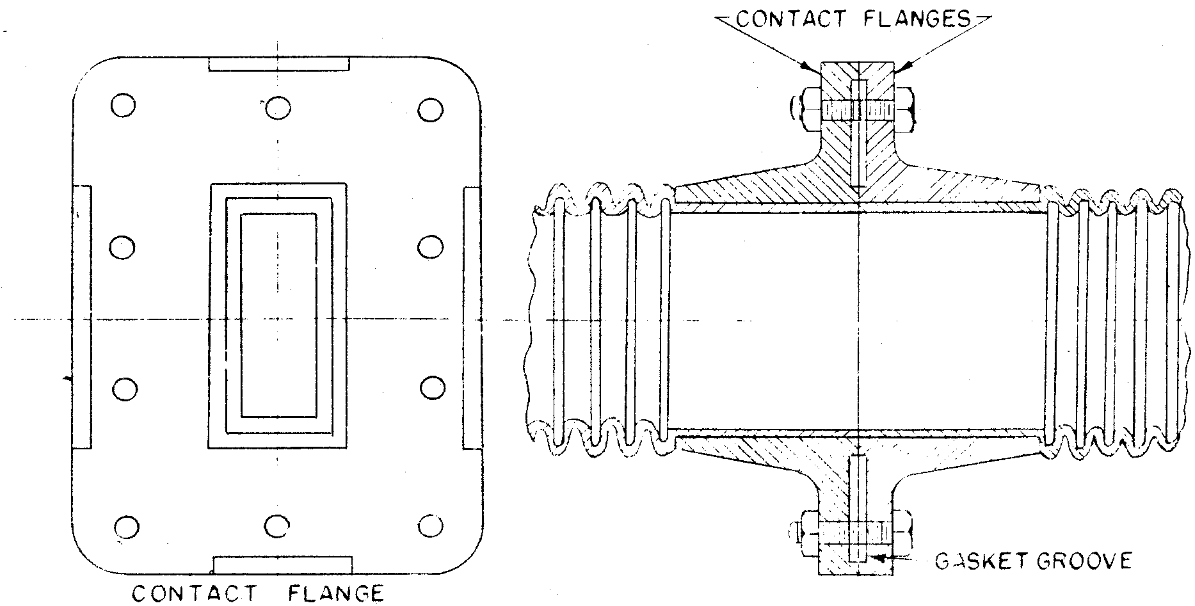


Figure 11-64. Contact Flanges

These flexible guides may be used in installations where a "boot" or "kidney" joint gives trouble. This is particularly true where shock-mounted equipment feeds through such a joint into a rigidly-mounted guide, and the amount of vibration is enough to cause varying signals, power loss (into the "boot"), etc. For this application use an 18 inch to 26 inch piece of guide. To reduce the strain, use the longer length for the larger guides (1-1/2 inch x 3 inches).

The power loss (attenuation) in flexible guides is 1-1/2 to 2-1/2 times greater than in the corresponding rigid guides; in other words, one foot of flexible guide has the same power loss as 1-1/2 to 2-1/2 feet of rigid guide. However, the use of this material in an emergency may mean the difference between being on the air or shut down.

4. CONSTRUCTION.

Flexible waveguide assemblies have suitable standard couplings at each end, and are made in one of the following ways.

a. WOUND TYPE.—Wound type consists of tubing made in rectangular form by spirally winding and interlocking a metal tape. Types A and B, Figure 11-66, are of this type.

b. CHOKE TYPE.—Choke type consists of individual sections inserted into and held in place by a molded synthetic rubber jacket. Type C (vertebra), Figure 11-66, is of this type.

c. SEAMLESS TYPE.—Seamless type is made by corrugating a thin-walled, seamless rectangular metal tube. Type D and E, Figure 11-66, is of this type.

Outside dimensions may vary depending on whether the waveguide has a jacket.

Wound and seamless flexible guides are made of non-ferrous metal such as silver-plated brass. Choke sections are made of aluminum or aluminum-base alloy.

The assemblies are made normally in the following lengths: 6, 12, 18, 24, 30, 36, 42, 48, 60 and 72 inches.

For battle damage control, or if lengths over 72 inches are required, the raw guide without fittings may be used when properly assembled.

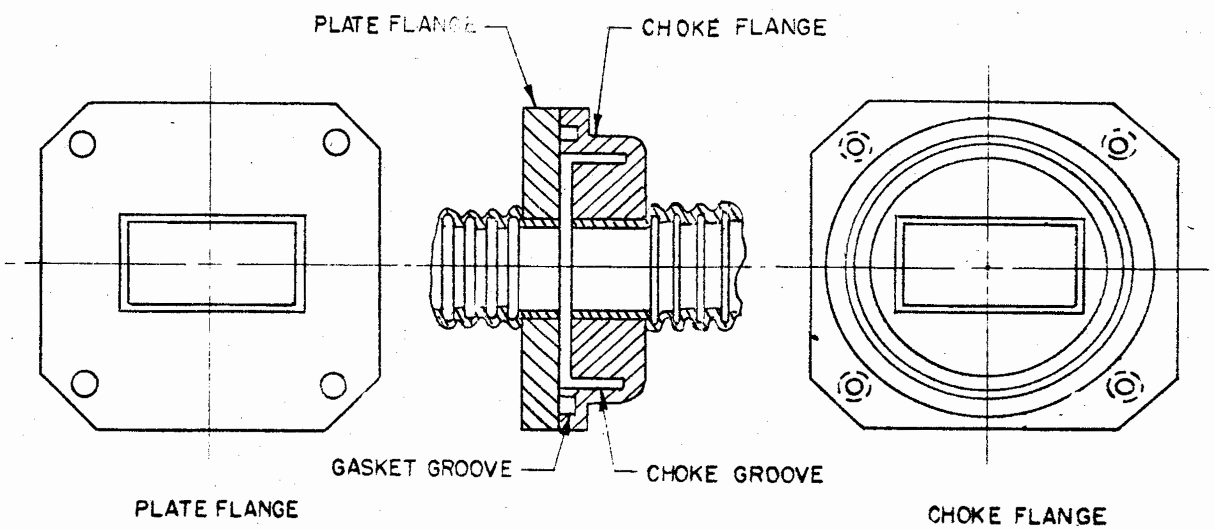


Figure 11-65. Choke Coupling

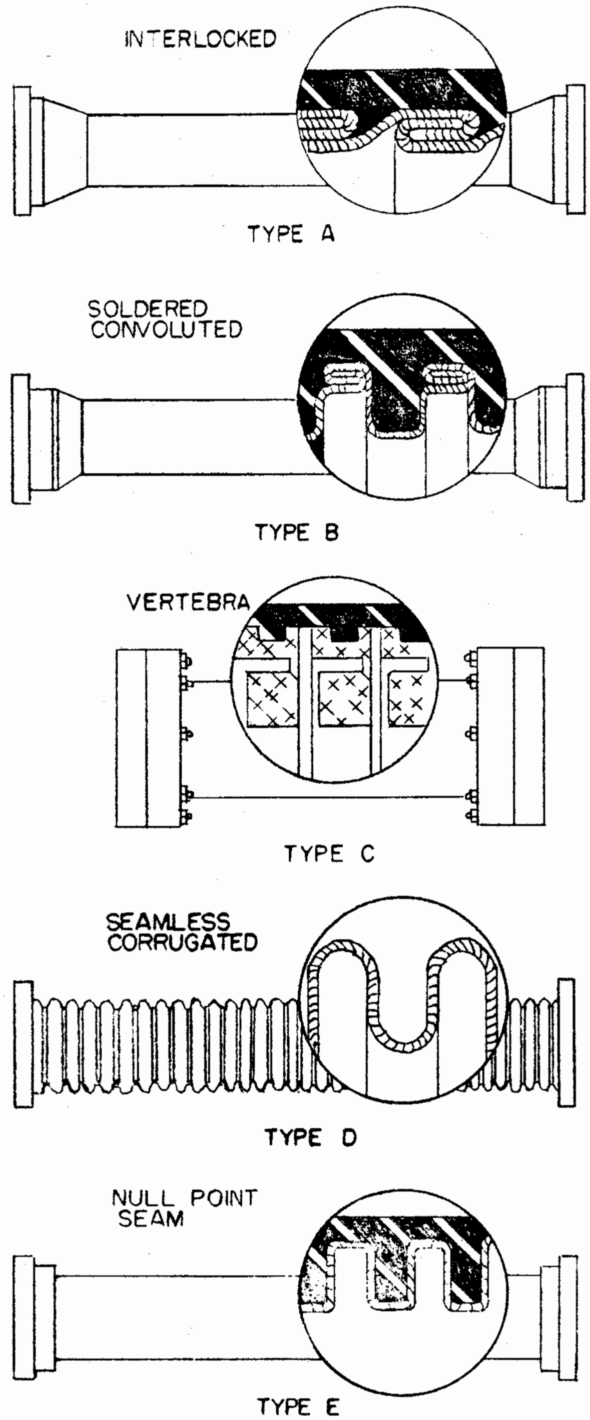


Figure 11-66. Various Constructions used for Flexible Waveguides

d. NOTES (Refer to Table 11-2).

(1) The parenthesis after CG- /U( ) contains the desired length information in inches, flange-to-flange-face of assemblies. Example: CG-537/U (3 ft 6 in.).

(2) Category is a guide in the use of flexible waveguides.

(a) Category 1 is the standard.

(b) Category 2 is satisfactory and widely used.

(c) Category 3 is for replacement purposes.

(3) Construction (Refer to Fig. 11-66)

A. INTERLOCKED. - Has good bending and twisting properties. Can be used for short or long lengths.

B. SOLDERED - CONVOLUTED. - Good bending properties but very little twisting. Can be used for short or long lengths.

C. VERTEBRA. - Excellent bending and twisting properties. Only used for short lengths due to power loss.

D. SEAMLESS CORRUGATED. - Good for bending but twisting is negligible. Used for short and medium lengths.

E. NULL-POINT SEAM. - Similar to Seamless Corrugated in application and use.

(4) The "H" bend radius is twice the safe "E" bend radius. Example: Safe "E" bend radius for CG-537/U is 25 inches. Safe "H" bend radius would be 50 inches.

AN Type No. Note 1	Equivalent to Rigid Waveguide	Category Note 2	Construction Note 3	Safe Bend Radius (E Bend) Note 4	Safe Twisting Data	Jacket	Mates with Flange Type	Material
CG-731/U	RG-69/U, 128/U, 132/U (6.66 x 3.41)	2	E	6 in.	± 6° per foot	Rubber	UG-417/U	Brass, Silver-plated
CG-537/U	RG-69/U, 128/U, 132/U (6.66 x 3.41)	3	A	25 in.	± 11° per foot	Rubber	UG-417A/U	Bronze, Silvered
CG-538/U	RG-104/U, 105/U (4.46 x 2.31)	3	A	18 in.	± 14° per foot	Rubber	UG-435/U	Bronze, Silvered
CG-736/U	RG-48/U (3 x 1.5)	2	E	4 in.	± 4° per foot	Rubber	UG-53/U, UG-54A/U	Brass, Silver-plated
CG-519/U	RG-48/U, 75/U (3 x 1.5)	3	A	13 in.	± 20° per foot	Rubber	UG-200A/U	Bronze, Silvered
CG-333A/U	RG-48/U, 75/U (3 x 1.5)	2	E	5 in.	± 4° per foot	Rubber	UG-53/U, 54A/U	
CG-333/U	RG-48/U 75/U (3 x 1.5)	3	E	5 in.	± 4° per foot	None	UG-53/U, 54A/U	
CG-170/U	RG-48/U, 75/U (3 x 1.5)	3	A	13 in.	± 20° per foot	Rubber	UG-66/U	Bronze, Silvered
CG-169A/U	RG-48/U, 75/U (3 x 1.5)	3	B	6 in.	± 4° per foot	Rubber	UG-66/U	Bronze, Silvered
CG-735/U	RG-49/U (2 x 1)	2	E	3 in.	± 4° per foot	Rubber	UG-14B/U, 149A/U	Brass, Silver-plated
CG-168/U	RG-49/U, 95/U (2 x 1)	2	A	8 in.	± 53° per foot	Rubber	UG-148B/U	Bronze, Silvered
CG-167A/U	RG-49/U, 95/U (2 x 1)	2	B	4 in.	± 4° per foot	Rubber	UG-148B/U	Bronze, Silvered
CG-734/U	RG-50/U (1.5 x .75)	2	E	2 in.	± 4° per foot	Rubber	UG-343A/U, 344/U	Brass, Silver-plated
CG-419/U	RG-50/U, 106/U (1.5 x .75)	3	A	6 in.	± 72° per foot	Rubber	UG-150/U	Bronze, Silvered
CG-418/U	RG-50/U, 106/U (1.5 x .75)	3	B	3 in.	± 4° per foot	Rubber	UG-150/U	Bronze, Silvered
CG-374/U	RG-50/U, 106/U (1.5 x .75)	3	A	6 in.	± 72° per foot	Rubber	UG-150/U	Bronze, Silvered
CG-343/U	RG-50/U, 106/U (1.5 x .75)	3				Rubber	UG-150/U	
CG-733/U	RG-51/U (1.25 x .625)	2	E	1 in.	± 4° per foot	Rubber	UG-51/U, 52A/U	Brass, Silver-plated
CG-684/U	RG-51/U, 68/U (1.25 x .625)	2	B	2 in.	± 4° per foot	Rubber	UG-52/U	Bronze, Silvered
CG-540/U	RG-51/U, 68/U (1.25 x .625)	3	C	6 in.	± 180° per foot	Rubber	UG-51/U, 52/U	Aluminum
CG-334/U	RG-51/U, 68/U (1.25 x .625)	3				Rubber	UG-51/U	
CG-166/U	RG-51/U, 68/U (1.25 x .625)	3	B	2 in.	± 4° per foot	Rubber	UG-52A/U	Bronze, Silvered
CG-165A/U	RG-51/U, 68/U (1.25 x .625)	3	B	2 in.	± 4° per foot	Rubber	UG-52A/U	Bronze, Silvered
CG-779/U	RG-52/U, 67/U (1 x 1/2)	2	B	2 in.	± 4° per foot	Rubber	UG-135/U	Bronze, Silvered
CG-732/U	RG-52/U (1 x 1/2)	2	E	1 in.	± 4° per foot	Rubber	UG-39/U, 40A/U	Brass, Silver-plated
CG-541/U	RG-52/U, 67/U (1 x 1/2)	3	C	6 in.	± 180° per foot	Rubber	UG-39/U, 40/U	Aluminum
CG-461/U	RG-52/U, 67/U (1 x 1/2)	2	D	1 in.	± 4° per foot	None	UG-40A/U	Beryllium Copper
CG-179A/U	RG-52/U, 67/U (1 x 1/2)	2	B	2 in.	± 4° per foot	Rubber	UG-40A/U	Bronze, Silvered
CG-164/U	RG-52/U, 67/U (1 x 1/2)	2	A	4 in.	± 95° per foot	Rubber	UG-40A/U	Bronze, Silvered

Table 11-2. Flexible Waveguide

SECTION 11-4A

BEAD-SUPPORTED COAX (TEFLON)

1. INTRODUCTION.

Bead-supported coaxial transmission line (Teflon) Navy Type 62200 is designed to operate at higher temperatures and efficiency than is possible with certain types of coaxial transmission lines This line, used for SR radar transmission, has an outer diameter of 1-5/8 inches and an inner conductor diameter of 0.638 inches. Its characteristic impedance is 51 ohms.

2. GENERAL DESCRIPTION.

A comparison of steatite bead coax and teflon bead coax is shown in Figure 11-67 for identification purposes.

Bead-supported coaxial transmission line (Teflon) consists of a large-diameter outer copper tube with a smaller-diameter copper tube supported in the center by insulation spacers. The large tube is the outer conductor, and the small tube is the inner conductor. The insulators are spaced three inches apart center-to-center as shown in Figure 11-67. They are held in position by ridges on the inner and outer conductors. Halfway between each pair of these ridges there are three scribed marks that show where to cut the line. The transmission line is supplied in 20-foot lengths.

Sections of line are connected by coupling units that are available in the following styles:

a. Inner-conductor connector (see Figure 11-68).

b. Straight coupling (see Figure 11-68).

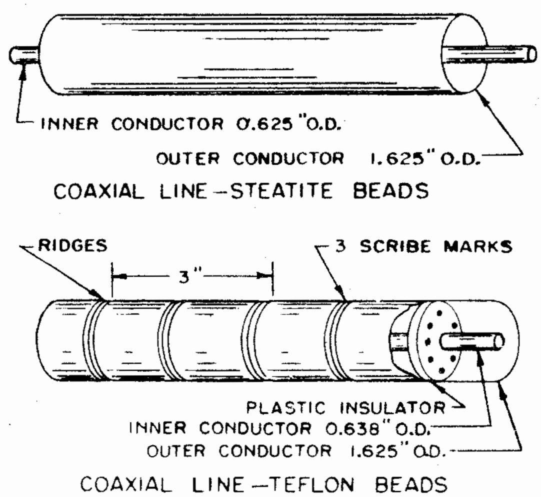


Figure 11-67. Comparison of Two Sections of Bead-Supported Coaxial Lines

c. 90-degree elbow coupling (see Figure 11-69).

d. 45-degree elbow coupling (see Figure 11-70).

e. Straight coupling tapped for air connection (see Figure 11-68).

f. Gas-admission coupling (see Figure 11-71).

g. Angle end seal (see Figure 11-72).

These are solderless connectors that will hold the necessary air pressure, make good electrical contact, and hold the line rigid.

NOTE

A coaxial line that loses air pressure will act as transmission line, but its efficiency is reduced.

The connector cable as shown in Figure 11-73 is used with bead-supported coaxial transmission line (Teflon) when it is necessary to have a flexible joint in the line. This cable is made up with a four-foot length of RG-18/U armor-shielded, flexible, coaxial cable. It has an adapter coupling at each end. Each end of the inner conductor has a male connector that fits in the inner conductor of the transmission line so that the cable can be connected to either a straight or elbow type coupling without the use of a separate inner-conductor connector.

These connector cables are factory-assembled and cannot be taken apart or changed in the field.

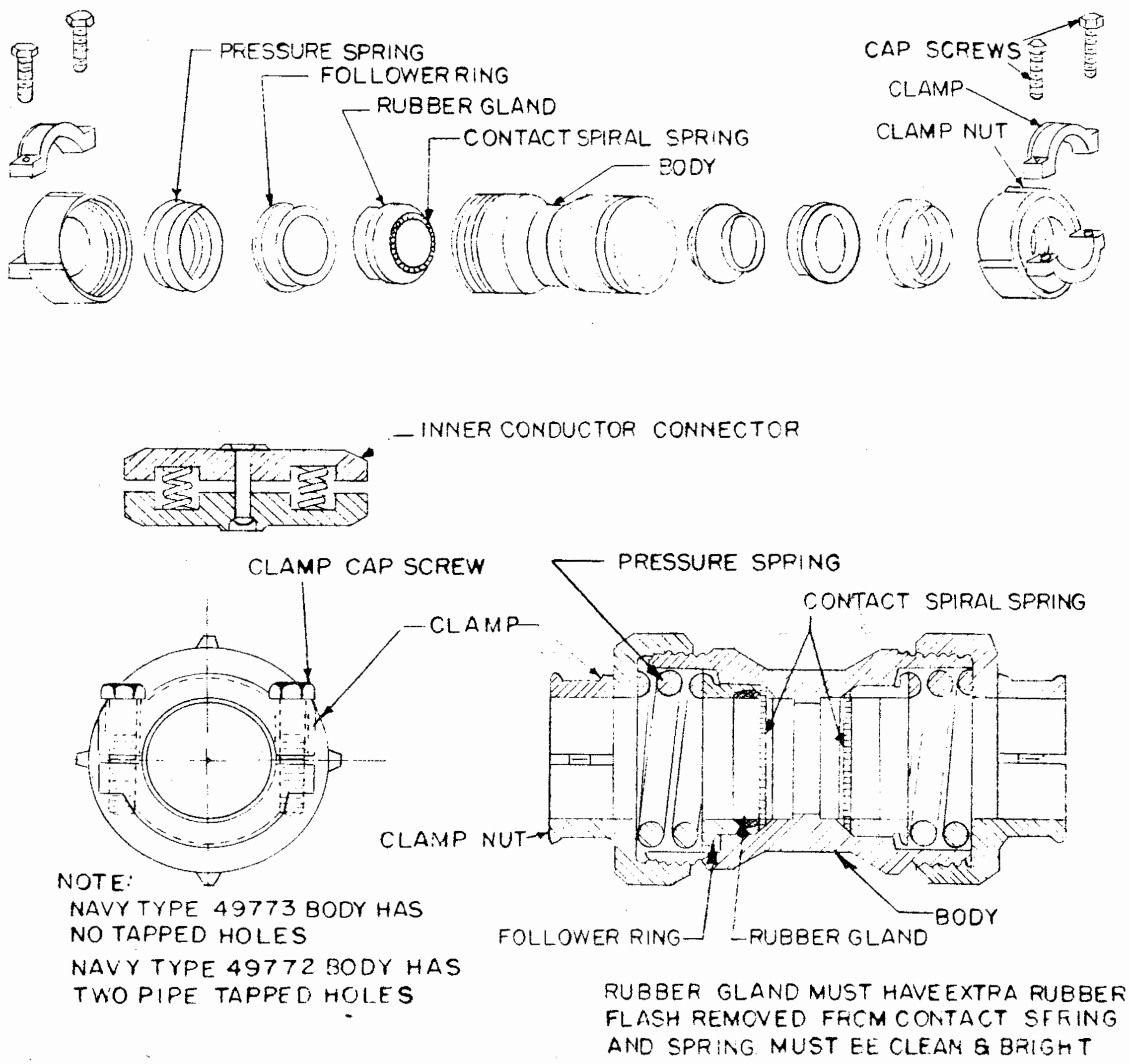


Figure 11-68. Straight Coupling, Assembly, Navy Types 49772-49773 and Inner Conductor Connector

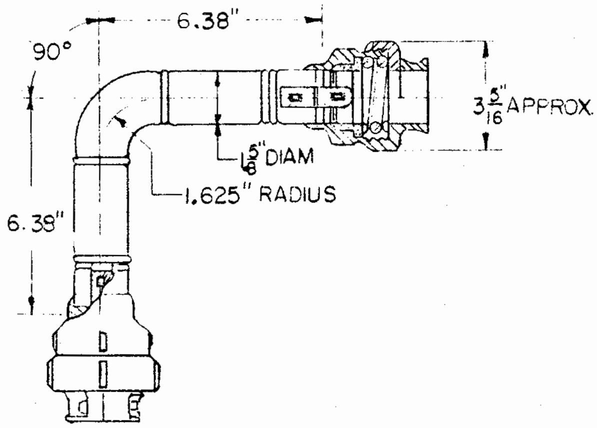


Figure 11-69. 90 Degree Elbow Coupling, Navy Type 49774

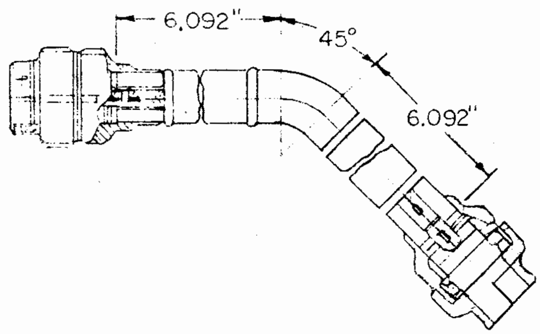


Figure 11-70. 45 Degree Elbow Coupling, Navy Type 49775

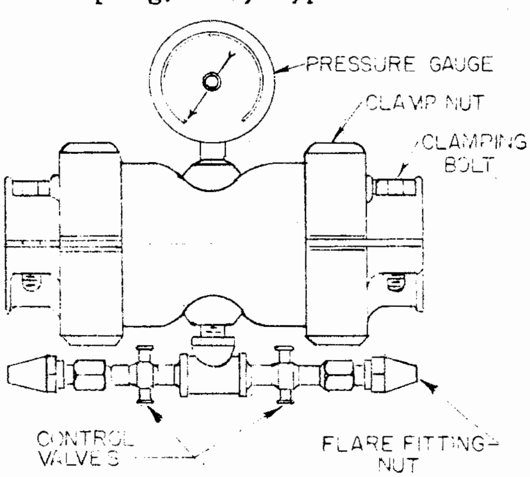


Figure 11-71. Gas-Admission Coupling Assembly

Bulkhead fittings are used to support and protect this type transmission line where it passes thru a bulkhead or a deck. See Figure 11-74.

