AIRCRAFT RIVETING

Part 1

PREPARED BY

INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PA.

Nº 2717

II

PROPERTY OF THE

BUREAU of AERONAUTICS
Manufacturing Operations Section

NAVY DEPARTMENT—WASHINGTON, D.C.

UNAUTHORIZED CIRCULATION OF THIS PAMPHLET
BY ANYONE IS PROHIBITED

AIRCRAFT RIVETING

(PART 1)

RIVETS

1. Application of Aircraft Riveting.—Riveting is the most common method of assembling aircraft parts. While other methods, such as spot and roll welding, may be used advantageously for certain applications, riveting still possesses the widest latitude of application and the greatest degree of flexibility of any of the present methods of assembly. The flexibility results primarily from the various methods of riveting available, the variety of rivet sizes and head shapes, and the adaptation of standard rivets to special applications by the constant research and development work being done by the aircraft manufacturers.

The importance of riveting in aircraft work is indicated by the number of rivets used in an airplane, as many as 160,000 for a medium bomber and 400,000 for a large bomber. The cost of the riveting, on an estimate of two and a half cents for each driven rivet, represents an important item in the cost of an airplane, not only because of the immense quantities of rivets required but also because aircraft riveting in general requires skilled workmen and specialized tools and equipment. More important, however, is the effect that the quality of riveting has on the airworthiness of the airplane and its ability to maintain flight under adverse conditions.

2. Kinds of Rivets.—In aircraft work many forms of rivets, including solid rivets, solid rivets with chamfered shanks, tubular or hollow rivets, semi-tubular rivets, and blind rivets, are used in their respective places. The rivets are supplied with a number of different types of heads; round, brazier, flat, and countersunk are most commonly used. In Fig. 1 are shown these four styles of rivet heads, the round head being shown in (*a*), the brazier head in (*b*), the flat head in (*c*), and the 100-degree countersunk, or flush, head in (*d*). In Tables II,

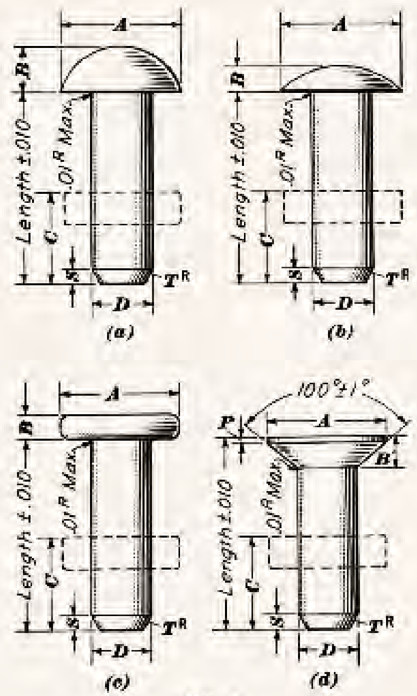

FIG. 1

III, and IV, are given rivet dimensions as specified by the Army-Navy Aeronautical Standards, *AN430, AN456, AN442,* and *AN426*. The chamfered end, which is optional and not used in general riveting work, allows of easier insertion of the rivet into its hole, particularly with automatic riveting machines. In addition to the 100-degree countersunk head, rivets having included angles varying from 78 to 120 degrees are now being used. However, most aircraft manufacturers have adopted the *AN426* rivet, as recommended by the National Aircraft Standards Committee in its effort toward the standardization of rivets within the industry.

3. The type of rivet head that should be used depends on the part of the airplane that is being riveted. For interior parts, round-head and some flat-head rivets are used. External sur-

TABLE I

AN430 ROUND-HEAD RIVETS

Nominal Diameter *D* Inch	Dimensions In Inches					
	D	*A*	*B*	*S*	T^R	*C*
1/16	.062 +.003 −.001	.125±.006	.047±.005	.016	.019	1/32
3/32	.094 +.003 −.001	.187±.009	.070±.005	.023	.029	3/64
1/8	.125 +.0035 −.001	.250±.012	.094±.005	.031	.039	1/16
5/32	.156 +.004 −.001	.312±.016	.117±.005	.039	.049	5/64
3/16	.187 +.004 −.001	.375±.019	.141±.007	.047	.059	3/32
1/4	.250 +.004 −.001	.500±.025	.188±.009	.062	.078	1/8
5/16	.312 +.004 −.001	.625±.031	.234±.012	.078	.098	5/32
3/8	.375 +.004 −.001	.750±.037	.281±.014	.094	.117	3/16

faces, however, where the least possible resistance to air flow is desirable, are flush riveted for aerodynamic efficiency. On some airplanes, all outside surfaces are flush riveted, whereas other airplanes have flush rivets on only the leading edges of the wings. The type of airplane and its use determine whether it should be flush riveted. High-speed airplanes require flush riveting, not only for aerodynamic reasons but because of weight considerations; whereas those of lower speed would benefit to only a limited extent by the use of flush rivets. The tendency at present, with the ever-increasing speeds, is to flush rivet all outside surfaces. Where flush rivets are not used on outside surfaces, some manufacturers use brazier-head rivets and others use round-head rivets. Brazier-head rivets have less area protruding than do round-head rivets, but one manufacturer uses no brazier-head rivets at all since, at best, they are a compromise

TABLE II
AN456 BRAZIER-HEAD RIVETS

Nominal Diameter *D* Inch	Dimensions In Inches					
	D	*A*	*B*	*S*	T^R	*C*
1/16						
3/32	.094 +.003 −.001	.156±.010	.031±.005	.023	.029	3/64
1/8	.125 +.0035 −.001	.235±.010	.047±.005	.031	.039	1/16
5/32	.156 +.004 −.001	.312±.010	.063±.005	.039	.049	5/64
3/16	.187 +.004 −.001	.390±.010	.078±.005	.047	.059	3/32
1/4	.250 +.004 −.001	.468±.010	.094±.005	.062	.078	1/8
5/16	.312 +.004 −.001	.625±.012	.125±.005	.078	.098	5/32
3/8	.375 +.004 −.001	.781±.015	.156±.005	.094	.117	3/16

