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AIRCRAFT SHEET METAL SURFACE REPAIR TRAINING GUIDE

**MARTIN SCHOOL OF AVIATION
ORANGE COUNTY AIRPORT
SANTA ANA, CALIF.**

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**MARTIN SCHOOL OF AVIATION
ORANGE COUNTY AIRPORT
SANTA ANA, CALIF.**

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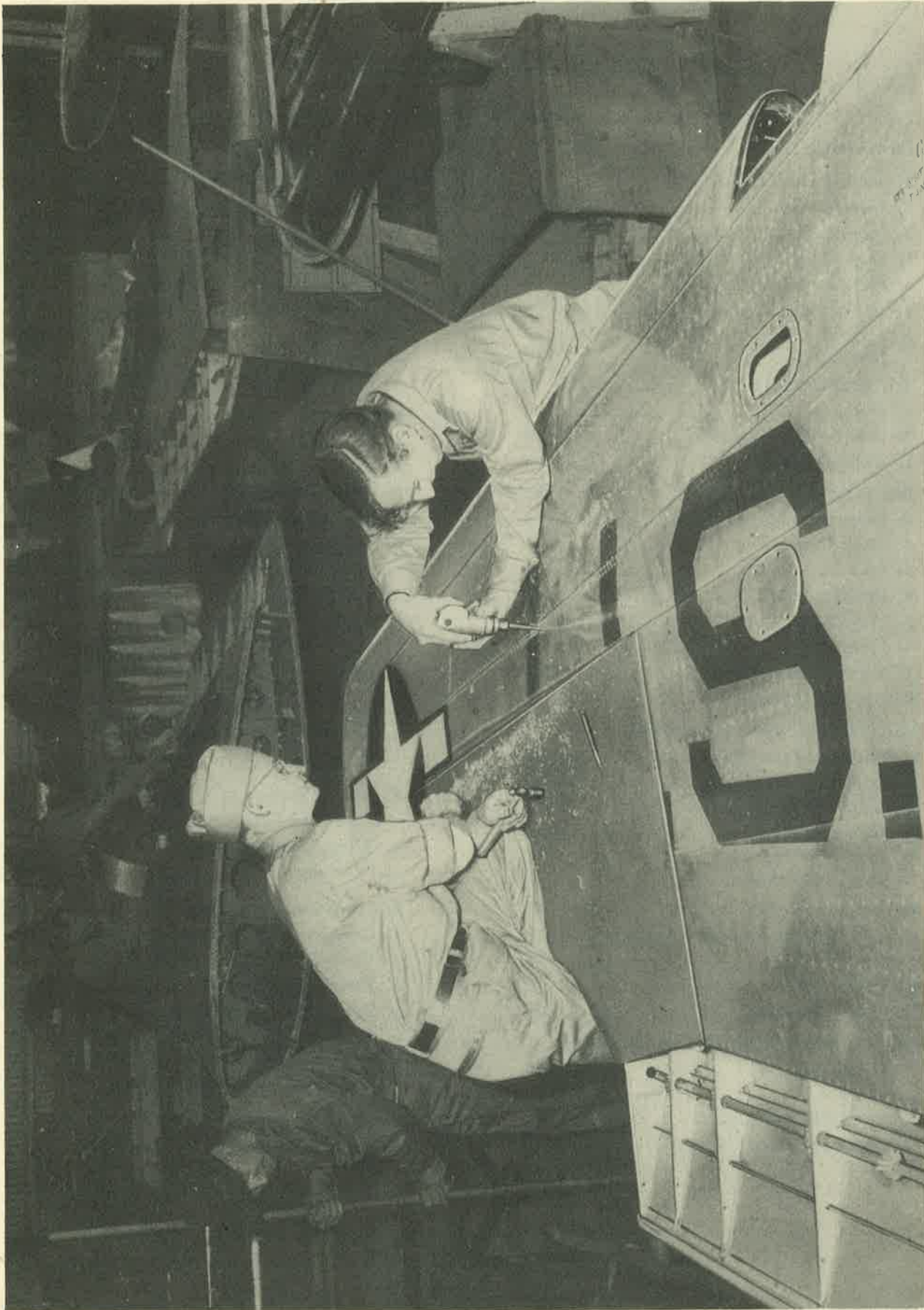


Figure 1—Airplane Surface Repair Shop

SECTION I INTRODUCTION

1. The first airplanes were built mainly of wood, with steel and other metals used for fittings only. Today most airplanes are built of metal, with the result that it has become necessary to train a great number of workers to be specialists in repairing the sheet metal surfaces (called *skin*) of the fuselage and wings.

2. To get an idea of what kind of work a sheet metal surface repair mechanic does, let us compare him to a tailor or a dress maker. Should a person get a hole or tear in his coat, he would take the coat to a tailor and have a patch sewed on. Similarly, when an airplane gets a hole or crack in its metal surface (or skin), a sheet metal mechanic is called upon to put a patch over the hole or crack.



3. The tools a tailor would use would be a yard stick or tape measure to measure the size of his patch, a pair of scissors to cut out the patch, and a needle and thread to sew the patch on. Everyone knows what these tools are, and how to use them. The sheet metal mechanic, however, working with sheet metal instead of cloth, will have to use different tools. He will need measuring and layout tools to layout his patch, and hand tools to cut out the patch; but instead of a needle and thread to sew the patch on, he will use a portable drill to drill the holes in the metal, and rivets to hold the patch in place. The tools of a sheet metal mechanic and how to handle them skillfully will be taken up first. When this has been learned, the practical work of making surface repairs to the skin of airplanes will be gone into, with the trainee taught to make actual repairs.



Figure 2—Tools

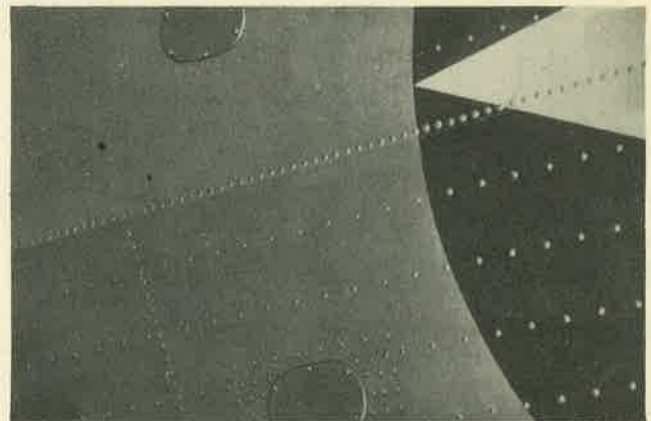


Figure 3—Metal Patches on Airplane Surface

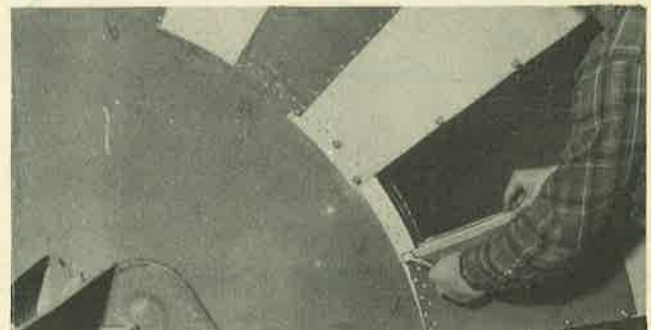


Figure 4—Typical Surface Repairs

SECTION II

MEASURING AND LAYOUT TOOLS

1. GENERAL.

a. The English system of linear measure, of which the *yard* is the unit of length, is the standard in American industry. In aviation shop work, the *inch* is the unit most commonly used.

b. The inch may be divided into smaller parts by means of either common or decimal fractional divisions. The fractional divisions of an inch are found by dividing the inch into equal parts, the more common of which are: halves ($\frac{1}{2}$); quarters ($\frac{1}{4}$); eighths ($\frac{1}{8}$); sixteenths ($\frac{1}{16}$); thirty-seconds ($\frac{1}{32}$); and sixty-fourths ($\frac{1}{64}$). (See figure 5.)

c. The fractions of an inch may be expressed in decimals called *decimal equivalents* of an inch; for example, $\frac{1}{8}$ of an inch is expressed as .125 (one hundred twenty-five thousandths of an inch), or $\frac{1}{4}$ of an inch would be expressed as .250 (two hundred fifty thousandths of an inch), etc.

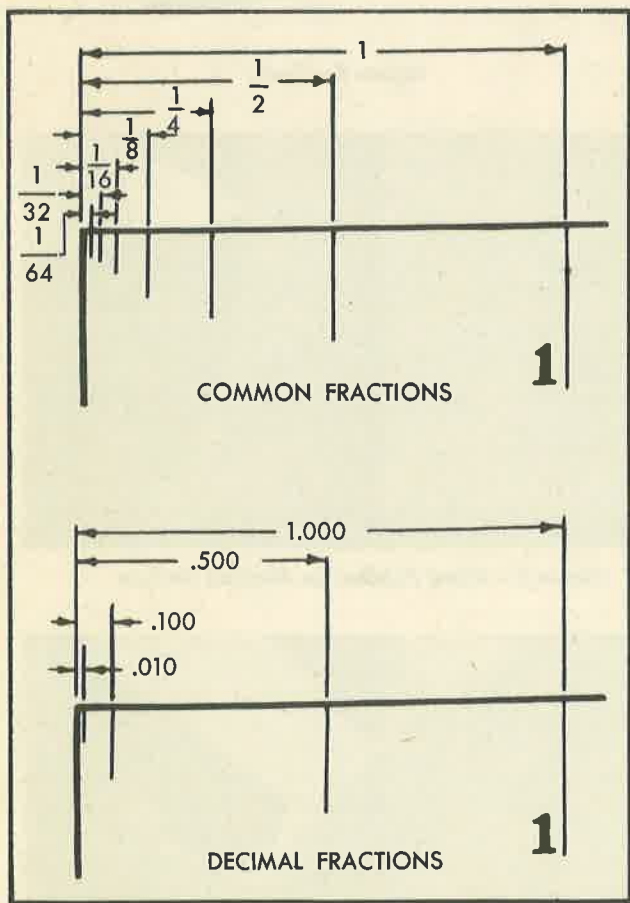


Figure 5—Two Systems of Dividing the Inch

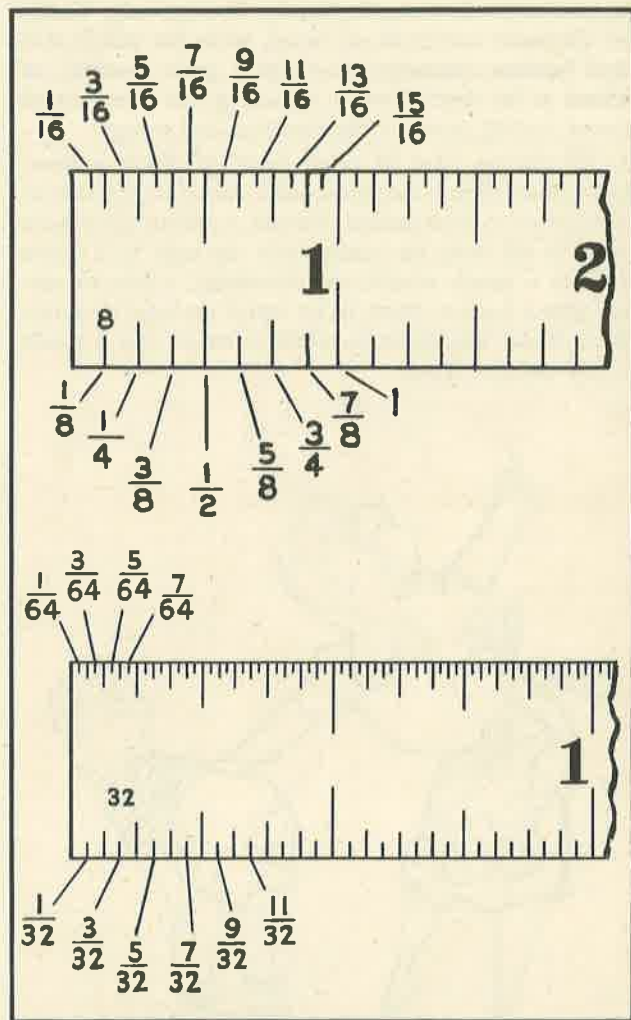


Figure 6—Graduations on a Steel Rule

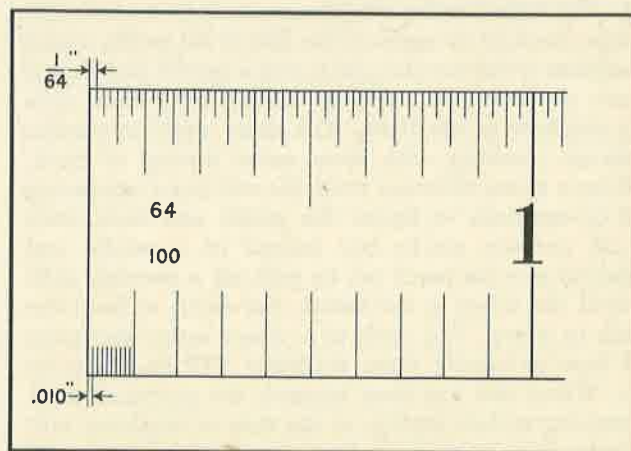


Figure 7—Decimal Fractions

NOTE

Inches are designated with a double prime ("): 3 inches = 3"; feet with a single prime ('): 5 feet = 5'.

2. STEEL RULE.

a. The *steel rule* is used for measuring either common fractions up to sixty-fourths of an inch, or decimal fractions up to one-hundredths of an inch. It may be used for two purposes: (1) as a measure, and (2) as a straight edge.

b. To measure a piece of stock, place the rule flat across the surface or distance to be measured, holding or steadying the work with the left hand.

c. With the rule held in the right hand and guided by the thumb nail, extend the rule until its end is even with the left-hand edge of the work. (See figure 10.) Read the graduations on the rule from left to right by noting where line on the rule coincides closest with the right-hand edge of the stock. (See figure 11.)

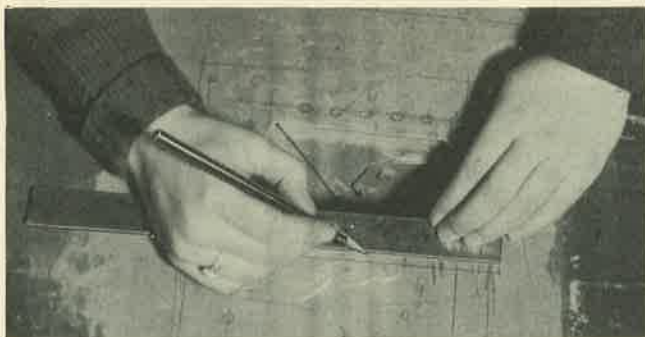


Figure 8—Steel Rule Used as a Measure

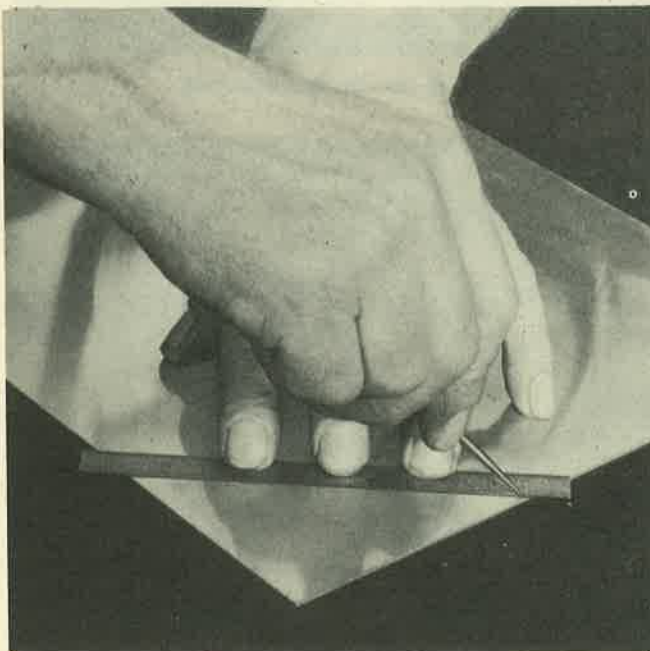


Figure 9—Steel Rule Used as a Straight Edge

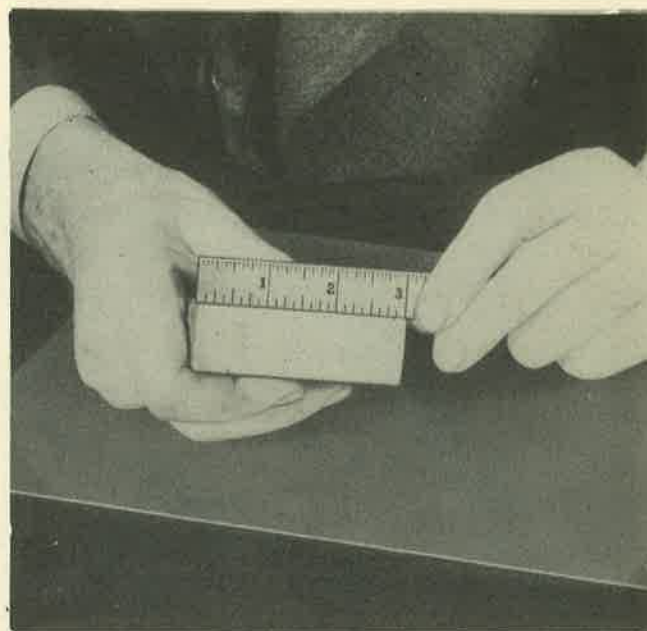


Figure 10—Measuring a Piece of Stock

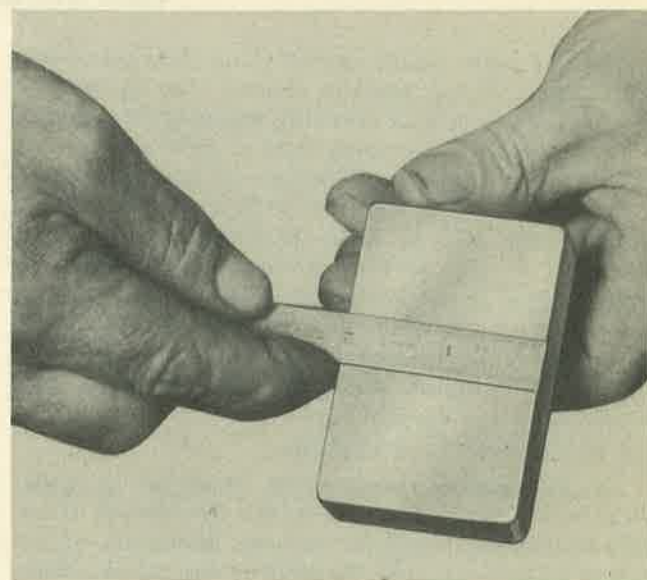


Figure 11—Reading a Steel Rule

NOTE

Select that edge of the rule which is graduated in fractional divisions of an inch for the desired dimension—*eighths*, *sixteenths*, *thirty-seconds*, or *sixty-fourths*. (See figure 6.)

3. COMBINATION SQUARE.

a. The combination square (figure 12) is one of the most useful and convenient tools for laying out small work. The blade can be moved along the stock and by means of a knurled nut, be clamped for any distance. It is used as a square for measuring or laying out 90-degree or 45-degree angles. A spirit level is mounted in the stock. A scribe is held in the lower end.

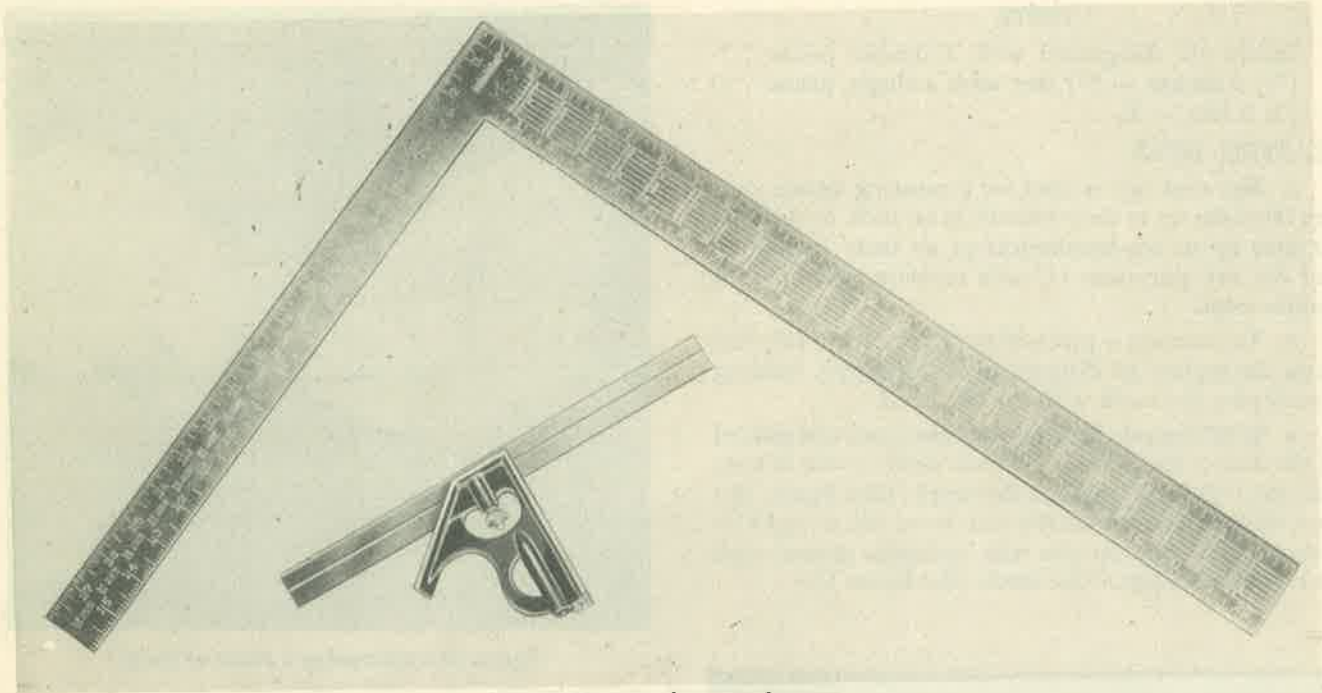


Figure 12—Combination Square

b. The stock can be moved along the steel blade and clamped in any position desired. (See figure 13.) It is used as a square for checking angles of 90 degrees, as a depth gage, for scribing lines at right angles to a surface, or for angles of 45 degrees. By setting the end of the steel rule flush with the stock, it may be used as a height gage, directly or in combination with a surface gage. A spirit level is mounted in the stock. A scriber is held in the lower end by a friction bushing. The scriber may be drawn out when needed. The steel blade or rule, which is part of the square, may be fitted to either the square stock, or used separately for measuring or as a straight edge.

4. MICROMETER CALIPER.

a. The smallest measurement which can be made with the use of the steel rule is one sixty-fourth of an inch in common fractions, and one hundredth of an inch in decimal fractions. To measure more closely than this (thousandths and ten-thousandths of an inch), a *micrometer caliper* (figure 15) is used. If a dimension given in common fractions is to be measured with the micrometer, the fraction must be converted to its decimal equivalent.

b. The principal parts of the micrometer are: the fixed parts—frame, barrel, and anvil; and the movable parts—the thimble and spindle. The thimble rotates the spindle, which moves in the threaded portion inside the barrel. Turning the thimble provides an opening between the anvil and the end of the spindle where the work is measured. The size of the work is indicated by the graduations on the barrel and thimble.

c. The lines on the barrel marked "1," "2," "3," "4," etc., indicate measurements of 10ths or .100 inch, .200 inch, .300 inch, or .400 inch, etc., respectively. (See figure 16.)

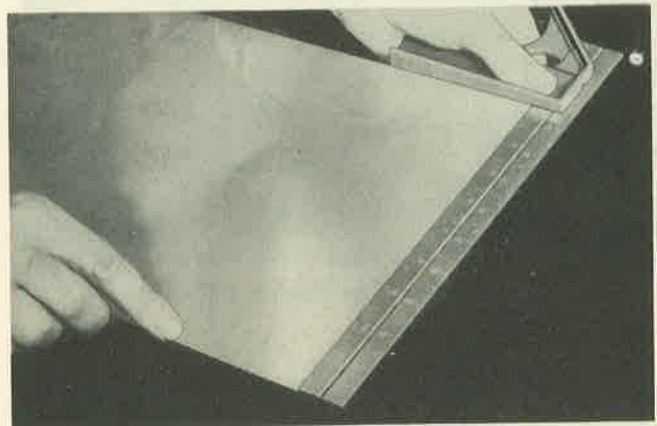


Figure 13—Outside Squaring

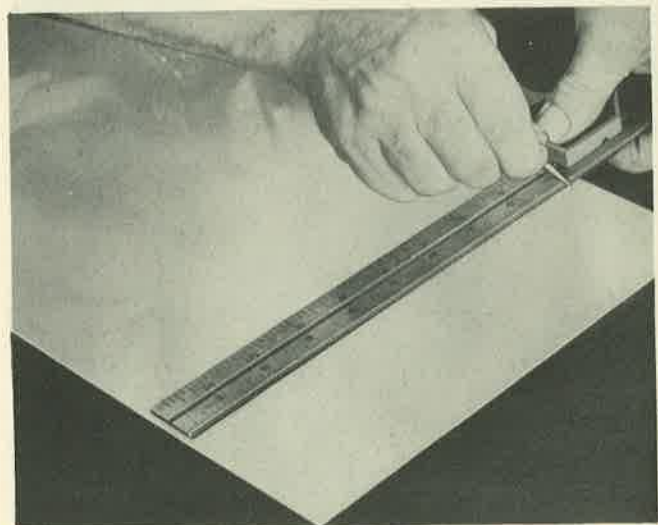


Figure 14—Drawing a Line Parallel to Edge

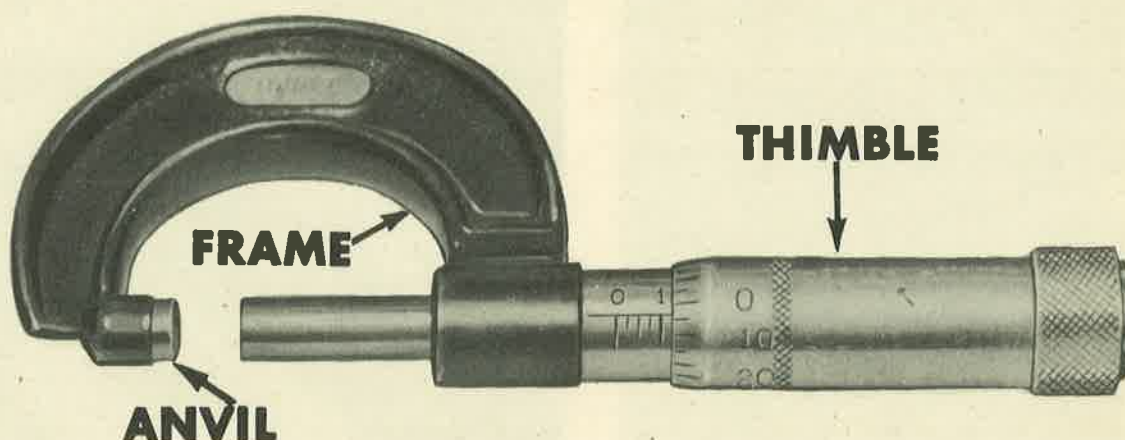


Figure 15—Parts of the Micrometer Caliper

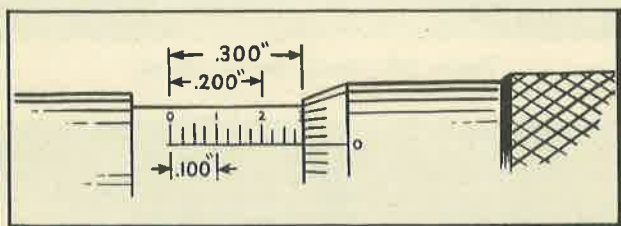


Figure 16—Readings of .100 inch, .200 inch, .300 inch

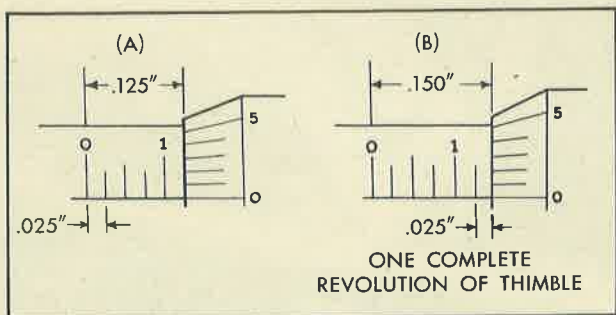


Figure 17—Divisions of .025 inch

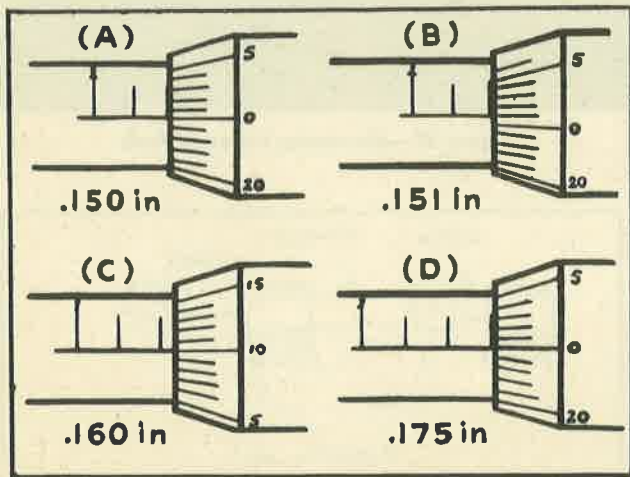


Figure 18—Micrometer Readings

d. Each of the sections between the 10th divisions (between "1," "2," "3," "4," etc.) is divided into four equal parts of .025 inch each. One complete revolution of the thimble (from zero on the thimble around to the same zero) moves it one of these divisions (.025 inch) along the barrel. (See figure 17.)

e. The bevel edge of the thimble is divided into 25 equal parts. Each of these parts represents one twenty-fifth of the distance the thimble travels along the barrel in moving from one of the .025-inch divisions to another. Thus, each division on the thimble represents one-thousandth (.001) of an inch. These divisions are marked for convenience at every five spaces by "0," "5," "10," "15," and "20." When 25 of these graduations have passed the horizontal line on the barrel, the spindle (having made one revolution) has moved .025 inch.

f. The micrometer is read by first noting the last visible figure on the horizontal line of the barrel, representing tenths of an inch. Add to this, the amount represented by the visible graduations beyond this figure (by multiplying the number of them by .025 inch), and the number of divisions on the bevel edge of the thimble that coincides with the line of the graduation. Figure 18 shows four sample readings.

NOTE

Since the micrometer is a precision tool, it must be handled carefully. If it is dropped, its accuracy may be permanently affected. Continually sliding work between the anvil and spindle may wear the surfaces. If the spindle is tightened too much, the frame may be sprung permanently.

(1) To measure a piece of work with the micrometer when the work is held in the hand, hold the frame of the micrometer in the palm of the right hand by the little finger (or the third finger, whichever is more convenient), allowing the thumb and fore-

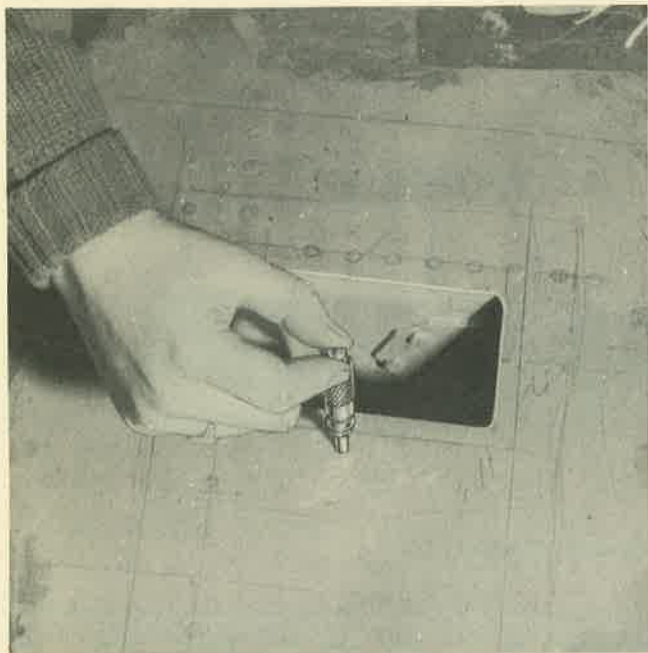


Figure 19—Using a Micrometer

finger to be free to revolve the thimble for the adjustment.

(2) Place the work between the anvil and the spindle. Turn the thimble until its movement has brought the spindle and the anvil in contact. (See figures 20 and 21.)

NOTE

Do not screw thimble too tight as this spreads the frame, resulting in erroneous readings.

(3) The measurement is taken from the graduations on the barrel and the thimble, as you have already learned. (See figure 22.)

NOTE

After the measurement has been determined, open the micrometer screw before removing it from the work. This practice prevents wear on the ends of the spindle and anvil, which impairs the accuracy of the tool.

NOTE

When using the micrometer as shown in figure 21 be sure to use the small Kimbal thimble to bring the anvil and spindle in contact with the work. The use of the small Kimbal thimble prevents the application of excessive pressure by slipping over a ratchet after so much pressure is applied.

5. STEEL SQUARE. (See figures 23, 24 and 25.)

a. PURPOSE.

The steel square is used to measure an angle of 90 degrees. Surfaces at 90 degrees to each other are said to be square with each other. (See figure 23.) The right angle, or perpendicular as it is also called, may be found on either the inside or outside of the square.

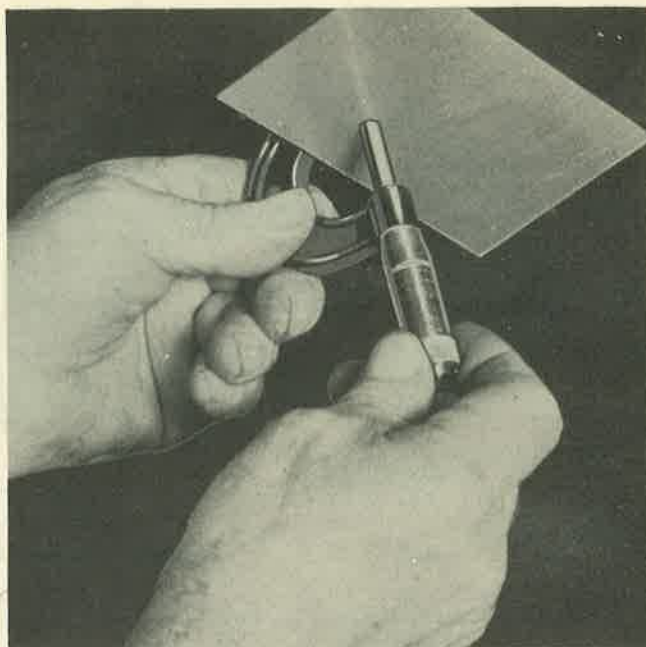


Figure 20—Measuring Flat Stock

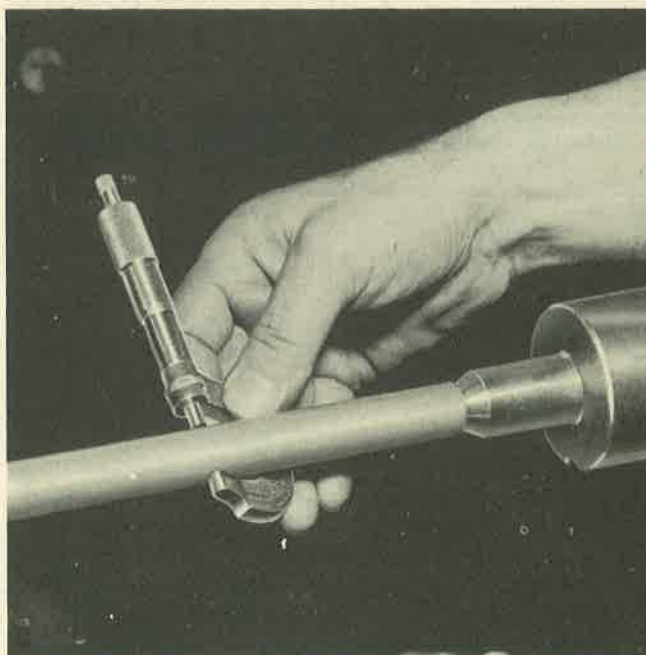


Figure 21—Measuring Tubes or Rods

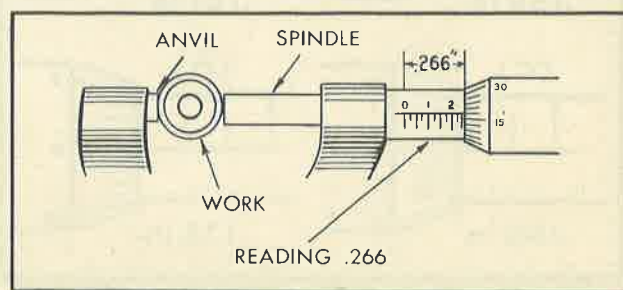


Figure 22—Final Reading

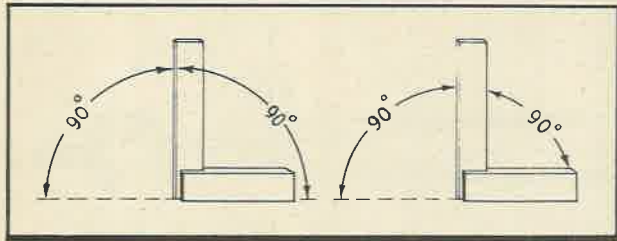


Figure 23—Steel Square

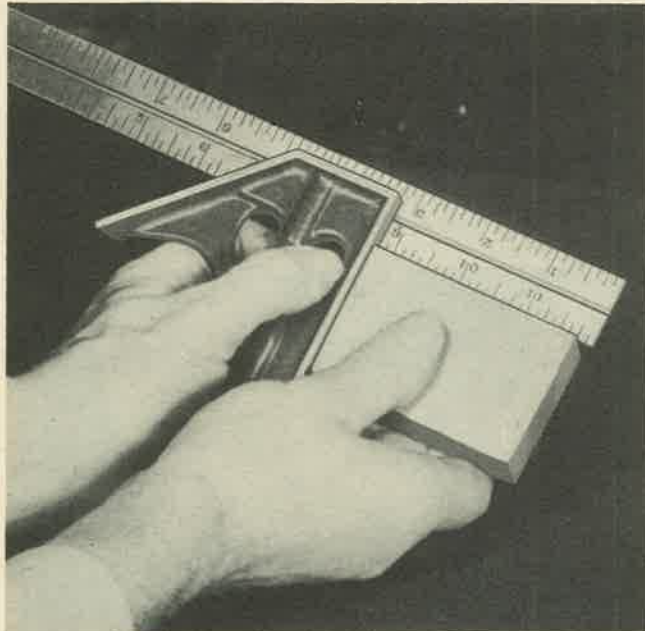


Figure 24—Checking Outside Right Angle

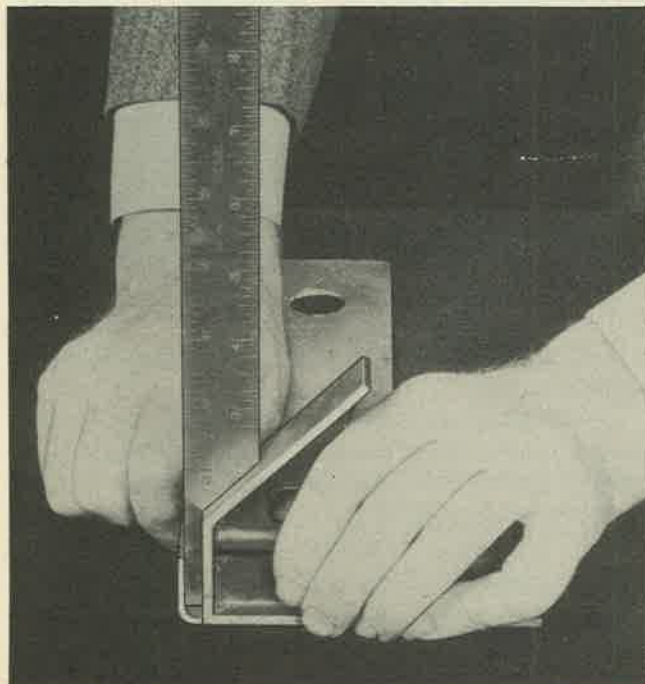


Figure 25—Checking Inside Right Angle

b. HOW TO USE THE STEEL SQUARE.

(1) Remove all burrs from the surface of the work to be checked. Wipe work clean of chips, oil and dirt.

(2) Wipe the square clean, and draw the edges to be used over the palm of the hand to insure absolute freedom from small particles.

(3) Face the light so that it will shine on the work.

(4) Place the inside of the square against a finished surface of the work so that the beam is full contact with one side, and slight space remains between the blade and the other surface of the work. (Figure 24, position A.)

(5) Lower the blade carefully to the surface of the work, and note where the blade first comes in contact with the surface. If the angle is square, all light will be excluded.

NOTE

The method of checking an inside right angle with the outside edges of the square is shown in figure 25.