3. INSTALLATION.

NO RADAR SYSTEM IS BETTER THAN ITS TRANSMISSION LINE.

The transmission line connects the radar transmitter to the antenna pedestal. The best place to start the layout and installation is at the antenna pedestal.

a. LAYOUT OF TRANSMISSION LINE. A typical installation layout for a radar transmission line is shown in Figure 11-75.

CAUTION

The entire transmission line should be pitched toward the transmitter so that there will be no place where water can be trapped in the line.

If it is necessary to form a water trap because of mechanical interference or other reasons, a drain-plug fitting should be installed from which any water collected in the trap may be forced out under the air pressure of the line. In making crossovers because of obstruction, always run transmission line above the obstruction instead of forming a dip below it.

The straight transmission line sections and the elbows that are furnished can be used for all parts of the line except where there are multiple or complicated turns. At places where complicated turns are necessary, such as at the base of the antenna pedestal, it is easiest to use one of the connector cables, although it is possible to use elbows as shown in Figure 11-76. The method that best suits the installation should be chosen and the layout should be planned accordingly. When a solid dielectric flexible connector cable is used at a turn between any two sections of gas-filled transmission line, the solid cable section must be bridged by a copper tube to carry the air, under

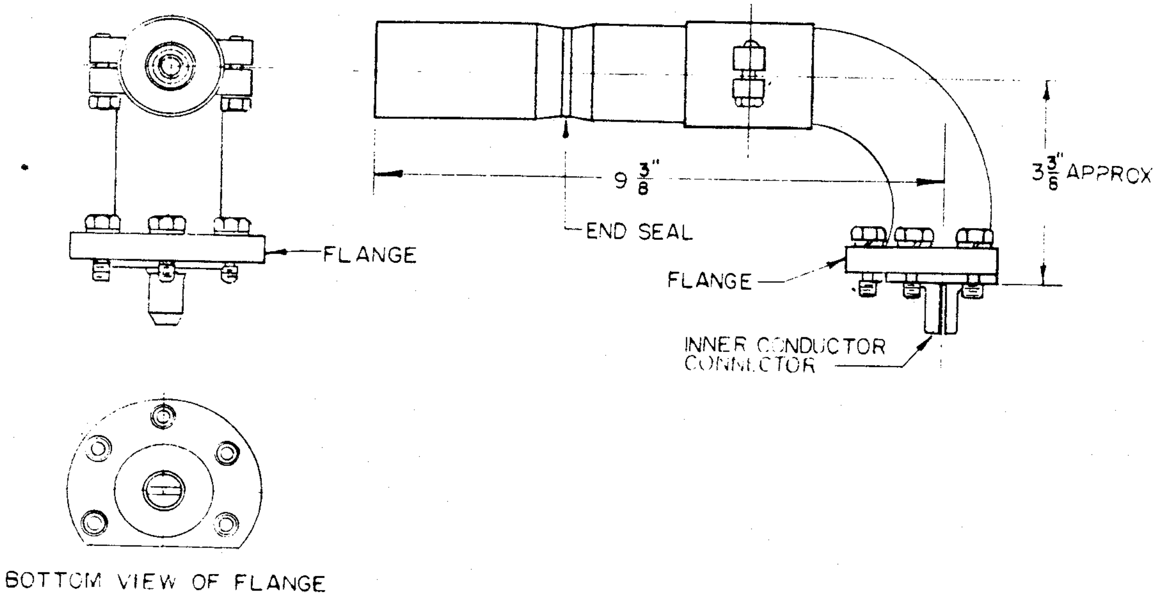


Figure 11-72. Angle End-Seal, Navy Type 10467

pressure, from one section of line to the other, as shown in Figure 11-76.

(1) PRECAUTIONS.

(a) The use of solid dielectric cable should be kept to a minimum because of excessive losses.

(b) Bead-supported (Teflon) transmission line should not be connected with any other type 1-5/8 inch OD coaxial transmission line.

(c) Heat of blow torches or soldering irons will ruin transmission line insulators. It should never be necessary to apply heat to any section of the line

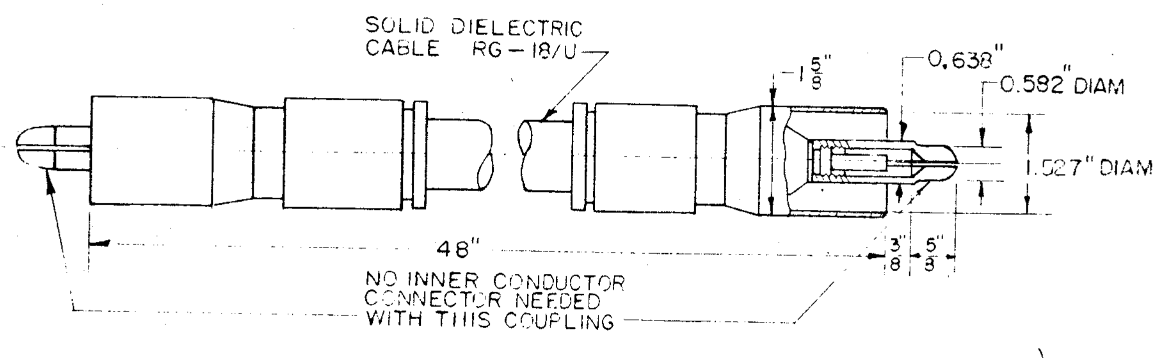


Figure 11-73. Flexible Connector Cable and Adapter Couplings, Navy Type 62202A

because it cannot be bent, and no soldering is required to make joints.

(d) When cutting a section of line to make a joint, cut only on the center scribe mark halfway between a pair of insulator ridges on the outside of the line.

(e) Do not attempt to cut any elbows.

(f) Absolute cleanliness is vital in the handling of this transmission line and its fittings. Filings or saw cuttings left inside the line can ruin the whole installation. Keep dirt out of the line. Always remember that small particles of dirt, copper, solder, and metal filings inside of the lines will cause arcs. Arcovers may char the insulators, pit the copper conductors and, by causing line failure, can prevent the radar system from working. So shop benches must be kept clean and extreme care must be taken to keep all kinds of dirt out of the line. For protection in shipping and handling, all lines, elbows, and couplings have "CELON" caps on each end to keep dirt out. These caps should remain in place until line is to be used.

b. PREPARING STRAIGHT TRANSMISSION LINE SECTIONS.— When the length of straight sections needed has been determined, proceed as follows to prepare all sections of less than 20 feet long:

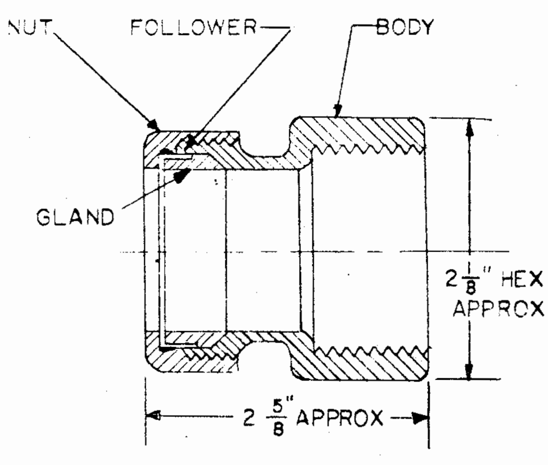


Figure 11-74. Bulkhead Fitting, Navy Type 10463

(1) Measure off the needed length on a straight section of line. Find the second set of cutting marks beyond this length. Cut the line carefully, at right angles, on the middle mark of the three. Use a piece of tape as a guide to the middle scribe mark and make all cuts with a 24-tooth hacksaw. This makes the line three inches longer than its final length; the extra three inches are for protection against saw cuttings and will be cut off. Now tilt the line so that the end just cut points down at about a 30-degree angle and cut off the extra three inches while keeping the line tilted so the saw cuttings will not fall back into the line. Discard the three-inch piece of line.

(2) Take the piece of line that is not to be used and clean out the end; then cover it with masking or friction tape, so that dirt will be kept out.

(3) On the line that is to be used, remove burrs with a knife or file. (Keep line tilted so that particles will not fall back into line.)

(4) Wipe out all inside surfaces with a clean cloth moistened with carbon tetrachloride.

NOTE

If a full, 20-foot section is to be used, just take the "CELON" end caps off the ends of the line and polish and clean the ends of the conductors.

(5) Using crocus cloth or fine sandpaper, polish the inside of the inner conductor.

CAUTION

Never use steel wool or emery in cleaning the sections of transmission line.

c. INSTALLING COUPLINGS.

(1) STRAIGHT COUPLINGS.— These couplings are made up of the parts shown in Figure 11-68 and Figure 11-77. They are to be installed as follows:

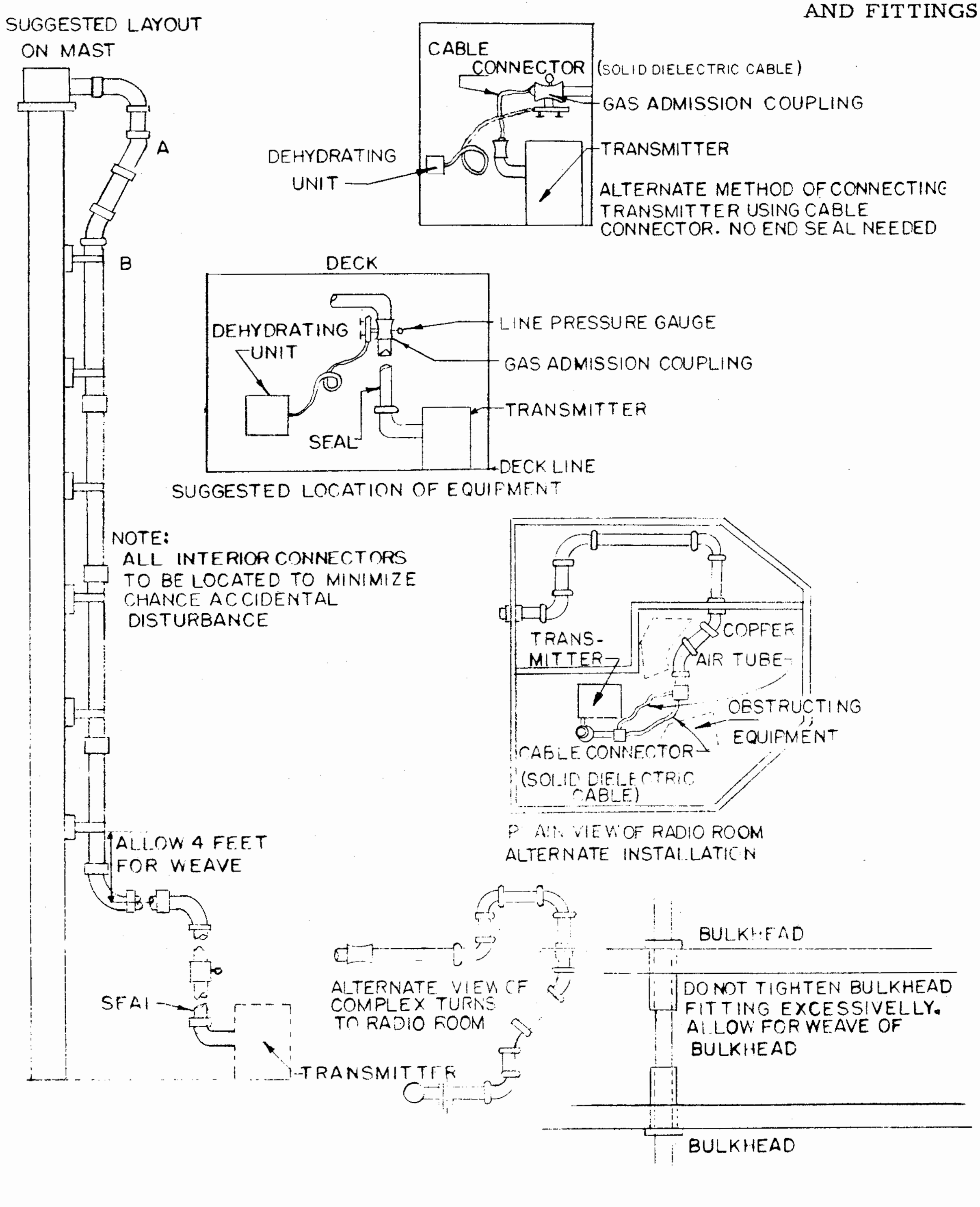


Figure 11-75. Installation Layout

(a) Push the inner conductor connector into the center of the inner conductor on one end of the straight line section until the shoulder is tight against the end of the conductor. See Figure 11-77 and Figure 11-78.

(b) Loosen the clamp nut on each end of the coupling until it is held by only one or two threads. The spring, rubber gland, and follower on each end are now loose.

(c) Loosen the cap screws on each clamp nut so that the line will slide freely into the coupling.

NOTE

It is not necessary to take the coupling apart to place it on the section of transmission line.

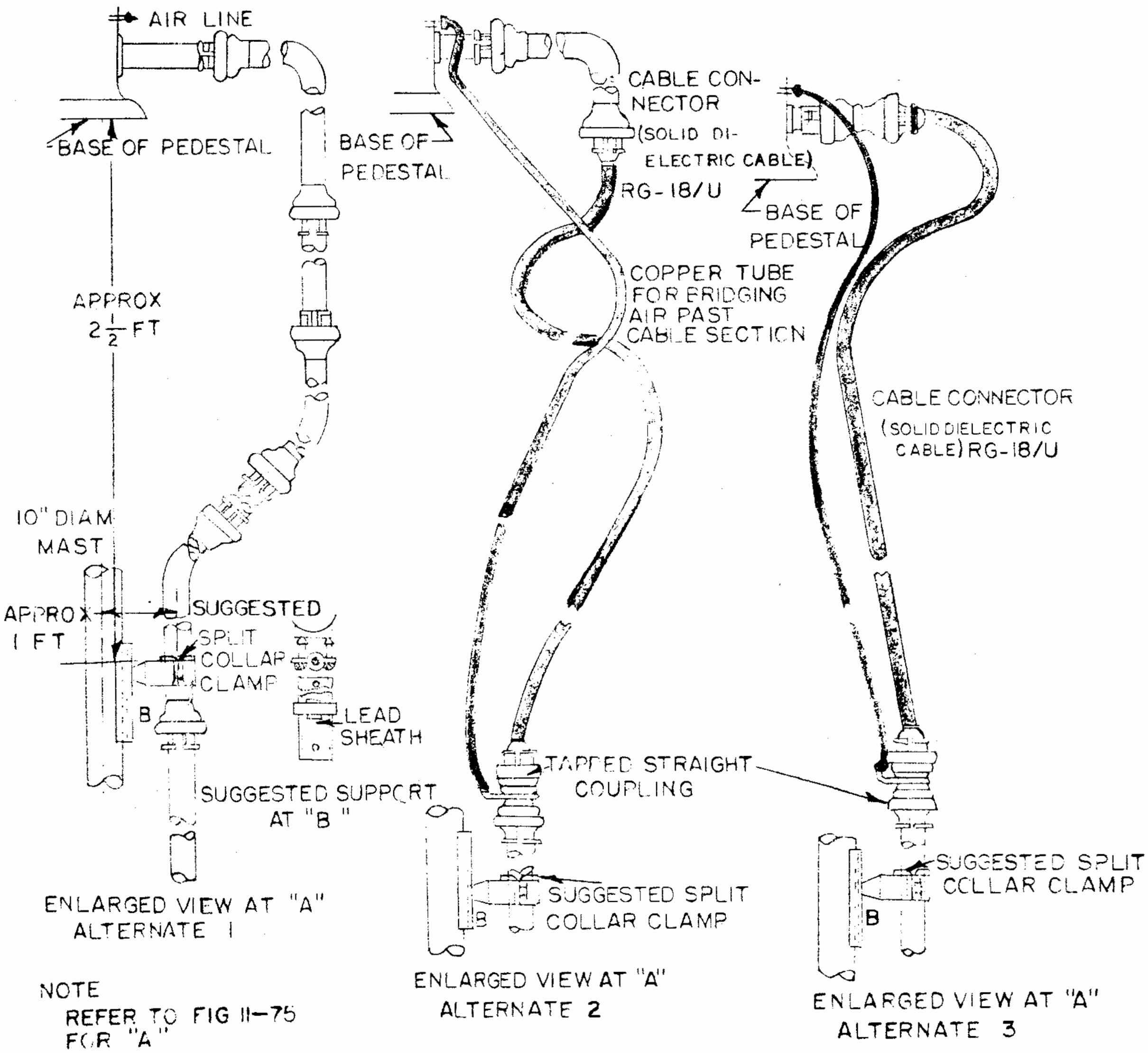


Figure 11-76. Transmission Line Installation

(d) Place the coupling on the end of the transmission line section that has the inner conductor connector in place. The coupling should be pushed onto the end of the line until all of the scribed marks between the first and second pair of insulator ridges are covered by the coupling clamp nut. When the marks are thus covered, the outer conductor is seated solidly against the shoulder in the body of the coupling. See point B on Figure 11-77.

(e) Tighten the clamp nut with pipe wrench until the rubber gland is fully compressed on the outer conductor. When the clamp nut is fully tightened, the scribed marks must remain covered. Tightening the clamp nut applies 150 pounds pressure to the gland follower which transmits this pressure to the rubber gland, making full contact and a gas-tight joint.

CAUTION

Do not use a pipe wrench on the straight transmission line section or on elbow bends.

(f) Tighten the two cap screws which will fasten the clamp nut of the coupling rigidly on the line.

(g) Push the next section of transmission line into the solderless coupling until all of the scribed marks between the first and second pair of insulator ridges are covered by the coupling clamp nut. This will seat the line firmly on the shoulders of the inner and outer connectors of the coupling. Remember to push on the end with a piece of wood to keep inner and outer conductors properly aligned when a short section of line is used. See Figure 11-79.

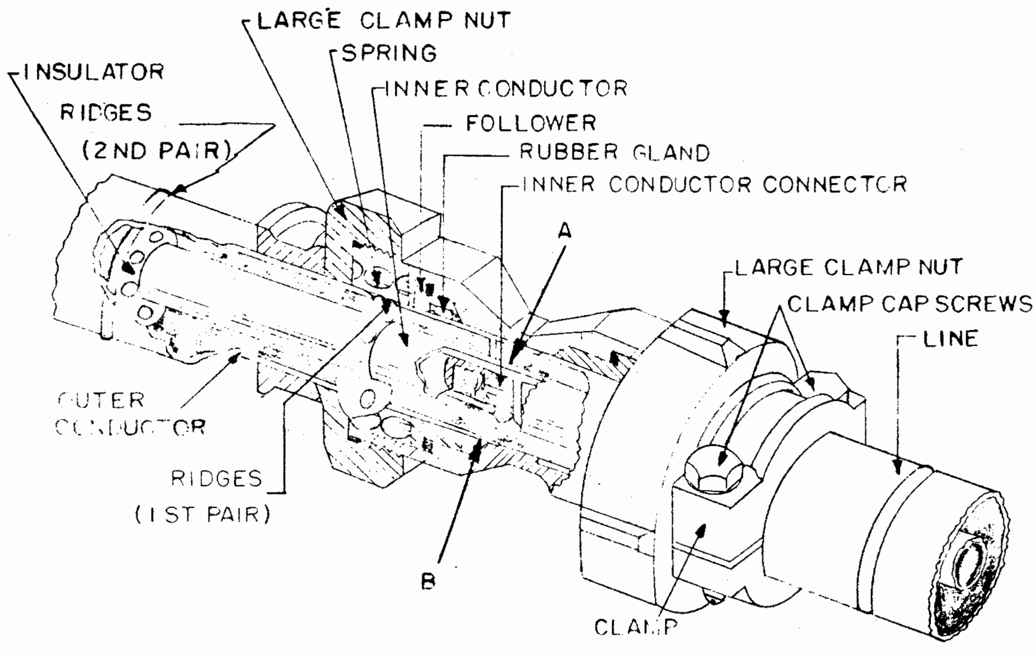


Figure 11-77. Cutaway View of Solderless Coupling Joint

(h) Tighten the clamp nut to its full limit and tighten the cap screws that fasten the clamp nut on the line.

