RESTRICTED
FILE: O

TECHNICAL ORDER No. 01-60E-3

HANDBOOK OF INSTRUCTIONS

STRUCTURAL REPAIR
O-47 SERIES AIRPLANES

Extract from A. R. 380-5, paragraph 18.b dated September 28, 1942. This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C., 31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

PUBLISHED BY AUTHORITY OF THE COMMANDING GENERAL, ARMY AIR FORCES BY THE HEADQUARTERS, FIELD SERVICES, AIR SERVICE COMMAND, PATTERSON FIELD, FAIRFIELD, OHIO

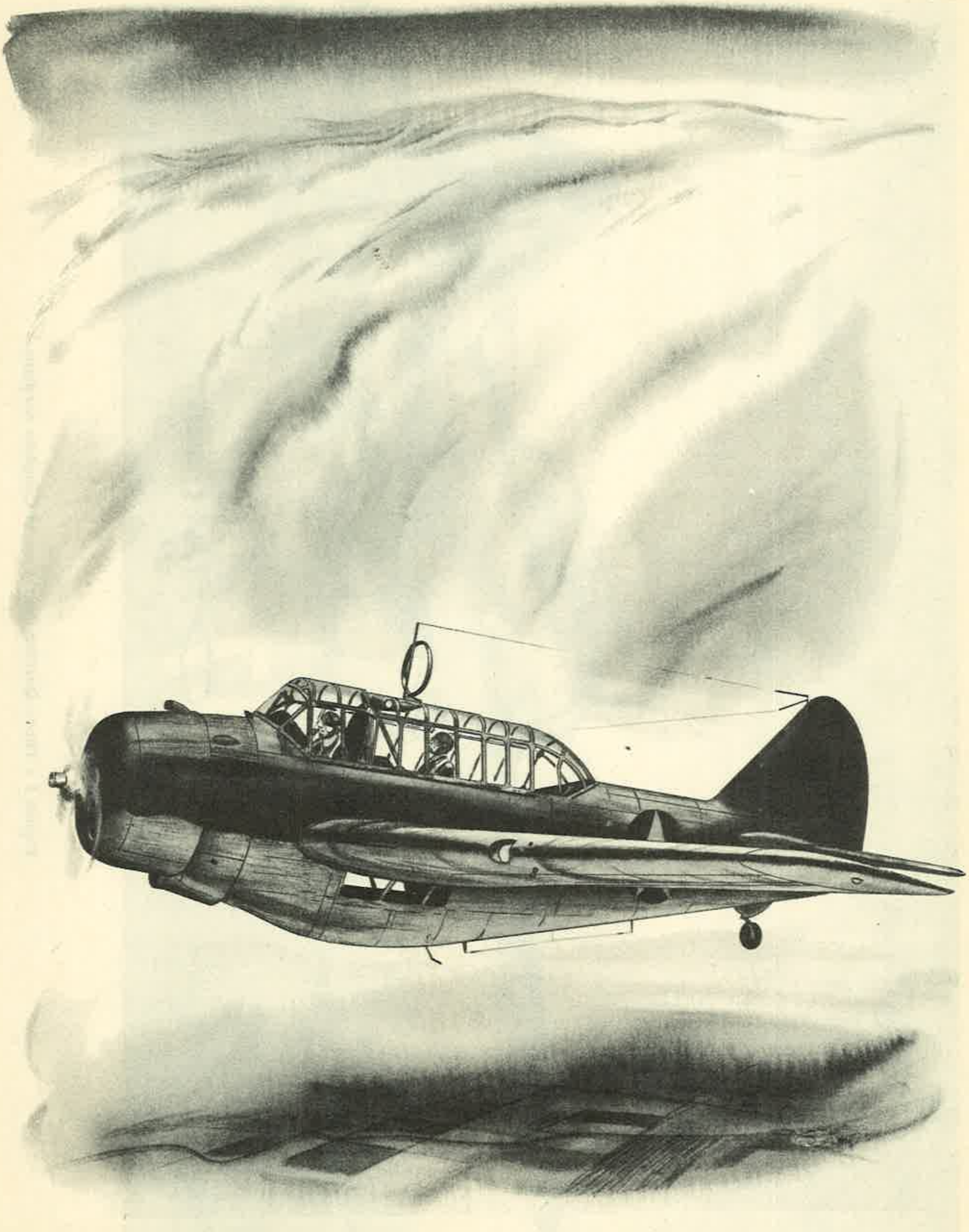
FOTO-LITH, INC.
15000—12-7-42

DECEMBER 5, 1942

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES



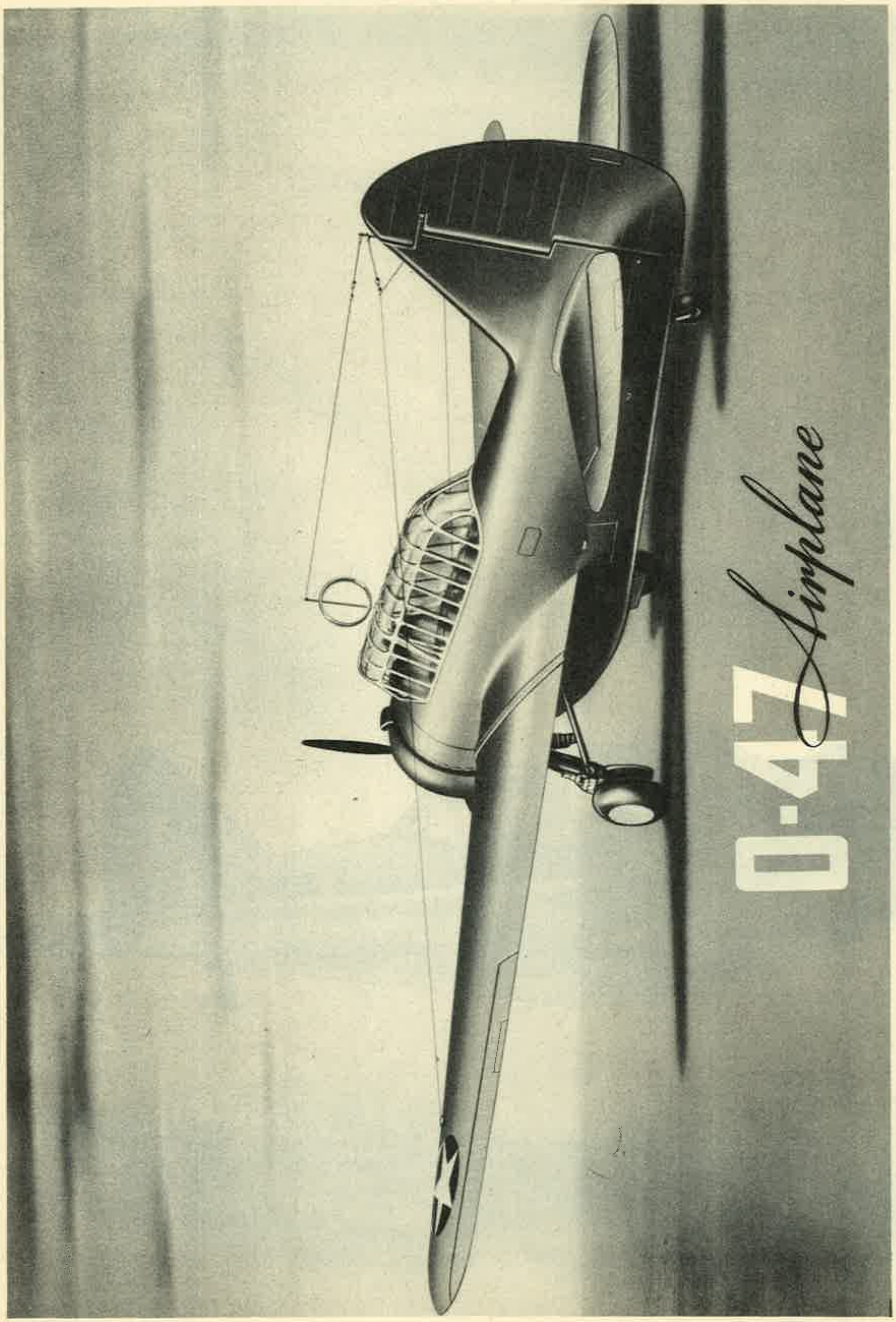


Figure 1 - Three-Quarter Rear View of Complete Airplane

SECTION I

INTRODUCTION

1. This Technical Order is a manual of instructions for the Structural Repair of the Models 0-47A and 0-47B Observation Airplanes, procured on contracts W535 ac-9443 and W535 ac-11994, according to Specification Nos. 98-408A and 98-409-1. It includes necessary information for the repair of structural parts of the airplane which have been damaged by accident or enemy action. This Technical Order is intended to include instructions for emergency repair rather than general overhaul instructions which are included in Technical Order Nos. 01-60EA-3 and 01-60EB-3.

2. It is intended in the preparation of this manual, to exclude any preconceived idea as to the extent of damage, but provide for the repair of any damage to any part of the airplane which may be repaired. Since the scope of possible damage is so broad, it would be impossible to outline any exact repair procedure. Only general repair methods are described which must be supplemented and altered to suit each specific situation. In considering a repair problem, remember that all parts of any aircraft structure must function one with another to support the loads applied. Frequently, the immediate damage done to a member may affect a change in stress distribution to other parts that will also render them critical. Difficulties in fabrication and assembly are frequently the cause of accumulated tolerances. It should be borne in mind that any dimensions and/or rivet requirements in this manual, must be considered a minimum.

SECTION II

GENERAL STRUCTURAL REPAIR INFORMATION

1. Drill Sizes.

The capacity of a bolt or rivet to transmit forces from one part of a structure to another depends upon the size and nature of the hole in which it is used. Certain standards have been created governing the drill size to be used in various instances.

Due to the unique circumstances affecting most repairs, and also due to the tolerances on drills, especially in service, the following data are set forth as standard practice in making all repairs. Wherever a bushing is used, the final hole shall be drilled or reamed in accordance with the original drawing instructions. Wherever a rivet or bolt is added to an existing group of rivets or bolts, the new hole shall correspond to the size hole used with the original. For example: A 1/4-inch bolt is added to a pattern of 4-1/4 inch bolts where the holes were first drilled and then reamed to .250 inch. The new hole should be drilled and then reamed to .250 inch. Wherever a repair requires the addition of rivets or bolts which were not formerly required, such as rivets for a stringer of sheet splice, the drilled hole shall be the nearest size larger than the nominal size of the rivet or bolt. For example: Drill No. 12 (.189 inch) for an AD6 rivet, a 1032 screw, or an AN3 bolt.

2. Steel Tubing Repairs.

Welded steel tube structures are used mainly in engine mounts and in fuselages. Several types of defects which occur in steel tubing construction are: imperfections such as cracks or inclusions in the material itself; dents or scratches due to maltreatment or enemy action; warpage due to improper fabrication; and insufficient length to provide a proper fit. In most cases, where the defect is of great magnitude, the damaged tube should be replaced. This pertains especially to cracks or inclusions, the extent of which is unknown.

a. Any tubular member, originally welded into a part of the structure, may be spliced according to the methods outlined here and in section VI provided the following precautions are considered:

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

(2) Only one splice can be made in any one bay of a structural member.

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

(4) 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 shall be replaced entirely in the case of web members, and in the case of continuous longerons, the splice shall be made in an adjacent bay.

(5) No splices shall be made by butt-welding any member between station points.

3. Stringer Splices.

Stringer splices are of importance to the structural repair of airplanes because of the great numbers of stringers used in the monocoque type of construction and also because of the various possibilities of errors in fabrication. Some of these possibilities are: cutting a stringer too short, causing insufficient edge distance for the end rivet or bolt, or the elimination of a rivet or bolt; misaligning a stringer causing the rivets or bolts to lie in the radius or too close to the edge; and damaging a stringer in any way and thereby reducing its ability to carry loads.

Information outlining the various defects, necessitating a stringer splice, is included in the following text and in section V, 4.

Due to the difference in the allowable stresses for stringers in tension and compression, and also due to the fact that upper surface stringers are designed by the compressive allowable, splices on the upper surface will require fewer rivets than on the lower surface.

a. All splices are to be made in accordance with the following principles:

(1) SKIN RIVETS AT THE END OF THE SPLICE MUST HAVE 3/8-INCH EDGE DISTANCE. THIS MAY NECESSITATE MAKING A SPLICE MEMBER LONGER THAN THAT NOTED ON THE SPLICE DRAWING.

(2) Under no circumstances shall the number of splicing rivets or the number of skin rivets in the joint be less than shown on the drawing.

(3) If the skin rivets are spaced at 1-1/4 inches from rivet center to rivet center or greater, double the number of existing skin rivets at the splice.

(4) No splices shall be made in the bay at the end of the stringer.

(5) Use flathead rivets where they are not exposed to the outer airplane surfaces.

(6) For butt fit, end of stringer should be filed smooth and at a right angle to axis of the stringer. Maximum tolerance, $\pm.005$.

(7) All splice members must be in the tempered condition.

4. Sheet Splices.

The following information is intended to give general directions for making structurally sound joints and splices and is of a general nature only. The most frequent causes for making splices may be summed up as follows: Direct physical damage causing breakage of sheet; mislocation of rivet holes; sheet trimmed too short in fabrication.

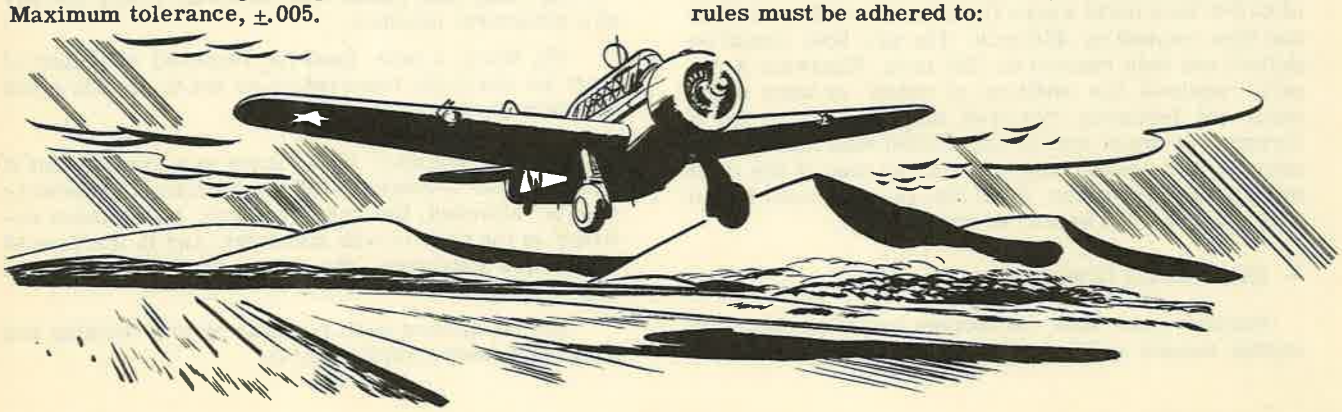
There are two types of sheet splices which may be used, the butt splice and the lap splice. Of these two types, the lap splice is preferable since the butt splice requires a backing plate and twice as many rivets. However, the butt splice is used more frequently because with its use, a smooth contour can be maintained.

The backing plate for a butt splice must be of equal or greater thickness than the material being spliced, and must be provided with 1/4-inch flanges.

All splices in the outer skin are subject to the following restrictions: No splice shall be made in the same bay with the end of the sheet; never shall two splices be made in the same bay; no span-wise splices shall be made on a wing within 15 inches of the spars; and no longitudinal splice shall be made on a fuselage adjacent to a longeron.

5. Bolted Joints.

Bolted and screwed joints are equally as important in aircraft production and repair as welded or pinned joints. Since all fittings cannot be permanently attached to other structural members, such as by welding, bolted connections are often used. To make a bolted or screwed joint equally as rigid as a welded connection, it is necessary that certain definite precautions be taken. The first precaution is that all bolt holes should be the smallest consistent with the design. This means using the first larger drill size over the nominal diameter of the bolt or else a close tolerance reamer. When in doubt, a safe rule is to drill the hole undersize and ream for a close fit. To make a joint structurally safe, the following general rules must be adhered to:



Rule 1 - THERE SHALL BE NO BOLT THREADS BEARING IN ANY PART OF A JOINT IN WHICH THE BOLT TRANSMITS A SHEAR LOAD EXCEPT AS NOTED HEREIN. (By shear load is meant a load acting at right angles to the bolt.)

Rule 2 - THERE SHOULD BE NO MORE THAN APPROXIMATELY TWO BOLT THREADS SHOWING BEYOND ANY SELF-LOCKING NUT OR NUT PLATE.

a. Summary of Requirements. - It is extremely important that great care be taken in the use of bolts and nuts, as improper installation may cause dangerous structural weaknesses. Therefore, the following information is given, even though it may repeat some foregoing statement:

(1) The threads must cut completely through the fibre of the nut so that a portion of the thread can be seen.

(2) Not more than approximately two threads should extend beyond the fibre of the nut.

(3) The proper wrench length and the proper pull must be used to avoid damaging the bolt or nut and yet insure a sufficiently tight joint.

(4) Taps must never be used in any holes in installation or assembly work except when specifically called for.

(5) Any bolt entering an anchor nut must run freely enough to engage the threads in the nut by hand without the use of a wrench.

(6) The surfaces under the nut and the head must provide a complete seat for the same and shall be reasonably smooth.

(7) There shall be no threads bearing in any part of a joint in which a bolt transmits a shear load except where specifically noted elsewhere in this section.

b. Tightness of Bolts and Screws. - To prevent excessive tightening of aircraft screws and bolts, the following data is included:

Bolt Size	Twist	Wrench Length (in.)	Pull (lb)
AN3 (1032)	55	5	11
AN4 (1/4)	90	5	18
AN5 (5/6)	150	6	25
AN6 (3/8)	348	6	58
AN7 (7/6)	496	8	62
AN8 (1/2)	496	8	62

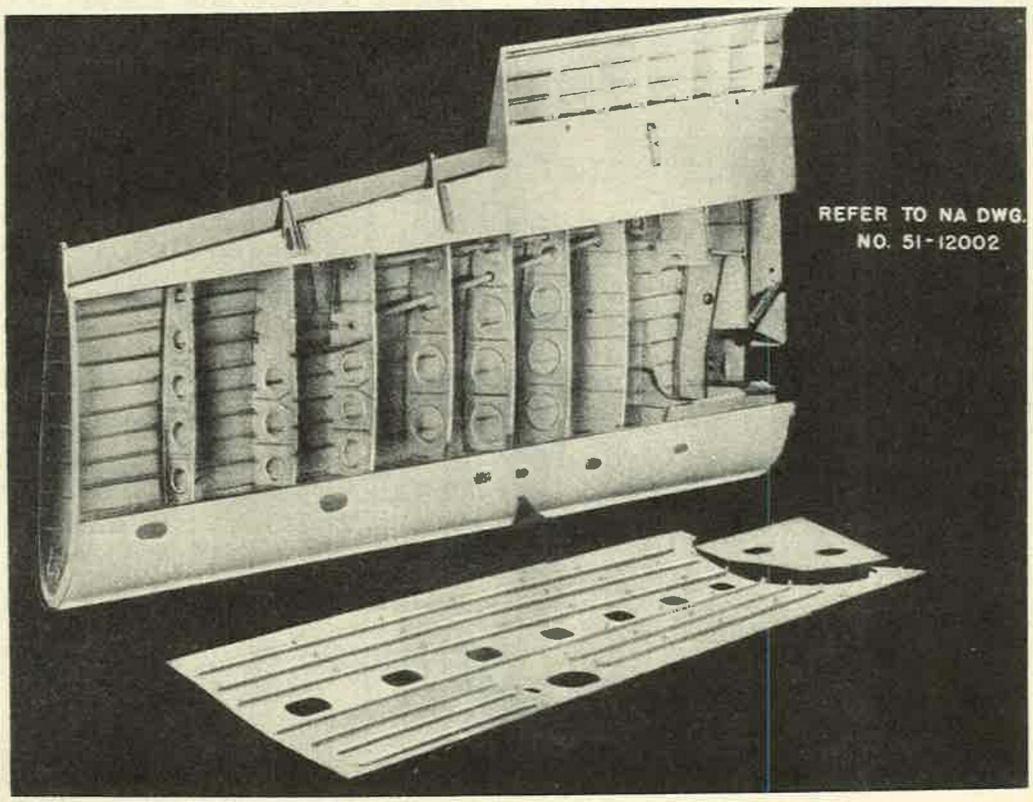


Figure 2 - Outer Wing Structure

SECTION III

WINGS

1. General.

The wing is a full cantilever metal-covered structure consisting of a center wing integral with the fuselage, and two removable outer panels with detachable wing tips. (See figure 2.)

2. Outboard Wing.

a. Extent of Damage. - Any damage to the outboard wing will be deemed reparable is sufficient tools and materials are available to repair the damage so that the airplane will be safe for flight. Severe injury to several wing ribs will generally require replacement. Minor damage such as small holes, cracks, bent ribs, or stringers may be repaired. Heat-treated parts can be repaired by welding in new members, but always after welding, the assembly must again be heat-treated. A major portion of the wing must be disassembled to remove the main spar, thus such repair would not be practical.

b. Access. - The outboard wing, being a stressed skin structure, is not readily disassembled other than by removing the wing tip, or the outboard panel from the center section. Access to internal damage may be gained by using present inspection holes, by removing skin covering where necessary, or by cutting additional access holes (sometimes called hand holes) in the skin. The cutting of such holes is limited in that they shall not cross any seam, stringer, or rib; the edge of the hole must not be closer than 1-1/2 inches to a rib or stringer, and no more than two such holes should be installed in any one bay.

For recommended types of access holes, refer to a following paragraph of this section and figures 3, 4, and 5.

(1) Flush Type Access Hole. - The flush type access hole is the most satisfactory for general use on the airplane. It is necessary to use this type of hole on the wing, forward of the front spar, to keep from distorting the smooth flow of air over the leading edge. The installation of a flush type access hole is illustrated in figure 3. The handhole is cut as shown, and is reinforced with a plate, which is installed inside of the skin, of 17STAL or 24STAL material one gage heavier than the skin material. Nut plates are riveted to the inside edge of this plate with AN425AD3 rivets. The plate is fastened to the skin with AN430AD3 rivets spaced approximately 1 inch apart in two staggered

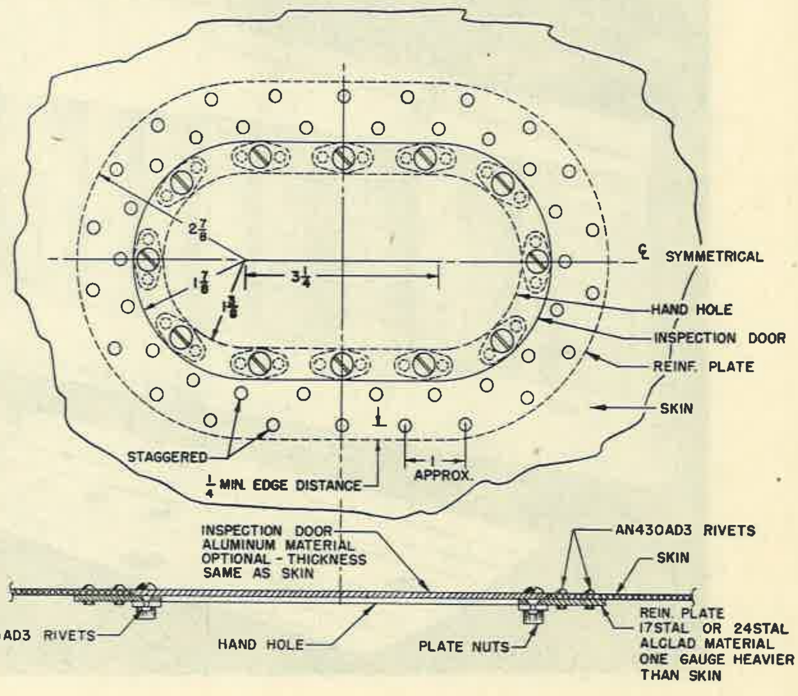


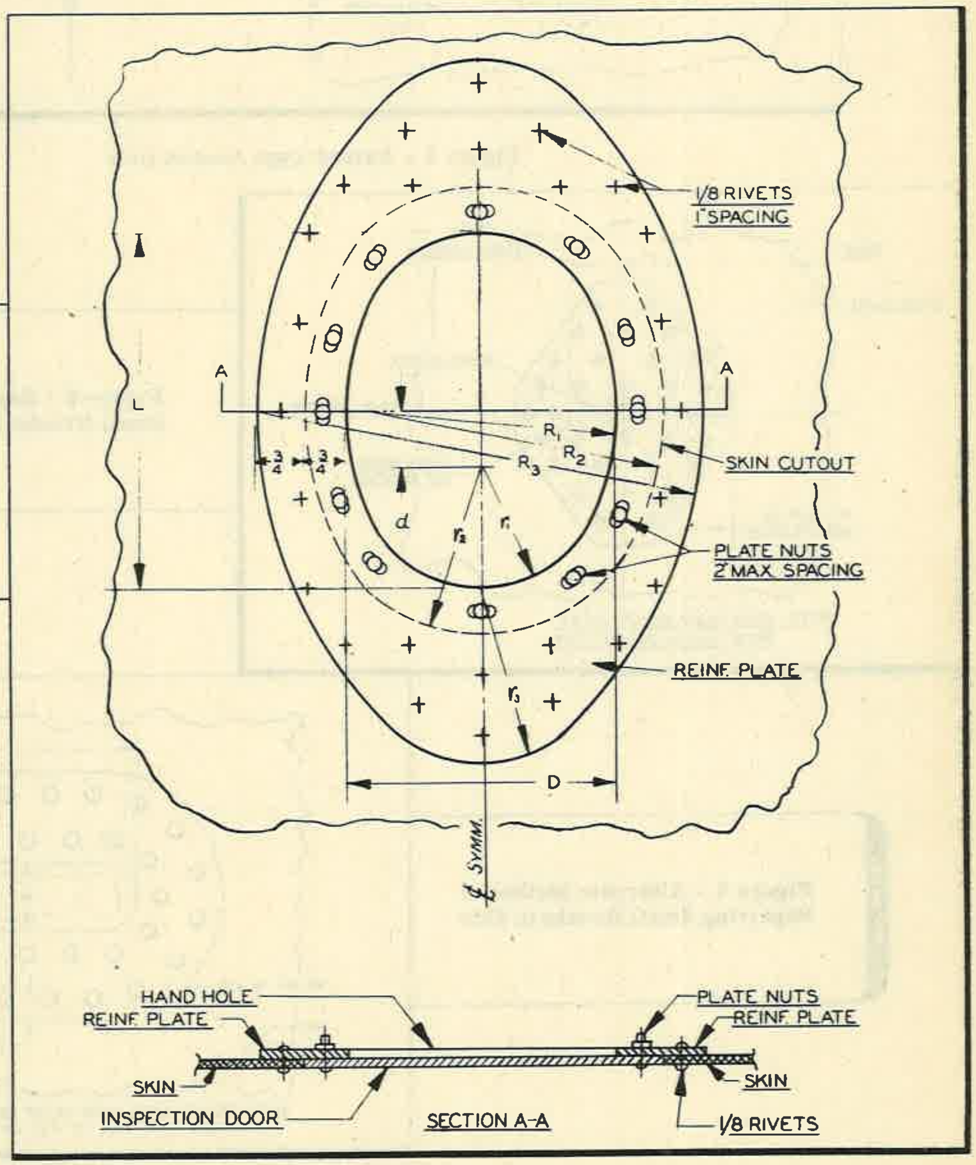
Figure 3 - Flush Type Access Hole (Type I)

rows 1/4-inch minimum distance from the edge of the plate. (See figure 3.) The inspection door, which is cut to fit the handhole in the skin may be of either 17STAL or 24STAL material of the same gage as the skin material. It is drilled to match the nut plates. 52SH material may be used for both the reinforcing plate and the inspection door, provided it is one gage heavier than the skin material. Another flush type access hole is illustrated in figure 4.

