ROYAL CANADIAN AIR FORCE

# STRUCTURAL TUBING REPAIR

REVISION
NOTICE

LATEST REVISED PAGES SUPERSEDE
THE SAME PAGES OF PREVIOUS DATE
Insert revised pages into basic publication.
Destroy superseded pages.

ISSUED ON AUTHORITY OF THE CHIEF OF THE DEFENCE STAFF

23 NOV 60
Revised 7 Oct 65

# LIST OF RCAF REVISIONS

| DATE | PAGE NO | DATE | PAGE NO |
|---|---|---|---|
| 25 Jan 65 | 6 | | |
| 7 Oct 65 | 3 | | |

# TABLE OF CONTENTS



# LIST OF ILLUSTRATIONS

# STRUCTURAL TUBING REPAIR

## REPAIR OF STRUCTURAL STEEL TUBING

General

1 Repairs to structural tubing consist of smoothing small nicks, scratches, and dents; reinforcing cracked members and dented areas; splicing damaged members; replacing damaged members when splicing is impractical; and correcting minor distortion. With the exception of correcting minor distortion, all repairs in steel tubing are accomplished by welding. Tubing used for telescope reinforcements or for splicing must be of at least the same tensile strength and wall thickness as that of the original member.

NOTE

Heat-treated aluminum alloy structural tubing is repaired by rivetting. (Refer to Paragraph 57, following).

Estimating Extent of Damage

2 When inspecting for damage, examine the structure surrounding any visual damage to ensure that no secondary damage, produced by the transmission of stress along the tube, remains undetected. Damage of this nature usually occurs where the most abrupt change in load travel is experienced. If this damage remains undetected, loads applied in the normal course of operation may cause failure of the part. Examine all joints for cracks, welding flaws, or failures. (See Figure 1).

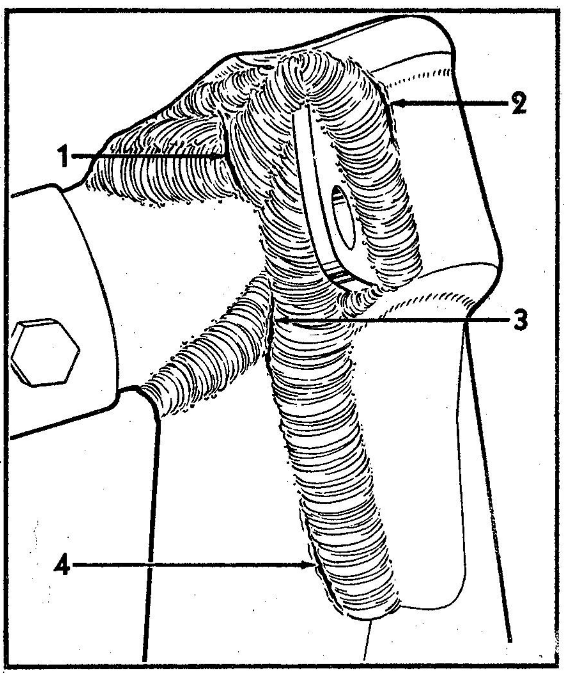



Figure 1 Typical Welding Failures

3 The nature of the damage will determine whether or not a fuselage section must be removed from the fuselage truss. In general, smoothing small dents and correcting minor distortion is accomplished without disassembly.

4 Some forms of damage to tubular structures may be considered negligible. Such damage takes the form of slight indentations, scratches, or minor bowing. Smooth dents not exceeding one-twentieth of the tube diameter in depth, without cracks, fractures, or sharp corners, and clear of the middle third of the length of the member may be disregarded. Examine tubular members carefully for the presence of sharp nicks and deep scratches. These nicks and scratches produce stress concentrations that may cause failure of the part. Structural tubing is subject to various stress conditions and it is almost impossible to assess the damage in a general manner by method of formula or scale as a guide line, since many factors govern the necessity of the replacement or the repair of structural tubing. Damage to the structural tubing members in the form of scratches cracks or abrasions where metal has been removed is to be assessed as individual damage by competent engineering personnel and the necessary action taken to have repairs initiated in accordance with the approved methods of this EO. Smooth out all sharp nicks and deep scratches with a fine file, fine emery paper (Item 2) or steel wool. The intense heat caused by welding necessitates isolating the area to be welded from all parts or members which might be injured by contact with heat. Use sheet asbestos (Item 1), or heavy wet cloths, to provide sufficient insulation to prevent heat distortion or damage to adjacent parts.

NOTE

All fire precautions must be observed before welding is started.

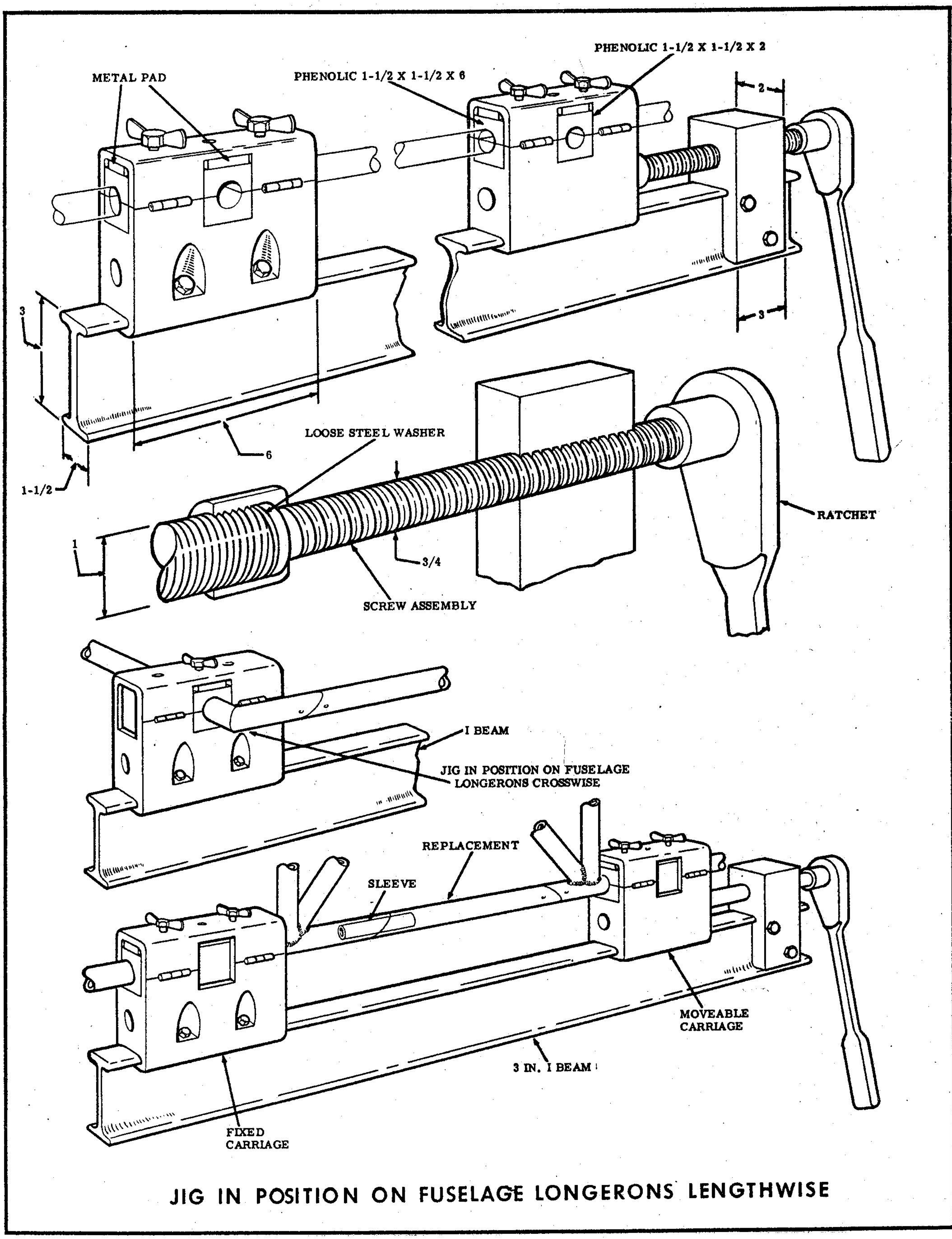



Figure 2 Welding Jig for Fuselage Members

# WELDING OF STEEL

General

5 Welding consists of fusing the metal of the welding wire or rod with the metal of the joint ends until the joint is built up with new metal. This is done by either electric arc welding or by oxy-acetylene welding.

6 The section of the tube adjoining a gas weld will be annealed by the welding heat for a distance of from 1/4 to 3/4 inch on each side of the weld. In electric arc welding this distance is reduced, as the weld proceeds much faster than in the case of gas welding and no preheating of the material is necessary.

Preparation

7 To prepare for welding, proceed as follows:

(a) Use sandpaper (Item 3) or wire brush to clean affected areas prior to welding. Do not use a brush of dissimilar metal, for example brass or bronze. The small deposit left by a brass or bronze brush will materially weaken the weld and cause cracking and subsequent failure.

(b) If a weld is to be made over a failure in an electric weld bead, remove all of the existing bead before applying a new weld to the area.

(c) Use a combination eye and face shield and a leather apron while welding. Ensure that proper ventilation is provided. The presence of gas vapours is a fire hazard, and all fire precautions must be observed before welding.

**CAUTION**

After a weld is made, do not file or smooth the weld or apply any solder or other filler to improve the appearance of the weld.

Welding of Assemblies

8 Weld assemblies or sub-assemblies in a jig or fixture which has sufficient rigidity to prevent misalignment due to expansion and contraction of the heated material. The relative position of the parts to be welded must be accurately located and held firmly in place. (See Figure 2). In this manner there will be no internal stress concentration.

| MATERIAL to be welded | SPECIFICATION | MANUFACTURER |
|---|---|---|
| | ELECTRODES | |
| Carbon and Low Alloy Steels<br>SAE1020, 4130 etc. | MIL-E-6843B<br>Class-E-10013 | Air Reduction Co. |
| | Class E 10013 electrodes are shallow penetration type electrodes used for welding sections up to 0.129 inch thickness. This electrode is suitable for use with both alternating and direct currents. When using direct current, the work is positive polarity and electrode-negative.<br>Flux is not normally used | |

(Figure 3 (Issue 1) Arc Welding Electrodes

## Electric Arc Welding of Steel

9 Before starting to weld, ensure that surface of parts to be welded is free of loose scale, oxide, oil and foreign matter. Use jigs, clamping devices, and tack welding to control warping and ensure proper alignment. (See Figure 2). Preheat only heavy fittings and forgings, and chamfer only on material of .140 inch wall thickness and greater.