TABLE III
AN442 FLAT-HEAD RIVETS

Nominal Diameter *D* Inch	Dimensions In Inches					
	D	*A*	*B*	*S*	T^R	*C*
1/16	.062 +.003 −.001	.125±.006	.025±.005	.016	.019	1/32
3/32	.094 +.003 −.001	.187±.009	.038±.005	.023	.029	3/64
1/8	.125 +.0035 −.001	.250±.012	.050±.005	.031	.039	1/16
5/32	.156 +.004 −.001	.312±.016	.062±.005	.039	.049	5/64
3/16	.187 +.004 −.001	.375±.019	.075±.005	.047	.059	3/32
1/4	.250 +.004 −.001	.500±.025	.100±.005	.062	.078	1/8
5/16	.312 +.004 −.001	.625±.031	.125±.005	.078	.098	5/32
3/8	.375 +.004 −.001	.750±.037	.150±.007	.094	.117	3/16

TABLE IV

AN426 100-DEGREE COUNTERSUNK-HEAD RIVETS

Nominal Diameter D Inch	Dimensions In Inches						
	D	A	B	S	T^R	C	P
1/16	.062 +.003 −.001	.105 +.002 −.006	.022 +.001 −.003	.016	.019	3/32	.004±.002
3/32	.094 +.003 −.001	.170 +.002 −.006	.036 +.001 −.003	.023	.029	5/32	.004±.002
1/8	.125 +.003 −.001	.216 +.002 −.006	.042 +.001 −.003	.031	.039	3/16	.004±.002
5/32	.156 +.003 −.001	.278 +.002 −.006	.055 +.001 −.003	.039	.049	13/64	.004±.002
3/16	.187 +.003 −.001	.344 +.003 −.007	.070 +.001 −.003	.047	.059	9/32	.004±.002
1/4	.250 +.003 −.001	.467 +.003 −.007	.095 +.001 −.003	.062	.078	3/8	.004±.002
5/16	.312 +.003 −.001	.555 +.003 −.007	.106 +.001 −.003	.078	.098	13/32	.004±.002
3/8	.375 +.003 −.001	.685 +.003 −.007	.134 +.001 −.003	.094	.117	9/16	.004±.002

between round-head and flush rivets and can readily be replaced by flush rivets on critical surfaces and by round-head rivets on surfaces where resistance to air flow is less critical.

4. **Rivet Materials.**—For aircraft work, rivets are made of aluminum alloys, monel metal, and steel. The commonly-used aluminum-alloy rivets are *2S*, *3S*, *17ST*, *A17ST*, and *24ST* for riveting aluminum-alloy structures, and *56S* for riveting magnesium alloys. Practice varies in the application of the alloys in different aircraft factories. Thus, one manufacturer uses *2S* rivets, which have plain heads, for riveting all *SO* material and for temporary assemblies, which later are to be torch welded, such as on fuel and oil tanks, to prevent leakage from under the heads of the rivets. On the contrary, another manufacturer uses *3S* rivets for the same purposes.

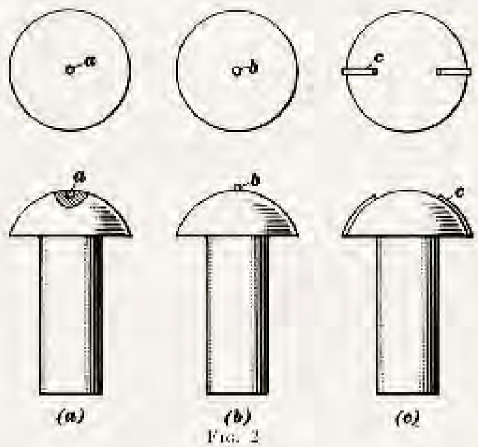

FIG. 2

In general, each application must be considered on the basis of its own requirements. Thus, a hard rivet would not be used in soft stock because of the probable distortion of the material. Neither would a soft rivet be used in hard stock, except in cases where the joint is lightly stressed. As a general rule, it is advisable to select a rivet having properties similar to those of the material into which it is to be driven.

5. The rivet alloy used for approximately 90 per cent of all aircraft riveting is the *A17ST*. As shown in Fig. 2 (*a*), it can be distinguished by a small depression, or dimple, *a*, in the head. These rivets do not require heat treatment, are easy to drive, and possess good strength characteristics. They are driven in the heat-treated and aged condition in which they are received. The *17ST* rivets, which are distinguished, as shown in view (*b*), by a small projection *b* on the head, are approximately 11 per cent stronger than *A17ST* rivets. However, they require heat treatment, refrigeration, if not driven within an hour after heat treatment, and more time and skill for driving because of their hardness and susceptibility to cracking, and, therefore, are used to only a limited extent.

When greater strength characteristics are necessary, *24ST* rivets are used. The shear strength of the *A17ST* rivet is 27,000 pounds per square inch; that of the *17ST* rivet is 30,000 pounds per square inch; and that of the *24ST* rivet is 35,000 pounds per square inch. Thus, *24ST* rivets are approximately 30 per cent stronger than *A17ST* rivets, and approximately 17 per cent stronger than *17ST* rivets. The *24ST* rivets are distinguished, as shown in view (*c*), by two raised dashes *c* opposite each other and extending radially from the center of the head. They must be heat treated and refrigerated if not driven within approximately 10 minutes after heat treatment. The *24ST* rivets are generally used in the larger sizes, since small rivets of this type are especially difficult to drive. On the larger sizes, $\frac{3}{16}$ inch and over, the greater strength results in fewer rivets being required, lower cost, and an appreciable reduction in weight of the rivets, and therefore of the riveted structure itself. Rivets of alloys *A17ST*, *17ST*, and *24ST* are generally used with an anodic coating, which improves the resistance to corrosion and also provides a better surface for painting.