(2) Raised Type Access Hole. - As an alternative to the flush type hole, the raised type access hole has proved to be satisfactory. An access hole of this type is illustrated in figure 5. A circular handhole of 4 inches maximum diameter is cut in the skin, and reinforced on the inside with a ring 3/4 inch wide. The ring is made from .032 sheet 17STAL or 24STAL material. No. 10-32 nut plates and screws spaced approximately 1-1/2 inches apart, are riveted to the ring with AN425AD3 rivets. The ring, which must be cut in half to insert in the hole, is then riveted to the inside of the skin with AN425AD4 rivets spaced two between each nut plate. The cover plate, of 5-1/2 inches maximum diameter, is drilled to match the nut plates. Either 17STAL or 24STAL material of the same gage or one gage heavier than the skin material may be used.

NOTE: It should be kept in mind that cutting an access hole in one area gives access to the same region of the two adjoining areas through the lightening holes in the ribs.

Figure 4 - Flush Type Access Hole (Type II)



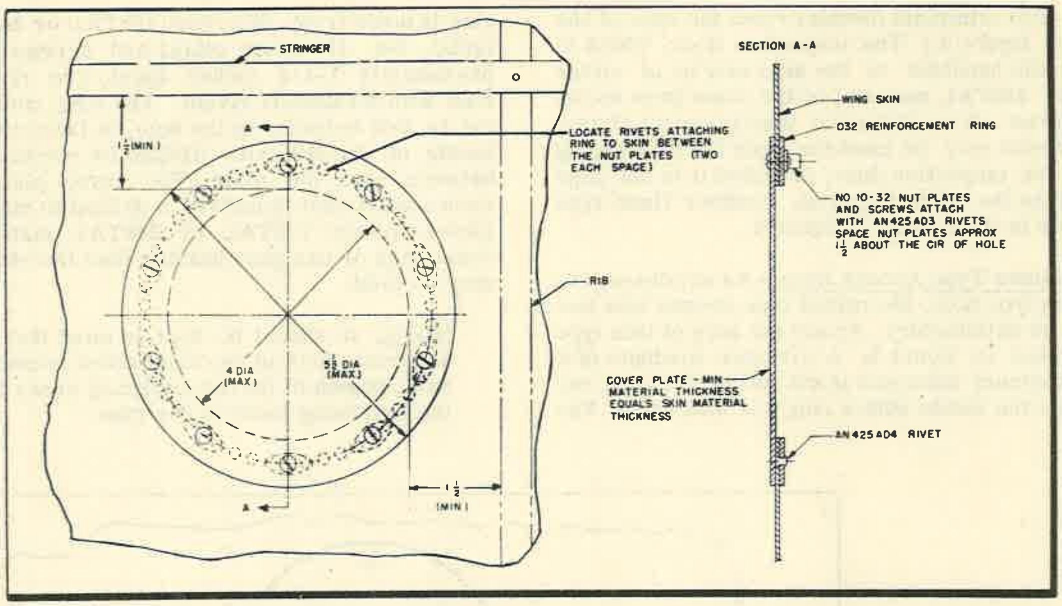


Figure 5 - Raised Type Access Hole

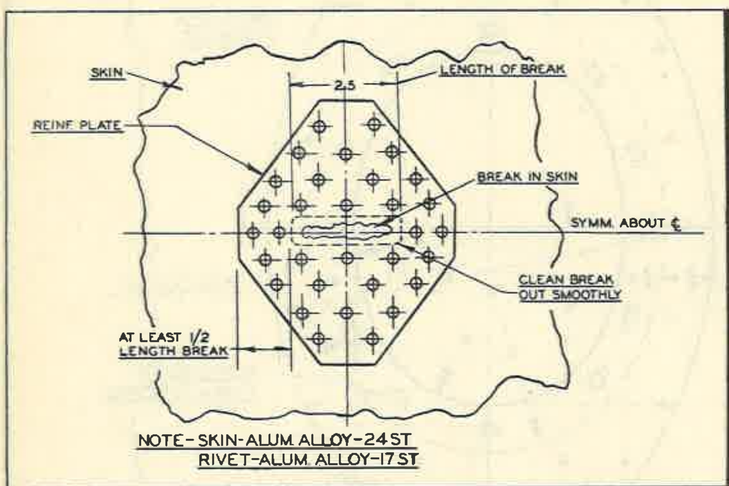


Figure 6 - Repair of Small Breaks in Skin

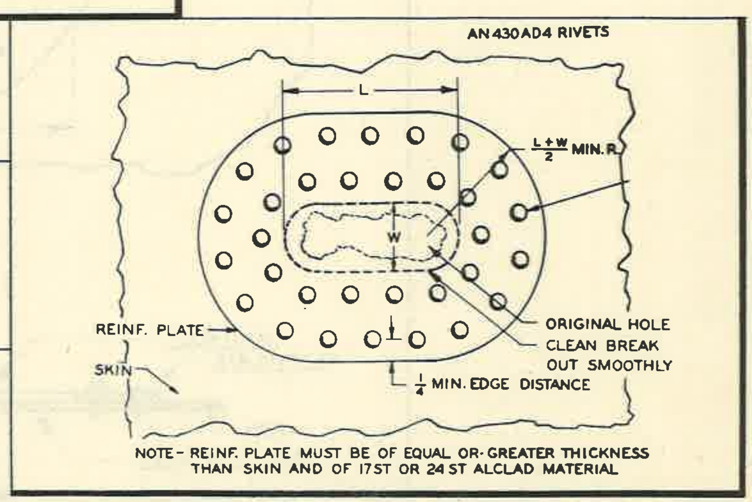


Figure 7 - Alternate Method of Repairing Small Breaks in Skin

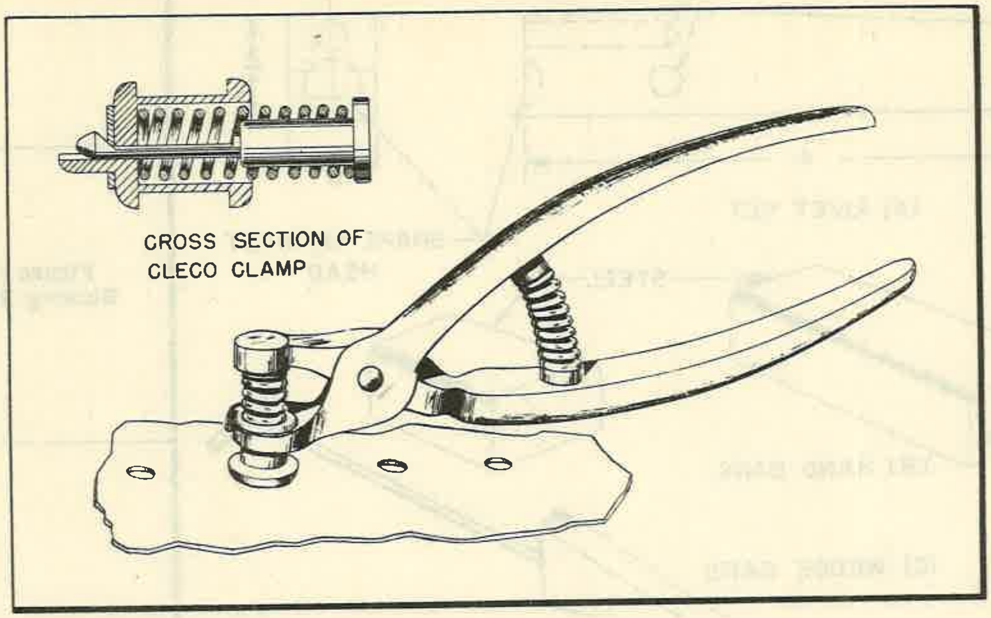


Figure 8 - Cleco Sheet Holders and Forceps

c. Skin Repair.

(1) Repair of Small Breaks in Skin. - Small breaks or punctures in the skin may be repaired as shown in figures 6 and 7. First cut away the ragged edges of the hole as shown by the dotted lines so that no sharp corners remain. Cut a patch from material of the same thickness as the skin panel or of one gage heavier material. In general, all aluminum alloy sheet (except landing gear and empennage fairing), all tubing (except fuel and oil lines), and all forgings, extruded sections and bar stock are heat-treated aluminum coated (Alclad) 24S aluminum alloy, AF Specification No. 11067. The shape and size of the patch should be similar to that shown in figures 6 and 7.

This patch is to be riveted to the skin, using AN430AD4 rivets as shown in the illustrations. To calculate the minimum number of rivets to be used, multiply the length of the hole after the ragged edges have been cut away by eight. The answer will be the minimum number of rivets required on each side of the break to attach the patch plate to the skin. As an example, assume that the length of the hole is 2.5 inches.

$$8 \times 2.5 = 20$$

Therefore, a minimum of 20 rivets must be used on each side of the hole or 40 rivets for the entire reinforcement.

(a) Standard Riveting. - In production, rivets are driven by pneumatic riveters, but in the field these tools are seldom available; so the rivets must be driven by hand. The tools necessary for riveting are a riveting hammer, a bucking iron, a rivet set, rivet cutters or nippers, and a drill.

The hole for the rivet should provide a good fit. This is essential if a good job is to result. If the hole is too small or has burrs left inside, the material will be bulged when the rivet is driven or the rivet itself will have grooves cut in its shank. If the holes are too large, the rivets will not prevent the sheets from shifting, causing consequent failure of the fastening. Rivets driven in holes too large are also likely to bend in the shank. If some holes are too large, the load is thrown entirely on the good rivets, putting an undue shearing strain on these rivets and possibly resulting in their shearing. The rivet is inserted in the correct size hole, so that it extends 1-1/2 times its diameter. If the rivet is too long, the end can be cut off with nippers. The sheets to be riveted must be firmly held together by machine screws or Cleco clamps during riveting. (See figure 8.)

The riveting is started by striking the rivet a few blows straight down while it is being supported with the bucking iron. Too many blows, or blows that are too heavy are likely to stretch the material around the rivet or bend the rivet itself. When the rivet has been swaged sufficiently to prevent its falling out, the head may be completed by placing the cup-shaped depression on a rivet set, over the rivet and hammering. It will help to produce a neater job if the head of the rivet set is rotated in a small circle as the heading proceeds, as this gives a more rounded finish to the head. (See figure 9.) Care should be taken in using the rivet set not to allow the edges of the set to dent the material. One of the most essential factors to a good riveting job is solidness of the bucking. For this reason a light bucking bar should never be used where it can be avoided. (See figure 10.) All aluminum alloy rivets used are A-17ST.

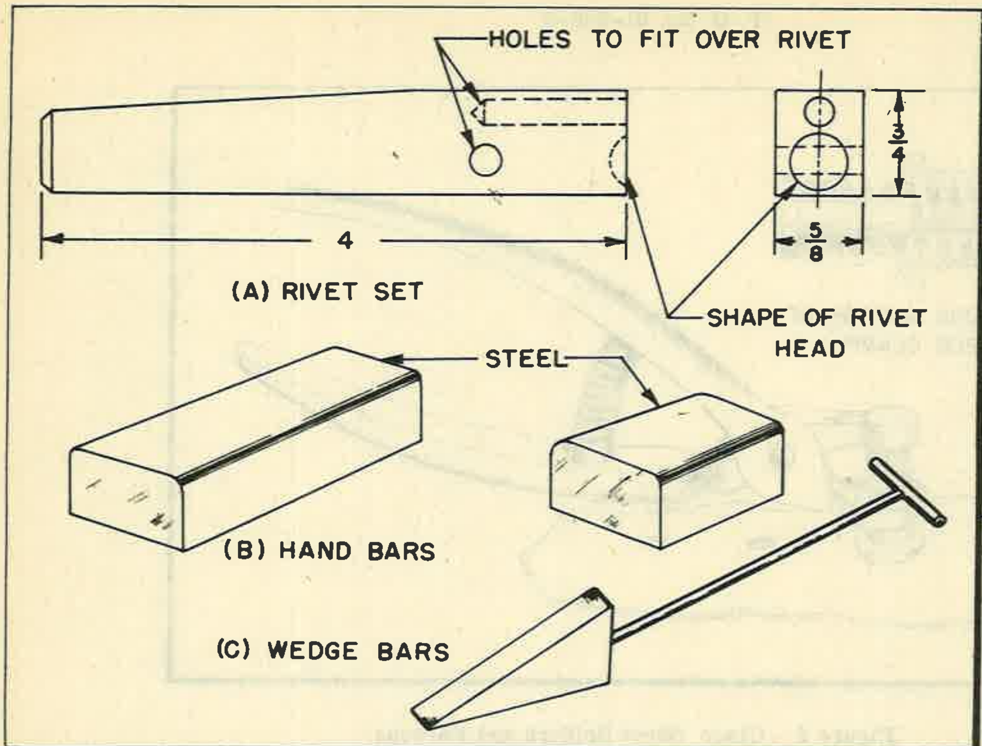


Figure 9 - Bucking Bars

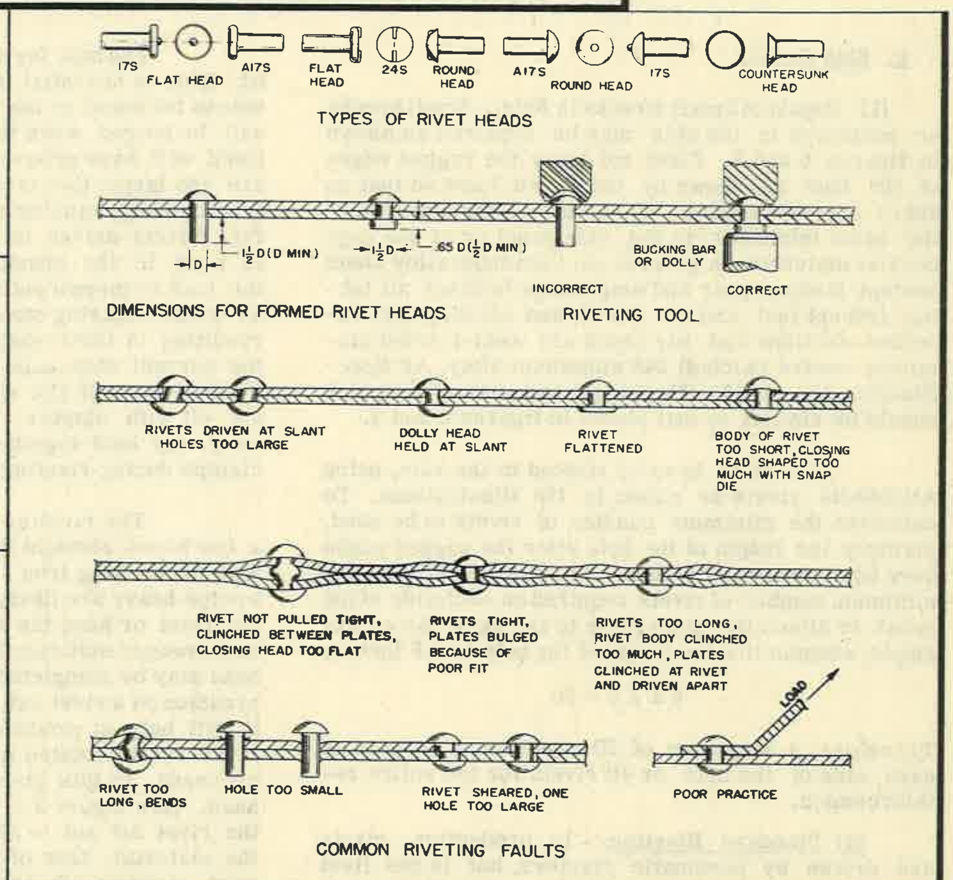


Figure 10 - Riveting

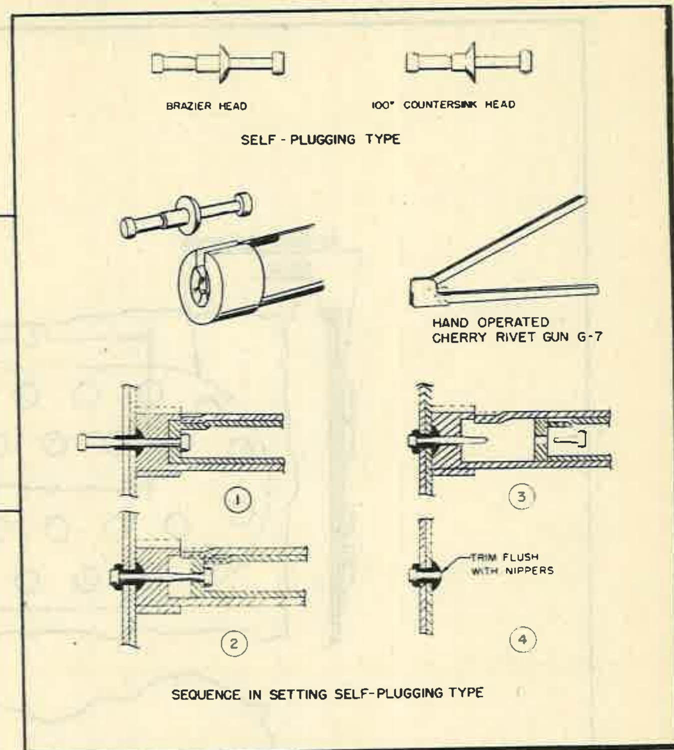


Figure 11 - Cherry Rivets

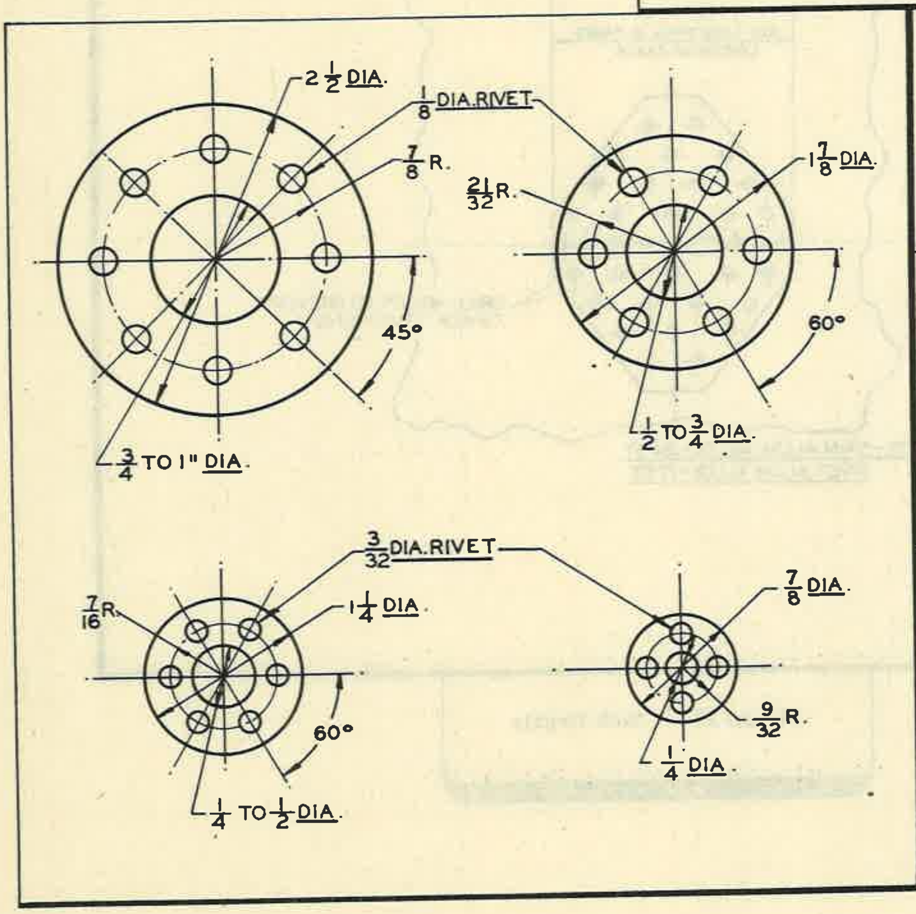


Figure 12 - Repair of Small Holes in Skin

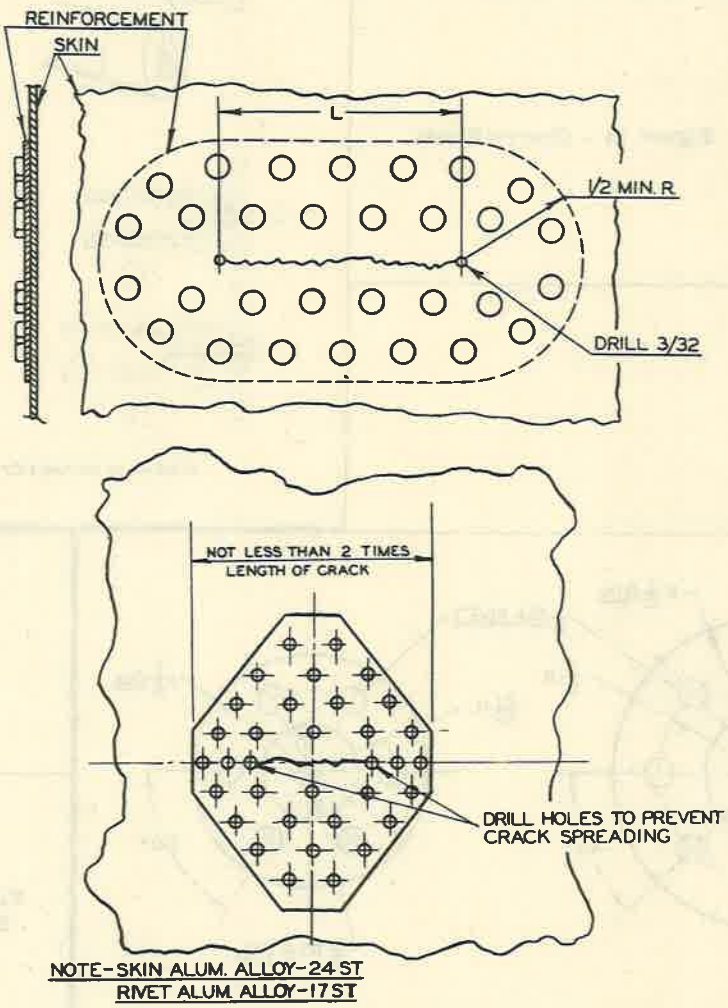


Figure 13 - Crack Repair

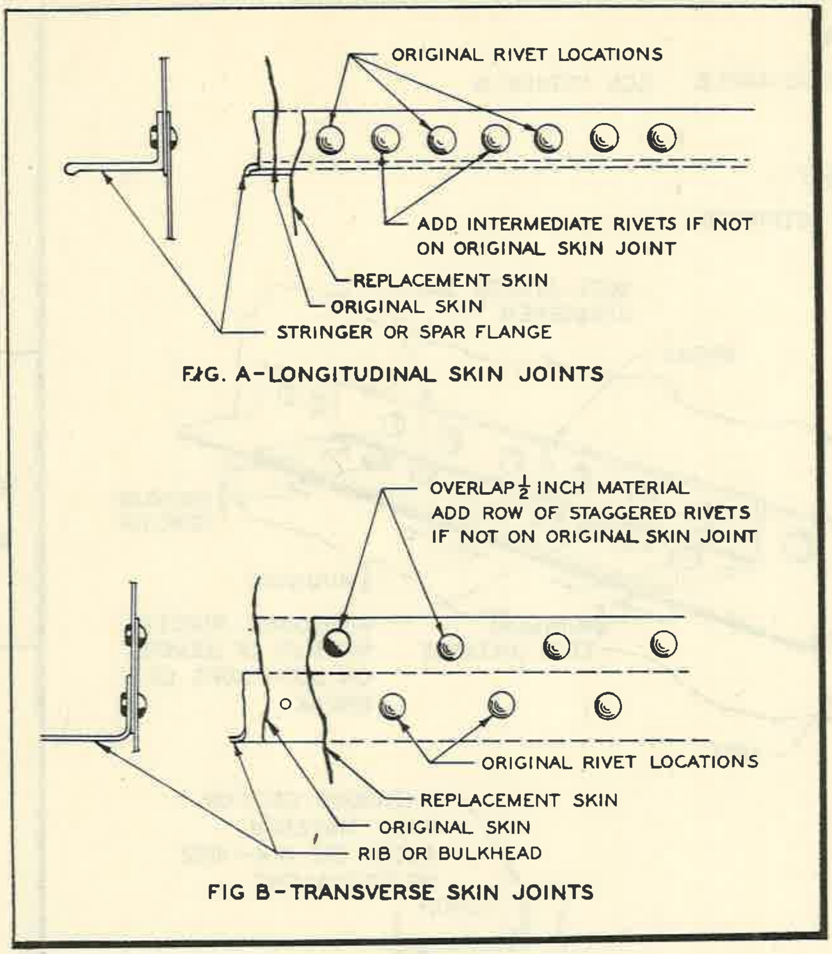


Figure 14 - Skin Repair Joints

(b) Blind Riveting. - There are two types of blind rivets that can be used for repairs where only one side of a part is accessible. The Cherry rivet, manufactured by the Cherry Rivet Company, Los Angeles, Calif., and explosive rivets, manufactured by the Du Pont De Nemours & Co. Inc., Wilmington, Deleware. Explosive rivets should be stored and handled according to the manufacturer's instructions, as the mishandling of such rivets will destroy their effectiveness. Care should be used when installing these rivets to see that the sheets of metal being riveted are pressed tightly together. Do not use a rivet in a total thickness greater or less than the grip range for which it is designed. Three metal thicknesses is the maximum number of metal thicknesses recommended when using explosive rivets.