10 Use electric arc-welding rods in accordance with Figure 3. In general, a heavily coated, mild steel welding rod should be used with the diameter of the electrode not greater than the tube wall thickness unless the operator increases the travel speed sufficiently to prevent overheating, undercutting, and burning through the metal.

11 Hold length of arc to approximately one-eighth inch. Use polarity recommended by electrode manufacturer or as found suitable for the job. All tack welding and weld endings must be accomplished using a crater eliminator if available. (See Figure 4). The small hole or crater at the weld end creates a stress concentration and fatigue point, and must be eliminated if possible.

12 Avoid rewelding, as porosity in the weld may result. When a weld is built up by two or more beads or passes, the preceding weld must be cleaned free of scale or flux by chipping and scraping, followed by brushing with a wire brush. Do not dress weld by removing metal from the joint unless further welding is to be done on the dressed region.

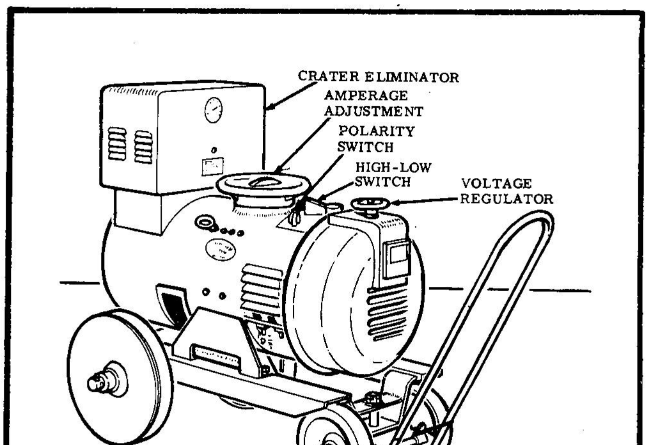



Figure 4 Arc Welding Generator with Crater Eliminator

13 Unless otherwise specified, make the maximum width of welds 1/4 inch for material thickness of not over .040 inch. Make the depth of penetration between 25% and 40% of the thickness of the base metal.

## Rosette Welds

14 Rosette welds are used to fuse an inner tube with an outer tube. Where a rosette weld is used, make hole in outer tube only and of sufficient size to ensure fusion of the inner tube. Use a hole diameter one-fourth the diameter of the outer tube. See Figure 5 for location of rosette welds.

## Heat-treated Parts

15 For heat-treated parts use a welding rod suitable for producing values comparable to those of the original parts. Such parts must be reheat-treated to the manufacturer's specifications after welding.

## Anti-corrosion Treatment

16 Refer to EO 05-1-3/23 for anti-corrosion treatment of welded steel tubing after welding repairs are completed.

## Oxy-acetylene Welding of Steel

17 The oxy-acetylene process is the more flexible type of welding and generally more convenient for repair work on aircraft. However, electric arc welding is acceptable, and repairs outlined are applicable for either type of welding. Keep flame pointed in the direction of welding in order to preheat the material. Maintain as neutral a flame as possible, for an excess of acetylene in the flame will carbonize the weld and an excess of oxygen will oxidize the weld. (See Figure 6). The feather part of the flame should not be more than 1-1/2 times the length of the flame cone and not more than one-eighth inch long. Avoid rewelding, as overheating and porosity may result. At the end of the weld do not raise the torch suddenly from the weld, as this action may cause a pinhole in the weld. Do not dress welds by removing metal from the joint unless further welding is to be done on the dressed region. If the thinnest of the tubes to

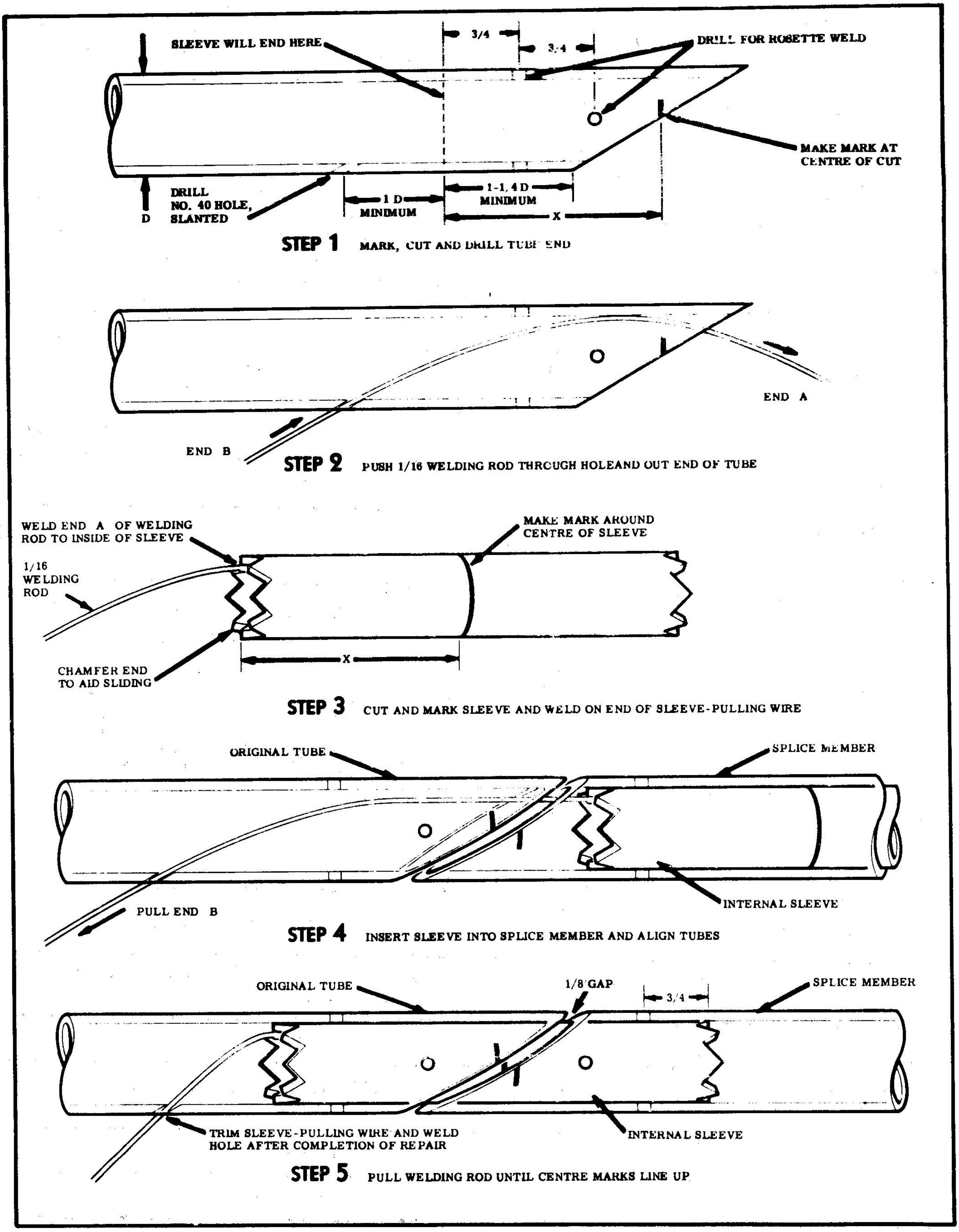



Figure 5 Centering Inner Sleeve in Steel Tube

be welded is less than .040 inch, the maximum width of the weld should not exceed one-quarter inch.

18 Welding wire used for oxy-acetylene welding of chrome molybdenum tubing must conform to Figure 7. Use torch tips of proper size for the thickness of the material to be welded. Commonly used torch tip sizes as given in Figure 8 are satisfactory.

Welding Fluxes

19 Welding fluxes are mixtures, in either liquid, powder or solid form, consisting of various chemicals which, at a heat equal to the welding temperatures of the weldable metals, will unite with the oxides in the weld to form a slag, thus purifying the weld. Due to the various welding temperatures of different weldable metals, several types of flux are required.

20 Usually, when welding chrome molybdenum steel and mild carbon steel, no flux is required. However, if difficulties are experienced, the following flux is recommended and should be applied to the surface of the metal:

| | |
|---|---|
| Boracic Acid (Item 5) | 35.5% |
| Sodium Chloride (Item 6) | 30.1% |
| Potassium Carbonate (Item 7) | 26.7% |
| Colophony (Item 8) | 7.6% |

21 To prevent corrosion of the metal, remove flux as soon as weld has cooled. Clean off flux by brushing with boiling water. If weld is inaccessible, immerse part in a cold 10% solution of sulphuric acid (Item 4) for 30 minutes, or a 5% solution of sulphuric acid at 66°C (150°F) for 10 minutes.

22 Remove acid by immersion in mild alkaline bath, followed by thorough washing in hot water and drying with hot or compressed air. (Refer to EO 05-1-3/20).

Welding Torch Technique

23 The torch used for welding should be light, compact, well balanced, and particularly adapted to welding steel up to 3/16 inch in thickness. To light the torch open the acetylene valve approximately one quarter turn, and light with a friction lighter, ensuring that the torch is not directed toward adjacent personnel, gas cylinders, hoses or any flammable material. Open the valve further until the flame blows away from the end of the tip and close the valve until the flame comes back to the end of the tip. The oxygen valve is then opened slowly and as the volume of oxygen increases, the flame will change.