6. SCRIBER. (See figure 26.)

a. DESCRIPTION.

The scriber is a piece of tool steel (usually drill rod) about $\frac{1}{8}$ inch in diameter, 4 inches to 12 inches long, tapered at both ends to a needle point. (Figure 26.) One end is bent to be used for reaching through holes. It is used to scribe or mark lines on metal surfaces. On aluminum, however, the scriber is used only to mark lines that will later be cut by metal shears.

b. HOW TO USE THE SCRIBER.

(1) Inspect the point of the scriber to make sure that it is sharp.

(2) Wipe the surfaces of the work to be scribed, clean and free of oil, dirt, and chips.

NOTE

Only the outside lines are scribed on aircraft sheet metal. All other lines are drawn with a pencil.

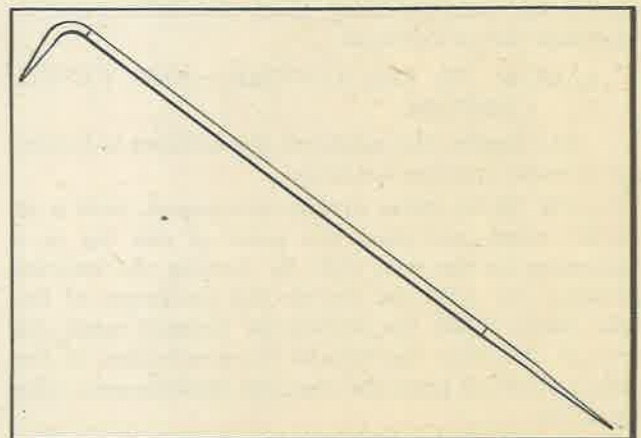


Figure 26—Scriber

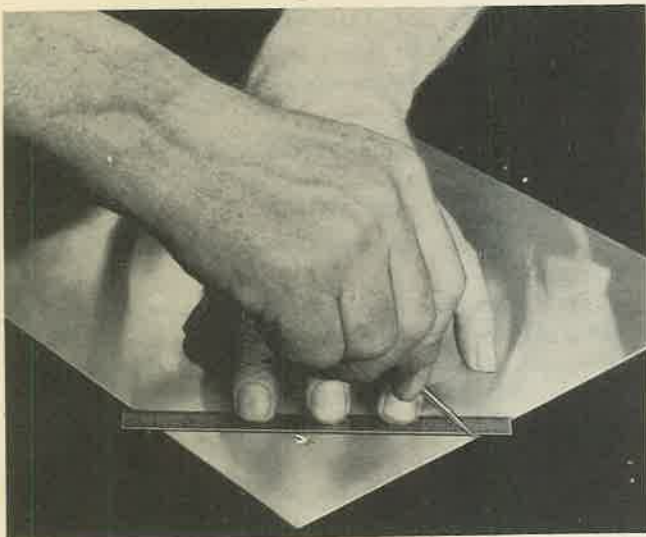


Figure 27—Scribing a Line

(3) Place the steel rule flat on the work in position for scribing. (See figure 27.)

(4) Hold the rule firmly by exerting pressure with the tips of the fingers of the left hand.

(5) Scribe the line by exerting pressure on the scribe and drawing it along the edge of the rule, inclining the top of the scribe slightly in the direction in which it is to be moved.

7. DIVIDERS.

Dividers have two straight legs, both tapered to a needle point and adjusted for opening by screw and knurled nut. (See figure 28.) They are used for describing circles and radii, for measuring distances between two points, and for transferring distances taken directly from the steel rule.

8. PENCIL COMPASS.

a. HOW MADE.

A *pencil compass* has two legs joined at the top by a pivot. One of the legs is tapered to a needle point, while the other leg has a pencil lead inserted, or a pencil clamped to its side. (See figure 29.) The compass is used to describe circles and arcs, and also for transferring measurements from the steel rule to aluminum aircraft surfaces.

b. HOW TO USE DIVIDERS AND PENCIL COMPASS.

(1) Inspect the points of the dividers and compass to make sure they are sharp.

(2) To set either divider or compass, hold it in the left hand, and place the point of one leg in a graduation on the steel rule. By turning the knurled adjusting nut with the thumb and forefinger of the right hand, adjust the divider or compass until the point of the other leg rests on the graduation of the steel rule, which gives the required measurement. (See figure 30.)

(3) To scribe an arc or circle with either the divider or compass, grasp the knurled thumb attach-

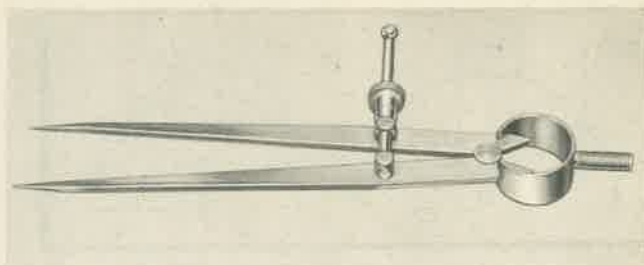


Figure 28—Dividers

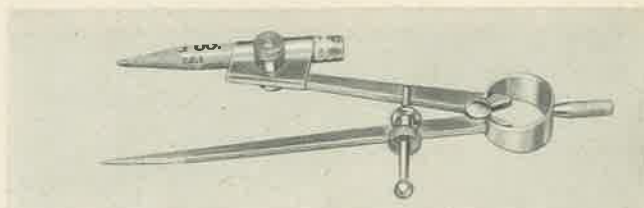


Figure 29—Pencil Compass

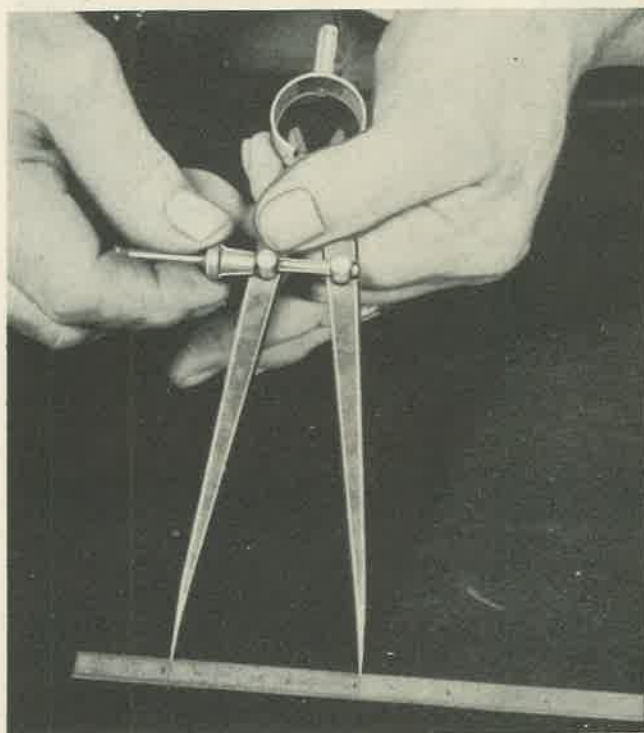


Figure 30—Setting Dividers

ment on the top with the thumb and forefinger of the right hand.

(4) Place the point of the pivoting leg in the punched mark. With pressure exerted on both legs, swing in a clockwise direction, and scribe the desired arc or circle. (See figure 31.)

NOTE

The tendency to slip is avoided by inclining the dividers or compass in the direction in which they are being rotated.

NOTE

Layout lines on aluminum should be drawn

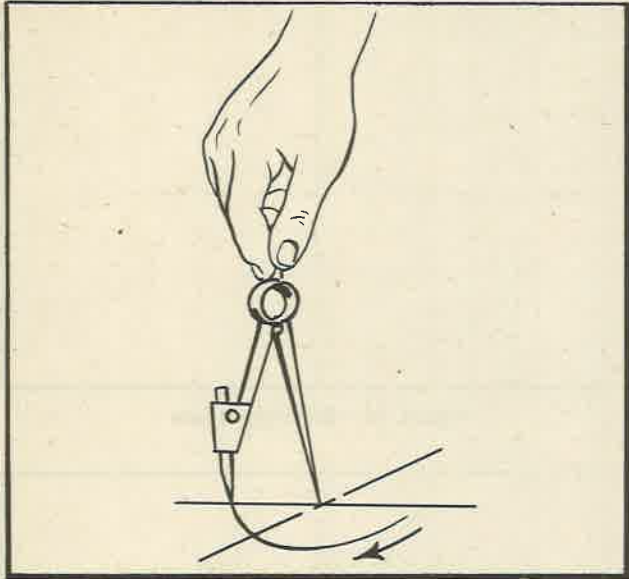


Figure 31—Scribing a Circle

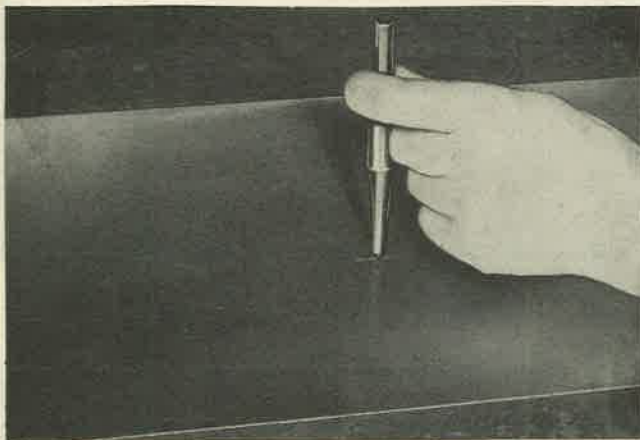


Figure 32—Prick Punch

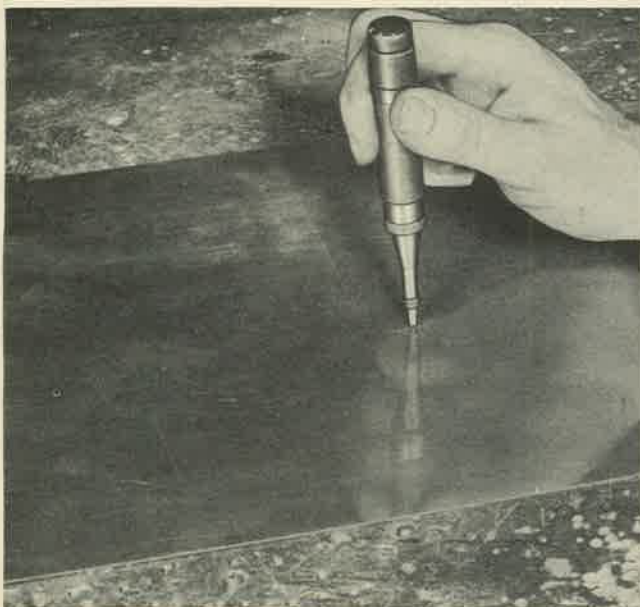


Figure 33—Center Punch

with a pencil, to avoid the scratching of the material.

9. PUNCHES.

a. **PRICK PUNCH.**—The *prick punch* is made of tool steel and is usually from 4 to 6 inches long. One end is tapered to a point that is ground to an angle of about 30 degrees. (See figure 32.) The prick punch is used for making small indentations along scribed lines, for marking the location of points and centers for divider points.

b. **CENTER PUNCH.**—The *center punch* is similar in design to the prick punch, except that the taper is ground to an angle of about 90 degrees. (See figure 33.) The center punch is used for making indentations along scribed lines, for marking the location of points and the centers of holes to be drilled.

c. **TRANSFER PUNCH.**—The *transfer punch* is usually about four inches long, and has a point that is tapered and then turned straight for a short distance in order to fit a drill-locating hole in a template. (See figure 34.) The tip has a point similar to that of a prick punch. As the name implies, this punch is used to transfer the location of holes through the template or pattern to the aircraft material.

(1) HOW TO USE PUNCHES.

Inspect the point of the punch to make sure that it is sharp.

(2) Grasp the center punch in the left hand, and punch directly on the line or intersection of lines to be marked.

NOTE

With a little practice, the beginner can feel the point of the punch when it strikes the scribed line or meets the intersection.

NOTE

When using center punch for marking the location of points and the centers of holes to be drilled, place steel backing plate under aluminum sheet to avoid dimpling of material.

(3) Hold the punch in a vertical position, and tap it lightly with a machinist's hammer. Repeat blow if indentation is not deep enough. (See figure 35.)

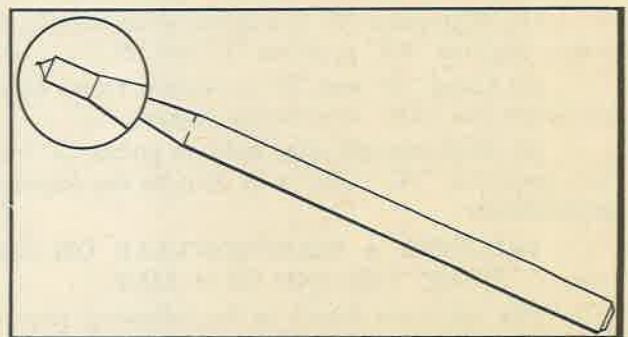


Figure 34—Transfer Punch

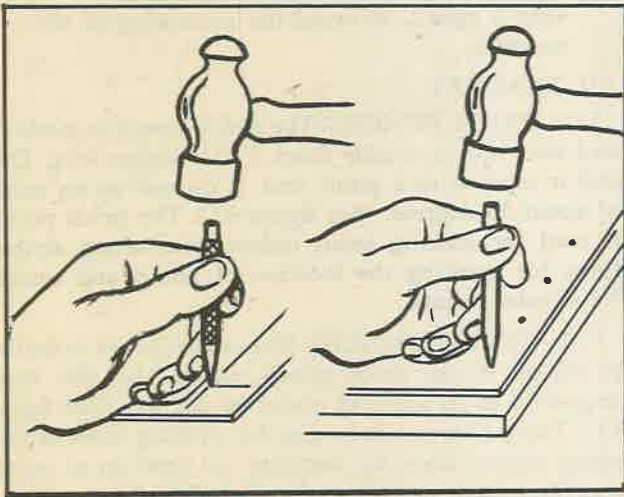


Figure 35—Using Center and Transfer Punch

NOTE

Tap the prick punch lighter than the center punch. The prick punch is used for making light indentations, such as for the divider. The center punch is used to make heavier indentations, such as the starting point for a drill on heavy material. Aluminum alloy sheets are drilled without center punching.

10. INDIRECT MEASUREMENT.

Every sheet metal mechanic should have some knowledge of the more elementary rules of layout practice. To this end a few fundamental geometric constructions will be given.

a. BISECTING A LINE.

(1) Set your dividers or pencil compass at a distance greater than half the length of the line you wish to bisect. (Line "AB," figure 36.)

(2) Using the ends of the line "AB" as centers, swing two arcs which intersect at "C" and "D."

(3) Draw line through points "C" and "D." This line will bisect the line "AB" and will also be perpendicular to it.

b. ERECTING A PERPENDICULAR.

(1) Given the line "AB" (figure 37) with point "F" located at a fixed distance from "A" and "B."

(2) With point "F" as a center, swing equal arcs intersecting line "AB" at points "E" and "D."

(3) Using "D" and "E" as centers, swing equal arcs below line "AB," intersecting at point "G."

(4) With straight edge held on points "F" and "G," draw line "FC." "FC" will then be the required perpendicular.

c. ERECTING A PERPENDICULAR ON (OR NEAR) THE END OF A LINE.

The operation shown in the following steps is very useful for erecting perpendicular reference lines near the edge of metal patterns. (See figure 38.)

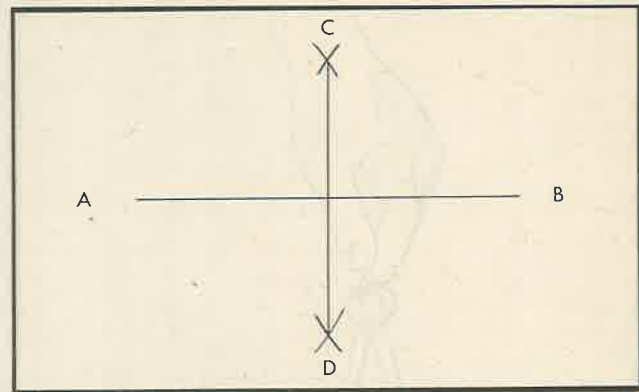


Figure 36—Bisecting a Line

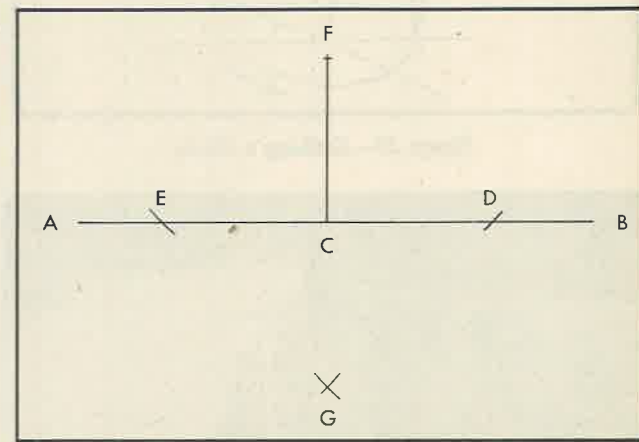


Figure 37—Erecting a Perpendicular

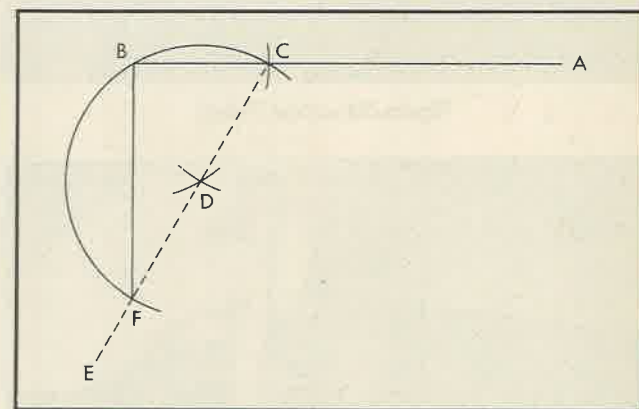


Figure 38—Erecting a Perpendicular on the End of a Line

(1) Set your pencil compass at any convenient distance, and, using "B" as a center, swing a short arc at "C" and "D."

(2) Keeping your compass set at the same distance, and with "C" as a center, swing a short arc to intersect other arc at "D."

(3) Line up the two intersections "C" and "D" with a straight edge, and draw a line from "C" through "D" to any point "E."

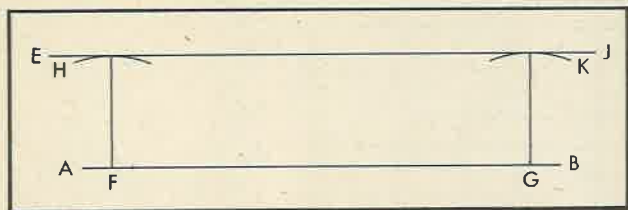


Figure 39—Constructing a Parallel to a Straight Line

(4) Using intersection "D" as a center, swing a circle through "C," "B," intersecting line "CE" at "F."

NOTE

You will not have to change the setting of your compass for any of these operations.

(5) With a straight edge, draw a line from "B" to "F." This line will be exactly perpendicular to the line "BA."

d. CONSTRUCTING A PARALLEL TO A STRAIGHT LINE.

(1) Draw a straight line "AB." (See figure 39.)
(2) Using "F" and "G" (which are any two points on line "AB") as centers, swing two arcs "H" and "K," with a radius equal to the required distance.

(3) Lay a straight edge tangent to the high points of the arcs, and connect with a straight line "EJ." This line "EJ" will be the required parallel line.

e. DIVIDING A LINE INTO EQUAL PARTS.

Line of a given length may be divided into any number of equal parts by the following method:

(1) If line "AB" (figure 40) is to be divided

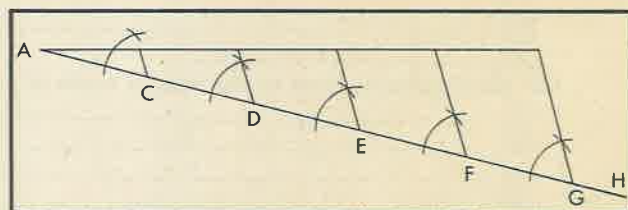


Figure 40—Dividing a Line into Equal Parts

into five equal parts, for instance, draw a line "AH" at any angle and long enough conveniently to lay out the required divisions.

(2) Step off five equal spaces on line "AH."

(3) Connect last point "G" with point "B."

(4) Draw lines parallel to "GB" from points "F," "E," "D," and "C" to intersect "AB." The intersection of these lines on "AB" will divide the line into the required number of equal parts.

11. APPLIED PROBLEMS.

a. USE OF SCALE IN TAKING LINEAR MEASUREMENTS.

With the steel scale, construct straight lines of the following lengths:

- | | |
|---------------------------|----------------------------|
| (1) $2\frac{1}{4}$ in. | (12) $5\frac{7}{32}$ in. |
| (2) $3\frac{3}{4}$ in. | (13) $1\frac{19}{32}$ in. |
| (3) $4\frac{1}{2}$ in. | (14) $2\frac{1}{64}$ in. |
| (4) $1\frac{1}{8}$ in. | (15) $1\frac{9}{64}$ in. |
| (5) $2\frac{5}{8}$ in. | (16) $3\frac{3}{64}$ in. |
| (6) $4\frac{3}{8}$ in. | (17) $4\frac{47}{64}$ in. |
| (7) $5\frac{7}{8}$ in. | (18) $1\frac{7}{10}$ in. |
| (8) $2\frac{1}{16}$ in. | (19) $2\frac{9}{10}$ in. |
| (9) $4\frac{5}{16}$ in. | (20) $3\frac{7}{100}$ in. |
| (10) $5\frac{9}{16}$ in. | (21) $5\frac{29}{100}$ in. |
| (11) $3\frac{15}{16}$ in. | (22) $4\frac{31}{32}$ in. |

b. LINEAR MEASURE.

(1) Measure these lines to the nearest *quarter* of an inch.

- (a) _____
(b) _____
(c) _____
(d) _____

(2) Measure these lines to the nearest *eighth* of an inch.

- (a) _____
(b) _____
(c) _____
(d) _____

(3) Measure these lines to the nearest *sixteenth* of an inch.

- (a) _____
(b) _____
(c) _____
(d) _____

(4) Measure these lines to the nearest *thirty-second* of an inch.

- (a) _____
(b) _____
(c) _____
(d) _____

(5) Measure these lines to the nearest *sixty-fourth* of an inch.

- (a) _____
(b) _____

- (c) _____
(d) _____
- (6) Measure these lines to the nearest *tenth* of an inch.
- (a) _____
(b) _____
(c) _____
(d) _____
(e) _____
(f) _____
(g) _____
(h) _____
(i) _____
(j) _____
- (7) Measure these lines to the nearest *one-hundredth* of an inch.
- (a) _____
(b) _____
(c) _____
(d) _____
(e) _____
(f) _____
(g) _____
(h) _____
(i) _____
(j) _____
(k) _____

c. USE OF COMBINATION SQUARE IN
SCRIBING PARALLEL LINES.

Materials

One piece of metal 12 inches square.

Tools

Combination square, and pencil.

- (1) Scribe line twice the diameter of an $\frac{1}{8}$ -inch rivet from the edge of the metal.
- (2) Scribe 11 lines 4 times the diameter of an $\frac{1}{8}$ -inch rivet, parallel to the line just drawn.
- (3) Scribe 12 parallel lines at right angles to lines drawn under (2) and (3) above, $\frac{1}{2}$ inch apart.
- (4) Submit to instructor for approval.

d. USE OF CENTER PUNCH.

- (1) Place metal on metal plate, and center punch lightly the intersections of all lines.
- (2) Submit to instructor for approval.

e. USE OF COMBINATION SQUARE,
STRAIGHT EDGE, PENCIL COMPASS
AND CENTER PUNCH.

Materials

Four pieces of metal approximately 12 inches square.

Tools

Combination square; straight edge; pencil compass and center punch; flat steel plate.

In the spacing of rivets (figure 41) the following rule most generally applies: "The minimum distance from center of hole to edge of sheet metal should be at least twice the diameter of the rivet; and the mini-

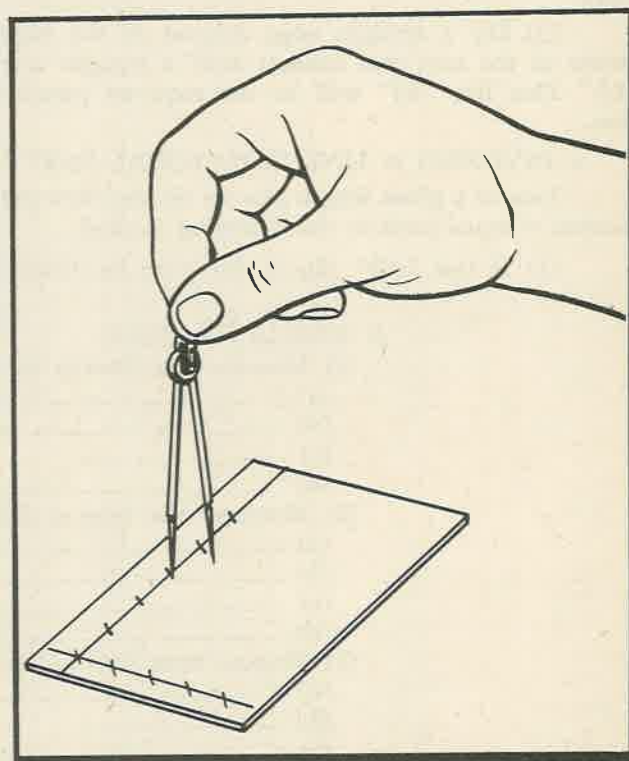


Figure 41—Spacing for Rivets

um distance from center of hole to center of hole should be four times the diameter of the rivet." Bearing this rule in mind, proceed with layout as follows:

- (1) Locate points for rivets where the rivets are $\frac{3}{32}$ inch in diameter.
- (2) Locate points for rivets where the rivets

are $\frac{1}{8}$ inch in diameter.

(3) Locate points for rivets where the rivets are $\frac{5}{32}$ inch in diameter.

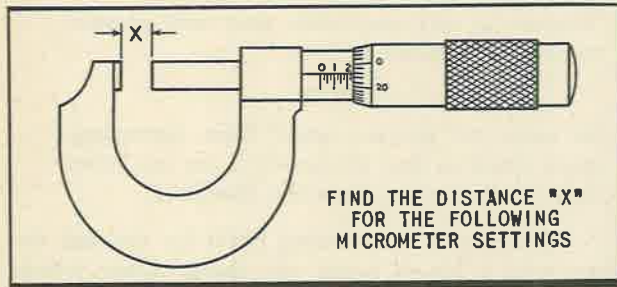
(4) Locate points for rivets where the rivets are $\frac{3}{16}$ inch in diameter.

(5) Center punch lightly all rivet locations.

(6) Submit to instructor for approval.

f. PROBLEMS IN READING A MICROMETER.

(1) Find the distance "x" for the following micrometer settings.



NOTE

Where possible, secure a micrometer. Set at the indicated positions, and note the reading in each instance.

Reading on sleeve is between	Nearest line on thimble	Reading
.000 and .025	6	
.075 and .100	14	
.125 and .150	24	
.250 and .275	5	
.325 and .350	15	
.450 and .475	23	
.400 and .425	4	
.575 and .600	16	
.525 and .550	22	
.675 and .700	3	
.600 and .625	17	
.700 and .725	21	
.775 and .800	2	
.825 and .850	18	
.900 and .925	20	

Reading on sleeve is between	Nearest line on thimble	Reading
.975 and 1.000	1	
.800 and .825	19	
.800 and .825	7	
.750 and .775	13	
.625 and .650	8	

(2) Take "step-down" shaft and obtain readings with micrometer at each gradation.

1st	6th
2nd	7th
3rd	8th
4th	9th
5th	10th

g. APPLICATION OF FUNDAMENTAL GEOMETRIC CONSTRUCTIONS.

(1) Erect a perpendicular to a line $2\frac{3}{4}$ inches long at a point $1\frac{1}{8}$ inches from the end of the line.

(2) Erect a perpendicular to a line $3\frac{3}{8}$ inches long at a point $1\frac{1}{8}$ inches from the end of the line.

(3) Erect a perpendicular one inch long to a line $4\frac{1}{2}$ inches long at a point 2 inches from the end of the line.

(4) Bisect a line $3\frac{1}{2}$ inches long.

(5) Bisect a line $6\frac{7}{16}$ inches long.

(6) Bisect a line $4\frac{13}{16}$ inches long.

(7) Divide a line $2\frac{5}{8}$ inches long into seven equal parts.

(8) Divide a line $3\frac{7}{16}$ inches long into eleven equal parts.

(9) Divide a line $1\frac{1}{8}$ inches long into five equal parts.

(10) Construct 8 parallel lines 5 inches long, and $\frac{3}{4}$ inch apart.

(11) Construct 10 parallel lines $4\frac{7}{8}$ inches long, and $\frac{5}{8}$ inch apart.

SECTION III BENCH TOOLS

1. LAYOUT.

You should now be able to layout the size and shape of your patch, and locate the points where the rivets are to go. But to cut out the patch from the rest of the sheet and to get it in condition to apply, you will need to learn how to use the bench or hand tools of the sheet metal mechanic.

2. HACK SAWS.

a. GENERAL.

The hand *hack saw* is used to cut bar stock, stringer stock, tubing, thick sheet stock, webs on drilled sections, and a variety of other shapes.

There are two types of hack saw frames used: the pistol grip (figure 42), and the straight handle

(figure 43). Both have adjustable frames to accommodate 8-, 10-, and 12-inch blades.

The saws are mounted on pins in sliding studs on each end of the frame. The sliding studs provide a means of setting the saw blade to cut with the frame in any one of four positions.

The selection of the hack saw frame is a matter of personal choice. A more important consideration is the selection of the proper blade, and it is the number of teeth per inch which is the deciding factor in selecting the right blade for the material to be cut.

The ease with which a piece of metal may be cut depends on the speed and the pressure applied to the saw. Manufacturers recommend a cutting speed of

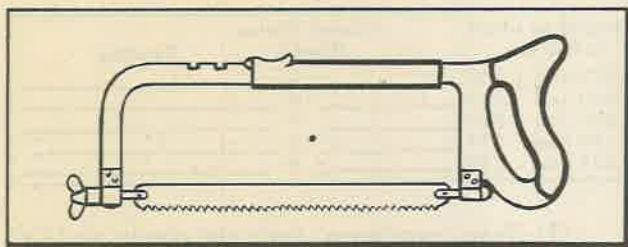


Figure 42—Pistol Grip Hack Saw Frame

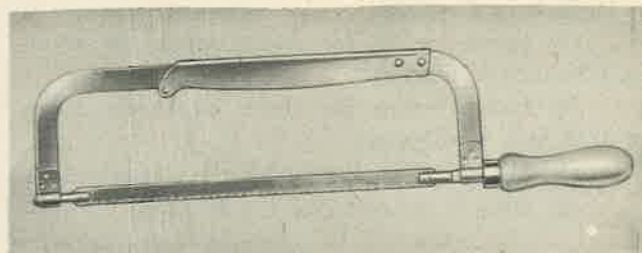


Figure 43—Straight Handle Hack Saw Frame

40 to 50 strokes a minute. This permits the operator to saw without tiring.

Hack saw blades are thin; if they travel too fast, the heat generated will draw the temper making the blade soft and useless.

Enough pressure should be applied on forward stroke when cutting, to prevent the blade from slipping or sliding. This slipping causes the cutting teeth to become glazed, thereby ruining the saw.

b. HOW TO CUT WITH A HACK SAW.

- (1) Select saw blade for job at hand.
- (2) Assemble blade in frame so that teeth point in direction away from operator.
- (3) Adjust tension of blade in frame to prevent saw from buckling and drifting.

NOTE

Use judgment when tightening the frame, to prevent breaking the blade, shearing the pins, or bending the frame.

- (4) Clamp work in vise so as to provide as much of a bearing surface as possible, in order to engage the greatest number of teeth.

NOTE

The use of soft removable jaws will prevent marring a finished surface.

NOTE

In order to prevent work from springing, place work so that the saw will cut not more than $\frac{1}{4}$ inch away from the vise jaws.

- (5) Indicate the starting point by nicking the surface with a file to break any sharp corner which might tend to strip the teeth. This mark will also aid in starting the saw at the proper place.

- (6) Grasp the handle of the frame securely with the right hand. The thumb should be on top, with the remaining fingers closed around the handle. The front end of the frame is held by the left hand to help guide the saw and to give added pressure when sawing. (See figure 44.)

- (7) The body should be in the correct position, with the left foot forward and pointed toward the bench. To give balance when sawing, the right foot should point to the right, and be placed back of the left foot.

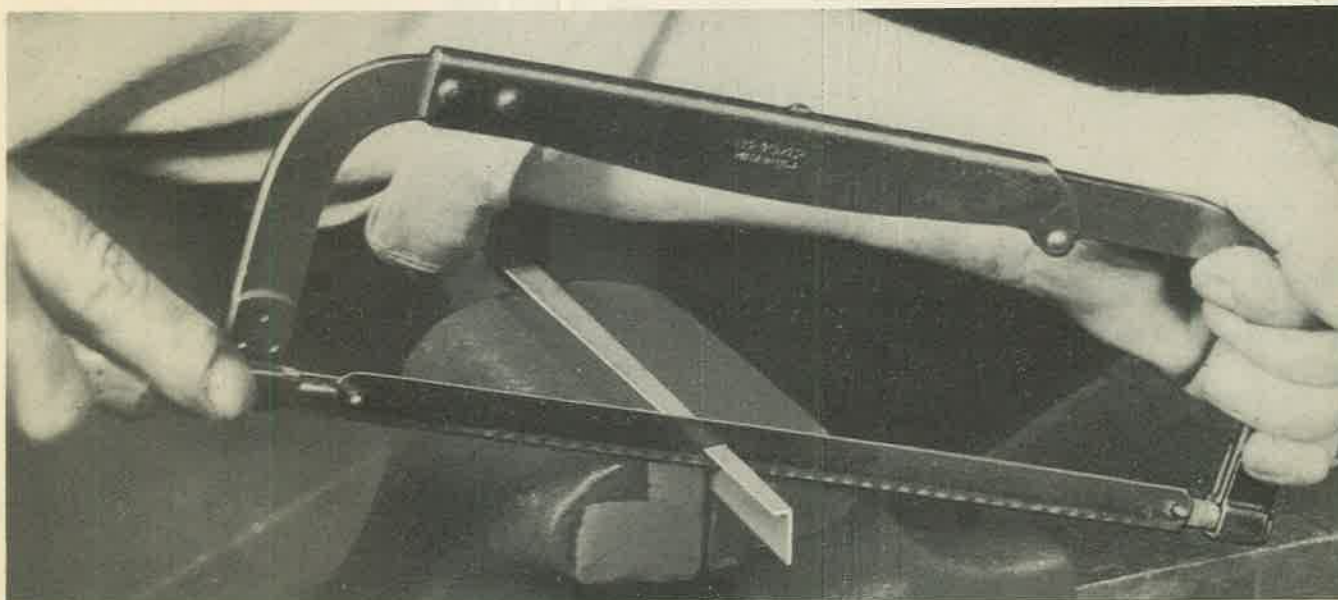


Figure 44—Sawing with a Hack Saw

(8) When sawing, the body should lean forward from the hips on the forward stroke for about two-thirds of the stroke, returning to the original position at the end of the return stroke.

NOTE

When sawing to a given line, place work in the vise so that the line is at right angles to the top of the vise jaws.

(9) To start the cut, place the front end of the blade on the mark. Apply slight pressure. Make the first stroke by pushing the saw straight across the surface of the work. Release the pressure, and return saw to starting position.

(10) Repeat the process, while slightly increasing the pressure on the succeeding strokes. Continue the process at the rate of 40 to 50 strokes a minute for average work.

NOTE

No lubricant is necessary when sawing by hand. However, a little oil applied to the sides of the blade with the finger will aid in taking a deep cut.

NOTE

Care should be taken to prevent either stripping the teeth or breaking the blade. Some of the causes of breakage are:

- (a) Blade too coarse for material.
- (b) Too much pressure applied on the cutting stroke.
- (c) Work moving in vise.
- (d) Cutting at an angle and then trying to straighten cut by twisting the saw.

NOTE

When a saw has been broken in an unfinished cut, the cut should be resumed in another place on the work, because the "set" of a new saw is thicker than that of a used saw. A new blade will break if forced into the old cut.

3. FILES.—(See figures 45, 46 and 47.)

a. GENERAL.

The file is a cutting tool which has a large number of teeth cut diagonally on the face. Most files are made of high grade tool steel and are hardened and tempered. Files are manufactured in a variety of shapes and sizes, and are known either by the cross section, the general shape, or by their particular use. The cuts of files must be considered when selecting them for various types of work and materials.

Files are used by the sheet metal worker to square ends, to file rounded corners, to remove burrs, slivers, or fins from sheets or jobs, to straighten uneven edges, to file holes and slots, and to smooth rough surfaces.

b. SHAPES OF FILES.—The proper selection of a file for the job requires a knowledge of the various shapes and their application. (See figure 46.) A flat



Figure 45—Parts of a File

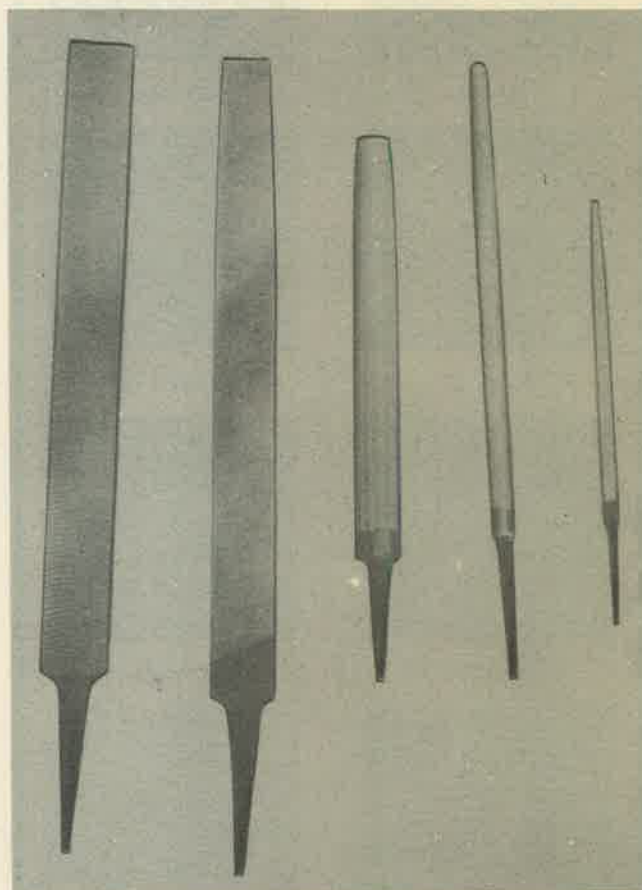


Figure 46—Shapes of Files Most Commonly Used

file is used to file flat surfaces. The mill file is an all-purpose file especially adapted for finish filing. The mill, flat, hand, and pillar files have about the same cross-section, the shape of the sides differing. The hand and pillar files have safe edges to prevent cutting both sides of a corner at the same time. Half-round files are used on concave surfaces and large radii, while round files are better suited to smaller radii.

c. CUT OF FILES.—Files are made in two types of cuts: the single-cut and the double-cut. The teeth of files vary in fineness, coarseness, and in arrangement. Figure 47 shows the various degrees of fineness and coarseness in the double-cut and single-cut types of files. The smooth files are used for finishing; the rougher files, for roughing and cutting soft materials.

d. HOW TO FILE—ROUGH AND FINISHED FILING.

- (1) Select the proper file.
- (2) Clamp the work to be filed in a vise. When possible, the work should be held at the level of the

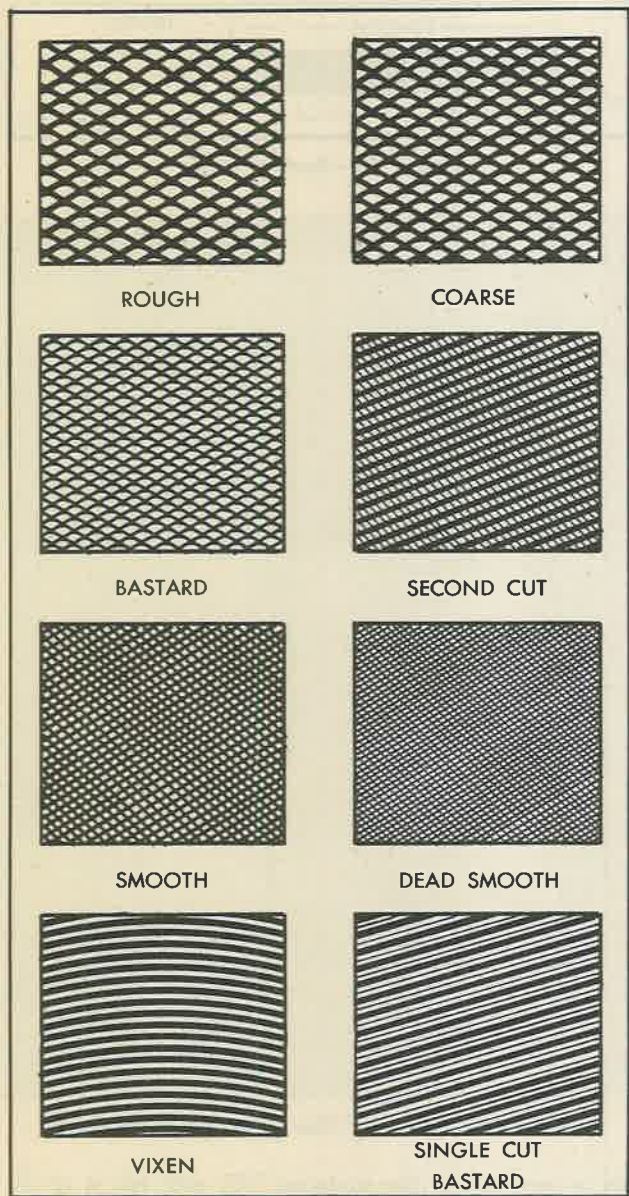


Figure 47—Cuts of Files

elbow of the workman, as he files. This position enables him to get the full swing of the arms from the shoulder.