The following information has been recommended by the Cherry Rivet Company for the use of self-plugging Cherry rivets: (See figure 11.)

1. No special precautions are necessary in handling Cherry rivets. Their general handling should be the same as solid rivets.

2. In drilling holes, care should be taken to have the holes at right angles to the sheets to be fastened together. The hole should be the same size as required for solid type rivets.

3. The sheets must be firmly held together while riveting so the use of clamps or sheet screws at reasonable intervals is recommended.

4. Several types of guns are manufactured by the Cherry Rivet Company. Some are hand operated, some are pneumatic, and some are combination pneumatic and hydraulic. The pulling heads on all of them operate on the same principal. Each has a slotted end into which the stem of the Cherry rivet is inserted. Each has an inside draw bar which on the application of force, pulls the head of the rivet against the gun and by continued pull forces the inside end of the stem into the tail of the rivet and eventually breaks the stem. Set the rivet in the jaws of the gun, insert the rivet in the hole, and with the head of the rivet held firmly against the metal, set the rivet.

5. The remaining portion of the stem is now snipped off flush with the rivet heads.

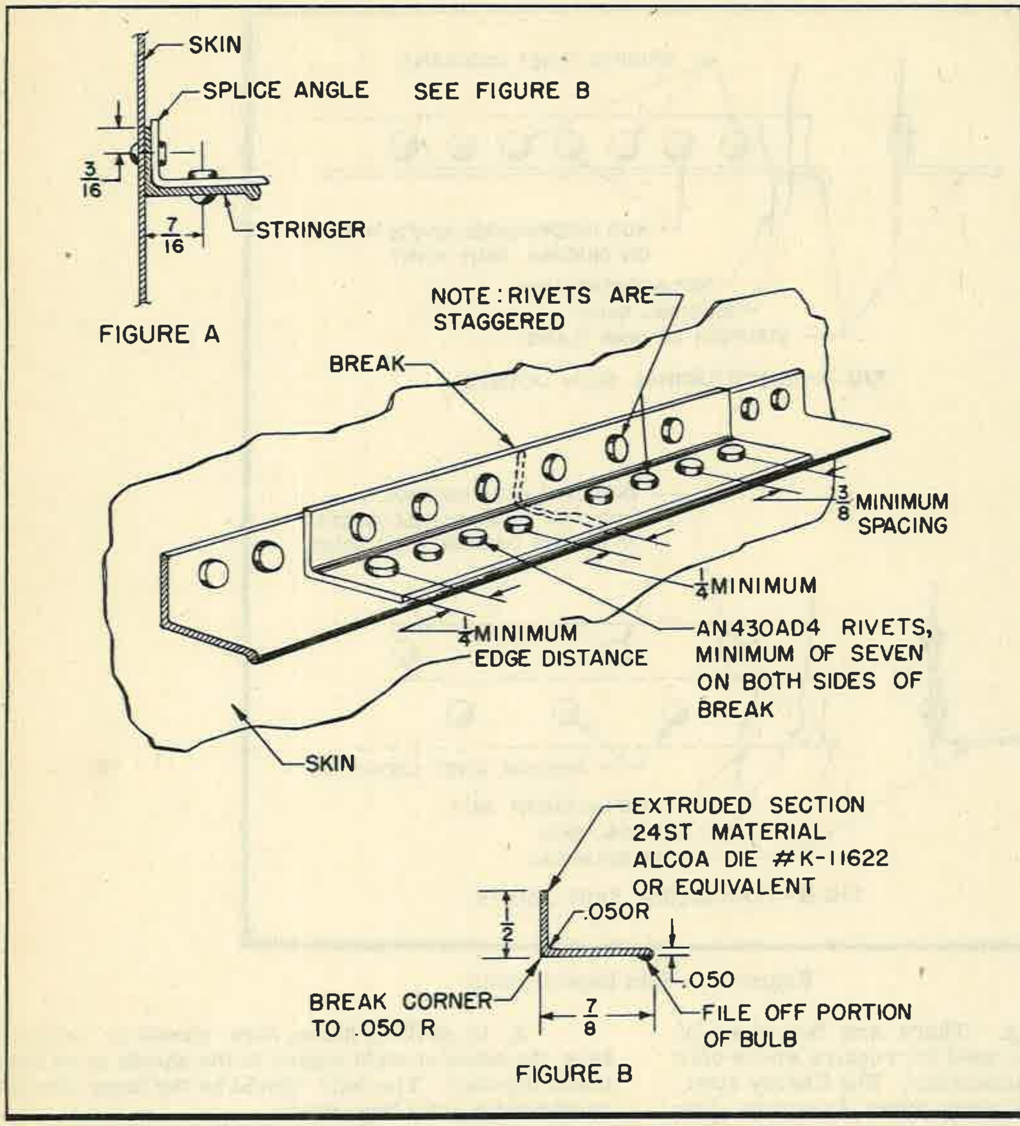


Figure 15 - Stringer Splice Extrusion Splice Angle

(2) Reinforcement for Small Round Holes. - Round holes up to 1 inch in diameter may be reinforced by a washer cut from material of the same gage or one gage heavier than the skin. Rivet washer to skin as shown in figure 12. Reinforcing the small hole rather than covering it, permits the use of the bucking bar in setting the rivets by inserting through the hole.

Cherry rivets are very useful for this type of repair. They must be used in place of the standard rivets. If Cherry rivets are used, a disc patch may be substituted for the washer, because there will be no need for access to the inside surface for bucking.

(3) Repair of Small Cracks in Skin. - In repairing small cracks in the airplane skin, first drill 3/32-inch holes at each end or at any sharp corner of the crack to prevent spreading. The patch plate should be large enough to clear all parts of the crack by 3/4 inch. The plate should be attached to the skin with AN430AD3 rivets spaced 3/4 inch apart. Put in two rows staggered 1/4 inch apart. (See figure 13.) If self-plugging Cherry rivets are available they may be substituted for the standard rivets.

(4) Replacement of Panels. - Normally, it will only be necessary to replace the skin between the structural members. However, in determining the amount of skin to be replaced, care should be taken to avoid, if possible, making a new joint on any structural member so that the joint will be a continuation of the original skin joint between old skin panels adjacent to the skin being replaced. It is also desirable to avoid making wing skin joints on the upper and lower surface on the same rib or stringer. It is more desirable to extend the replacement skin to the next member rather than to make such joints as described above.

(a) Replacement Material. - The skin material should be of equal or greater thickness than the damaged skin being replaced. The rivets at skin joints should be AN430AD4 and others should be AN430AD3 unless the original rivets were AN430AD4.

(b) Longitudinal Skin Joints. - These joints lie along spars and stringers. If the new joint is made along a member where there was an old skin joint, the same rivet spacing may be used. If the skin joint is made where there was no joint previously, the rivets should be spaced only half as far apart as the old rivets. (See figure 14.)

(c) Transverse Skin Joints. - These joints lie along the ribs. If the skin joint is made along a member where there was a skin joint previously, the original rivet spacing should be used. If the joint is made where there was no joint previously, the replacement skin should be cut to lap over the rib 1/2 inch and riveted with a staggered row of rivets using the original spacing. The 1/2-inch lap may be made on either side of the rib. (See figure 14.)

d. Stringer Repair. - Stringers may be spliced, or cracks in stringers may be repaired by the method shown in either figure 15 or figure 16. The splice angle may be formed from .064 24ST sheet and spliced as shown in figure 16. In nearly all cases where forming is necessary for repair, this forming can be done by hand. Short fittings can be formed in a vice by bending the flange over a block made of either steel or hard wood as is shown in figure 17. The radius of bend for this splice angle should be 3/16. Another method of bending a flange is illustrated in figure 17A.

Stringers may also be spliced by the method illustrated in figure 15. The extruded shape that is used must have the same cross sectional area as that of the original stringer. If the same alcoa section is used, it will be necessary to grind off a portion of the bulb in order to obtain a smooth fit. The rivets are of A17ST material and are to be spaced as shown.

If necessary to splice more than one stringer, the splices should be staggered in such a manner that no two splices fall at the same station. (See figure 18.)

e. Rib Repair. - Severe damage to several ribs may necessitate replacement. A careful survey of the damage should be made to see if it would be practical to make field repairs.