6. Refrigeration of 17ST and 24ST Rivets.—Since *17ST* and *24ST* rivets cannot be used as fast as they are heat treated, they must be refrigerated to retard their aging and hardening. Otherwise, they cannot be driven satisfactorily. Some aircraft manufacturers have a master storage box from which local storage boxes, located in various parts of the plant, are supplied at regular intervals. Since the rivets must also be refrigerated while in transit, traveling storage boxes are used. The temperature at which the storage boxes is maintained depends on plant practice. When rivets are ice-boxed at 32° F. immediately after the heat-treating quench, aging is partially retarded and satisfactory driving characteristics are maintained for as long as three days.

With mechanical refrigeration or by the use of dry ice, which is solid carbon-dioxide, temperatures as low as from −40° to −50° F. can be obtained. At such temperatures, the rivets will remain soft enough for fast and easy driving for a period of two

TABLE V

AN DASH NUMBERS FOR ALUMINUM-ALLOY RIVETS

Rivet Diameter Inch	Length of Rivets, Inches																
	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
	AN Dash Numbers																
$\frac{1}{16}$	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	2-12	2-14	2-16	2-18	2-20				
$\frac{3}{32}$	3-3	3-4	3-5	3-6	3-7	3-8	3-9	3-10	3-12	3-14	3-16	3-18	3-20	3-22			
$\frac{1}{8}$	4-3	4-4	4-5	4-6	4-7	4-8	4-9	4-10	4-12	4-14	4-16	4-18	4-20	4-22	4-24		
$\frac{5}{32}$		5-4	5-5	5-6	5-7	5-8	5-9	5-10	5-12	5-14	5-16	5-18	5-20	5-22	5-24	5-28	
$\frac{3}{16}$		6-4	6-5	6-6	6-7	6-8	6-9	6-10	6-12	6-14	6-16	6-18	6-20	6-22	6-24	6-28	6-32
$\frac{1}{4}$				8-6	8-7	8-8	8-9	8-10	8-12	8-14	8-16	8-18	8-20	8-22	8-24	8-28	8-32
$\frac{5}{16}$						10-8	10-9	10-10	10-12	10-14	10-16	10-18	10-20	10-22	10-24	10-28	10-32
$\frac{3}{8}$								12-10	12-12	12-14	12-16	12-18	12-20	12-22	12-24	12-28	12-32

weeks or more, depending on the rapidity of the reduction in temperature after quenching. However, the rivets in the local storage boxes are generally changed every 24 hours.

A rapid reduction in temperature of the rivets after heat treating is essential to prevent aging and hardening before the storage temperature is reached, and depends on the capacity of the refrigerator. When the storage temperature is from −40° to −50° F., the temperature reduction is fast enough to prevent aging during that period. Another advantage of using low storage temperatures is that satisfactory driving characteristics are maintained for a longer period of time after the rivets are removed from the storage box. Therefore, the operators are required to make fewer trips to the storage box since greater quantities of rivets can be taken each time, and can devote more of their time to driving rivets.

7. Army-Navy Rivet Designation.—In Army-Navy (AN) specifications, rivet alloys are designated by letters, as follows: *D* for *17ST*, *AD* for *A17ST*, and *DD* for *24ST*. Rivets of *2S* alloy are known as *A* rivets, but the letter is not used in the designation, a dash being used instead of the *A*. The type of head is designated by number as follows: *AN426*, 100-degree countersunk-head rivets; *AN430*, round-head rivets; *AN442*, flat-head rivets; and *AN456*, brazier-head rivets. The letter designating the material follows the head designation and in turn is followed by a number, which indicates the diameter of the rivet in thirty-seconds of an inch. Next, the length of the rivet is designated by a dash number indicating the length of the rivet in sixteenths of an inch, measured from the end of the shank to the under side of the rivet head for rivets having round, brazier, and flat heads, and to the top of the head for countersunk-head rivets. For example, *AN426AD3–5* means a 100-degree *A17ST* countersunk-head rivet, $\frac{3}{32}$ inch in diameter and $\frac{5}{16}$ inch long. A *AN430DD6–8* rivet is a round-head *24ST* rivet, $\frac{3}{16}$ inch in diameter and $\frac{1}{2}$ inch long. To facilitate identification, the dash numbers from the *AN* standards are given in Table V.

8. Monel-Metal and Steel Rivets.—For riveting steel structures in airplanes, it has been the practice in the past to use monel-metal rivets, designated as *SS* rivets. However, as this material is critical and becoming increasingly more difficult to obtain, these rivets have been replaced by steel rivets. One type, although made of a low-carbon steel and cadmium plated, is commonly known as a tinned-iron rivet. It is usually used in the flat-head style, patterned after the *AN441* rivet, or in the round-head style, *AN435*, and is employed for all steel joints whenever possible. For certain applications, such as when increased corrosion resistance is desirable or when the steel joints will be subjected to temperatures over 700° F., cold-forming stainless-steel rivets, having approximately 17 per cent of chromium and 7 per cent of nickel, can be substituted for monel-metal rivets.

9. Rivet Sizes.—The majority of rivets that are used in aircraft construction are either $\frac{1}{8}$ or $\frac{5}{32}$ inch in diameter. Of the remainder most are under $\frac{1}{4}$ inch, but rivets up to $\frac{3}{8}$ inch in diameter are being used. The smaller sizes are generally of the *AD* type, whereas the larger rivets are of the *DD* type. To facilitate driving, it is not advisable to specify rivets less than $\frac{1}{8}$ inch in diameter for general work. However, for special applications, smaller rivets may be satisfactory, such as when $\frac{1}{16}$-inch rivets are used primarily as tack rivets or for fastening the trailing edges of airfoil surfaces, and when $\frac{3}{32}$-inch rivets are used for attaching Dzus fasteners, plate nuts, or other small parts. As a general rule, the diameter of the rivet should be from one to two and one half or three times the thickness of the thickest part through which it is driven.