NOTE

If the work has finished surfaces, use soft jaws in the vise to prevent marring the surfaces.

(3) Grasp the file in the right hand with the thumb resting on top of the handle.

NOTE

The thumb is placed on top of the handle to assist in guiding the file.

(4) Stand at the vise and hold the file as in figure 48.

NOTE

The point of the file should be grasped with the thumb and the first two fingers.

(5) Hold the file parallel to the surface to be filed.

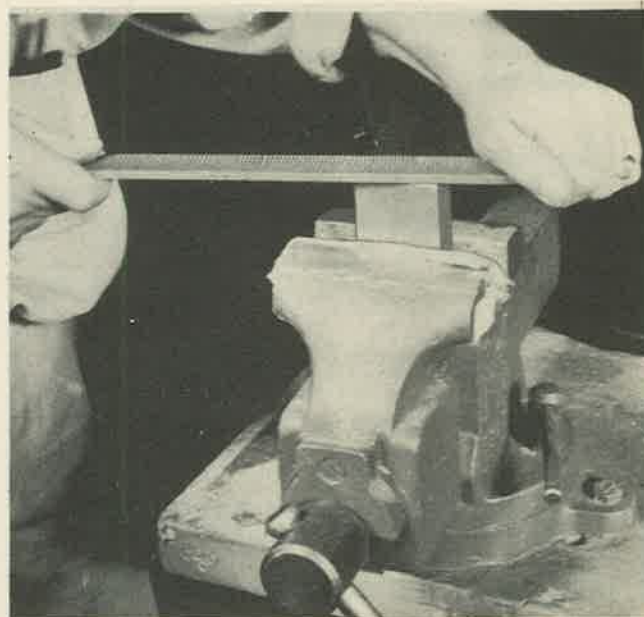


Figure 48—Filing Stock in a Bench Vise (rough cut)

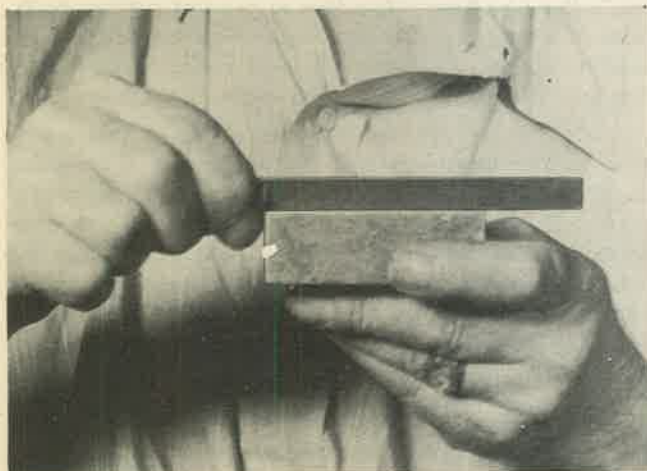


Figure 49—Testing for Flatness

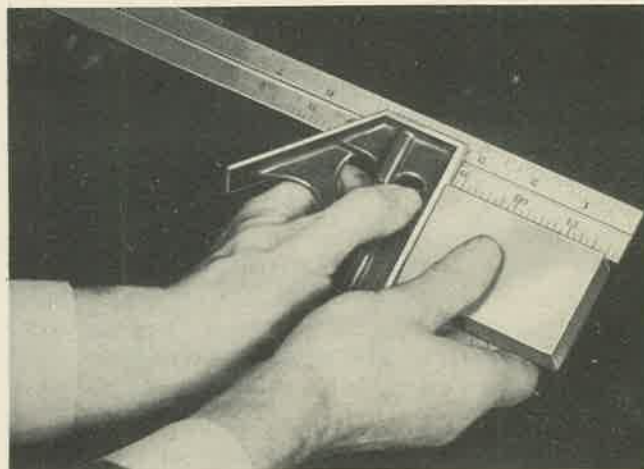


Figure 50—Testing for Squareness

(6) Push the file and bear down on the forward stroke.

NOTE

Avoid rocking the file, or an uneven surface will result.

(7) Release the pressure, and return the file to the original position for the next stroke.

(8) Test the work frequently with a square or scale to determine whether the filing is straight or square. (See figures 49 and 50.)

(9) For finish filing, use a "fine-cut" file. Grasp the file handle with the thumb and index finger of the right hand, the end of the handle resting lightly against the base of the thumb. The end of the file is guided with the thumb and index finger of the left hand, with the end of the thumb on top and the tip of the index finger beneath. (See figure 51.)

(10) Test with a straight edge or a combination square.

e. ROUNDING CORNERS.

When rounding a corner, clamp the work in the vise so that the layout line is above the vise jaws. Rough file to the line by filing across the piece. Reduce the corner with a series of angles until the required radius is obtained. (See figure 52.) Finish filing with a fine-cut file by following along the "rounded surface."

f. FILING SHARP CORNERS AND REMOVING BURRED AND JAGGED EDGES.

Sharp corners, ragged edges, and "fins" are removed with a single-cut file properly broken in. The work can be held in a vise; or if the work or sheet is large, it can be placed or clamped on a bench. For short distances, file across the edge.

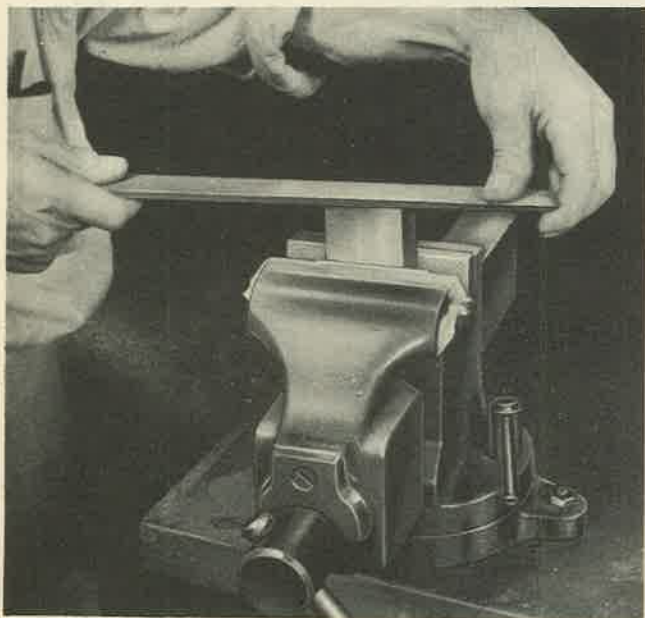


Figure 51—Holding a File for Finishing Cut

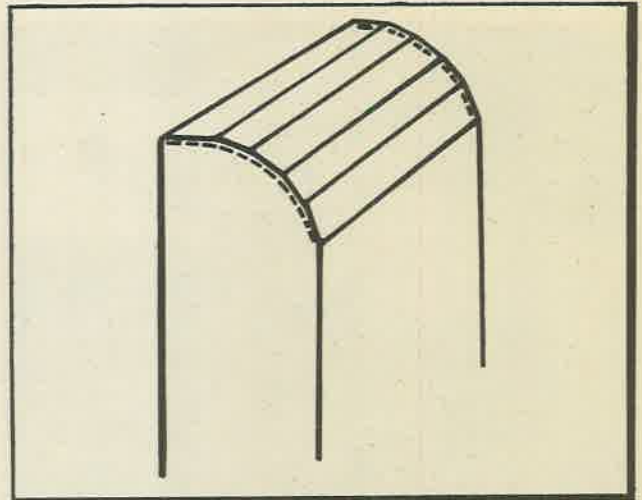


Figure 52—Rounding a Corner

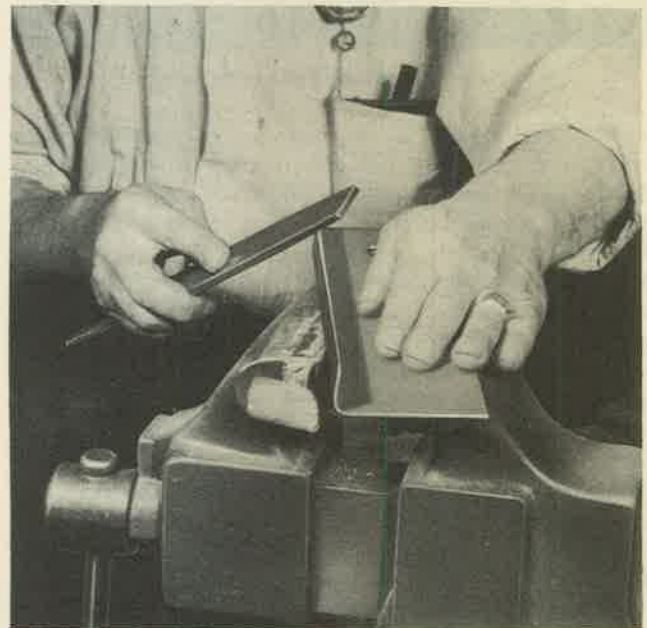


Figure 53—Burring With a File

When the edges are long, hold the file at a slight angle to the edge. Push the file along the edge of the entire length of the sheet. A chamfered edge is produced in the same manner. When filing with one hand, place the forefinger (instead of the thumb) on top of the file so as to control the file better.

g. REMOVING FINNS AND RAGGED EDGES FROM OPENINGS. (See figure 53.)

Select the proper shape file to suit the outline of the opening. For square corners, use a hand or pillar file with a safe edge. File across the edge. Give a slight twist of the file when using round or half-round files.

4. BURRING TOOLS.

a. PURPOSE.

Burred edges, nicks, and ragged or sharp corners may be removed by a number of different tools.

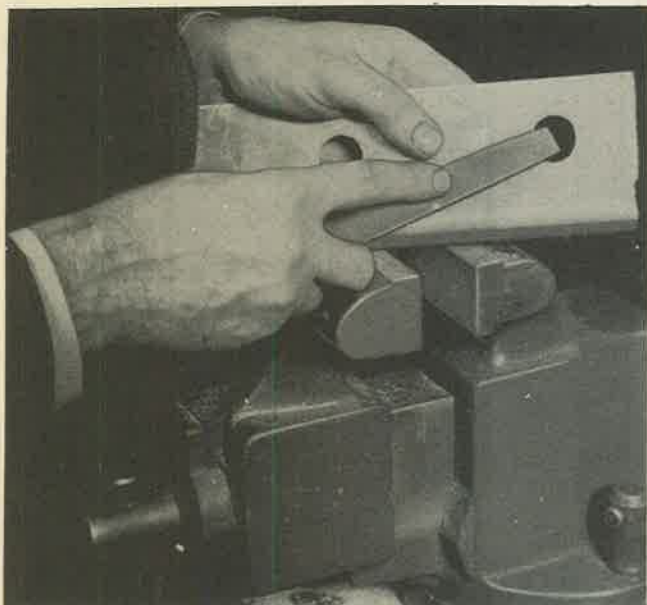


Figure 54—Burring Edges with Fine File

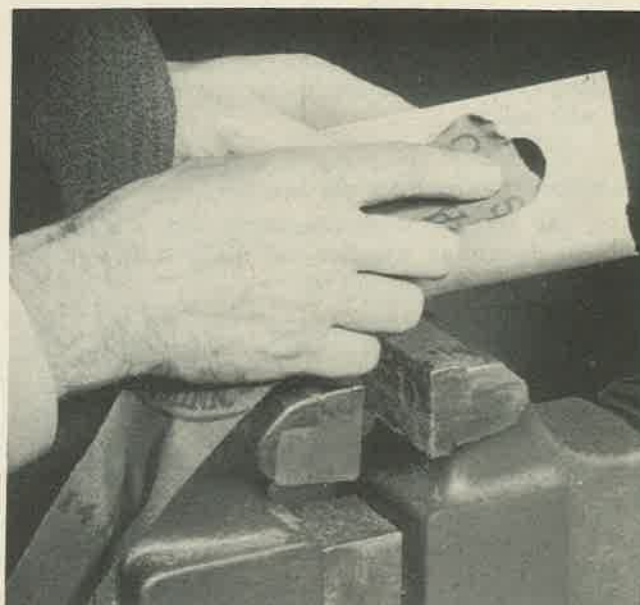


Figure 55—Finishing with Crocus Cloth

A fine file (figure 54) to remove the rougher edges and crocus cloth to finish off are very often used. (See figure 55.) Edges may be quickly burred by drawing a bearing scraper (figure 56) along them at an angle, or a tool commonly used for sharpening knives (figure 57) will work on some jobs. Burrs caused by drilling may be removed with a larger drill or a countersink tool turned by hand. Chips may be removed from between sheets with a steel blade without taking them apart. Practically every drilling and cutting operation on airplane parts produces burrs and chips. These must be removed to avoid personal injury while handling parts, and to avoid scratching and marring other parts to be assembled. Burrs and chips also prevent parts from properly fitting together. The aircraft mechanic must train himself, as a matter of habit, to burr parts whenever necessary, and to keep the work bench and parts being handled free from grit and chips at all times.

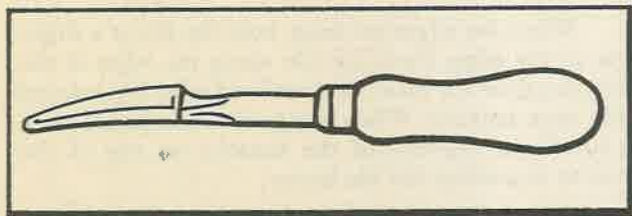


Figure 56—Bearing Scraper

b. HOW TO BURR.

- (1) Remove all chips and grit from bench with bench brush.

NOTE

Every precaution must be taken to avoid scratching aircraft material.

- (2) Remove chips and grit from parts.

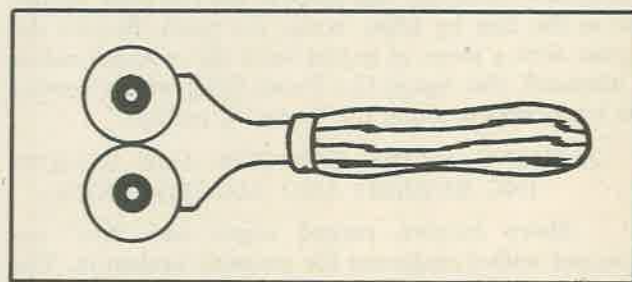


Figure 57—Edge Beveling Tool

CAUTION

Avoid cutting hands on sharp corners and jagged burrs.

- (3) Inspect the parts for burrs.

CAUTION

Be careful so as to avoid cutting the hands, if it is necessary to feel the work to determine the need for burring.

NOTE

The need for burring will be readily recognized after a little experience. It is very important to inspect all work as a matter of routine practice, both to avoid injury and for imperfect workmanship.

NOTE

Burrs will be formed on one or both sides of the work. Look for them. Do not feel for them.

- (4) Select the proper burring tool.

- (5) Work to be burred with a file should be clamped in a vise, or held on the bench with clamps or by hand.

CAUTION

Avoid injury to hands while drawing burring tools along sharp edges or over jagged burrs.

NOTE

Avoid excessive use of burring tools.

NOTE

Use soft jaws on vise, or use masking tape or other protective material on clamps, to avoid marring work when holding it.

(6) Burr ragged edges, remove nicks, and break corners with a file, as previously described.

(7) Burr sharp edges of sheets with a knife sharpener (figure 58), or a special edge beveling tool, by drawing the tool along the edge at right angles to the sheet. This tool breaks both edges in one operation.

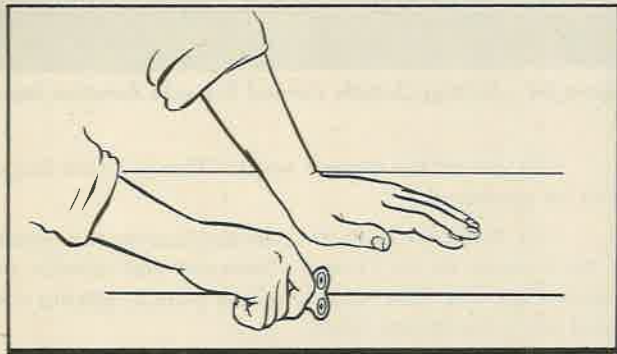


Figure 58—Burring with Knife Sharpener

(8) Remove the single burr caused by a squaring shear, by drawing a bearing scraper along the edge of the sheet.

(9) Remove burrs from drilled holes in aluminum alloy, with an oversized drill. The drill is usually fitted into a handle and turned by hand. (See figure 59.)

(10) Remove chips that accumulate between sheets being drilled, by inserting a steel blade type chip removing tool between the sheets, and pulling the chips out.

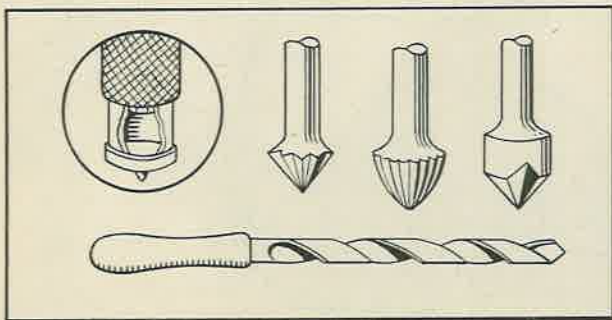


Figure 59—Hole Burring Tools

(11) Inspect work after burring operation.

5. HAND SNIPS.

Various kinds of *hand snips* are used for cutting and notching sheet metal. Hand snips are necessary because the shape, construction, location, and position of work to be cut often prevent the use of machine cutting tools. They are roughly divided into two groups: those for straight cuts, and those for circular cuts.

a. **STRAIGHT SNIPS.**—*Straight snips* have straight jaws for straight cutting. The various sizes of straight snips cut different thicknesses of mild sheet metal. (See figure 60.)

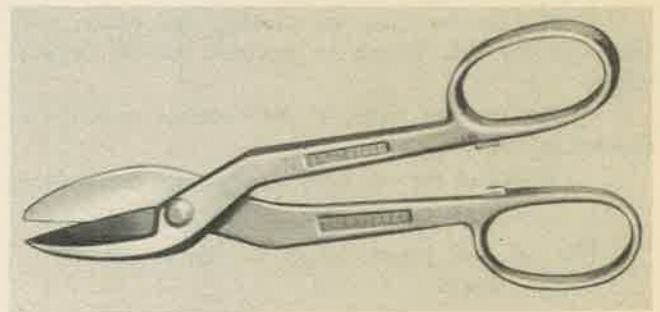


Figure 60—Straight Snips

b. **AVIATION SNIPS.**—*Aviation snips* have compound levers so that cutting can be done with less effort. (See figure 61.) These snips are used for cutting circles, square and irregular patterns, and come either right or left hand.

c. **JEWELERS SNIPS.**—*Jewelers snips* are small and are used for cutting small holes and getting into places where the other snips are too large to enter. (Figure 62.)

d. **HOW TO USE HAND SNIPS.**—The various kinds of snips require different techniques for their correct use. Straight and aviation snips are more practical because of the greater variety of cutting which can be done with them. Wire should not be cut with snips, or metal should not be cut by hammering on the handles or jaws of the snips.



Figure 61—Aviation Snips

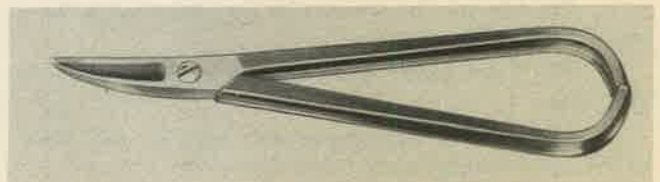


Figure 62—Jewelers Snips

e. MAKING STRAIGHT CUTS WITH STRAIGHT SNIPS.

(1) Grasp the snips in the right hand and the narrowest part of the sheet in the left hand. (See figure 63.)

NOTE

Rest the snips and sheet on bench if necessary.

(2) Open the blades of the snips as far as conveniently possible, and start the cut at the edge of the sheet.

NOTE

The snips should always be held at right angles to the sheet to be cut.

(3) Cut the sheet by closing the blades just short of the full length to prevent leaving jagged edges.

(4) Start the snips at the extreme end of the preceding cut.

(5) Finish the cut, keeping the snips on the line.

CAUTION

File off any jagged edges or slivers which might remain.

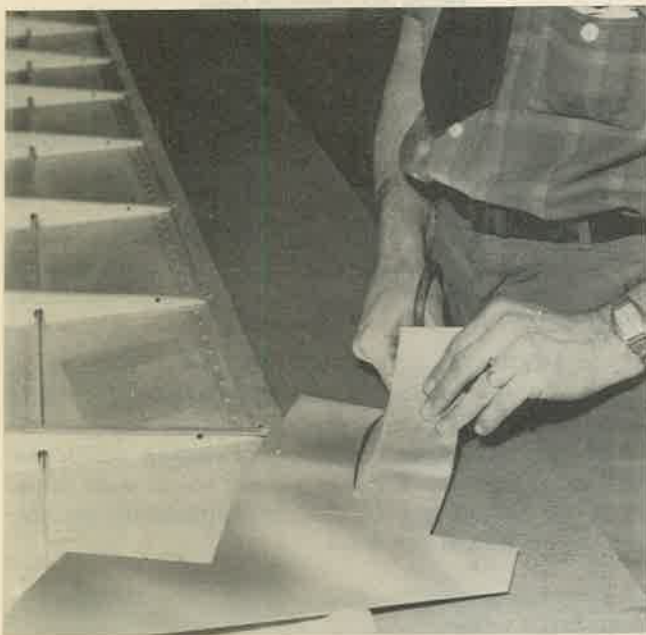


Figure 63—Making Straight Cut with Straight Snips

f. MAKING AN OUTSIDE CURVED CUT WITH AVIATION SNIPS.

(1) Cut off the corners of the metal to make it easier to handle.

(2) Take metal in left hand, and the snips in the right.

(3) Make a continuous cut, turning the metal as the cut is being made. (See figure 64.)

g. MAKING AN INSIDE CURVED CUT.

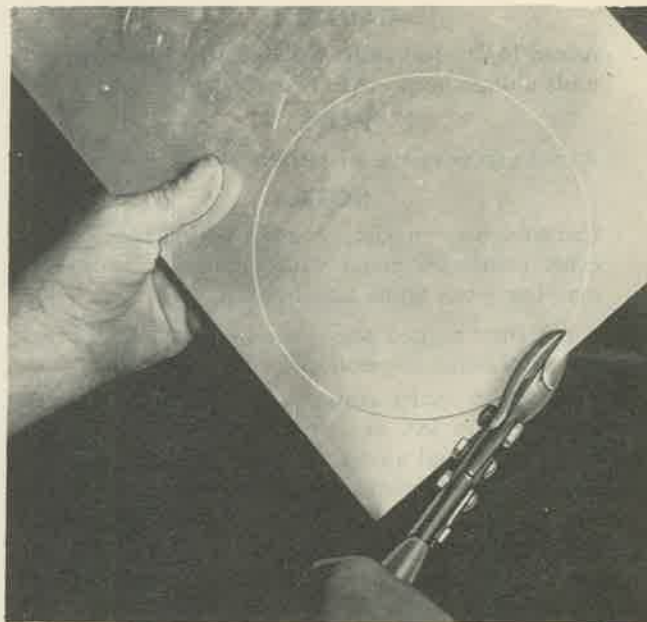


Figure 64—Making Outside Curved Cut with Aviation Snips

(1) Select the proper snips. (The aviation snips is to be preferred.)

(2) Make two slits at right angles near the center of the hole to be cut (using a hammer and chisel); or punch a starting hole with a hollow punch, resting the metal on a hardwood block.

(3) Insert the snips in the starting slit or hole from the top side of the metal. (See figure 65.)

(4) Start cutting at hole in center, gradually increasing the curve of the cut until the required opening is obtained.



Figure 65—Cutting Inside Curve with Aviation Snips

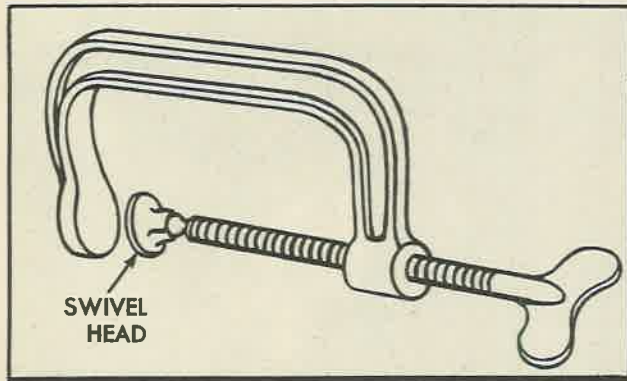


Figure 66—C-Clamp

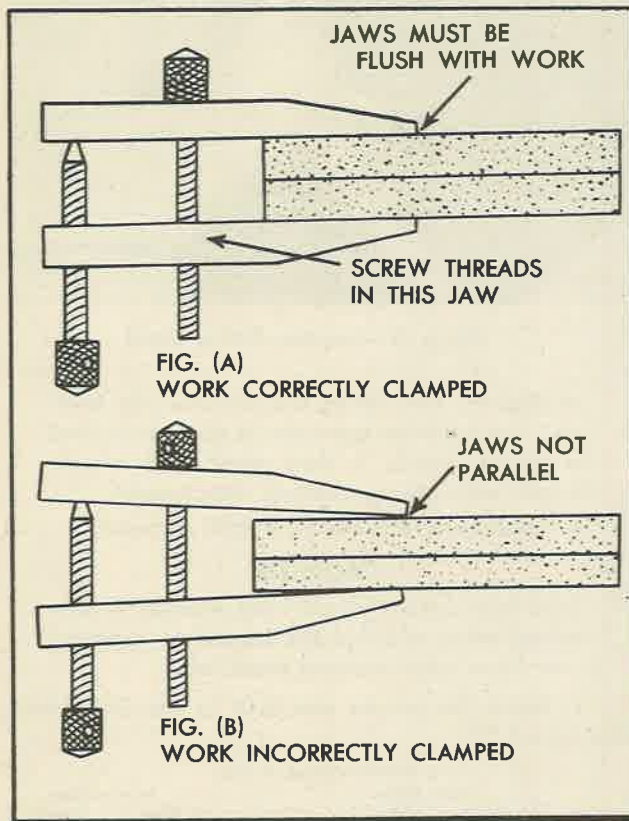


Figure 67—Work Correctly and Incorrectly Clamped

6. CLAMPS.

In bench work, two types of clamps are used: the *C-clamp* and the *parallel clamp*.

The movable part of the C-clamp is threaded and has a swivel head. In clamping, the head advances (but does not turn) as the screw turns. (See figure 66.) This prevents the work from being marred.

The parallel clamp has two knurled screws. The screw near the work tends to hold the jaws together. The screw on the outside pushes the jaws apart. The resulting leverage clamps the work when the jaws are parallel. (See figure 67.) To get good results, the jaws must be parallel so that the full surface of the jaws covers the work. If the jaws do not clamp the work evenly, the work will slip. (See figure 67B.)

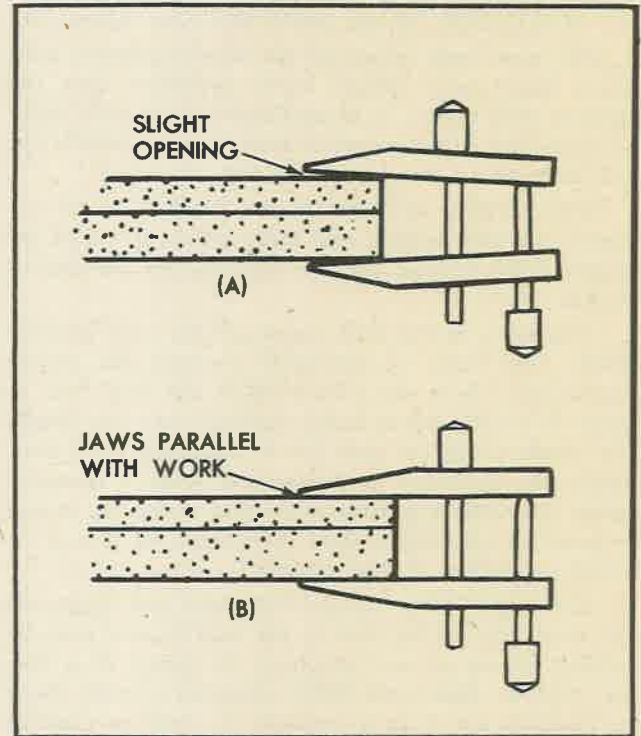


Figure 68—Adjusting a Parallel Clamp

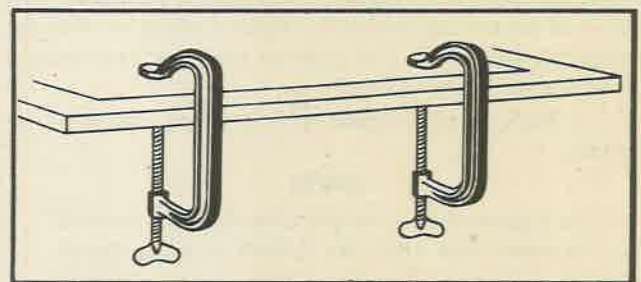


Figure 69—Holding Work with C-Clamps

a. HOW TO USE PARALLEL CLAMPS.

(1) Clean the surfaces being clamped, free of dirt or burrs.

(2) Open the clamps by turning the screws. Place the clamps so that as much of the jaws are in contact with the work as possible.

(3) Adjust the clamps until they are open a slight amount. (See figure 68.)

(4) Turn the rear screw until the jaws are closed. When the jaws are correctly closed, they rest flat on the work.

b. HOW TO USE THE C-CLAMPS.

(1) Clean the dirt and burrs from the work.

(2) Put a drop of oil in the swivel head occasionally.

(3) Place the clamps on the work with the swivel head downward. (See figure 69.) Tighten the clamps alternately if more than one clamp is being used.

7. PORTABLE DRILL MOTORS. (See figure 70.)

We now come to one of the most important tools that a sheet metal surface repair mechanic uses, the portable drill motor. It is used not only to drill holes for rivets, but it also is used to remove rivets, which you will learn about later in the course.

The portable drill motors are made in many different sizes and models, and most are compact, of extremely light weight, and are designed for continuous service.

The parts of the drill motor are the *body* and the *chuck*. The body of the drill encloses the power mechanism, while the chuck holds the drill bit. In figure 71 a drill bit is being inserted into the chuck. The chuck holds the drill bit in hardened steel jaws, which are tightened and loosened with a threaded sleeve. The sleeve is knurled so that it can be turned by hand. A moderately firm pressure is all that is required to tighten a good chuck.

After you have inserted the drill and tightened the chuck, check the drill to see that it runs true, by starting the motor and watching the point. If it does not run true; that is, the point describes a circle, check the drill to see if it is straight. If there is nothing wrong with the drill, see if you have it straight in the chuck. One or the other of these two defects would cause the drill to wobble. When you are satisfied that the drill is running smoothly, you are ready to drill the holes for the rivets. The general rules for operating a drill motor are as follows:

- a. Select a high speed or low speed motor, as required.

NOTE

As a general rule, small holes ($\frac{1}{8}$ inch or less) in aluminum alloy are drilled at high speeds

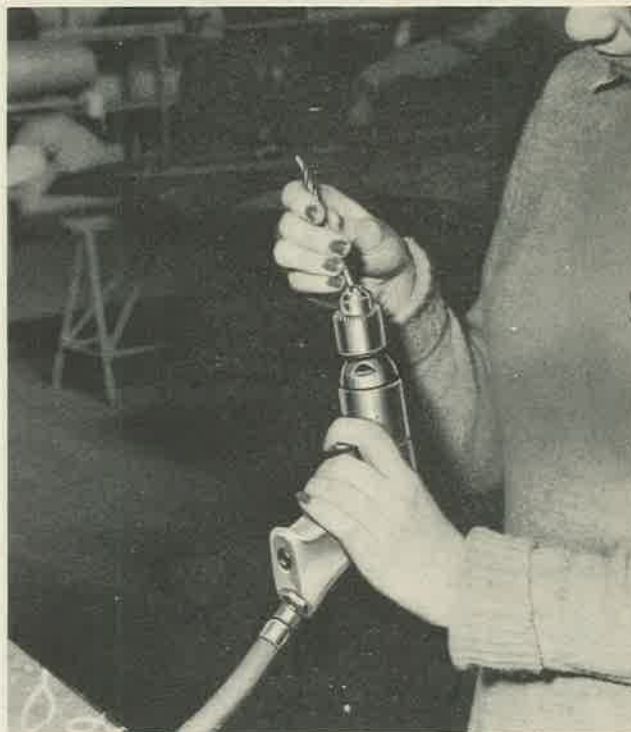


Figure 71—Inserting Drill in Chuck

of 2000 to 5000 RPM (revolutions per minute). Large holes and holes in steel are drilled at slower speeds. A slow speed drill is preferred when using drilling attachments.

- b. Connect drill motor to source of power.

CAUTION

Extension cords and air lines should be connected so as to avoid the hazard of tripping over them when moving about job.

- c. Insert the proper size drill in the drill check. (See figure 72.)

RIVET—HOLE SIZES

Rivet Holes				Access Holes	
Rivet Dia.	Drill Sizes	Rivet Dia.	Drill Sizes	Rivet Dia.	Drill Sizes
1/16	No. 51 (.067)	3/16	No. 10 (.194)	3/32	5/16 (.3125)
3/32	No. 40 (.098)	1/4	F (.257)	1/8	5/16 (.3125)
1/8	No. 30 (.128)	5/16	O (.316)	5/32	3/8 (.375)
5/32	No. 20 (.161)	3/8	V (.377)	3/16	3/8 (.375)

NOTE

In drilling holes for airplane rivets, select a drill that is a few thousandths of an inch larger than the rivet shank, to allow for swelling of the rivet without bulging the riveted sheets. A No. 30 drill, for instance, is .0035 larger than the shank of a $\frac{1}{8}$ rivet.

- d. Locate the starting point for the drill either by a pilot hole previously drilled, or by making a center punch mark, or by spotting the drill by turning the chuck with the fingers.

- e. Hold the drill perpendicular to the surface being drilled. (See figure 73.) This is very important, whether the surface is flat or rounded.



Figure 70—Portable Drill Motor

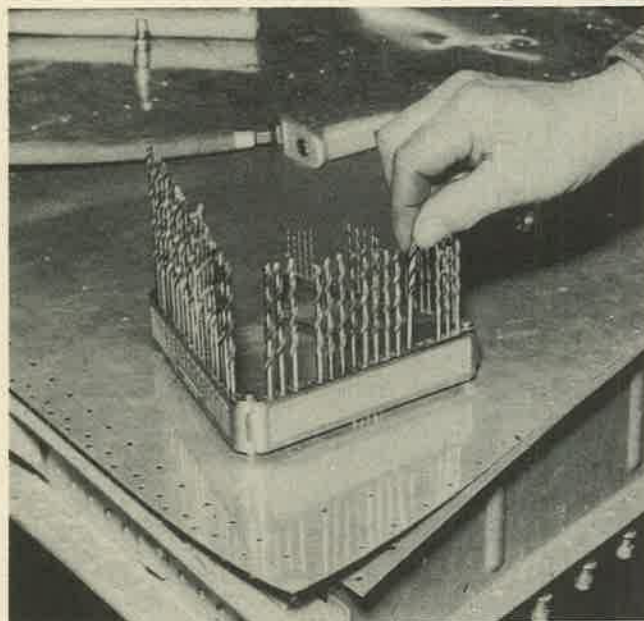


Figure 72—Twist Drills

f. Start the drill motor while applying a slight pressure.

NOTE

The pressure will vary with the size of the drill and the kind of materials being drilled.

g. Check the drill to see that it is centered, by removing it as soon as it is well started.

NOTE

This is very important when drilling with a large drill, or when center punch marks or pilot holes are not used.

If drill starts off center, it may be shifted by tilting the drill motor in the opposite direction to that which it is desired to move the drill.

b. Drill through the material, easing off on the pressure just as the drill breaks through.

CAUTION

Always make sure that the drill will not injure someone working on the other side of a sheet.

NOTE

Control the pressure so that the drill cuts its way, and is not pushed through the metal. Excessive pressure may bend or break small drills. Easing off on the drill, as it breaks through, reduces the burr to a minimum, and the drill is less likely to be broken.

i. Care of portable drilling equipment after use.

(1) Hang the motor, or place it where it will not fall when not in use.

(2) Lubricate motor, as required.

(3) Avoid damage to rubber hose or electric cords by cutting or pinching.

(4) See that no leaks exist in air line connections

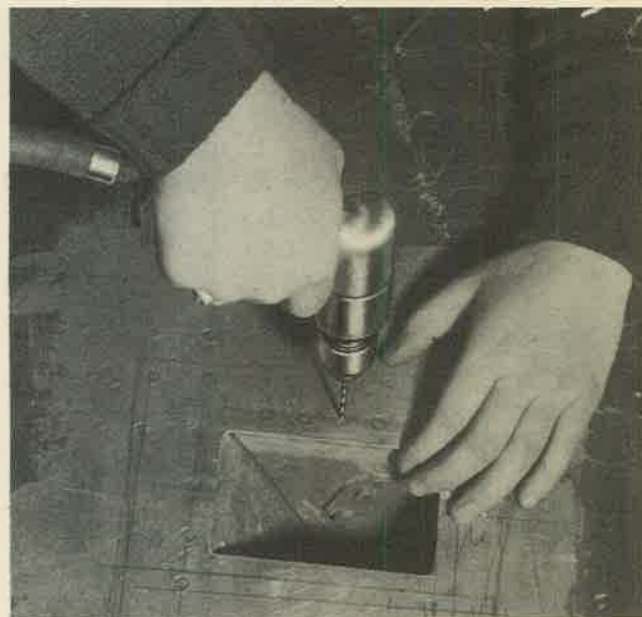


Figure 73—Holding Drill Perpendicular to Work

and that electric cords, plugs, and sockets are in good condition.

8. APPLIED PROBLEMS.

a. USE OF HACK SAW, FILE AND BURRING TOOLS.

Materials

Three pieces of stringer stock, "L", "Z", and "U", all $7\frac{1}{2}$ inches long.

Equipment

Hack saw	Files
Combination square	Burring tools
Straight edge	Scriber
Steel square	Vise with soft jaws

(1) Select L-shaped stringer. (See figure 74.)

(2) Square one end with square and scriber.

(3) With straight edge and scriber layout line $7\frac{3}{8}$ inches from squared end.

(4) With square and scriber, square this end.

(5) Place stringer in vise, and cut off with hack saw within $1/32$ inch from scriber line. (See figure 44.)

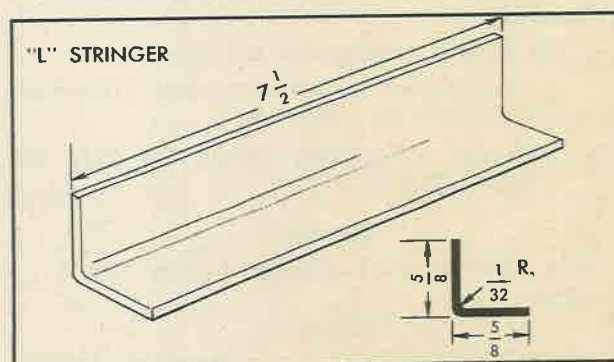


Figure 74—"L" Stringer

- (6) File to layout line and remove burrs.
- (7) With steel square, check cut end of stringer for squareness.
- (8) Repeat same process with other two stringers.
- (9) Submit to instructor for approval.

b. USE OF STRAIGHT SNIPS IN CUTTING STOCK.

Material

One piece of 24ST aluminum alloy 4-5/16 x 5 1/4 inches x .040 thick.

Equipment

Straight snips	Combination square
Straight edge	Scriber
Files	Burring tool
Steel square	Pencil

- (1) Select piece of aluminum alloy as above.
- (2) Layout to 4 1/8 x 5 1/8 inches, using pencil.
- (3) With straight snips, cut to within 1/32 inch of scribed lines.
- (4) File to finished dimensions.
- (5) Remove burrs.
- (6) Test for squareness.
- (7) Submit to instructor for approval.
- (8) If approved by instructor, mark "Flat Stock No. 1," and hold for future use.

c. USE OF AVIATION SNIPS TO CUT OUT-SIDE CIRCLE.

Materials

The piece of 24ST aluminum alloy, 4 1/8 x 5 1/8 inches cut to size in exercise just completed, marked: "Flat Stock No. 1."