CAUTION

When tightening clamp nuts, do not use a pipe wrench on the section of line or the elbow bends. Using a pipe wrench on the thin walls of these sections will bend or dent them.

NOTE

When solderless couplings are properly installed and the clamp nuts with their clamping cap screws are tightened to their limit, they act as a line brace. It is not necessary to use external bracing around a solderless coupling joint to prevent line sections from pulling out of the couplings.

(2) ELBOW COUPLINGS. - These couplings are shown in Figures 11-69 and 11-70 and must be used wherever turns or bends are made. (The straight sections of transmission cannot be bent.) Elbows are furnished with only one standard length of arm. In all 45-and 90-degree elbows, the arms are about nine inches long including the coupling. Because of its construction, an elbow coupling cannot be cut. As these couplings are the only means of making a bend, never run a transmission line closer than 10 inches to a bulkhead Elbows connect sections of line in exactly the same way as straight solderless couplings.

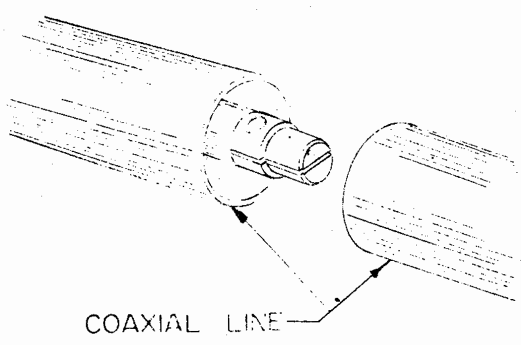


Figure 11-78. Inserting Inner Conductor Connector

(3) ANGLE END-SEAL. - The transmission line is connected into the transmitter through the angle end-seal. The angle end-seal is fastened to the transmitter with a flange that permits mounting at various angles for attaching to the transmission line. The end away from the transmitter is connected to the transmission line through the gas-admission coupling. When a cable connector, Navy Type 62202A (Figure 11-73), is used to connect the angle at the transmitter into the transmission line, no end-seal is needed on the angle connection. See Figure 11-75.

(4) GAS-ADMISSION COUPLING. - The point where the dehydrating unit is to be coupled into the line is usually located near the radar transmitter; the gas-admission coupling is used at this point. It is joined to the transmission line in exactly the same way as a straight solderless coupling. The tube carrying dry air from the dehydrating unit is fastened to one of the 1/4 inch flare fittings with a flare-fitting union nut.

d. BY-PASSING THE CONNECTOR CABLE WITH AIR LINE. - Whenever a complicated turn is made with a connector cable, a straight coupling with tapped holes in the body (Navy Type 49772, Figure 11-68) is used at each end of the connector cable so that a 1/4 inch tube can be connected to by-pass air around the solid-dielectric cable. The by-pass connection is made as follows. Fasten the adapter couplings, attached to the ends of the cable, into the tapped straight solderless couplings connecting the connector cable into the line. In each of the solderless couplings, replace one of the pipe plugs with a 1/4 inch flare-fitting elbow. Connect the two 1/4 inch flare-fitting elbows together with 1/4 inch copper tube. This forms a bridge to by-pass air under pressure from one section to another section of the transmission line. Figure 11-76 shows the joining of the adapter couplings, the straight solderless couplings and the straight section of line. If an adapter coupling is joined to an elbow coupling, it must be run to the next straight solderless coupling past the elbow coupling because the 1/4 inch tubing can only be connected to the tapped, straight couplings.

e. ERECTING TRANSMISSION LINE.

(1) CONNECTING ANTENNA PEDESTAL. -Approved methods of connecting the transmission line to the pedestal are shown in Figure 11-76. Use the method most convenient for the job at hand.

(2) SUPPORTING LINE ON MAST.- Strap the transmission line to the mast with supports of the type shown in Figure 11-76. Attach the supports about five feet apart. Keep the supports at least three inches from all couplings so the line can be taken apart if necessary.

(3) CARRYING LINE THROUGH DECKS OR BULKHEADS.-Use bulkhead fitting as shown in Figure 11-75.

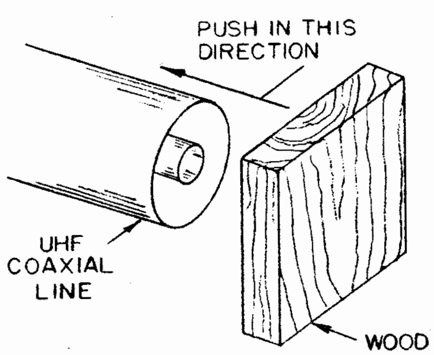


Figure 11-79. Pushing Short Section of Line into Coupling

(4) CONNECTING LINE TO TRANSMITTER.- Install the angle end-seal on the transmitter and to gas-admission coupling to complete the connection between the transmission line and the angle end-seal.

(5) CONNECTING SYSTEM TO DEHYDRATING UNIT. - Measure off a piece of copper tubing about six feet longer than the run from the gas-admission coupling to the dehydrating unit. Coil up two turns, about ten inches in diameter, in the copper tubing so that it may act as a shock absorber between the line and the dehydrator. Connect one end of the tubing to the dehydrator and the other end to one of the valve fittings on the gas-admission coupling.

CAUTION

When connecting the fittings at the dehydrating unit, always use a wrench on the dry-air outlet as well as on the flare-fitting nut.

4. TESTING.

a. TEST FOR CONTINUITY. - When the transmission line is fully installed, test both the inner and outer conductor for continuity with a micro-ohmmeter. There should be a resistance of less than 150 micro-ohms on the outer conductor across individual solderless joints when tested with a micro-ohmmeter. Resistance will read this low or lower when coupling and clamp nuts are properly tightened. Insulation resistance (from inner conductor to outside tubing) should always measure infinity. For this test the inner conductor should be ungrounded. See Figure 11-80.

b. TEST FOR AIR LEAKS.-When the transmission line is fully installed and

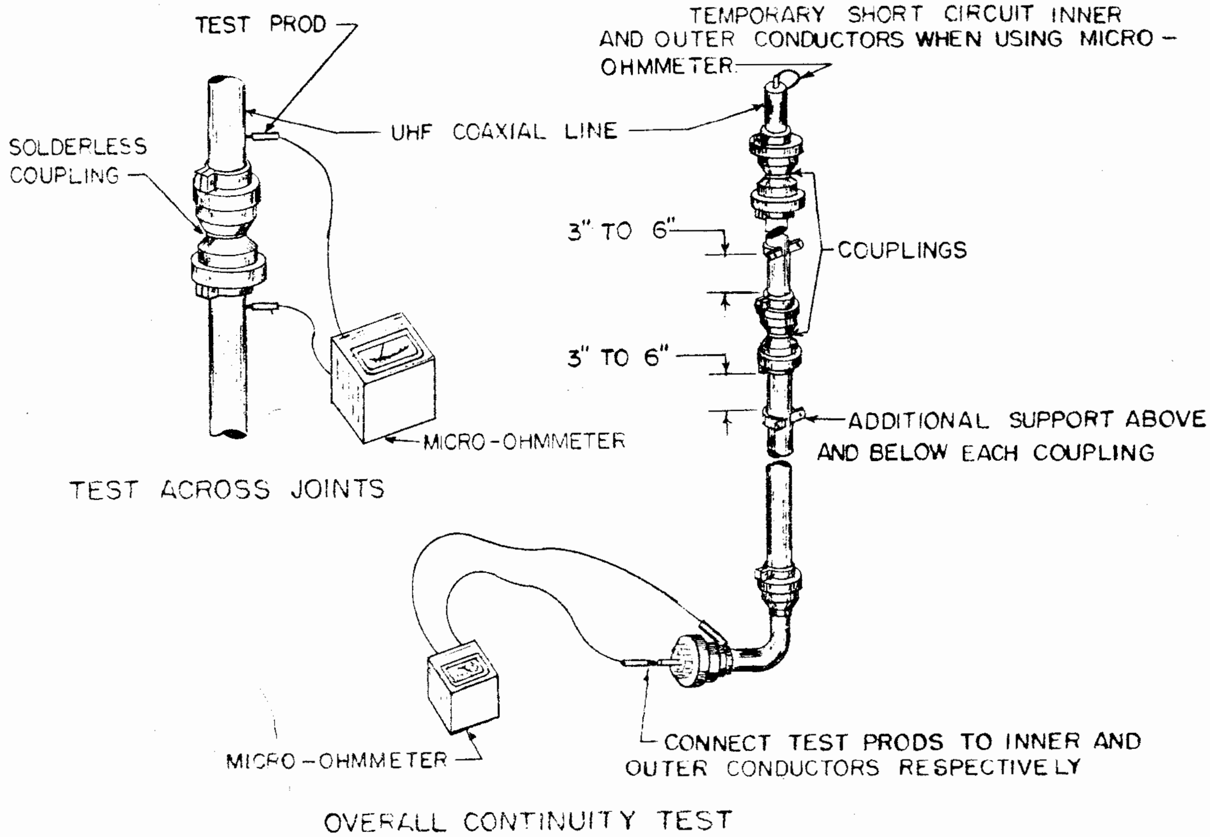


Figure 11-80. Typical Continuity Test Set-Up Using Micro-Ohmmeter

the dehydrating unit is connected, all joints and connections must be tested for pressure tightness. Use the following procedure to check the installation: Start the dehydrating unit and turn LINE PRESSURE regulator valve until gauge on the gas-admission coupling reads 20 pounds per square inch pressure. Shut off the air pressure from the dehydrating unit and note the drop in pressure over a period of one hour. If the pressure drops more than one pound per square inch, examine the transmission line for leaks. Use the Freon-Halide Torch Detector method when testing the installation for leaks.

CAUTION

When using the Freon-Halide Torch Detector method make sure that all Freon gas is expelled from the line after completion of test, otherwise corona will form at insulators causing breakdown.

As an alternate, the liquid soap film method of examining the transmission line may be used. Apply a liquid soap to a connector with internal air pressure in the line and watch for any air bubbles at the leak. If any brazed joint or elbows, solderless couplings, or the gas-admission coupling, show signs of leaking, replace the coupling or the elbow. A properly installed solderless coupling joint will not leak when the large clamp nut is tightened to its limit. If a flare-fitting elbow is found leaking on tube connection, retighten flare union nuts. If it still leaks, wrap a small piece of lamp-wick packing around the swaged end of tube before retightening the flare nut. If the pipe-thread end of the flare-fitting elbow leaks, take off the fitting and put a touch of Insulating Varnish on the pipe threads. When replacing the elbow, tighten down an extra turn over previous setting. If the Insulating Varnish treatment does not stop the leaking, use a new elbow. When the transmission line will hold twenty pounds per square inch pressure without loss of one pound pressure for a period of one hour, it may be considered air tight. Insulating Varnish (SNSN G52-V-1240, 1 pint can; G52-V-1245, 1 quart can).

5. FIRST DRYING OF THE TRANSMISSION LINE.

On the front panel of the dehydrating unit there is a humidity indicator. When the crystals in this humidity indicator are blue, the dehydrating unit is delivering moisture-free air. When it is known that the transmission line is free of leaks, the line must be dried. Proceed as follows to dry the transmission line:

a. Turn the LINE PRESSURE REGULATOR on the front panel of the dehydrating unit until LINE PRESSURE GAUGE indicates a line pressure of twenty pounds per square inch.

b. Open the air-escape valve on the top of the pedestal all the way.

c. Allow the air to escape freely for two hours.

d. Turn the LINE PRESSURE REGULATOR until the LINE PRESSURE GAUGE on the dehydrating unit reads seven pounds per square inch; then lock regulator control with thumbnut.

e. Close the air-escape valve on the pedestal. The line is now dry and ready for use. Operate with line pressure at seven pounds per square inch.

SECTION 11-4B

BEAD-SUPPORTED COAX (STEATITE)

1. INTRODUCTION.

Concentric bead-supported lines have been used because of their good electrical characteristics. Some undesirable factors are: lack of flexibility, difficulty of maintaining air-tightness, and the difficulty of assembly without putting at least one full set of fingerprints on the inner conductor and beads. To anyone used to working with plumbing, the precautions called for in this type of work may seem out of order, but the reasons given below are proof that all the required operations are necessary.

The inner and outer conductors of a concentric bead-supported line are separated by beads. The beads are wax impregnated to reduce water pickup. The insulation resistance and voltage breakdown depend on the insulation and spacing between conductors. A fingerprint on a bead means a low resistance path across the bead. It also means the two conductors are not so far apart, electrically. Arcing begins. The wax of the bead carbonizes, reducing the insulation resistance, and the coax line is out of action. Dirty and greasy cleaning rags can do the same thing. Copper filings and other metal particles are also harmful, in a slightly different way.

Solder globules from careless soldering may do it also. Add water to each of the above and the result is failure of the line. The entire line must be tight. The line must be run and assembled in such a way that water can be removed quickly and conveniently.

2. GENERAL DESCRIPTION.

Two types of Steatite bead-supported lines have been used for transmission lines. One size has an outer conductor diameter of 7/8 inch, and the size of the other outer conductor is 1-5/8 inches.

Because the beads that support the line are made of Steatite, a shock or severe blow can shatter this type of ceramic. Whenever installations are made with this type of transmission line, plan the installation so that the line will stay fairly rigid in spite of mast weaving or shock due to gunfire. Install a removable steel casing where the line might be subjected to mechanical injury.

These lines are strong and a considerable number can be stacked in one horizontal bin. The ends should be closed with paper caps or similar means to keep dust and dirt out. They should be stored in a dry area because the beads can slowly absorb moisture. The lines can be dented and such a dent will probably make the line useless since flashover can occur at that spot. Heavy material should never be placed on top of lines. Be careful in the manner of piling and handling so that the ends are not knocked out of round, as this would make assembly very difficult. Couplings and fittings should also be capped and stored separately, each in its own bin and not adrift on top of the lines.

3. INSTALLATION.

The first step in installing this type of transmission lines is to go aboard the ship and plan the installation run. Include templates of all bends and offsets that are to be made. With this information, the next step is to make the necessary bends of the transmission line.

a. PREPARATION OF THE CONDUCTORS FOR BENDING.— Assuming that the layout of the transmission line has been made, and the position and radius of the various bends determined, remove the inner conductor from the outer sheath and lay them side by side on a long, CLEAN bench.

(1) Lay off, on both conductors, the lengths that are to be curved and straight as the case may be.

(2) The following table will determine the length of the bent portions for various bends.

Radius (Inches)	Bend (Degrees)	Anneal (Inches)
12	90	21-7/8
12	60	15-1/2
12	45	12-1/2
12	30	9-1/4
9	90	17-1/8
9	60	12-1/2
9	45	10-1/8
9	30	7-3/8
6	90	12-1/2
6	60	9-1/2
6	45	7-3/4
6	30	6-1/8

(3) Asbestos tape, soaked in water, should be wrapped around the outer conductor beyond the portion to be bent in order to prevent annealing too much of the outer conductor.

(4) Blow nitrogen through the outer tubing a few moments at a moderate rate (about 10 lb pressure) and then cap the ends at about five pounds pressure. This is to prevent oxidation of the inner surface.

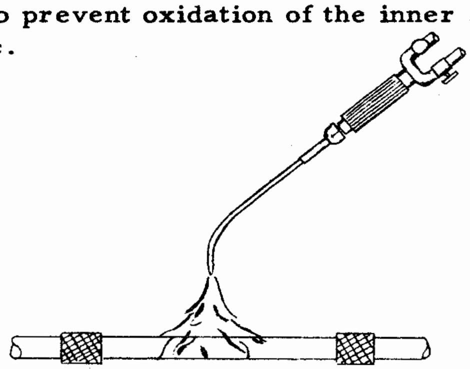


Figure 11-81. Annealing 1-5/8 Inch Outer Sheath by Torch

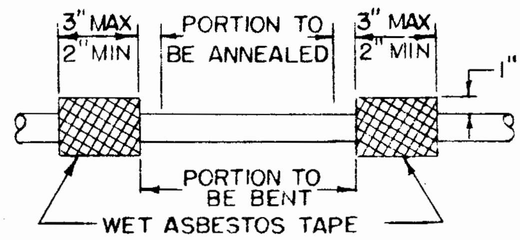


Figure 11-82. Placing Wet Asbestos Tape on Inner Conductor

(5) An ordinary gas flame, or any other clean flame, is then applied to the tubing between the asbestos tapes until it shows a dull red. See Figure 11-81.

(6) The inside of the line should then be swabbed out, first with a wad of steel wool attached to a cloth covered steel snake, then with a clean cloth to remove all loose foreign matter.

(7) Wet asbestos tape should be wrapped around the inner conductor between the pair of insulators adjacent to the ends of the portions to be bent to prevent annealing beyond the desired limits. See Figure 11-82.

(8) The 1/4 inch inner conductor for 7/8 inch coaxial line may be annealed by passing a sufficiently high current through it from either a welding generator or transformer. With this method it is unnecessary to wrap the line with asbestos tape; resulting in a considerable saving of time when a number of bends are to be made. The following data is taken from a typical annealing job on a 1/4 inch inner conductor.

(a) Length of annealed portion, 12-1/2 inches (for 8 inch radius bend).

(b) Distance between connectors, 17 inches.

(c) Distance from either connector to start of annealed portion, 2-1/2 inches.

(d) Current through tubing, 400 amperes.

(e) Time required for annealing, 5 minutes.

The above data will necessarily vary with the terminal voltage and volt-ampere rating of the welding generator or transformer, the size of the tubing, etc. It will be noted that annealing does not start immediately at the connectors, due to their relatively large mass.

The largest tubing that can be properly annealed by this method will depend on the amount of current that can be passed through the tubing.

(9) It is very important to anneal the line before attempting a bend. Annealing makes the metal pliable and easy to bend evenly. If the metal is not properly annealed the bend will be irregular and unsatisfactory. The metal should be cooled in air after heating. To cool it quickly in water would cause tempering and hardening.

(10) After the tubing has been allowed to cool slowly, the outer and inner conductor and insulators must be cleaned thoroughly. A steel "snake" covered with cotton sleeving to prevent scoring the inside of the outer sheath is used to draw a swab of steel wool through the outer sheath. This operation is followed by drawing at least two swabs of cheesecloth to remove any small particles of steel wool that may be left in the line. The cheesecloth swab should be moistened with carbon tetrachloride.

An excellent method of cleaning the inner conductor and beads by means of carbon tetrachloride as it is assembled in the outer sheath is as follows:

A canvas covered "V" trough is positioned horizontally at the edge of the work bench with a pan directly in line and under one end. A hanger on the end of the bench in line with the "V" canvas-covered trough and a trestle at the same level will provide support for the outer sheath. There should be a space between pan and hanger to allow the carbon tetrachloride to dry before the inner conductor goes into the sheath. This arrangement is shown in Figure 11-83. Do not touch the insulators. Contamination of the insulators from sweaty or dirty hands will increase the losses in the transmission line. When preparing the ends of the line for assembly, clean cheesecloth stuffed into the ends of the line will help keep copper particles from entering the line when trimming hacksaw burrs, trimming ends with file, etc. The line should also be tilted so that the particles will fall from the line instead of into the line. Don't forget to remove the cheesecloth.

It is of the utmost importance that lines be kept clean before, during, and after installation. When a section of dirty or dented line is installed in a run, double work will result because it must be replaced on next availability.

There is no substitute for cleanliness in gas-filled coaxial lines.

(11) A hardwood block form of the proper radius for the desired bend must now be made. Various forms are shown in Figure 11-84.

(12) After the line has been annealed, use care in handling the line. Do not lift the line without providing adequate support at several points or it will bend due to its own weight. If the line kinks, it will be ruined. The proper radius of the form for any bend is determined as follows:

R block = R bend (7/16 + 1/8 + 1/16 inch)

where 7/16 = radius of outer conductor.
1/8 = diameter of reinforcing spring.
1/16 = amount allowed for springback of tubing after bending.

b. BENDING THE LINE.— With the line laying flat, full length on the bench, slide the steel spring reinforcement over the end and along the tubing to the position of the proposed bend. Since the spring, in its relaxed state, is a tight fit over the tubing, it is necessary to twist the ends (by means of the projections) in opposite directions so as to expand the spring slightly. The spring must cover every

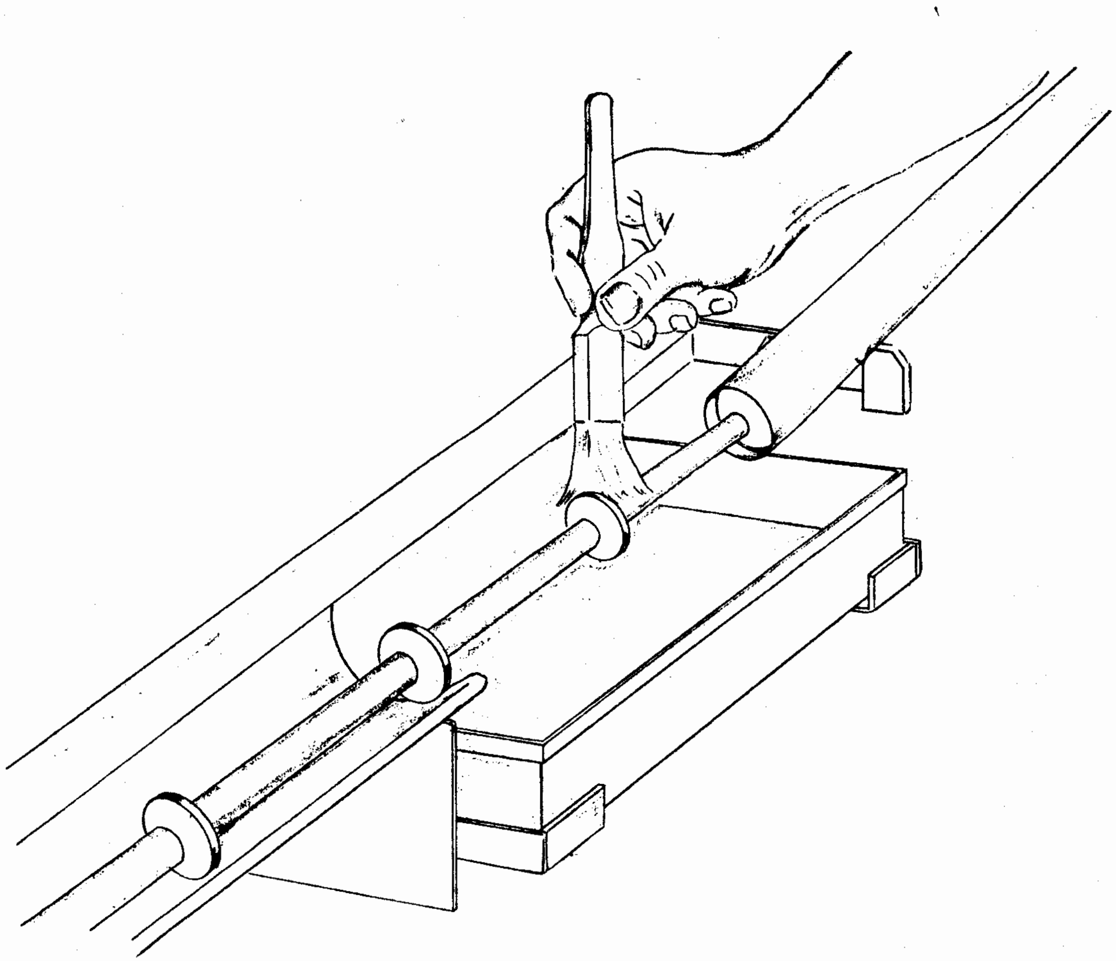


Figure 11-83. Cleaning an Inner Conductor

part of the bend. See Figure 11-85.