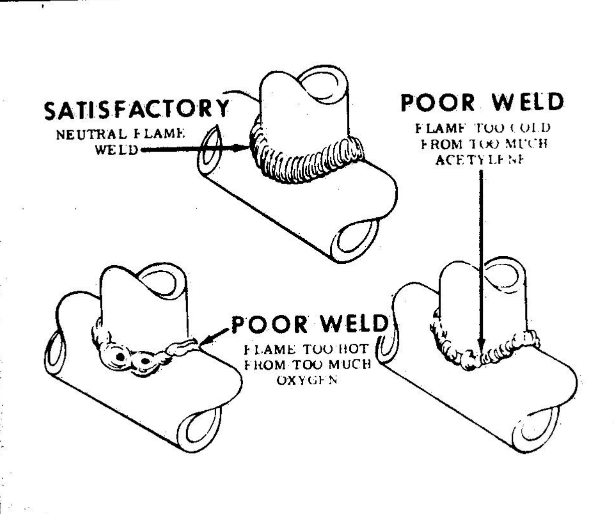



Figure 6 Weld Types

| Material to be Welded | Specification | Manufacturers Designation | Manufacturer |
|---|---|---|---|
| Carbon and Low Alloy Steels SAE 1020, 4130, etc. | ROD | | |
| | MIL-R-5632 Class 2 | Oxweld #32CMS | Dominion Oxygen Co. |
| | FLUX | | |
| | Not Required | | |

Figure 7 Gas Welding Rods and Flux

### Torch Flame

24 There are three general types of flame possible with oxy-acetylene; the neutral flame, the carburizing or reducing flame, and the oxidizing flame, identifiable as fcllows:

(a) The neutral flame can be identified by its clear, well-defined, white cone and is generally preferred as it gives a thoroughly fused weld.

(b) The carburizing or reducing flame can be identified by a long, feathery edge, without any white cone. It introduces carbon into the weld, and is produced when an excess of acetylene is burned.

(c) The oxidizing flame can be identified by a small, pointed, white cone and its envelope of flame. It will oxidize or burn the metal and result in a porous weld. It may be used to cut metal in emergencies when cutting equipment is not available.

### Condition of Completed Welds

25 After welding, remove scale by wire brushing or sandblasting. The finished weld should incorporate the following characteristics:

(a) The seam should be smooth and of uniform thickness.

(b) The weld should be built up to provide extra thickness at the seam.

| Thickness of Steel | Diameter of Hole in Tip | Drill Size |
|---|---|---|
| .015 to .031 | .026 | No. 71 |
| .031 to .065 | .031 | No. 68 |
| .065 to .125 | .037 | No. 63 |
| .125 to .188 | .042 | No. 58 |
| .188 to .250 | .055 | No. 54 |
| .250 to .375 | .067 | No. 51 |

Figure 8 Torch Tip Sizes

(c) The weld metal should taper off smoothly into the base metal.

(d) No oxide should be formed on the base metal at a distance of more than one-half inch from the weld.

(e) The weld should show no signs of blow-holes, porosity or projecting globules.

(f) The base metal should show no signs of pitting, burning, cracking or distortion.

(g) The beads must be of correct size and number.

(h) The depth of penetration must be sufficient to ensure fusion of base metal and filler rod.

### Inspection for Defective Weld

26 Make the following test of suspected welds:

(a) Soak the part in oil (Item 9) or heated paraffin.

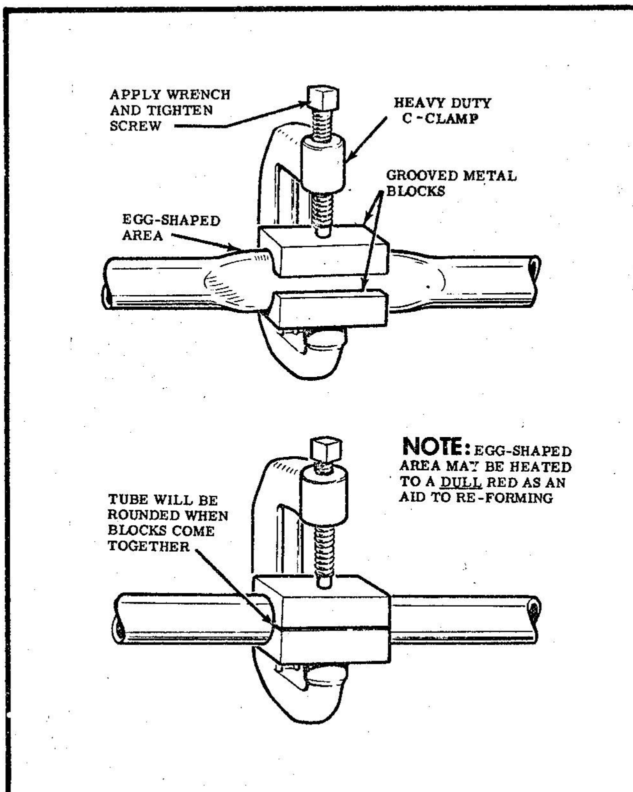



Figure 9 Correcting Oval-shaped Steel Tube Distortion

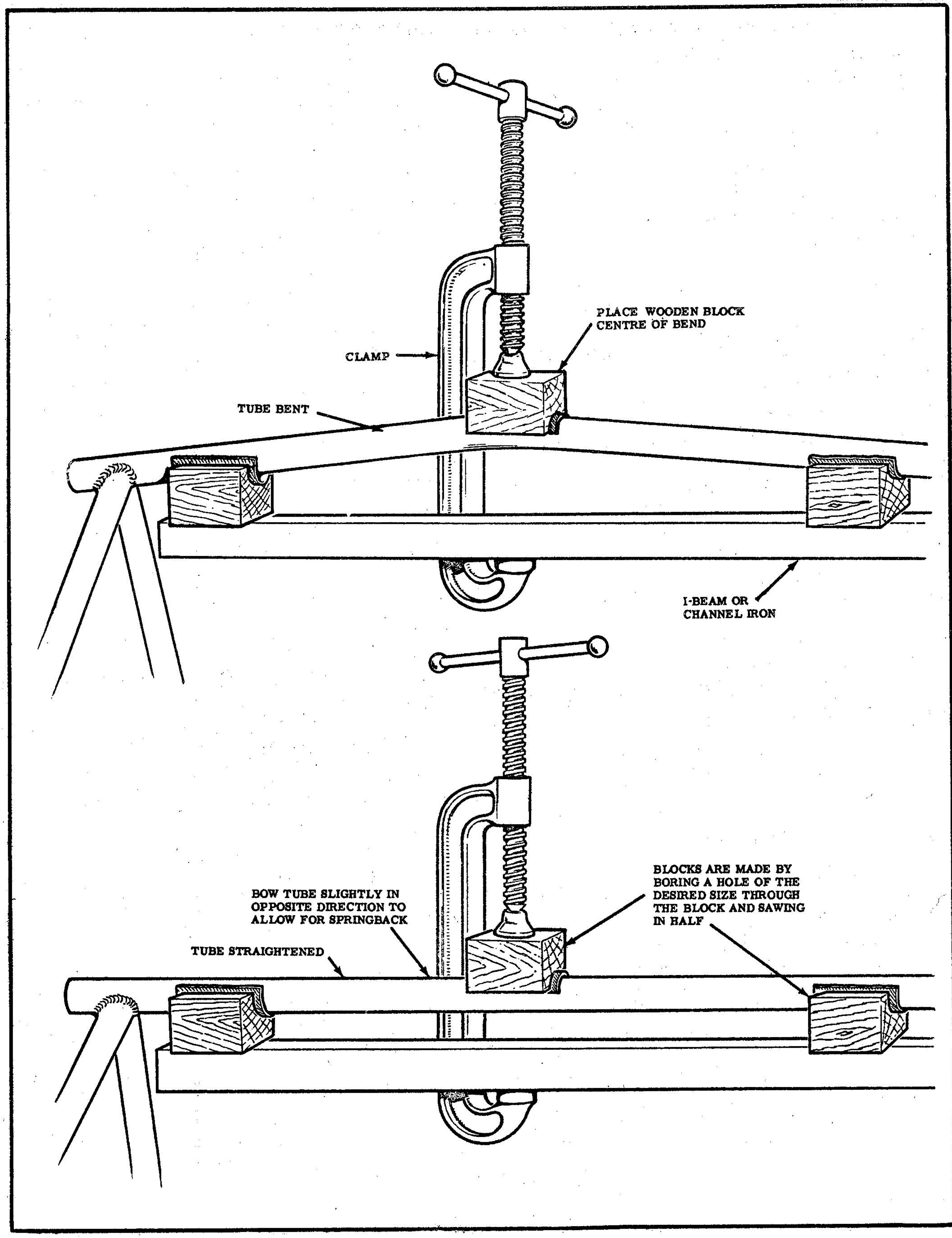



Figure 10 Straightening Bowed Steel Tubes

(b) Clean thoroughly and apply a coat of talc (Item 10). Cracks in the weld will be evident by the appearance of oil from the cracks.

(c) Clean the part and mark location of crack for subsequent repair.

Testing the Completed Repair

27 Test the completed repair in the following manner:

(a) Apply air pressure of approximately 30 psi to a convenient point on the structure, plugging the outlet.

(b) Apply a heavy mixture of soap suds (Item 11) over the suspected weld. A deficiency will be indicated by the formation of large bubbles over the defective weld. Defective welds must be re-welded.

Anti-corrosion Treatment

28 Refer to EO 05-1-3/23, for anti-corrosion treatment of welded steel tubing after welding repairs are complete.

Smooth Dents in Steel Tubes

29 A minor smooth dent in steel tubing is removed as follows:

(a) Remove one of the self-tapping screws provided at the extremities of the main steel tubes and apply an air pressure of upwards of 75 psi to the inside of the steel truss.

(b) Heat the dented area evenly to a dull red, (see heat colour chart in EO 05-1-3/4 with an acetylene torch until the internal air pressure forces out the dent and restores the original tube contour.

(c) If internal air pressure and heat are not sufficient to remove the dent, tack weld a welding rod to the centre of the dent and pull on the rod while heating the area.

(d) After the dent is removed, allow the area to cool and then release the internal air pressure.

(e) Re-treat for anti-corrosion purposes as detailed in EO 05-1-3/23.

CAUTION

Do not apply heat above a dull red to the middle third of the length of any tube.

Steel Tubes Out of Round

30 If the tubing is partially flattened to an oval shape, the circular section may be restored, cold, by pressure applied by grooved steel form blocks, (see Figure 9), as follows: follows:

(a) Drill a steel block to the diameter of the damaged tube, saw the block along the axis of the hole and separate the two sections of the block.

(b) Apply the two form block sections to the oval-shaped area on the affected tube.

(c) Slip a heavy clamp over the blocks, tighten the clamp, and exert pressure on the area until the oval-shaped tube area is restored to the normal circular shape. If difficulty is encountered in shaping the tube in the cold condition, heat the area to a dull red (see heat colour chart in EO 05-1-3/4, then apply the steel blocks and clamp.

(d) Remove the clamp and the blocks.

(e) If the oval-shaped area is longer than the length of the steel form blocks, re-apply the form blocks and the clamp to successive affected areas until the entire length of the oval-shaped area is restored to the normal circular shape.