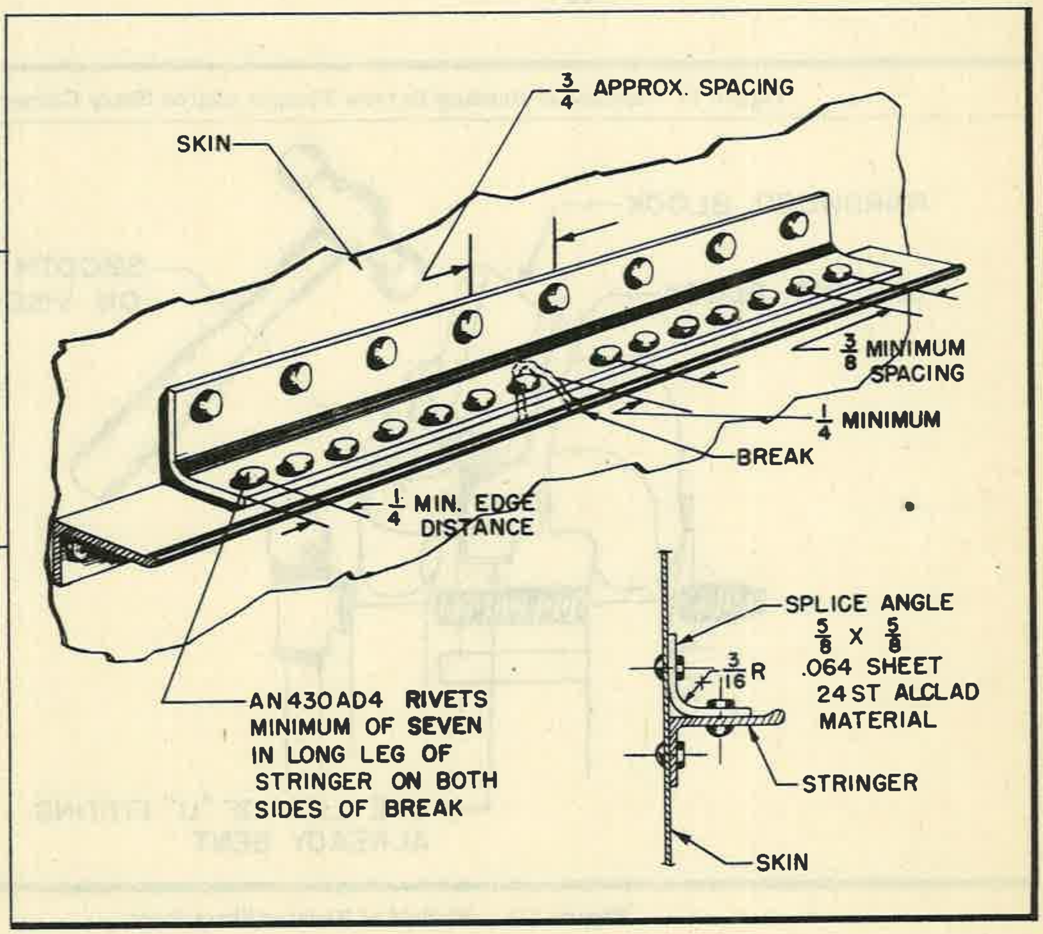


Figure 16 - Stringer Splice Formed Splice Angle

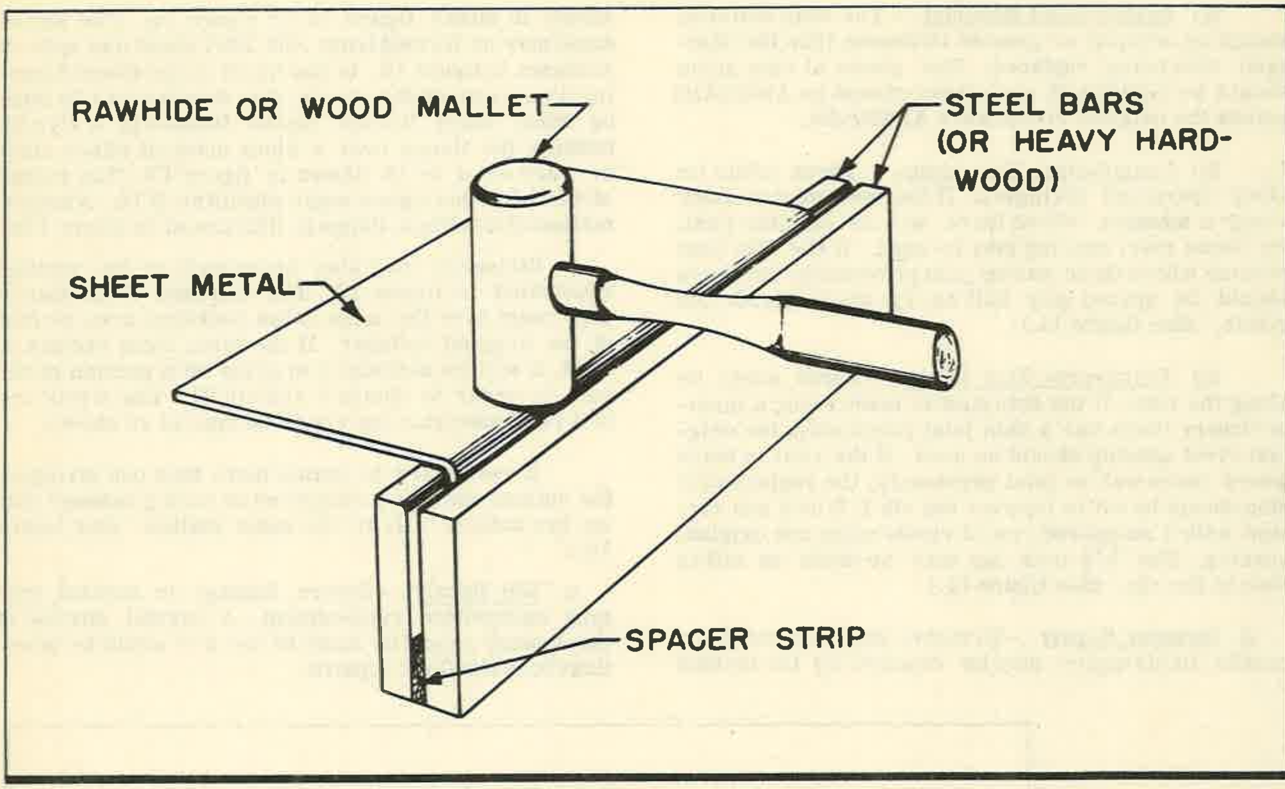


Figure 17 - Method of Bending Narrow Flanges and/or Sharp Corners

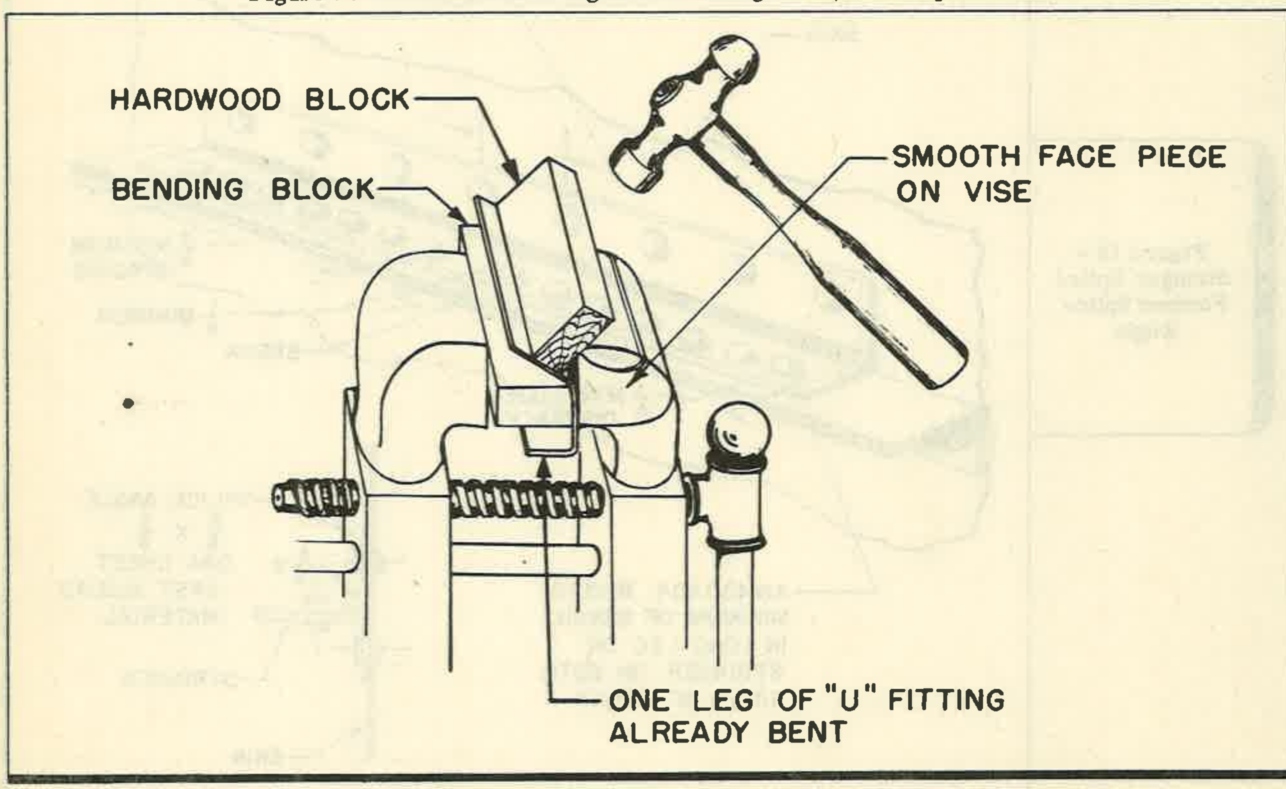


Figure 17A - Method of Bending Sheet Stock

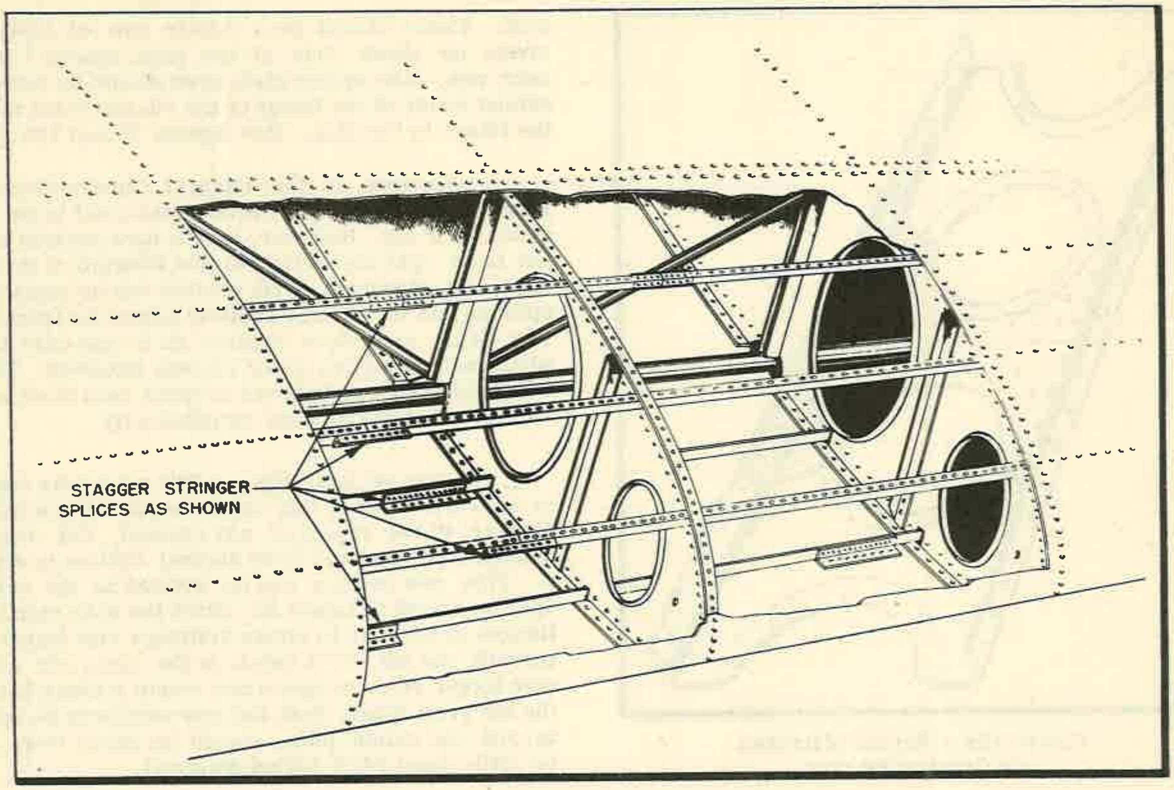


Figure 18 - Staggering of Wing Stringer Splices

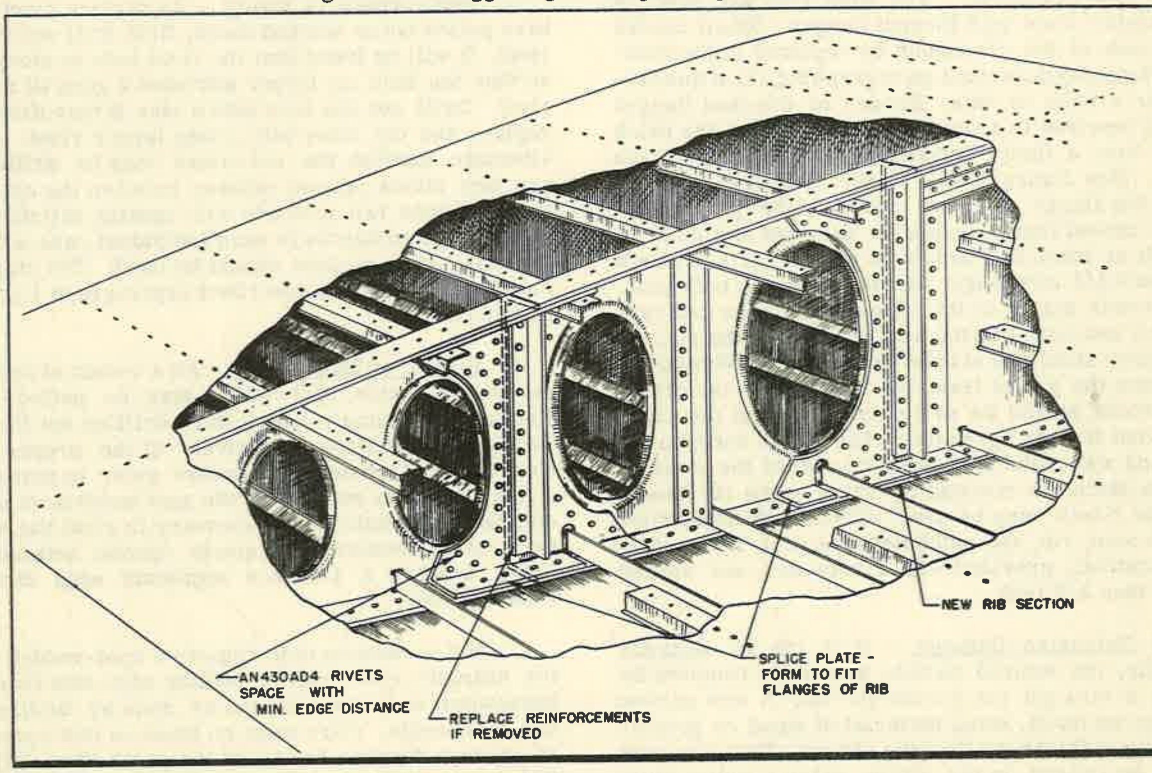


Figure 19 - Splicing in New Rib Section

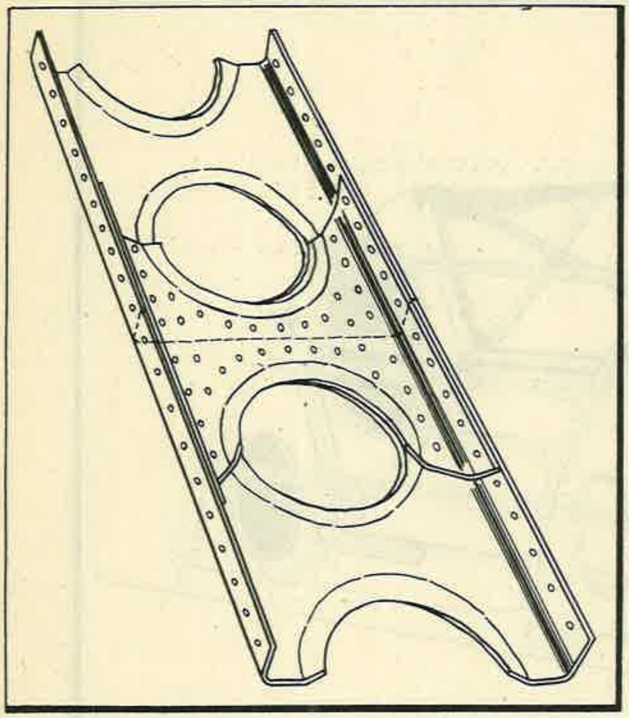


Figure 19A - Repair of Broken or Cracked Flanges

(1) Small Cracks. - The wing ribs are made of 24ST Alclad sheet with formed flanges. Small cracks in the web of the rib should be repaired in the manner previously described (paragraph 2.c.(3) of this section) for cracks in skin. Broken or cracked flanges may be repaired in a similar manner except the patch should have a flange formed on it so as to fit the rib flange. (See figure 19A.) If the crack is entirely within the flange and runs along it, the patch plate should extend from flush with the edge to a point on the web at lease 3/4 inch from the corner and should be at least 3/4 inch longer than the crack on both ends. If the crack starts at the edge of the flange and runs across it and down into the web, or back of the rib, the patch plate should be at least 1-1/2 inches wide and extend down the web at least 3/4 inch beyond the crack. Small holes should be drilled at the end of the crack to prevent it from spreading. The rivets between the patch and web of the rib should be spaced the same as the skin patch. In riveting the patch to the rib flange, the skin rivets may be used with an additional rivet through skin, rib, and patch between each of the original locations, provided the rivets are not spaced closer than 3/8 inch.

(2) Extensive Damage. - If a rib is damaged seriously, the injured portion should be removed by making a straight cut across the rib. A new portion may then be made, using material of equal or greater strength and thickness than the old rib. This new part should be spliced to the rib by using a splice plate of the same material as the rib and at least 2 inches wide. There should be a double row of AN430AD3 rivets on either side of the joint, spaced 1 inch in each row. The splice plate used should be formed to extend inside of the flange of the rib and rivet through the flange to the skin. (See figures 19 and 19A.)

Because of the integral construction of the ribs with the front spar, it is impractical to put in an entire new rib. However, a new nose section can be put in by splicing to the rib just forward of the front spar, and, similarly, a rib section can be replaced by splicing into the rib immediately behind the front spar. The same procedure applies as in the case above, where only a portion of the rib was removed. This is a difficult process because so much skin must be removed, but it can be done satisfactorily.

f. Repair of Rear Spar. - The wing rear spar is, in effect, a channel and can be repaired in a manner similar to the repair of any channel. Cut away the damaged portion and form another section to replace it. This new section can be spliced to the original spar as shown in figure 20. Rivet the wing skin to the flanges of the spar by either drilling a size larger hole through the old rivet holes of the skin, and using a size larger rivet, or space new rivets midway between the old rivet holes. Both the new section to be spliced in, and the splice plate, should be made from .032- or .040- sheet 24ST Alclad material.

g. Replacement of Rivets. - To replace rivets that have pulled out or worked loose, first drill out the old rivet. It will be found that the rivet hole is elongated, so that the hole no longer provides a good fit for the rivet. Drill out the hole with a size larger drill, and replace the old rivet with a size larger rivet. As an alternate method, the old rivets may be drilled out and new rivets spaced midway between the old rivet holes. These two methods are equally satisfactory, and the circumstances in each individual case will determine which method should be used. The standard riveting procedure is described in paragraph 1.c.(1)(a) of this section.

h. Repair of Spot Welds. - As a result of accident or enemy action, spot welds may be pulled loose. This is quite simply repaired by drilling out the spot welds and replacing with rivets of the proper size. For standard riveting procedure refer to paragraph 1.c.(1)(a) of this section. If the spot welds have pulled out, leaving a hole, it is necessary to rivet the members back together with rivets spaced between the holes, keeping a 1/4-inch minimum edge distance from the hole.

If it is necessary to remove a spot-welded part, for example removing the leading edge skin from the horizontal stabilizer, it can be done by drilling out the spot welds. Care must be taken in this operation to prevent damage to one of the parts when drilling. The part or parts can then be reassembled by riveting with the proper size rivets for the holes drilled.

3. Wing Tip.

a. General. - The shape of the skin of the wing tip is retained by a single rib, parallel to the ribs of the outboard wing, and intersecting bulkheads, parallel to the front spar. (See figure 21.)

b. Repair. - The methods for the repair of the bulkheads, skin, and stringers in the wing tip are the same as for the outboard wing. (Refer to paragraph 2.a., of this section.) If the trailing edge portion of the "V" section of the wing tip bow is damaged, flatten the "V" section and bolt through it. Do not change the contour of the leading edge of this part. In general, if the wing tip is damaged to such an extent that it would be unsafe for flight, repairs could not readily be made in the field. In this case it will be necessary to replace the wing tip.

4. Ailerons.

The Frise type ailerons are fabric-covered. The left aileron is equipped with a small fixed metal tab and a controllable trim tab operable from the front cockpit only. (See figure 22.)

a. Repair of Aileron Ribs. - Cracks or breaks in the web or flange of an aileron rib may be repaired by first cutting the fabric away from the damaged area. The fabric should be cut to the nearest frame member. Drill small holes at the sharp corners of the crack to prevent further spreading. If the crack is small and to the center of the web, a patch similar to a skin patch may be used. If the crack is near, or in the flange, it will be necessary to form the patch around the flange and place rivets in the flange as well as in the web. When the crack is large and covers a large area, a splice as illustrated in figure 23 should be used. The damaged area should be cut out in this case before making the splice. If the damage to the rib is to such an extent that the repair of it is impractical, a new rib should be formed from the same material used in the old rib and the old rib replaced.

b. Repair of Aileron Nose Skin. - In order to repair the metal nose skin on the aileron, the fabric covering adjacent to the damaged portion must be removed. The size of the nose section prohibits the use of any handholes as an aid in attaching the repair sheet. The simplest way is to remove a complete section of the nose skin and install a new one, or use blind rivets to apply a patch. To insure a rigid joint, all splices will be made at a rib. The gage of the repair sheet should be the same as the gage of the original nose cover.

c. Repair of Trailing Edge. - To repair a damaged trailing edge, cut out the damaged section and replace it with a new piece, making the splice as shown in figure 24. It is usually most convenient to make the extremities of the cut, centrally between the trailing edge ribs. This permits the splice block for attaching the new section to be installed more easily. The splice block may be 52SH or any stronger aluminum alloy. A minimum of three rivets on each side of the cut will be permitted.

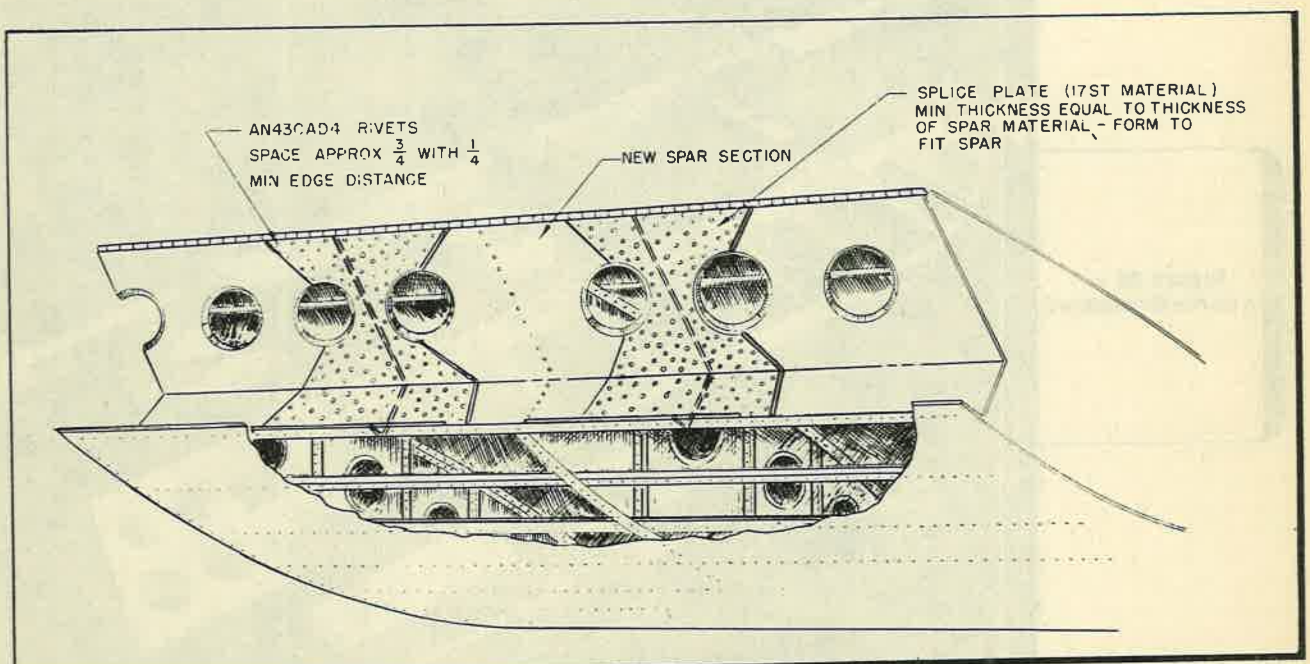
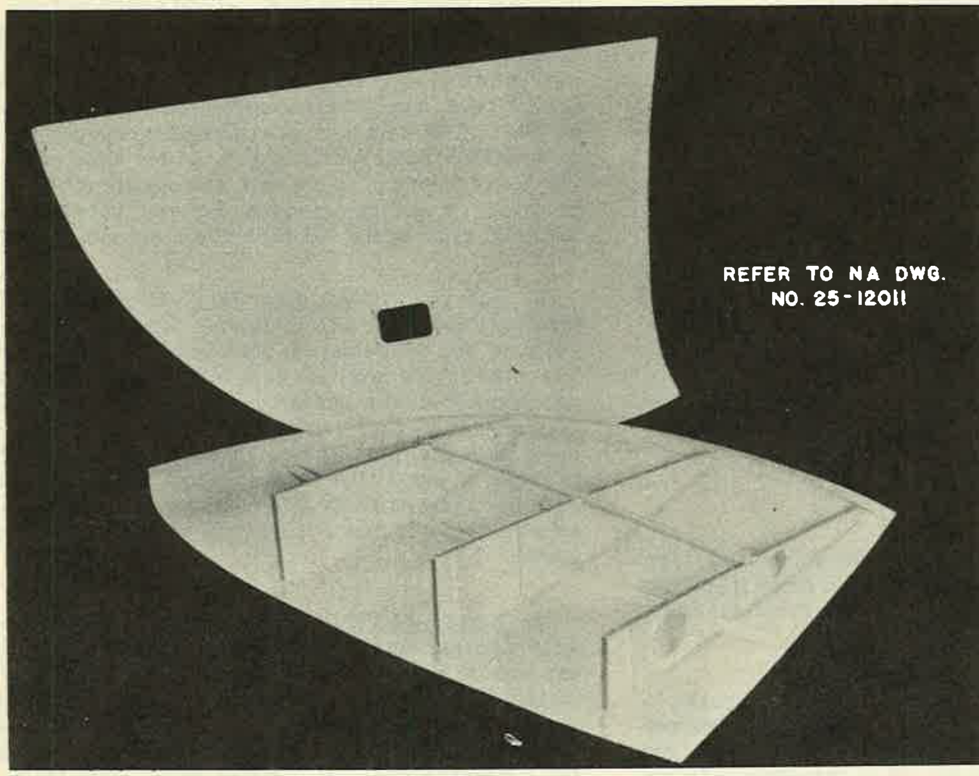
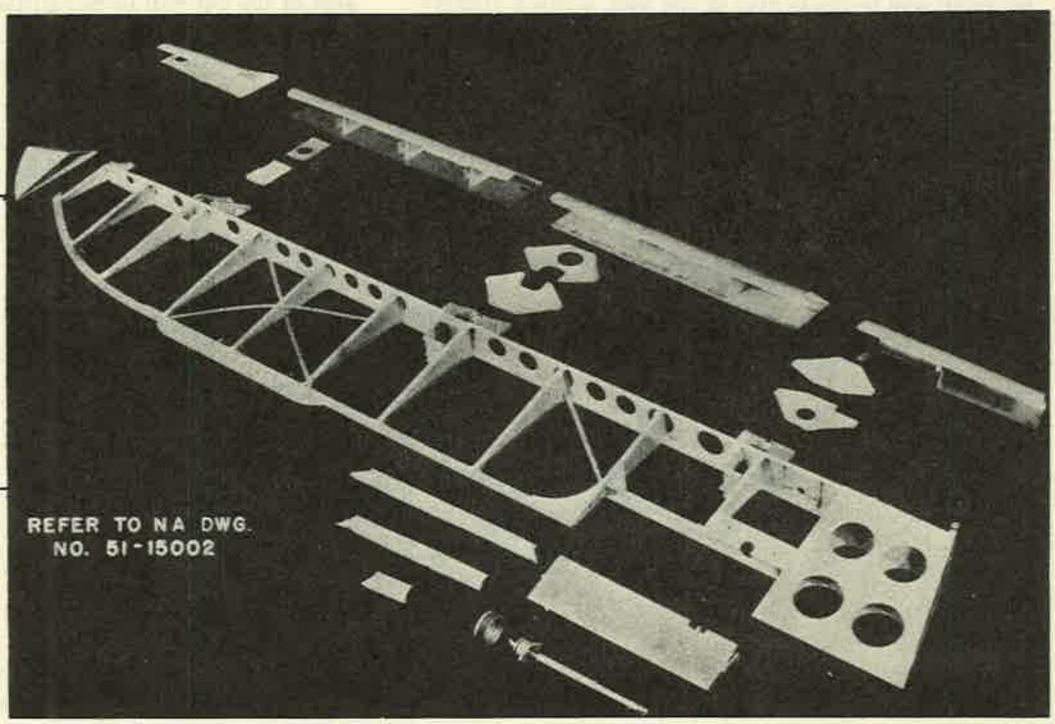


Figure 20 - Repair of Wing Rear Spar



★★★ Figure 21 - Wing Tip Structure



★★★ Figure 22 - Aileron Breakdown

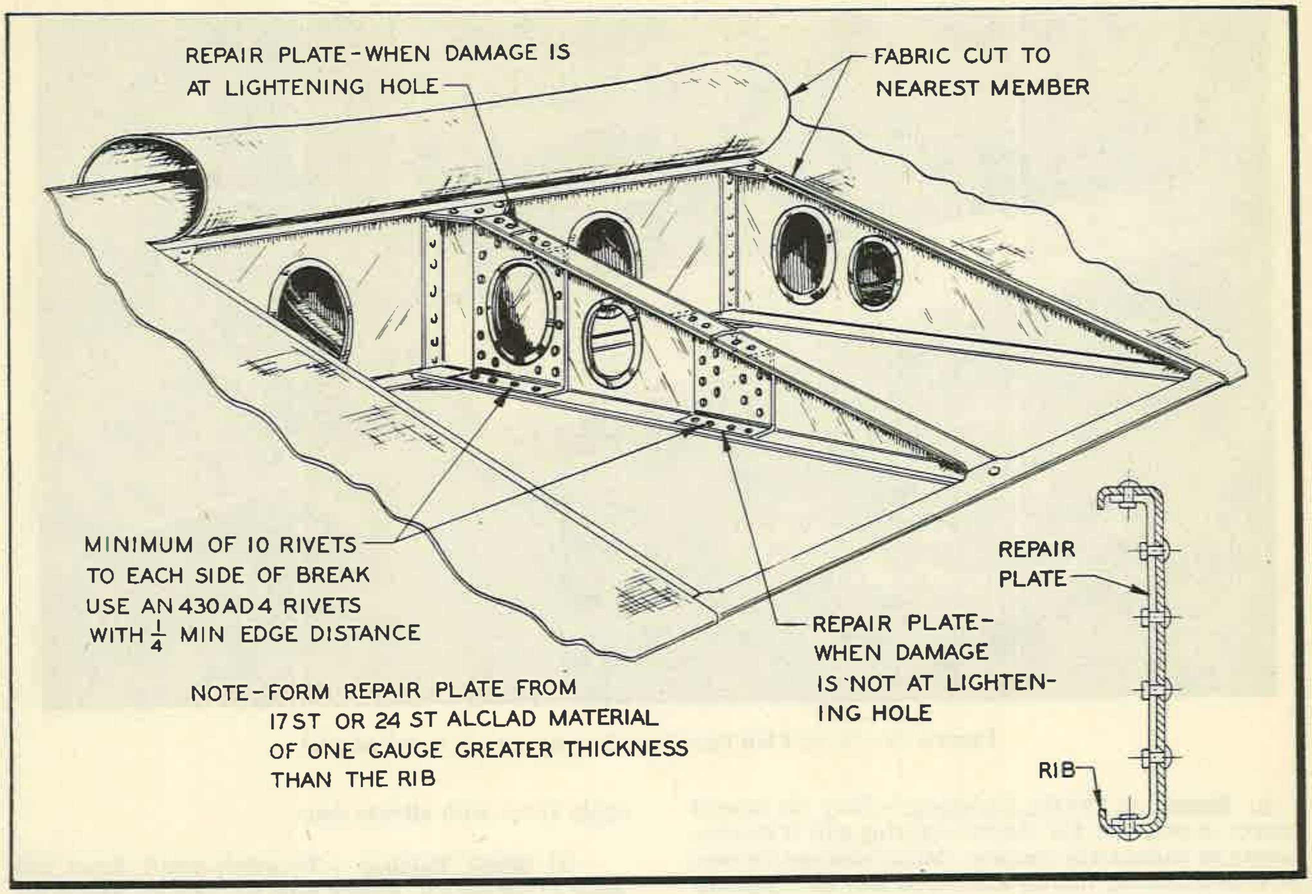


Figure 23 - Method of Repairing Rib-Elevator, Rudder Aileron, Flap

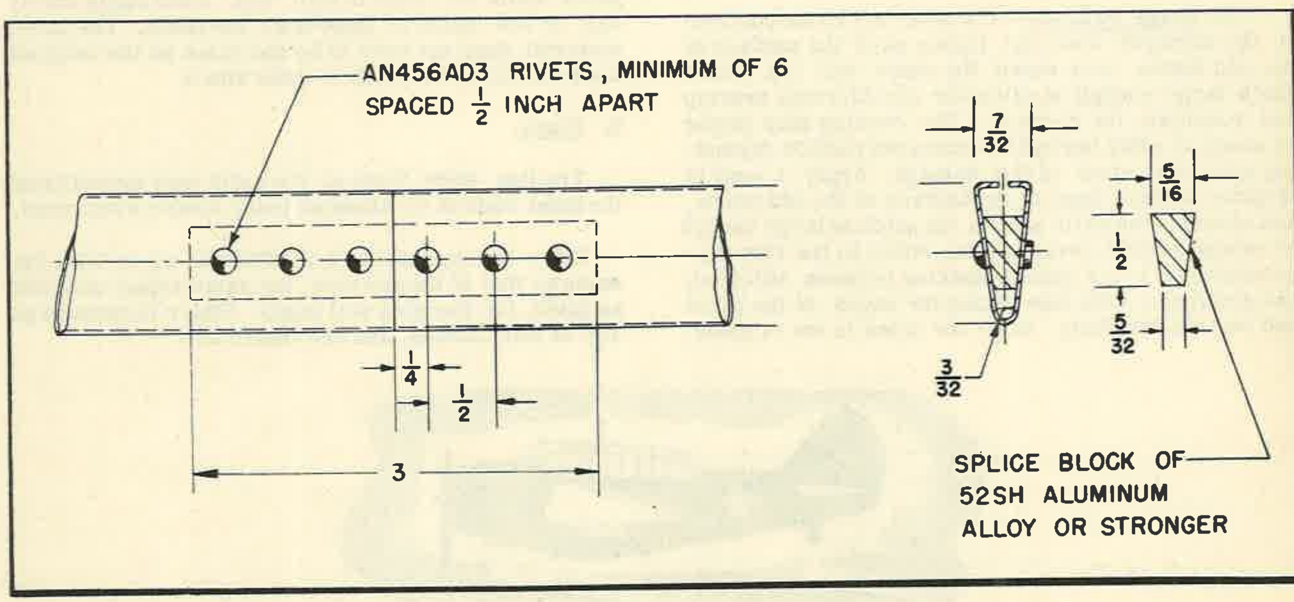


Figure 24 - Repair of Aileron, Flap and Elevator Trailing Edge Section

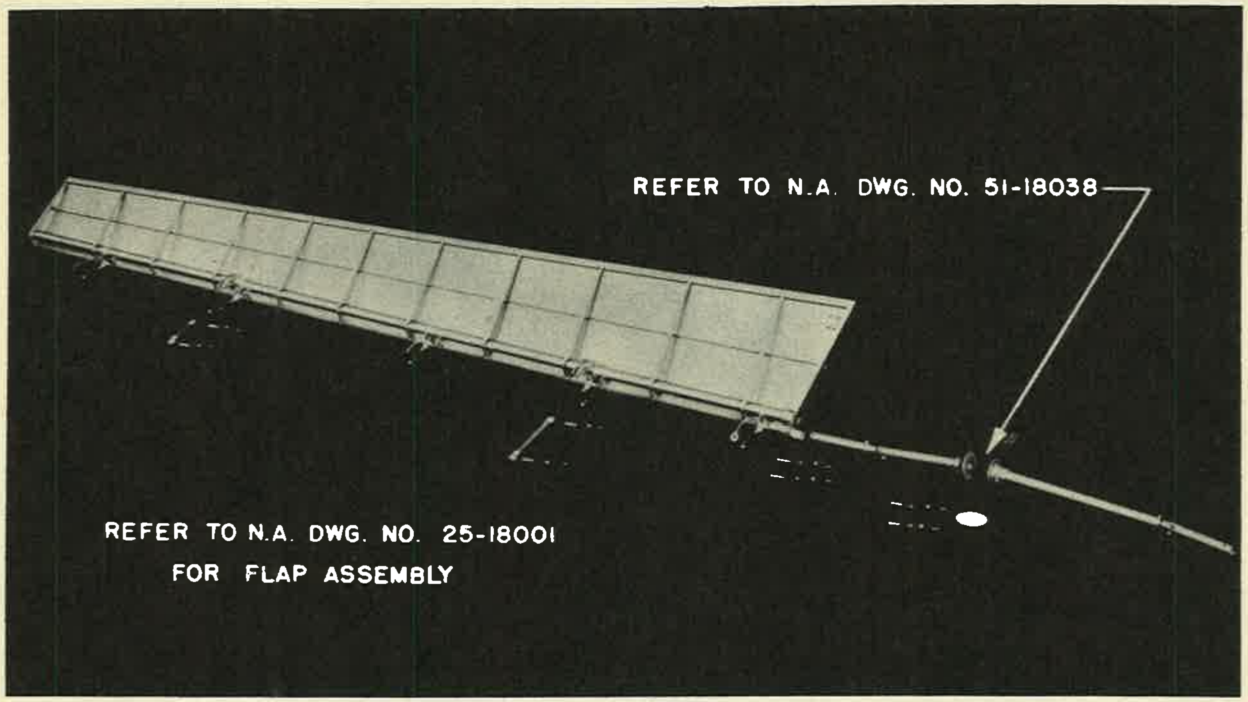


Figure 25 - Wing Flap Panel and Synchronizing Arrangement

d. Repair of Fabric Covering. - Only in case of severe damage to the fabric covering will it be necessary to completely recover. Minor damage or even damage extending into several bays may be repaired. The patch material should be grade A fabric (Specification No. AN-CCC-C-399) or the equivalent.