(1) With the spring in place, grasp the ends and twist so as to tighten it, thus giving an absolutely tight fit over the tubing.

(2) The wood form is clamped solidly to the bench. An anchor block should also be clamped to the bench to keep proper alignment as shown in Figure 11-86.

(3) The tubing is then pulled around the form by hand, moving the spring along as necessary until the end of the portion to be bent is reached. The final bend should carry the spring one inch beyond the end of the bend, same as at the start. Never use a hammer or mallet to drive the tubing around the form.

(4) The spring is removed the same way it was put on, twist it to expand, and slide it off.

(5) On 90° bends, a six-inch radius is the sharpest recommended for this method of bending the 7/8 inch line. Even on this radius, some slight flattening is produced on the outside knee of the bend, but not enough to affect the electrical characteristics of the line. For 1-5/8 inch line the minimum radius is 24 inches.

(6) As soon as a bent section is completed, the ends should be capped using the caps supplied with the line. If the outer conductor is cut back to allow the inner conductor to project, cap with a solderless coupling. In all cases, the

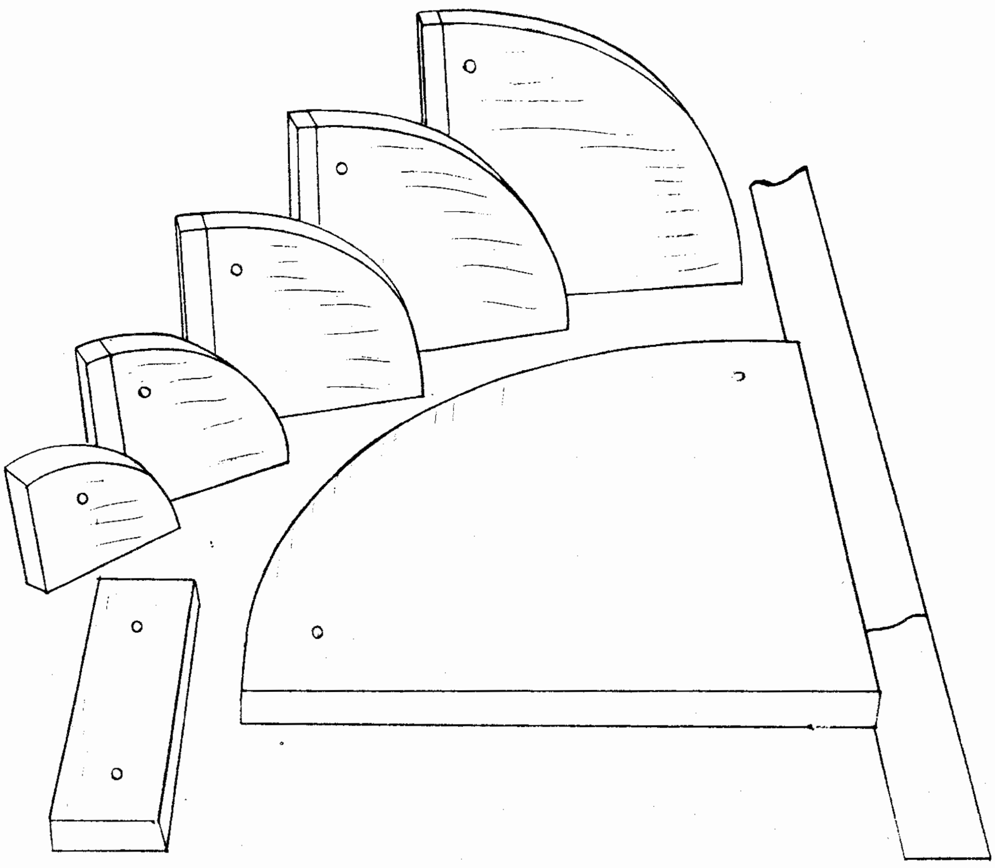


Figure 11-84. Bending Forms of Various Sizes

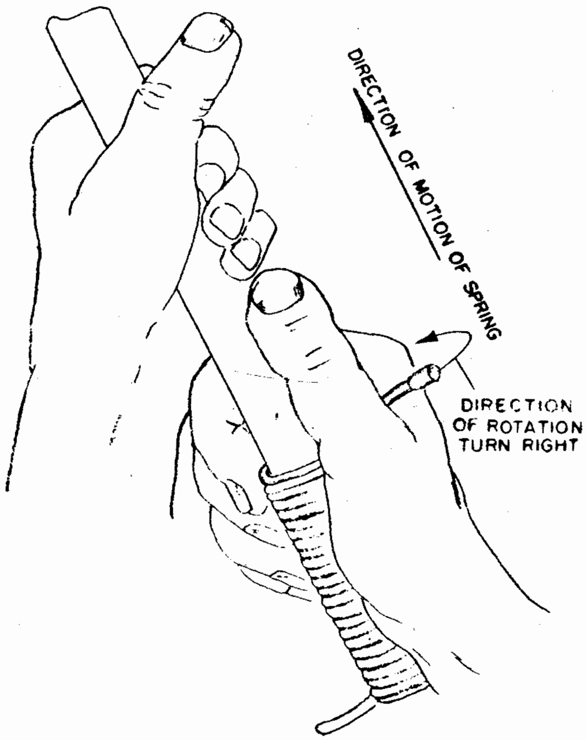


Figure 11-85. Sliding Spring on Outer Conductor

ends must be closed to prevent dirt and foreign matter from entering.

(7) If one end of the line is rigid, the bend nearest that end must be made first. For example, if three separate bends are to be made on one continuous section of line, the bends must be made progressively. Both end bends cannot be made before the center bend is accomplished. The inner conductor recedes slightly into the sheath on each bend.

(8) If the foregoing instructions are followed with care, suitable bends may be made for any coaxial installation. It is well to use as many straight runs as possible to ease replacement in case of battle damage. Whenever practicable, bends and offsets should be made at the desired points in the 20 foot line sections, without cutting. The number of splices and fittings should be kept to the absolute minimum. This reduces the chances for leaks, means lower losses in the line and more power in the antenna.

c. RUNNING AND SUPPORTING COAXIAL LINES.— All coaxial transmission lines should be run so they pitch to the transmitter in such a manner that no water can be trapped in the line. If it is necessary to form a trap because of interference or other reasons, a drain plug should be installed at the low point furthest away from the gas-servicing end of the line. The runs are to be as free from humps and dips as possible. Offset when used, should be run over rather than under obstructions.

All lines should be installed in such a manner as to allow proper access for repairs, servicing and replacement, especially fittings and splices.

(1) STRAPPING THE LINES.— The sheaths of all 7/8 inch coaxial transmission lines shall be thoroughly bonded to the ship's structure at intervals of not more than 18 inches. Strapping between these intervals may be at random to suit mechanical supporting of the line. Suitable tags should be marked with the line

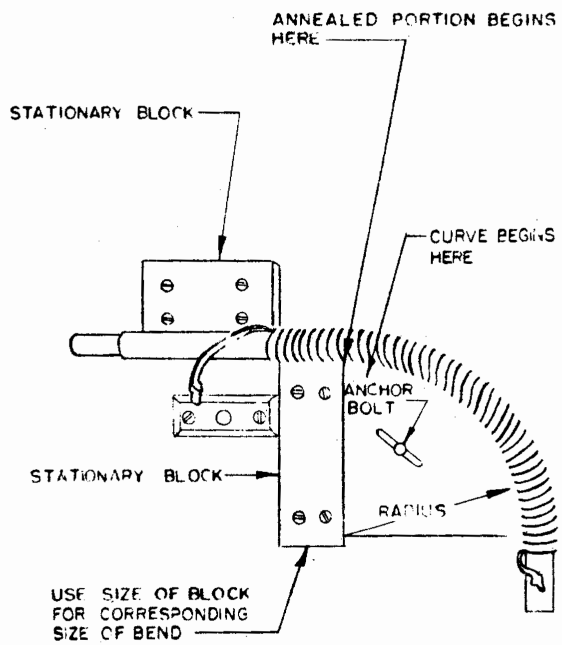


Figure 11-86. Method of Bending Line

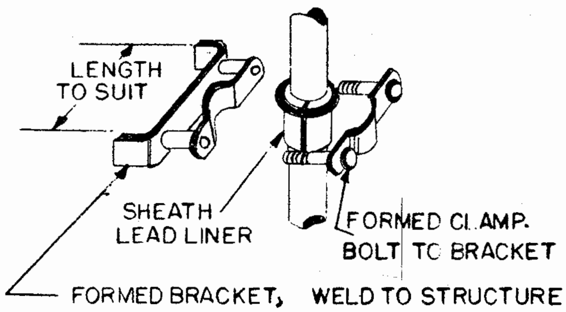


Figure 11-87. Detail of Brackets for Coax Line

designation and placed on the line at not more than 50 foot intervals. The end of the line fitted with a gas-admission line valve is considered as the origin.

The sheaths of all 1-5/8 inch coaxial transmission lines should be bonded to the ship's structure at intervals of not more than five feet. Strapping between these intervals may be at random as mechanical supporting requires.

The contacting surfaces of transmission line sheaths, strap liners, strap hangers and step hangers should be thoroughly cleaned at the time of strapping. See Figure 11-87.

(2) DECK AND BULKHEAD PIPE-SLEEVE CONNECTIONS.— Pipe-sleeve connections to WT bulkheads shall have welds on both sides for double-deck layers. Single weld will do for other WT bulkheads and decks. See Figure 11-88.

(3) ANCHOR JOINT ASSEMBLY.— Recommended for use only on upper ends of long vertical runs and next to short radius bends which end in long straight runs. An anchor joint is not needed next to prefabricated elbows. See Figure 11-89.

(4) 1-5/8 inch FLANGE BRACKETS, COUPLINGS.— Brackets are used on vertical runs with but one exception, on the horizontal run from antenna pedestal to gooseneck. The bridge sleeve should be soldered far enough from the edge of the line so that the solderless coupling may be moved back while inspecting the joint.

(5) GAS SERVICING SOLDERLESS COUPLING.— A gas-servicing coupling should be employed at each of the following points:

(a) At the base of each dip where practicable, or at a splicing point remote to the dip.

(b) At the splicing point nearest the remote end of each horizontal run; e.g., just preceding each hump or vertical run of each line.

The gas-servicing vents should be installed along a 45° line rather than vertically as shown in Figure 11-89 and the slot in the sheath member should be aligned with the lower orifice.

(6) SPLICING AT COUPLINGS.— Solder type couplings will not be used wherever it is possible to use the solderless type.

Cut the inner conductor midway between the beads so as to keep a uniform insulator spacing and cut the sheath according to the dimensions shown in the typical section for the type of fitting to be attached. Use regular large tubing cutter for outer conductor of 7/8 inch line and regular small tubing cutter to cut the 1/4 inch inner conductor. Clean the inner conductor and sheath along the lengths that form part of the splice, using fine sanding tape so that the splicing pin will fit easily. DO NOT USE EMERY CLOTH. REMOVE ALL BURRS AND BRUSH OR TAP OUT ALL CHIPS. (DO NOT BLOW).

(7) ASSEMBLY OF SOLDERLESS COUPLINGS.— To assemble solderless-type sheath couplings, slip the respective coupling sleeve components over the sheaths, unassembled but in proper order. Push them clear of the sheath gap while soldering the inner conductors, then insert the slotted sheath members and contract them just enough to permit sliding the sleeve components into their proper position. Never put a solderless-type coupling on a part of line that has

been annealed because the line is soft and will crease due to the pressure of the coupling.

The soldering of the inner conductor is to be done with 40/60 grade solder, rosin core. Never use other than rosin flux. Use a No. 2-A Thermogrip Electric Soldering Tool for inner conductor connections. For solder-type sheath connections, use a No. 5 tool. Sand each solder joint smooth, and clean with carbon tetrachloride. Test the line insulation resistance, following each splicing operation. On solderless couplings, turn the nuts up tight with the hands (being sure that hand tightness results from normal gland compression and not because of burred threads, cocked gland followers, or foreign obstructions). Then take up an additional half turn only with the aid of an ordinary wrench. Clean the coiled metal armor or other metallic

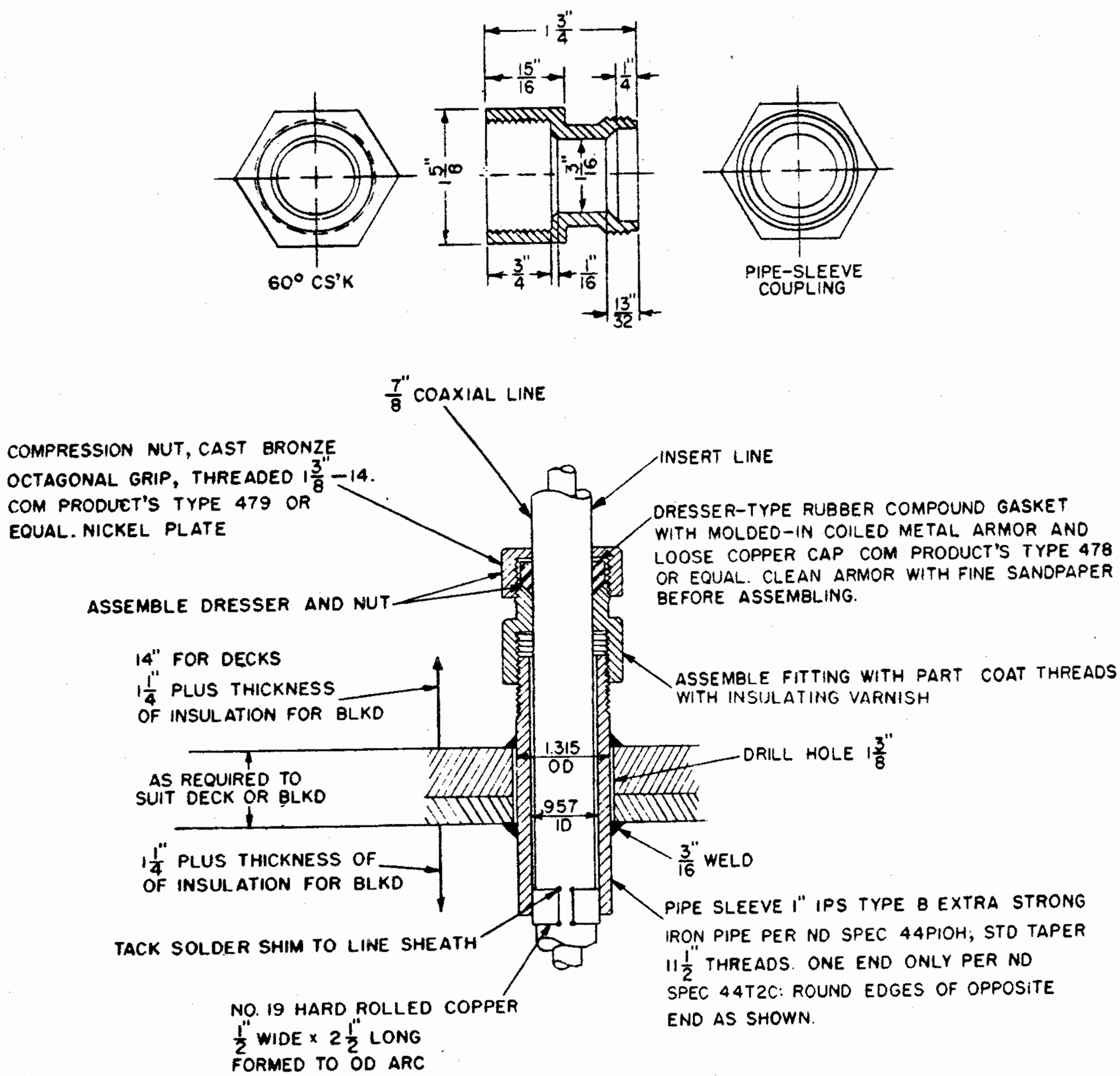
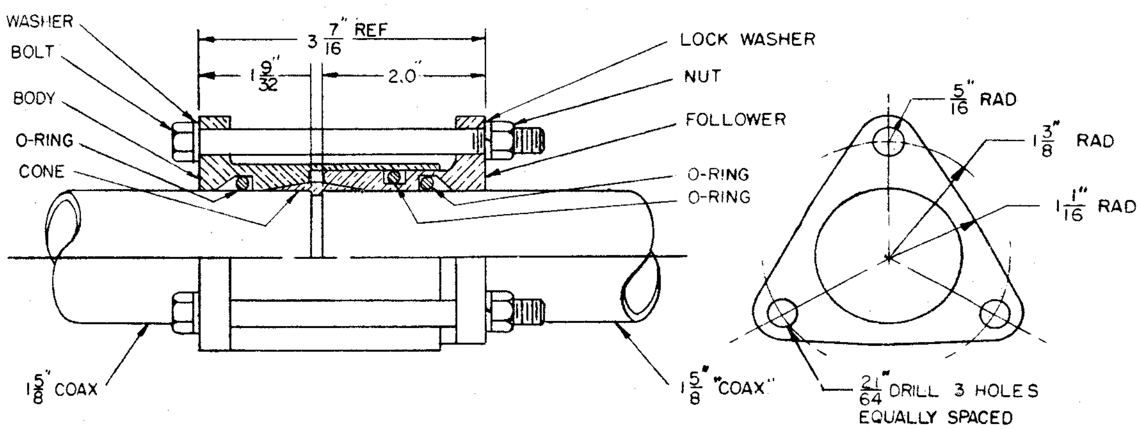


Figure 11-88. Typical Watertight Deck or Bulkhead Connection



ADAPTOR MX—1066/U
RAYBOLD TYPE COUPLING

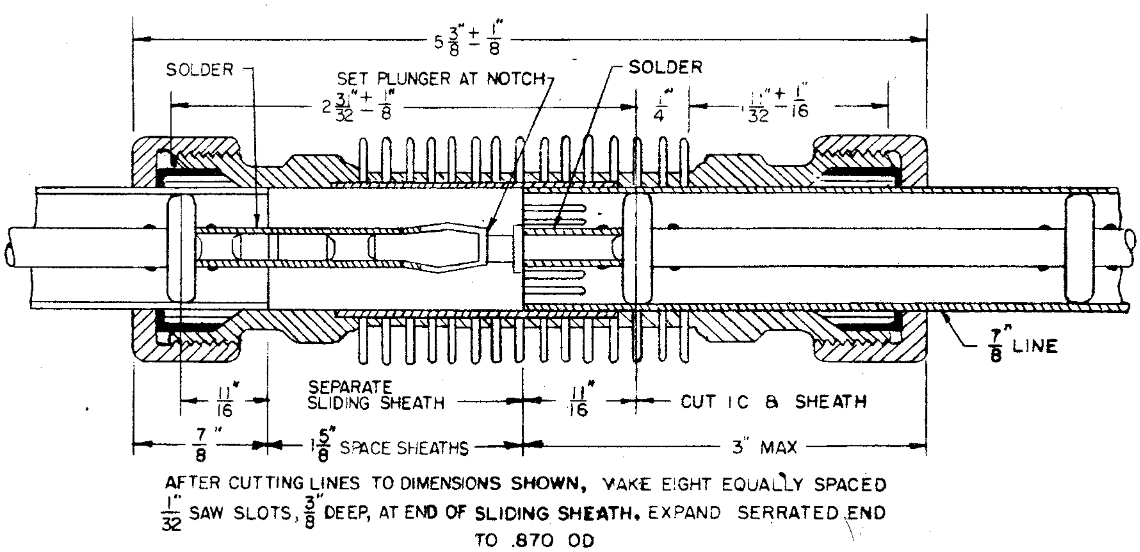


DIAGRAM OF EXPANSION COUPLING

Figure 11-89. Various Type Couplings

contact ring in each rubber gland with fine sandpaper before assembly.

CAUTION

Avoid painting any surface used with rubber glands and compression nuts.

4. TESTING.

After installation and during preventive maintenance, it is desirable to test the line to determine its insulation resistance and dielectric strength.

The insulation resistance of a dry and well assembled line should read infinity on a Megger. If the reading is less than 100 megohms, the line should be dried by purging it with dry nitrogen or air that is known to be dry. If this does not do the job, then there must be dirt in the line, or the beads are in poor condition.

The dielectric strength test is not designed to produce flashover, but to determine if the line can take this minimum value safely. The values are:

7/8 inch line ....5000 volts
1-5/8 inch line ....7500 volts

When running this high-voltage test be sure to follow all the necessary precautions for protection from a dangerous shock. Connect the high-voltage terminal of the transformer through a series resistor as a current limiter to the inner conductor. Always connect the outer conductor to the ground side of the transformer. Someone may be touching the line topside. Build up to the maximum test voltage gradually, at the rate of about 500 volts per second. Keep it there for about a minute, or until sure that the line is not "spitting" somewhere along its length. The resistor is used to prevent the burning of an insulator if a flashover occurs.

If a flashover does occur, it is necessary to take the line down, time permitting. Remove the inner conductor and look for black streaks on the beads, where the arcing may have carbonized a path. Wash all beads well with clean, chemically pure carbon tetrachloride and remove all traces of carbon. Chemically pure carbon tetrachloride is necessary because any other kind may leave impurities on the insulators. Be very careful not to put any new impurities into the line when it is reassembled, such as fingerprints on the insulators.