Bowed Steel Tubes

31 Steel tubes which have been bowed without evidence of cracking may be straightened in the cold condition as follows, (see Figure 10).

(a) Cut three hardwood blocks grooved to fit the contour of the tube, and line the grooves with leather or canvas.

(b) Obtain a length of channel iron equal to the length of the bow in the tube. Locate one of the grooved blocks at either extremity of the bow and apply the channel iron beam so that the beam spans the bowed area and backs up the two blocks. Apply the third block on the opposite side of the tube at the point of the maximum bend near the centre of the bow.

(c) Slip one end of a heavy C-clamp over the channel iron beam and tighten the clamp down on the block at the centre of the bend. In order to allow for springback of the tube, continue tightening the clamp until the tube is bent slightly in the opposite direction. (See Figure 10).

(d) Remove the clamp and the blocks.

(e) Check the alignment of the tube by placing an accurate straightedge on both the side and the top of the tube. If the straightedge check reveals a slight bow in the tube, re-apply the blocks and clamp, and check until the tube lines up with a straightedge in both reference planes.

(f) If cracks appear at the point where the maximum bow was corrected, drill a No. 40 (.098) hole at the ends of the crack and weld a split steel sleeve over the area as outlined in Paragraph 34, following.

(g) In every case where a bent tube is

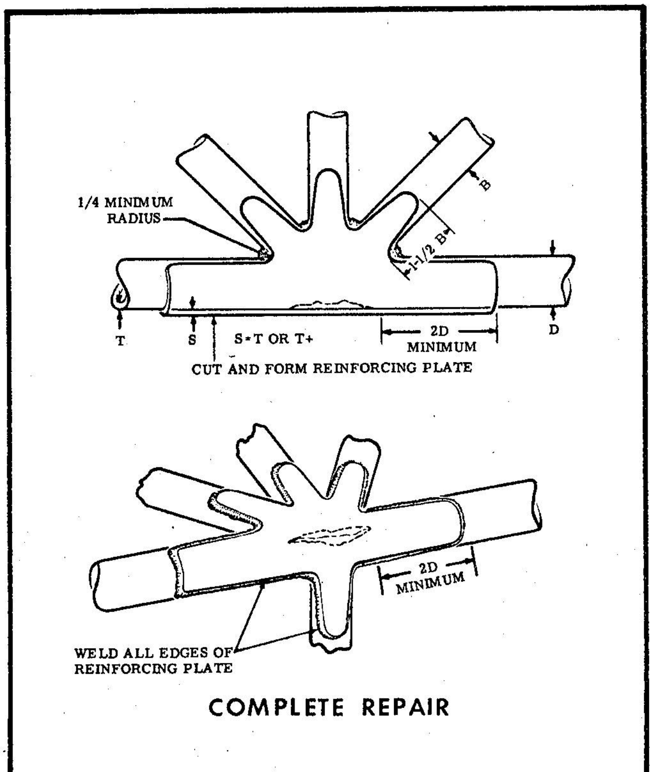



Figure 11 Dent Reinforcement at Steel Tube Cluster Joint

restored, carefully test all adjacent welded joints for cracks, and repair the cracks.

Small Cracks at Steel Tubing Cluster Joints

32 If it is necessary to check an individual tubing joint for cracks, proceed as follows:

(a) Apply a liberal coat of light oil (Item 9) to the affected area.

(b) Thoroughly wipe the oil from the joint.

(c) Spray with mixture of talc (Item 10) and alcohol. A crack in the joint will usually be shown by the appearance of oil on the talc from the crack recess. (See Figure 1).

(d) Remove all finish from the area by rubbing with steel wool or a wire brush.

(e) If the crack is located in an original weld bead, carefully chip, file or grind out the existing weld bead and reweld over the crack along the original weld line.

(f) When grinding off the original weld bead, take particular care to avoid removing any of the existing tube or gusset material.

(g) If the crack is near a cluster joint but away from the original weld bead, remove the finish from the area, drill No. 40 (.098) holes at the ends of the crack, and weld an overlapping doubler over the area. No more than two cracks may be repaired in the same general area.

(h) Apply one coat of zinc chromate primer, (refer to EO 05-1-3/23), to the area from which the finish was previously removed.

(j) Apply finish coats to match the adjacent surface.

Sharp Dents at a Steel Tube Cluster Joint

33 Repair sharp dents at a steel tube cluster joint by welding a formed steel patch plate over the dented area and surrounding tubes (see Figure 11). To prepare the patch plate proceed as follows:

(a) Cut a section of steel plate of a thickness equal to or greater than that of the damaged tube. Trim the reinforcing plate so that the plate extends a minimum of two times the diameter of the tube from the nearest edge of the dent and over adjacent tubes 1-1/2 times the diameter of the tube.

(b) Remove existing finish on the damaged cluster joint area to be covered by the reinforcing plate.

(c) Form reinforcing plate before any welding is attempted.

(d) Cut and tack-weld the plate to one or more of the tubes forming the cluster joint, then heat and pound it around the joint contour as required to produce a smooth contour. Avoid unnecessary heating of the reinforcing plate while forming. Allow a gap of no more than one-sixteenth inch from the contour of the joint to the reinforcing plate. While forming the plate, exercise care to prevent damage at the apex of the angle formed by any two adjacent fingers of the plate.

(e) After the reinforcing plate is formed and tack-welded to the cluster joint, weld the plate edges to the cluster joint.

(f) At the conclusion of the repair, refer to EO 05-1-3/23, for a method of protecting the surface.

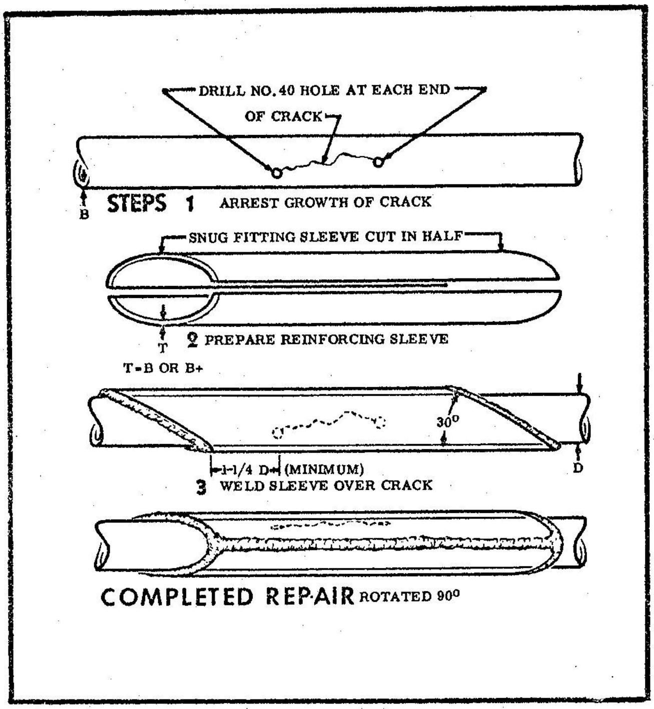



Figure 12 Dent or Crack Reinforcement in Steel Tubing

Repairing Sharp Dents or Cracks

34 If a crack appears in a length of steel tube, usually as the result of previously straightening the tube, drill a No. 40 (.098) hole at each end of the crack and remove the finish around the tube for a distance of approximately three inches on each side of the damage. If the damage is in the form of a sharp dent which cannot be removed by any of the methods previously outlined, remove the finish in the same manner.

35 In order to reinforce the dented or the cracked area, select a length of steel tube having an inside diameter approximately equal to the outside diameter of the damaged tube and of the same wall thickness. Diagonally cut the steel sleeve reinforcement at a 30° angle on both ends, so that the distance of the sleeve from the edge of the crack or dent is not less than 1-1/4 times the diameter of the damaged tube. (See Figure 12). Cut through the entire length of the reinforcing sleeve and separate the half sections of the sleeve. Clamp the two sleeve sections to the proper positions on the affected areas of the original steel tube. Weld the reinforcing sleeve along the length of the two sides, and weld both ends of the sleeve to the damaged steel tube as shown. Repeat anti-corrosion procedure, (refer to EO 05-1-3/23, and refinish as required.

## SPLICED REPAIRS

General

36 Welded tubular structures may be repaired as described in the following paragraphs. However, control surfaces such as the elevators, rudder and ailerons should not be repaired if the added weight will change their aerodynamic characteristics by inducing flutter or vibration.

37 Damaged tubular members are replaced by splicing in a new section of tubing held in place by the use of reinforcing sleeves. Two types of sleeve are available, internal, (see Figures 5 and 13), and external (see Figure 14). Two types of splice welds are permitted, the fishmouth and the 30° diagonal. The fishmouth is the preferable type. When using the external sleeve, the sleeve is fishmouthed or diagonally cut and the inside structural member is square cut. When using the internal sleeve, the sleeve is

notched and the outside structural member is fishmouthed or diagonally cut. Internal sleeve repairs require rosette welds, located as shown in Figures 5 and 13. Although rosette welds are not essential for external sleeves, they strengthen the joint and are recommended.

NOTE

Internal sleeve repairs are lighter, produce less bulge and require less welding, while external sleeve repairs are stronger and easier to apply.

Precautions

38 Any tubular member originally welded into a part of the structure may be spliced according to the methods outlined, provided the following precautions are considered:

(a) Splices are not to be made in the middle third of the bay.

(b) Only one repair may be made in any one bay of a structural member.

(c) When a tube has to be removed at a joint, it must be carefully removed so as not to disturb other members terminating at that joint.

(d) If a member is damaged at a joint so that it is impossible to retain a stub to which another member can be attached, the member must be replaced entirely in the case of web members. In the case of continuous longerons, make the splice in an adjacent bay.

(e) No splices may be made by butt welding any member between station points.

(f) If the welded assembly was heat-treated subsequent to welding, the repaired assembly must be reheat-treated to the same strength.

(g) Material used to replace a section of original tubing, or used as a liner, must be of the same material and strength as the original tubing.

(h) To avoid putting additional stress on a structure being repaired, ensure that the structure is adequately supported prior to cutting any damaged member. Use a jury strut or protected trestles, and attempt to duplicate original condition prior to cutting by straightening bowed tubing and supporting the aircraft in normal flying condition.