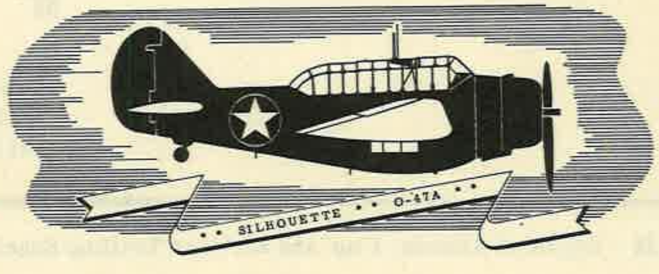
(1) Large Patches. - Cut away all loose portions of the damaged area and lightly sand the surface of the old fabric over which the patch will lap. Cut a patch large enough to allow for considerable overlap and round all the corners. The overlap may extend as much as a bay beyond the damaged portion depending upon the extent of the damage. Apply a coat of airplane nitrate dope to the surface of the old fabric, and attach patch while wet. If the patch is large enough to extend across several ribs, stitch to the ribs (approximately 1-1/2 inches spacing between stitches), and reinforce with tape along the edges of the patch and the rib stitching. After the patch is set in place, apply cover with nitrate dope.

(2) Small Patches. - To patch small holes and tears in the fabric, lightly sand the surface where the patch is to be applied. Apply a coat of nitrate dope to the old fabric around the hole or tear, and set the patch while the dope is still wet. Then apply freely one or two coats of dope over the patch. The patch material does not have to be the same as the original material when the patch is quite small.

5. Flaps.

Trailing edge flaps of the split type extend from the inner ends of the ailerons to the center wing panel.

Since the structure of the flaps is essentially the same as that of the ailerons, the same repair methods as given for the wing will apply. (Refer to paragraph 4.b. of this section, and see figure 25.)



SECTION IV

EMPENNAGE

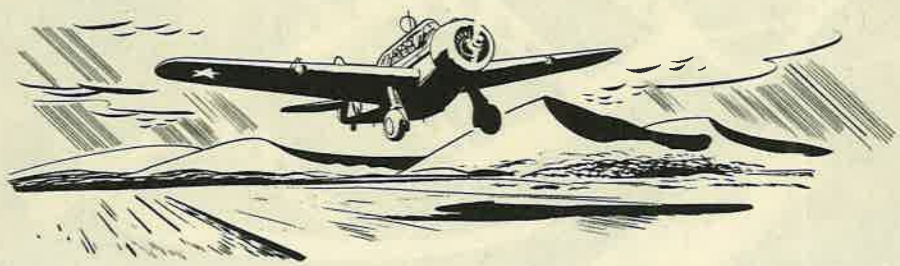
1. General.

The all-metal stabilizers are nonadjustable. The rudder and elevator are fabric-covered and are equipped with trim tabs operated from the front cockpit only.

2. Horizontal Stabilizers.

a. General. - This is a stressed skin panel of all aluminum alloy structure. The ribs are attached to a front and rear spar and supported along this span by extruded-angle stringers. (See figure 26.)

b. Repair of Horizontal Stabilizer. - The greatest difficulty encountered in repairing the horizontal stabilizer lies in the fact that poor access is to be had to places of very little or no working clearance. The principles of repair are the same as those previously described for the outboard wing. Access to the area froward of the front spar can best be obtained by removing the leading edge skin. (See figure 27.) It is permissible to cut an access hole; the same limitations prevail as in the case of the outboard wing. For recommended types of access holes refer to paragraphs 2.b.(1) and (2) of section III.



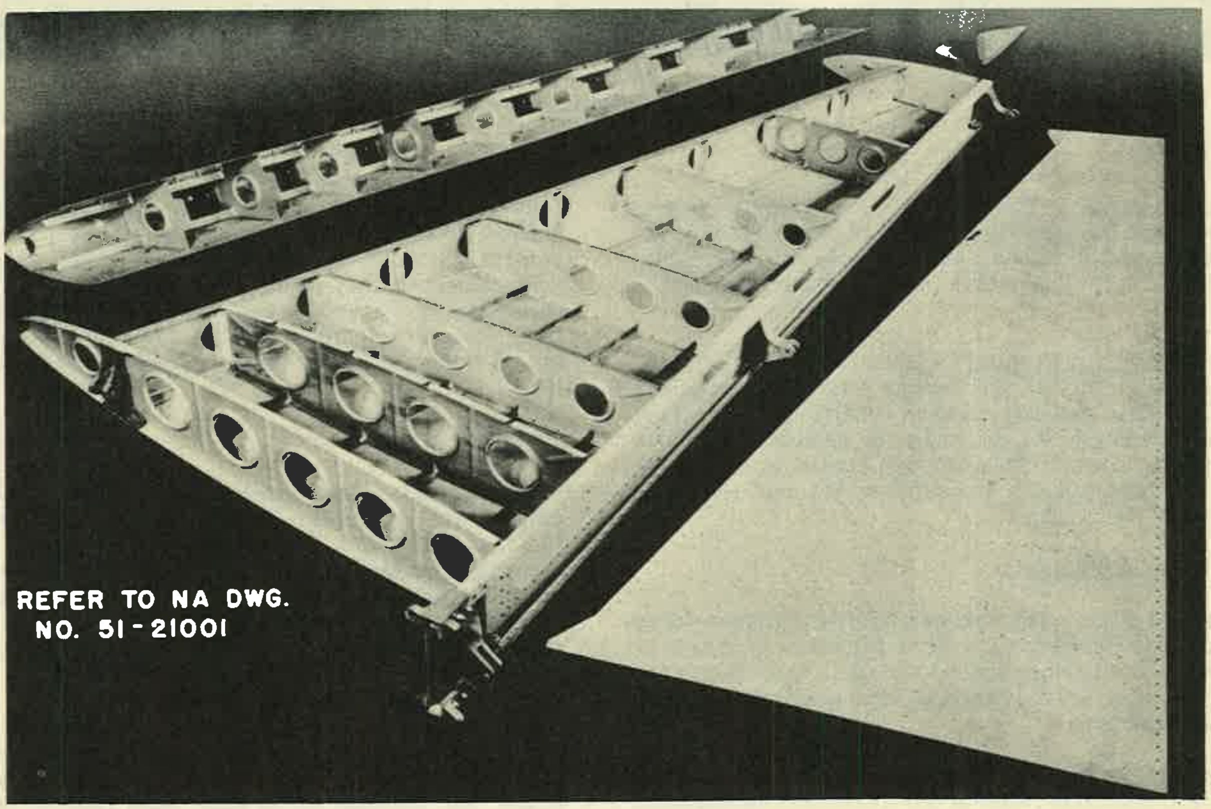


Figure 26 - Horizontal Stabilizer Breakdown

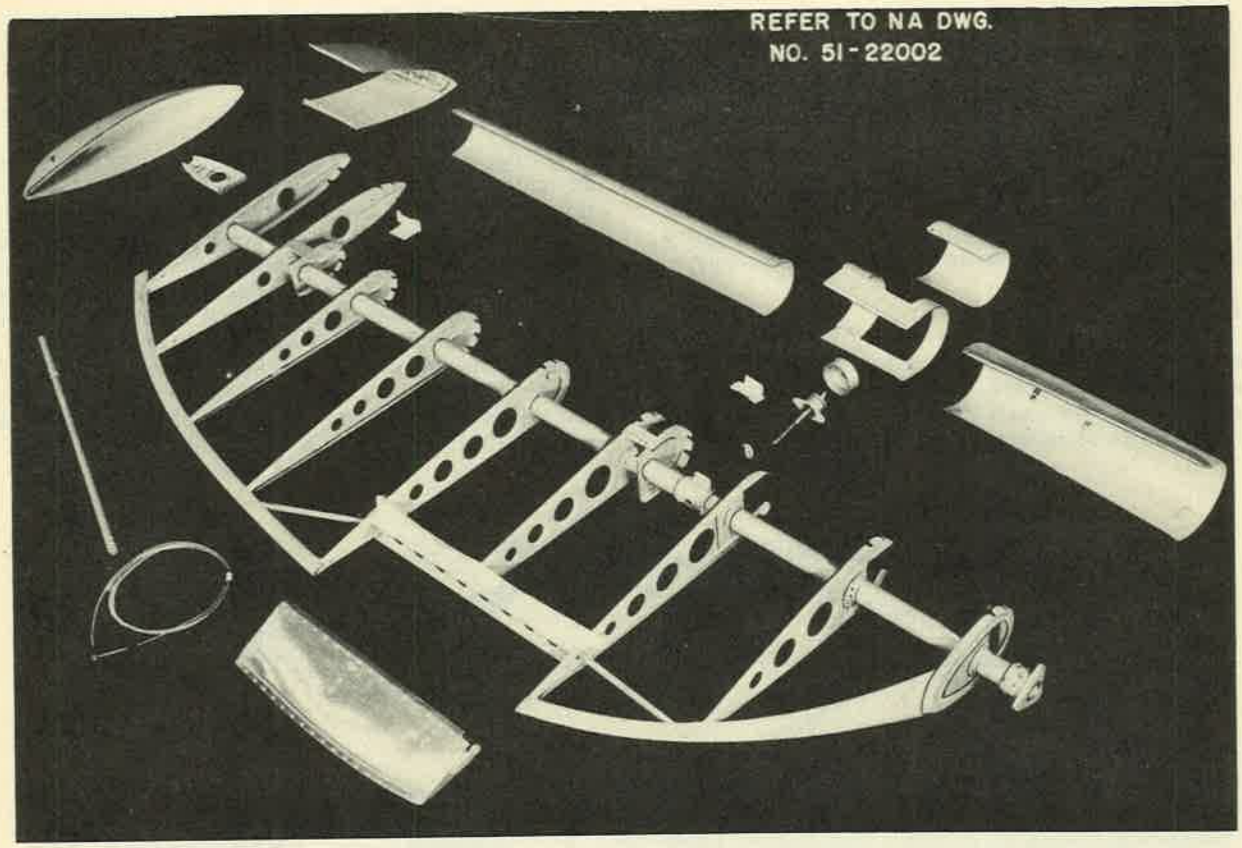


Figure 27 - Elevator Breakdown

3. Elevator.

a. General. - The elevator is a fabric-covered aluminum alloy structure similar in construction to the other control surfaces, and is hinged to the horizontal stabilizer. The elevator is shaped by ribs attached to a spar.

b. Repair of Elevator. - Damage to the nose skin, ribs, spar, fabric, and trailing edge can be repaired by the same methods used in repairing the ailerons. (See paragraph 4.a.,b., and c. of section III.) Repair the bulkhead to which the tabs are hinged, by cutting out the damaged portion and splicing in a new section as shown in figure 23.

4. Vertical Stabilizer.

a. General. - The vertical stabilizer (figure 28) is attached to the fuselage in fixed alignment by means of standard AN machine screws through angles riveted to the fuselage. It is a stressed skin panel of aluminum alloy structure.

b. Repair of Vertical Stabilizer. - In repairing the vertical stabilizer, similar difficulties are encountered as in repairing the horizontal stabilizer, in that poor access is to be had to places of very little or no working clearance. The fin inspection door, located on the outboard side of the stabilizer, gives access to only a very limited working area. For satisfactory structural repair of the vertical stabilizer, it will be necessary to remove the skin by drilling out the rivets. For the replacement of skin panels, refer to paragraph 2.c.(4) of section III. As in the case of the horizontal stabilizer, repair principles are the same as those given for the outboard wing. (See paragraph 1.a. of section III.)

5. Rudder.

a. General. - The rudder is a fabric-covered control surface of similar construction to the ailerons, flaps, and elevators. The rudder is shaped by 11 ribs fastened to a spar and reinforced by diagonal braces and bulkheads. (See figure 29.) The nose section of the rudder is made of metal skin supported by nose ribs. A trimming tab is built into the trailing edge of the rudder.

b. Repair of Rudder. - To repair damage to the trailing edge of the rudder, remove the damaged portion and splice in another section in the manner shown in figure 30. Damage to the nose skin, ribs, or fabric covering may be repaired by the same methods described in paragraph 4.a.,b., and c. of section III.

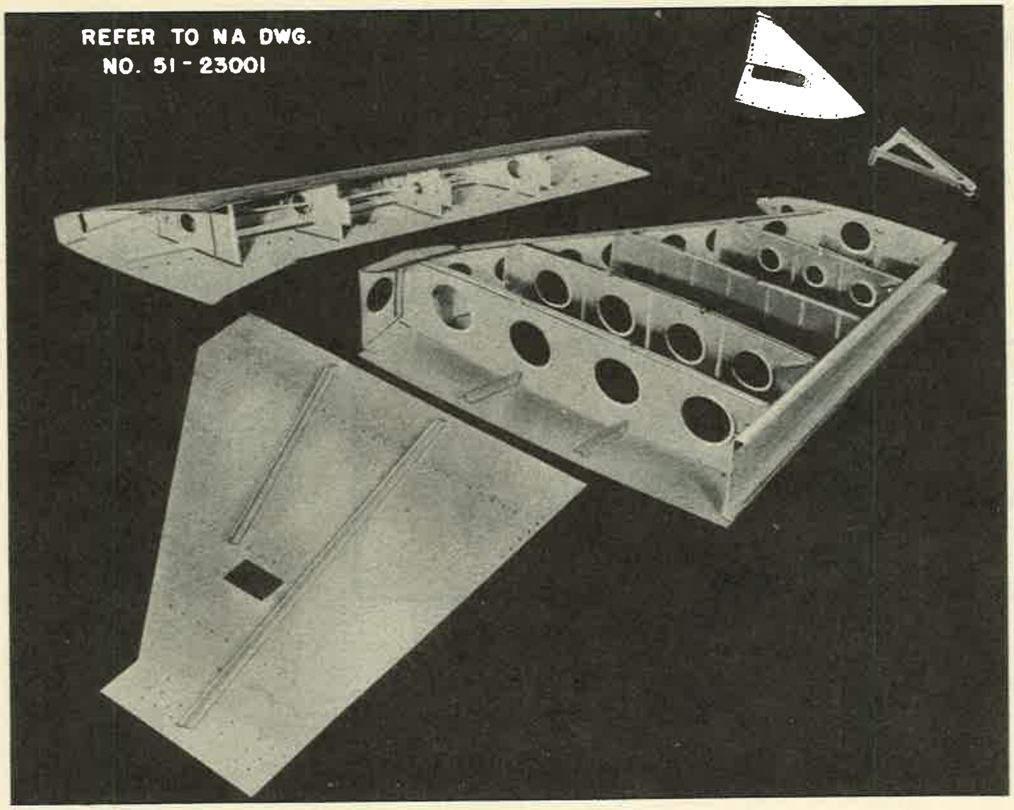


Figure 28 -
Vertical Stabilizer
Breakdown

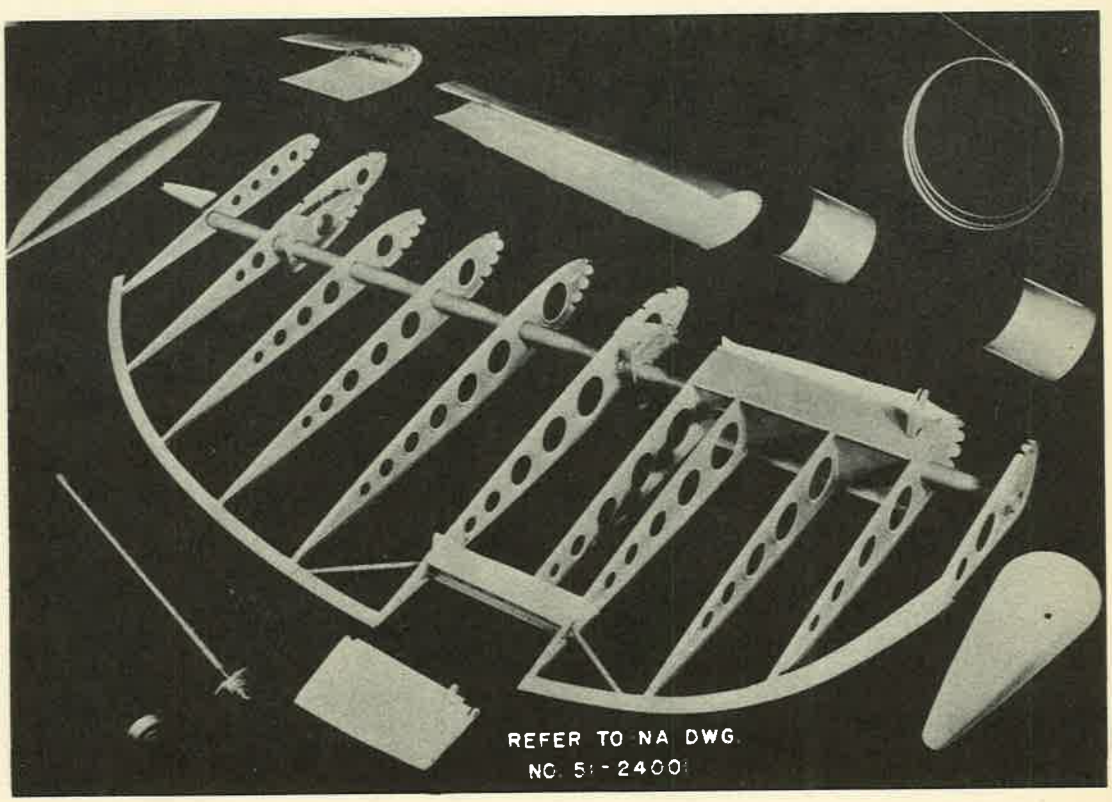


Figure 29 -
Rudder
Breakdown

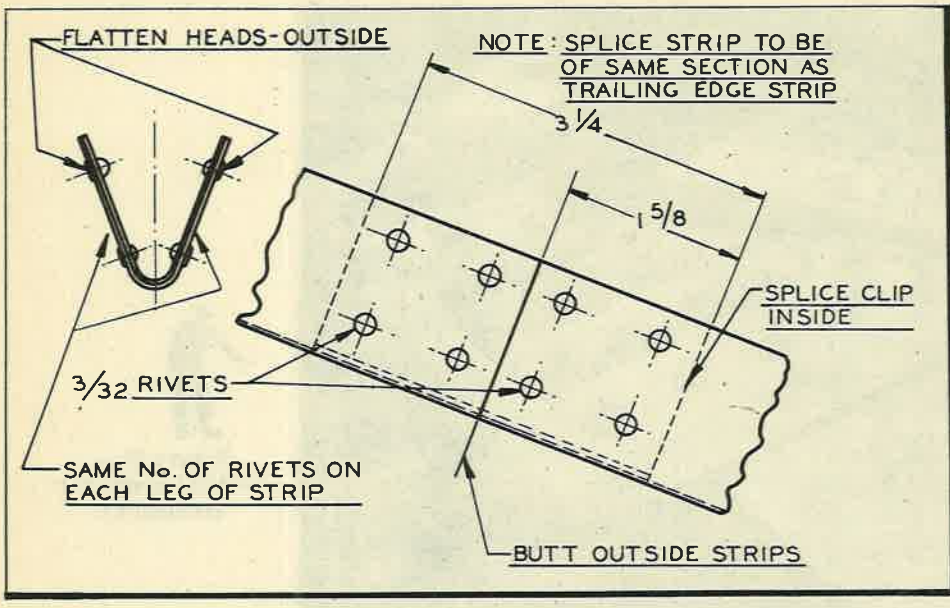
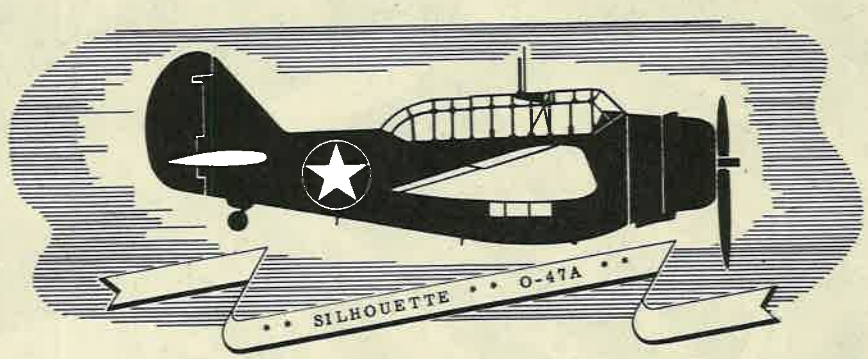


Figure 30 - Repair of Rudder Trailing Edge Section



SECTION V

FUSELAGE AND CENTER SECTION

1. General.

The construction of the fuselage and center section are such that they are integral with each other. The frame of the center section is a welded tubular steel truss (figures 32 and 32A) which carries fittings for the outboard wing and landing gear. The framework of the stressed skin fuselage is constructed of full bulkheads and minor bulkheads riveted to the stringers running fore and aft through the fuselage, and in turn the skin is riveted to both stringers and bulkheads. The flooring is the fuselage is supported by a floor structure of intersecting channels attached to the bulkheads and skin. Figures 31 and 32 illustrate the constructions of the fuselage.

2. Repair of Bulkheads.

If less than 50 percent of the bulkhead is damaged, repair will be made by removing the damaged section and splicing a new piece onto the remaining part. If more than 50 percent of the bulkhead has been damaged, a new bulkhead will be installed. In no case will new bulkhead or the new part to be spliced have a gage less than that of the original bulkhead. If the original bulkhead consisted of sections, care will be exercised in duplicating the original bulkhead. Small cracks in the face of the bulkheads may be repaired in the same manner as a skin crack as described in paragraph 2.c.(1) of section III. If the damage is in the flange, repair may be made by forming a splice channel to fit the inside of the bulkhead and long enough to extend at least 2 inches on either side of the damaged portion. This channel must be at least one gage thicker than the bulkhead and of similar material. Splice by using AN430AD4 rivets spaced at intervals of not more than 1 inch with a minimum of 1/4-inch edge spacing. The use of 16 rivets to any one splice will be a minimum. (See figure 33.) The splice channel arrangement shown in figure 34 may also be used to splice in a new section. A method for hand forming a new bulkhead section is shown in figure 35.