10. The lengths of rivets vary by sixteenths of an inch from $\frac{1}{8}$ to 1 inch, and by eighths from 1 to 2 inches. One manufacturer uses no *A* rivets over $\frac{5}{8}$ inch in length, no *AD* rivets over $1\frac{1}{2}$ inches, and none over 2 inches. The length that should be used depends on the grip, or combined thicknesses of the sheets or parts being riveted together, plus an allowance for upsetting. Thus, the *AN* rivet standards call for a length equal

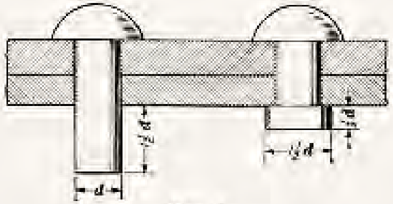

FIG. 3

to the grip plus 1.5 the diameter of the rivet. The nearest standard rivet length greater than the calculated sum is then used. The allowance permits upsetting the shank to a flat, or squash, head, as shown in Fig. 3, equal in height to approximately ½ the diameter *d* of the rivet and in width to 1½ the diameter. Many aircraft manufacturers, however, have set up their own standards for determining the length of rivet to use. Thus, the standards as set up by one manufacturer specify that for grips up to $\frac{15}{32}$ inch, the length of rivet should equal the grip plus 1½ the diameter; for grips from ½ to $\frac{31}{32}$ inch, the driving allowance should be increased by $\frac{1}{16}$ inch; for grips from 1 to $1\frac{15}{32}$ inches, the allowance should be increased by ⅛ inch; and for grips from 1½ to $1\frac{31}{32}$ inches, the allowance should be increased by $\frac{3}{16}$ inch.

11. Another manufacturer has set up the standards given in Table VI. The results obtained from the use of this table differ somewhat from both those given in the *AN* standard and those obtained by use of the foregoing formulas. Thus, for a total thickness of parts, or grip, of .140, or $\frac{9}{64}$, inch and rivets of $\frac{5}{32}$ inch in diameter, the length specified by the *AN* standard would be $\frac{9}{64}+1\frac{1}{2}\times\frac{5}{32}=\frac{3}{8}$ inch, whereas the length given in the table is $\frac{5}{16}$ inch.

12. In a method employed by another manufacturer the rivet length is determined by the use of the diagram, or nomograph, shown in Fig. 4. With a known grip and a selected diameter of the rivet, the length of the rivet is determined by placing a straight edge on the known grip, as indicated on the left vertical line, and on the selected diameter, as indicated on

TABLE VI

MINIMUM AND MAXIMUM GRIPS FOR VARIOUS RIVET DIAMETERS

Rivet Length Inches	Rivet Diameter, Inches — Minimum and Maximum Grips: 3/32 Min.	3/32 Max.	1/8 Min.	1/8 Max.	5/32 Min.	5/32 Max.	3/16 Min.	3/16 Max.	1/4 Min.	1/4 Max.	5/16 Min.	5/16 Max.
5/32		.031										
3/16	.032	.062	.015	.078								
7/32	.063	.093										
1/4	.094	.125	.079	.140	.031	.093						
5/16	.126	.187	.141	.203	.094	.156						
3/8	.188	.234	.204	.234	.157	.218	.125	.187				
7/16	.235	.281	.235	.296	.219	.250	.188	.218	.109	.172	.078	.140
1/2	.282	.343	.297	.359	.251	.312	.219	.281	.173	.234	.141	.203
9/16	.344	.406	.360	.421	.313	.375	.282	.343	.235	.296	.204	.265
5/8	.407	.468	.422	.484	.376	.437	.344	.406	.297	.359	.266	.328
11/16	.469	.500	.485	.515	.438	.468	.407	.468	.360	.421	.329	.390
3/4	.501	.578	.516	.578	.469	.531	.469	.500	.422	.484	.391	.453
13/16	.579	.641	.579	.640	.532	.593	.501	.562	.485	.546	.454	.515
7/8	.642	.703	.641	.703	.594	.656	.563	.625	.547	.609	.516	.578
15/16	.704	.750	.704	.734	.657	.718	.626	.687	.610	.671	.579	.640
1	.751	.781	.735	.796	.719	.750	.688	.718	.672	.734	.641	.703
1 1/8			.797	.921	.751	.843	.719	.843	.735	.859	.704	.828
1 1/4									.860	.984	.829	.953
1 3/8									.985	1.109	.954	1.078
1 1/2									1.110	1.234	1.079	1.203

Courtesy of Boeing Aircraft Co.

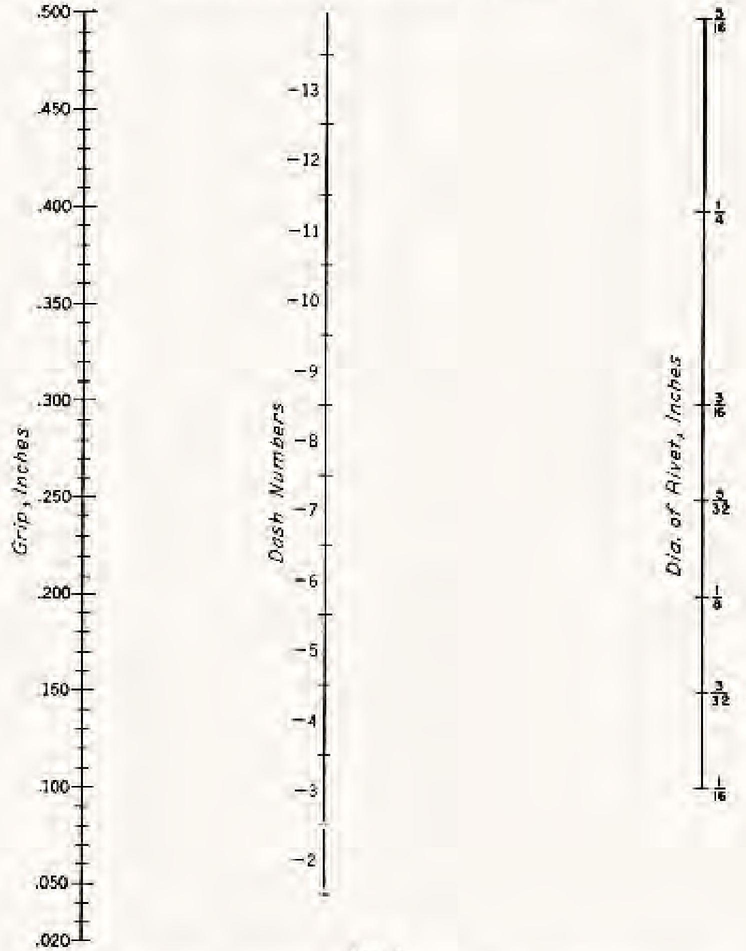

Fig. 4

the right line. The length can then be found at the intersection of the straight edge and the center line. The lengths are given in dash numbers, each of which is equal to $\frac{1}{16}$ inch. Thus, for a grip of .140 inch and rivets of $\frac{5}{32}$ inch in diameter, the rivet length would be determined as -5, or $\frac{5}{16}$ inch. Where two lengths are in question that is, at the dividing line, the greater length of the two should be specified, in order to assure adequate material for the proper forming of the upset.