Determination of Repair Tubing Sizes

39 For the proper size of tubing to be used in external and internal sleeve splices using

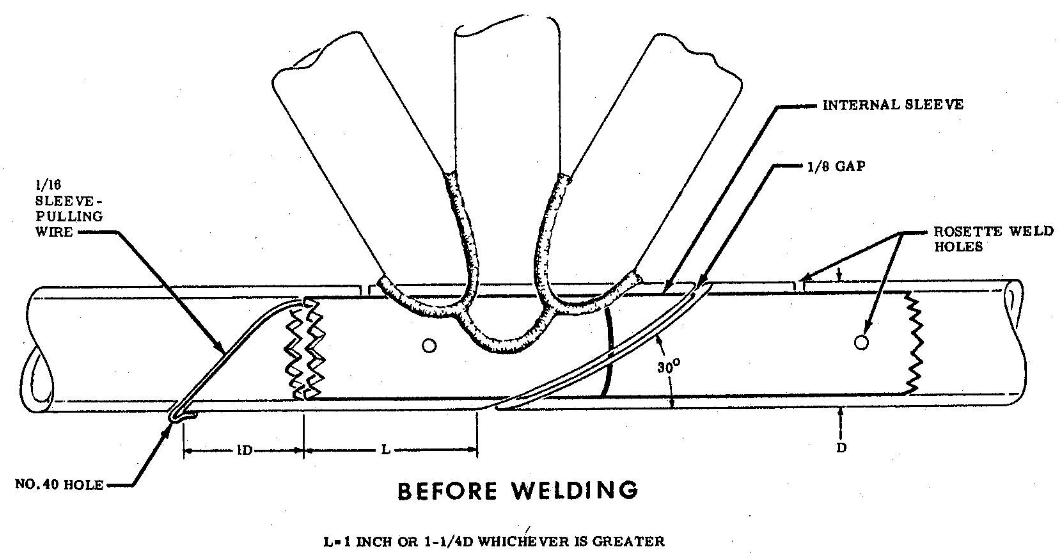



Figure 13 Steel Tube Inner Sleeve Splice

SAE1025 and SAE4130X steels, see Figures 15 and 16.

Initial Measurement

40 Before cutting any tubular member prior to making the repair, take a measurement between centre lines of the stations adjacent to the member to be repaired. In this way the original dimension may be maintained while splicing in the new tube, ensuring proper alignment of the structure. If tube is bent, it will be necessary to straighten it before obtaining this dimension. (See Figure 10). The dimension may be obtained from the drawing of the part, or it may be taken from adjacent stations on the the opposite side of the structure wherever two sides of the structure are identical.

Splicing Structural Tube by Outer Sleeve Method

41 Splice structural tube by outer sleeve method as follows:

(a) Cut out the damaged section of the tube, locating the cuts away from the middle third of the tube section.

(b) Cut a replacement tube of same material to match the outside diameter, wall thickness and length of the removed tube. This replacement tube must bear against the stubs of the original tube with a tolerance of one thirty-secondth of an inch.

(c) Select a length of steel tubing of inside diameter approximately equal to the outside diameter of the damaged tube and of the same wall thickness. This outer sleeve tube material must fit about the original tube with a maximum tolerance of one sixty-fourth of an inch. From this material, cut two sections of tubing, diagonally or fishmouth, each of such a length that the nearest ends of the outer sleeve are a minimum distance of 1-1/4 tube diameters from the ends of the cut on the original tube. (See Figure 14).

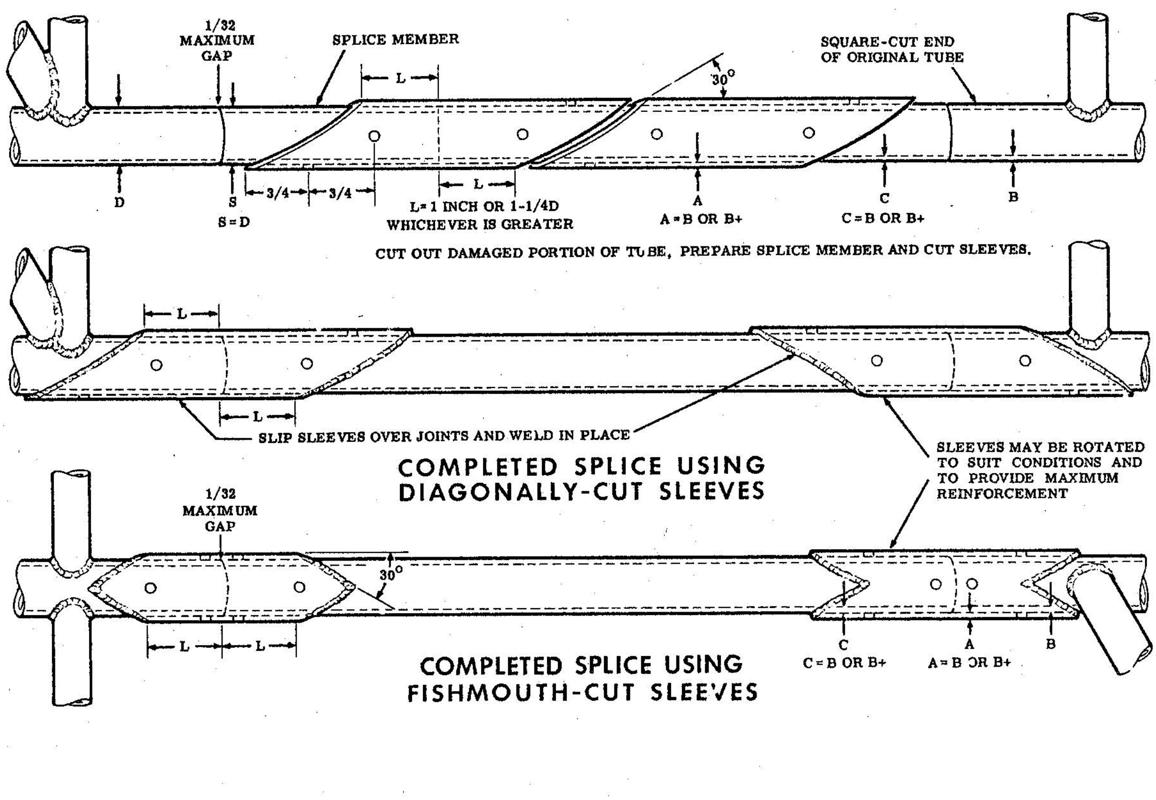



Figure 14 Steel Tube Outer Sleeve Splice

| Material A | Diameter Inches | | Wall Thickness - Inches | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A = .028 | | | | A = .035 | | | | A = .049 | | | | A = .058 | | | |
| | | | 1025 | | 4130 | | 1025 | | 4130 | | 1025 | | 4130 | | 1025 | | 4130 | |
| | A,B | C | B | C | B | C | B | C | B | C | B | C | B | C | B | C | B | C |
| 1025 | 5/8 | 1/2 | .028 | .049 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .065 | .035 | .049 | .058 | .083 | .049 | .058 |
| 4130 | | | .058 | .083 | .028 | .049 | | .095 | .035 | .049 | | | .049 | .065 | | | .058 | .083 |
| 1025 | 3/4 | 5/8 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .065 | .035 | .049 | .058 | .083 | .049 | .058 |
| 4130 | | | .058 | .065 | .028 | .035 | | .083 | .035 | .049 | | .120 | .049 | .065 | | | .058 | .083 |
| 1025 | 7/8 | 3/4 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .065 | .035 | .049 | .058 | .083 | .049 | .058 |
| 4130 | | | .058 | .065 | .028 | .035 | | .083 | .035 | .049 | | .120 | .049 | .065 | | | .058 | .083 |
| 1025 | 1- | 7/8 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .083 | .049 | .058 |
| 4130 | | | .058 | .058 | .028 | .035 | | .083 | .035 | .049 | | .120 | .049 | .058 | | | .058 | .083 |
| 1025 | 1-1/8 | 1- | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .083 | .049 | .058 |
| 4130 | | | .058 | .058 | .028 | .035 | | .083 | .035 | .049 | | .120 | .049 | .058 | | | .058 | .083 |
| 1025 | 1-1/4 | 1-1/8 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .083 | .049 | .058 |
| 4130 | | | .049 | .058 | .028 | .035 | | .083 | .035 | .049 | | .120 | .049 | .058 | | .120 | .058 | .083 |
| 1025 | 1-3/8 | 1-1/4 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .065 | .049 | .058 |
| 4130 | | | .049 | .058 | .028 | .035 | | .083 | .035 | .049 | | .120 | .049 | .058 | | .120 | .058 | .065 |
| 1025 | 1-1/2 | 1-3/8 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .065 | .049 | .058 |
| 4130 | | | .049 | .058 | .028 | .035 | | .083 | .035 | .049 | | .120 | .049 | .058 | | .120 | .058 | .065 |
| 1025 | 1-5/8 | 1-1/2 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .065 | .049 | .058 |
| 4130 | | | .049 | .058 | .028 | .035 | | .083 | .035 | .049 | | .095 | .049 | .058 | | .120 | .058 | .065 |
| 1025 | 1-3/4 | 1-5/8 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .065 | .049 | .058 |
| 4130 | | | .049 | .058 | .028 | .035 | | .083 | .035 | .049 | | .095 | .049 | .058 | | .120 | .058 | .065 |
| 1025 | 1-7/8 | 1-3/4 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .065 | .049 | .058 |
| 4130 | | | .049 | .058 | .028 | .035 | | .083 | .035 | .049 | | .095 | .049 | .058 | | .120 | .058 | .065 |
| 1025 | 2 | 1-7/8 | .028 | .035 | .028 | .028 | .035 | .049 | .028 | .035 | .049 | .058 | .035 | .049 | .058 | .065 | .049 | .058 |
| 4130 | | | .049 | .058 | .028 | .035 | | .083 | .035 | .049 | | .095 | .049 | .058 | | .120 | .058 | .065 |