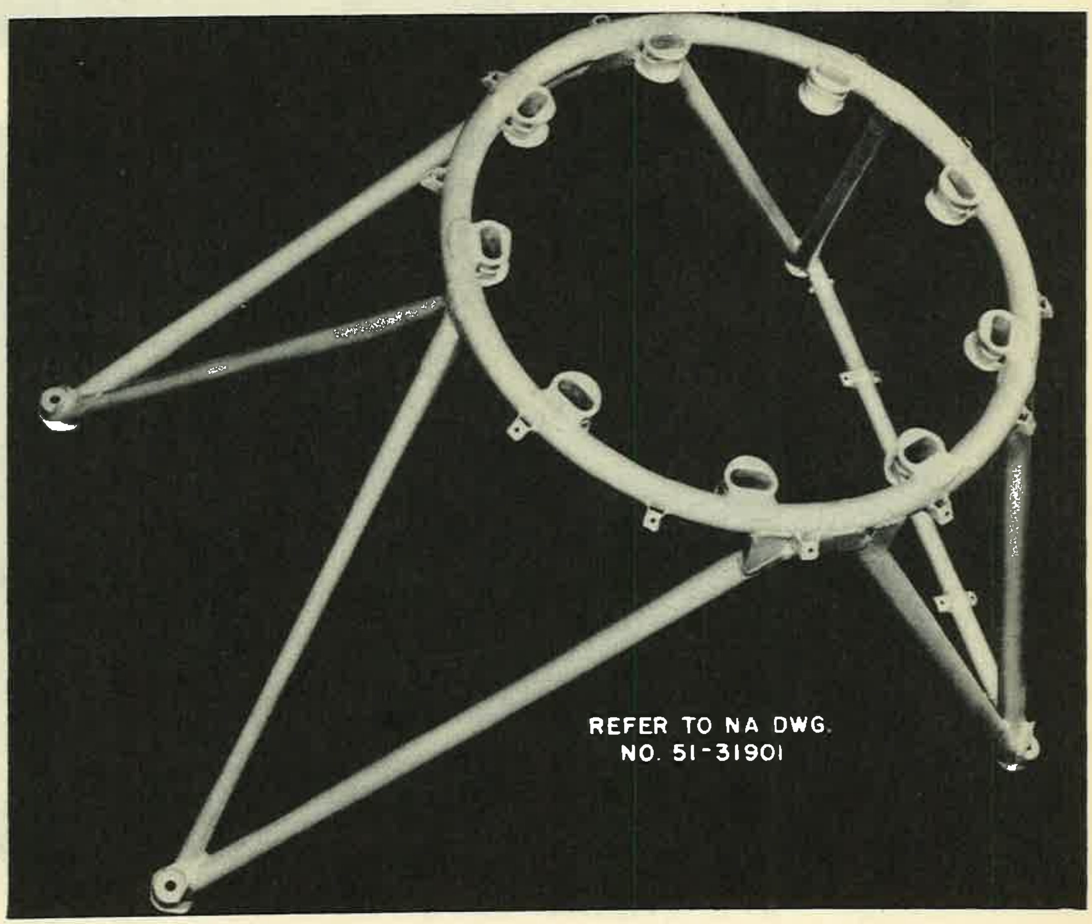


Figure 31 - Engine Mount

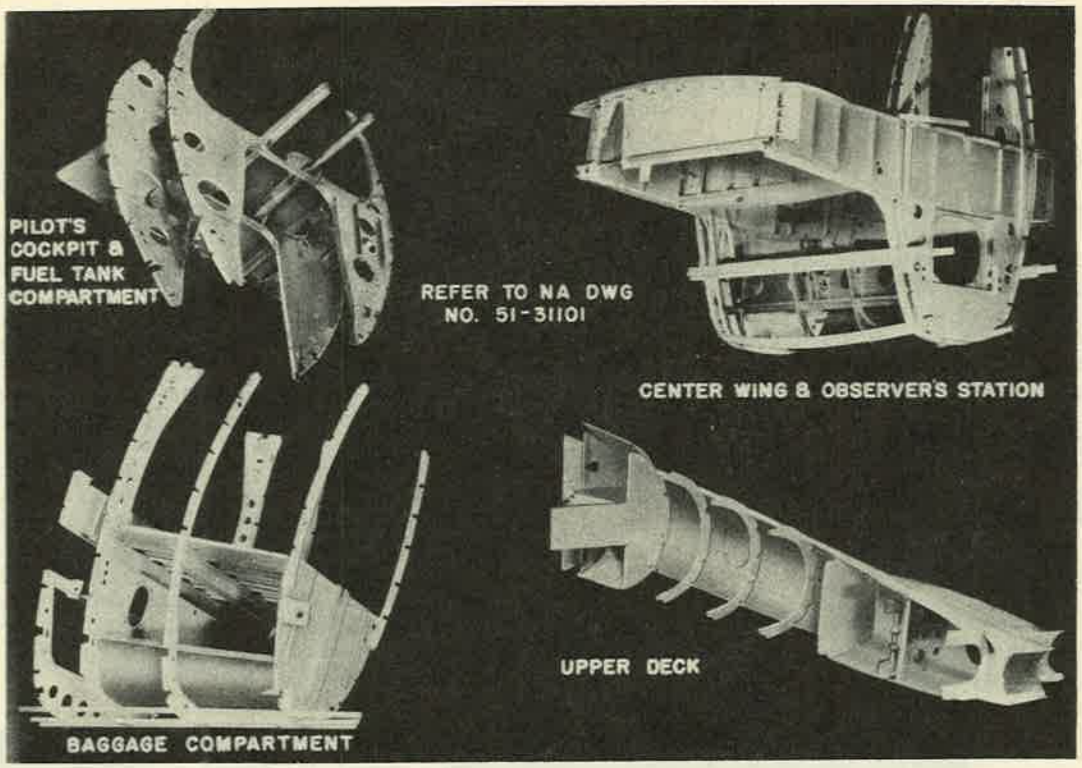


Figure 32 - Fuselage Structural Details

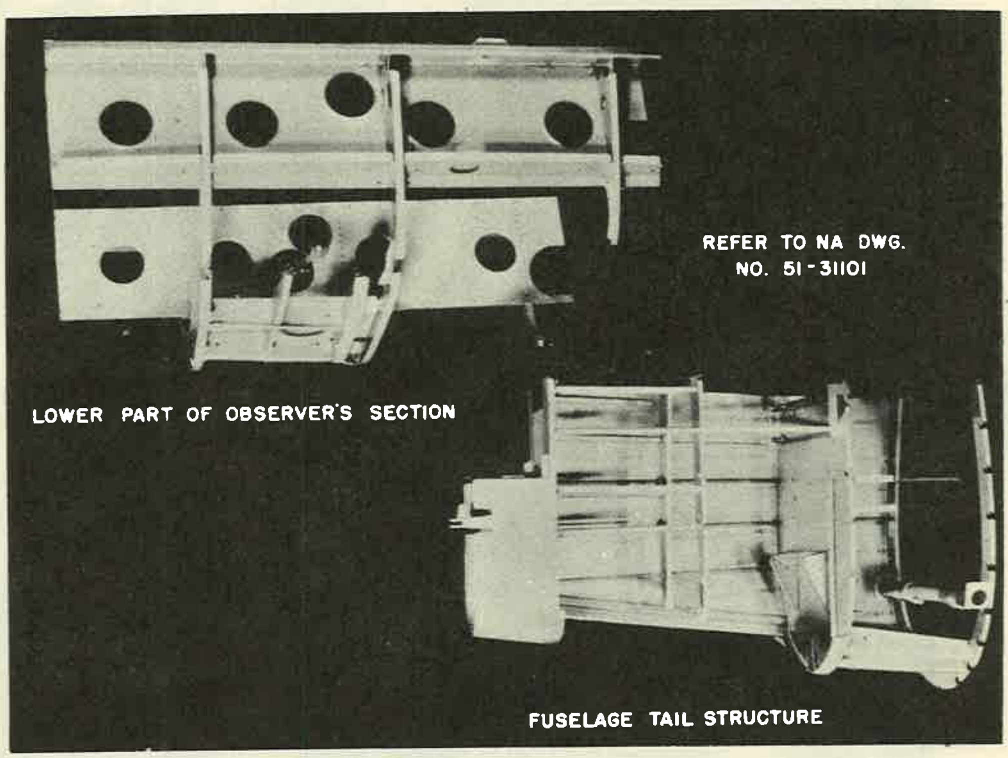


Figure 32A - Fuselage Structural Details

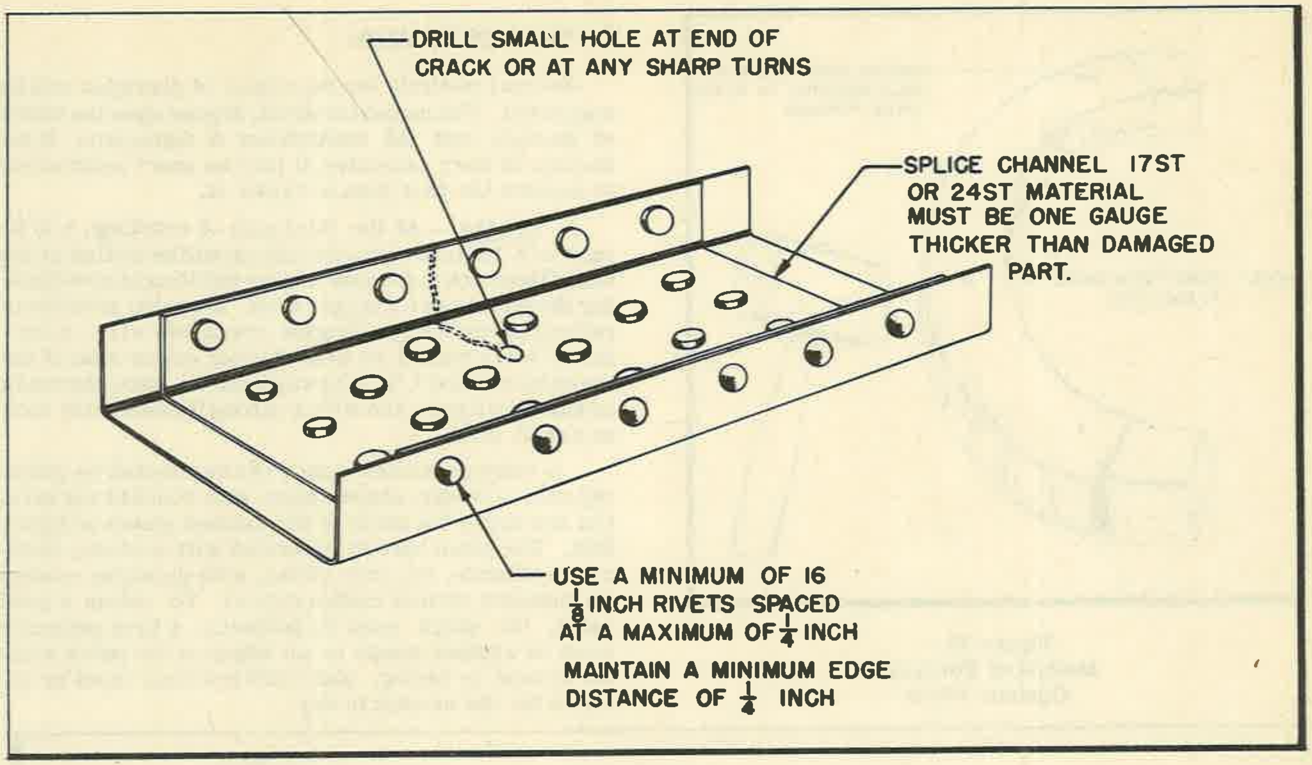


Figure 33 - Channel Repair - Inside Splice Plate

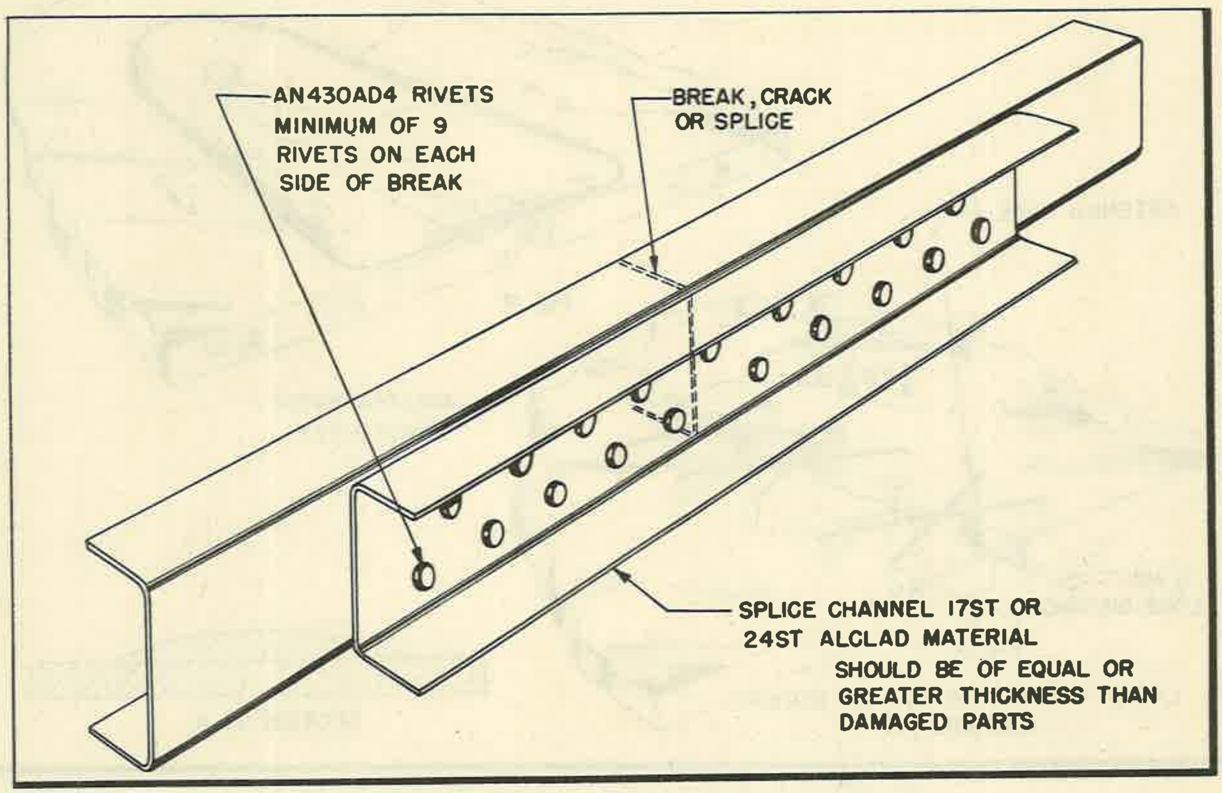


Figure 34 - Channel Repair - Back-To-Back Splice Plate

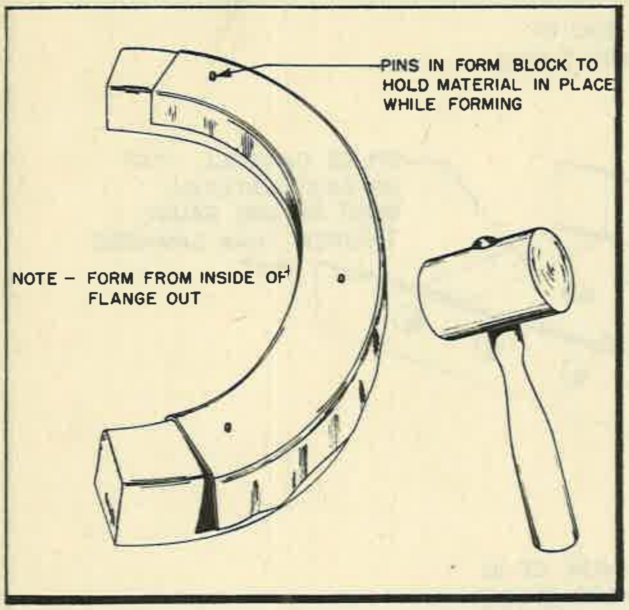


Figure 35 -
Method of Forming
Contour Parts

3. Repair of Plexiglas.

Several methods for the repair of plexiglas will be suggested. The method used will depend upon the extent of damage and the availability of materials. If the damage is very extensive, it may be more economical to replace the part than to repair it.

a. Cracks. - At the first sign of cracking, a 1/8-inch to 3/16-inch diameter hole should be drilled at the end of the crack to prevent further splitting by distributing the strain over a larger area. It is also possible to relieve the strain by lacing the crack with wire. A series of holes should be drilled along either side of the crack but at least 1/2 inch away from it. Lace the crack as shown in figure 36A with a strong flexible wire such as aerial wire.

A more permanent repair can be effected by patching with a wedge-shaped piece with rounded corners. Cut and apply the patch in the manner shown in figure 36B. The patch may be cemented with acetone, ethylene dichloride, or, even better, with plexiglas cement (monomeric methyl methacrylate). To obtain a good patch, the patch must fit perfectly, a firm pressure must be applied evenly to all edges of the patch while the cement is drying, and sufficient time must be allowed for the cement to dry.

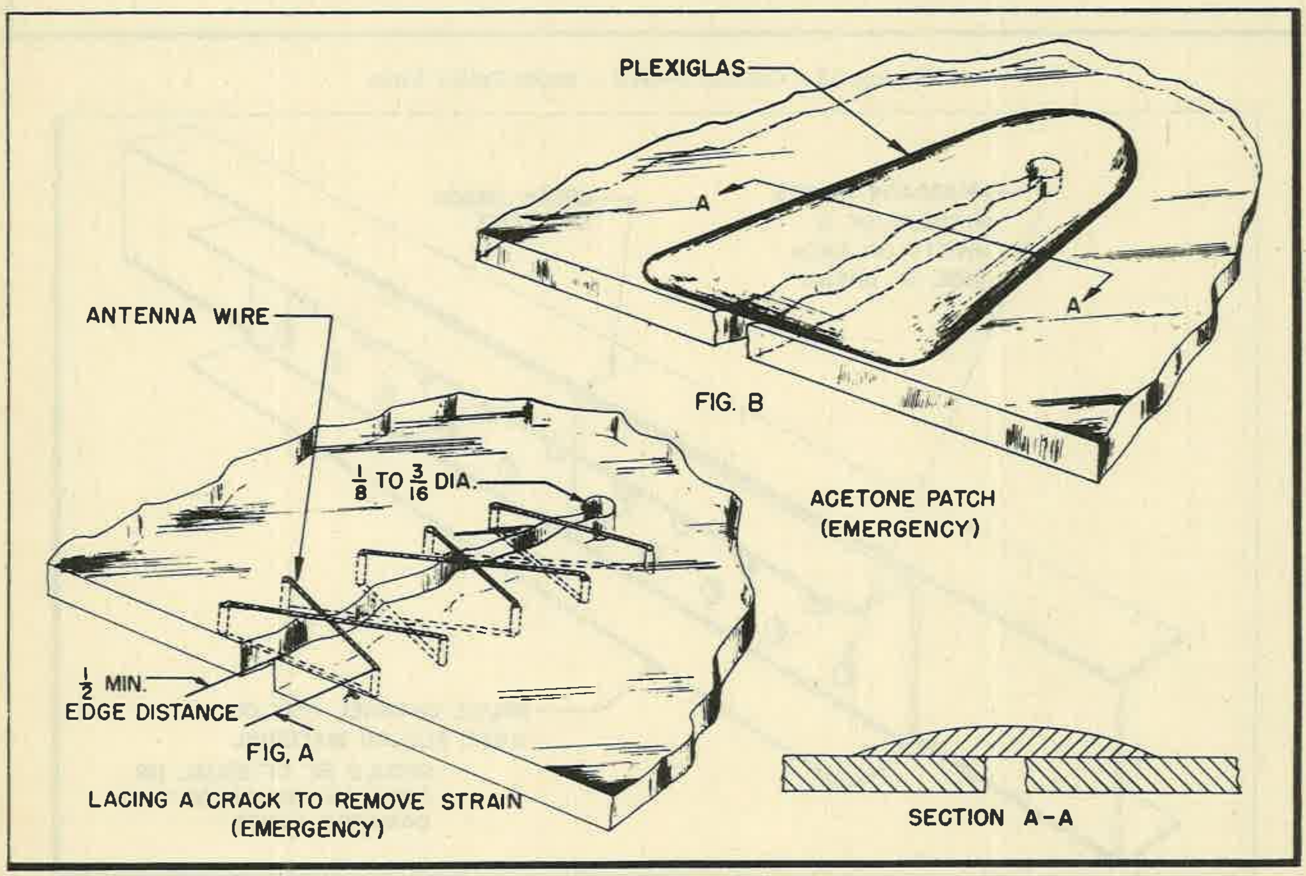


Figure 36 - Plexiglas Repair (Temporary)

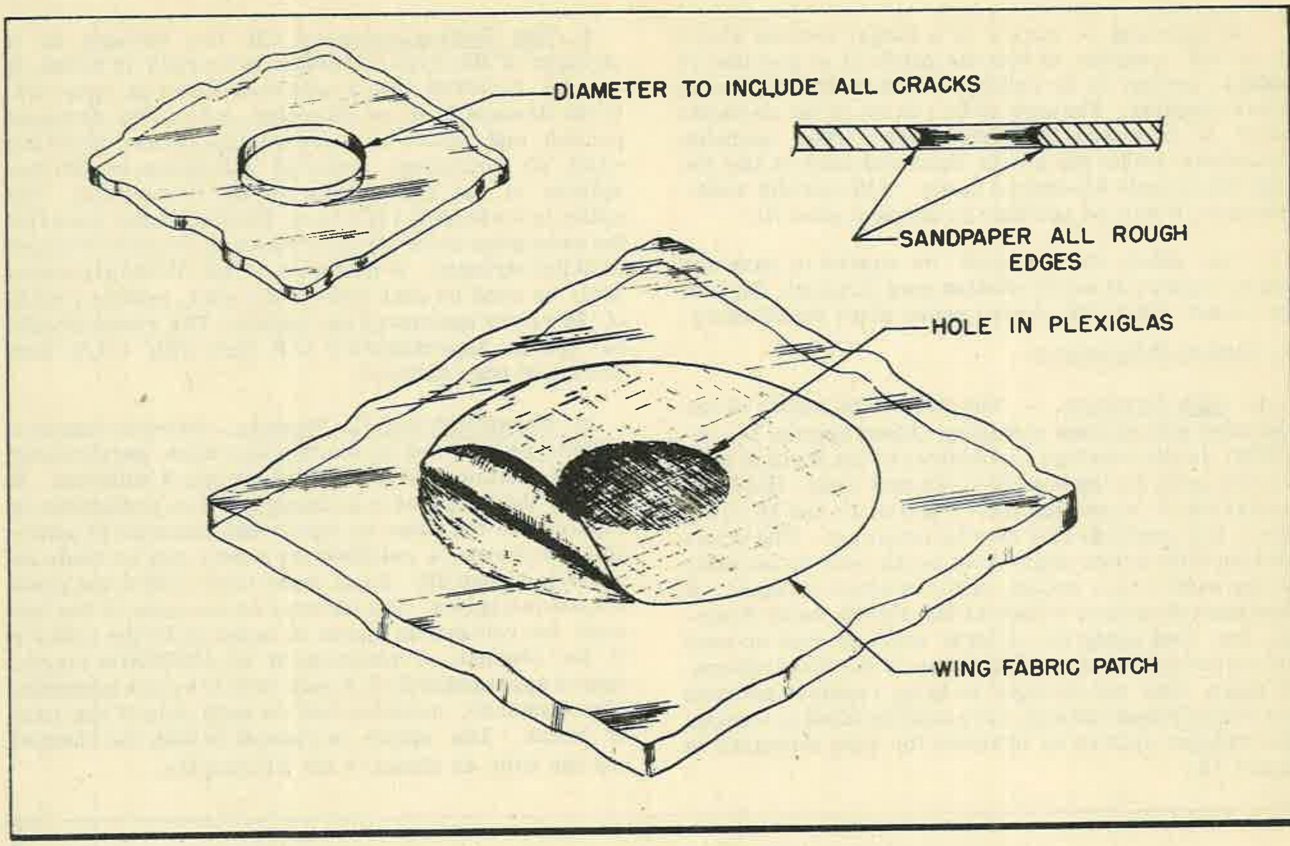


Figure 37 - Temporary Repair of Holes in Plexiglas

b. Holes. - The first step in repairing any hole in plexiglas is to trim the hole and surrounding cracks to a circle as soon as possible. This will prevent the development of radial cracks and will confine the damage to a minimum area. As an emergency repair, the hole can quickly be patched with fabric, or thin plastic sheeting applied to both surfaces with airplane dope. (See figure 37.)

To patch a hole in plexiglas, the hole is trimmed to a perfect circle or oval and the edges of the hole given a slight taper. (See figure 38.) The patch is cut out of plexiglas slightly thicker than the section to be repaired and given a more oblique taper than the hole itself. Its edges are heated in an oven or over an alcohol lamp until it is very soft and pliable. Then it is forced into the hole and allowed to cool.

The patch is then removed and both surfaces masked with masking paper. The edges of the patch are allowed to soak in plexiglas cement (monomeric methyl methacrylate) or ethylene dichloride until the edges are considerably softened. This may require 30 to 45 minutes for monomer or 2 to 3 minutes for ethylene dichloride. The patch is then inserted in the hole again. Because the edges are tapered, pressure need be applied only on one surface and equal pressure will automatically apply to all edges. It is advisable to leave the patch under light pressure for 24 to 36 hours and preferably longer before any attempt is made to clean up the patch by filing, sanding, and buffing it to the level of the patched piece.

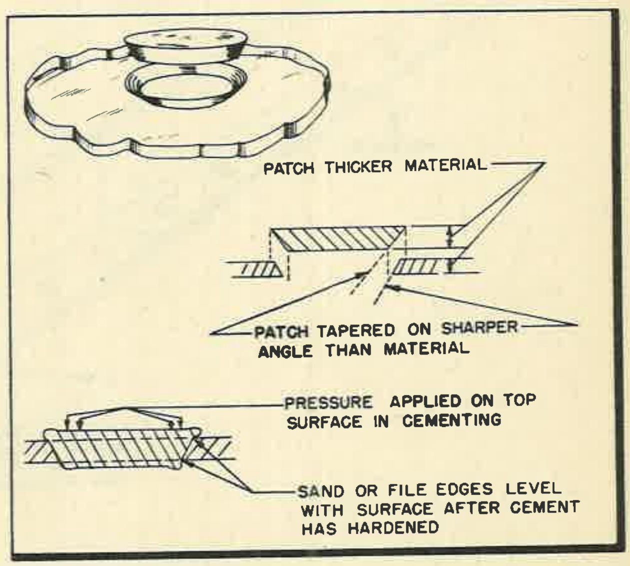


Figure 38 - Permanent Repair of Holes in Plexiglas

In patching a curved or a larger section where it is not possible to heat the patch, it is possible to obtain a perfect fit by cutting the patch first and using it as a template. The area to be cut out of the damaged piece is indicated by scribe lines. The operator should saw within the scribe lines and sand or file the edges to smooth 45-degree taper. With careful workmanship, it will be possible to obtain a good fit.

The patch should never be square or have any sharp corners at which strains may develop. An oval or round patch will always prove more satisfactory.