5. LEAKS.

While a pressure of one pound per square inch in the system is enough to keep the line in operation, 15 pounds per square inch is better. Check the pressure gauge periodically for advance notice of trouble. If the pressure starts to fall off, trouble is indicated.

If a leak is known to exist in the line, the following four methods are described for locating the leak:

a. THE SOAP AND WATER METHOD.- This involves preparation of a soap solution, causing it to froth, and then brushing it around the area suspected to be leaking. This method is good if the leak is large and the gas escapes rapidly. Otherwise, the soap dries up before bubbles can be noted, a matter of a few minutes.

b. THE FREON GAS METHOD.- This involves forcing a small amount of Freon gas into the transmission line through the compressor intake, then in about ten minutes to one hour (depending on the size of the leak) looking for the leak using a Halide detector. This is aboard every vessel having refrigeration equipment as standard allowance. The various makes of detectors include the "Turner Torch", the "Prestonite", the "Frigidair" and the "Justrite". The torch is lit, and the intake end of the air intake tube, a flexible rubber tube, is used as a probe for the leak. The pressure of escaping Freon is shown by a rapid and distinct change of the color of the flame from yellow or blue to a bright green. The test is very sensitive and very fast. When the color changes, the test is over as this change is positive evidence of the presence of a leak. There is no danger to personnel involved in the use of this equipment.

When the whole line has been checked for leaks and sealed off, the line is purged thoroughly by opening the escape valve at the top of the line and blowing dry nitrogen from a cylinder or compressed air from the compressor through until the Halide tester used for checking at the escape valve shows no trace of Freon. The Freon should not be used when the line is operating, because in the event of an arc, the resultant gases will reduce the breakdown strength and insulation resistance of the line.

c. THE LACQUER METHOD.— This involves brushing the lacquer (polystrene cement, red glyptal lacquer, etc.) in a thick layer around the area suspected to be leaking. This method is good for slow leaks; the presence of the remaining lacquer helps seal off minor leaks in the future. The presence of a leak is shown by the formation of a bubble which finally hardens. The lacquer method is better than the soap in that when it dries, the bubble retains its shape and does not collapse as does the soap bubble. Hence, it is not necessary to stand by each brushed spot until certain. All suspicious points may be treated, and then a check made to find the trouble spot.

d. THE FENOX METHOD.— This involves the use of Fenox, an electrical sealing compound of plastic consistency. The material is formed into a sheet which is wrapped and lapped around the line just below the suspected joint and shaped as shown in Figure 11-90. Water is poured in until the level is above the joint. Leaking gas shows itself by the formation of bubbles. To empty, form a lip as shown by the dotted lines of Figure 11-90, drain water, and remove Fenox from the line for re-use. (Dry to original plasticity before re-use). Fenox is an electrical sealing compound manufactured by Halowax Products Divisions of the Union Carbon & Carbide Corporation, 30 East 42nd St., New York City, New York.

In each case, the leaks are more easily found if the line pressure is increased to 30-35 pounds per square inch.

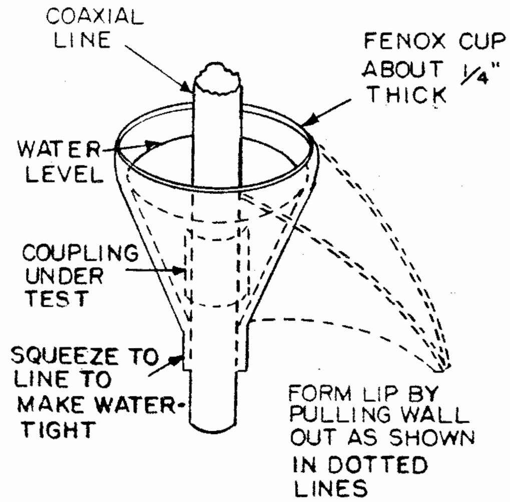


Figure 11-90. Method of Testing for Leaks using Fenox

6. GENERAL NOTES.

Soldering operations must be done with care. A good soldered joint is one that is both mechanically and electrically secure. It is very important to avoid the building up of excess solder on the inner conductors of lines, since it tends to build up the diameter and change the characteristics of the line. Solder falling into the line and resting on the inside of the outer conductor must be avoided, but more harm results from excess solder on the inner conductor.

A minimum spacing of 18 inches should be preserved between all coaxial transmission lines and any surface hotter than 232° C (450° F). Where subject to high or rapidly changing ambient temperatures, they may be covered with non-absorbent pipe insulation and covered with No. 22 USG (0.0312 inch) sheet steel. Where such treatment is used, removable sections should be provided to extend at least 3-1/2 inches beyond each side of all line couplings (6 inches in the case of expansion couplings) with sufficient clearance inside to permit free movement of the expansion joint. All lines should be installed in such a manner as to allow proper access for repairs, servicing and replacement, particularly with regard to all line splices and fittings.

7. TOOLS.

The most useful tools are listed as follows:

a. Tools used on installation of 1-5/8 inch coaxial lines.

(1) 30 amp tong transformer for soldering conductor, solder joints and bridge flange.

(2) 10 amp tong transformer for soldering inner conductor for splicing mechanical pins.

(3) Springs and wood blocks for bending of 1-5/8 inch lines.

(4) Gas torch for annealing outer conductor.

(5) Welding transformer for annealing inner conductor.

(6) Large tube cutter (similar to plumbing pipe cutter).

b. Tools used on installation of 7/8 inch coaxial line.

(1) 10 amp tong transformer for soldering outer conductor.

(2) Soldering iron for soldering inner conductor.

(3) Spring and wood blocks for bending.

(4) Welding transformer for annealing inner conductor.

(5) Gas torch for annealing outer conductor.

(6) A small tube cutter (similar to plumbing pipe cutter).

c. Additional equipment used:

(1) Carbon tetrachloride used for cleaning inner conductors.

(2) Steel wool and cheesecloth used for cleaning outer conductor.

(3) Sand cloth (do not use emery cloth).

(4) Solder, 40/60 grade.

(5) Asbestos tape.

(6) Nitrogen flasks.

(7) Round wooden plugs for sealing ends of outer conductor during annealing operations.

(8) Hacksaw.

(9) Miscellaneous common electrician's tools.

(10) Flat mill file, 10 inch.

(11) End caps for sealing 7/8 inch or 1-5/8 inch line.

(12) Pressure gauge (0-20 lb scale) to fit joint.

(13) T-joint to fit 7/8 inch or 1-5/8 inch line.

(14) Gas inlet valve for T-joint.

SECTION 11-5

STUB-SUPPORTED COAXIAL LINES

1. GENERAL DESCRIPTION.

Stub-supported coaxial lines are the most efficient concentric lines because they do not contain any dielectric except air or, if pressurized, an inert gas. But they are not as efficient as waveguides. That is why they are not used on new installations of radar equipments.

The only stub-supported coax line used extensively has been the 7/8-inch size. Descriptions and figures in this section relate to this size; information on other sizes will be found at the end of this section in Tables 11-3 and 11-4.

A stub-supported coaxial line is made up of an outer conductor of brass tubing, and an inner conductor of copper tubing supported by stubs as shown in Figure 11-91. Minimum losses occur when the inner conductor of the stub is exactly one-quarter wavelength of the operating frequency. This is because the energy reflected from the shorted end of the quarter-wave stub is exactly in phase with the energy in the main line. So it is important that the stubs be exactly one-quarter wavelength long; if a line is to be operated with equipment having a broad band-width characteristic, the stub length should correspond to one-quarter wavelength for the frequency in the middle of this band.

Any coaxial line has a certain impedance, determined by the size of the inner conductor and the space between the inner conductor and the outer wall. To have constant impedance, it is very important that the inner conductor be perfectly centered inside the outer tubing and that no globs of solder or dents exist in the line.

Figures 11-92 and 11-93 show the right way to assemble and install stub-supported coax.

2. CUTTING.

When it becomes necessary to use less than a full length of line, several details must be observed very carefully in cutting the line:

a. Cut the inner and outer conductors to the same length. Be sure ends are cut off square.

b. Remove all burrs.

3. INSTALLING COUPLERS.

Whenever a coupler is used, be sure to allow for the length of the coupler. Each coupler takes one inch of length; so the line must be cut one inch short of the full distance to allow for the coupler. After the line is cut, install the coupler as follows:

a. Soft-solder the bullet into the inner conductor at the male end of the connection.

b. Slide a locking ring onto each section of line.

c. Push one of the mated coupling flanges onto the end of each outer conductor. Be sure the flange is all the way on so that it is tight against the end of the outer conductor.

d. Soft-solder the flanges to the outer conductor. Be sure to solder all around.

4. INSTALLING LINE.

For proper electrical performance, the following rules should be strictly observed.

a. There should be no bends in the lines, although slight offsets such as

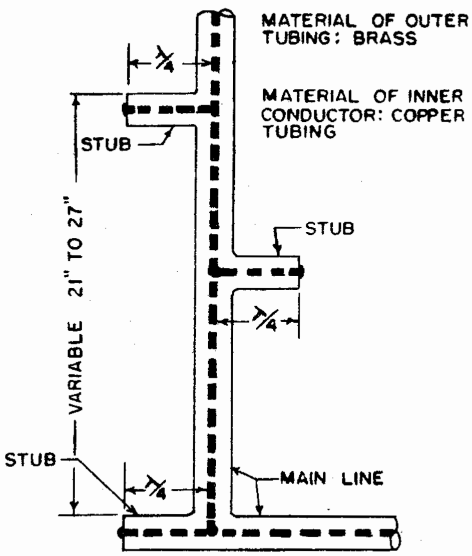


Figure 11-91. Stub-Supported Coaxial Line

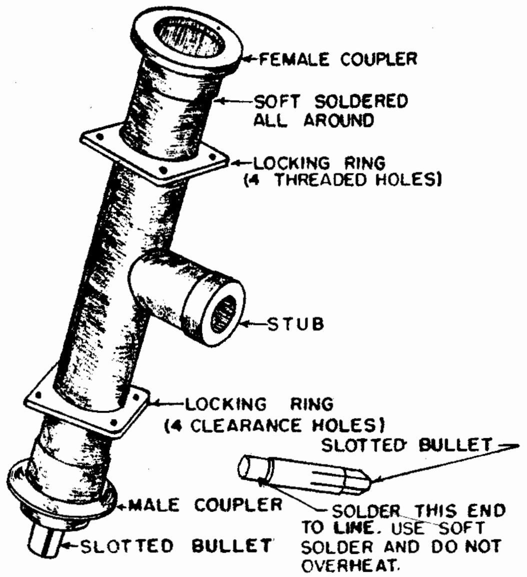


Figure 11-93. Stub-Supported Coaxial Line Coupler.

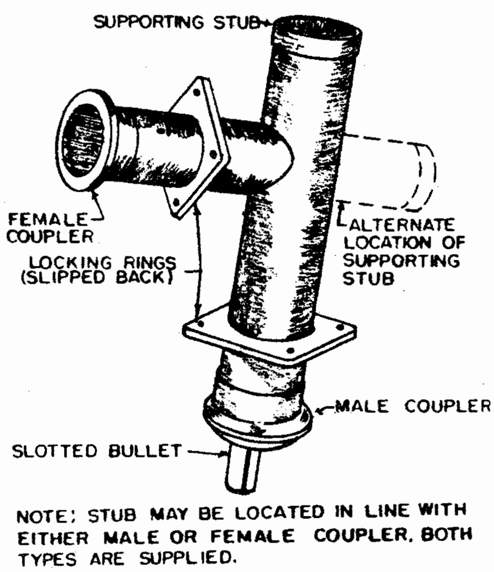


Figure 11-92. Right-Angle Stub-Supported Coaxial Line

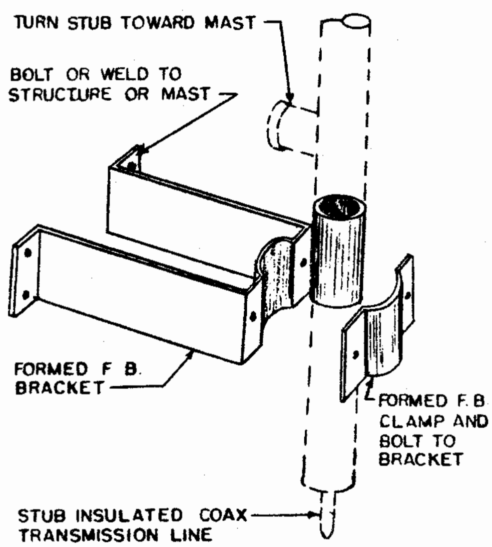


Figure 11-94. Details of Hanger for 7/8 Inch Line

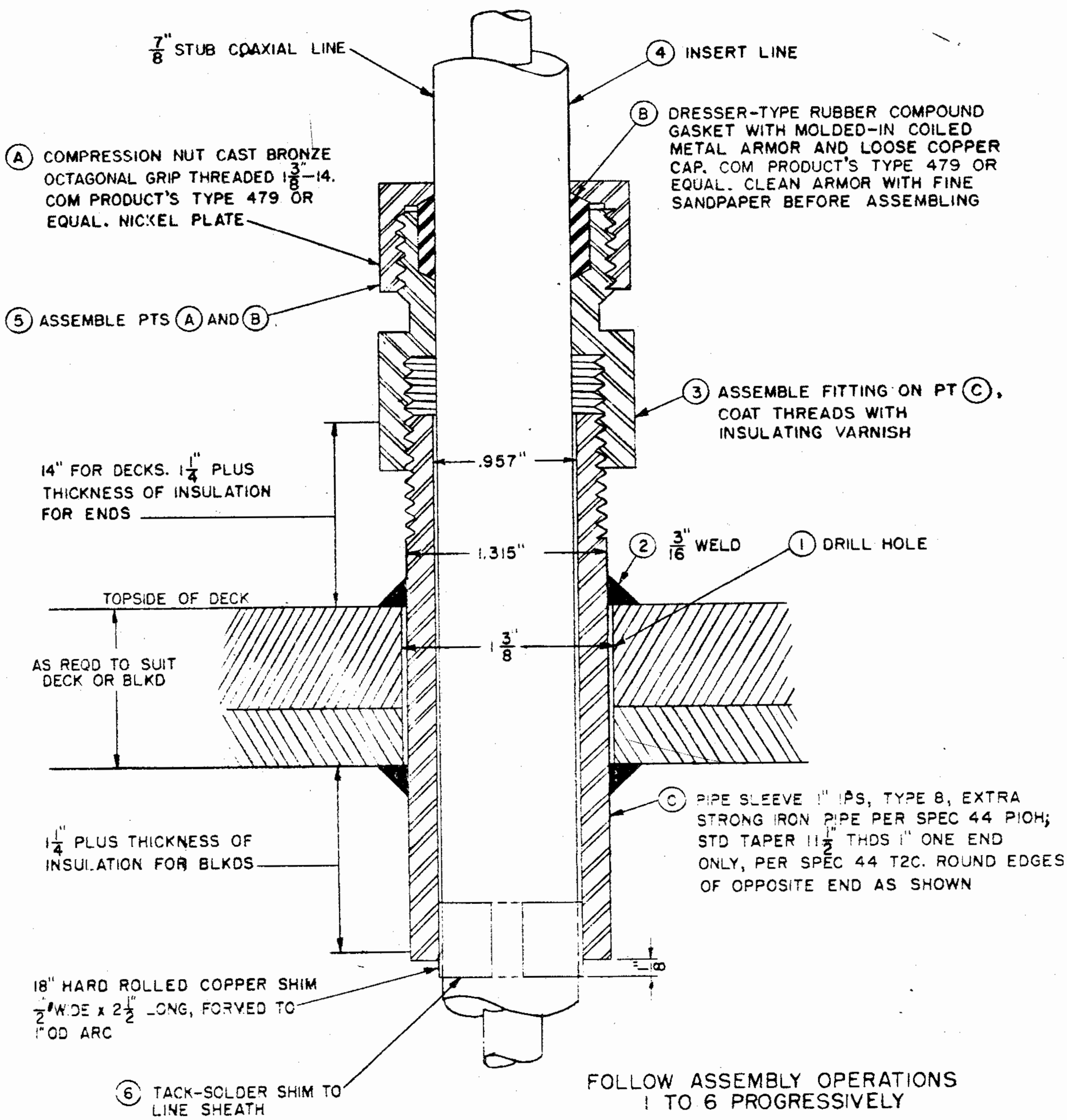


Figure 11-95. Method of Passing Line Through Decks and Bulkheads.

required to follow the rake of the mast are permissible.

b. Before securing sections of lines, the ends of the lines must be carefully cleaned and the slotted bullet must be sprung open so as to make firm contact into the 3/8-inch OD tubing of the section.

c. In coupling two flanges together, the faces should be drawn together tightly. (The design of the coupler and the coupling ring assembly assures that the two faces will be drawn together evenly.)

d. There must be no dents or bumps of any kind on the inner wall surfaces of the outer conductor or the outer surface of the inner conductor. Special attention must be taken to be sure that no sharp edges result from poor cutting or poor fit, and that solder globules are avoided.

e. The line should be fastened to the mast or structure as shown in Figure 11-94.

f. When the line is passed through a deck or bulkhead, the method shown in Figure 11-95 will insure a watertight job.

CAUTION

Use extreme care in handling and installing stub-supported lines. Make sure that the line is not distorted, twisted or bent before and after installation. Never install the line in an area that may expose it to future damage unless a shield or protective hood is also installed. Never have a stub hanging below the line, either in a horizontal run or at a right-angle bend. A stub full of condensed moisture will cause serious energy losses.

The following tables list types of stub-supported coax lines and couplings:

AN TYPE	OD SIZE (inches)	NOMINAL IMPEDANCE	OUTER WALL THICKNESS	DIAM INNER CONDUCTOR	INNER WALL THICKNESS
	5/16	50 ohm	0.025	0.125	0.032
RG-47/U	1/2	50 ohm	0.032	0.1875	0.032
RG-76/U	5/8	50 ohm	0.032	0.250	0.022
RG-44/U	7/8	50 ohm	0.032	0.375	0.032
RG-45/U	1 1/4	50 ohm	0.049	0.500	0.032
RG-46/U	1 5/8	50 ohm	0.049	0.625	0.035
	7/8	70 ohm	0.042	0.250	0.032
	7/8	70 ohm	0.032	0.250	0.022
	7/8	70 ohm	0.045	0.2187	0.032

Note 1: All above coaxial lines are made of brass.
Note 2: All above coaxial lines are weatherproof.
Note 3: In ordering - specify location of stubs and length of stubs.

Table 11-3. Stub-Supported Coaxial Lines

AN TYPE	NAME	SIZE LINE (inches)	FOR USE WITH RG- /U	ANRFCCC or NAVY DWG NO.	ARMY OR OTHER DRAWING NO.
UG-43/U	Male	1/2	47	RE49F209	M. I. T. B-4386
UG-44/U	Female	1/2	47	RE49F209	M. I. T. B-4386
UG-140/U	Male	5/8	76	RE49F271	Sperry R-5221832 R-5221833
UG-141/U	Female	5/8	76	RE49F271	R-5221941 R-5221945 R-5221942 R-5221946
UG-45/U	Male	7/8	44	RE49F210	C-1973
UG-46/U	Female	7/8	44	RE49F210	C-1973
UG-47/U	Male	1 1/4	45	RE49F211	B-4460
UG-48/U	Female	1 1/4	45	RE49F211	B-4460
UG-49/U	Male	1 5/8	46	RE49F212	B-2168
UG-50/U	Female	1 5/8	46	RE49F212	B-2168
	Male	5/16			C-2357
	Female	5/16			C-2368

Note 1: All above couplings are weatherproof.

Table 11-4. Couplings For Stub-Supported Lines

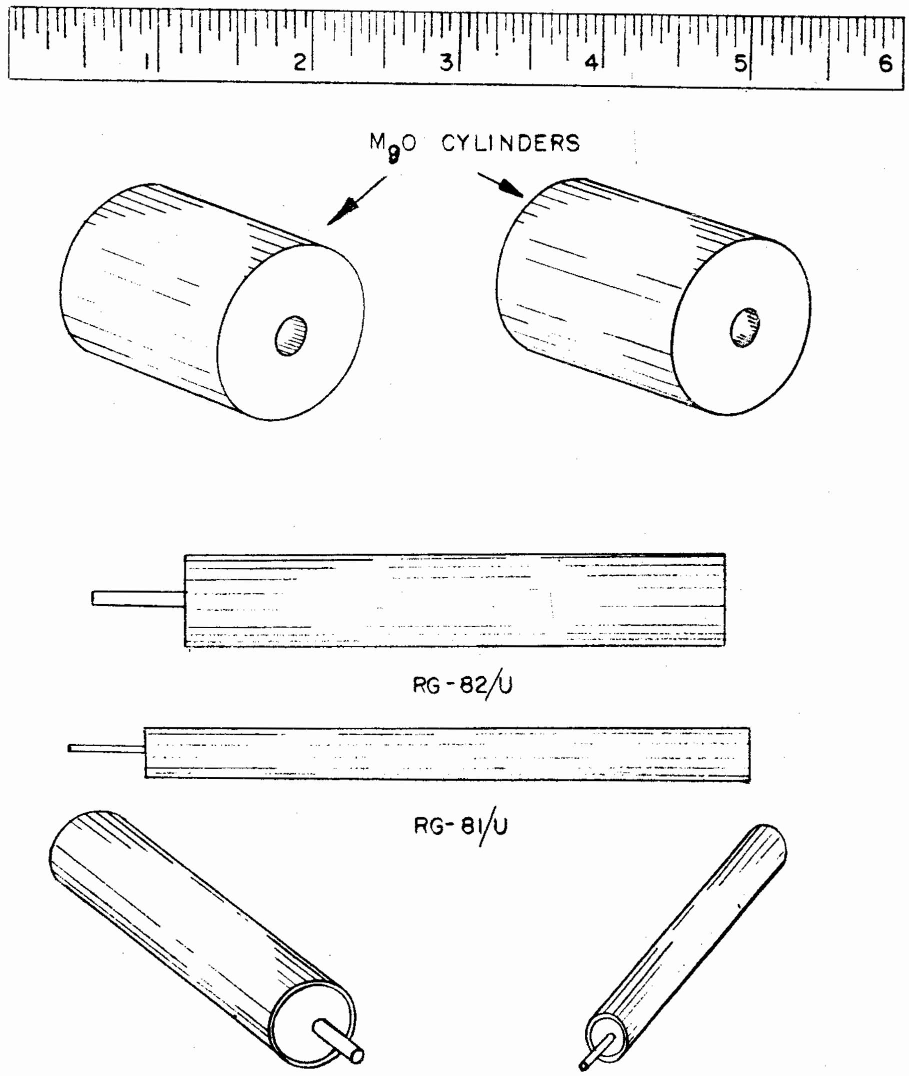


Figure 11-96. RG-81/U, RG-82/U and Magnesium Oxide Cylinders

SECTION 11-6

PYROTENAX CABLE

1. INTRODUCTION.

Pyrotenax coaxial RF cables, shown in Figure 11-96, have a solid copper inner conductor, a seamless copper outer conductor, and a tightly-packed powdered magnesium oxide dielectric. They are fireproof and pressure-proof, and are designed for installations where these properties are important. Two sizes are available, RG-81/U and RG-82/U; each has a characteristic impedance of 53 ohms. Special handling and installation methods are required for bending, clamping, cutting, brazing and splicing. RG-82/U cable can be used at a maximum peak voltage of 8,000 volts, if certain precautions are observed when assembling fittings to the cable.