A - Original Tube B - Replacement Tube C - Inside Sleeve

Figure 15 Internal Repair Tube Sizes

| Material A | Diameter Inches | | Wall Thickness - Inches | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A = .028 | | | | A = .035 | | | | A = .049 | | | | A = .058 | | | | A = .065 | | | |
| | | | 1025 | | 4130 | | 1025 | | 4130 | | 1025 | | 4130 | | 1025 | | 4130 | | 1025 | | 4130 | |
| | A,B | C | B | C | B | C | B | C | B | C | B | C | B | C | B | C | B | C | B | C | B | C |
| 1025 | 1/2 | 5/8 | .028 | .028 | .028 | .028 | .035 | .028 | .035 | .028 | .049 | .049 | .049 | .028 | .058 | .049 | .058 | .028 | .065 | .058 | .065 | .028 |
| 4130 | | | .058 | .049 | .028 | .028 | .065 | .049 | .035 | .028 | .095 | | .049 | .049 | .120 | | .058 | .049 | | | .065 | .058 |
| 1025 | 5/8 | 3/4 | .028 | .028 | .028 | .028 | .035 | .035 | .035 | .028 | .049 | .049 | .049 | .028 | .058 | .049 | .058 | .035 | .065 | .058 | .065 | .035 |
| 4130 | | | .058 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .049 | | | .065 | .058 |
| 1025 | 3/4 | 7/8 | .028 | .028 | .028 | .028 | .035 | .035 | .035 | .028 | .049 | .049 | .049 | .028 | .058 | .049 | .058 | .035 | .065 | .058 | .065 | .049 |
| 4130 | | | .058 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .049 | | | .065 | .058 |
| 1025 | 7/8 | 1- | .028 | .028 | .028 | .028 | .035 | .035 | .035 | .028 | .049 | .049 | .049 | .035 | .058 | .058 | .058 | .035 | .065 | .058 | .065 | .049 |
| 4130 | | | .058 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | | | .065 | .058 |
| 1025 | 1- | 1-1/8 | .028 | .028 | .028 | .028 | .035 | .035 | .035 | .028 | .049 | .049 | .049 | .035 | .058 | .058 | .058 | .049 | .065 | .058 | .065 | .049 |
| 4130 | | | .058 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | .120 | | .065 | .058 |
| 1025 | 1-1/8 | 1-1/4 | .028 | .028 | .028 | .028 | .035 | .035 | .035 | .028 | .049 | .049 | .049 | .035 | .058 | .058 | .058 | .049 | .065 | .058 | .065 | .049 |
| 4130 | | | .058 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | .120 | | .065 | .058 |
| 1025 | 1-1/4 | 1-3/8 | .028 | .028 | .028 | .028 | .035 | .035 | .035 | .028 | .049 | .049 | .049 | .035 | .058 | .058 | .058 | .049 | .065 | | .065 | .049 |
| 4130 | | | .049 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | .120 | | .065 | |
| 1025 | 1-3/8 | 1-1/2 | .028 | .028 | .028 | .028 | .035 | .035 | .035 | .028 | .049 | .049 | .049 | .049 | .058 | .058 | .058 | .049 | .065 | | .065 | .049 |
| 4130 | | | .049 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | .120 | | .065 | |
| 1025 | 1-1/2 | 1-5/8 | .028 | .028 | .028 | .028 | .035 | .035 | .035 | .028 | .049 | .049 | .049 | .049 | .058 | .058 | .058 | .049 | .065 | | .065 | .049 |
| 4130 | | | .049 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | .120 | | .065 | |
| 1025 | 1-5/8 | 1-3/4 | .028 | .028 | .028 | .028 | .035 | .035 | | .028 | .049 | .049 | .049 | .049 | .058 | .058 | .058 | .049 | .065 | | .065 | .058 |
| 4130 | | | .049 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | .120 | | .065 | |
| 1025 | 1-3/4 | 1-7/8 | .028 | .028 | .028 | .028 | .035 | .035 | | .028 | .049 | .049 | .049 | .049 | .058 | .058 | .058 | .049 | .065 | | .065 | .058 |
| 4130 | | | .049 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | .120 | | .065 | |
| 1025 | 1-7/8 | 2- | .028 | .028 | .028 | .028 | .035 | .035 | | .028 | .049 | .049 | .049 | .049 | .058 | .058 | .058 | .049 | .065 | | .065 | .058 |
| 4130 | | | .049 | .049 | .028 | .028 | .065 | .058 | .035 | .035 | .095 | | .049 | .049 | .120 | | .058 | .058 | .120 | | .065 | |

Figure 16 External Repair Tube Sizes

(d) Deburr the edges of the sleeves, replacement tube and original tube stubs. Slip the two sleeves over the replacement tube, line up the replacement tube with the original tube stubs, and slip the sleeves out over the centre of each joint. (See Figure 14). Adjust the sleeves to suit the area and to provide maximum reinforcement.

(e) Tack weld the two sleeves to the replacement tube in two places before welding. Apply a uniform weld around both ends of one of the reinforcing sleeves and allow the weld to cool. Then weld around both ends of the remaining reinforcing tube. (See Figure 14).

(f) Allow one sleeve to cool before welding the remaining tube, to prevent undue warping.

(g) For anti-corrosion and surface finish refer to EO 05-1-3/23.

Splicing of Streamline Tubing by Outer Sleeve Method

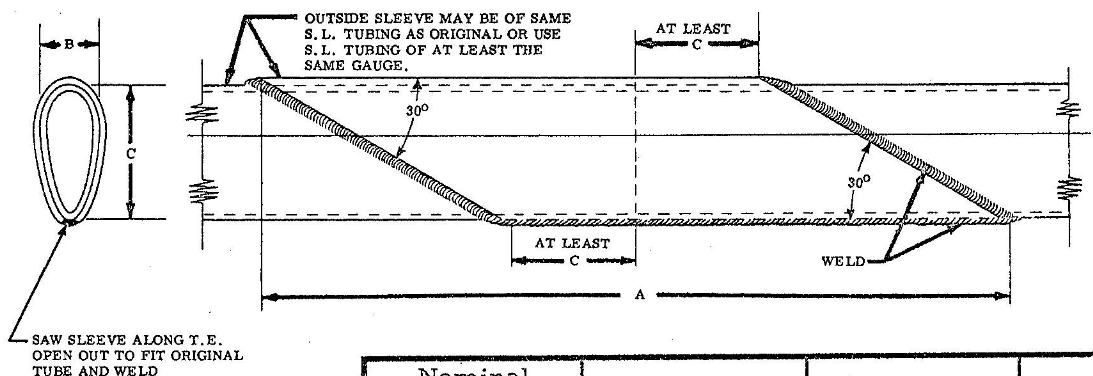
42 For splicing of streamline tubing by this method see Figure 17.

Splicing Structural Tubes using Larger Diameter Replacement Tubes

43 This method of splicing structural tubes requires the least amount of cutting and welding but cannot be used where the damaged tube is cut too near the adjacent joints, or where bracket mounting provisions make it necessary to maintain the same replacement tube diameter as the original. To effect this type of repair proceed as follows:

(a) Cut the original damaged tube, leaving a minimum short stub equal to 2-1/2 tube diameters on one end, and a minimum long stub equal to 4-1/2 tube diameters on the other end, (See Figure 18). The cuts must be away from the middle third of the affected tube.

(b) Select a spare length of steel tubing having an inside diameter approximately equal to the outside diameter of the damaged tube and of the same wall thickness as, or greater than, the damaged tube. This replacement tube




A - Minimum Length of Sleeve

B - Streamline Tube Length of Minor Axis

C - Streamline Tube Length of Major Axis

| Nominal Size | A | B | C |
|---|---|---|---|
| 1 | 7.324 | .572 | 1.340 |
| 1-1/4 | 9.128 | .714 | 1.670 |
| 1-1/2 | 10.960 | .858 | 2.005 |
| 1-3/4 | 12.784 | 1.000 | 2.339 |
| 2 | 14.594 | 1.144 | 2.670 |
| 2-1/4 | 16.442 | 1.286 | 3.008 |
| 2-1/2 | 18.268 | 1.430 | 3.342 |

Figure 17 Streamline Tube Splice using Outer Split Sleeve

should fit about the original tube with a maximum tolerance of one sixty-fourth of inch. From this replacement tube material, cut a section of tubing of such a length that each end of the tube is a minimum distance of 1-1/4 tube diameters from the end of the cut on the original tube. Use a fishmouth-cut replacement tube wherever possible, (see Figure 18), however a diagonally cut tube may also be used.

(c) Deburr edges of replacement tube and original tube stubs. If a fishmouth cut is used, file the sharp radius of the cut with a small, round file.

(d) Drill replacement tube for rosette welds located as shown in Figure 5.

(e) Slip the replacement tube over the long stub, then back over the short stub. Centre the replacement tube between the stubs of the original tube.

(f) Tack weld one end of the replacement tube in several places, then weld completely around the end. In order to prevent distortion, allow the weld to cool completely.

(g) Weld the remaining end of the replacement tube to the original tube and weld rosettes.