4. Repair of Stringers.

a. Bulb Stringers. - The method of repair of the extruded bulb section stringers (Alcoa Section No. K-11622) in the fuselage is identical to the method used for the same stringer in the outboard wing. (Refer to paragraph 3. of section III.) Figures 15 and 16 illustrate two methods that may be employed. The cross section of the splice angle must be as near as possible to the same cross section of the original stringer. A minimum of seven 1/8-inch A17ST rivets, which transfer the load along the stringer must be used on each side of the splice, spaced as shown in the illustrations. If more than one stringer is being repaired between any two bulkhead stations, care must be taken to stagger the stringer splices as is shown for wing stringers in figure 18.

b. Hat Section Stringers. - If the damage to a stringer of this type is limited to a crack or break, it can be repaired with a splice as shown in figure 39. If the damage is more extensive, cut out the damaged portion and splice in a new section formed from the same or equivalent material and splice in with two splices of the type shown in the illustration. The splice is made from 17STAL or 24STAL sheet material the same gage as the stringer material which is formed to fit the stringer. A minimum of six AN430AD rivets shall be used on each side of the joint, making a total of 24 rivets necessary per splice. The rivets should be spaced approximately 5/8 inch with a 1/4 inch minimum edge distance.

c. Repair of 5/8 x 1/2 Channels. - Several channels of this type are used on the fuselage nose, particularly on the bottom side forward of the No. 4 bulkhead. If one of these channels is damaged, it is preferable to replace it if the same or equivalent material is available. However, a satisfactory repair can be made as shown in figure 40. A bar made from .125 dural plate is used as a splice. The corners on one side of the bar must be rounded as shown in order to fit the contour of the channel. A minimum of 10 AN430AD4 rivets, spaced approximately 1/2 inch with 1/4-inch minimum edge distance, must be used on each side of the joint or break. The splice is riveted to both the channel and the skin, as shown in the illustration.

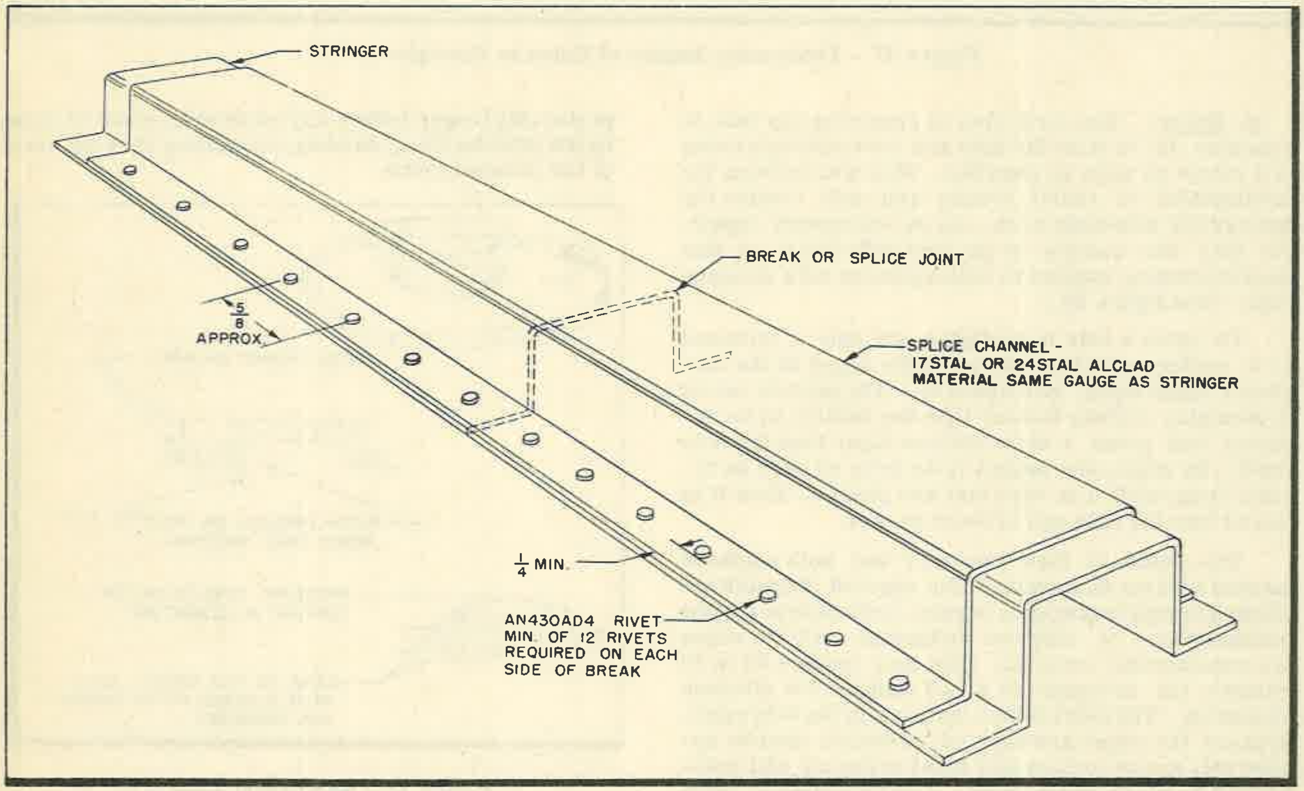


Figure 39 - Repair of Hat Section Stringers

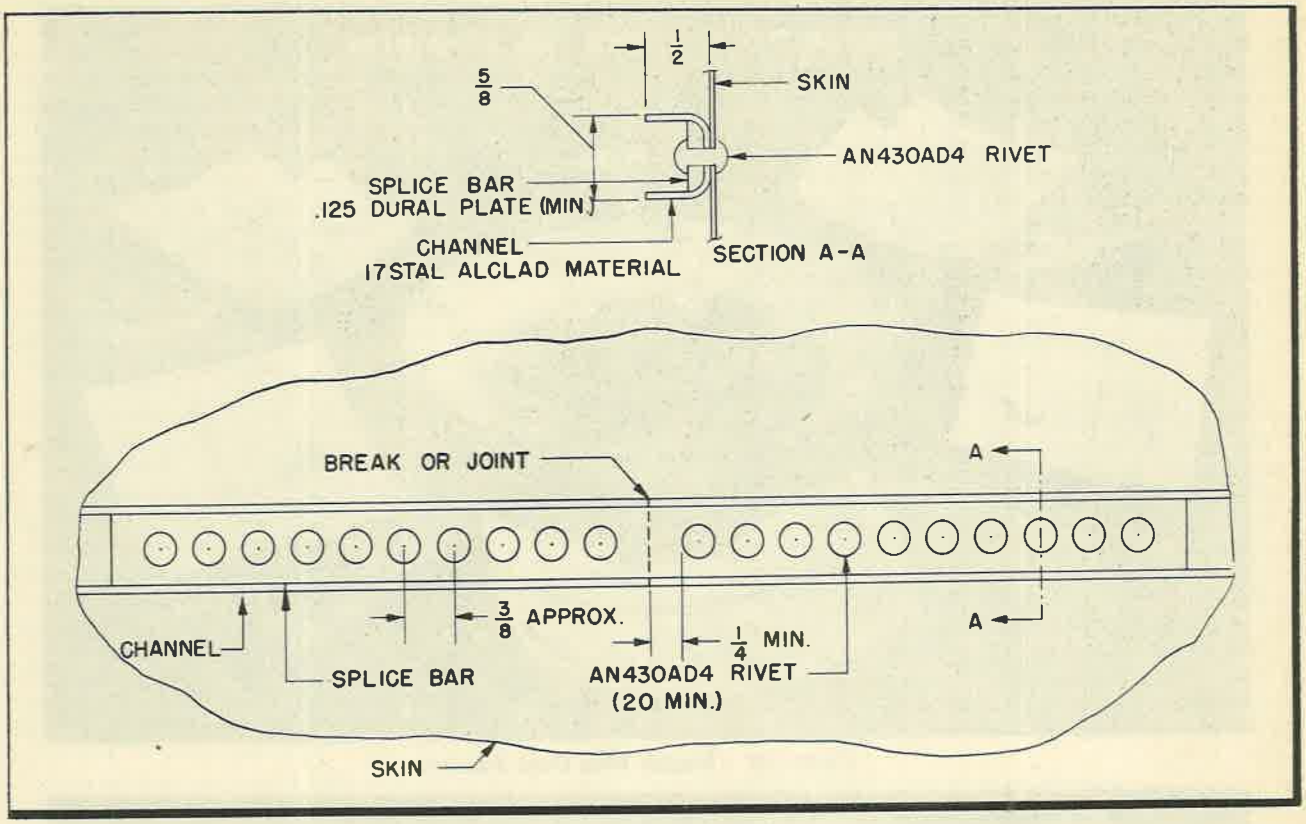


Figure 40 - Repair of 1/2 x 5/8 U-Channel

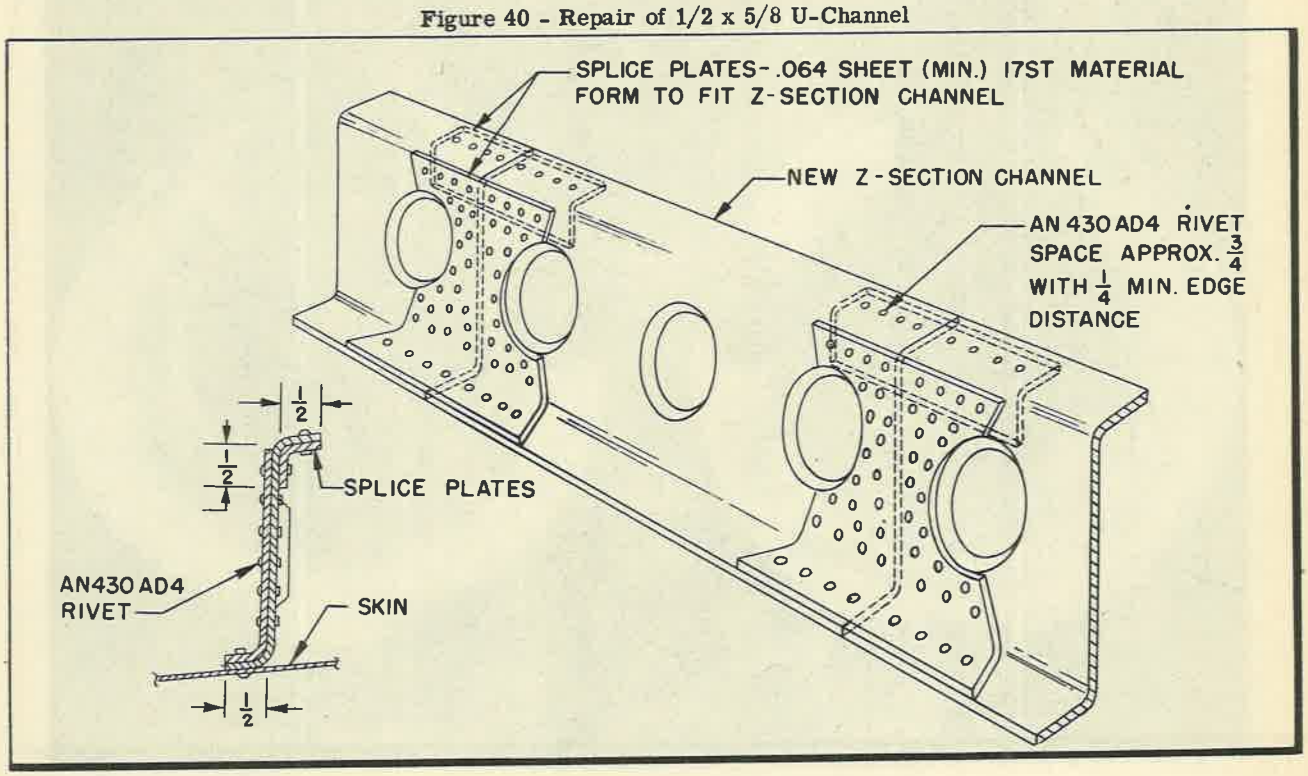


Figure 41 - Repair of Z - Section Channel

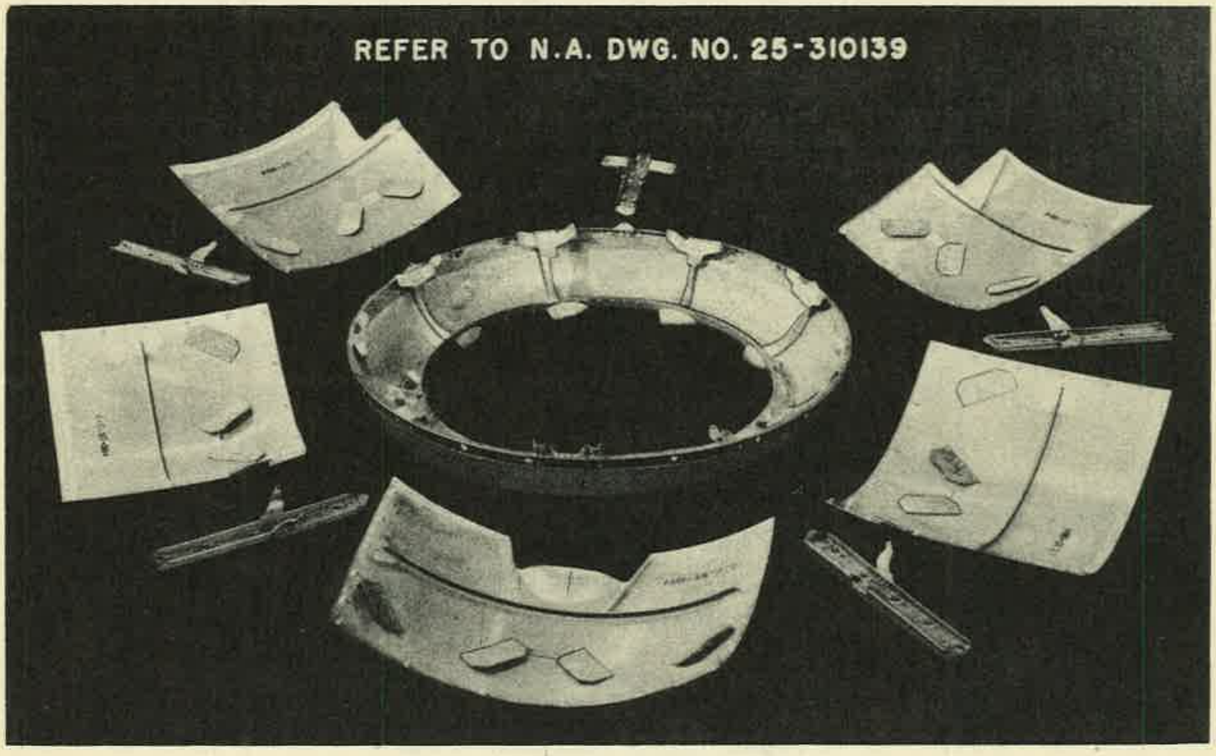


Figure 42 - Engine Ring Cowl Panels

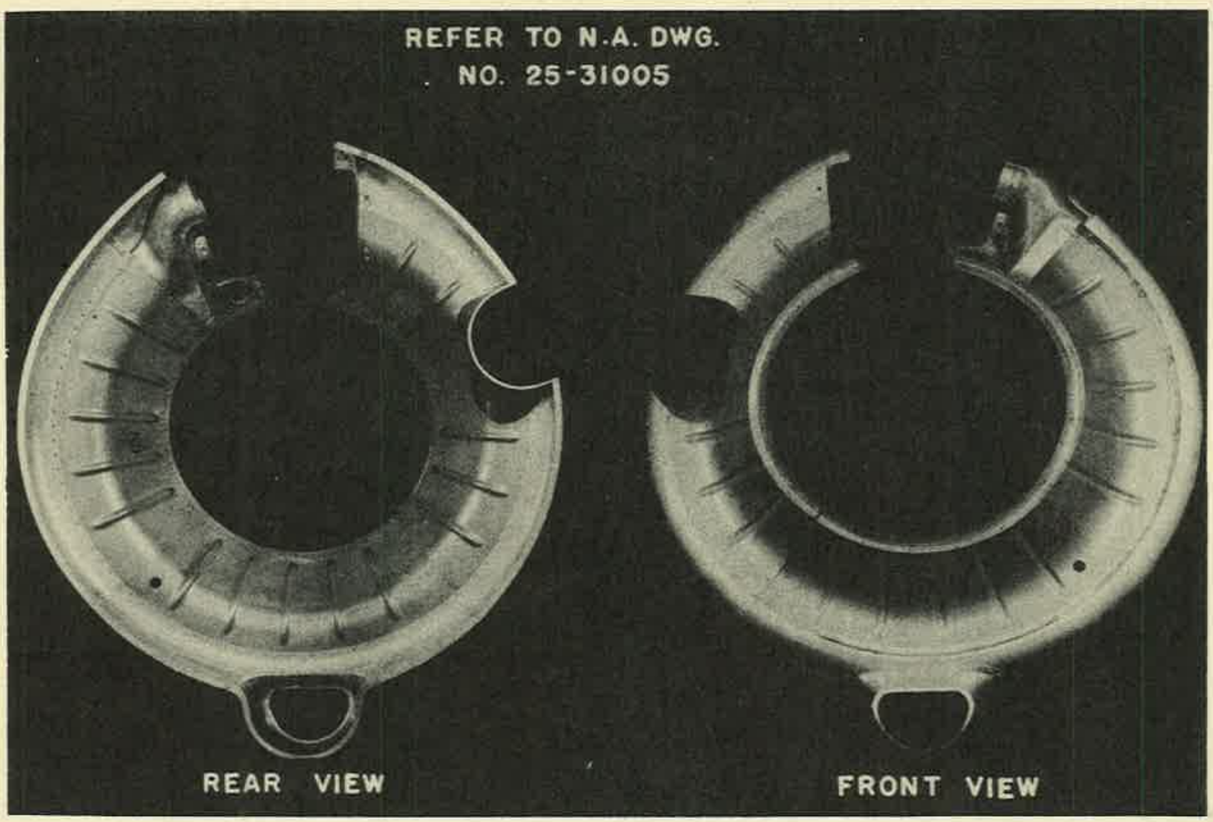


Figure 43 - Engine Fixed Cowl

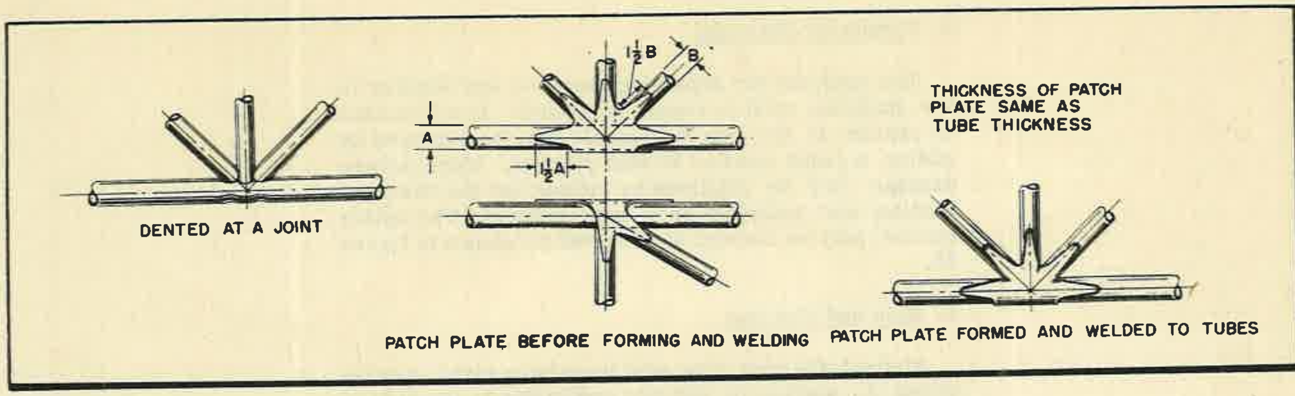


Figure 44 - Repair of Local Damage at Joint by Patch Plate

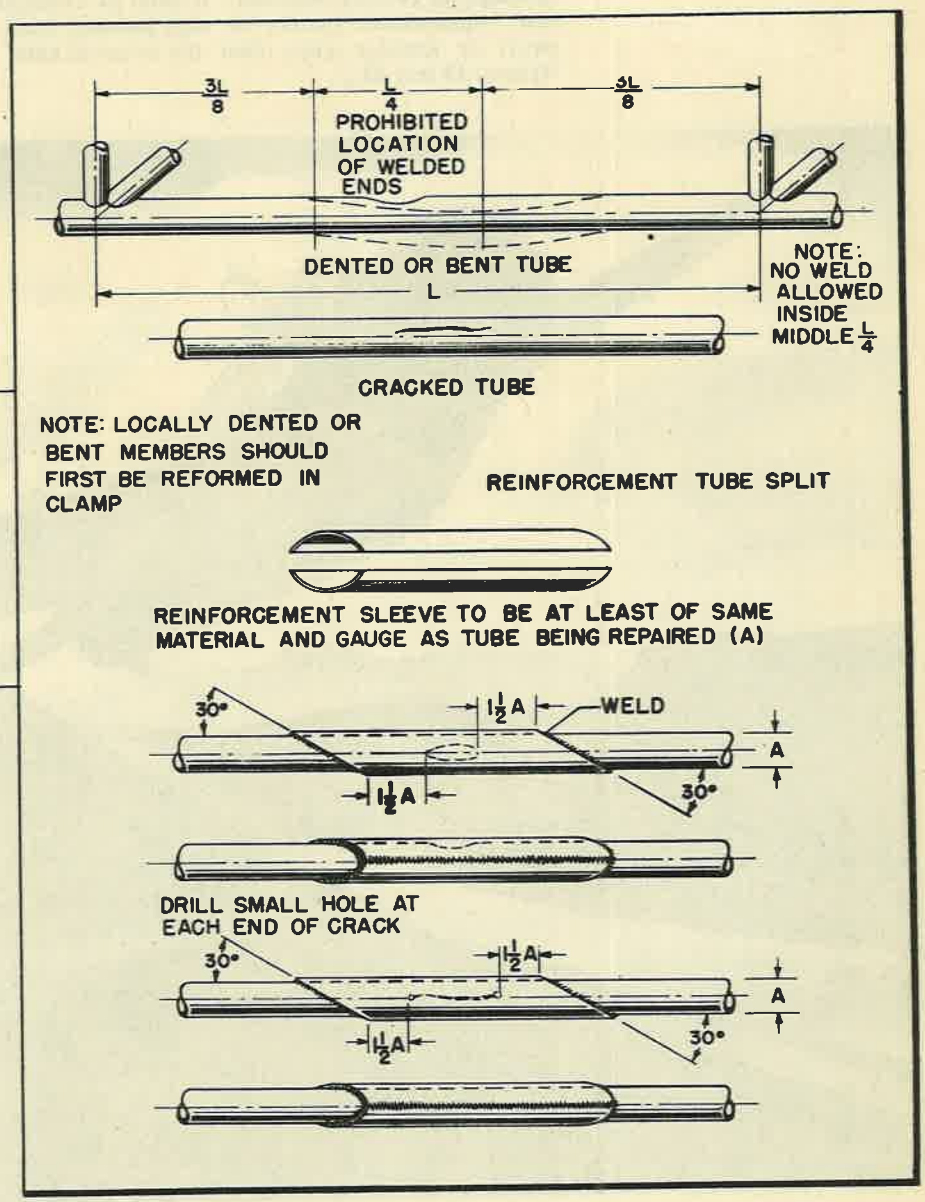


Figure 45 - Tube Repair by Split Sleeve Reinforcement

5. Repair of Channels.

The methods for repairing channels are similar to the methods used to repair bulkheads. Small breaks or cracks in the web of channels may be repaired by adding a patch similar to skin patches. More severe damage may be repaired by cutting out the damaged section and splicing in a new section. The splice channel may be formed and riveted as shown in figure 33.

6. Skin and Cowling.

Methods for repairing skin have been given in paragraph 3. section II, and are applicable to the skin of the fuselage and cowling. Access to all parts of the fuselage is readily obtained. It must be remembered that replacement panels or skin patches must be of equal or greater gage than the original skin. (See figures 42 and 43.)

SECTION VI

LANDING GEAR

1. General.

The semicantilever landing gear is retractable by means of hydraulic struts. A shock absorber of the air-oil type and 33-inch diameter smooth contour tires are incorporated. The retracting mechanism consists of an engine-driven hydraulic pump, emergency hand pump, locks for the extreme positions, and a bungee to operate lock pins in the event of hydraulic failure.

2. Repair.

Welded tubular structures that have not been heat-treated, will be deemed reparable, but it is not advisable to attempt to repair a damaged heat-treated member unless proper facilities are available, Such parts can be repaired, but must then be properly heat-treated.

The elements to be welded should be rigidly held in place to prevent misalignment due to expansion and contraction of the heated material and to insure accuracy. No welds should be filed in an effort to make a smooth appearing job, as such treatment causes a loss in strength. All old weld material should be removed before rewelding. Never weld over weld if it can be avoided, because continual heating causes the material to lose its strength and to become brittle. Prior to welding, clean part to be welded by sandpapering or brushing with a wire brush or other similar methods.