AIRCRAFT RIVETING METHODS

DRILLING PRACTICE

13. Rivet Holes.—Rivet holes in aluminum alloys may be either drilled or punched to size, or punched small and then reamed to size during assembly. Many parts are punched or drilled during fabrication. For example, the rivet holes in longitudinal stringers may be punched in one operation by using a series of individual piercing units set up in a power press brake. The skin that fits over the stringers can then be drilled with hand-size drills by using the punched holes as a guide; in this way, perfect matching of the holes is obtained.

From a standpoint of strength, drilling of rivet holes is often preferred to punching. Thus, whenever parts are blanked on radial-arm routers, the rivet holes are drilled with a radial-drill which is used in conjunction with the drill templets that locate the rivet holes. Formed parts that have not been drilled or punched during blanking are generally drilled in jigs, so that the rivet holes will coordinate with corresponding holes in attaching parts. In many cases, pilot holes are drilled before the assembly operations and then, during assembly, are enlarged with a drill of the proper size in order to insure coordination.

Whenever holes are drilled, either during sub-assembly or final assembly, the burrs and chips must be removed from around the holes and between the sheets even if it is necessary to disassemble the parts and then reassemble them after the chips are removed. A convenient method of removing chips without disassembling the parts is to insert between the parts a chip remover, which is a thin blade of steel with a hook on one end, and draw it along the line of rivet holes.

14. Drilling Rivet Holes.—During both final and subassembly, rivet holes are invariably drilled with hand-size electric or air drills, operating at speeds up to 5,000 revolutions per minute and using standard twist drills ground to a point of 118 degrees. Both electric and air drills give satisfactory service

FIG. 5

and the choice between the two types depends on the conditions under which the drilling is to be done, the location of the work within the plant, and the availability of a supply of compressed air. One advantage of an air-operated drill is that its speed can be more readily controlled than that of an electric drill. It can be started more slowly when spotting a hole, and therefore is particularly good for drilling out bad rivets.

15. The fastest and most accurate means of drilling a part is by use of a drill jig. When a jig cannot be used or is not available, the holes must be laid out according to blueprint specifications. As the metal should not be marred, a pencil and a pencil compass, rather than scribers or dividers, should be used to layout the positions of the rivet holes. The rivet line along the edge of a part can readily be marked with the pencil compass. In marking the rivet line, it is important that the specified edge distance be maintained since it is a critical factor in the strength of the joint.

TABLE VII

TWIST-DRILL SIZES

Diameter of Rivet, Inches	Drill Size	Diameter of Rivet, Inches	Drill Size
$\frac{1}{16}$	No. 51 (.067)	$\frac{3}{16}$	No. 10 (.193)
$\frac{3}{32}$	No. 40 (.098)	$\frac{1}{4}$	F (.257)
$\frac{1}{8}$	No. 30 (.128)	$\frac{5}{16}$	P (.323)
$\frac{5}{32}$	No. 20 (.161)	$\frac{3}{8}$	W (.386)

The centers are scaled off along the rivet line and are center-punched deeply enough to receive the point of the drill, in order that the drill will not slip out of position and damage the part. A drill stop made of rubber or fiber, or as a spring-supported metal collar, may be slipped over the twist drill to prevent any marking of the sheet by the drill chuck in case the drill passes through the hole too far. However, if the front part of the drill housing is held with the last three fingers, and the fore finger and thumb are extended and pressed against the sheet, as shown in Fig. 5, the drill can be prevented from passing more than $\frac{1}{4}$ inch beyond the material.

16. Size of Rivet Holes.—The size of hole for any particular diameter of rivet is a critical factor in that a hole too large will result in bulging and separation of the sheets, bent or eccentric upsets, and possibly loose rivets. If the hole is large and the rivet has not been driven enough to fill the hole properly, the full strength of the rivet will not be developed. On the contrary, if the hole is oversize and the rivet has been driven enough to fill the hole, internal cracks may be developed by the excessive cold working and lead to the failure of the rivet. Most aircraft manufacturers use the smallest clearance that will allow the rivets to be inserted easily and without delay. The drill sizes that are used by one manufacturer for the various rivet diameters are given in Table VII. Another manufacturer has increased the hole size to a .010-inch clearance for small rivets, and more for

FIG. 6

larger rivets, in order to obtain better matching of holes and to allow easier insertion of the rivets.

17. Sheet-Holders.—During riveting, the rivet holes tend to get out of alinement because the parts slip and the sheet metal swells. The parts to be riveted, therefore, are fastened together by some type of sheet-holder that prevents the sheets from slipping and that holds them tightly enough to prevent the rivets from squeezing out between the joints. For example, when parts are assembled in a fixture, they are fastened together in this manner in preparation for the final riveting operation. The sheet-holders are then taken out, one by one, as the riveting proceeds.