44 Refer to EO 05-1-3/23, for anti-corrosion procedure and surface finish as required.

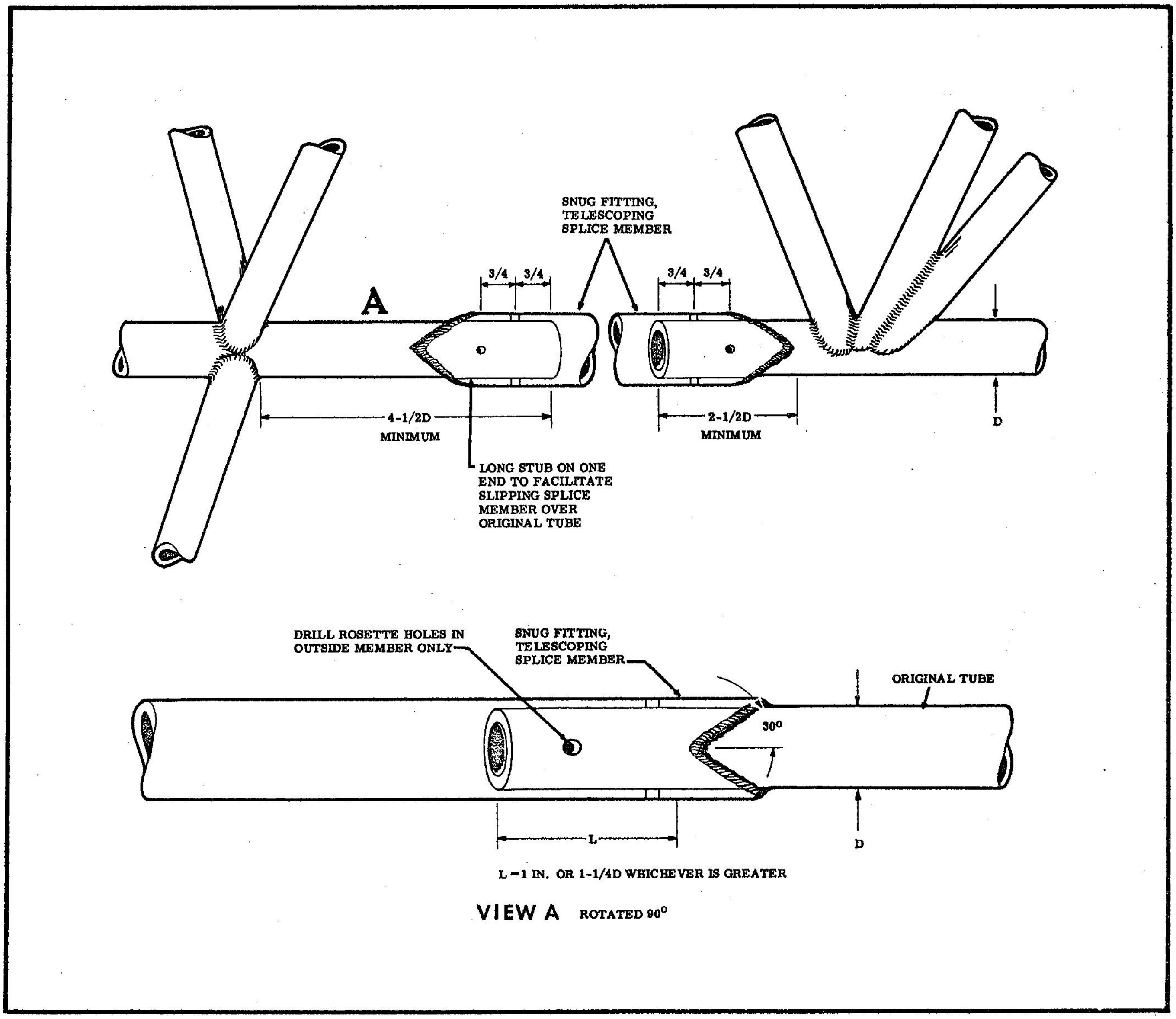



Figure 18 Fishmouth Splice using Larger Size Replacement Tube

Splicing Structural Tube by Inner Sleeve Method

45 For partial replacement of a tube, the inner sleeve splicing method is used where a smooth tube surface is required. (See Figure 13). Proceed as follows:

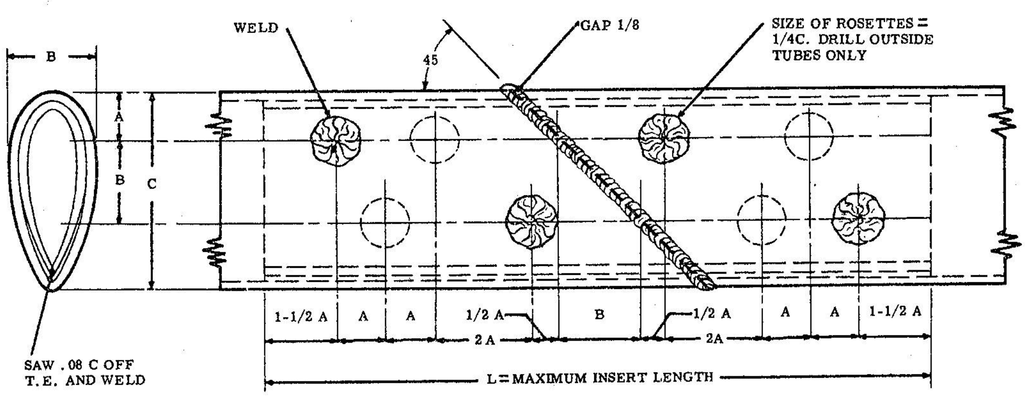
(a) Diagonally cut out the damaged portion of the tube with a hacksaw, locating the cuts away from the middle third of the affected tube section. Deburr the edges of the cuts.

(b) Diagonally cut a replacement tube to match the diameter, wall thickness, and length of the removed portion of the damaged tube.

(c) At each end of the replacement tube allow a 1/8 inch gap from the diagonal cuts to the stubs of the original tube.

(d) Select a length of steel tubing of the same wall thickness and of an outside diameter approximately equal to the inside diameter of the damaged tube. This inner sleeve should fit snugly within the original tube, with a maximum tolerance of one sixty-fourth of an inch. From this inner sleeve tube material cut two sections of tubing, each of such a length that the ends of the inner sleeve will be a minimum distance of 1-1/4 tube diameters from the nearest end of the diagonal cut. (See Figure 13). Notch ends of inner sleeves as indicated in Figure 5.

(e) With thin paint, metal dye, or emery paper (Item 2) make a narrow mark around the centre of the reinforcing sleeve. Mark the outside of the diagonally cut original tube stub midway along the diagonal cut. (See Figure 5).




Insert Tube is of Same Streamline Tubing as Original

A - 2/3 B

B - Minor Axis Length of Original Streamline Tube

C - Major Axis Length of Original Streamline Tube

| Nominal Size | A | B | C | L |
|---|---|---|---|---|
| 1 | .382 | .572 | 1.340 | 5.16 |
| 1-1/4 | .476 | .714 | 1.670 | 6.43 |
| 1-1/2 | .572 | .858 | 2.005 | 7.72 |
| 1-3/4 | .667 | 1.000 | 2.339 | 9.00 |
| 2 | .763 | 1.144 | 2.670 | 10.30 |
| 2-1/4 | .858 | 1.286 | 3.008 | 11.58 |
| 2-1/2 | .954 | 1.430 | 3.342 | 12.88 |

Figure 19 Landing Gear Streamlined Tube Splice using Split Insert

(f) Drill holes in stub tubes for rosette welds as shown in Figure 5.

(g) At a minimum distance of 2-1/4 times the tube diameter, measured from the nearest end of the diagonal cut, centre punch the tube and start drilling the No. 40 hole at a 90° angle. After a shallow hole is started, slant the drill toward the cut and drill at a 30° angle. Slanting the hole in this manner aligns the edges of the hole with the line of pull of the sleeve-pulling wire, and prevents the wire from scraping the hole edges. Deburr the edges of the hole with a round, needle-point file. Obtain a length of 1/16 inch welding or brazing wire, insert one end into the drilled hole, and push the wire out the end of the tube, (see Figure 5). Weld the end of the wire to the inside of the reinforcing sleeve.

(h) Slip the sleeve into the replacement tube so that the welded wire is 180° from the drilled hole. If the inner sleeve fits very tightly in the replacement tube, chill the sleeve with dry ice or in cold water. If necessary, polish down the diameter of the sleeve with emery cloth. Chilling or polishing allows more clearance from the inner sleeve to the inside wall of the tube stubs. Align the original tube stubs with the replacement tube.

(j) Pull on the exposed end of the sleeve-pulling wire until the centre mark on the sleeve is directly in line with the centre mark on the diagonal cut, (see Figure 5). When this occurs, the inner sleeve is centered beneath the joint.

(k) Sharply bend the pulling wire over to hold the sleeve in position. At each side of the replacement tube, weld the inner sleeve to the tube stubs through the 1/8 inch gap between the stubs, (see Figure 5). Completely fill the 1/8-inch gap and form a weld bead over the gap.

(m) Weld up rosette welds.

(n) Snip off the pulling wire flush with the surface of the tube and weld over the hole.

(p) Refer to EO 05-1-3/23, for anti-corrosion procedure. Refinish as required. See Figure 2 for a suitable type of fuselage welding jig.

## REPLACING STRUCTURAL TUBES

### General

46 When tubes are severely damaged, replace them. Tube replacement is necessary where an original tube stub is too short to attach a replacement and where splice welds would be made in the middle third of a member.

### Removal of a Member at Joint or Cluster

47 To remove a member at a joint or from a cluster of tubes, use a fine-toothed hacksaw and remove the tube carefully and completely from the structure. While cutting out the tube, exercise caution to prevent any damage to adjacent tubes or welds. Where new welds are made over existing welds, completely chip or file off the old welds. When installing a new tube member, allow a clearance of one thirty-secondth of an inch at either end for expansion. After the new tube has been welded in place, clean the welded joints with a wire brush or steel wool. Refer to EO 05-1-3/23, for the anti-corrosion procedure. Refinish as required.

### Landing Gears

48 Landing gears made of round tubing may be repaired using standard repairs and splices.

49 Landing gears made of streamlined tubing may be repaired by using methods detailed, with limiting dimensions as shown in Figure 19.

### Ski Pedestals

50 Damaged pedestals made of steel tubing may be repaired by using any of the applicable methods.

### Wing and Tail Surface Brace Struts

51 When spare parts are not available for the repair of these components, use the repair methods detailed in previous paragraphs with limiting dimensions as shown in Figure 17. Steel brace struts may be spliced at any point along the length of the strut provided the splice does not overlap any part of an end fitting. The jury strut attachment is not considered an end fitting, therefore, a splice may be made at this point. The repair procedure and workmanship should be such as to minimize

distortion due to welding and the necessity for subsequent straightening operations. Every repaired strut should be carefully observed during initial flights to ascertain that the vibration characteristics of the strut and attaching components have not been adversely affected by the repair. The check should cover a wide range of speed and engine power combinations.