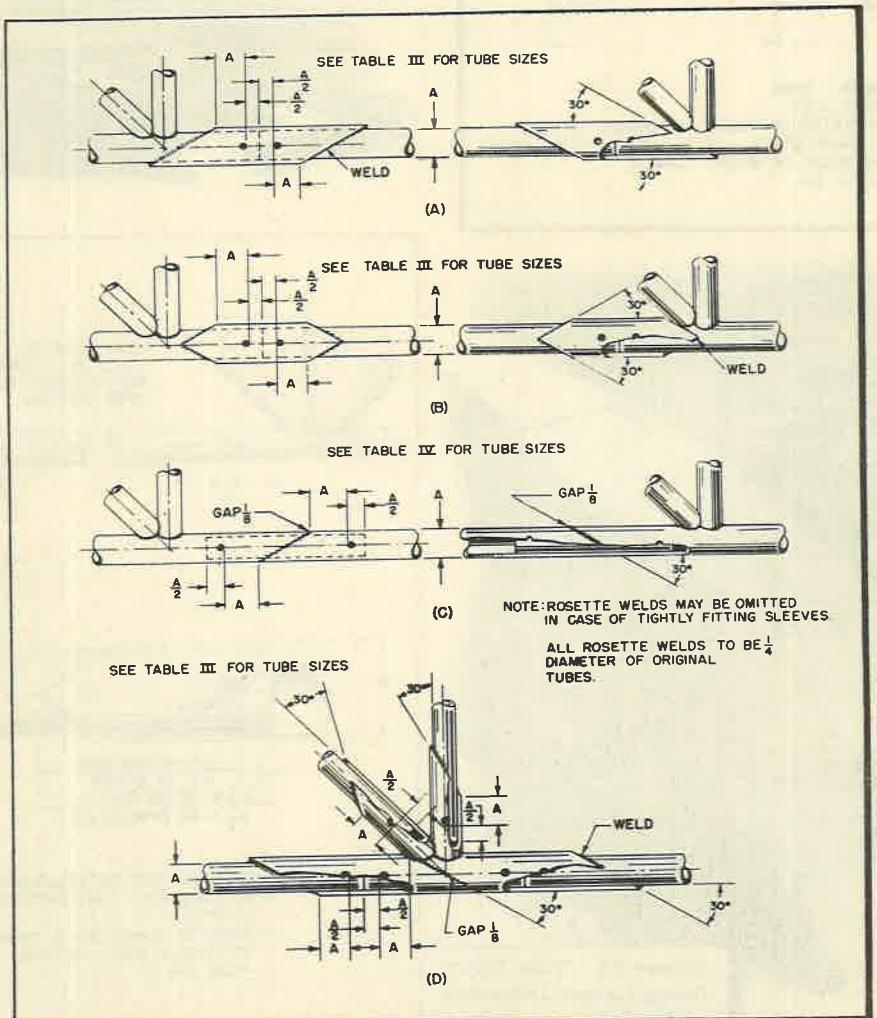
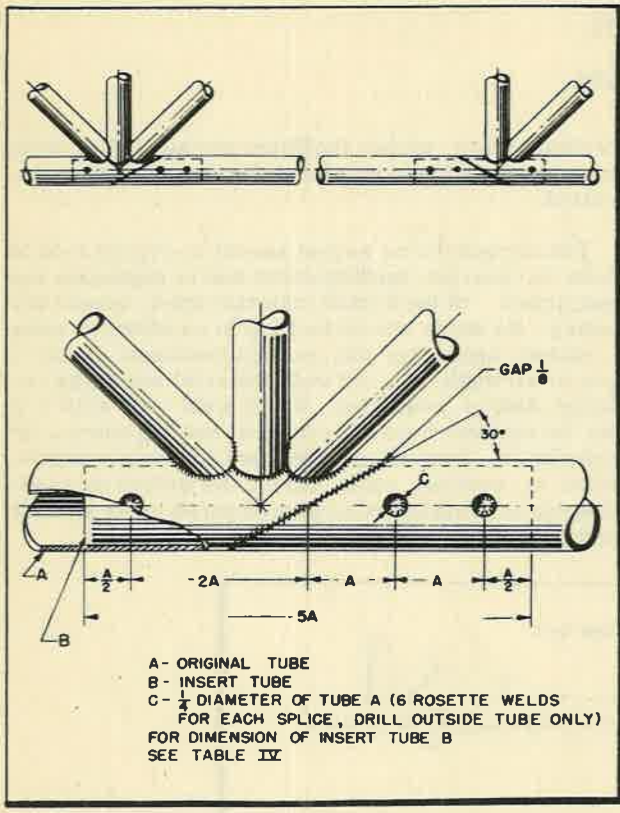
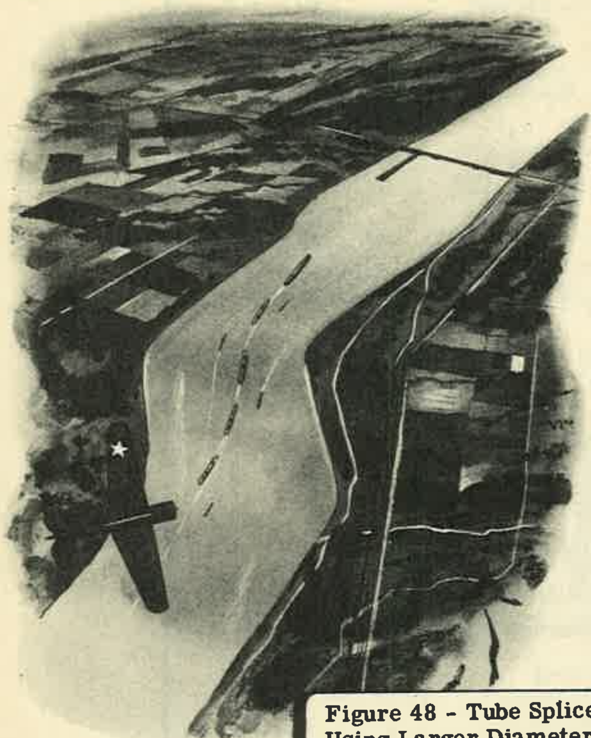


Figure 46 - General Tube Repair Methods

Figure 47 - Tube Splice Using Same Diameter Replacement Tube





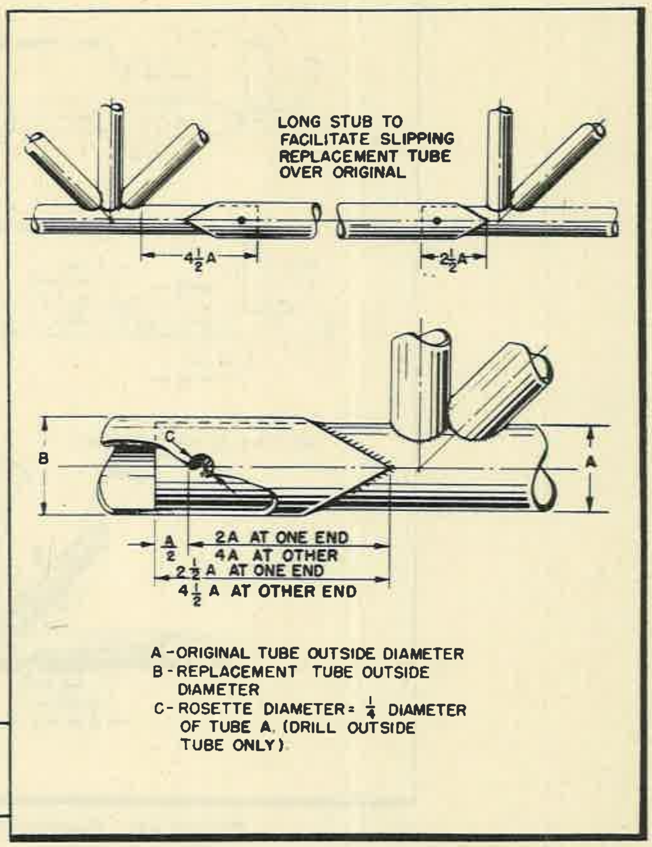


Figure 48 - Tube Splice Using Larger Diameter Replacement Tube

If tubular members have sustained local damage at a joint, they may be repaired by the addition of a patch plate as shown in figure 44. Dented, bent, cracked, or otherwise damaged members may be repaired after first carefully straightening the members and then using a split sleeve reinforcement as shown in figure 45. The filling of kinks with welding red in place of reinforcing the member by either of the methods shown in the above figures is not considered acceptable. Tubular members may be repaired at a station or between stations by various forms of acceptable splices as shown in figure 58. Figure 46D shows a method of repairing a tubular member where the bays are short and there is difficulty in springing the tube to install a sleeve. It is accomplished by sawing out a section at the joint, adding a new section made up of two pieces as indicated. The two pieces of sleeve are first slipped on the tube, one piece on each stub, and pulled back far enough to allow insertion of a tube the same size as the original tube and the length of the gap between the two ends of the tube. The two pieces of sleeve are then brought together and welded at the center of the joint as indicated.

A typical splice using the same diameter replacement tube and what is considered the most efficient type of repair in this category, is shown in figure 47. An equally satisfactory repair using a larger diameter replacement tube in connection with a fish-mouthed, telescoped joint may be found in figure 48.

Figure 49 illustrates a method for straightening bent tubes. The blocks of the straightening jig are made by boring a hole of the desired size through the block and then sawing it in half.

3. Tail Gear.

A non retractable steerable tail wheel mounting a 12-1/2 inch diameter smooth contour tire is provided. Repairs may be made as outlined in the foregoing paragraphs on landing gear.

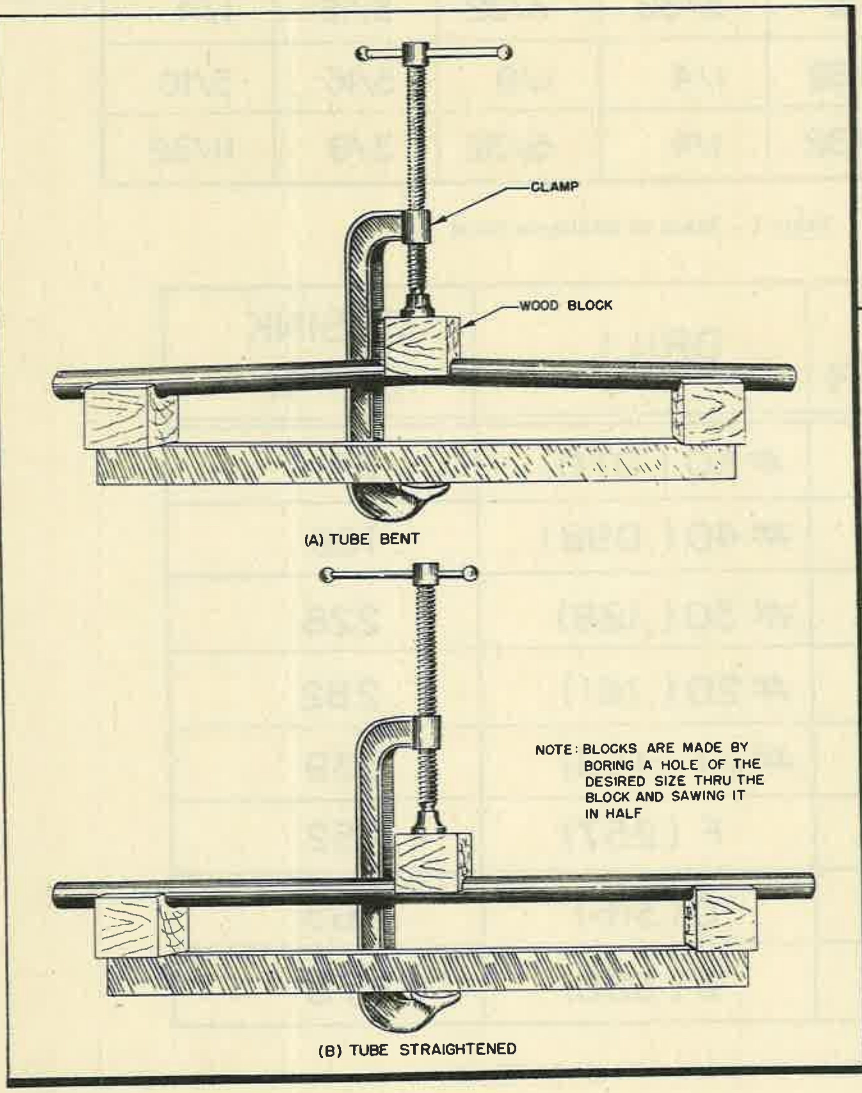


Figure 49 - Jig for Straightening Bent Tubes

SHEET THICKNESS	MINIMUM BEND RADIUS				
	17SO	17ST	24SO	24ST	52SH
.020	1/32	1/32	1/32	3/32	1/16
.025	1/32	1/16	1/32	1/8	3/32
.032	1/32	1/16	1/32	1/8	3/32
.040	1/16	3/32	1/16	5/32	1/8
.051	1/16	1/8	1/16	3/16	5/32
.064	1/16	5/32	3/32	3/16	1/4
.081	3/32	1/4	1/8	5/16	5/16
.091	3/32	1/4	5/32	3/8	11/32

Table I - Table of Minimum Bend

RIVET DIAMETER	DRILL	C'SINK 82° X
1/16	#50 (.070)	.117
3/32	#40 (.098)	.168
1/8	#30 (.128)	.226
5/32	#20 (.161)	.282
3/16	#10 (.193)	.339
1/4	F (.257)	.452
5/16	O (.316)	.565
3/8	W (.386)	.678

Table II - Table of Drills for Rivets

DIAMETER INCHES		WALL THICKNESS - INCHES															
		A=.028		A=.035		A=.049		A=.058		A=.065		A=.083		A=.095		A=.120	
A,B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C
3/8	1/4	.028	.049	.035	.058	.049		.058		.065		.083		.095			
1/2	1/4									.065		.083		.095		.120	
1/2	3/8	.028	.049	.035	.058	.049	.083	.058	.095								
5/8	3/8									.065		.083		.095		.120	
5/8	1/2	.028	.049	.035	.049	.049	.065	.058	.083								
3/4	1/2									.065	.120	.083		.095		.120	
3/4	5/8	.028	.035	.035	.049	.049	.065	.058	.083								
7/8	5/8									.065	.120	.083		.095		.120	
7/8	3/4	.028	.035	.035	.049	.049	.065	.058	.083								
1	3/4									.065	.095	.083	.156	.095	.188	.120	.188
1	7/8			.035	.049	.049	.058	.058	.083								
1 1/8	7/8									.065	.095	.083	.156	.095	.156	.120	
1 1/8	1			.035	.049	.049	.058	.058	.083								
1 1/4	1									.065	.095	.083	.120	.095	.188	.120	.188
1 1/4	1 1/8			.035	.049	.049	.058	.058	.083								
1 3/8	1 1/8									.065	.095	.083	.120	.095	.156	.120	.156
1 3/8	1 1/4			.035	.049	.049	.058	.058	.065								
1 1/2	1 1/4									.065	.095	.083	.120	.095	.156	.120	.156
1 1/2	1 3/8			.035	.049	.049	.058	.058	.065								
1 5/8	1 3/8									.065	.083	.083	.120	.095	.250	.120	.250
1 5/8	1 1/2			.035	.049	.049	.058	.058	.065								
1 3/4	1 1/2									.065	.083	.083	.120	.095	.188	.120	.188
1 3/4	1 5/8			.035	.049	.049	.058	.058	.065								
1 7/8	1 5/8									.065	.083	.083	.120	.095	.120	.120	
1 7/8	1 3/4			.035	.049	.049	.058	.058	.065								
2	1 3/4									.065	.083	.083	.120	.095	.120	.120	.156
2	1 7/8			.035	.049	.049	.058	.058	.065								
2 1/8	1 7/8															.120	.156
2 1/8	2					.049	.058	.058	.065								
2 1/4	2									.065	.083	.083	.120	.095	.120	.120	.156
2 1/4	2 1/8							.058	.120								
2 1/2	2 1/4					.049	.058	.058	.065	.065	.083	.083	.095	.095	.120	.120	.156

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

X4130 Chromium - Molybdenum Steel (Normalized)
Specification AN-WW-T-850

Table III - Wall Thickness of Tubes for Splices Using Outside Sleeves

DIAMETER INCHES		WALL THICKNESS - INCHES																	
		A=.028		A=.035		A=.049		A=.058		A=.065		A=.083		A=.095		A=.120		A=.156	
A, B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C
3/8	1/2	.028	.035	.035	.035	.049	.049	.058	.058	.065	.058								
3/8	5/8											.083	.095	.095	.095				
1/2	5/8	.028	.035	.035	.035	.049	.049	.058	.058	.065	.058								
1/2	3/4											.083	.095	.095	.095	.120	.120		
5/8	3/4	.028	.035	.035	.035	.049	.049	.058	.058	.065	.058								
5/8	7/8											.083	.095	.095	.095	.120	.120		
3/4	7/8	.028	.035	.035	.035	.049	.049	.058	.058	.065	.058								
3/4	1											.083	.095	.095	.095	.120	.120	.156	.120
7/8	1	.028	.035	.035	.035	.049	.049	.058	.058	.065	.058								
7/8	1 1/8											.083	.095	.095	.095	.120	.120	.156	.120
1	1 1/8			.035	.035	.049	.049	.058	.058	.065	.058								
1	1 1/4											.083	.095	.095	.095	.120	.120		
1 1/8	1 1/4			.035	.035	.049	.049	.058	.058	.065	.058								
1 1/8	1 3/8											.083	.095	.095	.095	.120	.120	.156	.120
1 1/4	1 3/8			.035	.035	.049	.049	.058	.058										
1 1/4	1 1/2									.065	.095	.083	.095	.095	.095	.120	.120	.156	.120
1 3/8	1 1/2			.035	.035	.049	.049	.058	.058										
1 3/8	1 5/8									.065	.095	.083	.095	.095	.095	.120	.120		
1 1/2	1 5/8			.035	.035	.049	.049	.058	.058										
1 1/2	1 3/4									.065	.095	.083	.095	.095	.095	.120	.120		
1 5/8	1 3/4			.035	.035	.049	.049	.058	.058										
1 5/8	1 7/8									.065	.095	.083	.095	.095	.095	.120	.120		
1 3/4	1 7/8			.035	.035	.049	.049	.058	.058										
1 3/4	2									.065	.095	.083	.095	.095	.095	.120	.120	.156	.120
1 7/8	2			.035	.035	.049	.049	.058	.058										
1 7/8	2 1/8									.065	.120	.083	.120	.095	.120	.120	.120	.156	.120
2	2 1/8			.035	.049	.049	.049	.058	.058										
2	2 1/4									.065	.095	.083	.095	.095		.120	.120	.156	.120
2 1/8	2 1/4					.049	.058	.058	.058										
2 1/8	2 1/2															.120	.156		
2 1/4	2 1/2							.058	.095	.065	.095	.083	.095	.095	.095	.120	.120	.156	.120
2 1/2	2 3/4					.049	.120	.058	.120	.065	.120	.083	.120	.095	.120	.120	.120		

A - Original Tube
B - Replacement Tube
C - Sleeve

X4130 Chromium - Molybdenum Steel (Normalized)
Specification AN-WW-T-850

Table IV - Wall Thickness of Tubes for Splices, Using Inside Sleeves

SECTION VII

HEAT-TREATED PARTS AND MATERIAL LIST

1. General.

Primary and secondary structural and operating parts used on the 0-47A and 0-47B airplanes, which have been heat-treated are listed below. Heat treatment processes are in accordance with AAF Specification Nos. 98-10025 and 98-10026. The engine mount is constructed of WD-4130 chrome-molybdenum steel tubing purchased to AAF Specification No. 57-180-2 in the normalized condition having a tensile strength of 95,000 pounds per square inch.

2. Aluminum Alloy.

The wings and fixed tail surfaces and the fuselage are of full cantilever and semimonocoque aluminum alloy construction, respectively. In general, all aluminum alloy sheet (except landing gear and empennage fairing), all tubing (except fuel and oil lines), and all forgings, extruded sections and bar stock are heat-treated aluminum coated (Alclad) 24S aluminum alloy purchased to AAF Specification No. 11067. Formed sheet stock which is used in the soft state to facilitate fabrication should be subsequently heat-treated in accordance with AAF Specification No. 98-10026, after forming. All aluminum alloy rivets used are A-17ST.

3. Material Code.

The following code simplifies the identification of materials and heat treatment processes to be used with the following parts list:

CM-S - Chrome-Molybdenum Steel Sheet	(AAF Specification No. 57-136-8; WDX-4130)
CM-B - Chrome-Molybdenum Steel Bar	(AAF Specification No. 10083; WD-4140)
CM-R - Chrome-Molybdenum Steel Rod	(AAF Specification No. 57-107-19; WDX-4130)
CM-T - Chrome-Molybdenum Steel Tube	(AAF Specification No. 57-180-2)
CM-F - Chrome-Molybdenum Steel Forging	(AAF Specification No. 57-105)
NS-R - Nickle-Steel Rod	(AAF Specification No. 57-107-17; WD-3330)
MC-F - Mild-Carbon Steel Forging	(AAF Specification No. 57-105)
AA-T - Aluminum Alloy Tube	(AAF Specification No. 10235)
AA-F - Aluminum Alloy Forging	(AAF Specification No. 57-153)
MA-C - Magnesium Alloy Casting	(AAF Specification No. 57-74-1; Gr. 2) Cond. H.T.)
SS-W - Spring Steel Music Wire	(AAF Specification No. 48-7)
NS-B - Nickel Steel Bar	(AAF Specification No. QQ-N-321)
CR-S - Corrosion Resistant Steel Sheet	(AAF Specification No. 57-136-9)
C-T - Copper Tube	(AAF Specification No. WW-T-799)

4. Heat-Treated Parts List.

Part No.	Title	Material Code	Tensile Strength H.T. in Pounds per Square Inch or as Noted
B1074	Eye - Bolt - ball bearing	CM-F	125-145,000
B1132	Lug - Engine mount vibration absorber cushion	MC-F	Normalize
B1173	Eye - Bolt - ball bearing	CM-F	125-145,000
B1180	Ring - Airplane mooring	CM-F	125-145,000
19-33447	Wrench - Special	CM-S	180-200,000
19-52305	Link - Aileron control rod	CM-F	Normalize
23-53070	Plunger - Seat adjusting	CM-R	125,000
25-11026	Plate - Center wing front spar	CM-F	150,000
25-11026-1	Plate - Center wing front spar	CM-F	150,000
25-11027	Plate - Center wing rear spar	CM-F	150,000
25-11028	Fitting - Center wing rib 49-3/8 front spar attaching	CM-F	160-180,000
25-11029	Fitting Assembly - Center wing rib 28-3/8 rear spar attaching	CM-F	125-140,000
25-12023	Fitting Assembly - Outer wing landing gear lock pin socket	CM-F	160-180,000
25-12028	Fitting - Outer wing landing gear lock pin brace	CM-F	Normalize
25-31142	Fitting - Fuselage engine mount attaching	CM-F	125-145,000

Part No.	Title	Material Code	Tensile Strength H.T. in Pounds per Square Inch or as Noted
25-31143	Fitting - Fuselage nose-over frame front leg attaching	CM-F	Spec. H.T.
25-31902	Fitting - Engine mount attaching	CM-F	Normalize
25-31902-2	Fitting - Engine mount attaching	CM-F	Normalize
25-33105	Joint Assembly - Landing gear	CM-F	160-180,000
25-33106	Hook - Landing gear retracted retaining	CM-F	125-140,000
25-33107	Fitting Assembly - Landing gear rear strut upper attaching	CM-F	125-140,000
25-33107-1	Fitting Assembly - Landing gear rear strut upper attaching	CM-F	125-140,000
25-33108	Fitting Assembly - Landing gear rear strut lower attaching	CM-F	125-145,000
25-33116	Shaft - Landing gear universal joint pivot	NS-B	160-180,000
25-33119	Bolt - Landing gear oleo attaching	NS-B	125-140,000
25-33124	Spacer - Landing gear universal joint	CM-T	125-140,000
51-31040	Spring - Fuselage parachute flare rack door	SS-W	*(10 minutes)
51-31062	Bracket Assembly - Engine ring removable cowl former support	CM-T	Normalize
51-310188	Bolt - Engine removable cowl bracket attaching	NS-B	125,000
51-318174	Spring - Cockpit enclosure gunner's hood control release operating		*(20 minutes)
51-318248	Finger - Cockpit enclosure movable panel release	CM-S	160-180,000
51-42012	Shaft - Carburetor air mixing chamber	CM-T	125,000
51-42018	Stack Assembly - Engine exhaust front	CR-S	Normalize
51-44023	Spring - Propeller control stabilizer		*(10 minutes)
51-47032	Stud - Oil tank sump	NS-R	125,000
51-48070	Fitting - Fuel tank upper retainer adjusting	CM-B	125,000
51-48825	Line Assembly - Fuel engine pump drain	C-T	Anneal
51-53011	Tube - Gunner's seat adjusting	CM-T	125-140,000
51-53018	Plunger - Gunner's seat adjusting lock	CM-B	125-140,000
51-53021	Spring - Gunner's seat adjusting lever tension		*(10 minutes)
51-53033	Spring - Gunner's back rest lock		*(10 minutes)
51-53044	Spring - Auxiliary pilot's back rest lock		*(10 minutes)
51-53118	Tube Assembly - Observer's seat support	CM-T	160,000
51-54071	Spring - Landing gear warning switch		*(10 minutes)
51-54147	Spring - Throttle switch		*(10 minutes)
51-55018	Ring Assembly - Towing bar	CM-B	125,000
51-55019	Tongue Assembly - Towing bar	CM-T	180,000
51-55021	Jaw - Towing bar fixed	CM-B	180,000
51-55022	Jaw - Towing bar adjustable	CM-B	180,000
51-55025	Screw - Towing bar jaw adjusting	CM-B	125,000
51-58102	Spring - Hydraulic pressure control valve one-way valve disc		*(10 minutes)
51-58107	Spring - Hydraulic pressure relief valve		*(20 minutes)
51-62047	Spring - Flexible gun and gun camera stowage latch		*(20 minutes)
51-65025	Spring - Parachute flare release lever		*(10 minutes)
19-33416	Spring - Master brake cylinder valve		*(5 minutes)
19-33457	Spring - Brake cylinder external		*(20 minutes)

* Heat-treat spring at 500-550°F for period noted.