Equipment

Aviation snips	File
Dividers or Compass	Steel rule

- (1) Clean off bench.
- (2) Place stock on bench.
- (3) By the use of a steel rule, set dividers or compass to describe a circle 3 1/2 inches in diameter.
- (4) With aviation snips, cut on curved line, removing waste material in one piece. (See figure 64.)
- (5) File off any jagged edges or slivers which may remain.
- (6) Submit to instructor for approval.
- (7) If approved by instructor, mark "Filler Stock No. 2," and reserve for future use.

d. USE OF AVIATION SNIPS TO CUT IN-SIDE CIRCLE.

Materials

One piece of 24ST aluminum alloy 8 x 8 inches.

Equipment

Aviation snips	Pencil compass
Hammer	Chisel
Steel rule	Burring tool
	Files

- (1) Select stock as indicated.
- (2) Clean off bench so that it is free from any material that might scratch stock.
- (3) Set pencil compass to describe a circle 3-15/32 inches in diameter.
- (4) With chisel and hammer, make one-inch cut in center of circle.
- (5) Insert snips, and cut to 1/32 inch of circular line. (See figure 65.)
- (6) File to layout line.
- (7) Remove all burrs.
- (8) Submit to instructor for approval.
- (9) If approved by instructor, mark "Frame Stock No. 3" and hold for future use.

e. USE OF PORTABLE DRILL.

Materials

Filler stock No. 2
Frame stock No. 3

Equipment

Portable drill	1/8-inch twist drill
Pencil compass	Straight edge
"C" clamps	File
Burring tool	Center punch
Steel plate	Wooden block

- (1) Select filler stock No. 2.
- (2) Using rivet spacing rule, lay out rivet locations for 1/8-inch rivets.
- (3) Select frame stock No. 3.
- (4) Using the same rivet spacing rule, lay out rivet locations around circle and four sides.
- (5) Place filler stock No. 2 on steel plate, and lightly center-punch all rivet locations.
- (6) Place frame stock No. 3 on steel plate, and lightly center-punch all rivet locations.
- (7) Insert 1/8-inch drill in drill motor.
- (8) Using "C" clamps, clamp filler stock No. 2 to wooden block.
- (9) Drill hole at each rivet location, using center punch mark as a guide.
- (10) Remove from block, and burr all rivet holes.
- (11) Proceed in similar manner with frame stock No. 3.
- (12) Submit to instructor for approval.

f. CUTTING OUT HOLE IN METAL BY DRILLING A SERIES OF SMALL HOLES.

Material

One piece of 24ST aluminum alloy 6 x 6 inches

Equipment

Portable drill	1/8-inch twist drill
Pencil compass	Steel rule
Dividers	Center punch
Files	Drift punch

- (1) Select stock, as given.
- (2) Scribe circle in center 3 inches in diameter.
- (3) Scribe smaller circle $2\frac{7}{8}$ inches in diameter inside of larger circle.
- (4) Layout a series of small holes on smaller circle by use of dividers.

NOTE

These holes should be evenly spaced and close enough together to leave as small amount of material as possible between them.

(5) Center punch each hole lightly, using steel plate for backing.

(6) Using $\frac{1}{8}$ -inch drill, drill all holes in circle. (See figure 75.)

(7) If metal does not fall out after all holes are drilled, cut out webs between holes with drift punch.

(8) Rough out hole with a half-round bastard file, but do not touch line.

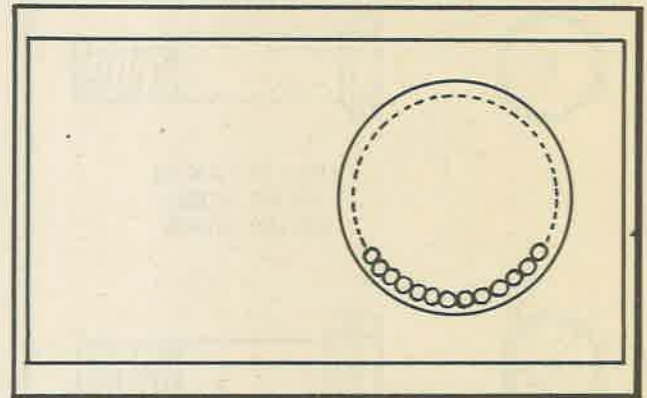


Figure 75—Removing Material by Drilling a Series of Holes

(9) Finish filing with half-round mill file. Split the line so that half the line will remain on the finished part.

(10) Submit to instructor for approval.

SECTION IV

AIRCRAFT BOLTS, NUTS, COTTER PINS AND OTHER FASTENERS

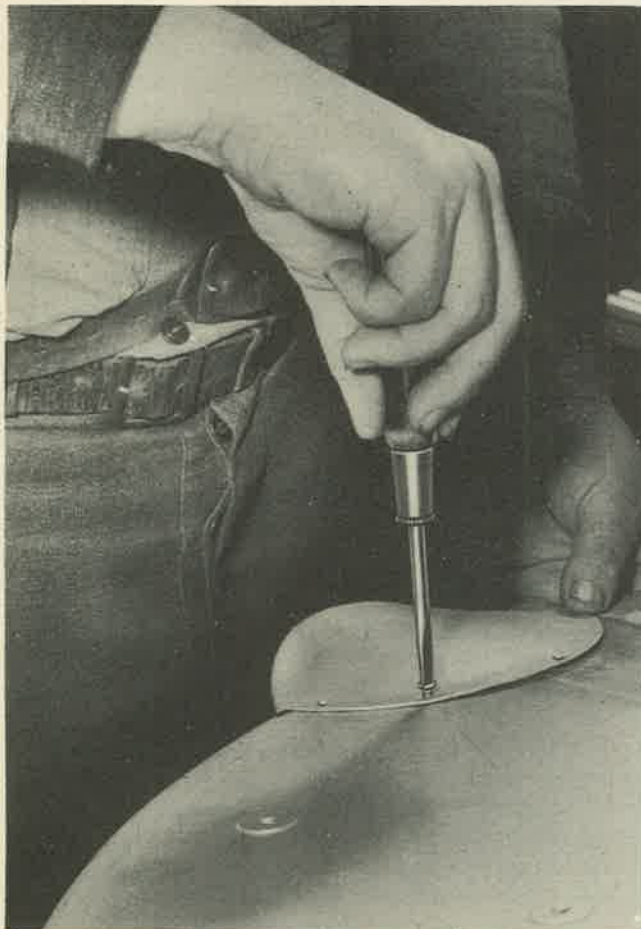


Figure 76—Inserting Machine Screw

1. GENERAL.

Bolts, screws, and other fasteners are used in the aircraft industry to hold or fasten metal parts together. Some are used as permanent fasteners, while others are used merely to hold metal parts together until a more permanent fastener, like a rivet, can be installed. (See figure 76.)

2. BOLTS—HEXAGON HEAD.

Standard aircraft bolts are available in plain hexagon head, clevis bolt, and eye bolt type. They are made of nickel steel or aluminum alloy and may be drilled for cotter pins, or undrilled as desired. Plain or drilled hexagon-head bolts (figure 77) are marked with a symbol or trade mark either raised or sunk into the head to identify them. They are referred to by Army and Navy (AN) code numbers which designate the diameter, length, and kind of material as shown.

Code Numbering for Aircraft Bolts

Example: AN 3-5A

AN= Army and Navy

3= Diameter of bolt in $\frac{1}{16}$ inch ($\frac{3}{16}$ inch)

5= Length of bolt in $\frac{1}{8}$ inch ($\frac{5}{8}$ inch)

A= Bolt not drilled for cotter pin

NOTE

"DD" following the part number (first number after AN) indicates aluminum.

"A" following dash number indicates undrilled shank.

"A" preceding dash number indicates coarse thread.

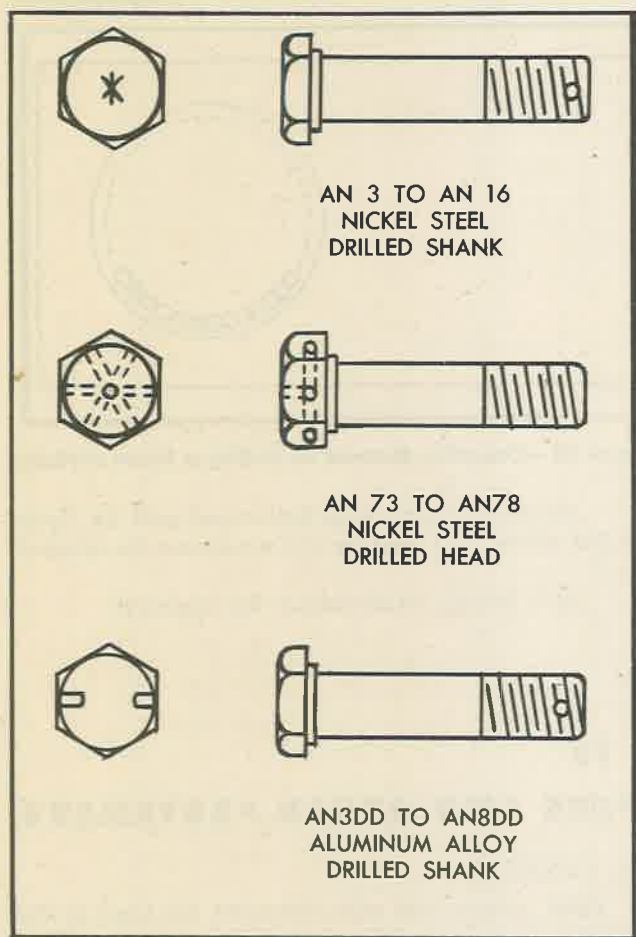


Figure 77—Aircraft Bolts

3. CLEVIS BOLTS.

Clevis bolts (figure 78) are made of nickel steel cadmium plated. They have marked heads to identify them as aircraft bolts and are referred to by the Army and Navy code numbering system as follows:

Code Numbering for Clevis Bolts

Example: AN25-9 or 19

AN=Army and Navy

2=Clevis Bolt

5=Diameter in 1/16 inch (5/16 inch)

9=Length in 1/16 inch (9/16 inch) or

19=Length in inches and sixteenths (1-9/16 inch)

4. AIRCRAFT NUTS.

Aircraft nuts are made in a variety of shapes and sizes. (See figure 79.) They are made of nickel steel cadmium plated, stainless steel, brass, or aluminum alloy anodized, and may be obtained with right- or left-hand threads. They are referred to by Army and Navy *part and dash numbers*. The part number indicates the type of nut. The kind of material is indicated by a letter following the part number. The dash number indicates the diameter and number of threads per inch. Right- or left-hand threads are indicated by an "R" or an "L" following the dash number.

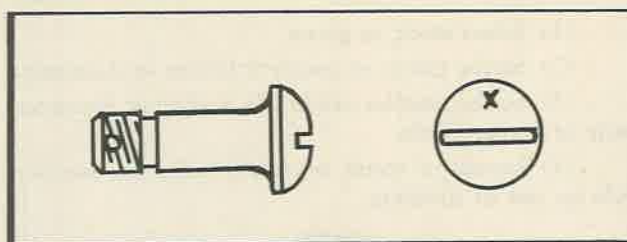


Figure 78—Clevis Bolts

Code Numbering for Aircraft Nuts

Standard Nuts

AN310	Army and Navy part number
AN 310DD	Nickel steel, cadmium plated
AN 310C	Aluminum alloy 24ST, anodized
AN 310-5	Stainless steel
AN 310-5 R/L	5/16 inch x 24 threads per inch
	Right- or left-hand thread

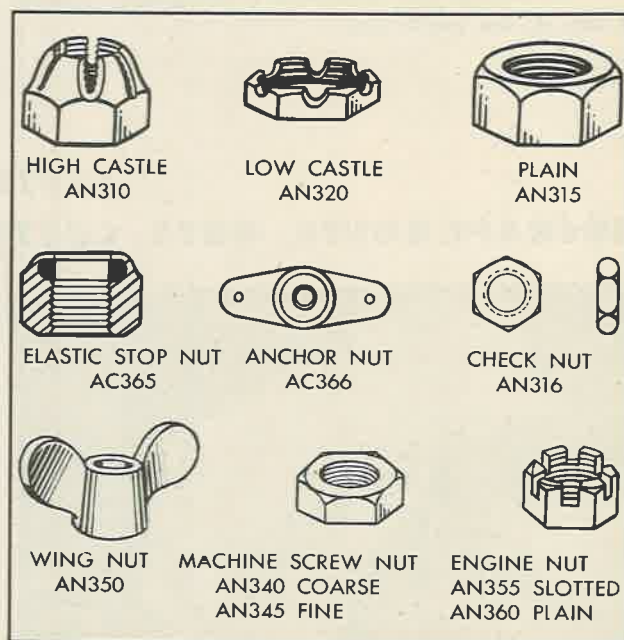


Figure 79—Aircraft Nuts

5. ELASTIC STOP NUTS.

a. *Elastic stop nuts* (figure 80) are made of the same materials and under the same government regulations as all other aircraft nuts. They are self-locking and do not require the use of cotter pins, safety wire, or lock washers. The locking is accomplished by means of a fiber collar built into the top of the nut. The fiber collar is untapped, and the inside diameter is slightly smaller than the bolt for which the nut is made.

b. The locking is accomplished by the bolt threads impressing themselves into the collar as the nut is installed, thereby forcing the load carrying surfaces of the nut tightly against the bolt threads. This keeps the threads in positive contact at all times and eliminates the possibility of the nut vibrating loose.

c. They are made in all standard shapes and sizes and may be used on structures except when tempera-

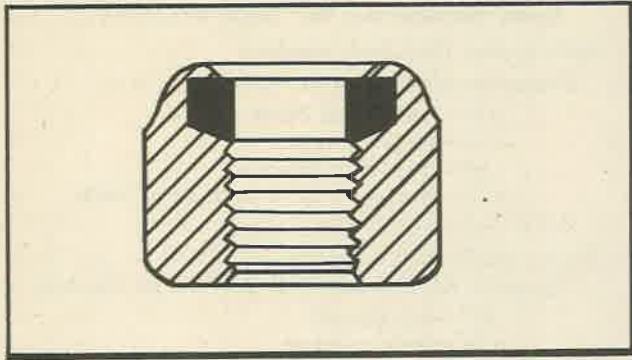


Figure 80—Elastic Stop Nut

tures exceeding 240° F. are encountered.

d. In addition to the regular types, they are also made with lugs so that they can be attached for blind mounting where the nut could not be installed or held while the screw is inserted. These lug or nut plate type of anchor nuts are made for regular blind mounting, or for flush mounting with countersunk screws. (See figure 81.) They are made with various type lugs including double lug, single lug, two-rivet corner lug, lug at right angle to the nut, and self-aligning nut plate strips.

e. The nut plate strips, or gang channels, are regularly provided in 72 inch lengths, with the nuts spaced either $\frac{3}{4}$ inch, $\frac{7}{8}$ inch, or 1 inch apart. The strips can be cut to the required length and drilled for attaching rivets, as specified for each installation.

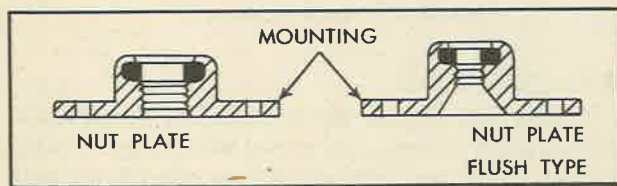


Figure 81—Nut Plates

Code Numbering for Elastic Stop Nuts

- AC=Air Corps
- AC365=Part number standard nut
 - 428=Size and number of threads per inch ($\frac{4}{16}$ inch or $\frac{1}{4}$ inch x 28 threads)
- AC364=Thin hexagon nut
 - B420=Brass $\frac{4}{16}$ inch or $\frac{1}{4}$ inch x 20 threads per inch
 - D428=17ST aluminum alloy $\frac{1}{4}$ inch x 28 threads

6. MACHINE SCREWS.

Machine screws for aircraft are usually made of SAE 1120 or better steel, 24ST aluminum alloy, or brass, and are available in a variety of head shapes. (See figure 82.) They are made to conform to AN standards and are identified by part and dash numbers.

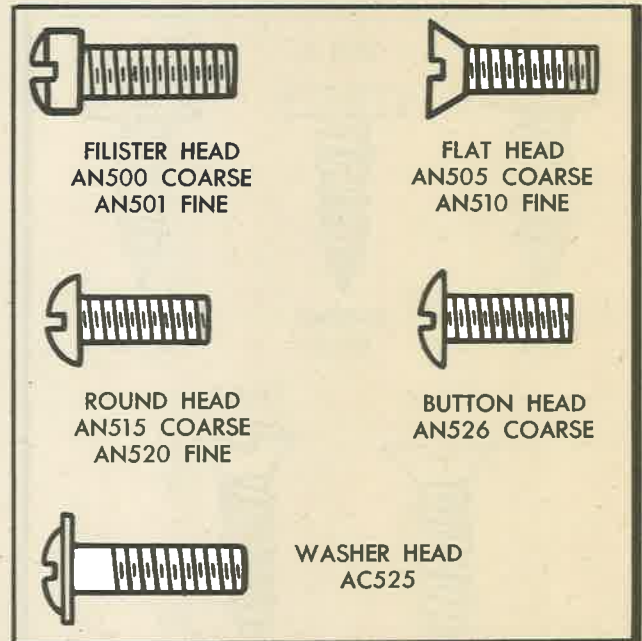


Figure 82—Machine Screws

Code Numbering for Machine Screws

Example: AN500-6-7

AN=Army and Navy

500=Part number coarse thread

6=Diameter No. 6

7=Length in $\frac{1}{16}$ inches ($\frac{7}{16}$ inch)

Example: AN501 B-416-7

AN501=Army and Navy, fine thread

B=Brass

416=Diameter $\frac{4}{16}$ inch or $\frac{1}{4}$ inch

7=Length in $\frac{1}{16}$ inch ($\frac{7}{16}$ inch)

("D" in place of "B" would mean "Aluminum Alloy")

7. SELF-TAPPING SHEET METAL SCREWS.

Self-tapping sheet metal screws (figure 83) are made of hardened steel and form their own thread in the material being fastened together, thereby doing away with tapping operations and making it possible to join sheets that are too thin for ordinary tapping. They are made in many shapes, sizes, and head styles. The heads are provided with plain or special type screw driver slots, hexagon tops for installation with wrenches, or plain surfaces for driving with a hammer or press. They are plated with nickel, brass, or copper, or given a parkerized finish. (See figure 84.)

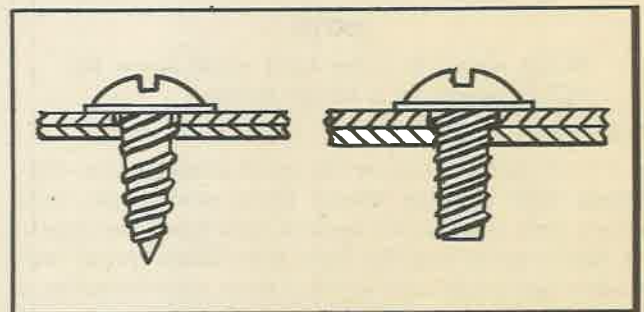


Figure 83—Self-Tapping Sheet Metal Screws

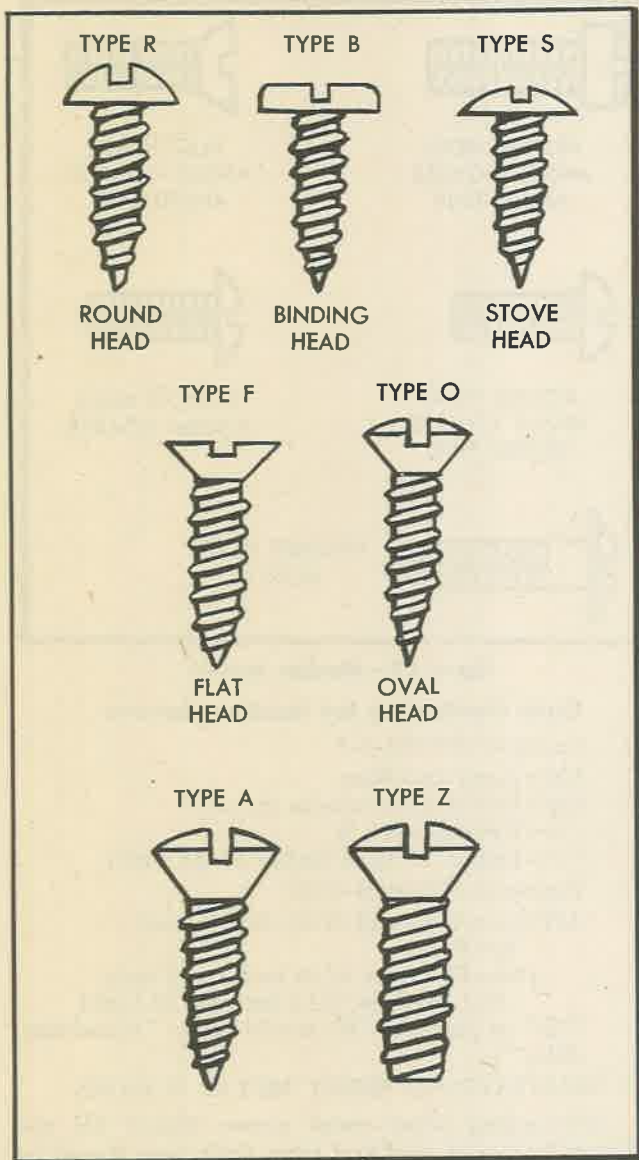


Figure 84—Various Types of Self-Tapping Sheet Metal Screws

Code Numbering for Self-tapping Screws

Example: AC530-6-8

AC=Air Corps

530=Part number (round head)

6=Diameter of screw (No. 6)

8=Length in 1/16 inch (8/16 inch or 1/2 inch)

NOTE

AC531 would be a flat head metal screw and
AC535 would be a driver screw.

8. LOCK WASHERS.

Lock washers (figure 85) are available in the split-spring type and the special shake-proof type. Split-spring lock washers are made in two types, the regular (or heavy type) and the light type. Shake proof lock-washers are made with internal teeth, external teeth, or both internal and external teeth in flat and countersunk types.

Code Numbering for Lock Washers

Split spring type lock washers

Example: AN935-10 or 416

AN=Army and Navy

935=Regular type

10=Bolt size No. 10

416=Bolt size 6/16 inch or 1/4 inch

AN935-L=Light type

Shake proof lock washers

Example: AC936-A6-416, B6-416 or C6-416

AC=Air Corps

936=Part number

A=Internal teeth

6=Size No. 6 (screw sizes 6-8-10 and 12 only)

B=External teeth

C=External countersunk

6=Screw size

416=Size 4/16 or 1/4 inch

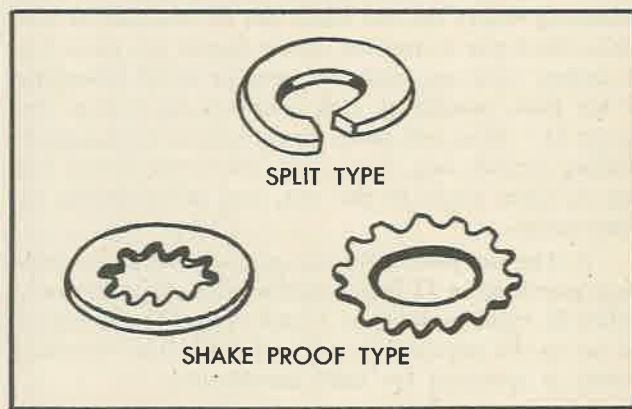


Figure 85—Lock Washers

9. COTTER PINS.

Cotter pins (figure 86) for aircraft construction work are made of cadmium plated steel, brass or stainless steel. They are made strictly in accordance with Army and Navy (AN specifications), and are code and dash numbered as follows:

Code Numbering for Cotter Pins

Example: AN380-2-2

AN=Army and Navy

380=Part number

2=Diameter in 1/32 inch (2/32 inch or 1/16 inch)

2=Length in 1/4 inch (2/4 inch or 1/2 inch)

NOTE

AN380B would be brass cotter pins, and 390C would be stainless steel.

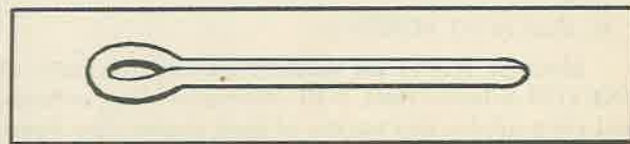


Figure 86—Cotter Pin

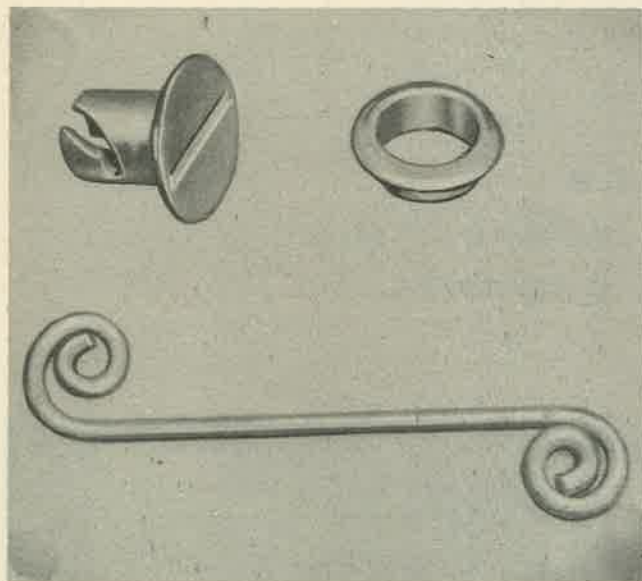


Figure 87—Dzus Fasteners

10. SPECIAL FASTENERS.

a. **DZUS FASTENER.**—*Dzus fasteners* (figure 87) are self locking. They consist of a fastener, spring, and grommet and are used for fastening cowlings, fairings and floor boards. They are usually made of aluminum and are available in several sizes and styles to suit the individual requirements.

b. **CAMLOC FASTENER.**—*Camloc fasteners* (figure 88) are used to fasten cowling, fairing, and compartment or inspection doors. These fasteners consist of two main parts; a *cam collar* to be fastened into the inside sheet of airplane skin or covering and a *stud assembly* to be fastened into the cowling.

c. **DILL LOK-SKRU.**—The *Dill lok-skr* is a special fastener used to install accessories and parts in otherwise inaccessible places. (See figure 89.) They are usually made of aluminum and have a hollow threaded center. They serve the same purpose as rivets and are used in places where rivets cannot be installed. They can be installed from one side of the skin or covering without access to the other side.

Before any screw, nut, or bolt is used in airplane repairs, they are tested for flaws by a patented system known as Magnaflux. In making the test, the part is first magnetized and then submerged into the "Magnaflux" solution, which is an iron oxide (magnetic rouge) mixed with kerosene. The iron oxide will collect and pack into any flaw, and can be readily seen with the unaided eye.

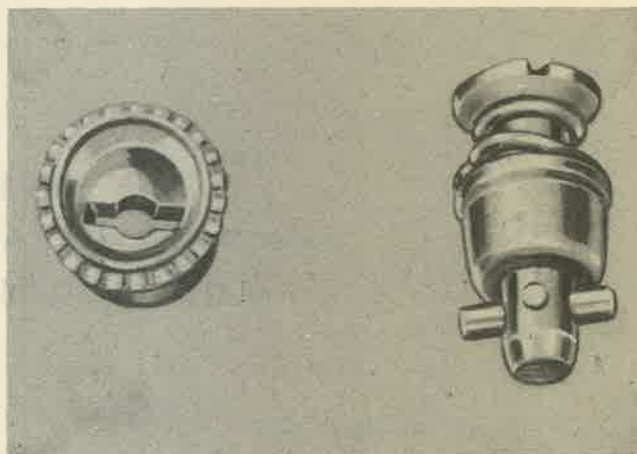


Figure 88—Camloc Fasteners

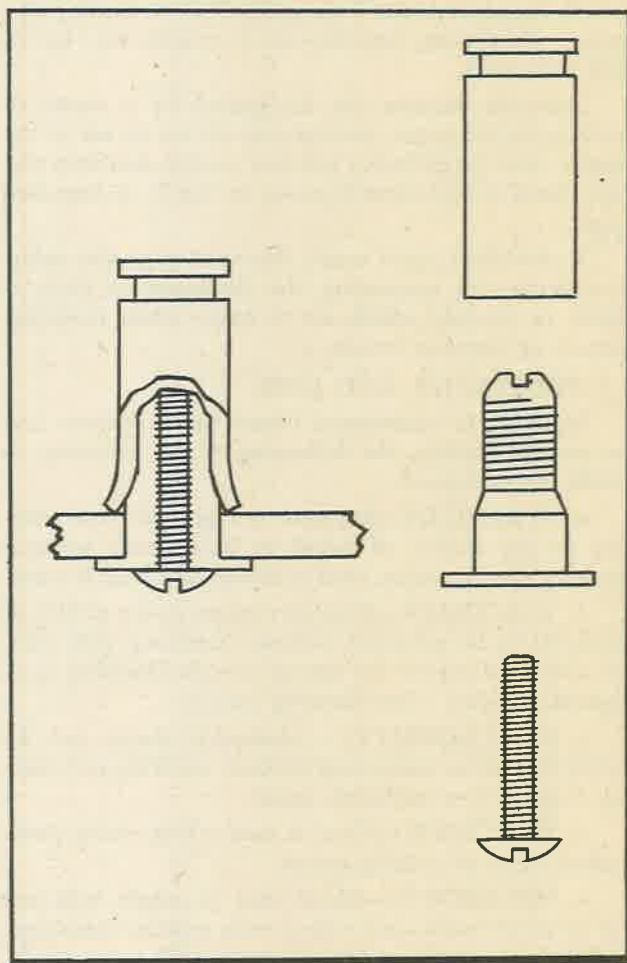


Figure 89—Dill Lok-Skr



SECTION V

AIRCRAFT METALS, COMPOSITION AND WORKING QUALITIES

1. GENERAL. (See figure 90.)

Metal sheets, wire, and band iron are the most widely used materials in the sheet metal trade. The sheets may be plain, ribbed, or corrugated and made of such metals as black iron, galvanized iron, tin plate, copper, aluminum, stainless steel, monel, etc., up to 9/64 inch thick.

Sheet thicknesses are designated by a series of numbers called *gages*. Several systems are in use at the present time for different kinds of metals, but iron and steel sheets should be designated by the U. S. Standard Gage.

In the sheet metal trade, the word *gage* also refers to a device for measuring the thickness or gage of sheets, or devices which act as stops when marking, cutting, or forming metals.

2. PROPERTIES AND USES.

In order to understand better the properties and the uses of metals, the following terms referring to metals are explained:

a. STRENGTH.—*Strength* is a general term referring to the ability of metal to hold loads without breaking. For instance, steel is strong, but lead is weak.

b. DUCTILITY.—*Ductility* refers to the ability of the metal to be stretched without breaking. Soft iron, soft steel, and copper are ductile metals. Ductility is an important factor when bending metals.

c. MALLEABILITY.—*Malleable* metal can be rolled, forged, or hammered without cracking or breaking. Copper is a malleable metal.

d. HARDNESS.—Metal is *hard* which resists penetration, wear, or cutting action.

e. TOUGHNESS.—Metal that is *tough* will not tear or shear easily and will stretch without breaking. Rolled sheet steel is tough.

f. BRITTLENESS.—Metal that will shatter easily is *brittle*. Such materials as cast iron, glass, and very hard steel are brittle.

g. COLD-WORK.—If a piece of metal is formed while cold, the material is said to be *cold-worked*. Practically all the work a sheet metal worker does on metal is cold-work. Cold-working causes the metal to become hardened and brittle. If the metal is cold-worked too much, that is, if it is bent back and forth at the same place too often, it will crack or break.



Figure 90—Aircraft Metal

Usually the more malleable and ductile a metal is, the more cold-worked it can stand before cracking or breaking.

b. ALLOY.—A base metal such as steel or aluminum to which has been added small quantities of other metals in order to change the physical or chemical properties of the base metal. Pure aluminum, for instance, has very little strength; but when certain other metals are added, such as manganese, magnesium, copper, etc., its strength is increased tremendously. With these other metals added, it is called *aluminum alloy*.

i. ANNEALING.—Annealing is a heating and cooling operation for the purpose of removing hardness and strain from a metal brought on by forming, or cold-working, in order to make the metal softer, and refine the grain of the metal. The temperature to which metal should be heated for annealing, means of cooling, depend entirely upon the metal and the properties desired.

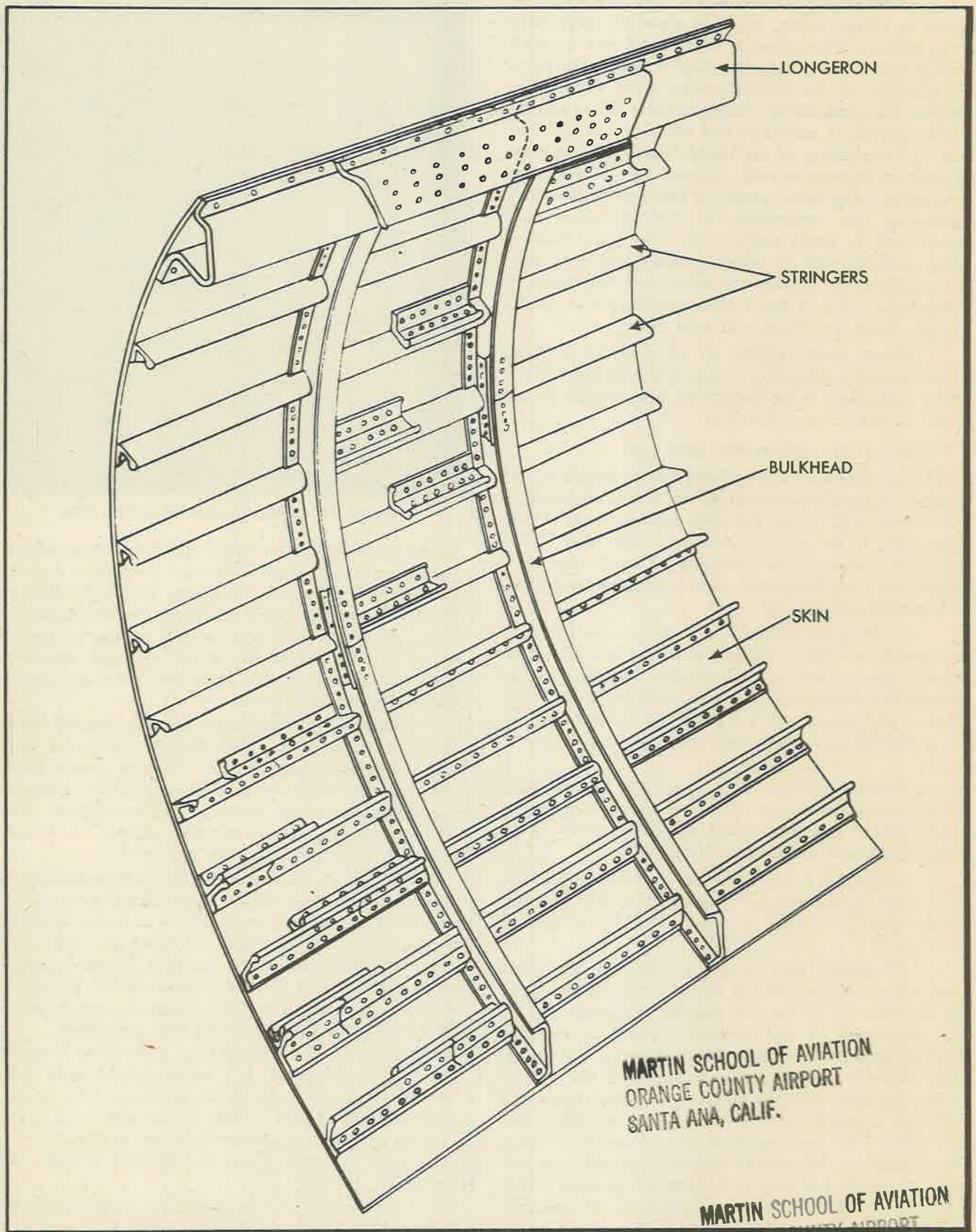


Figure 91—Extruded Shapes

j. **CORROSION.**—*Corrosion* is caused by exposing metals to fumes, water, acids, or moist air (especially moist salt air). The corrosion of iron and steel is called rusting and results in the forming of iron oxide (iron and oxygen) on the surface of the metal. Iron oxide (or rust) has a reddish-brown appearance. When rusting is once started, it continues and results in the destruction and weakening of the metal. The rust may form all over the surface or only in spots. Corrosion can be reduced by using better grades of iron and steel (metals containing less impurities), by adding special materials such as small amounts of chromium, and by using coatings such as paints, enamel, tin, lead, zinc and cadmium to protect the surface. If the metal is worked too much so that surface cracks appear, or the coating flakes, corrosion will take place.

When water collects on unprotected surfaces, corrosion forms; therefore, stock should be kept in dry places and away from fumes. No acid should be allowed to remain on the surface.

3. TYPES OF AIRCRAFT METALS.

a. Stainless steel is one of the newest metals in the industry. It is corrosion-resistant and can be obtained in a wide variety of forms. The most common steel of this group used in the aircraft industry is the "18-8." This particular stainless steel contains 18 to 25 per cent chromium, 8 to 13 percent nickel, and approximately 0.02 percent carbon.

At the present time the principal use of stainless steel (not 18-8) in aircraft is in the fabrication of exhaust stacks, firewalls, manifolds, collector rings, ammunition boxes and flare cans. Because of its resistance to corrosion from hot gases and various acids, it has a decided advantage over ordinary steel for such work.

b. Sheet *aluminum*, used in aircraft construction, is approximately 99 per cent pure and is practically unaffected by exposure to air, although certain commercial gases will cause it to corrode.

Aluminum is very light, but has no great amount of strength unless alloyed with other metals; for this reason pure aluminum is never used for structural members.

c. Aluminum and its *alloys* constitute the principal structural material for use in the construction of the airplane. Of all the raw metallic materials used in the fabrication of the airplane (excluding engines, accessories, and other items of equipment), the aluminum alloys constitute over nine-tenths of the weight of the airplane. Aluminum and its various alloys are available in two basic forms only; *wrought alloys* and *cast alloys*. The cast condition is produced by heating the material to the melting temperature, pouring into suitable molds, and cooling to room temperature. The wrought condition is always derived from the cast condition, and is produced by heating the cast ingot to a temperature of approximately 850° F. and reshaping by rolling, forging, or extruding while in the hot condition. The hot rolling, forging, or extruding process

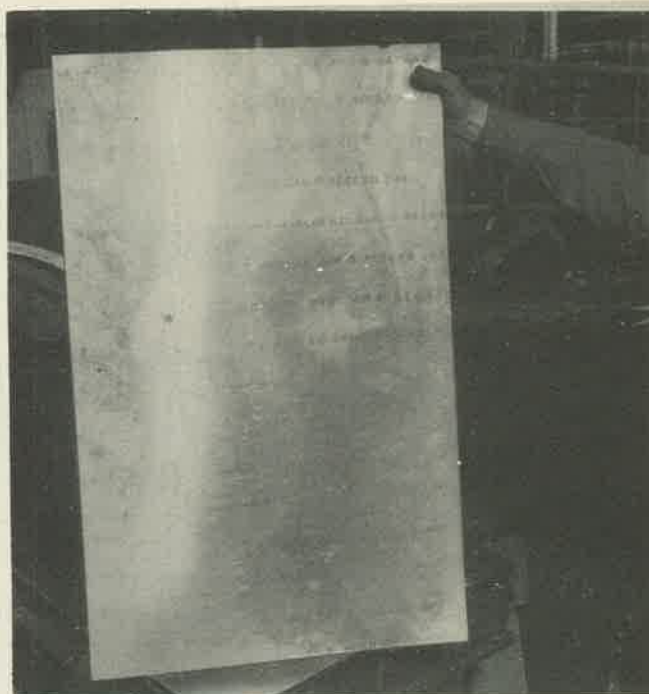


Figure 92—Alclad Coated Aluminum Alloy

breaks up the grain structure and produces a material possessing more desirable physical properties than can be obtained in the cast condition. The cast ingots are usually forged or rolled down into billets known as rolled or forged *billets*. After this rolling or forging operation, the billets are in the wrought condition. They may be then rolled, while hot, down into smaller bars and rods or into sheets.

Extruded shapes are produced by forcing heated aluminum cast ingots through a die having an opening of the desired shape. The extrusion process makes possible the production of shapes which eliminate much machine work, forming and bending on structural assemblies. These extruded shapes are usually made of 17^s or 24^s alloy. (See figure 91.)

Alloys are added to the metallic aluminum before it is cast into ingots. From these many of the structural shapes are wrought by rolling, drawing, extruding, or forging. Instead of being cast into ingots, some aluminum alloys are cast into certain structural shapes or forms by the use of sand molds, permanent molds, or die casts. These aluminum castings, however, do not have the strength of the wrought metal.

As has been stated, pure aluminum is almost immune to corrosion; but when alloyed with other metals, the corrosive action is increased. This is overcome by coating the surface of the alloy with a thin coating of pure aluminum (known as Alclad) or by anodizing, which is an electrochemical process. (See figure 92.)

Aluminum and its alloys are divided into two main classes: *non-heat treatable* and *heat treatable*. The non-heat treatable class consists of either pure aluminum or aluminum containing a very small percentage of other elements such as manganese, magnesium,

chromium, or copper. "Strain hardening" is the only means of hardening this material, and this is usually done by the cold-rolling or cold-working process. This material is identified by a code system as follows: 2 or 3SO; S $\frac{1}{4}$ H, S $\frac{1}{2}$ H or SH.