The most popular sheet-holder is the spring type, of which several different makes are available. It is applied, as shown in Fig. 6, by a special type of plier that holds the body *a*, Fig. 7, of the sheet-holder while pushing out the plunger *b* against the

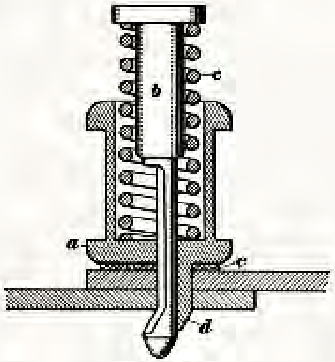

FIG. 7

action of the spring *c*. The plunger and the extension *d* of the body are inserted through the rivet holes in the two sheets, and the spring is released. The enlarged end of the plunger, which is now backed up by the extension *d*, cannot pass through the rivet holes and therefore holds the sheets firmly together. A fiber washer *e* prevents scratching of the metal surface. The holders should be placed close enough together to prevent buckling of the sheet metal. An obvious advantage of the spring type of holder is that it can be inserted and removed from one side of the sheet and access to both sides is not required.

HAMMER RIVETING

18. Types of Riveting Hammers.—The majority of rivets in aircraft work are driven by portable, pneumatic, riveting hammers, or guns, that are of four general types: slow-hitting, fast-hitting, one-shot, and corner. These hammers are made in a variety of sizes and with various styles of handles to adapt them to all assembly conditions. The handle styles include pistol-grip with either outside or inside trigger, offset or right-angle with inside trigger, angle or revolver-type, straight with button or lever control, and center-grip.

The hammers are fitted with rivet sets, or dies, of different sizes and shapes to accommodate different sizes and types of rivets. In aircraft riveting, the blows from the hammer are

Fig. 8

applied to the head of a rivet while a bucking bar is held against the end of the rivet shank. The piston of the hammer strikes the rivet set held in the nose of the hammer, and the impact is transmitted through the rivet to the bucking bar. The impact causes the structure being riveted to deflect slightly so that the inertia of the bucking bar can upset the shank of the rivet.

19. Slow-Hitting Hammers.—Slow-hitting hammers, one type of which is shown in Fig. 8, are the most popular for aircraft riveting. They are air-operated and of the piston type, and strike from 900 to 2,500 blows per minute. Their slow, accurately-controlled blows cause the metal of a rivet to flow uniformly without structural deterioration. A number of blows is necessary to form the upset and they are delivered as long as the trigger is depressed. An operator with some practice can soon determine closely how long the trigger should be held down. Under normal conditions, a slow-hitting hammer should upset a

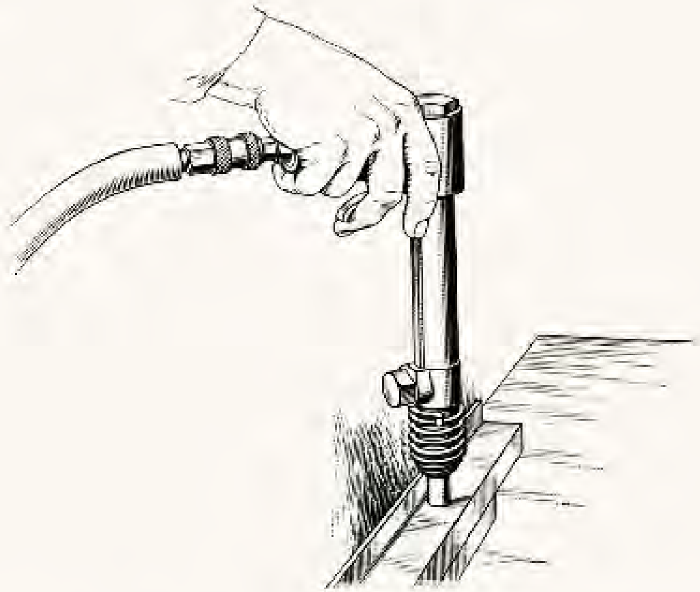

Fig. 9

rivet in from 1 to 2 seconds. Since a rivet should be upset in as few blows as possible in order to prevent excessive work hardening, the proper size of hammer and the correct air pressure should be used. Rivets $\frac{3}{32}$ inch in diameter require an air pressure of about 25 pounds per square inch; $\frac{1}{8}$-inch rivets about 40 pounds; $\frac{5}{32}$-inch rivets about 60 pounds; and $\frac{3}{16}$-inch rivets about 90 pounds. The air pressure is adjusted by a needle valve on the handle of the hammer. If the correct impact cannot be obtained by varying the air pressure, the hammer is of the wrong size. If the hammer is too powerful, it cannot be controlled properly. If it is too small, too many blows are required to upset the rivet and a larger hammer should be used.

20. **Fast-Hitting Hammers.**—Fast-hitting hammers, also known as vibrators, strike from 3,000 to 5,000 blows per minute and are of the same general construction as slow-hitting hammers, except that the former have a larger bore, or piston diam-

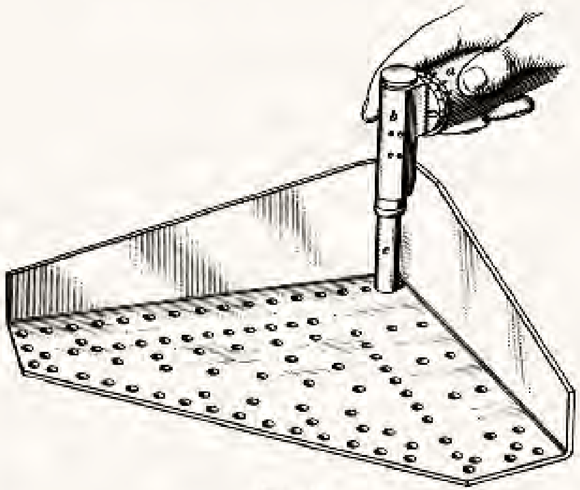

FIG. 10

eter, and a shorter stroke. They are more difficult to control and consequently are used only to a limited extent, such as for very light work. Like the slow-hitting hammers, they continue to strike as long as the trigger is depressed

21. One-Shot Hammers.—One-shot hammers, one type of which is shown in Fig. 9, have long strokes, as compared to either slow-hitting or fast-hitting hammers, and have enough power to upset rivets with a single blow. When the trigger is depressed, the piston makes only one stroke and stops. To strike another blow the trigger must again be depressed. This action makes the one-shot hammer easily controlled on the work, except on thin sheet, where the impact might be too heavy, and it can be used with little danger of damaging the rivet or the sheet. The properly controlled impact of this type of hammer results in a tightly and uniformly driven rivet without stretching or straining the surrounding metal. Rivets of type *AD* are upset in one blow, but *D* or *DD* rivets are upset in two or more blows to take advantage of progressive cold working so as to stay within the plastic range. One-shot hammers are operated by hand, or are mounted on pedestals and mechanically operated.