Pyrotenax combines the advantages of solid dielectric flexible cables with the fireproof quality and resistance to high temperature of stub- or bead-supported lines.

2. GENERAL DESCRIPTION.

a. Some important electrical characteristics of Pyrotenax are listed below:

(1) The corona voltage and dielectric strength ratings are higher than those of equal size air- or gas-filled lines but much lower than those of Polyethylene-dielectric cables of equal size.

(2) The dielectric constant is fairly high (about 3.5).

(3) The conductor DC resistance is slightly higher than in Polyethylene-dielectric cables with the same dielectric diameter.

(4) The power factor is about the same as that in Polyethylene-dielectric cables.

(5) Electrical shielding of the inner conductor is practically perfect.

(6) Attenuation at UHF transmission is higher than in Polyethylene-dielectric cable of equal size, and power loss is increased by the standing waves set up by irregularities in the construction of the line. This is serious at UHF and makes the line hard to match to a load or generator.

b. Some points to keep in mind when installing or working with Pyrotenax are itemized below:

(1) The insulation resistance is very good if the dielectric is kept dry. If the insulation gets wet or is exposed to air for long periods, the cable is useless.

(2) Pyrotenax is somewhat hard to install.

(3) Maintenance is easy if the original installation was good, but Pyrotenax is hard to repair if cut or damaged.

(4) Mechanically, it is fairly strong but the copper jacket is soft and can be easily nicked or dented.

(5) The ends must be sealed against moisture, even in storage. However, the sealing process is quite simple.

Pyrotenax is non-inflammable and fire-resistant, but the connectors, end seals, and other fittings are not always fire-resistant.

The resistance to heat is excellent, and only oxidation of the copper limits the operating temperature. For this reason, it should not be subjected continuously to temperatures over 250°C (480°F). This cable may be heated for a short time to a temperature near the melting point of copper, 1083°C (1982°F), without damage. The magnesium oxide dielectric is not likely to be seriously damaged since its melting point is 2800°C (5097°F). It can be bent fairly sharply but should not be bent back and forth repeatedly.

3. INSTALLATION.

a. MEASURING INSULATION RESISTANCE.—The most important single fact about the use of Pyrotenax is that it must be kept dry. Moisture in the magnesium oxide may be detected by measuring the insulation resistance between the inner and outer conductors. This measurement is best made by use of a megohm meter with a 500- or 1000- volt generator. See Figure 11-97.

b. DRYING.—If the insulation resistance of a piece of Pyrotenax does not measure infinite, the cause is probably moisture. Magnesium oxide is hygroscopic and if exposed to air, it absorbs enough moisture in to make the line temporarily useless. However, the

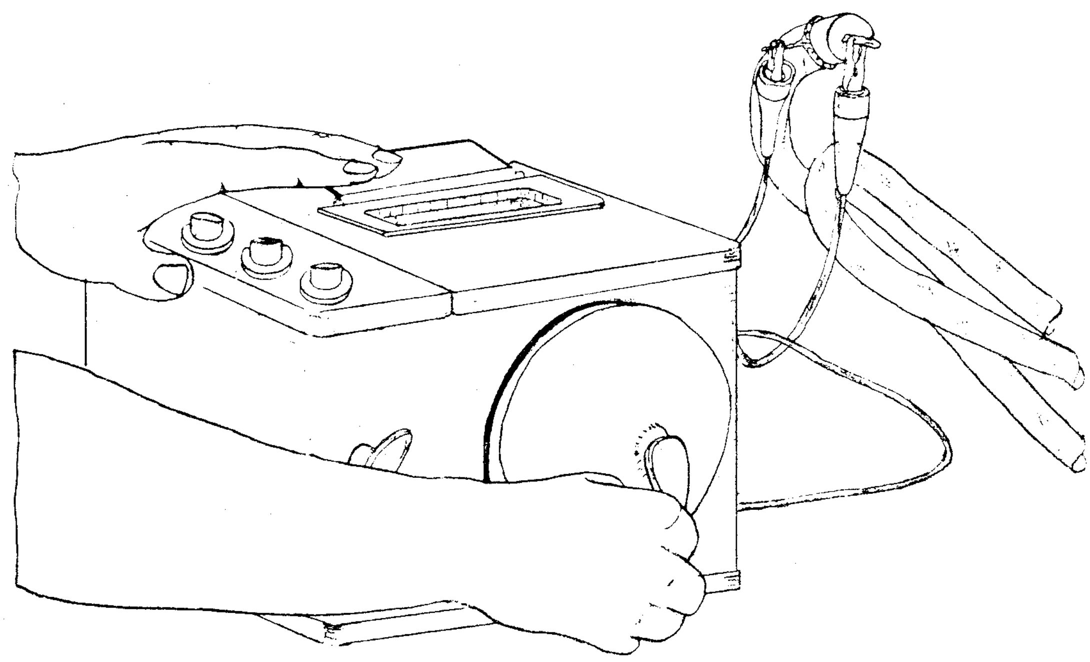


Figure 11-97. Testing Pyrotenax Cable for Insulation Resistance with a "Megger"

moisture can be driven off by applying heat near the exposed points.

For heating, a small Prestolite torch is recommended. Any torch other than Prestolite may burn through the copper sheath. The flame should be played directly on the outer conductor, about three inches from the end, heating evenly until the copper shows colors. See Figure 11-98. The cable should be kept hot for about five minutes. The resistance will decrease at first, but will rise slowly and continue to rise long after the heating has been discontinued. Usually, if the resistance is about 20 megohms when hot, it will measure infinite when cool if the moisture was in the part heated. If both ends have been exposed, both must be treated. If the insulation resistance still measures less than infinite, the process must be repeated; in this case, heat must be applied to six inches of each end, or more if necessary.

When the open end of Pyrotenax is exposed to air moisture penetration depends mainly on the humidity and the length of time exposed. If under water the penetration depends on pressure as well as on the time factor. Thus, in the case of a piece of RG-82/U with a leaky end seal, installed on a submarine for over two months, 18 inches had to be cut off, and moisture was found to have penetrated a few inches beyond that. Exposure to air alone seldom results in more than six inches of moisture penetration. In one test, RG-82/U was subjected to 1000 pounds per square inch in water for a few minutes; moisture penetrated only about four inches.

Flame should not be played directly on the magnesium oxide as it will crack under excess heat and may be chemically changed by the flame.

c. SEALING.—The dielectric should not be exposed to air for more than three or four hours without sealing. There are several methods for sealing, the particular method used depending upon what is to be done with the cable afterwards.

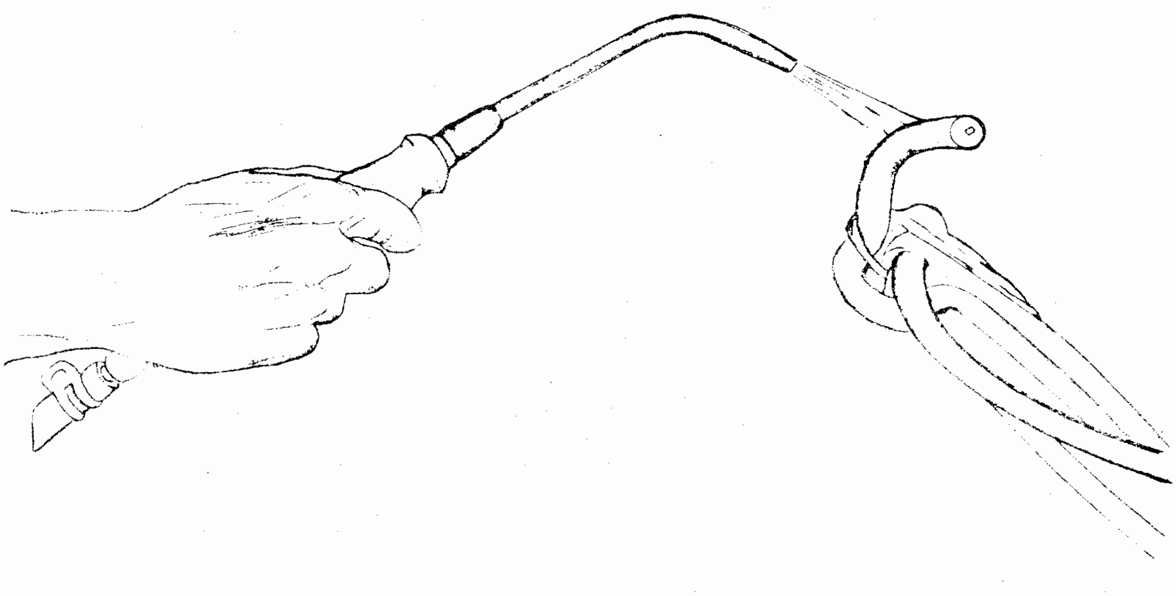


Figure 11-98. Drying Out End of Pyrotenax Cable with Prestolite Torch

Pyrotenax "breathes" considerably when heated, as there is gas in the spaces between the particles of magnesium oxide powder. There is a considerable delay, sometimes as much as 20 minutes, between the time the heat is removed and the time the "exhaling" stops. For this reason, the cable should not be sealed immediately after heating. If the sealing material bubbles when a thin layer is applied to the dielectric, the seal should not be completed until the bubbling has stopped. It is best to seal when the cable is "inhaling", while it is cooling, as the sealing material is thus pulled into very good contact with the dielectric.

Among the materials that may be used for sealing are pitch, beeswax, rubber cement, and polystyrene-base coil dope. The latter has the advantages of having low electrical loss and requiring only a thin film, and is recommended in most cases where good electrical characteristics are needed. (See method described in Paragraph 4, NOTES ON AFFIXING FITTINGS TO RG-82/U FOR HIGH VOLTAGE SERVICE). If coil dope, rubber cement, or similar materials are used, three or four coats should be applied.

If Polyethylene, beeswax or pitch is used, the dielectric should be reamed out for about a half inch. Special reaming tools (Figure 11-99) have been designed for this purpose. (Drawings for these tools appear in Figures 11-100 and 11-101.) Figure 11-102 shows a reaming tool that can be made for use with a slow-speed electric drill to ream out the dielectric. If these tools are not available, the dielectric can be dug out with a screwdriver or similar tool. The inner conductor should not stick out beyond the outer conductor as any blow received by the inner conductor may crack the seal.

All sealers should make a good bond to cleaned surfaces on the inner and outer conductors as well as on the dielectric. If the dielectric has been reamed out and is not flush with the ends of the conductors, the conductors should be cleaned with emery cloth and/or a rag dampened with carbon tetrachloride. All particles of dielectric should be removed from the place where the sealing agent is to make contact. A water-dampened rag may be used if the cleaning is done before drying or while the cable is still fairly warm.

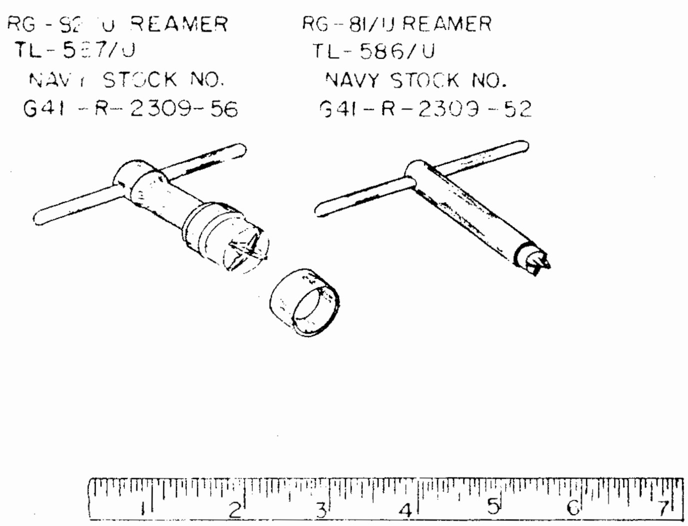
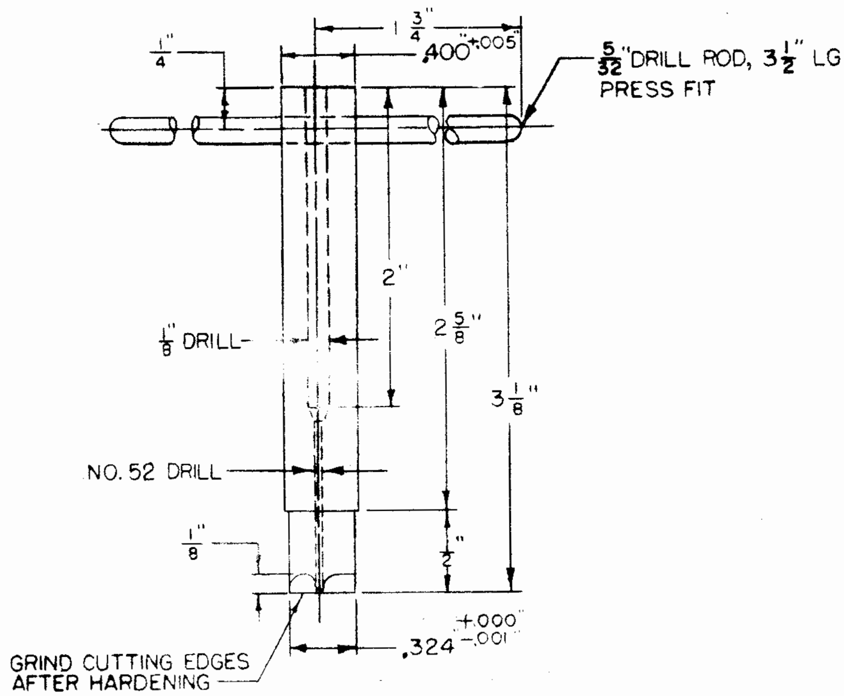


Figure 11-99. Reaming Tools for RG-81/U and RG-82/U



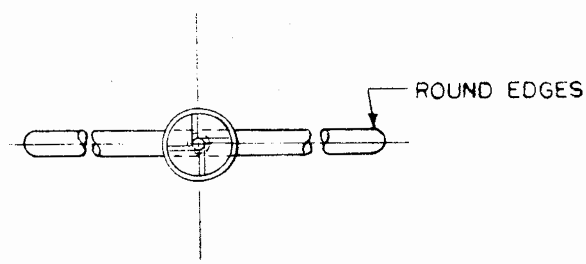


Figure 11-100. Drawing of Reaming Tool TL-586/U for RG-81/U

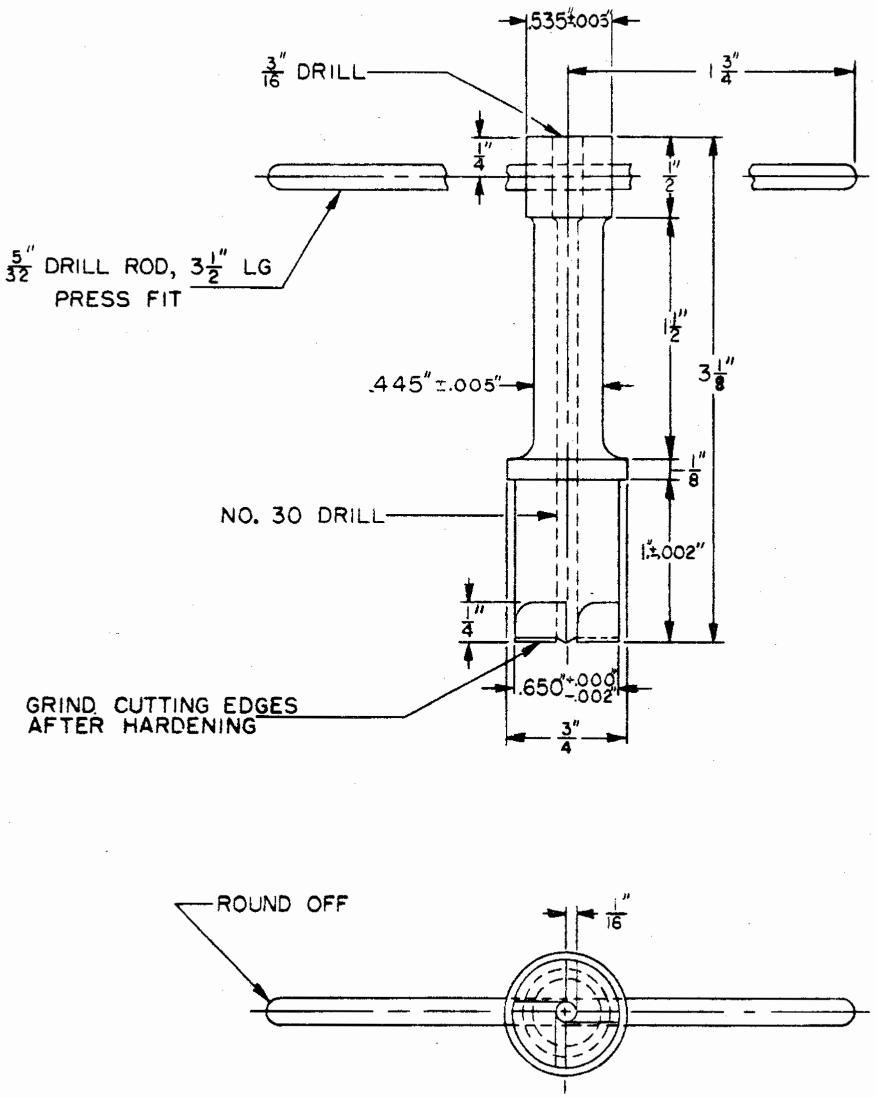


Figure 11-101. Drawing of Reaming Tool TL-587/U for RG-82/U

Sealing with Polyethylene is done as follows.

Heat the cable with the Megger attached until the Megger reads at least eight megohms. Then apply strips of Polyethylene until the reamed out space is completely filled. Polyethylene is clear when hot, white in cooling, and grey when cold. When cold, take a sharp knife and cut the Polyethylene even with the face of the cable.

d. STORAGE AND TRANSPORTATION.– Before storage or shipment, the ends must be well sealed. In such cases, the dielectric should be reamed out, the conductors cleaned, and sealing accomplished as described above; or, for this purpose, rubber cement or coil dope may be used as the sealing agent. Making the seal in the reamed portion protects it from accidental damage.

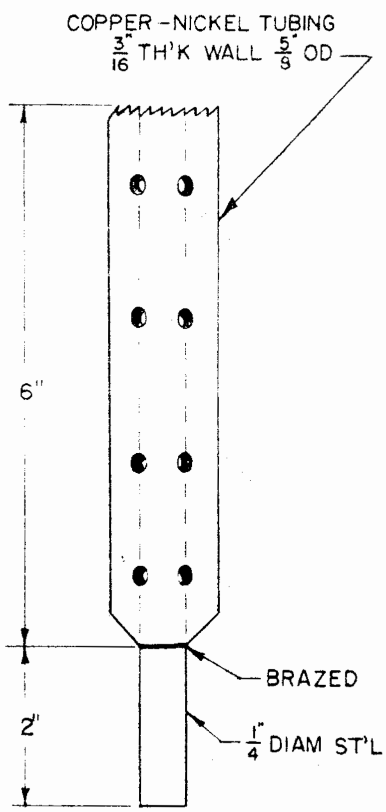


Figure 11-102. Reaming Tool for Use with Slow-Speed Drill

Pyrotenax can be coiled, but coils should be as large in diameter as practicable. The minimum diameter for an RG-82/U coil is 4 feet; for RG-81/U, it is 2-1/2 feet (Figure 11-103).

When Pyrotenax is to be shipped, the coil should be wrapped with heavy paper or burlap to prevent injury to the copper, and the entire coil should be crated to prevent bending or denting.

e. BENDING. –Although it bends more easily than concentric bead-supported lines, considerable care must be taken in bending Pyrotenax. It bends so readily that there is danger of kinking the line. Bends in RG-82/U should have no less than a 6-inch radius; in RG-81/U, a 4-inch radius is the minimum. Wooden blocks of proper radius should be used whenever practicable, both for appearance and for electrical and mechanical reasons (Figure 11-104). Drawings of other bending tools are shown in Figures 11-105 and 11-106.

As received from the manufacturer, Pyrotenax is in the annealed state. Bending should be done when the cable is cool. If bends of 12-inch or shorter radius are made, the line should be annealed after bending by heating the entire length of bend until the copper jacket becomes dull red in color. It should then be allowed to cool slowly. If the cable has been bent previously, without annealing, and straightening or re-bending is desired, the cable should be annealed before as well as after the bending. If the outer jacket is not soft when bent, it will wrinkle at the bend.

f. CLAMPING. –Pyrotenax should be supported about every two feet, by clamps or hangers. The cable should be wrapped with 1/16-inch sheet lead at each bracket to minimize corrosion and to allow thermal expansion without damage.

g. CUTTING.—In cases where it is not necessary to use great care in cutting Pyrotenax, it can be cut with a hacksaw. RG-81/U can even be cut with a bolt cutter, but cutting by this method will result in serious distortion of the end. Outer conductors can be cut very handily with a tube cutter.

If the cut end is to be used with a constant-impedance or high-voltage fitting, considerable care in cutting is necessary to avoid damage to the magnesium oxide, which flakes and chips very easily; to avoid burrs or indentations on the inner surface of the outer conductor; to avoid nicks or burrs on the inner conductor; and to insure a square end. Such cuts should be made in the shop if possible.