Example: 2 S $\frac{1}{2}$ H
2=99 per cent pure aluminum
S=Wrought
 $\frac{1}{4}$ = $\frac{1}{4}$ hard
H=Hard

Example: 3SO
3=97 per cent pure aluminum
1.-1.5 manganese
0.2 copper
S=wrought
O=annealed (dead soft)

4. HEAT TREATMENT.

Heat treatment is the process of hardening or softening metal to any desired condition by heating it to varying degrees of heat and cooling it either fast or slowly.

Heat treatable alloys contain from 92 percent to 96 percent pure aluminum, and a small amount of manganese, magnesium, chromium, copper, zinc and nickel and some also contain silicon. In most cases they contain a much higher percentage of copper than the 3S material. This material can be hardened by heat-treatment and by strain hardening or by both to bring out its maximum strength. The heat treatable alloys are identified by a code numbering system as 17 or 24SO, ST, SRT, or SW.

Example: 24=92% Aluminum
.3-.90 Manganese
1.25-1.75 Magnesium
3.6-4.7 Copper
S=Wrought
O=Annealed
T=Maximum allowable hardness
R=Strain hardened
W=Intermediate heat treatment

5. USES OF ALUMINUM AND ITS ALLOYS:

2S $\frac{1}{2}$ H	Tubing, bar and sheet	Electric conduit
3S $\frac{1}{2}$ H	Sheet, bar and tubing	Tanks, tank flanges, and cowlings
52SO	Tubing, bar and sheet	Fuel, oil and instrument lines
53S $\frac{1}{4}$ H	Sheet or strip	Cowling

17SO	Sheet, tubing, and rivets	Structures (to be heat treated)
17ST	Sheet, tubing, bar extrusions and rivets	General structures

NOTE

17S alloy is now being replaced by 24S as fast as present stock is depleted.

24SO	Sheet, strip and rivets	Skins and highly stressed structural parts (to be heat treated)
24ST	Sheet, strip, bar extrusions and rivets	Skins, highly stressed structural parts and streamline struts

Aluminum alloys are heat treated by heating at the temperatures specified in the table, "Heat Treating Procedure for Aluminum Alloys," followed by cooling in the air or a furnace.

Heat Treating Procedure for Aluminum Alloys

Alloy No.	Annealing temperature ° F.	Solution treatment		Aging		Tensile strength (pounds per square inch)
		Temperature ° F.	Quench	Temperature ° F.	Time (hours)	
2	625-700					12,000
3	725-775					19,000
17	650-800	925-950	Cold water	Room	16-24	55,000
24	650-800	910-930	Cold water	Room	16-24	62,000
52	650-800					31,000

NOTE

Alloys 2, 3, and 52 are non-heat treatable; hence no hardening or aging data are given.

The process of hardening aluminum alloys consists of heating, quenching and aging. Heating is done either in a salt bath or furnace for the length of time and at the temperatures indicated in the above table.

Quenching is in cold water, but castings may be quenched in hot water or soapsuds to reduce warping. Aluminum alloys cool rapidly when removed from the furnace atmosphere, therefore, quenching tanks must be located close to the furnace and the transfer from furnace to tank handled with maximum speed.

AGING.—After the solution treatment, the material will tend to harden gradually; and after a period of time (approximately 4 days), dependent on the composition and the thickness of the material, it will reach its maximum strength and hardness.

SECTION VI

STRESSES AND STRENGTH OF MATERIALS

1. GENERAL.

The sheet metal aircraft maintenance mechanic is responsible for the maintenance of the structural strength of the aircraft which he is maintaining. In order to perform this work successfully, it is necessary for the mechanic to become familiar with the various

stresses which act upon an aircraft, and the strength of the various materials which are used in aircraft repair and construction. A knowledge of the ability of these various materials to withstand the various stresses is also essential.

There are six fundamental stresses that will be

considered: bending, compression, torsion, tension, bearing, and shear. Tension, bearing, and shear are considered from a mathematical point of view, since these three stresses are more closely related to the practical work of the aircraft maintenance mechanic than the other three stresses. However, the entire six stresses are very closely related, and all of them can be resolved in terms of each other.

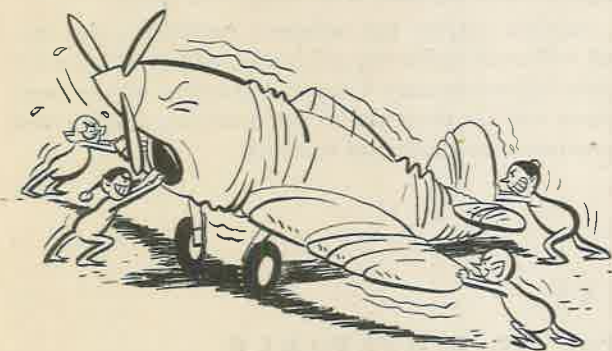
2. BENDING.

Bending is a force or stress which tends to deform a material by deflecting or inclining it. If the material was originally straight, bending may cause the material to curve. If the material was originally curved, a decrease in the curvature may result.



3. COMPRESSION.

Compression is a force or stress which tends to deform material by pressing or squeezing the material. This compressive or squeezing stress which tends to force the material into a smaller space may cause the material to become deformed in shape.



4. TORSION.

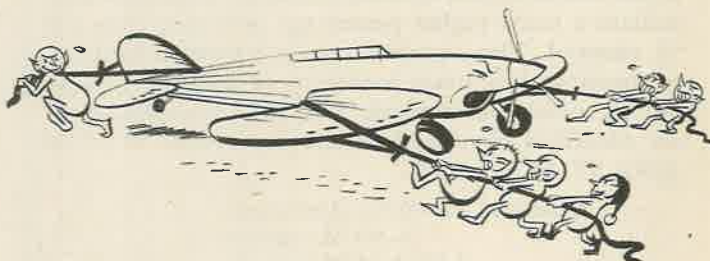
Torsion is a force or stress which tends to deform material by a twisting or turning action. This stress may occur on torque tubes (hollow tubes designed to transmit rotary motion), the wing of an aircraft during flight, and the fuselage of an aircraft during flight.



5. TENSION.

Tension is a force or stress which tends to deform material by a pulling or stretching action. This stress tends to cause a lengthening of the material and occurs mainly on all the stressed skin of an aircraft.

Tensile strength is expressed in terms of force per unit area as pounds per square inch. For instance, 24S-T sheet aluminum has a tensile strength of 62,000 pounds per square inch.



6. BEARING.

Bearing stress is a form of compression where the rivet causes an enlargement or stretching of the rivet hole toward the edge of the sheet. This stretching action causes the rivet holes to tear out or bear out in a direction opposite to the direction of the stress on the sheet. (See figure 93.)

In every case, the edge distance measured from the center of the rivet hole to the edge of the sheet must be equal to or greater than twice the diameter of the hole. If the edge distance is decreased, the bearing strength is considerably reduced.

7. SHEARING.

a. SHEAR STRESS.

Shear stress tends to exert a cutting or shearing action on the material. This form of stress may occur on the leading edge of a wing or on the fuselage of an aircraft during flight. However, it occurs mainly in riveted joints and acts upon the rivets in the manner indicated in figure 94.

This cutting or shearing of the rivets is indirectly due to the load acting upon the sheet in the direction indicated by the arrows.

The following method and calculations illustrate the principles that may be applied in the repairing of all stressed skin structures:

b. REPAIR OF STRESSED SHEET SKIN.

In smooth skin structures the maximum allowable tension stress will be taken as 60,000 pounds per square inch. All skin is assumed to be subjected to this stress. In structures with thin skin, the reinforcement plate will be the gage of the damaged skin; or if that gage is not stocked, the next heavier gage. The ragged edges of a hole will be cut away so that there will be no sharp corners. This type of repair applies only to smooth skin that carries stress. It does not apply to cowlings, fairings, etc. A specific example of smooth skin reinforcement is given below:

- (1) Assume skin thickness equals 0.032 inch.
- (2) Assume skin stress equals 60,000 lb. to the square inch.
- (3) Assume length of hole = 2.0 in. (Width of patch must not be more than two times the length of break.)
- (4) Cross-sectional area of break = $0.032 \times 2.0 = 0.064$ square inch.
- (5) Load in reinforcement = $0.064 \times 60,000 = 3840$.
- (6) Allowable bearing of $\frac{1}{8}$ -inch rivet on 0.032 = 300 lb. (See Table 5-11.)
- (7) Allowable shear of $\frac{1}{8}$ -inch 17ST "D" rivet = 368 lb. (See Table.)
- (8) Number of rivets required = $1.25 \times 3840 / 300 = 16$ (1.25 = a rivet factor).
- (9) A minimum of 16 rivets will be used on both sides of the break to attach the reinforcement to the skin.

NOTE

If one patch is to be used to cover more than one break, the length of the break is to be considered the greatest distances between any parts of the damaged section.

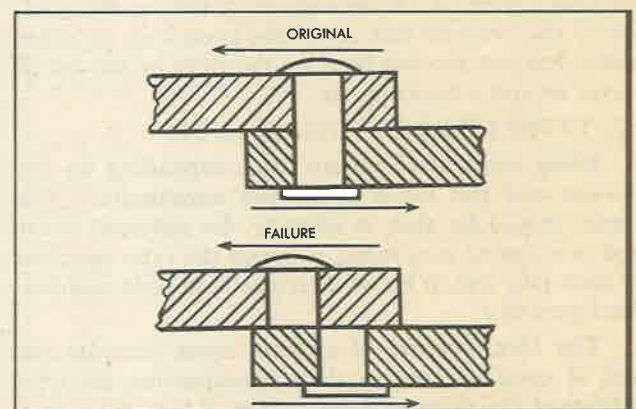
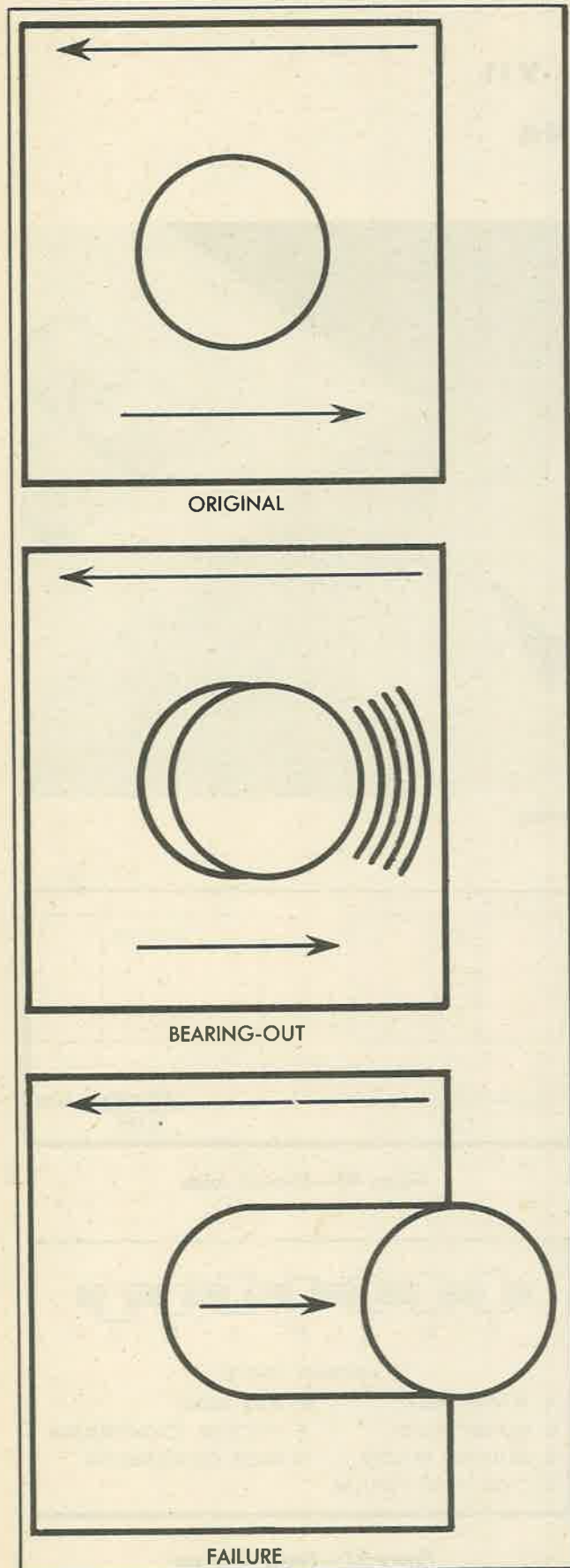


Figure 94—Shearing

Figure 93—Bearing

SECTION VII

RIVETING

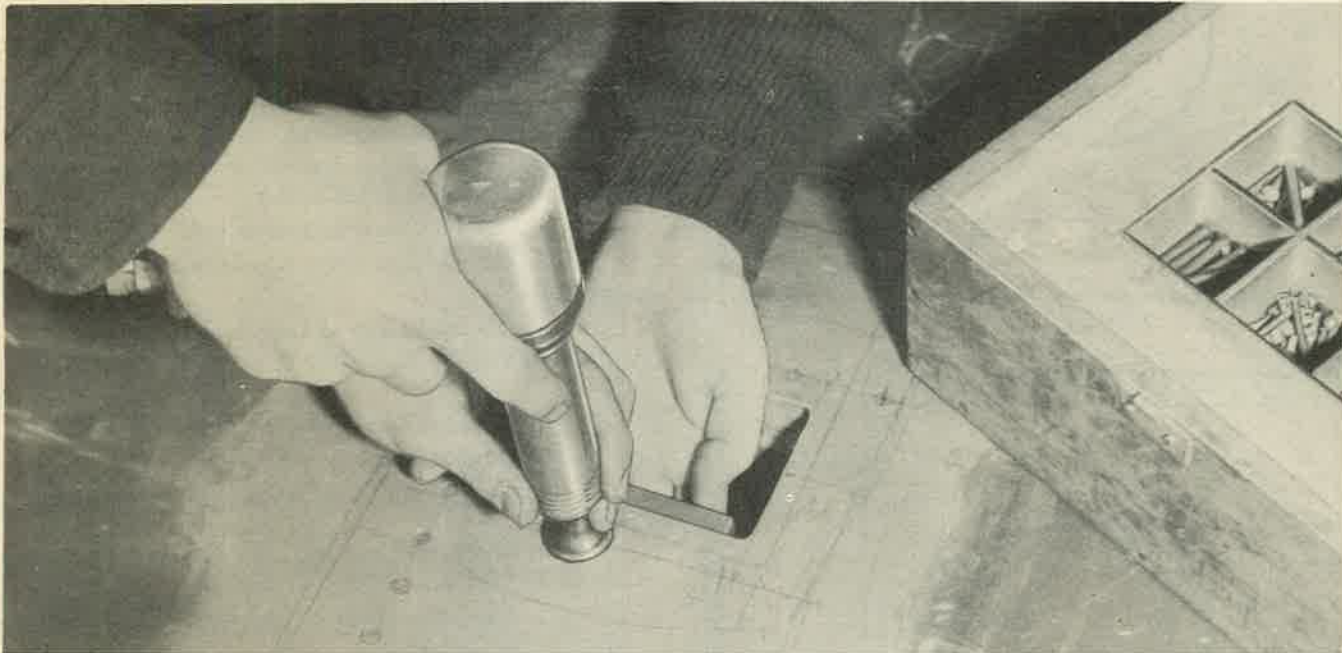


Figure 95—Riveting

1. GENERAL. (See figure 95.)

There are many ways of joining metal together, but one of the most important is riveting. (See figure 96.) And it is riveting that we will take up now, as that is the method that a sheet metal mechanic uses to attach a metal patch to the metal surface of an airplane. Riveting, in brief, consists in drilling a hole in the two pieces of metal that you want to join together, inserting a rivet, and flattening, or up-setting, the small end of the rivet so that it cannot come out. In other words, you put another head on the rivet by the use of a rivet set and a bucking bar.

2. TYPES OF RIVETS. (See figure 97.)

Many types of rivets are used, depending on the location and the kinds of stresses encountered. The riveter should be able to identify the different rivets used in airplane structures; to select the type specified for each job; and to know their part and code number. (See figure 98.)

The identification of aircraft rivets includes the kind of material used in their manufacture, the type and size of the rivet, and the degree of heat treatment. The name of the rivet is taken from the cross sectional shape of the head, such as round, flat, countersunk, etc. The size is gaged by the length and diameter of the body, except in case of a countersunk rivet where the

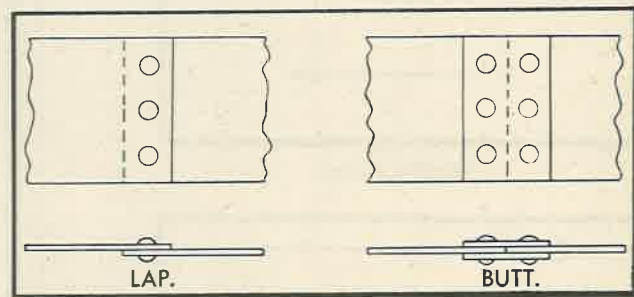


Figure 96—Riveted Joints

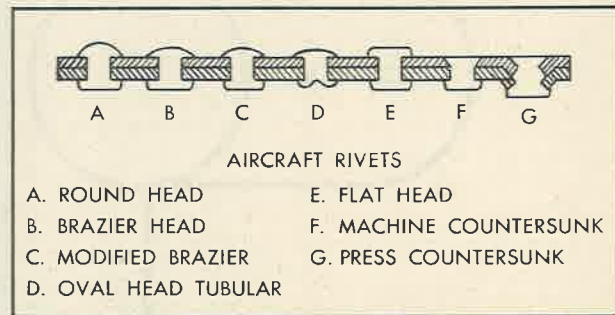
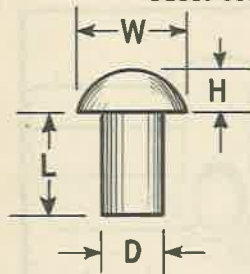


Figure 97—Types of Rivets

RIVET IDENTIFICATION AND SPECIFICATION CHART

Rivet	Kind	Shank* Diameter	Head Width	Head Depth	Number	Used For
	Round Head	1/8 to 3/16	2 D	.75 D	AN430	Structures
	Brazier Hd.	1/8 to 1/4	2.50 D	.50 D	AN455	Structures
	Modified Brazier	1/8 to 3/16	2 D	.35 D	NAF671D	Skins
	Flat Heads	1/8 to 1/4	2 D	.4 D	AN442	Structures
	**Countersunk Hd.	1/8 to 3/16	1.5 D	.063 D	AN425	Skins
	Oval Head Tubular	1/8 to 3/16	2 D	.37 D	NAF670D	Skins and Structures
	Countersunk Tubular	1/8 to 3/16	2 D	.4 D to .5 D	NAF672D	Skins
	Open End Tubular	1/8 to 3/16	2 D	.5 D	NAF630D	Tubular Structures

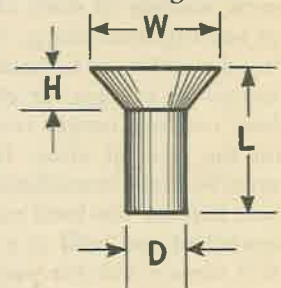
*Most commonly used sizes. **The degree of countersink varies from 78 degrees to 120 degrees.



Code Explanation
AN=Army and Navy
AN430-4-6=
430=Specification Number
-4=32nds in Diameter
-6=16ths in Length
NAF=Naval Aircraft Factory

NOTE: Some Aircraft Manufacturers specify length in 32nds.

Figure 98—Rivet Identification and Specification Chart



length is measured from the top of the head to the end of the body. The physical characteristics are indicated by markings on the rivet heads. (See figure 99.)

a. A raised smooth head, "A" in figure 99 indicates 2S or pure aluminum, and a smooth head with a figure "3" stamped on the body or shank, indicates 3S aluminum alloy (not heat treatable).

b. A raised dot in the center of the head "B" in figure 99, and a letter "D" following the code or part number (AN 430 D) for example, indicates that this is a 17ST aluminum alloy heat-treatable rivet and must be used either immediately after quenching, or it must be refrigerated at zero degrees until used. The "D" and "DD" rivets are what are known as the ice box rivets.

c. A dimple in the center of the rivet head "C" in figure 99 and the letters "AD" following the code or part number indicate that this rivet is heat treatable, but is not full hard, can be stored at room temperature and be used at any time.

d. A double dash raised on the head "D" in figure 99, and the letters "DD" following the code or part number indicate a 24ST composition rivet.

NOTE

"D" and "DD" rivets are not to be used unless heat treated.

e. Many different kinds of special rivets have been designed for use in places where it is either exceedingly difficult or impossible to buck ordinary rivets. Some of these special rivets are also used to install accessories after the airplane is completed.

(1) EXPLOSIVE RIVET.—The *explosive rivet* is one that has an explosive charge sealed into the hollow end of the shank, which is exploded when a hot iron is touched to the head. This causes the inner end of the shank to expand almost in the same manner as if it were "bucked." (See figure 100.)

(2) RIV-NUT.—The *riv-nut* consists of a hollow threaded shell with an external flange or rim on one end. (See figure 101.) It can be installed from one side of the sheet metal with a special tool, which crimps the thin wall of the shell against the back of the sheet. (See figure 102.) This clamps the sheet tightly between the rim and the crimp on the shell.

(3) **CHERRY RIVET.**—The *cherry rivet* (figure 103) is another type of rivet that can be installed from one side of the sheet metal and does not need a bucking bar to upset it. Like the riv-nut it requires a special tool to crimp the end against the back of the sheet. After crimping, there is a part projecting above the metal (figure 103), which is clipped off.

(a) In drilling holes for the use of cherry rivets, take care to have the hole at right angles to the sheets. The following hole sizes are recommended:

	Rivet Diameter		
	1/8	5/32	3/16
Drill No. for self-plugging rivets	30	20	10
Drill No. for hollow rivets	30	20	11

(b) When using countersunk rivets and dimpled holes, it is very important to have the rivet holes smooth. Chips must be carefully eliminated from between the sheets, and any burrs resulting from drilling should be removed, as they prevent proper seating of the manufactured head, as well as of the shop-head. In general, material for riveting with cherry rivets should be prepared in the same way as though driven rivets were used.

3. HEAT TREATMENT OF RIVETS.

Aluminum alloy rivets are heat treated in the same manner as sheet aluminum. The process consists of heating, quenching, and aging. The heating is done in an electric air furnace (figure 104) or a nitrate bath, heated by oil, gas, or electricity. The temperature for heat treating ranges from 625° to 930° F., depending on the type of alloy. Driving of a heat-treated rivet must be done immediately after quenching, or the rivet will become too hard to drive. However, rivets may be quenched and held at a temperature below 32° F. and still remain soft for periods as long as two weeks.

4. SPACING OF RIVETS.

For every case or type of riveting, specific rules for spacing cannot be given. Spacing in any joint ordinarily depends upon the proportions of the members joined. There are several general rules, which, if understood and followed, will enable the mechanic to space rivets correctly in all cases.

a. When making a repair job, the rivets should be spaced like those in the original structure, if possible.

b. The spacing of rivets in rows depends upon several things. (See figure 105.) The thickness of the sheets, size of the rivets, and the stresses to which the sheet will be subjected are the governing factors. Rivets should never be spaced so close that they cannot be driven without interference. The spacing is seldom less than four diameters of the rivet. The maximum spacing in compression members may be governed by the possibility of the buckling of the component parts between rivets. When rivets are used simply to hold plates or shapes together, the spacing may be determined by the designer's sense of proportion. A general rule recommended for maximum spacing is that it

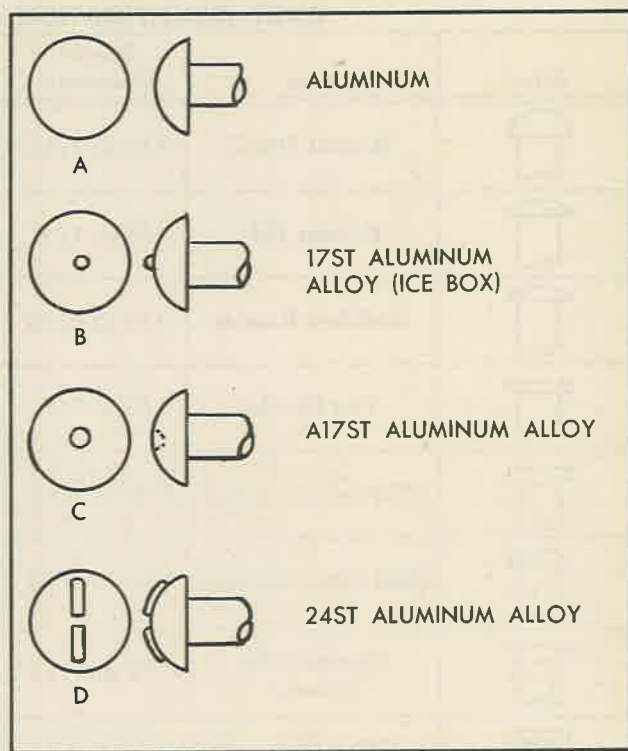


Figure 99—Identification of Rivets

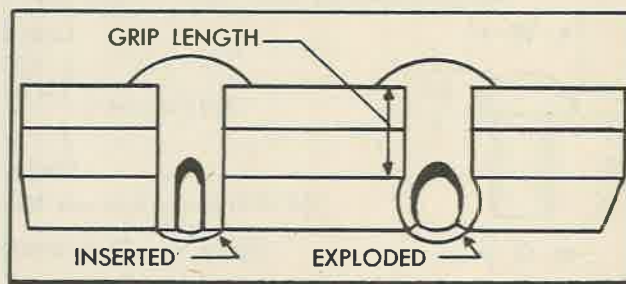


Figure 100—Explosive Rivet Cross Section

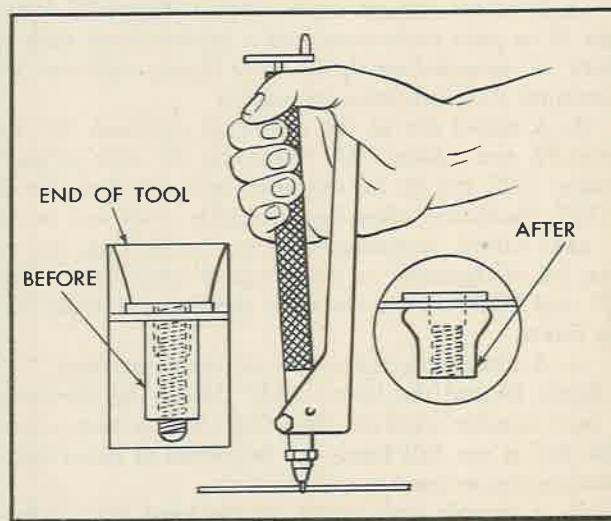


Figure 101—Installing Riv-Nut



Figure 102—Riv-Nut Tool

should not exceed 24 times the thickness of the sheet.

c. If two rows of rivets are used, they are usually staggered. The usual rule for the distance between rows is 75 percent of the rivet pitch.

d. Except in highly stressed joints, the spacing in pitch is from 6 to 12 diameters of the rivet.

5. LENGTH OF RIVETS.

The correct length of rivets depends upon the thickness of the sheets being riveted. The shank should extend through the material from one and one-half to two times the diameter. For heavy work, they should extend two times the diameter. For light work, such as two thin sheets, they should extend from one and one-half times to slightly more. A rivet which is too short will form an inadequate head. A rivet that is too long will bend, either in the shank or the extended portion, when headed. The height of the bucked head should be $\frac{1}{2}$ to $\frac{3}{8}$ times the original diameter of the rivet. The diameter of the bucked head should be $1\frac{1}{2}$ to 2 times the original diameter of the rivet.

6. RIVETING HINTS.

Before starting in on the practical work of riveting, it would be well to study the following hints on the subject and bear them in mind whenever you have an actual riveting job to do.



Figure 103—Cherry Rivet Installation

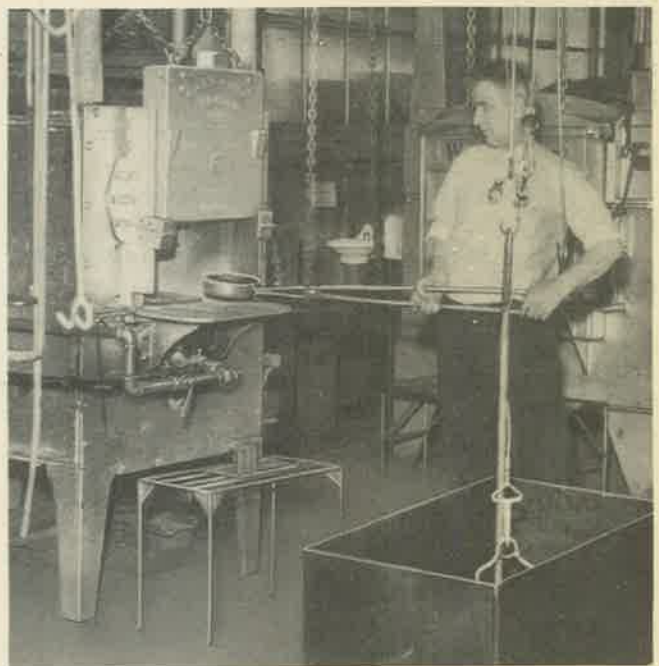


Figure 104—Heat Treating Rivets

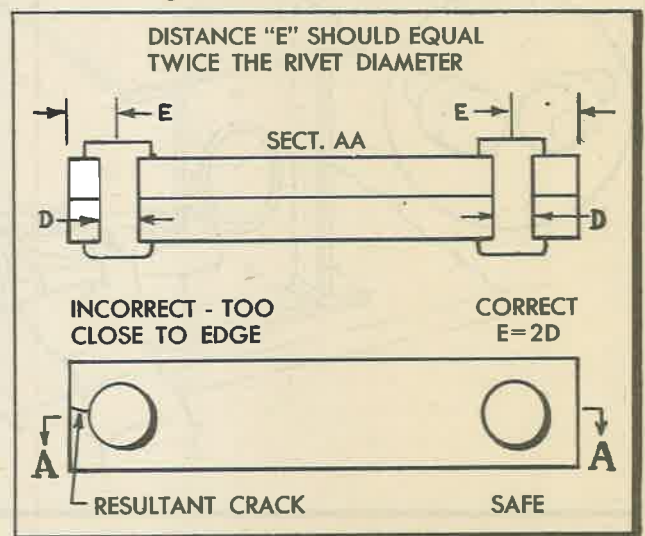


Figure 105—Rivet Edge Distance

a. A soft lead pencil is used for rivet layout because it is least likely to scratch the material.

b. When center punching of material is necessary, be sure the material is well supported to prevent dimpling.

c. Rivet holes should not exceed 5 percent the diameter of the rivet to be used.

d. .002 to .003 is sufficient clearance for a rivet hole.

e. At no time should a rivet be forced or driven through an undersized hole.

f. Drills should be sharp and straight to prevent the drill from crawling away from rivet location, from making a large hole, or from making a ragged or irregular hole.

g. Always tighten the drill in the chuck, to prevent slipping.

h. Place a drill block on the twist drill, to keep it from going too far through the material, after the hole has been drilled.

i. A No. 40 drill affords sufficient clearance for a 3/32 rivet.

j. A 3-48 machine screw or cleco is used for a 3/32 hole.

k. A No. 30 drill is used when drilling for 1/8-inch rivet.

l. A 5-40 machine screw or cleco is used for a 1/8-inch rivet.

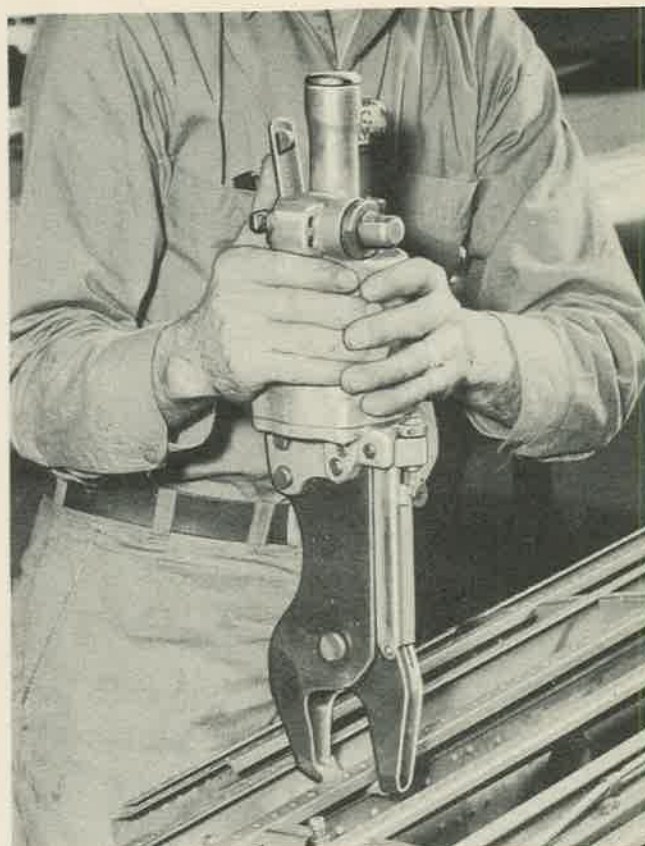


Figure 106—Rivet Squeezer

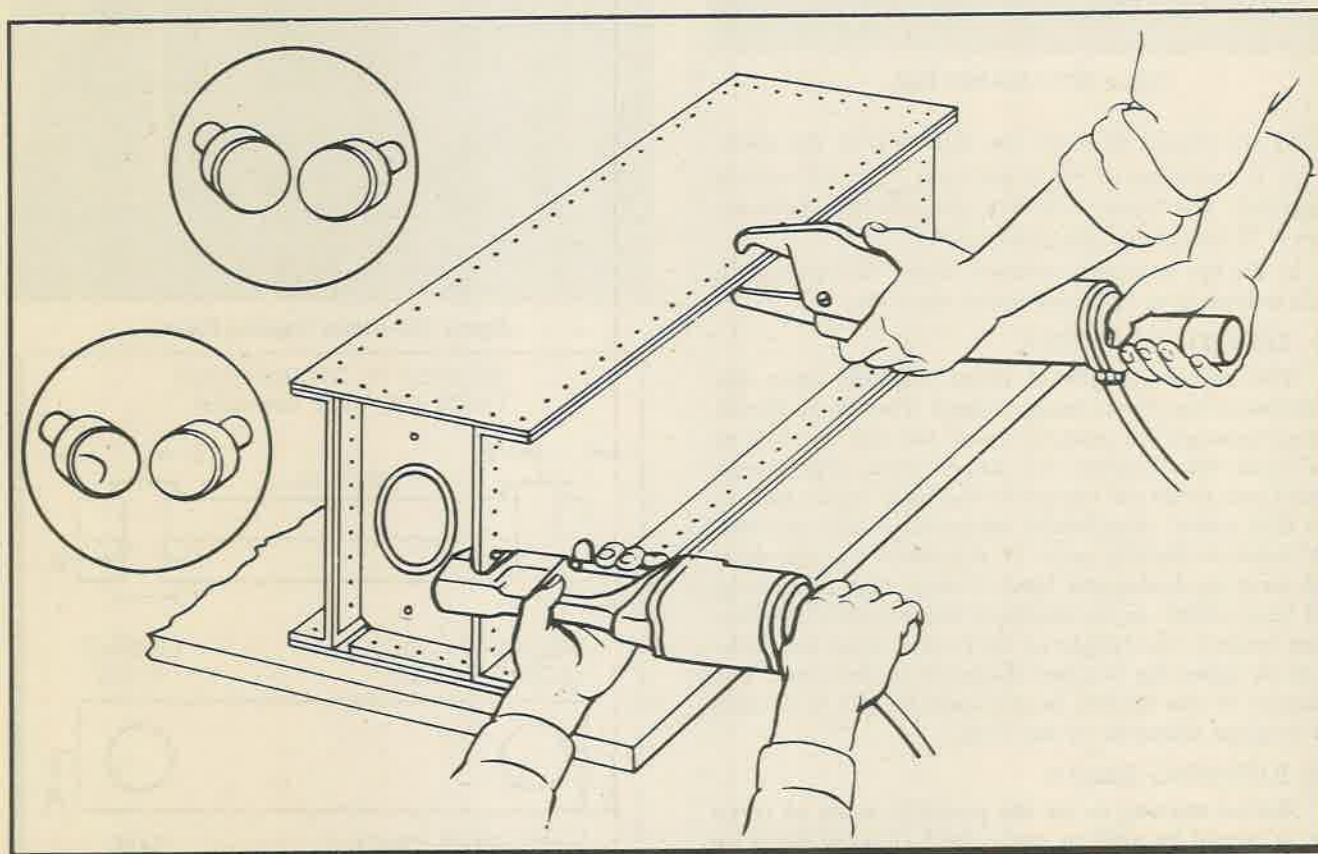


Figure 107—Riveting with Portable Pneumatic Squeezer

m. Use fiber washers under the heads of P.K. or machine screws, to prevent scratching metal.

n. Chips must be cleaned from between two sheets after cleaning.

o. Burring of holes should only be deep enough to cut the sharp edge around the hole.

p. Adjust air pressure properly before attempting to drive a rivet.

q. Rivet should protrude through the metal approximately $1\frac{1}{2}$ times the diameter of the rivet.

r. The height of the bucked head should be approximately $\frac{1}{2}$ to $\frac{5}{8}$ times the original diameter of the rivet.

s. The diameter of the bucked head should be $1\frac{1}{2}$ times the original diameter of the rivet.

t. Select a heavy bucking bar in preference to a lighter one whenever possible.

u. Wrap the bucking bar with masking tape at any point where it will scratch or mark the metal.

v. When riveting at the bench, it is good practice to keep the bench clean in order to prevent scratching the material.

w. For safety, always keep your air hose and electric cord as much as possible out of the way in order to prevent someone from tripping.

7. RIVETING TOOLS.

a. RIVET SQUEEZER. (See figure 106.)

Portable pneumatic squeezers are used extensively for riveting aircraft structures. They are easily handled and have the advantage of being movable, as they are connected to the air supply line by means of a long flexible rubber hose. (See figure 107.) This enables the operator to do riveting at various angles and points on the structure. Squeezer riveting has the advantage of producing uniform work with a minimum of effort on the part of the operator.



Figure 108—Riveting Hammer

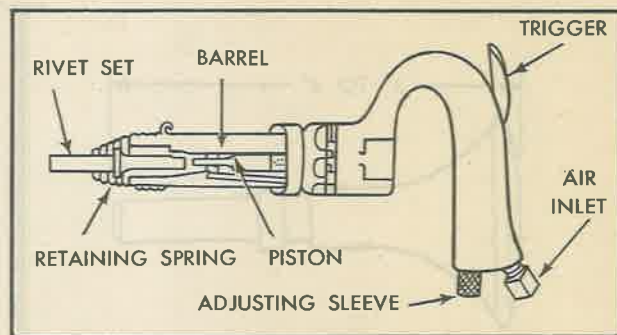


Figure 109—Pneumatic Riveting Hammer Parts

b. PNEUMATIC RIVETING HAMMERS.

(See figure 108.)

(1) TYPES.

Pneumatic riveting hammers, or riveting guns, as they are called, are made in three general types: the fast hitting riveter which delivers 2500 to 5000 blows per minute, the slow hitting riveter, delivering up to 2500 blows per minute, and the one-shot riveter.

One-shot riveting hammers are larger than most of the fast-hitting riveting guns and are preferred for some riveting jobs. These hammers have a longer cylinder than most guns because they must hit hard to head a rivet with one blow.

The most satisfactory type of riveting hammer can best be determined by a practical test on the job. The size, the material, and the hardness of the rivet have a bearing on the choice of a riveting hammer. It is essential that rivets be driven with as few blows as possible.

(2) OPERATION OF RIVETING GUN.—Compressed air is admitted to the rivet gun (figure 109) through an adjustable valve. The flow of air, which controls the blows per minute, is regulated by adjusting this valve. The air passes through the throttle valve, which is controlled by the trigger. After passing the throttle valve, the air is admitted to the cylinder of the gun through the valve that controls the movement of the piston. The action of the air in the cylinder forces the piston to travel rapidly up and down the steel barrel. On the down stroke the piston strikes the rivet set with considerable force, and the rivet set transmits this force from the piston to the rivet head.

c. RIVET SETS.—Rivet sets fit into the end of the riveting hammer (figure 109) and are held in place by a retaining spring, sometimes called a *beehive*. They are made in different sizes and shapes, with the ends or tips of the sets made to fit the various types of rivet heads. A flat-faced set (figure 110) is used for flat head or counter sunk head rivets, and cup-shaped sets are used for brazier and round-head rivets. (See figure 111.) It is important that the proper set be used to get the best results.