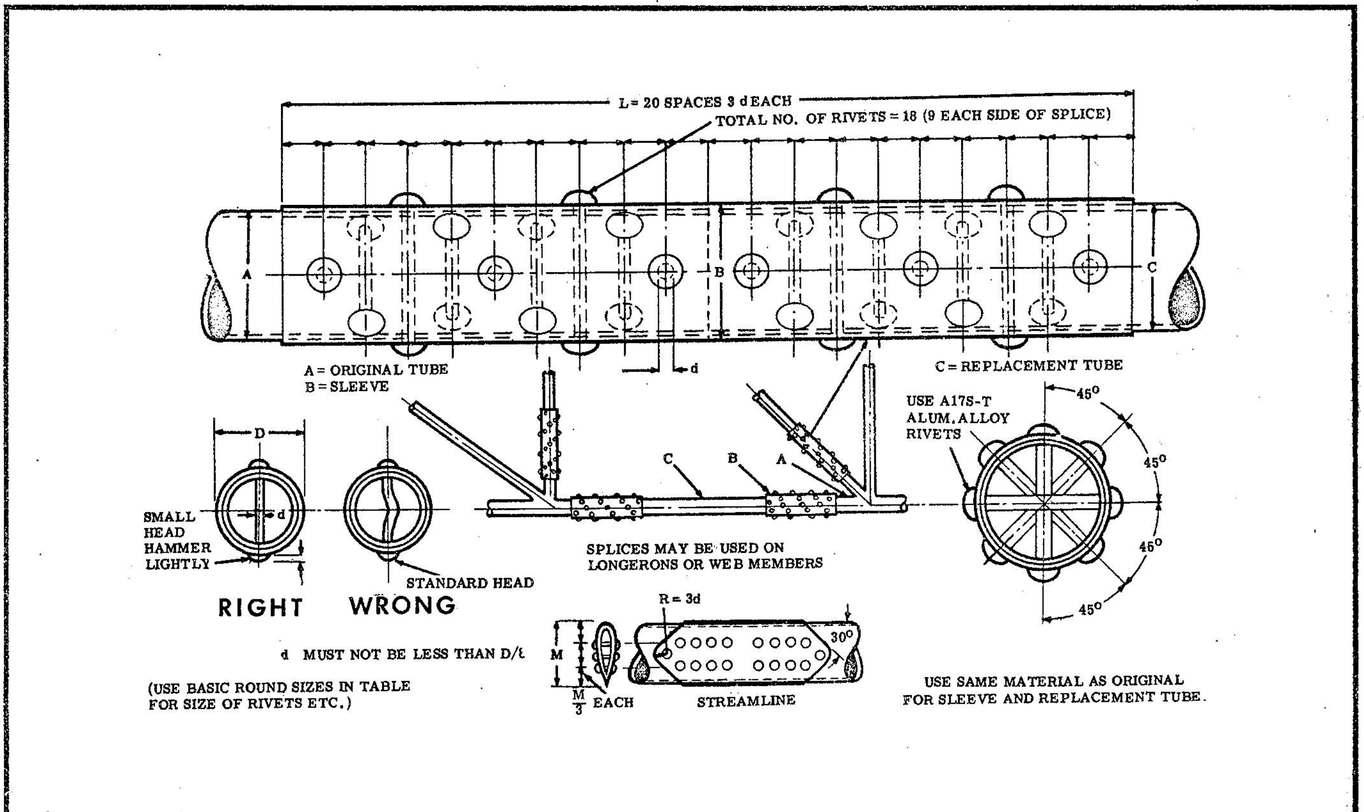
52 When making repairs to wing and tail surface brace members pay particular attention to proper fit and alignment to avoid eccentricities.

Engine Mounts

53 Engine mount members are repaired by using a larger diameter replacement tube telescoped over the stub of the original member and using fishmouth and rosette welds.

Check of Alignment

54 Repairs to engine mounts are governed by accurate means of checking alignment. When repairs are made, the original alignment of the structure must be maintained. This is done by measuring the distance between points of




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A, C* | 3/4 | 7/8 | 1 | 1-1/8 | 1-1/4 | 1-3/8 | 1-1/2 | 1-5/8 | 1-3/4 | 1-7/8 |
| | .065 | .065 | .065 | .065 | .058 | .058 | .058 | .058 | .058 | .058 |
| B | 7/8 | 1 | 1-1/8 | 1-1/4 | 1-3/8 | 1-1/2 | 1-5/8 | 1-3/4 | 1-7/8 | 2 |
| | All .058 Thick | | | | | | | | | |
| Rivet Dia. | 5/32 | 5/32 | 3/16 | 3/16 | 3/16 | 3/16 | 1/4 | 1/4 | 1/4 | 1/4 |
| L | 9-3/8 | 9-3/8 | 11-1/4 | 11-1/4 | 11-1/4 | 11-1/4 | 15 | 15 | 15 | 15 |

* Includes all Thicknesses up to and Including Maximum Shown.

Figure 20 Typical Tubular Repair for Aluminum Alloy corresponding members that have not been distorted, and by reference to the manufacturer's drawings.

Cause for Rejection

55 If any member is out of alignment, the engine mount must be replaced.

Engine Mount Ring Damage

56 Minor damage, such as a crack adjacent to an engine attachment lug, may be repaired by rewelding the ring and extending a gusset or a mounting lug past the damaged area. Engine mount rings which have been extensively damaged should not be repaired but should be replaced unless the method of repair is specifically approved by engineering authority.

Rivetting of Tubes

57 Round or streamline tubular members may be repaired by splicing and rivetting as shown in Figure 20. Splices in struts should not overlap the fittings.

58 When solid rivets go completely through hollow tubes, their diameter should be at least one-eighth of the outside diameter of the outer tube. Rivets which are loaded in shear should be hammered only enough to form a small head, and no attempt should be made to form the standard head. The amount of hammering required to form the standard head often causes the rivet to buckle inside the tube. Correct and incorrect examples of this type of rivet application are shown in Figure 20.

Attachment of Built-in Fittings

59 Repair structural members, which have built-in fuselage fittings, according to the standard procedures described, or replace the member and reweld the fitting in place, taking care to ensure correct alignment.

Bending of Tubing

60 To bend a tube, cut a length approximately 8 inches longer than the finished size. Drive a wooden plug into one end, pack tightly with fine

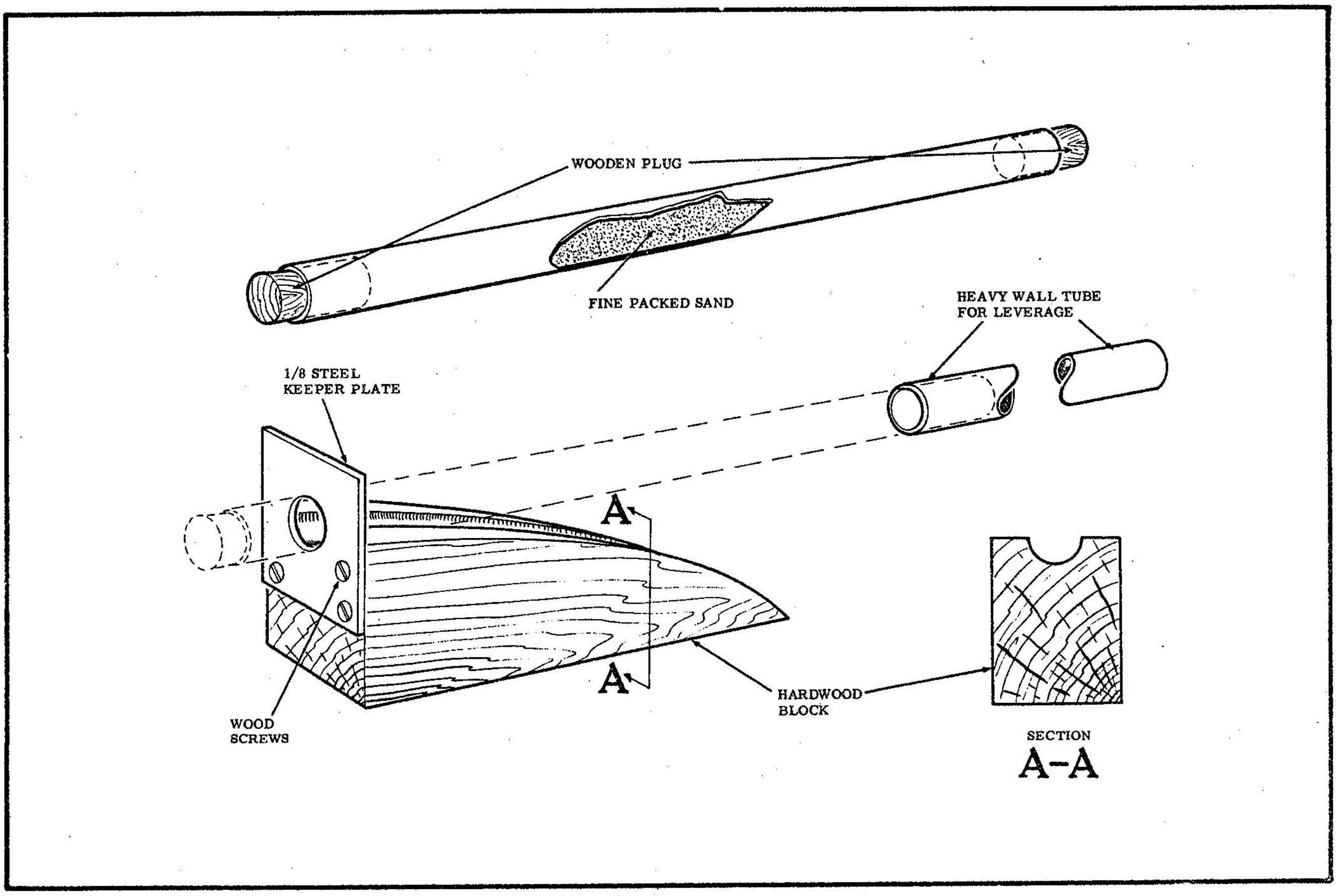



Figure 21 Bending Jig for Structural Tubing

sand, and drive a wooden plug into the open end. Make a hardwood bending jig, (see Figure 21), somewhat smaller than the required radius of the tube to be bent to allow for spring back. Clamp jig securely in a vise. Insert one end of the tube into the keeper hole, and, with a heavy walled tube slipped over the other end to give added leverage, bend tube around the form. Trim ends to required length and install.

Material Specifications

61 For material specifications, item numbers and manufacturers, see Figure 22.

| ITEM NO. | MATERIAL | RCAF REF | SPECIFICATION | MANUFACTURER |
|---|---|---|---|---|
| 1 | Asbestos, Sheet | 32E/ | MIL-A-17472 | Commercial Grade |
| 2 | Paper, Emery, Fine | 29/1834 | | |
| 3 | Sandpaper | 29/1868 | | |
| 4 | Acid, Sulphuric | 33C/4 | 15-GP-8a | |
| 5 | Acid, Boracic | 14B/ | | Commercial Grade |
| 6 | Sodium Chloride | 33C/525 | | Commercial Grade |
| 7 | Potassium Carbonate | | | |
| 8 | Colophony | | | Technical Grade |
| 9 | Oil, ME, SAE10W | 34A/35 | 3-GP-45 | |
| 10 | Talc, Chalk, French | 33C/11 | MAT-2-1 | |
| 11 | Soap, Bubble Fluid, Diluted 1 to 10 | 33C/NIC | | B.W.Deane & Co. 3620 Namur St., Montreal |

Figure 22 Table of Material Specifications