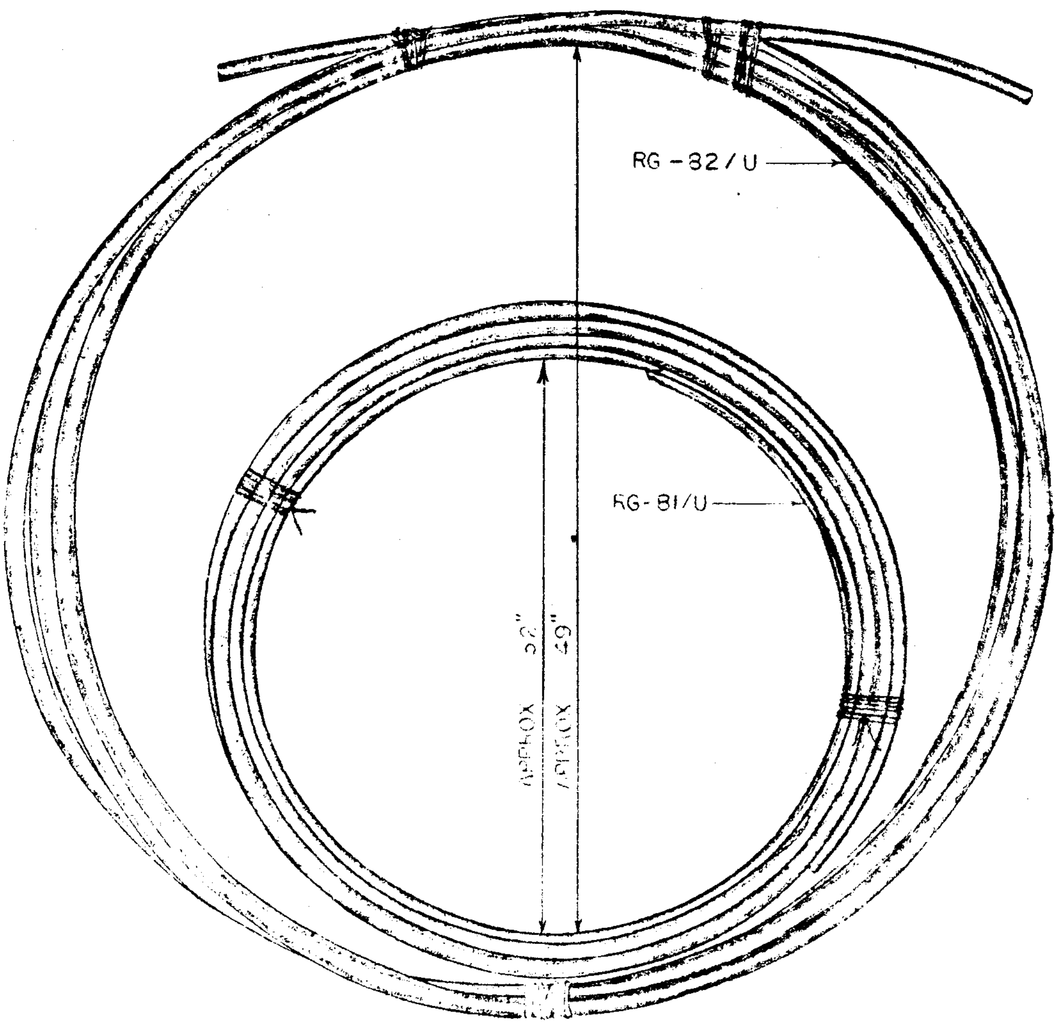


Figure 11-103. RG-81/U and RG-82/U in Coils of Proper Diameter

Avoid hitting, twisting, or bending the inner conductor, as this may loosen the dielectric.

The following method of cutting is recommended:

(1) Straighten the Pyrotenax and clean the outer surface with a fine-grit emery cloth.

(2) On the outer conductor, make a pencil mark at the place to be cut. This mark corresponds to the necessary length of cable.

(3) If the inner conductor is to extend beyond the outer, measure the amount of this extension and cut through the cable at this point with the tube cutter and hacksaw, or hacksaw alone. If the inner conductor is to be flush with the outer, the cable should be cut through in the same way but about 1/2 inch longer than the necessary length originally marked in step (2) above.

(4) Now cut into the outer conductor with the tube cutter at the point already marked in step (2) to a depth not more than halfway through the copper wall (Figure 11-107).

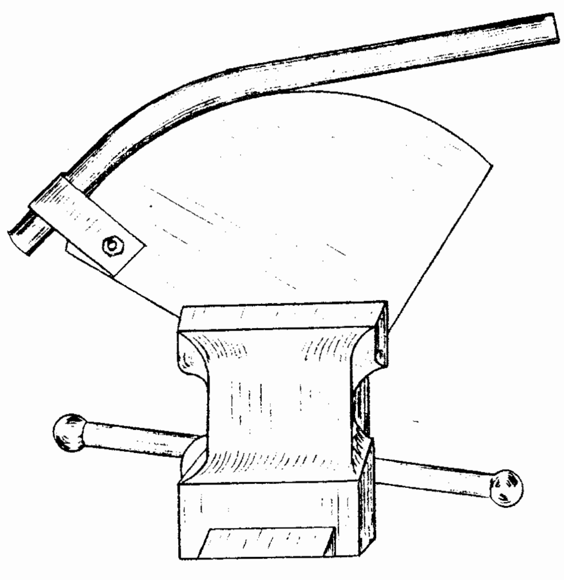


Figure 11-104. Bending RG-82/U to 6-inch Radius by Use of Improvised Wooden Block

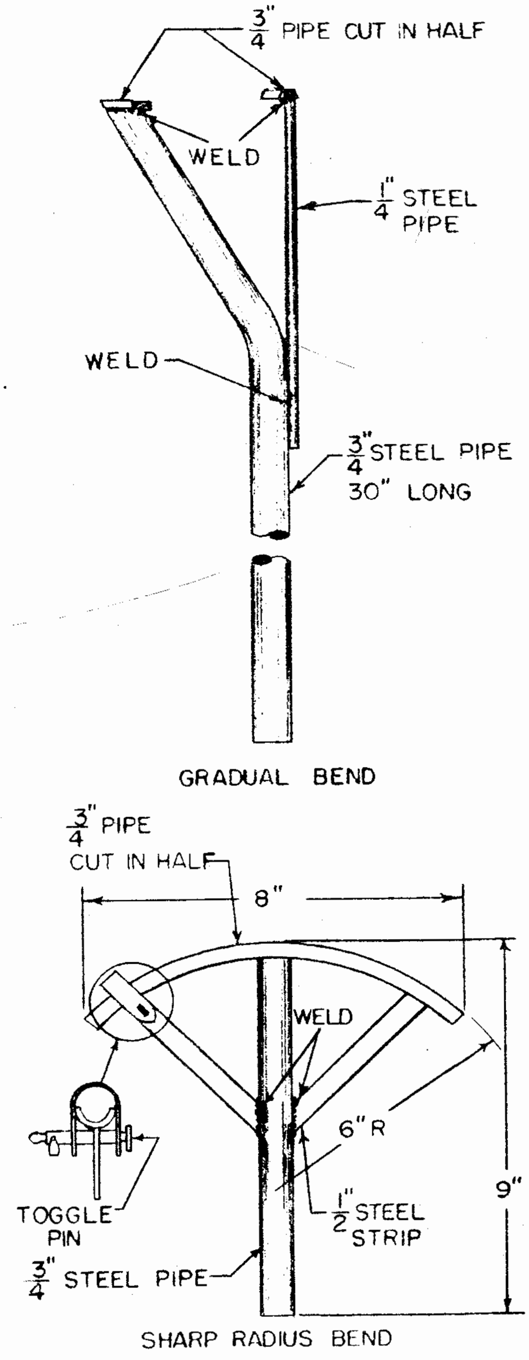


Figure 11-105. Forms for Bending Pyrotenax Cables

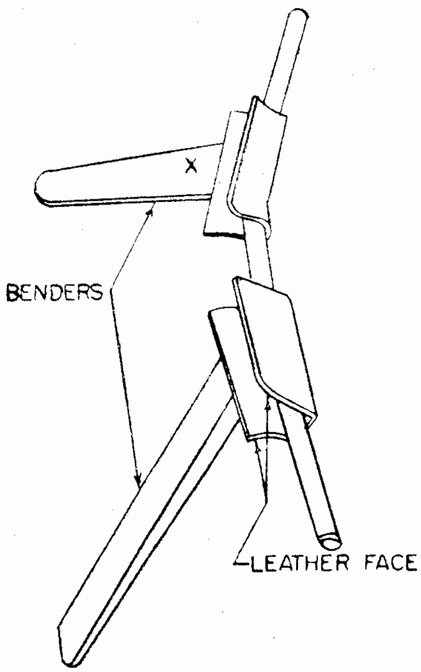


Figure 11-106. Lever for Bending Pyrotenax Cable

(5) Cut the end of the outer conductor at an angle with diagonal cutting pliers in the same way that a key-opening tin can is opened. Spiralling should progress downwards until the split reaches the groove made by the tube cutter; peeling is then continued all around the groove (Figure 11-108).

(6) With a razor blade or sharp, thin, knife blade, shave the entire dielectric square with the outer conductor.

(7) Place a squaring sleeve on the Pyrotenax with the end 1/64 inch or more, as required, from the end of the outer conductor. (The squaring sleeve is a short tube of hardened steel which fits closely over the Pyrotenax and has true-square ends.) A set screw holds it in position. See Figure 11-109.

(8) If the center conductor is to be flush with the outer, cut it with a fine saw with light strokes, or with cutting pliers held close to the dielectric.

(9) File the end square, with the squaring sleeve used as a guide. Filing should be limited to the minimum necessary to provide a true surface. Choice of file is important for good results without burrs. A 10-inch long angle-lathe file is best for this purpose. Otherwise, a small mill-smooth or dead-smooth file may be used and the surface of the file chalked to prevent pinning. The edges of the file should be made "safe" by grinding off the cut, if any, to prevent damage to the inner conductor in installations requiring it to extend beyond the outer conductor. (The lathe file is normally "safe".) Alternatively, a piece of wiring "spaghetti" can be slipped over the inner conductor for the same purpose. Figure 11-110 is a drawing of the squaring sleeve.

(10) Take out the sleeve and remove any external burrs with fine emery cloth.

h. BRAZING AND SOLDERING.—The outer conductor is normally silver-brazed to fittings, and the inner conductor is normally soft-soldered when soldering is required. If brazing is called for, the surface must not be tinned with soft solder. In any soldering operation, there must be no contact of the dielectric with solder, flux, or flame. When a brass fitting is brazed onto a piece of the cable, overheating of the brass must be prevented as it melts with surprising ease under an oxyacetylene torch. Whenever the copper sheath is being heated, the torch must be kept in motion to avoid burning holes in the sheath. Silver brazing may be done with a Prestolite torch if the cable is well protected, but if it is exposed to wind or cold air, an oxyacetylene torch is usually required.

Some fittings for use at UHF require that there be a good electrical connection at the very end of the Pyrotenax. These fittings usually have a socket-like end into which the Pyrotenax fits and a shoulder on the inside of the fitting against which the outer conductor butts. In such a case, the shoulder (and only the shoulder) in the fitting may be tinned fairly thick with soft solder. Flux for the silver-brazing is placed on the outside of the Pyrotenax, and the fitting is slid on and silver-brazed. The joint should be fed plenty of hard solder and heated so that the hard solder will run back to the shoulder. Another type of fitting has an internal groove at the point at which the connection is desired. A ring of small-diameter silver-solder wire is placed in the groove and the outside of the Pyrotenax is fluxed. The fitting is slipped on and heat applied until the solder flows.

i. SPLICING RG-82/U.—RG-82/U can be spliced satisfactorily without serious harm to the electrical properties of the line. The procedure outlined below is recommended:

(1) The two pieces are dried, cut, and squared carefully, with the inner conductor flush with the outer.

(2) The inner conductors are drilled about 1/2 inch deep with a No. 45 drill. In this operation, it is advisable to use a drill guide. This consists of a hardened

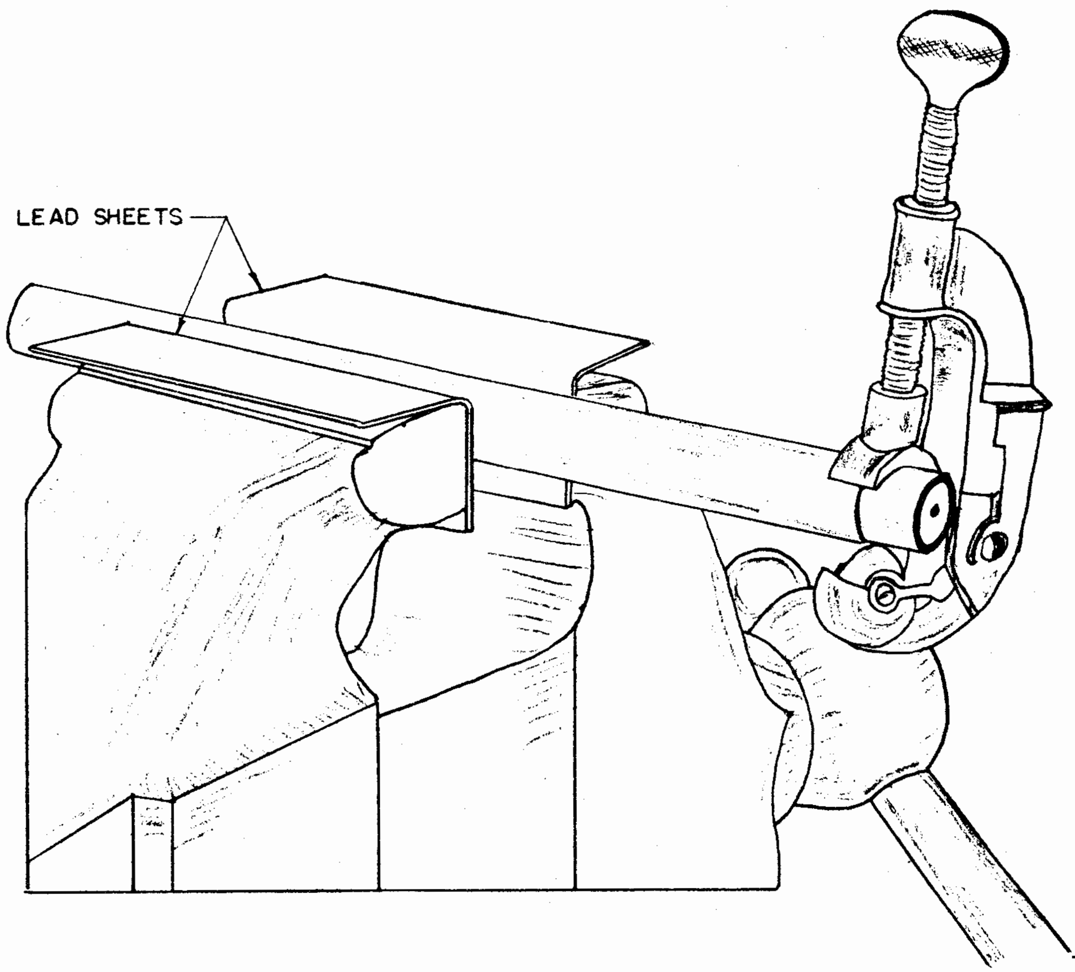


Figure 11-107. Cutting Outer Conductor of RG-82/U with Tube Cutter

steel cylinder open at one end. The other end should be at least 1/4 inch thick and have a No. 45 hole drilled accurately in its center. The socket part should be about an inch long and should fit snugly on RG-82/U. See Figures 11-111 and 11-112.

NOTE

In the following operations care must be taken that flux, solder, and flame do not contaminate the dielectric.

(3) The holes in the inner conductor are tinned and all excess solder is shaken out. A piece of tinned No. 12 copper wire about 7/8 inches long is soldered into one end.

(4) A copper sleeve, about 1/2 inch long (fitting closely on RG-82/U) is slid onto one of the ends, which is then clamped loosely in a vise or splicing jig. See Figure 11-113. (An improvised splicing jig is shown in Figure 11-114.) The end without the No. 12 wire is heated sufficiently to melt the tinning, and the two ends are butted together with the wire connecting the inner conductors.

(5) The clamps are now tightened, with the two ends accurately aligned, and the sleeve is slid along to cover the joint. The sleeve is then silver-brazed on both ends. Figure 11-115 shows the completed splice.

j. PASSING THROUGH BULKHEADS AND HULLS.—A satisfactory method of passing Pyrotenax through hulls, bulkheads, and decks is that of welding a steel tube into the plate metal. The length

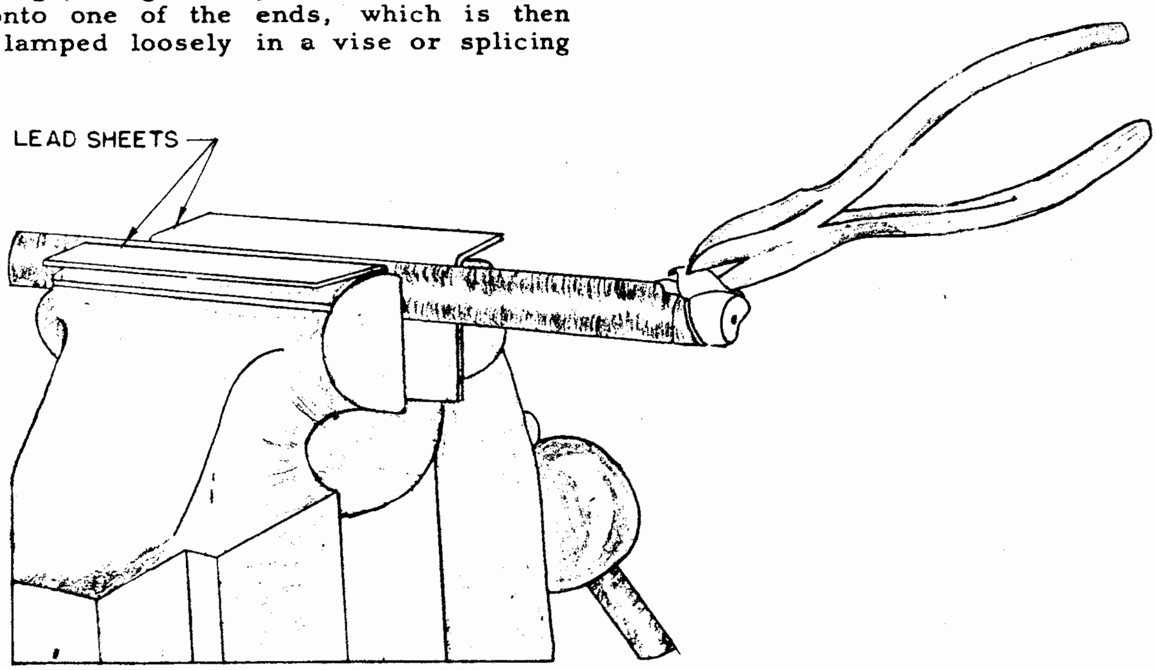


Figure 11-108. Peeling Outer Conductor of RG-82/U To Groove Made by Tube Cutter in Order to Produce Square End Without Burr

of the tube and the amount by which it projects into the space on either side depends on circumstances, but the tube should be kept short to facilitate passing the cable through. The inside diameter of the tube should be about 1/32-inches to 1/16-inches larger than the Pyrotenax.

When the proper length of Pyrotenax has been pulled through, it should be silver-brazed in place at both ends of the tube.

4. NOTES ON AFFIXING FITTINGS TO RG-82/U AND RG-81/U FOR HIGH VOLTAGE SERVICE.

Pyrotenax cables are not outstanding in dielectric strength but RG-82/U can easily carry a kilowatt of RF power, even when there is a fairly high standing wave ratio along the line. This requires that the cable and fittings be able to withstand a few thousand volts. RG-82/U is not recommended for over 8000 volts peak.

The following factors are important in preventing voltage breakdown in fittings and at the joint between fittings and Pyrotenax cables:

a. Exclusion of air, especially near the inner conductor.

b. Prevention of distortion of the electric field.

c. Use of low-loss dielectric.

d. Use of arc-resistant and high dielectric strength materials.

e. Elimination of roughness, abrupt changes in dimensions, and dis-symmetry that would cause concentration of lines of electric force at points or rings.