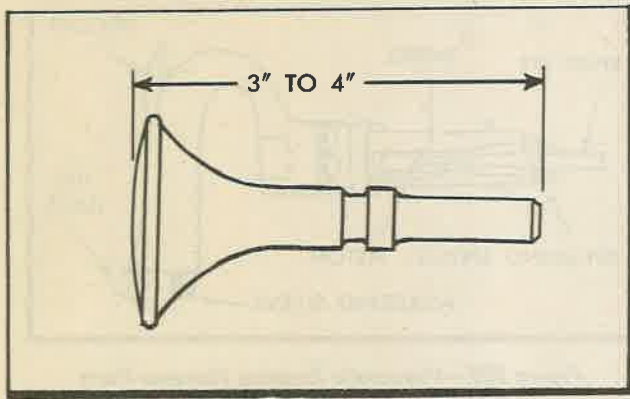


Figure 110—Flat Faced Rivet Set

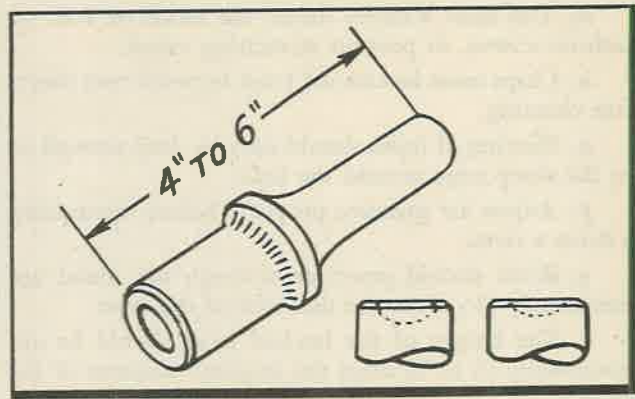


Figure 111—Cup-shaped Rivet Set

d. BUCKING BARS. (See figure 112.)

Bucking bars are made in a great variety of shapes and sizes. Where obstructions are encountered, and in places where plain bucking bars cannot be used, special bucking bars must be devised to meet such conditions. The size, shape, and weight of the bucking bar is governed by the size, kind, and location of the rivets being set. They are made of tool steel and should be heavy enough to buck the rivet solidly, but light enough to be conveniently handled by the "buck-up" man. (See figure 113.)

The bucking bar may be used either on the commercial head or on the shank end of the rivet. When riveting by hand, the bucking is usually done on the head of the rivet and is called "reverse bucking."

(See figure 114.) When riveting with a pneumatic riveting hammer, the bucking is done on the shank end of the rivet while the hammer, fitted with the proper rivet set, is used on the head of the rivet.

When bucking is being done by the "reverse bucking" method, a plain bucking bar is used for flat head rivets, and a bucking bar "cupped or recessed" to fit the rivet head, is used for round or oval rivets.

e. COUNTERSINKING, DIMPLING AND COUNTERBORING TOOLS.

Whenever it is necessary to set rivets or screws flush with the material that is being fastened together in order to provide a smooth surface without any rivet heads or screw heads showing, *countersinking* or *dimpling* is done. (See figures 115 and 116.)

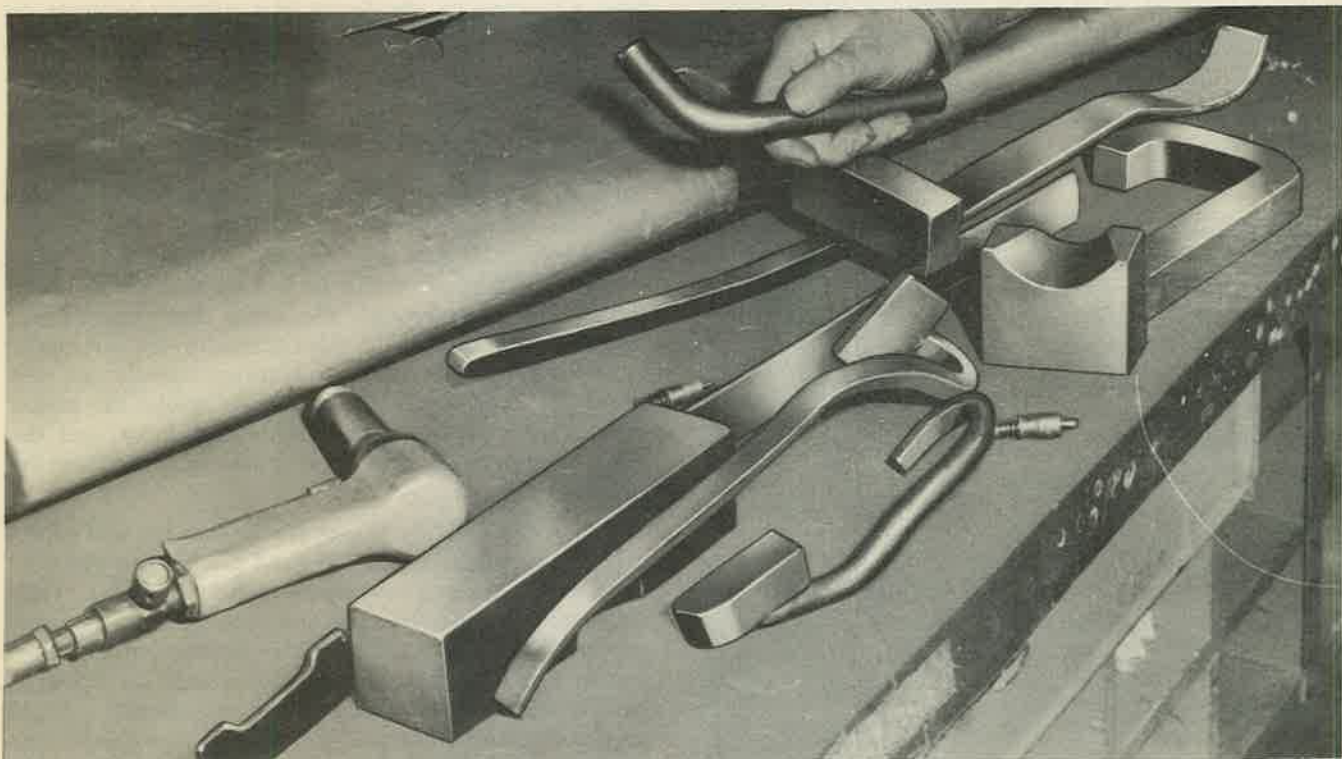


Figure 112—Bucking Bars

(1) COUNTERBORING.

Counterboring is done when it is desired to enlarge a portion of a hole (figure 117) already drilled, or to spot face around a hole on round or irregular surfaces to provide a flat spot for the head of a bolt or screw. Different tools are used for each operation.

(2) COUNTERSINKING AND DIMPLING SHEET FOR FLUSH RIVETS.

The installation of flush rivets requires that the skin be suitably recessed to receive the rivet-manufactured head. If the skin is of sufficient thickness, this may be accomplished by using a suitable 100-degree or more countersinking tool to cut away the metal around the rivet hole. In the case of thin sheets, however, it is necessary to dimple or counterpunch the material around the rivet hole to form a suitable recess for the rivet head. The following table shows the required recess diameter, and what method is necessary for various combinations of AN426 100-degree rivet diameters and sheet thicknesses.

Sheet thickness (in.)	Diameter of Rivet			
	3/32	1/8	5/32	3/16
	Diameter of Countersink or Dimple			
0.025	0.179 in.	0.225 in.	0.287 in.	0.335 in.
0.032	Dimple	Dimple	Dimple	Dimple
0.040	Dimple	Dimple	Dimple	Dimple
0.051	C'sink	Dimple	Dimple	Dimple
0.064	C'sink	C'sink	Dimple	Dimple
0.072	C'sink	C'sink	C'sink	Dimple
0.081	C'sink	C'sink	C'sink	C'sink



Figure 113—Bucking Rivets—Team Riveting

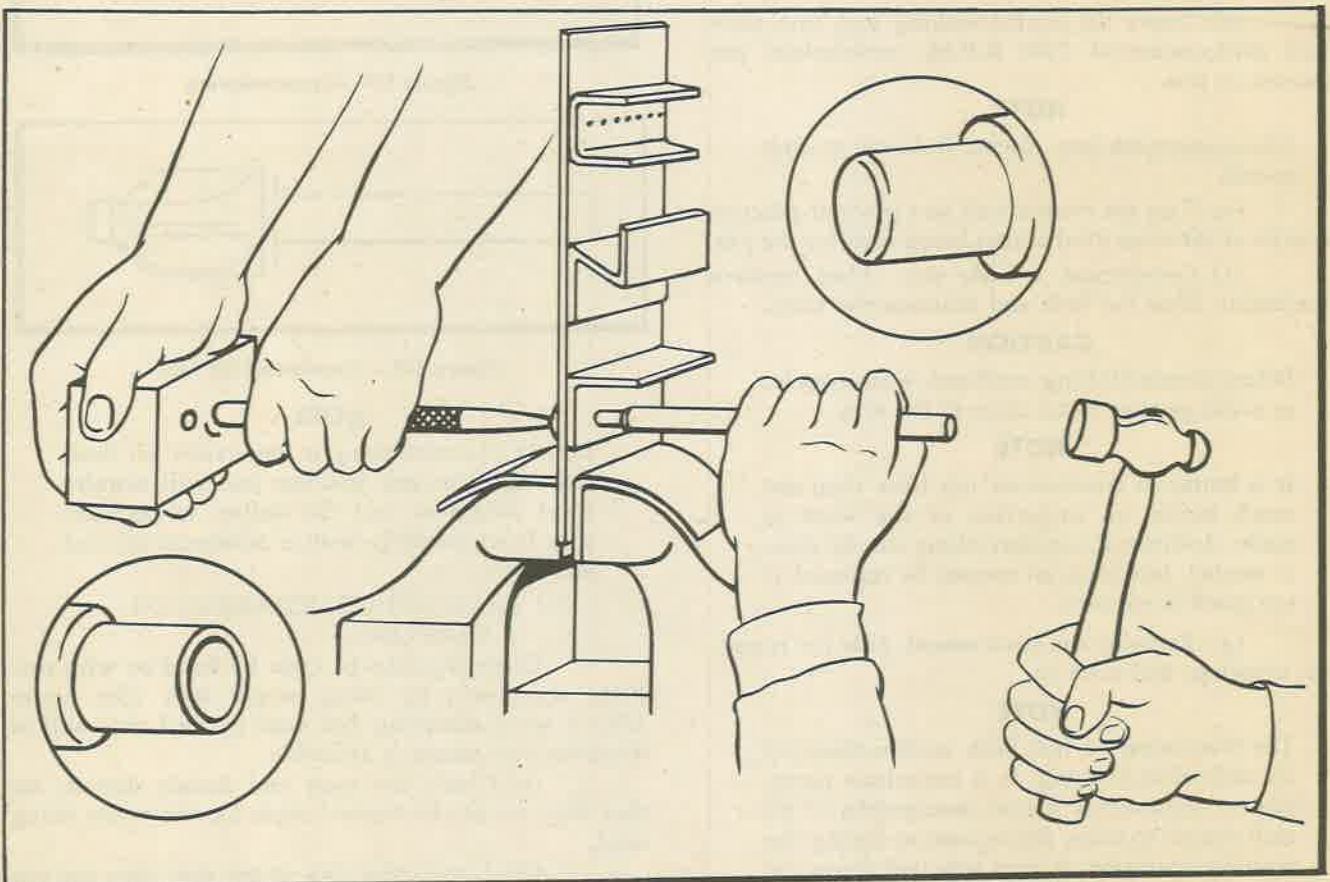


Figure 114—Reverse Bucking

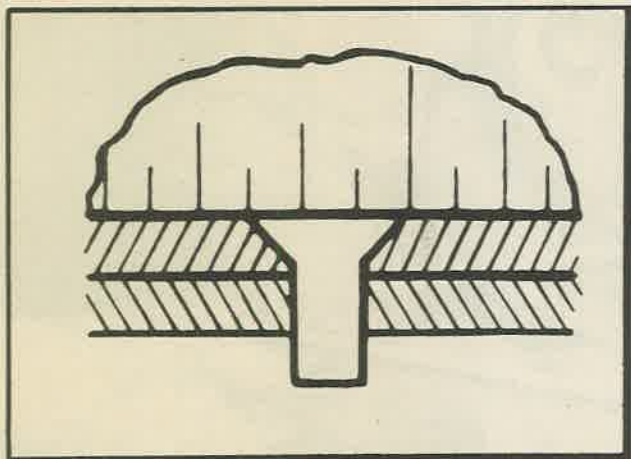


Figure 115—Machine Countersunk Hole

(3) MACHINE COUNTERSINKING.

(a) Get a machine countersinking tool of the same angle as the rivets being used. (See figure 118.)

NOTE

The angle of countersunk head rivets being used range from 78 degrees to 120 degrees.

(b) Check the countersink tool to make sure that it is sharp.

(c) Keep the shaft bearings of the countersink tool well oiled.

(d) Insert the countersinking tool in a slow speed drill motor of 2500 R.P.M. (revolutions per minute), or less.

NOTE

The countersink may chatter if driven at high speeds.

(e) Test the countersink in a piece of practice material of the same kind as that being used for the job.

(f) Countersink a little way. Then, remove countersink from the hole and examine the work.

CAUTION

When countersinking overhead, wear goggles to avoid getting metal chips in the eyes.

NOTE

It is better to countersink too little than too much before an inspection of the work is made. Additional countersinking can be done if needed, but material cannot be replaced if too much is removed.

(g) Examine the countersunk hole for roundness, evenness, and rivet fit.

NOTE

The rivet must be just flush with surfaces of the skin after riveting. It is sometimes necessary to countersink a few thousandths of an inch deeper to allow for expansion during the riveting operation. A steel rule laid across the rivet makes a good checking tool. (See figure 115.)

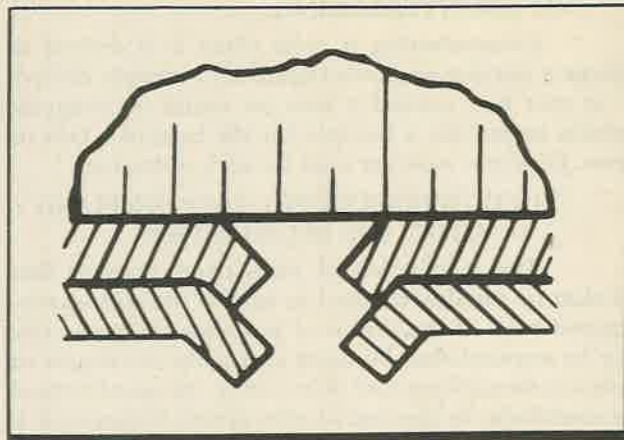


Figure 116—Dimpled Hole

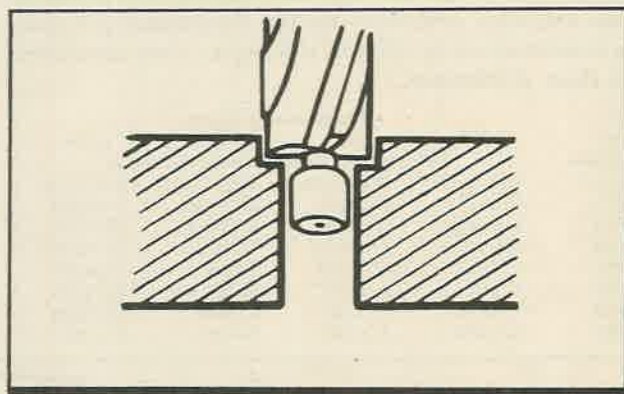


Figure 117—Counterboring

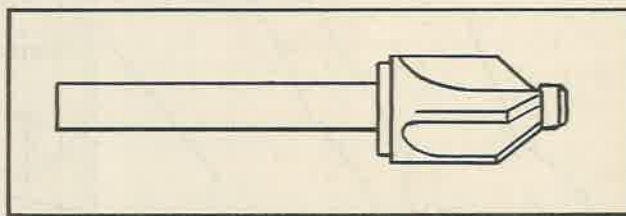


Figure 118—Countersinking Tool

NOTE

Perfect countersinking is imperative for flush riveting. Through practice one will acquire good judgment and the ability to countersink holes properly with a minimum of trial and error.

(4) PRESS COUNTERSINKING OR DIMPLING.

Dimpling may be done by hand or with machine equipment by using proper dies. (See figure 119.) A set of dimpling dies must be used, that will fit whatever equipment is available.

(a) Check the male and female dies to see that they are of the correct angle for the rivets being used.

(b) Inspect the dies to see that they are not nicked or burred.

(c) Check the male punch adjustment.

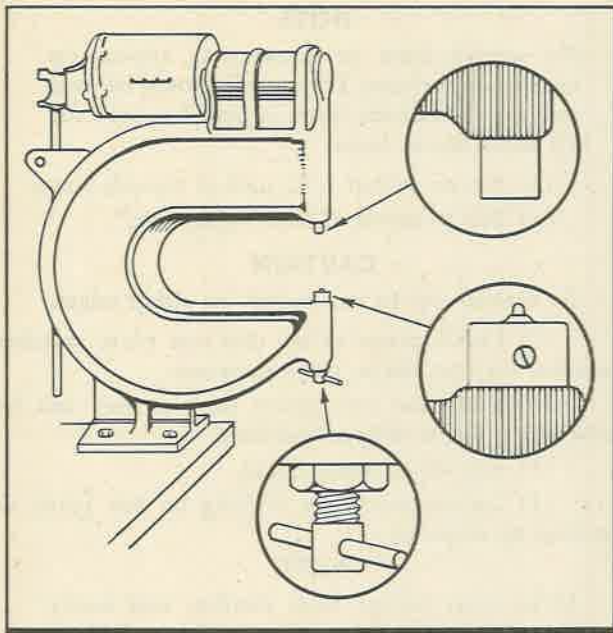


Figure 119—Pneumatic Squeezer

NOTE

If the punch is of the two-piece type, the large diameter of the punch should be flush with the face of the holder.

NOTE

If the punch is too high, the sheet will be ringed or bulged around the dimple. (See figure 120.) If the punch is too low, the dimple will not be deep enough. (See figure 121.)

(d) Adjust the male punch by removing it from the holder and adding or removing a spacing washer.

(e) When a bench squeezer is used, the female die is in the upper half of the squeezer, and the male punch in the lower half. (See figure 119.)

(f) Loosen the lock nut, and lower the adjustable punch holder until you are certain that the punch and die will not meet when the squeezer is closed.

(g) Over the male die, insert a practice piece of drilled skin of the same material and thickness as that to be used for the job.

(h) Close the squeezer by operating the control valve.

CAUTION

Keep fingers away from the dies when operating valve.

(i) Adjust the adjustable holder until the metal is tightly squeezed between the punch and die.

(j) Operate and adjust the squeezer until the head of a rivet fitted into the dimple is flush with the skin. (See figure 122.)

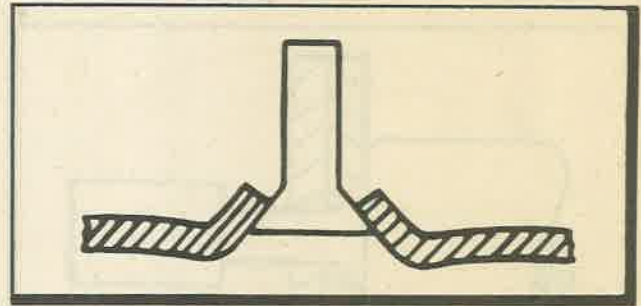


Figure 120—Punch too High

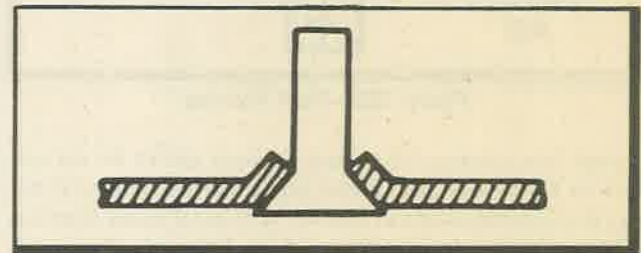


Figure 121—Punch too Low

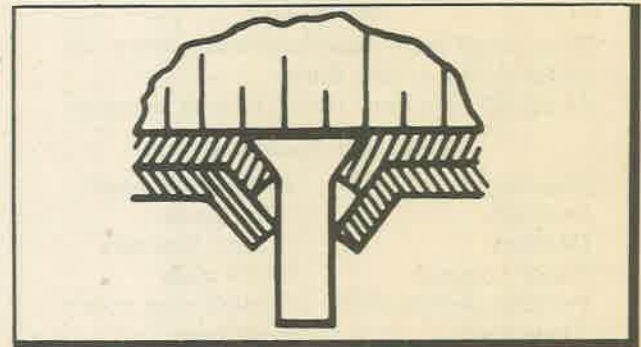


Figure 122—Testing Dimpled Hole

NOTE

Several changes in the adjustment may be necessary before a satisfactory dimple is obtained.

(k) Inspect the counterpressed hole to see that the material around it is not marred or distorted. The skin must be flat and straight after the dimpling is completed.

(l) Clean parts of all chips and burrs.

(m) Rivet skin to stringer or patch to skin using countersunk head rivets.

NOTE

A smooth, flat-faced bucking bar will be used on countersunk rivet heads. (See figure 123.)

8. TYPES OF RIVETING.

a. **HAND RIVETING.**—Although most aircraft riveting is done with power equipment such as pneumatic hammers and pneumatic squeezers, it is still necessary to set some rivets by hand because of the size and shape of the parts to be riveted and the impossibility of reaching the place except by hand. Hand riveting is also done on assemblies where only

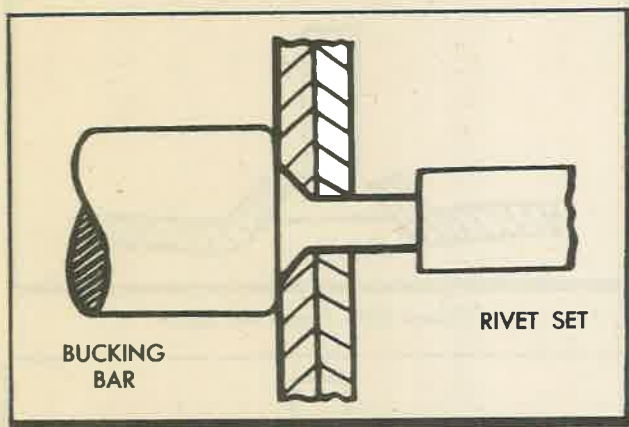


Figure 123—Flush Riveting

a very few rivets of a variety of sizes are to be driven, and in field work for minor repairs when power riveting equipment is not available. A typical hand riveting job would be to rivet two flat plates of aluminum together using figure 124 as a job sheet drawing.

Materials

Two pieces 24ST aluminum alloy, $4\frac{1}{2} \times 5\frac{1}{2}$ inches $\times$.040 or .050 thick.
35 A17ST flat head rivets, $\frac{1}{8}$ -inch diameter.

Tools and Equipment

Hand snips	Ball pein hammer
Steel rule	"C" clamps
Dividers	"Cleco" fasteners
Pencil compass	Bench plate
Portable electric drill	Combination square
Twist drills	Rivet gage
Rivet set (flat faced)	Pencil
Micrometer	Thickness gage

Procedure

- (1) Select stock, as indicated on job sheet.
- (2) Lay out two flat plates, as indicated on job sheet drawing.

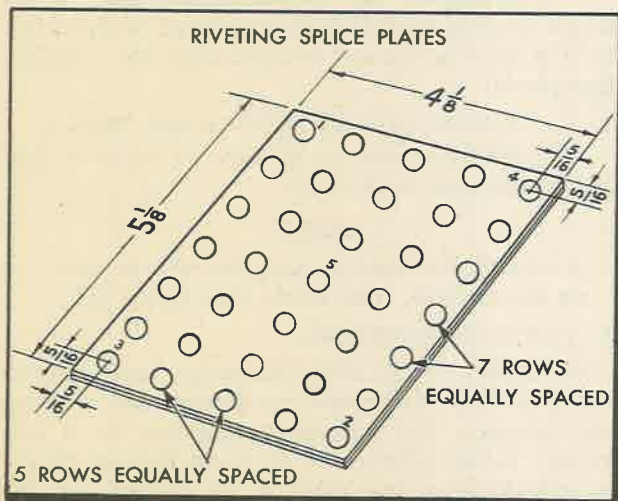


Figure 124—Riveting Splice Plates

NOTE

No scratch lines or marks may appear on aluminum surfaces. The scriber should be used only on the outside lines. A pencil is used for all other layout lines.

- (3) Cut to within $\frac{1}{32}$ inch of outside lines.
- (4) File to center of line—"split line."

CAUTION

Be careful not to cut fingers on sharp edges.

(5) Check plates to see that one plate matches the other for size, shape, and squareness.

(6) Mark the two plates so that they can be reassembled in the original position.

(7) File off all sharp edges.

(8) Locate points for drilling on one plate, as specified on drawing.

NOTE

Make rivet layout lines distinct and heavy enough (with pencil) to indicate drilling points clearly.

- (9) Clamp work for drilling. (See figure 125.)

NOTE

Place wood block under metal to avoid drilling holes in bench.

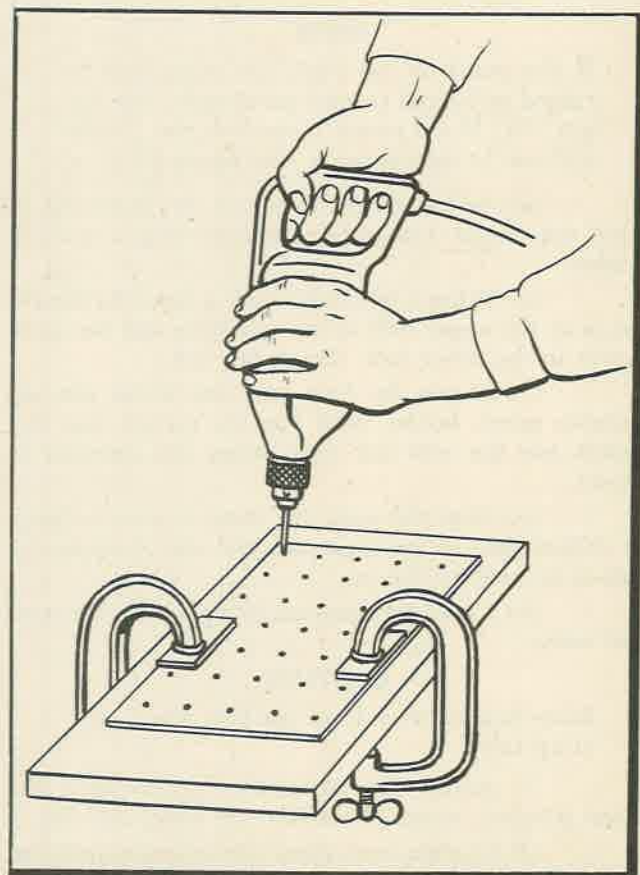


Figure 125—Drilling Flat Plate

NOTE

Plates to be drilled must be held so that they will not be bent when pressure is applied with the drill.

NOTE

Avoid marring soft materials with clamps, by placing pieces of fiber or other protective material between the clamps and the work.

(10) Center punch lightly all rivet locations.

(11) Drill pilot holes with No. 41 drill in one plate. (See figure 125.)

(12) Remove burrs and chips from holes.

NOTE

Care must be taken not to burr rivet holes too much. Only burrs and ragged edges should be removed.

(13) Fasten plates together with "C" clamps. (See figure 125.)

NOTE

Protect plates to avoid marring with clamps.

(14) Drill five holes for rivets through both plates as indicated in figure 125 using locating holes in top plate as guides.

NOTE

Refer to job sheet for size of rivet.

NOTE

It is common practice to drill holes for rivets slightly larger than the rivet body, to facilitate installation and to avoid possible damage to skin, or the formation of burrs under rivet heads that may be caused by forcing a rivet into place.

(15) Separate plates and clean out burrs and chips.

(16) Fasten plates together with "Cleco" fasteners at each corner and in the center. (See figure 126.)

(17) Complete all drilling for rivets.

NOTE

When large sheets are being drilled, it is advisable to separate the sheets to remove burrs and chips after every ten holes.

(18) Complete all burring and remove chips and grit.

(19) Reassemble plates with fasteners.

NOTE

Check to see that the plates are fitted as before.

(20) Insert proper size rivet in hole adjacent to one of the fasteners, indicated in figure 126.

NOTE

The proper size rivet should protrude through the metal not more than one and one-half times its diameter.

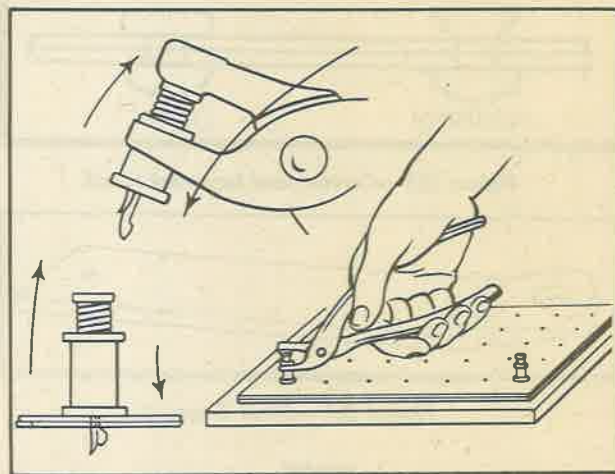


Figure 126—Installing Metal Fasteners

(21) Tap material lightly on each side of rivet to draw material together.

(22) Upset the body or end of the rivet with a flat-faced rivet set and hammer (figure 127) while the flat or commercial head is resting on the bench plate.

NOTE

The diameter of the developed head should be at least one and one-half times the diameter of the body of the rivet, and one-half as high.

NOTE

Drive rivets with as few short blows as possible to produce a perfectly formed head (figure 128) and to prevent hardening.

(23) Use rivet gage (figure 129), which may be made in the riveting shop, to check the developed head size.

NOTE

The gage will indicate whether the rivet is too long, or too short, or whether it is riveted too much.

(24) Drive the next four rivets adjacent to remaining fasteners.

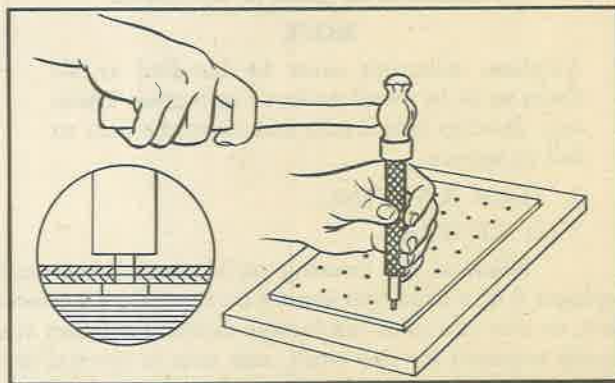


Figure 127—Hand Riveting

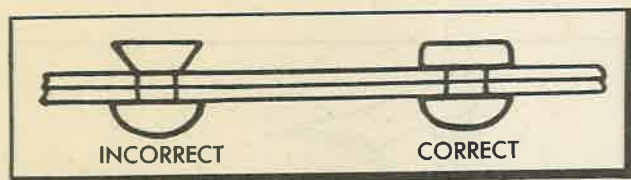


Figure 128—Correct and Incorrect Head

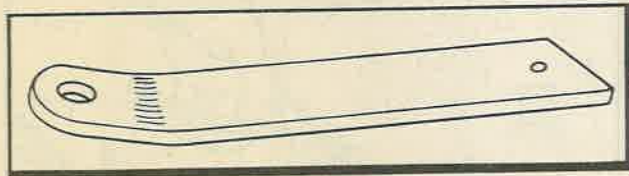


Figure 129—Rivet Gage

NOTE

Check each rivet head as it is developed. It is better not to rivet too much. If the check indicates that more riveting is necessary, it can be done. If the check indicates that the head is riveted too much, the rivet must be removed.

(25) Remove fasteners after rivets are in place to hold work.

(26) Drive all remaining rivets.

(27) Inspect finished job according to riveting standards, paying special attention to the following:

(a) Developed head diameter and height.

NOTE

Use gage. (See figure 129.)

(b) Centering of developed head over body.

NOTE

Rows of rivet heads should be in line both ways.

(c) Tightness of commercial head to metal.

NOTE

Use feeler gage.

(d) Clearance between the two plates.

NOTE

The plates must be flat with no clearance between them at any point.

(e) Scratches on metal or rivet head.

NOTE

Airplane materials must be handled at all times so as to avoid nicks or scratches. These may develop into cracks and cause the part to fail in service.

b. TEAM RIVETING.

(1) GENERAL.

Much of the riveting on airplane wings and fuselages is of a kind that cannot be riveted on a bench plate, or that one man can handle alone. Two men are usually required for this work; one man to operate the riveting hammer, and the other to handle the bucking bar. This is called *team riveting*. (See figure 130.)

In a typical system of team riveting, the riveting gun operator places the gun set on the rivet head. The buck-up man gives one tap on the rivet shank to indicate that he is ready. The rivet is then upset, or flattened, with one "burst" with the riveting gun. The buck-up man gives one tap after the riveting operation, if an additional extra short burst is necessary to complete the riveting. Two taps indicate that the rivet is satisfactory.

The bucking bar must be held firmly against the rivet until the riveting operation is finished.

The rivet head must not be pushed away from the work by too much pressure on the bucking bar.

The bucking bar must be held squarely on the rivet to avoid bending the rivet shank with the first blows, or marring the material around the rivet with the final blows.

(2) PROCEDURE.

(a) Select a pneumatic riveting hammer.

(b) Connect riveting hammer to air line.

NOTE

Be sure that the air line is free from grit or dirt.

CAUTION

Be sure that the air line is securely fastened before opening the air valve.

(c) Select a rivet set which has the correct shank to fit the hammer and is properly formed to fit the head of the rivet being used.

(d) Insert the rivet set in the hammer.

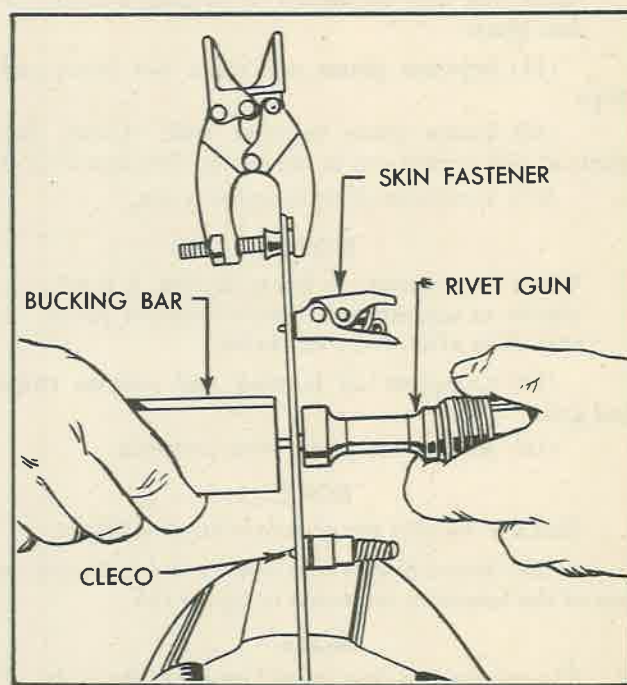


Figure 130—Team Riveting

CAUTION

Be sure that the retaining spring is in place, to avoid the possibility of the set being blown from the gun if the trigger is accidentally pressed.

(e) Place the rivet set against a block of wood and adjust the riveting hammer to the desired speed, or B.P.M. (blows per minute). (See figure 131.)

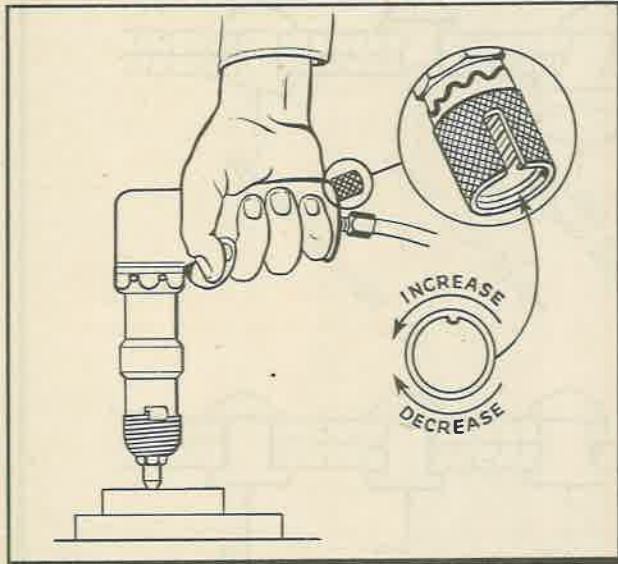


Figure 131—Adjusting Riveting Hammer

CAUTION

Do not point the hammer at anyone.

NOTE

The operator should become accustomed to the vibrating action of the gun before attempting to set a rivet.

(f) Place the gun set on the rivet head, and apply a firm pressure.

NOTE

Hold the gun set at right angles to the material. Failure to do this may mark the rivet head, or leave a ring or dent on the material surrounding the rivet. (See figure 132.)

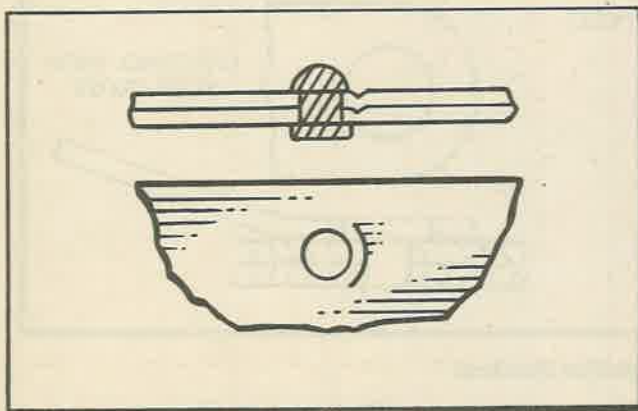


Figure 132—Skin Damaged by Gun Set

NOTE

Never operate the gun until the man with the bucking bar indicates by one tap that he is ready.

NOTE

The duration of the riveting should be neither too long nor too short. It is better to be on the short side since the gun may be applied again, whereas a long riveting action may damage the work.

NOTE

Stop the hammer before taking the gun off the rivet, as failure to do so may damage the material or jam the plunger.

NOTE

Do not allow the bucking bar to shift around or tip during the riveting operation, or faulty rivet heads will result.

NOTE

The bucking bar must not be removed from the rivet while the hammer is in operation, even though the rivet is not being properly upset.

NOTE

Place the bucking bar along side the rivet, if necessary, to draw the material together. A very short gun blow is enough.

(g) Set the first rivet when the buck-up man signals that he is ready.

NOTE

The gun operator should try to govern the duration of the operation so that the rivet is upset in one "burst." This is the most rapid and efficient method of riveting.

(b) Tap the rivet twice with the bucking bar if the formed head is satisfactory.

(i) Place the bucking bar against the rivet, and tap the rivet once if more riveting is needed. The riveter will then give an additional short "burst" with the riveting hammer.

(j) Inspect each rivet after it is driven. (See figure 133.)

9. IMPORTANT RULES TO OBSERVE WHEN REPAIRING AIRPLANE METAL STRUCTURES.

a. Any part of aircraft structure that has been torn or buckled can never be depended upon to carry its full load again, no matter how well it has been straightened. It must be replaced or reinforced with another piece, equal to its strength.

b. Particular care must be taken in selecting the proper material for each minor or major repair. Never use scrap metal not properly identified.

c. Detail parts must be held together for riveting by cleco fasteners, to prevent the rivet from spreading between the parts.