22. Corner Hammers.—When riveting is necessary in corners, close quarters, or confined spaces, corner hammers may be employed. As shown in Fig. 10, the corner hammer has its handle *a* at right angles to its cylinder *b*. The rivet set *c* is located off-center in the cylinder in order that very close riveting can be done by swinging the handle away from the interfering part, and bringing the rivet set nearly against the projecting member. Thus, the hammer in the illustration would be swung, for very close riveting, so that it would point directly into the corner of the part.

23. Rivet Sets.—The impact of the piston of a riveting hammer is transmitted to the rivet through the rivet set, which fits into the nose, or end of the cylinder body, and is held in place by a retaining spring or a rubber band. Rivet sets are made of hardened steel and are given smooth, polished surfaces in order that no tool marks are left to cause stress concentrations that may result in breakage. Rivet sets can be shaped to fit approximately the head of the rivet; that is, for round or brazier heads the set would be cupped, whereas for flat or flush heads the end of the set would be left flat. At one factory, however, driving of round-head rivets with a flat set is permitted in order to reduce the cost of the rivet sets, and to speed up production since less time is required to get on the rivets, that is, to place the set firmly against the rivet head. A flat set flattens the rivet head, but does not weaken it, or cause it to crack.

24. When a cupped set is used, the cupping must be slightly wider and shallower than the manufactured head of the rivet, so that the initial impact will be at the end of the head and directly in line and concentric with the shank. This condition is shown in Fig. 11, in which the rivet *a* is to be upset between the cupped rivet set *b* and the bucking bar *c*. With incorrect cupping, as shown in Fig. 12, the shank of the rivet *a* will be driven up into the head and the rivet or skin will be marked, or ringed, by the rivet set *b* as the rivet is bucked by the bar *c*. The cupping dimensions for rivet sets that are supplied by one manufacturer, are given in Table VIII for round-head and

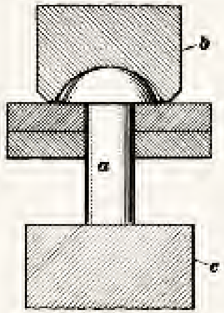

FIG. 11

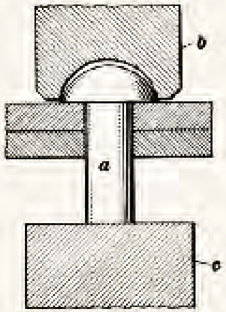

FIG. 12

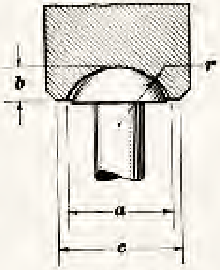

FIG. 13

brazier-head rivets from $\frac{3}{32}$ to $\frac{1}{4}$ inch in diameter, the dimension letters referring to Fig. 13. These dimensions vary to some extent, depending on the design of the rivet set.

25. Rivet-Set Shanks.—Rivet sets for hammers are made in two types of shanks, straight and Parker taper, as shown at *a* and *b*, Fig. 14, and two shank diameters of .401 and .498 inch. The dimensions of the rivet sets vary according to the manufac-

TABLE VIII

CUPPING DIMENSIONS OF RIVET SETS

Type of Head	See Fig. 13	Diameter of Rivet, Inch				
		$\frac{3}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{1}{4}$
		Cupping Dimensions, Inch				
Round Head	a	.202	.271	.339	.406	.543
	b	.063	.084	.105	.126	.168
	c	.295	.365	.430	.500	.635
	r	.113	.151	.189	.226	.303
Brazier Head	a	.256	.344	.430	.515	.689
	b	.039	.053	.066	.079	.105
	c	.350	.440	.525	.610	.780
	r	.229	.308	.384	.460	.615

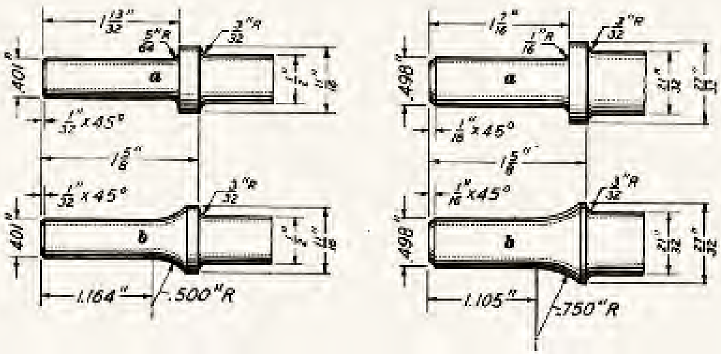

Fig. 14

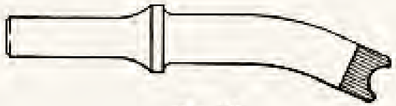

Fig. 15

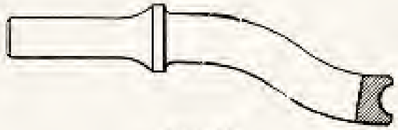

Fig. 16

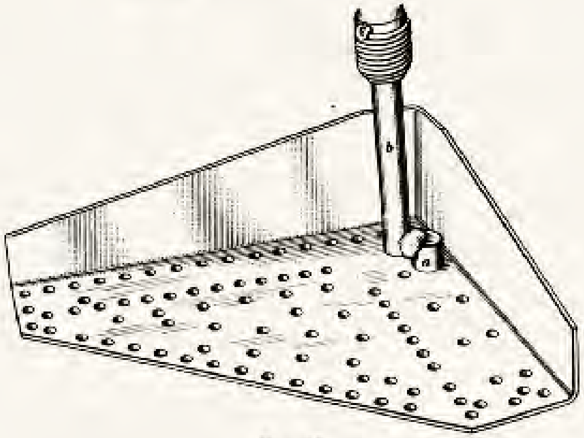

Fig. 17

turer. Both straight and taper shanks are used, but the taper shank has a definite advantage in that it is stronger and less liable to break. The smaller size of taper shank is generally used in small riveting hammers; whereas, the .498-inch shank is used principally in larger hammers.