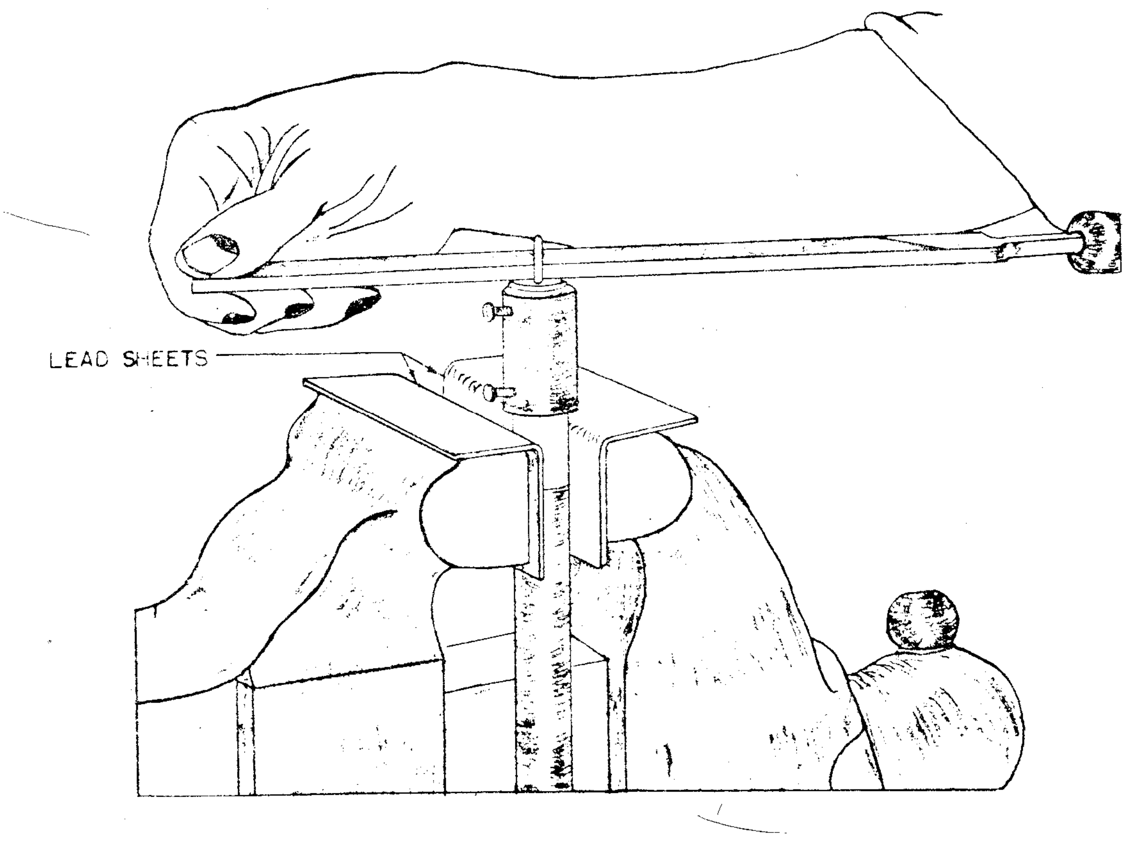


Figure 11-109. Squaring End of RG-82/U by Use of Sleeve and Lathe File

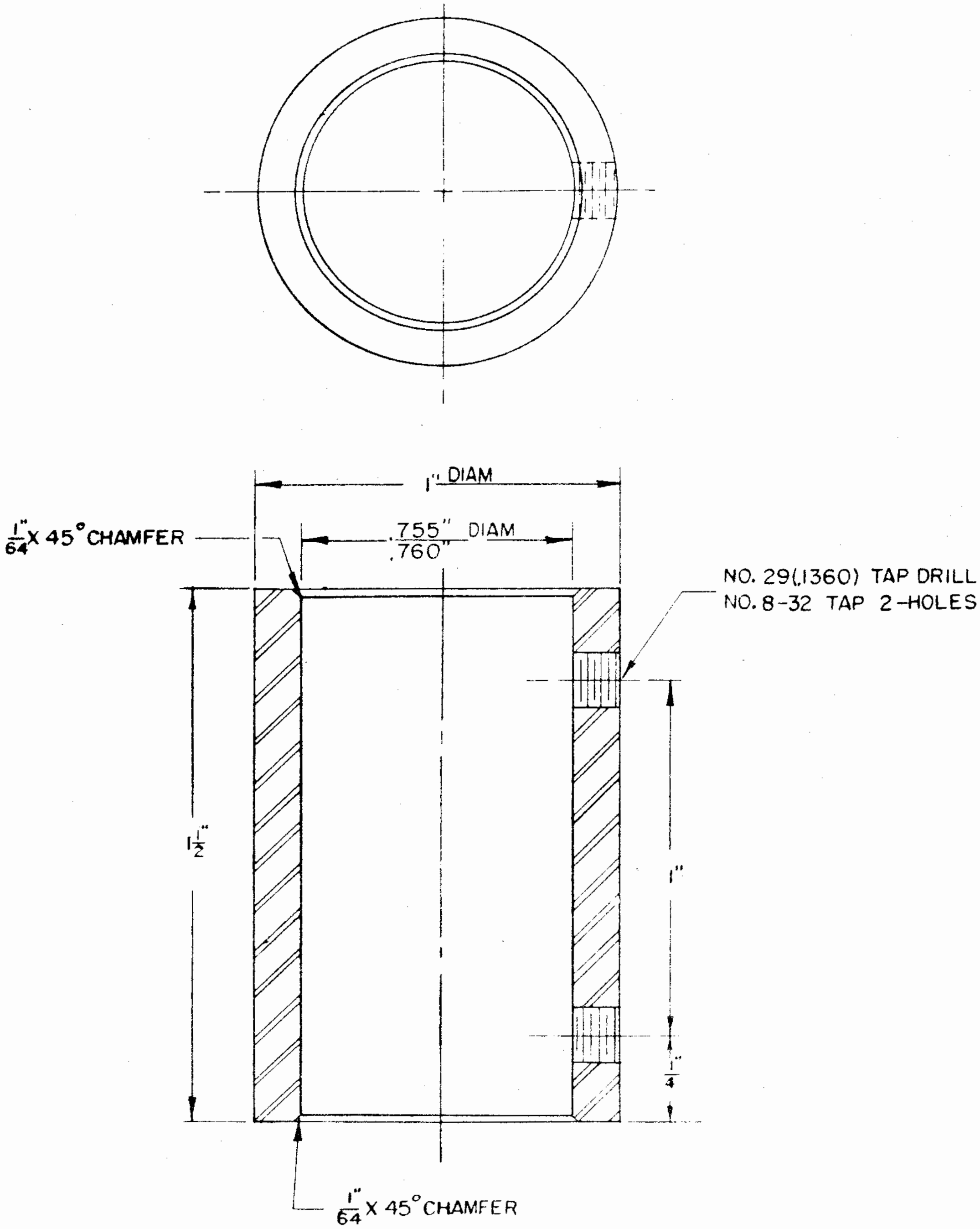


Figure 11-110. Drawing of Squaring Sleeve for RG-82/U

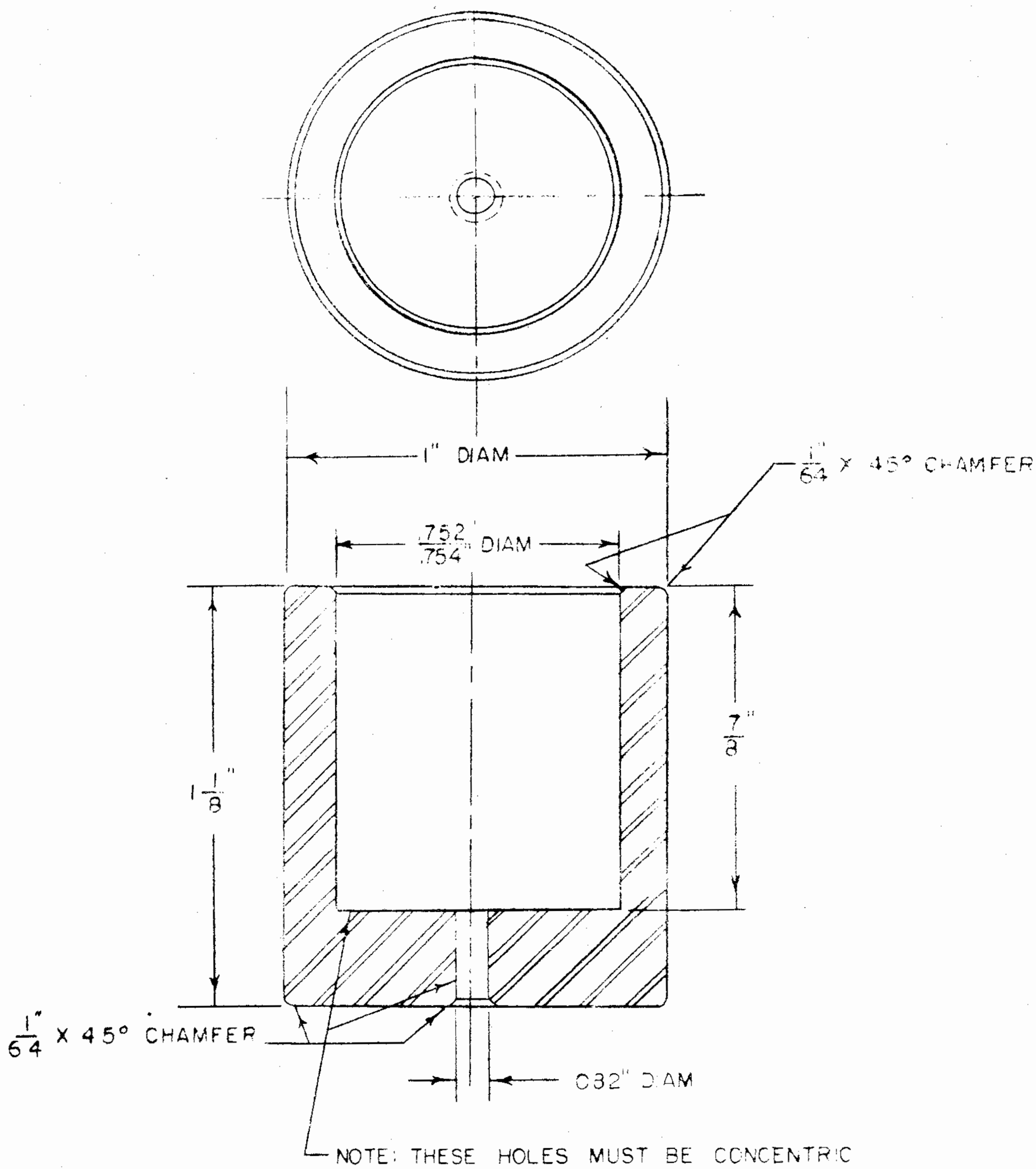


Figure 11-111. Drawing of Drill Guide for Drilling Inner Conductor of RG-82/U

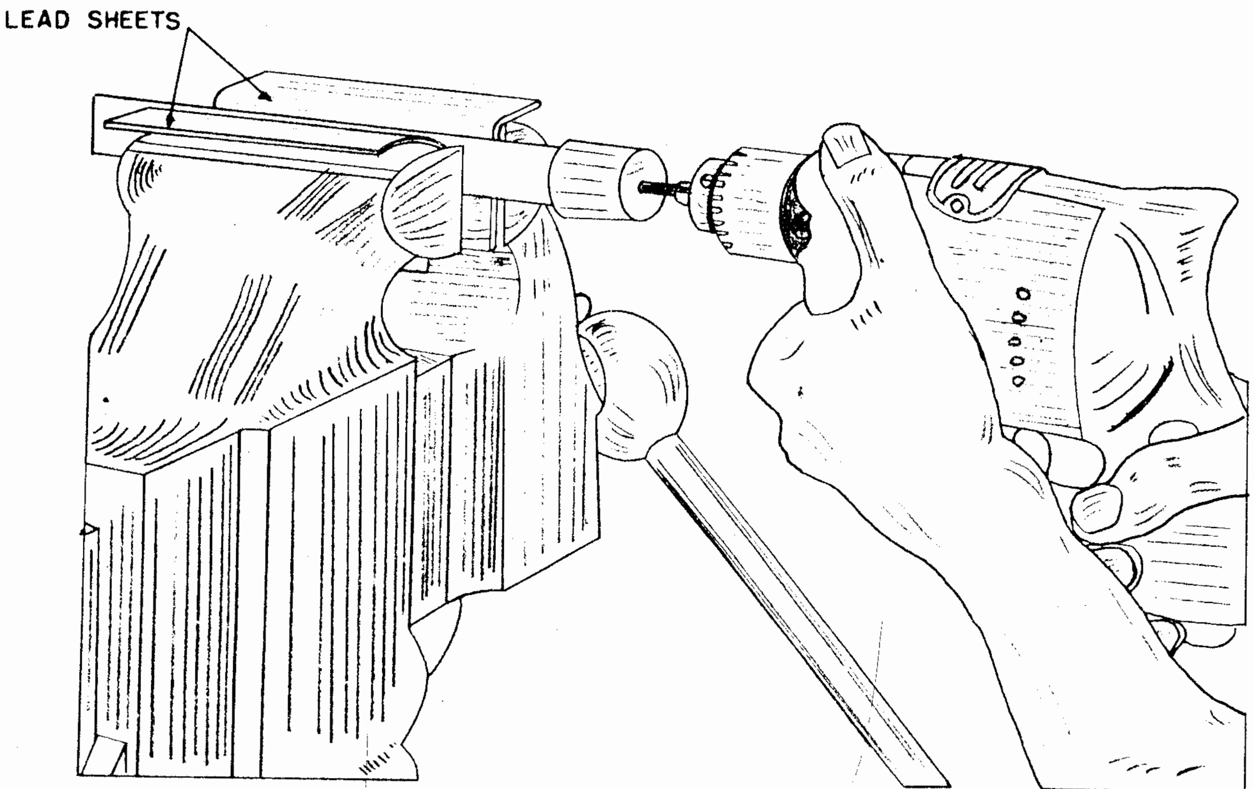


Figure 11-112. Drilling Inner Conductor of RG-82/U by Use of Drill Guide

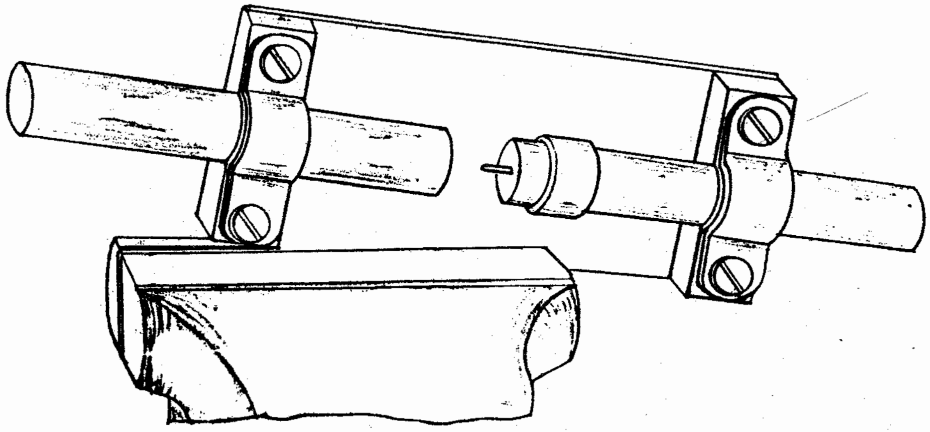


Figure 11-113. Splicing Two Pieces of RG-82/U

f. Little or no change in dielectric constant along lines of electric force.

In accordance with these principles, the magnesium oxide should be cut or reamed to a flat surface at right angles to the inner and outer conductors. Sealing material should be applied in such a way that air is excluded from the interface. (Joint between the sealing agent and magnesium oxide.) Air can be eliminated by applying heat to the end of the cable. The heat should be started about

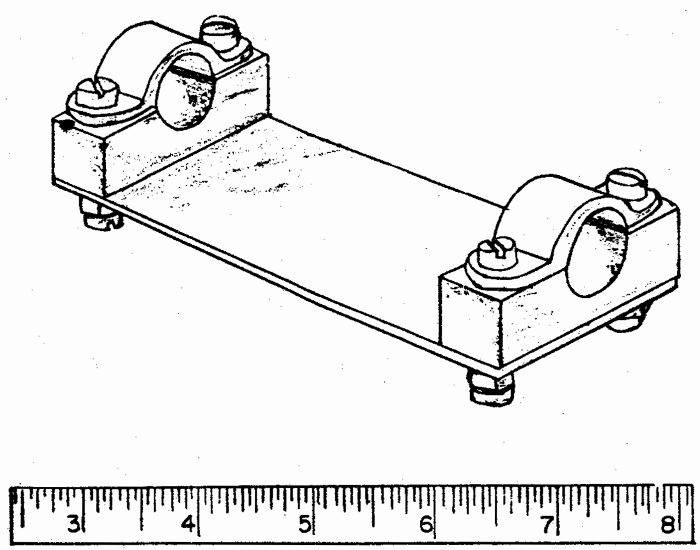


Figure 11-114. Improvised Splicing Jig for RG-82/U

8 inches from the end until the copper sheath shows colors; the flame and color should then be moved slowly to the end of the cable. The cable should be allowed to cool until it is just cool enough to handle, at which time it should be "inhaling". At this time, the material which is to adjoin the magnesium oxide is added. This should be done with as much pressure as possible. If thermoplastic materials are used, the amount of heat depends on the material. Polyethylene is a suitable plastic for this purpose and requires only a moderate amount of heat. Dielectric Compound can also be used if retained by a tight-fitting plug.

Any material put in with heat should have pressure applied constantly during its cooling process. Polyethylene, in particular, has a large thermal expansion coefficient and is likely to pull away at the interface unless preventive steps are taken.

Completely satisfactory joints must be insured at the interfaces as they are often the weakest points in the transmission line with regard to voltage breakdown.

Further details on attaching fittings to RG-81/U and RG-82/U will be found in Chapter 10 (FLEXIBLE TRANSMISSION LINES AND FITTINGS).

5. TOOLS.

a. MK-60/U CABLE REPAIR KIT. - For installing, checking or repairing Pyrotenax coaxial RF cable or associated fittings, MK-60/U Cable Repair Kit (Navy Stock No. N16-C-14051-1001) is available and contains the following items:

1 reaming tool TL-586/U for RG-81/U (with stop sleeve)
1 reaming tool TL-587/U for RG-82/U (with stop sleeve)
1 tube cutter (3/4 inch cap)
1 pair diagonal cutting pliers
1 squaring sleeve for RG-81/U
1 squaring sleeve for RG-82/U
1 long angle lathe file (10 inch)
1 mill smooth file (6 inch)
1 thread restorer including 18 and 24 thread per inch
1 electric soldering iron (350 w)
Allen hex key wrenches (1/16, 5/64 and 3/32 inches across flats (2 each)
90-degree wooden arcs for bending cables (2 inch radius, 1/2 inch thick; 3 inch radius, 1/2 inch thick; 5 inch radius, 3/4 inch thick; 9 inch radius, 3/4 inch thick)
Polystrene - base cement (4 oz)
Vinylite solvent (4 oz)
Seals for RG-81/U (10 to 25)
Seals for RG-82/U (20 to 50)
Dielectric Compound (four 8 oz tubes)
Rosin core solder, 1/16 inch diameter (1/2 lb)
Crocus cloth (5 to 10 sheets)
Pipe cleaners (10 to 20 each)

b. Figure 11-116 illustrates tools and jigs required for installing Pyrotenax cable.

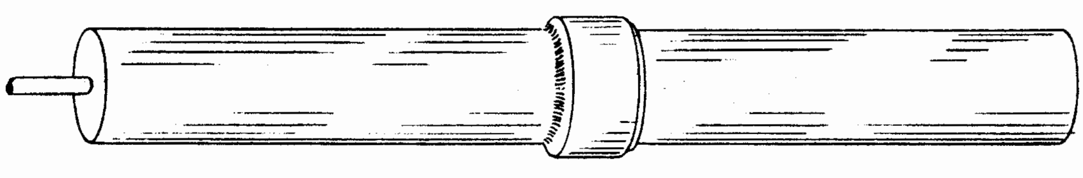


Figure 11-115. Completed Splice of RG-82/U

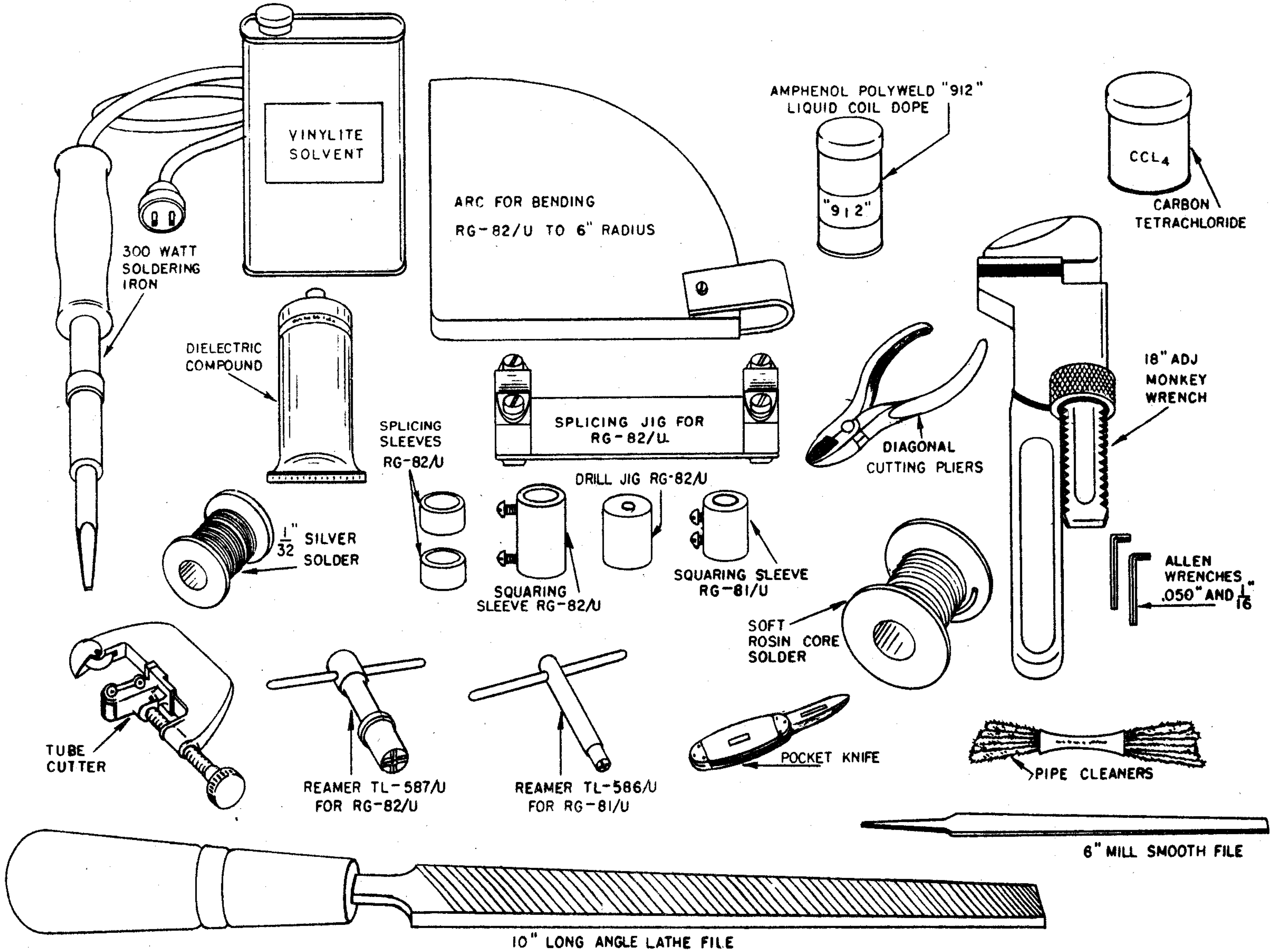


Figure 11-116. Tools and Materials Required for Working on Pyrotenax Cable and Associated Fittings

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