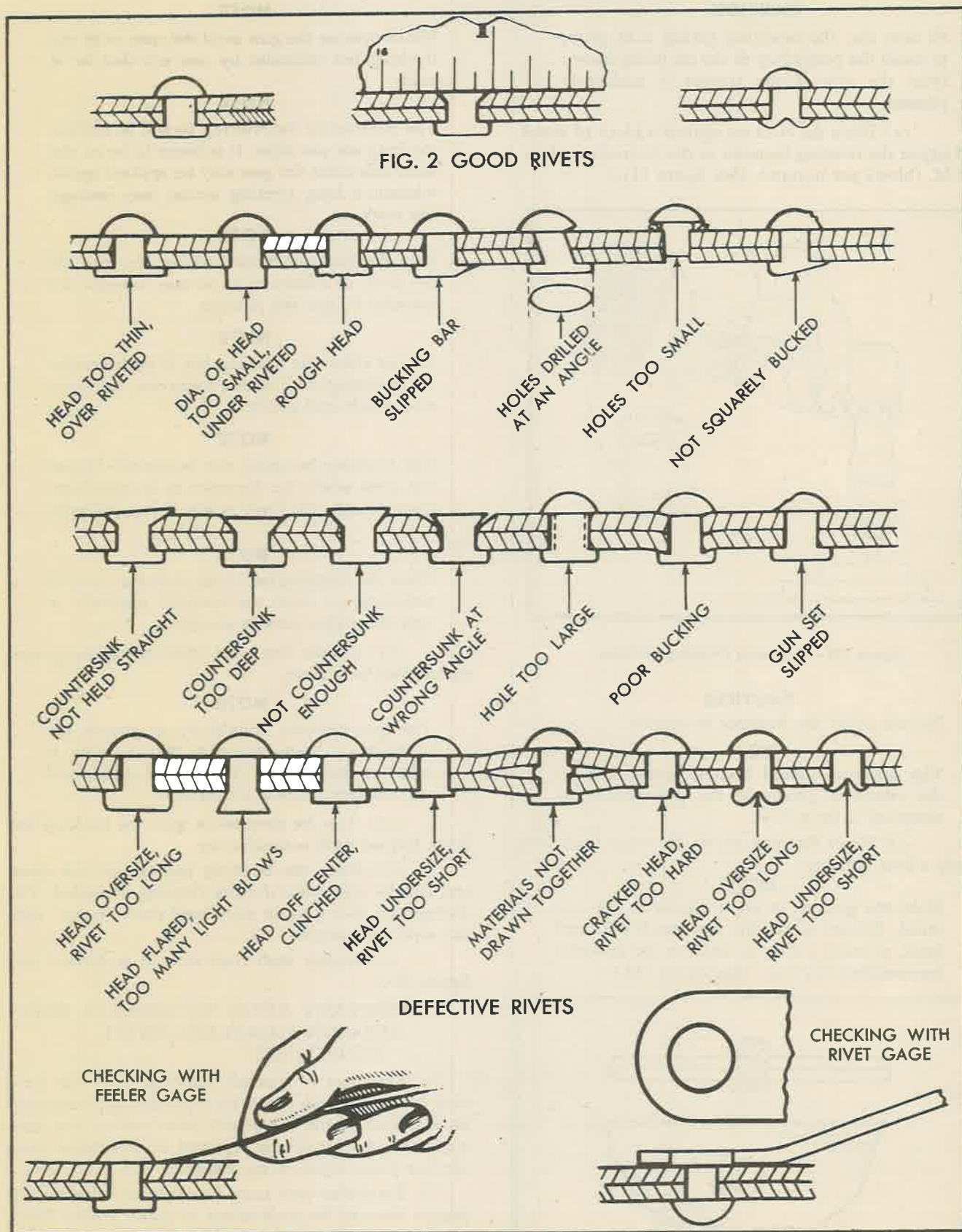


Figure 133—Rivet Inspection Standards

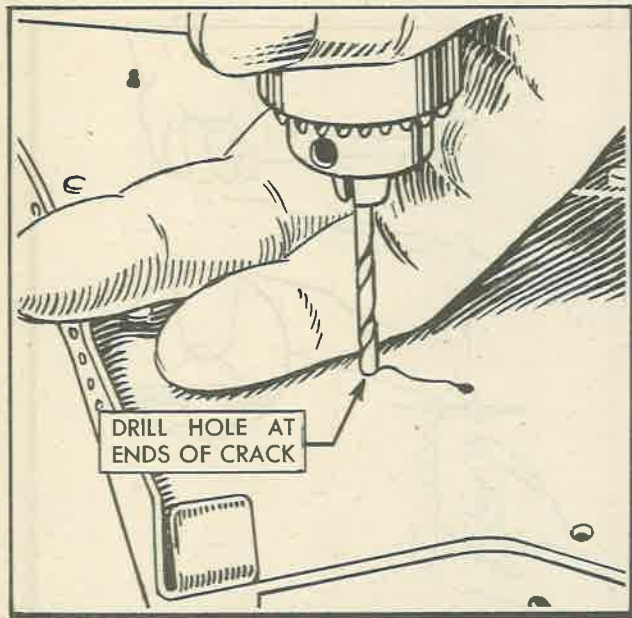


Figure 134—Arresting Growth of Crack

d. Before patching a crack in a member, drill a small hole at the end of crack to prevent further crack-
ing. (See figure 134.)

e. Extreme care must be taken in drilling out rivets to avoid distorting hole in members. A distorting rivet hole will result in poorly started rivets. The head of rivets should always be drilled with a drill slightly smaller than the rivet shank. Drill to approximate depth of rivet head before attempting to knock-off head.

f. Rivets should be regularly and equally spaced. Rivet size and spacing should be as nearly as possible like the original at points in the adjacent critical area.

g. The centers of rivets should not be placed nearer to the edge of either skin or patch than two times the thickness of rivets.

b. If more than one row of rivets is used, rivets in adjacent rows should be staggered.

i. The diameter of the rivet should not be more than $2\frac{1}{2}$ times the thickness of the metal joined. The diameter should not be less than that of thickest plate through which it is driven. Strict adherence to this rule is not demanded in all cases. Exceptions are per-

mitted under certain circumstances.

j. The proper lengths of rivets are obtained from the drawing of the particular member to be repaired. If the repaired member is different from the original, additional rivet lengths must be allowed to take care of extra thickness of material and any increase in size of the rivet holes. (See figure 135.)

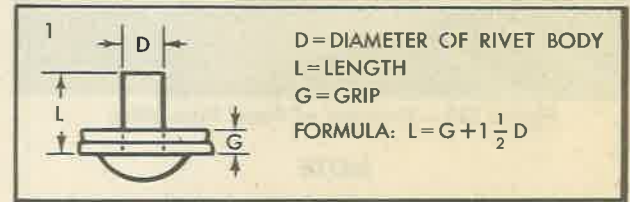


Figure 135—Rivet Sizing

k. Ice box rivets must be kept in dry ice containers, and not used after exposed to room temperature over 30 minutes.

l. In replacing stress skin, the patch or doubler plate should be not greater than one gage heavier than the skin. As the size of the cut-out increases, the gage of the patch should increase accordingly.

m. Whenever two or more openings, reasonably close together, are cut into the skin in the same line of stress, the use of a single double plate is recommended to reinforce the openings.

n. The strength of rivet and skin should be the same. Do not use $\frac{1}{4}$ rivets in .025 skin. The shear value of the rivet and tear strength of skin should be nearly alike as possible.

o. In order to avoid stress concentration in repairs, joints should be broken, rivet lines tapered off, and, wherever possible, patches on holes should be curved or rounded off on edges and corners.

p. Remember that when a rivet job is perfect, it is possible to obtain 100 percent of the original strength. Therefore, it is obvious that all work be well planned and a high standard of workmanship maintained.

q. The use of riv-nuts for repairs is undesirable and will not be used unless absolutely necessary.

r. Don't guess. Know what you are doing, and why you are doing it before you start to cut or drill. If you don't know, ask someone who does.

SECTION VIII REMOVING AIRCRAFT RIVETS

1. REMOVING PANEL FROM WING.

In making aircraft surface repairs it frequently becomes necessary to remove a section or panel from the wing or fuselage. (See figure 136.) To do this, it will be the job of the mechanic first to remove all the rivets which hold the section or panel to the stringers or formers underneath. Rivets are removed by drilling

off the heads and punching them out. They should not be cut off with a cold chisel as this will result in enlarging the hole.

2. PROCEDURE.

a. Center punch the rivet head if it is not dimpled. "Buck-up" thin material. (See figure 137.)

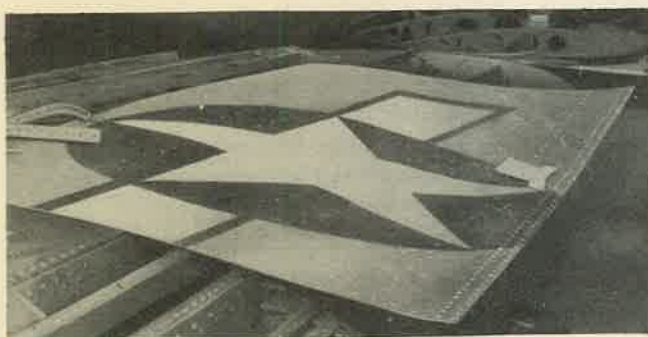


Figure 136—Removal of Panel from Wing

NOTE

An experienced mechanic can usually locate the drill in the rivet head without center punching, by turning the chuck by hand.

b. To allow for error in misjudging center of rivet head, select a drill slightly smaller in diameter than the rivet shank is assumed to be.

c. Place the drill point in the center punch mark, or start the chuck by hand.

d. Hold the drill straight, and drill just enough to get the hole started in the rivet head. (See figure 138.)

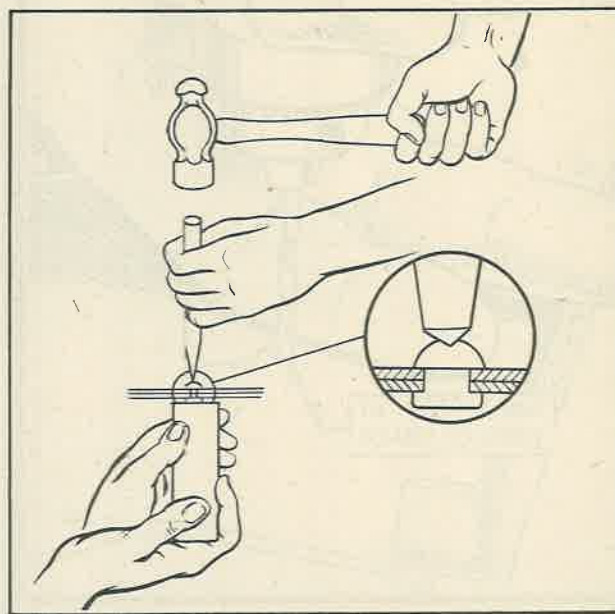


Figure 137—Counterpunching Rivet Head



Figure 138—Drilling Rivet Head

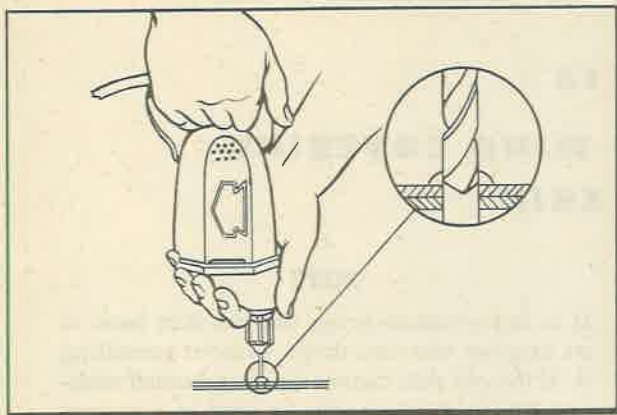


Figure 139—Drilling Rivet Head (close up view)

NOTE

Be careful not to mar riveted surfaces by letting the drill slip.

e. Remove the drill. Check to see whether the hole is centered in the rivet head.

NOTE

If the hole is not started in the center, it can be shifted by tilting the drill opposite to the directions in which it is desired to move the hole.

f. Continue drilling, checking frequently for centering and depth, until the hole is just drilled through the head to the body of the rivet. (See figure 139.)



Figure 140—Removing Rivet Head with Punch

NOTE

Avoid the possibility of enlarging the hole by being careful not to drill too far.

g. Remove head with punch by flipping it out. (See figure 140.)

b. Drive body of rivet through material. (See figure 141.)

NOTE

Make certain that no one will be struck by the rivet as it is driven out.

NOTE

"Buck-up" on the opposite side to avoid distorting light materials.

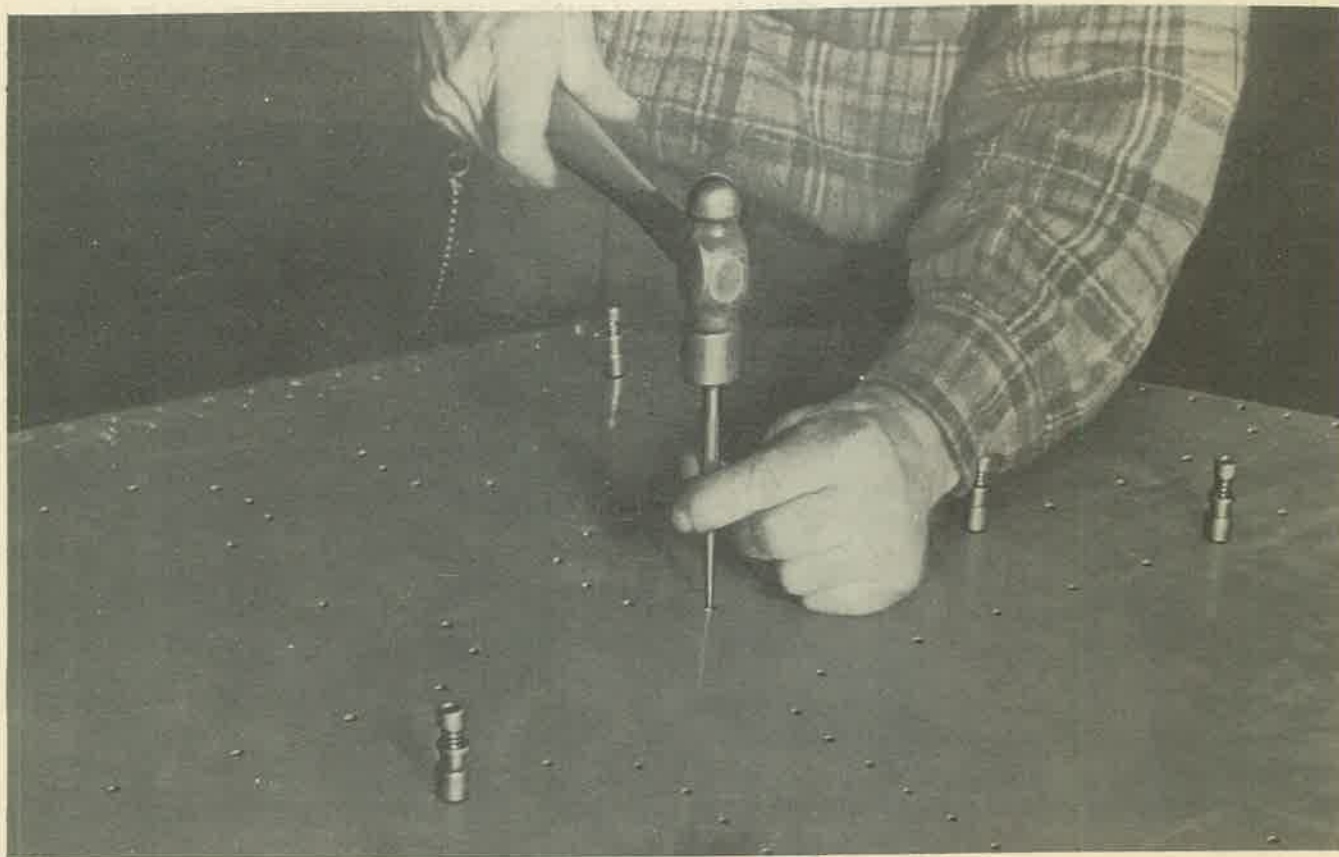


Figure 141—Driving out Rivet

SECTION IX

REPLACING SECTION OF WING COVERING WITH NEW SKIN

1. WING COVERING REPAIR.

When only a part of a wing covering is damaged, cut out the damaged section and replace just that section with a new sheet. If the bulkheads, ribs, or stringers are not damaged, or the damage can be easily repaired, the old rivet holes in them can be used again. This necessitates drilling holes in the new skin, that have exact alignment with corresponding holes in the framework. To do this the old skin is used for a pattern, not only for the rivet holes, but also for the shape of the damaged section of the wing to be replaced.

2. PROCEDURE.

- a. Drill out attaching rivets. Remove skin.
- b. Determine type and thickness of old skin. Obtain new material.
- c. Inspect old skin to determine if it can properly be straightened without annealing it.
- d. If annealing is necessary, it should be accomplished before the straightening is begun.
- e. Place the skin on the floor, or a smooth bench, and use a mallet to smooth out bumps or other deformed places.

NOTE

It is important to bring the old skin back to its original size and shape without stretching it. If the old skin cannot be straightened without stretching, it cannot be used as a pattern because the holes would not have the proper alignment. Usually where the skin is damaged beyond use as a pattern, the frame work must be replaced. In most cases, however, all but a few of the old holes can be transferred.

f. Inspect the old skin for burrs or sharp edges of any kind that may scratch the new sheet.

g. Remove all sharp edges and burrs, cutting out the more severely damaged portions if necessary.

b. Place the sheet on a drill board, with the old skin on top. (See figure 142.)

NOTE

The drill board may be a single board, or several fastened together, forming a smooth surface. A piece of plywood may also be used for the drill board. The object of the drill

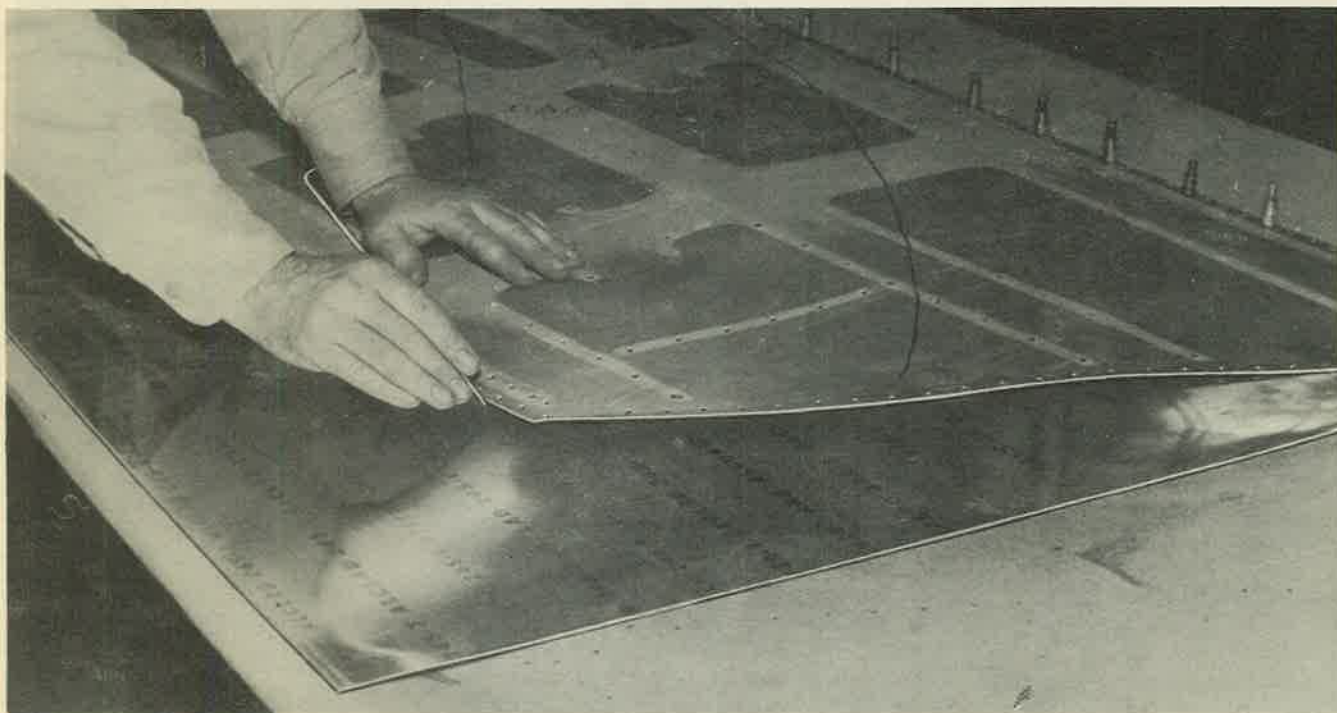


Figure 142—Using damaged Panel as a Pattern

board is to form a flat surface for the punching and drilling of the new skin.

i. Place weights on the sheets so that they are held flat on the board, and so that there will be no space between the sheets.

j. Select the right size lay-out punch for the holes in the old skin, and insert it into the old rivet holes.

k. Hit the lay-out punch with a hammer, taking care not to hit hard enough to cause the new sheet to become dimpled or stretched out of shape around the punch mark.

l. Proceed to punch all the holes in this manner.

NOTE

Be careful not to move the sheets if it becomes necessary to move any of the weights; because if you do, you will throw the holes out of alignment.

m. Drill a hole at each of the punch marks, starting at center and working out to sides and ends, at the same time smoothing sheet as work progresses.

NOTE

After first few holes are drilled, fasten sheets together with cleco fasteners.

NOTE

The pilot hole is one rivet size smaller than the size rivet to be used. For a $3/32$ -inch rivet, use a $1/16$ -inch pilot hole; for a $1/8$ -inch rivet, use a $3/32$ -inch pilot hole; for a $5/32$ -inch rivet, use a $1/8$ -inch pilot hole; for a $3/16$ -inch rivet, use a $5/32$ -inch pilot hole.

n. Mark around old skin with scriber. (See figure 131.)

NOTE

Here the old skin is used as a pattern, so it is important that the outline of the old skin be followed exactly.

o. Remove all fasteners. Cut new skin along scribed lines.

p. Place the new skin on the framework. Line up the pilot holes with each of the corresponding rivet holes.

q. Clamp the sheet in place with cleco fasteners. (See figure 143.)

NOTE

In duplicating holes from frames to skin, extreme care must be exercised or both frame and skin may be ruined. Since most bulkheads, ribs, and stringers depend on the skin for some of its rigidity, they can easily be forced out of alignment in the drilling process. The skin must be firmly against the framework, or the pressure from the drilling will force it away from the frame and cause the holes to be out of alignment.

This is overcome by placing a block of wood



Figure 143—Clamping Panel in Place with Cleco Fasteners

on the skin and holding it there firmly while drilling. The wood also prevents injury to workmen, who may be working near the place where the drill comes through.

NOTE

Great care must be taken to drill at a 90 degree angle to the skin, or the holes will be elongated and out of alignment. The workman must make sure the drill is in the holes in the frame before starting the drill. In most cases, especially if the structure is large, a helper is required to hold the wooden block.

r. Drill one hole in the corner or center of the sheet, being sure to support the skin with a block of wood on the side opposite the drill.

s. Install a cleco clamp in the hole which is drilled.

t. Holding the block of wood against the skin again, drill another hole from the frame to the skin.

u. Install a cleco in the second hole.

v. Repeat this process until the skin is securely fastened.

NOTE

The skin will be considered securely fastened when clecos have been installed around the edges and throughout the sheet every four or five inches. To fasten the skin, start at the center, and work out both ways; or start at one end, and work to the other end. In either case, make sure the skin lies against the frame smoothly.

w. Finish duplicating holes with a drill motor or air-angle drill.

NOTE

If an angle drill has to be used, it will be necessary to use a mirror; or by "feel," locate the twist drill in the hole in the frame.

- x. Remove the skin for the burring and cleaning.

NOTE

When it is impossible to duplicate holes from the frame to skin with a drill, it can be done with a duplicating punch backed up solidly by a block of wood on the opposite side of the sheet.

- y. Replace skin. Secure with cleco fasteners.

- z. Drive all rivets. (See figure 144.)

aa. Inspect the rivets. Replace wherever necessary. (See figure 133 for riveting inspection standards.)

(1) Condition of the manufactured or commercial head.

(a) Destruction of protective coating or cracked head.

(b) Deformed or marred head.

(c) Countersunk head not flush.

(d) Commercial head not tight against material.

(2) Condition of developed head.

(a) Head of improper height or diameter.

(b) Head marred or cracked.

(c) Head distorted or out of line (off center).

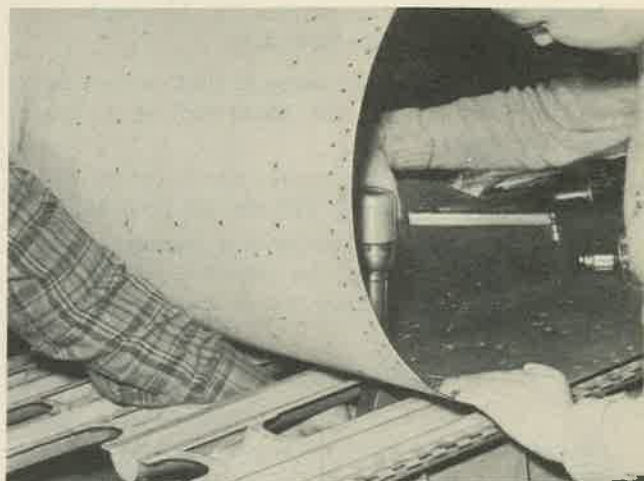


Figure 144—Riveting New Panel to Frame

(3) Condition of skin or structural members.

(a) Hole too small or too large.

(b) Hole elongated.

(c) Holes out of line.

(d) Marred surfaces.

(e) Parts not drawn together.

(f) Stretched material (oil cans).

SECTION X

RIVETING PATCHES TO SKIN

1. OCTAGON TYPE STRESSED SKIN PATCH.

(See figure 145.)

In performing this and the following riveting jobs, if a section of a wing or fuselage is not available, a large sheet of aluminum should be placed in a strong frame, and this used as the skin of an airplane. Trainees will work in two-man teams on these assignments. They should take turns bucking and riveting and each should do a part of all operations. (See figure 146.)

a. MATERIALS.

One piece of 24ST aluminum alloy 7 x 5½ inches. x .040 or .050.

32 A17ST round-head rivets ⅛ inch in diameter.

b. TOOLS AND EQUIPMENT.

Riveting hammer	Hand snips
Bucking bars	Pencil compass
Rivet set	Pencil
Drill motor and drills	Straight edge
Burring tools	Dividers
Files	Hammer
Rivet gage	Combination square

c. PROCEDURE.

(1) Check the damage to determine the size and shape of the patch to be used.

NOTE

Assume tear to be 2¼ x ½ inches before cleaning away broken edges.

NOTE

Let patch be same shape as shown in figure 134.

(2) Remove all paint from the damaged area, and examine carefully for any cracks or tears radiating from the edges of the break.

(3) Trim away with shears or hack saw all ragged edges so as to form a symmetrically shaped hole all the way around. (See figure 146.)

NOTE

Assume break, after cleaning away ragged edges, to be 2½ x ¾ inches.

(4) Select stock as specified, and layout patch 5 x 6¼ inches.

(5) Cut out patch.

(6) Chamfer all edges 45 degrees.

(7) Locate rivet holes on patch and drill with No. 40 drill.

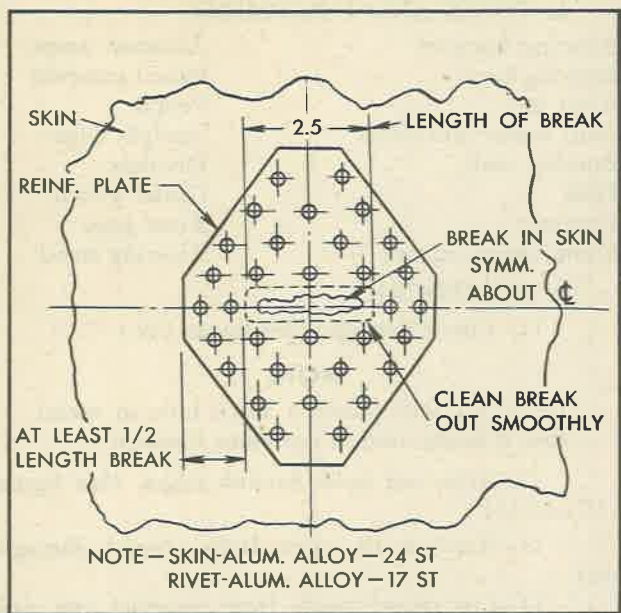


Figure 145—Octagon Type Patch



Figure 146—Patching Stressed Skin

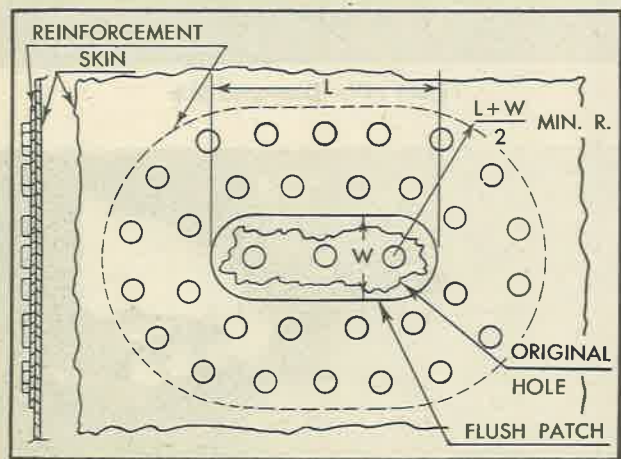


Figure 147—Flush Type Patch

NOTE

Rivet edge distance to be no less than $2\frac{1}{2}$ x rivet diameter. Rivet spacing to be $\frac{3}{4}$ inches.

(8) Remove all burrs.

(9) Transfer hole locations to skin. Drill with No. 30 drill, fastening with cleco fasteners as drilling proceeds.

NOTE

Be sure the patch sets firmly against the skin, or else the holes will be found out of alignment when riveting is started.

NOTE

Drill will be much easier if a block of wood is held against the metal from the inside.

(10) Take off patch. Remove burrs.

(11) Replace patch. Fasten with clecos.

NOTE

If the patch is to be watertight, it will be necessary to place a layer of mercerized cotton fabric, soaked in a suitable cement, between the patch and the metal being riveted.

(12) Rivet patch to skin.

(13) Inspect the rivets. Replace wherever necessary. (See figure 133 for riveting inspection standards.)

(14) Submit to instructor for approval.

2. FLUSH TYPE PATCH. (See figure 147.)

Flush patching together with flush riveting is practiced wherever possible because of the reduced air resistance to this type of patch and riveting. It consists of the patch being riveted to the inside of the structure, and a plug or filler inserted in the hole or break in the skin. This plug or filler is riveted to the patch with countersunk rivets.

a. MATERIALS.

One piece of 24ST aluminum alloy 7 x $5\frac{1}{2}$ inches x .040 for patch.

One piece of 24ST aluminum alloy 4 by 3 inches for plug (gauge to be one gauge heavier than skin).

Aluminum alloy A17ST countersunk head rivets $\frac{1}{8}$ inch.

b. TOOLS AND EQUIPMENT.

Pneumatic Riveting
Hammer
Bucking bar
Rivet set
Electric drill motor
Twist drills
Burring tools
Files
1" Micrometer
Rivet gage

Hand snips
Pencil compass
Pencil
Straight edge
Dividers
Metal fasteners
Hammer
Combination square
Riveting stand

c. PROCEDURE.

(1) Check the damage to determine the size and shape of the patch to be used.

NOTE

Have instructor set size of break.

(2) Remove all paint, if any, from around the damaged area.

(3) Trim away with shears or hack saw all rugged edges so as to form a symmetrically shaped hole.

(4) Smooth edges carefully with file.

(5) Select stock 10 percent heavier than skin from which to cut patch.

(6) Cut out plug or filler of same gage as skin being repaired.

(7) Smooth edges with file.

(8) Locate rivet holes on patch, and drill with No. 40 drill.

(9) Transfer hole locations to skin, and drill with No. 30 drill.

(10) Countersink holes in skin.

(11) Rivet patch to skin with specified rivets.

(12) Locate holes in plug, and drill.

(13) Rivet plug to patch.

(14) Inspect all rivets. Replace where necessary.

(15) Submit to instructor for approval or disapproval.

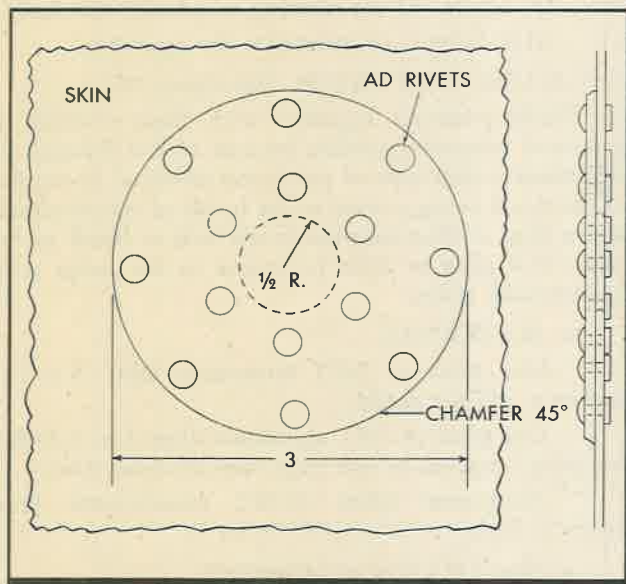


Figure 148—Layout for Small Round Patch

3. ROUND-TYPE PATCH.

The *round-type patch* is generally used for small holes. They can be either an outside patch or a flush patch, depending upon their location. Using the riveting stand, apply an outside patch to cover a hole $1\frac{1}{4}$ inches in diameter. (See figure 148.)

a. MATERIALS.

One piece of 24ST aluminum alloy $3\frac{1}{2} \times 3\frac{1}{2}$ inches.

14 A17ST $\frac{1}{8}$ -inch rivets.

b. TOOLS AND EQUIPMENT.

Riveting hammer
Bucking bars
Rivet set
Drill motor and drills
Burring tools
Files
Hammer
Combination square

Aviation snips
Pencil compass
Pencil
Straight edge
Dividers
Center punch
Rivet gage
Riveting stand

c. PROCEDURE.

(1) Check damage. (See figure 149.)

NOTE

Instructor will punch a small hole in metal that is being used to represent fuselage.

(2) Trim out hole. Smooth edges. (See figures 150 and 151.)

(3) Remove all paint from around damaged area.

(4) Cut round patch from material one gage heavier than skin.

(5) Chamfer edge 45 degrees.



Figure 149—Damaged Skin



Figure 150—Trimming Out Hole

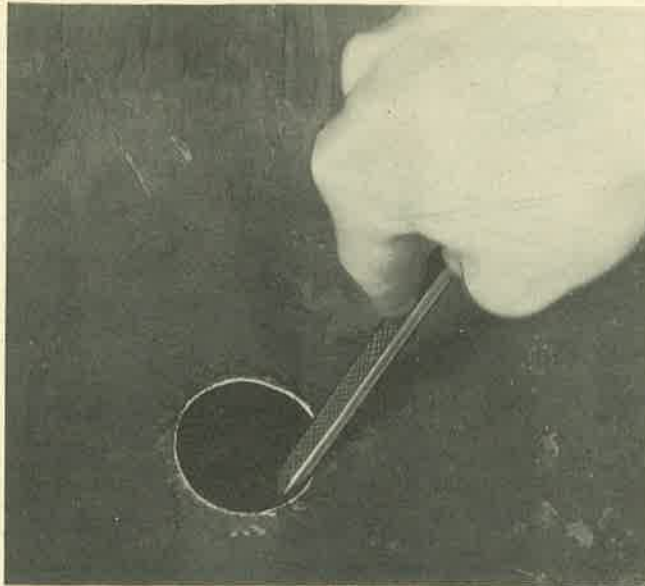


Figure 151—Smoothing Edges

NOTE

Patch should overlap hole at least $1\frac{1}{4}$ inches (the width of the hole).

(6) Locate rivet holes on patch. Drill with No. 40 drill.

NOTE

Rivet edge distance to be no less than $2\frac{1}{2}$ x rivet diameter.

NOTE

Rivet spacing to be no less than 8 x rivet diameter in outer row and 6 x rivet diameter in inner row.

(7) Remove all burrs.

(8) Transfer hole locations to skin. Drill with No. 30 drill, fastening with cleco fasteners as drilling proceeds.

(9) Take off patch. Remove burrs.

(10) Replace patch. Fasten with clecos.

(11) Rivet patch to skin.

(12) Inspect rivets. Replace where necessary.

(13) Submit to instructor for approval.

4. ROUND FLUSH TYPE PATCH.

Using the same size patch as in job just completed, proceed with the application of a flush-type patch (figure 152). Bear in mind that in this type of patch, the patch is riveted to the inside of the skin with countersunk rivets, and that a plug or filler is inserted in the hole and riveted to the patch. The patch should be one gage heavier than the skin, while the plug or filler should be the same gage.

Upon completion, submit to the instructor for approval.

5. RIVETING WING BEAM.

Modern airplane design employs many types of built-up structures. The use of thin skin, reinforced with suitable extruded or formed flanges, is one method

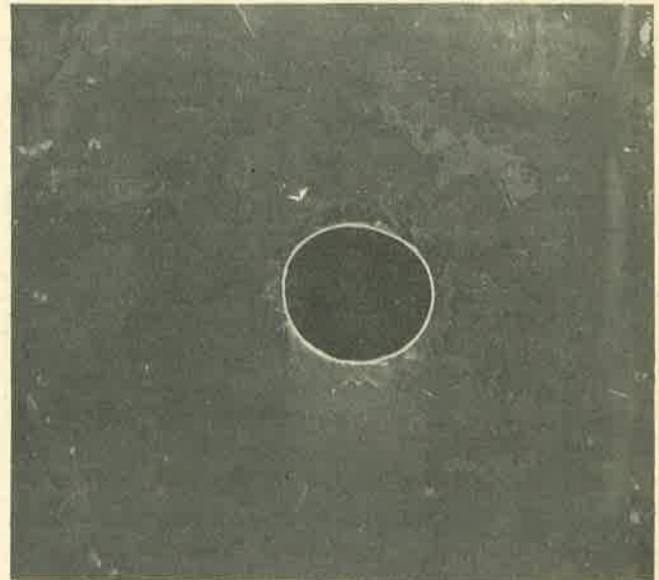


Figure 152—Ready for Patch

of making an airplane wing beam which combines strength with light weight. It is the purpose of this exercise to show the use of extruded or formed stringers, and to teach the use of identification marks in aircraft construction.

a. MATERIALS.

One piece of 24ST aluminum alloy, 6 x $20\frac{3}{4}$ x .040 or .050 inches thick (Web).

One piece of "L," bulb, or "Z"-shaped stringer stock 30 inches long.

Two pieces of "L"-shaped stock 21 inches long.

A17ST round head rivets $\frac{1}{8}$ inch diameter.

b. TOOLS AND EQUIPMENT.

Portable rivet squeezer

Rivet sets

Straight edge

Steel scale

Steel square

File

Electric drill motor

Twist drills

Pencil compass

Pencil

Metal fasteners

Hand snips

"C" clamps

Burring tools

Hack saw

c. PROCEDURE. (See figure 153.)

(1) Select stock for web, right-angle sections, and stiffeners, as specified.

(2) Lay out the web, stiffeners, and angle sections, as shown in drawing.

(3) Cut the web to size with hand snips.

(4) Cut the right angle sections and stiffeners to length with a hack saw.

(5) Finish to size. Burr all edges and ends of parts with a file.

(6) Check all edges for straightness, and all corners for squareness.

(7) Check to see that all parts fit flush with each other and that the dimensions are accurate.

(8) Lay out all rivet holes on web. (See figure 154.)

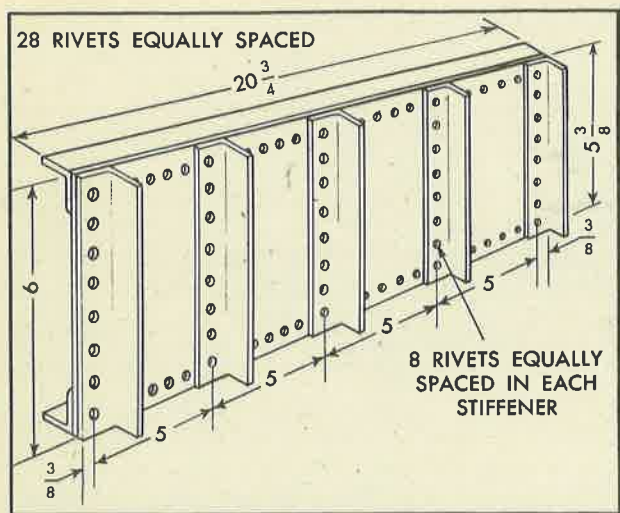


Figure 153—Riveting Wing Beam

NOTE

Edge distance is specified on drawing. The rivets may be spaced in the row from three rivet diameters to as much as $1\frac{1}{8}$ inches.

NOTE

All the rivets should be evenly spaced so that the stiffeners will be correctly located on the web.

- (9) Drill all rivet pilot holes in the web.

NOTE

Pilot holes are drilled smaller than the actual rivet size. A No. 40 drill is used to drill pilot holes for $\frac{1}{8}$ -inch rivets.

- (10) Burr all pilot holes.

- (11) Clamp right-angle longitudinal sections in their proper positions on the web.

NOTE

Stringers may be located by having one side flush with the edge of the web, or by drawing a pencil line lengthwise along the back of the "L" section. This line is to be centered through the pilot holes in the web.

NOTE

Avoid marring material with clamps, by using fiber or paper washers between clamps and washers.

- (12) Check all parts for flush fit at the ends and edges.

- (13) Drill a fastener hole next to each clamp, and one approximately in the center of the longitudinal stringer. (See figure 154.)

- (14) Install fasteners and remove clamps.

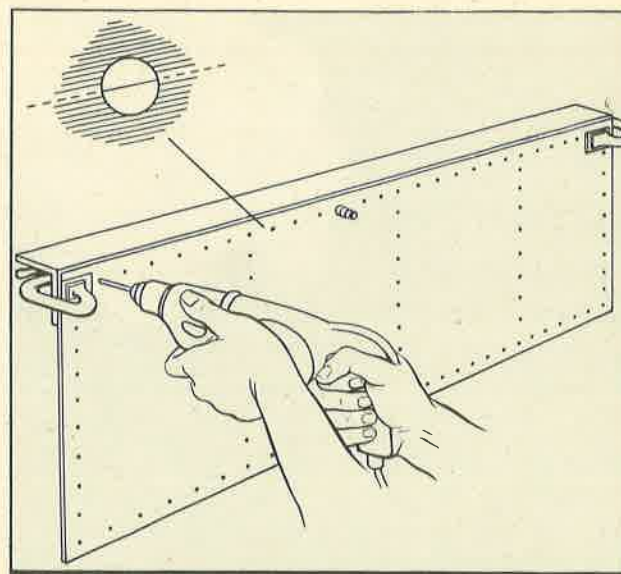


Figure 154—Locating Stringer and Drilling Fastener Holes

NOTE

On airplane structures, the fasteners should not be more than one foot apart; they may be closer when necessary to prevent buckling of the parts of an assembly.

- (15) Clamp stiffeners in position so that the ends are flush with the web.

NOTE

Locate stiffeners by drawing a line along the back, through the rivet center locations. Install stiffener so that the line will center through the pilot holes in web.

- (16) Drill a fastener hole at each end of each stiffener, through the web and angles. (See figure 155.)

- (17) Install 10 fasteners (figure 156). Remove clamps.

- (18) Finish drilling all rivet holes.

- (19) Mark all parts for identification and locations, as "Top," "Bottom," "Left," "Right," "A," "B," "C," etc.

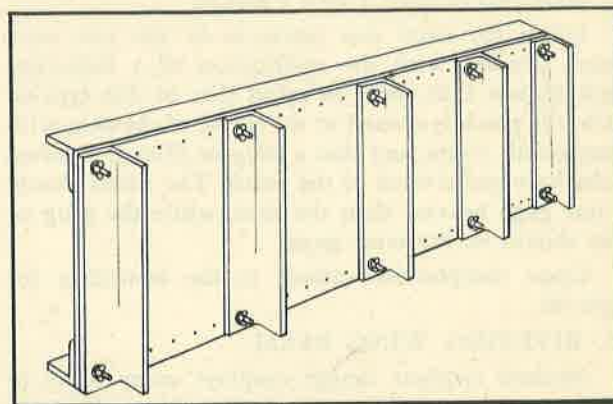


Figure 155—Stiffeners Located and Held with Fasteners

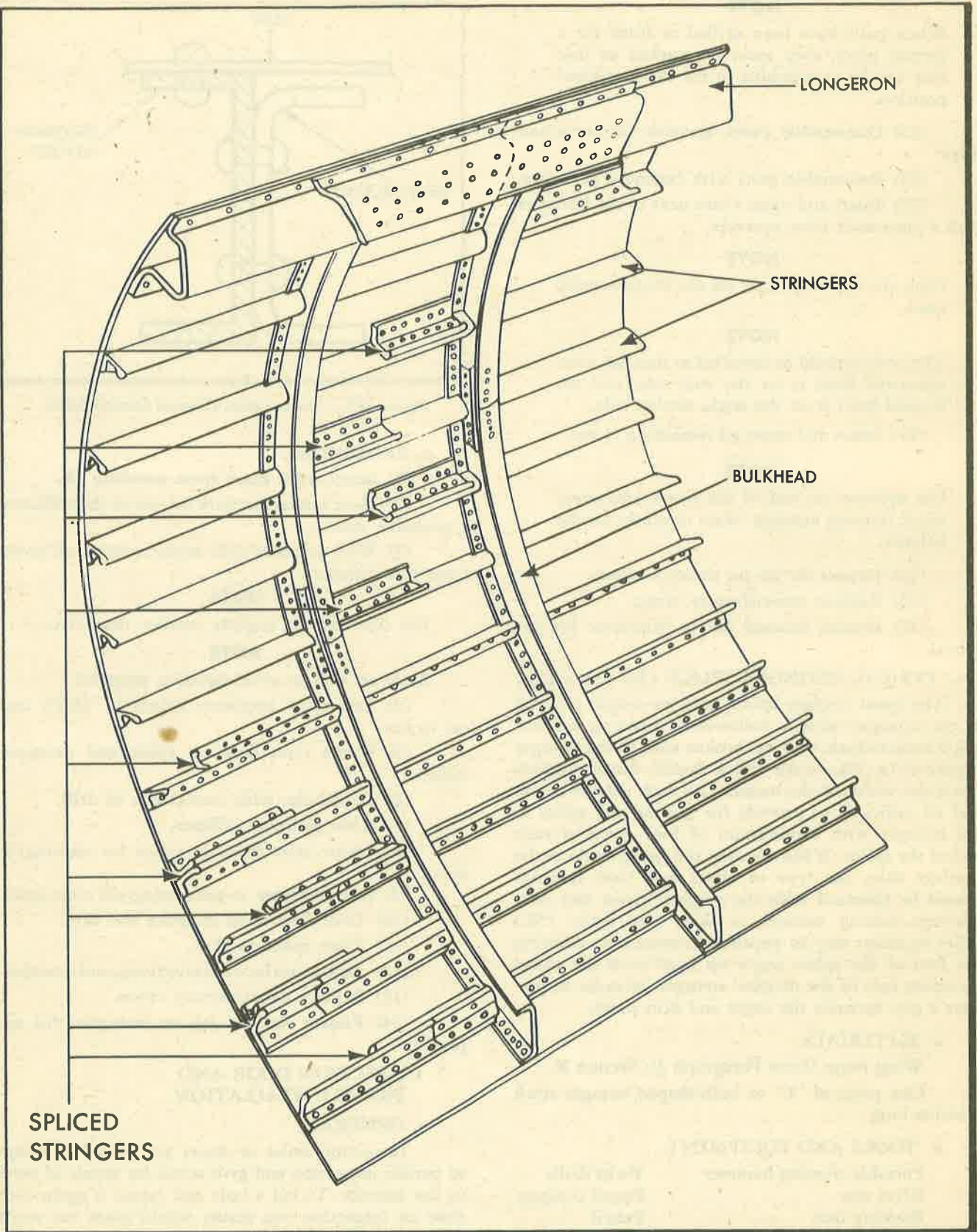


Figure 156—Spliced Stringers

NOTE

When parts have been drilled or fitted for a certain place, they must be marked so that they can be reassembled in the exact original position.

(20) Disassemble parts. Remove all burrs and chips.

(21) Reassemble parts with fasteners, as before.

(22) Insert and upset rivets next to the fasteners with a pneumatic rivet squeezer.

NOTE

Place the cup-shaped set on the manufactured head.

NOTE

The rivets should be installed so that the manufactured head is on the web side, and the formed head is on the angle section side.

(23) Insert and upset all remaining rivets.

NOTE

Use squeezer on half of the rivets, and pneumatic riveting hammer (team riveting) for the balance.

(24) Inspect the job for defective rivets.

(25) Replace unsatisfactory rivets.

(26) Present finished job to instructor for approval.

6. TYPICAL STRINGER SPLICE. (See figure 156.)

The usual stringer splice involves simple removal of the damaged section, followed by riveting a splice angle back-to-back with the broken ends of the stringer (figure 157). The repair splice should extend at least twice the width of the member on each side of break, and be sufficient to provide for joining the splice to the stringer with a minimum of four rivets at each end of the splice. When riveting the splice angle to the fuselage skin, the type of rivets and rivet spacings should be identical with the original rivets and rivet spacings joining stringer to skin. (See figure 158.) Filler or shims may be required in some cases to bring the face of the splice angle up level with the corresponding face of the original stringer, in order to prevent a gap between the angle and skin patch.

a. MATERIALS.

Wing beam (from Paragraph 3), Section X.

One piece of "L" or bulb-shaped stringer stock 6 inches long.

b. TOOLS AND EQUIPMENT.

Portable riveting hammer	Twist drills
Rivet sets	Pencil compass
Bucking bars	Pencil
Straight edge	Metal fasteners
Steel square	"C" clamps
File	Burring tools
Electric drill motor	Hack saw

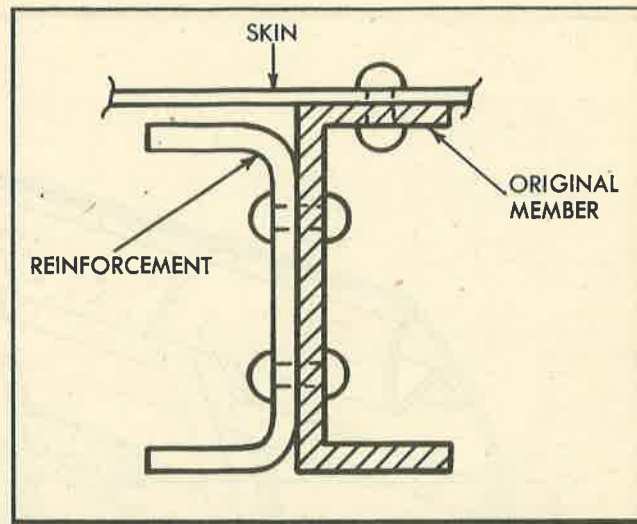


Figure 157—Cross-section Channel Section Splice

c. PROCEDURE.

(1) Select wing beam from previous job.

(2) Have instructor mark on one of the stiffeners a probable defect.

(3) With portable drill motor, remove all rivets from this stiffener.

NOTE

Use drill that is slightly smaller than rivet.

NOTE

Buck up web to avoid bending material.

(4) Determine necessary length of splice, and cut to size.

(5) Locate rivet holes in splice and damaged stiffener.

(6) Drill holes with correct size of drill.

(7) Rivet splice to stiffener.

(8) Locate rivet holes in splice for riveting to skin.

(9) Rivet stiffener to web, using old rivet holes.

(10) Drill rivet holes in splice and skin.

(11) Rivet splice to skin.

(12) Inspect job for defective rivets, and scratches.

(13) Replace unsatisfactory rivets.

(14) Present finished job to instructor for approval.

7. INSPECTION DOOR AND FRAME INSTALLATION.

a. GENERAL.

Inspection holes or doors are placed in wings to permit inspection and give access for repair of parts in the interior. To cut a hole and repair it again each time an inspection was made, would cause too much inconvenience and loss of time, so inspection doors are placed at certain specified places where frequent inspection is necessary. They are also cut whenever necessary in repair work on the airfoil. In the present

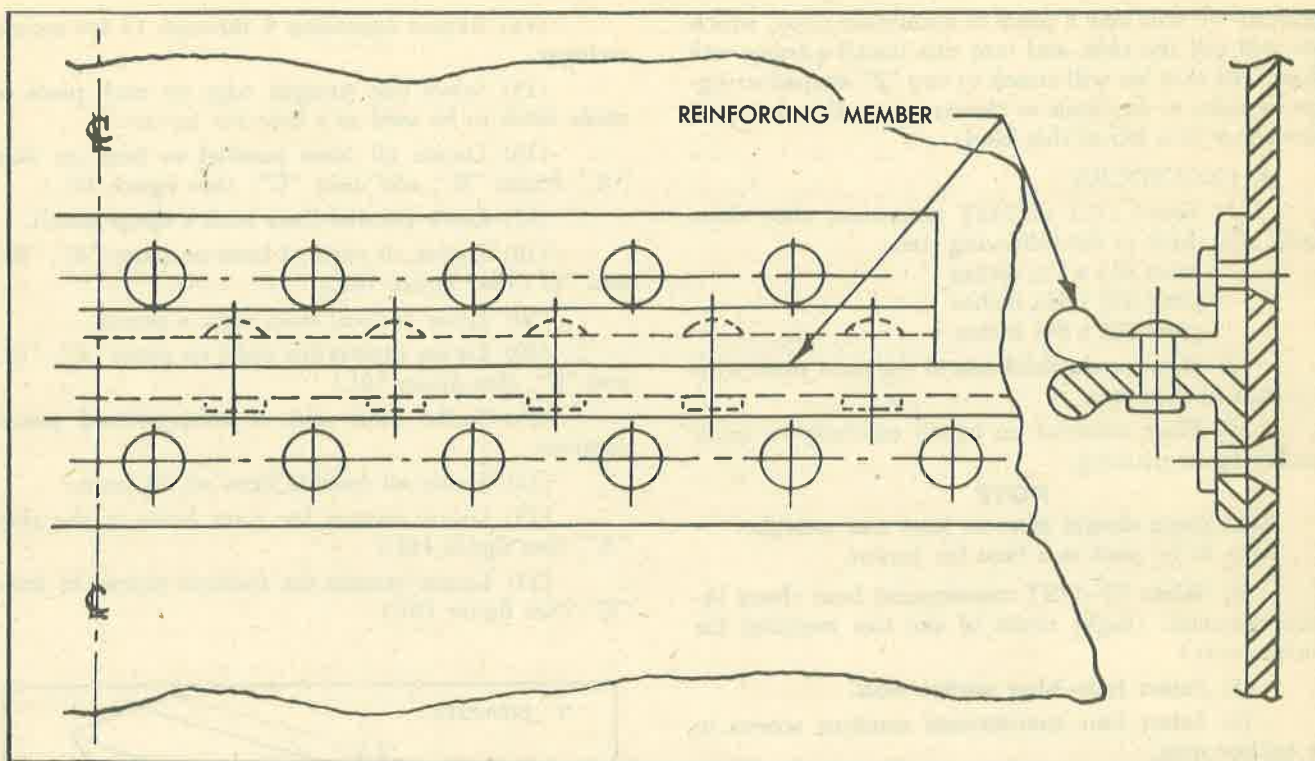


Figure 158—Bulb Angle Stringer Splice

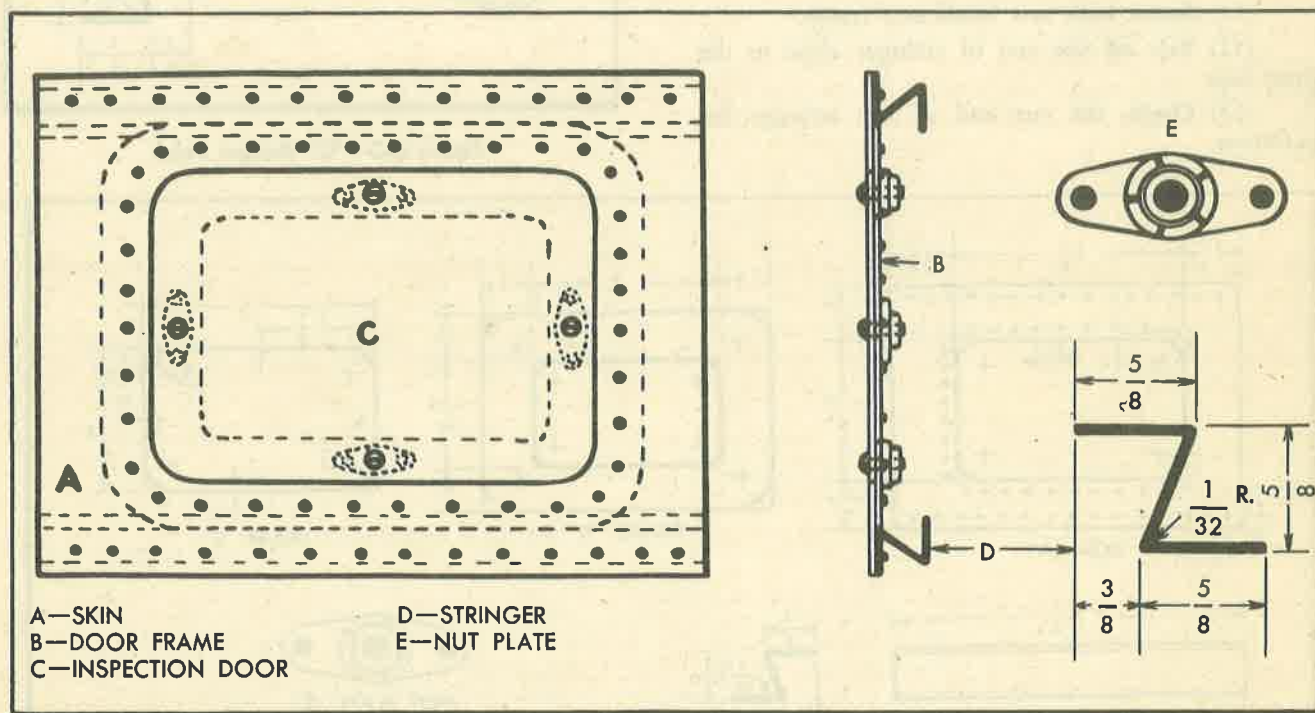


Figure 159—Inspection Door and Frame Installation

exercise we will take a piece of aluminum alloy, which we will call the *skin*, and into this install a frame and door. The skin we will attach to two "Z"-shaped stringers in order to duplicate as closely as possible the usual procedure in a job of this kind.

b. PROCEDURE.

(1) Select 17ST or 24ST aluminum alloy sheet stock .050 thick in the following sizes:

1 piece $6\frac{1}{2} \times 7\frac{1}{2}$ inches

1 piece $4\frac{1}{4} \times 5\frac{1}{4}$ inches

1 piece $5\frac{1}{4} \times 6\frac{1}{4}$ inches

(2) Measure the thickness of the sheet stock with a 1-inch micrometer.

(3) Place material on bench carefully to avoid scratching or marring.

NOTE

Each piece should have at least one straight edge to be used as a base for layout.

(4) Select 70-17ST countersunk head rivets $\frac{1}{8}$ -inch diameter. (Eight rivets of the size required for anchor nuts.)

(5) Select four 2-lug anchor nuts.

(6) Select four countersunk machine screws to fit anchor nuts.

(7) Select two pieces of "Z" shaped, $\frac{3}{8}$ -inch stringer stock, $7\frac{1}{2}$ inches long. (See figure 160.)

(8) Check dimensions with drawing.

(9) Place soft jaws in vise.

(10) Clamp stringer in vise with "cut off" line close to vise.

(11) Select hack saw blade and frame.

(12) Saw off the end of stringer close to the layout line.

(13) Check the cut end of the stringer for squareness.

(14) Repeat operation 9 through 13 for second stringer.

(15) Select one straight edge on each piece of sheet stock to be used as a base for lay-out.

(16) Locate all lines parallel to base on skin "A", frame "B", and door "C". (See figure 161.)

(17) Draw parallel lines with a sharp pencil.

(18) Locate all vertical lines on parts "A", "B", and "C". (See figure 161.)

(19) Draw vertical lines with a pencil.

(20) Locate centers for radii on parts "A", "B", and "C". (See figure 161.)

(21) Scribe radii with a sharp-pointed pencil compass.

(22) Scribe all outside lines on all parts.

(23) Locate centers for rivet holes in the skin "A". (See figure 161.)

(24) Locate centers for fastener screws in door "C". (See figure 161.)

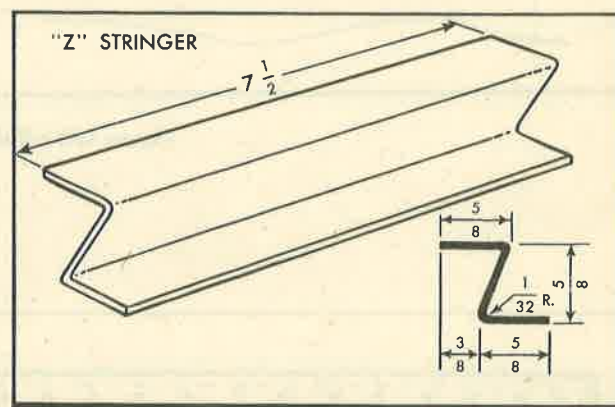


Figure 160—"Z" Stringer Stock

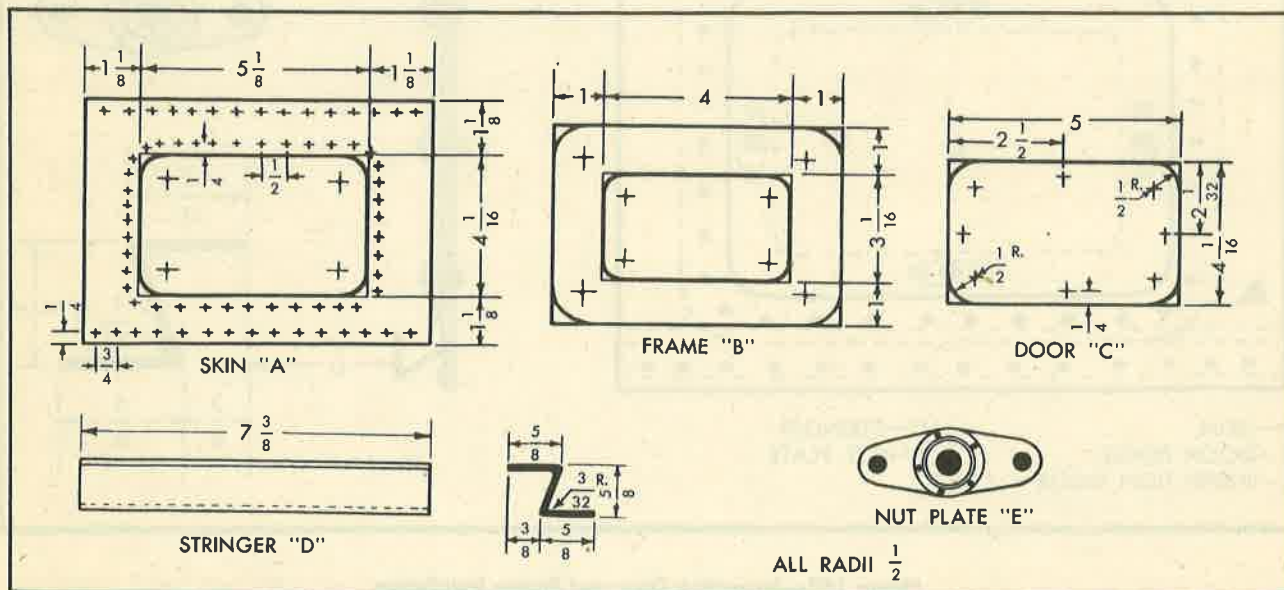


Figure 161—Laying Out Material

(25) Square one end of stringer "D" (see figure 161) with square and scribe.

(26) Lay-out length of stringer, and square the other end.

(27) Locate center of stringer flange to be riveted. (See figure 162.)

(28) Draw sharp pencil lines along center of stringer flange.

(29) Repeat operations 25 through 28 for other stringer.

(30) Recheck all dimensions on all parts.

(31) Cut out center of skin "A". (See figure 163.)

NOTE

Make all cuts close to the lay-out line, but do not touch it with snips. Allow a slight margin for finishing. (See figure 163.)

NOTE

Be careful not to distort the metal by cramping the snips or taking too large a cut at one time.

(32) Cut straight sides of skin "A". (See figure 163.)

(33) Cut out center of frame "B". (See figure 163.)

(34) Cut straight sides of frame "B". (See figure 163.)

(35) Round off corners of frame "B" with snips. (See figure 163.)

(36) Cut straight sides of door "C". (See figure 163.)

(37) Round off corners of door "C" with snips. (See figure 163.)

(38) Inspect parts for scratches, nicks, and distortion. Submit to instructor for approval or disapproval.

(39) Burr all edges to avoid personal injury and to avoid scratching parts. (See figure 164.)

NOTE

Burr parts as frequently as necessary after cutting, filing, drilling, and fitting operations.

(40) File all straight edges and radii to the lay-out lines on the flat pieces. (See figure 164.)

(41) Check frequently with straight edge, square, and radius gage to insure accurate workmanship.

(42) Check fit of the door in the opening in the skin. (See figure 164.)

(43) Burr all edges.

(44) File the ends of the stringers for squareness and accuracy of length.

NOTE

It is good practice to mark parts after they are fitted, so that they can be easily replaced in the original positions.

(45) Burr all drilled holes.

(46) Drill all holes in skin "A" with a No. 40 drill. (See figure 165.)

(47) Locate and clamp frame B to underside of skin "A".

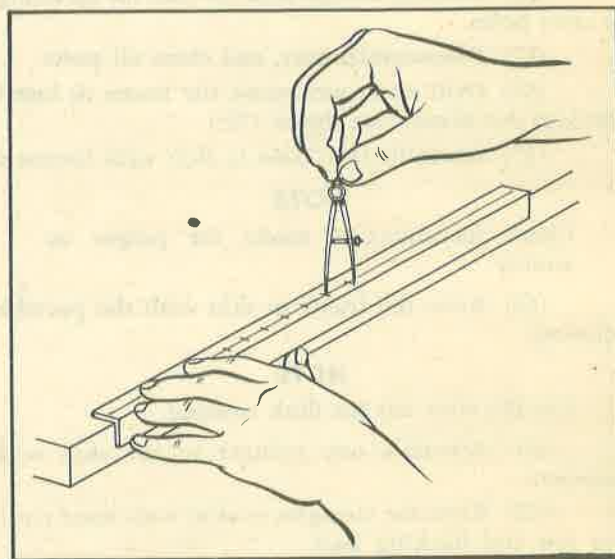


Figure 162—Locating Center of Stringer Flange and Rivet Holes

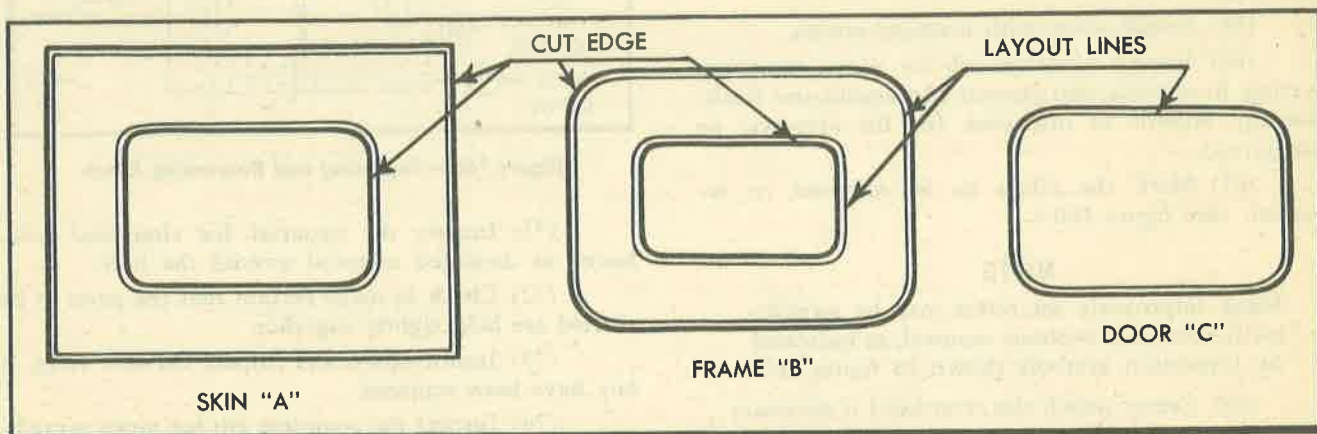


Figure 163—Cutting Stock with Snips

(48) Drill hole in one side of frame through pilot hole in skin, and install fastener. Then, drill the remaining three holes.

(49) Locate and clamp stringers to skin.

(50) Drill holes in ends of stringers through pilot holes in skin, and install fasteners.

(51) Drill all rivet holes with a No. 30 drill.

(52) Drill machine screw holes in door "C" and frame "B". (See figure 165.)

(53) Assemble the frame to the skin with metal fasteners. (See figure 159.)

NOTE

Check with identification marks for proper position.

(54) Machine countersink the skin for all rivet holes in the frame.

(55) Assemble stringers to skin with metal fasteners.

(56) Machine countersink the skin for all stringer rivet holes.

(57) Disassemble, burr, and clean all parts.

(58) Drill and countersink the frame to install the four nut plates. (See figure 159.)

(59) Assemble the frame to skin with fasteners.

NOTE

Check identification marks for proper assembly.

(60) Rivet the frame to skin with the portable squeezer.

NOTE

Use flat rivet sets for flush riveting.

(61) Assemble one stringer to the skin with fasteners.

(62) Rivet the stringers to skin with hand riveting sets and bucking bars.

(63) Rivet four nut plates in place. (See figure 159.)

(64) Countersink the attaching screw holes in the cover.

(65) Install cover with machine screws.

(66) Inspect complete job for nicks, scratches, riveting, fit of parts, and general appearance and workmanship. Submit to instructor for his approval or disapproval.

(67) Mark the rivets to be removed or reworked. (See figure 166.)

NOTE

Many improperly set rivets may be satisfactorily reworked without removal, as indicated by inspection symbols shown in figure 167.

(68) Center punch the rivet head if necessary.

(69) Drill the rivet head.

(70) Drive the rivet out with a pin punch.

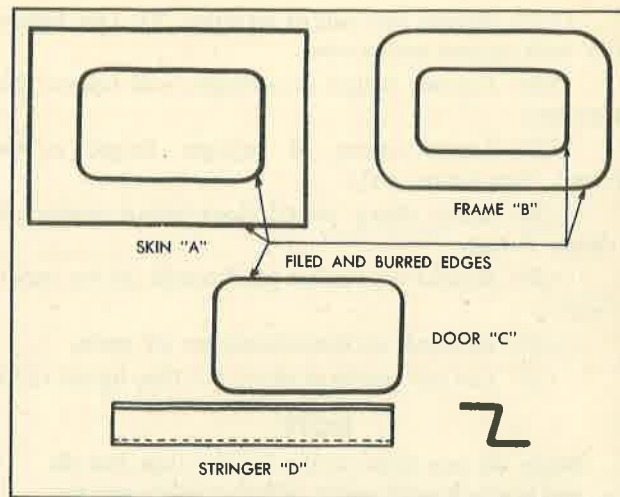


Figure 164—Filing and Burring Parts

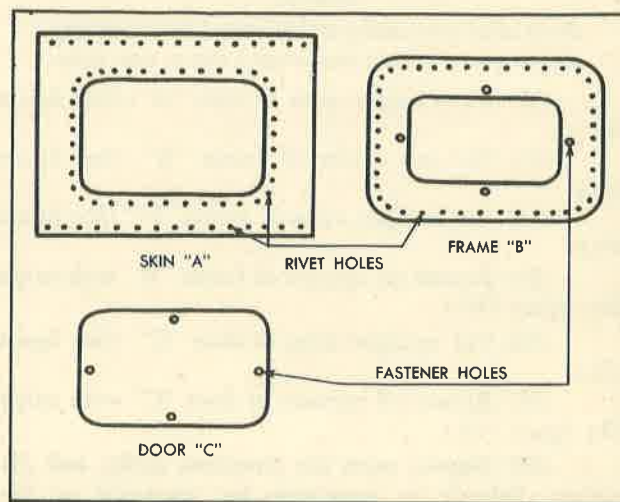


Figure 165—Drilling Rivet and Fastener Holes

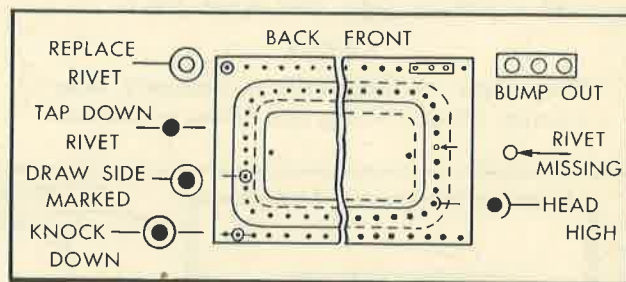


Figure 166—Replacing and Reworking Rivets

(71) Inspect the material for elongated hole, burrs, or damaged material around the hole.

(72) Check to make certain that the parts to be riveted are held tightly together.

(73) Insert, upset, and inspect the new rivet, if any have been replaced.

(74) Inspect the complete job for nicks, scratches, riveting, general appearance and workmanship. Get final approval of instructor.

SECTION XI

TABLES

DRILL SIZES COMMONLY USED FOR STANDARD AIRCRAFT RIVETS

<i>Diameter of rivet</i>	<i>Size of drill</i>
1/16 inch	Number 51 (.067)
3/32 inch	Number 40 (.098)
1/8 inch	Number 30 (.128)
5/32 inch	Number 21 (.159)
3/16 inch	Number 11 (.191)
1/4 inch	Number 17/64 inch

SYSTEM OF DRILL SIZES

<i>Number Size Drills With Decimal Equivalents</i>				<i>Letter Size Drills With Decimal Equivalents</i>	
<i>Number</i>	<i>Decimal Equivalent</i>	<i>Number</i>	<i>Decimal Equivalent</i>	<i>Letter and Diameter</i>	<i>Decimal Equivalent</i>
1	.2280	31	.1200	A	.234
2	.2210	32	.1160	B	.238
3	.2130	33	.1130	C	.242
4	.2090	34	.1110	D	.246
5	.2055	35	.1100	E	.250
6	.2040	36	.1065	F	.257
7	.2010	37	.1040	G	.261
8	.1990	38	.1015	H	.266
9	.1960	39	.0995	I	.272
10	.1935	40	.0980	J	.277
11	.1910	41	.0960	K	.281
12	.1890	42	.0935	L	.290
13	.1850	43	.0890	M	.295
14	.1820	44	.0860	N	.302
15	.1800	45	.0820	O	.316
16	.1770	46	.0810	P	.323
17	.1730	47	.0785	Q	.332
18	.1695	48	.0760	R	.339
19	.1660	49	.0730	S	.348
20	.1610	50	.0700	T	.358
21	.1590	51	.0670	U	.368
22	.1570	52	.0635	V	.377
23	.1540	53	.0595	W	.386
24	.1520	54	.0550	X	.397
25	.1495	55	.0520	Y	.404
26	.1470	56	.0465	Z	.413
27	.1440	57	.0430		
28	.1405	58	.0420		
29	.1360	59	.0410		
30	.1285	60	.0400		

DECIMAL EQUIVALENT TABLE

1/64..... .015625	17/64..... .265625	33/64..... .515625	49/64..... .765625
1/32..... .03125	9/32..... .28125	17/32..... .53125	25/32..... .78125
3/64..... .046875	19/64..... .296875	35/64..... .546875	51/64..... .796875
1/16..... .0625	5/16..... .3125	9/16..... .5625	13/16..... .8125
5/64..... .078125	21/64..... .328125	37/64..... .578125	53/64..... .828125
3/32..... .09375	11/32..... .34375	19/32..... .59375	27/32..... .84375
7/64..... .109375	23/64..... .359375	39/64..... .609375	55/64..... .859375
1/8..... .125	3/8..... .375	5/8..... .625	7/8..... .875
9/64..... .140625	25/64..... .390625	41/64..... .640625	57/64..... .890625
5/32..... .15625	13/32..... .40625	21/32..... .65625	29/32..... .90625
11/64..... .171875	27/64..... .421875	43/64..... .671875	59/64..... .921875
3/16..... .1875	7/16..... .4375	11/16..... .6875	15/16..... .9375
13/64..... .203125	29/64..... .453125	45/64..... .703125	61/64..... .953125
7/32..... .21875	15/32..... .46875	23/32..... .71875	31/32..... .96875
15/64..... .234375	31/64..... .484375	47/64..... .734375	63/64..... .984375
1/4..... .250	1/2..... .500	3/4..... .750	1..... 1.000

MATHEMATICAL RULES

To Find Circumference

Multiply diameter by.....3.1416

To Find Diameter

Multiply circumference by.....0.3183

To Find Radius

Multiply circumference by.....0.1592

*To Find Side of an Inscribed Square*Multiply diameter by.....0.7081
Or, multiply circumference by.....0.2251*To Find Side of an Equal Square*Multiply diameter by.....0.8862
Or, circumference by.....0.2821*Square*

A side multiplied by 1.4142 equals diameter of its circumscribing circle.

A side multiplied by 4.443 equals circumference of its circumscribing circle.

A side multiplied by 1.128 equals diameter of an equal circle.

A side multiplied by 3.547 equals circumference of an equal circle.

To Find the Area of a Circle

Multiply circumference by one-quarter of the diameter.

Or, multiply the diameter by the diameter by 0.7854.

Or, multiply the circumference by the circumference by .07958.

Or, multiply the radius by the radius by 3.1416.

To Find the Surface of a Sphere or Globe

Multiply the diameter by the circumference.

Or, multiply the square of diameter by 3.1416.

Or, multiply four times the square of radius by 3.1416.

To Find the Volume of a Sphere

Multiply the cube of diameter by 0.5236.

To Find the Cubic Content of a Cone

Multiply the area of the base by one-third of the altitude.

To Find the Area of a Triangle

Multiply the base by one-half the perpendicular height.

TOTAL STRESS TO BE CARRIED BY RIVETS ON BOTH SIDES OF BREAK IN STRESSED SKIN. 62,000 LB/SQ IN. ASSUMED SKIN STRESS THROUGHOUT TABLE

<i>Distance across Cut-out in Inches</i>		1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2	1-5/8
<i>Gage of Skin in Inches</i>	.020	620	775	930	1085	1240	1395	1550	1705	1860	2015
	.025	775	969	1162	1356	1550	1744	1937	2131	2325	2519
	.032	992	1240	1488	1736	1984	2232	2480	2728	2976	3224
	.036	1116	1395	1674	1953	2232	2511	2790	3069	3348	3627
	.040	1240	1550	1860	2170	2480	2790	3100	3410	3720	4030
	.045	1395	1744	2092	2441	2790	3139	3487	3836	4185	4534
	.051	1581	1976	2371	2767	3162	3557	3953	4348	4743	5138
	.064	1984	2480	2976	3472	3968	4464	4960	5456	5952	6448
	.072	2232	2790	3348	3906	4464	5022	5580	6138	6696	7254
<i>Distance across Cut-out in Inches</i>		1-3/4	1-7/8	2	2-1/8	2-1/4	2-3/8	2-1/2	2-5/8	2-3/4	2-7/8
<i>Gage of Skin in Inches</i>	.020	2170	2325	2480	2635	2790	2945	3100	3255	3410	3565
	.025	2713	2906	3100	3294	3487	3681	3875	4069	4263	4456
	.032	3472	3720	3968	4216	4464	4712	4960	5208	5456	5704
	.036	3906	4185	4464	4743	5022	5301	5580	5859	6138	6417
	.040	4340	4650	4960	5270	5580	5890	6200	6510	6820	7130
	.045	4883	5231	5580	5929	6278	6626	6975	7324	7673	8021
	.051	5534	5929	6324	6719	7115	7510	7905	8300	8696	9091
	.064	6944	7440	7936	8432	8928	9424	9920	10416	10912	11408
	.072	7812	8370	8928	9486	10044	10602	11160	11718	12276	12834
<i>Distance across Cut-out in Inches</i>		3	3-1/8	3-1/4	3-3/8	3-1/2	3-5/8	3-3/4	3-7/8	4	
<i>Gage of Skin in Inches</i>	.020	3720	3875	4030	4185	4340	4495	4650	4805	4960	
	.025	4650	4844	5038	5231	5425	5619	5813	6006	6200	
	.032	5952	6200	6448	6696	6944	7192	7440	7688	7936	
	.036	6696	6975	7254	7533	7812	8091	8370	8649	8928	
	.040	7440	7750	8060	8370	8680	8990	9300	9610	9920	
	.045	8370	8719	9068	9416	9765	10114	10463	10811	11160	
	.051	9486	9881	10277	10672	11067	11462	11858	12253	12648	
	.064	11904	12400	12896	13392	13888	14384	14880	15376	15872	
	.072	13392	13950	14508	15066	15624	16182	16704	17298	17856	

**TABLE 5-11
SHEAR AND BEARING STRENGTHS
OF ALUMINUM ALLOY RIVETS AND SHEET
ALLOWABLE SINGLE SHEAR STRENGTH
OF ALUMINUM ALLOY RIVETS (LB.)**

<i>Dia. of Rivet or Pin, in.</i>	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
AD A17ST (Fsu=25,000psi)	76	172	306	479	690	1227	1917	2761
D 17ST (Fsu=30,000psi)	92	206	368	574	828	1472	2300	3313
DD 24ST (Fsu=35,000psi)	107	241	429	670	966	1718	2684	3865

**ALLOWABLE BEARING STRENGTH OF
17ST ALUMINUM ALLOY SHEET (LB.)
(Fbr=75,000psi)**

<i>Dia. of Rivet or Pin, in.</i>	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
.014	65	98	131	164	196	262	328	393
.016	75	112	150	187	225	300	375	450
.018	84	126	168	210	253	337	421	506
.020	93	140	187	234	281	375	468	562
.025	117	175	234	293	351	468	585	703
.032	150	224	300	375	450	600	750	900
.036	168	253	337	421	506	675	843	1012
.040	187	281	375	468	562	750	937	1125
.045	210	316	422	527	632	843	1054	1265
.051	239	358	478	597	717	956	1195	1434
.064	300	449	600	749	900	1200	1500	1800
.072	337	506	675	843	1012	1350	1687	2025
.081	379	569	759	949	1139	1518	1898	2278
.091	426	639	853	1066	1279	1706	2132	2559
.102	478	716	956	1195	1434	1912	2390	2868
.128	600	899	1200	1499	1800	2400	3000	3600
5/32	732	1097	1464	1829	2196	2928	3661	4393
3/16	878	1317	1757	2196	2636	3515	4394	5473
1/4	1171	1756	2343	2928	3515	4687	5859	7031

**ALLOWABLE BEARING STRENGTH OF
17ST ALCLAD ALUMINUM ALLOY SHEET (LB.)
(Fbr=68,000psi)**

<i>Dia. of Rivet or Pin, in.</i>	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
.014	59	89	119	148	178	238	297	357
.016	68	102	136	170	204	272	340	408
.018	76	114	153	191	229	306	382	459
.020	85	127	170	212	255	340	425	510
.025	106	159	212	265	318	425	531	637
.032	136	203	272	339	408	544	680	816
.036	153	229	306	382	459	612	765	918
.040	170	254	340	424	510	680	850	1020
.045	191	286	382	478	573	765	956	1147
.051	216	325	433	541	650	867	1083	1300
.064	272	407	544	679	816	1088	1360	1632
.072	306	458	612	764	918	1224	1530	1836
.081	344	516	688	860	1032	1377	1721	2065
.091	386	579	773	966	1160	1547	1933	2320
.102	433	650	867	1083	1300	1734	2167	2601
.128	544	815	1088	1359	1632	2176	2720	3268
5/32	663	995	1327	1659	1991	2655	3319	3983
3/16	796	1194	1593	1991	2390	3187	3984	4781
1/4	1062	1593	2125	2655	3187	4250	5312	6375