26. Styles of Rivet Sets.—A variety of rivet sets may be used in the riveting hammer to meet the driving conditions. The proper length of set also depends on the driving conditions. A short, straight set is most efficient when the hammer can be taken close to the work. When structural members interfere, however, longer sets must be used. Besides the straight sets shown in Fig. 14, curved and offset rivet sets may be employed where rivets are difficult to reach. They should not be used unless necessary, since they tend to shear off the rivet heads during the driving operation and therefore weaken the rivet. An offset rivet set of a common style is shown in Fig. 15, and a curved set in Fig. 16. As these sets are placed with the cup squarely on the head of the rivet, the blow is struck on an angle and gives the shearing effect.

Another type of offset rivet set is shown in Fig. 17. This set has been made by welding an extra piece *a* to the main body *b* of the shank. As the weld metal tends to crack under the contact impact of riveting, the one-piece offset rivet set is more commonly used.

27. For flush riveting, two types of rivet sets, solid and swivel, are used. The solid type is similar to a flat-face straight set, except that the head is mushroomed to various face diameters to eliminate any possibility of marring the surface of the sheet. The face of the set may be either flat or slightly convex. A swivel device, shown at *a*, Fig. 18, is sometimes used so that the face of the set can adjust itself to the skin surface in case the set is not held exactly perpendicular to the skin. This swiveling action is advantageous for driving flush rivets in restricted places and insures uniform results.

28. Set Retainers.—The most common form of retainer used to hold rivet sets in riveting hammers is a coil spring,

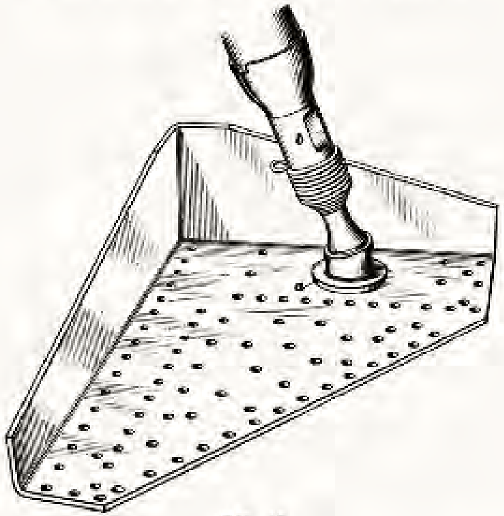

Fig. 18

known as the *beehive* retainer. One of these is shown mounted on a hammer at *b*, Fig. 18. The set may be provided with a groove in its collar to receive the spring. To mount the set in a hammer, the spring is removed from the nose of the hammer, screwed over the collar, and then, together with the set, screwed back on the nose. Another method of holding the rivet set in the hammer is by looping a heavy rubber band around the set below the collar, and then back over the handle of the hammer. With this type of retainer, rivet sets can be changed quickly, but care should be taken in its use since it is decidedly unsafe for the operator. Some operators use no retainer, but this practice is not recommended since the rivet set might accidentally be shot from the hammer and injure another worker, or it might be dropped on the work and damage the surface.

29. Bucking Bars.—Bucking bars, or bucks, which are held against the end of the rivet shank to provide the inertia and therefore the force that upsets the rivet, are of many styles. One manufacturer of bucking bars alone has one thousand separate designs, shapes, and sizes, and also supplies special bars to

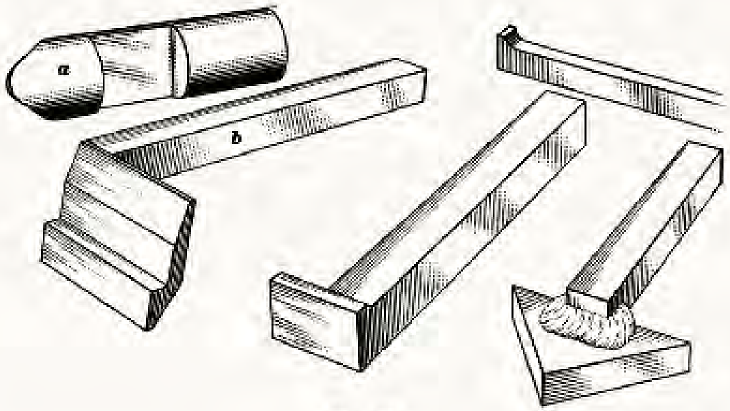

Fig. 19

specifications. The kind, shape, and size of bucking bar that should be used for any particular application depends on the size of the rivet, the thickness of the sheets, and the conditions under which it is to be used. It should be heavy enough to upset the rivet, but if it is too heavy, the rivet may be bent or the sheet may be dimpled. The bar must be shaped so that its face can be held at right angles to the rivet, even under difficult bucking conditions; otherwise, the shank will be upset to one side, producing a *clinched* rivet, which will not pass inspection.

The most common form of bucking bar is simply a piece of square, cold-rolled, steel-bar stock. More complicated bars are forged, cast, or built up by welding. In Fig. 19 are shown several special bars that are used for specific jobs; they indicate the variety of shapes that is necessary. The bars with square shanks are for flat bucking, whereas the round bar *a* has a depression in its pointed end for the forming of a shaped upset.

30. The use of a bucking bar is illustrated in Fig. 20, in which the bucking bar *a* is similar to that shown at *b*, Fig. 19. The bar is held by the bucker beneath the angle *b*, Fig. 20, to upset the rivet being driven by the hammer *c*. Another bucking operation that requires a special tool is shown in Fig. 21. As in the previous case, the bar must be shaped to upset rivets in a

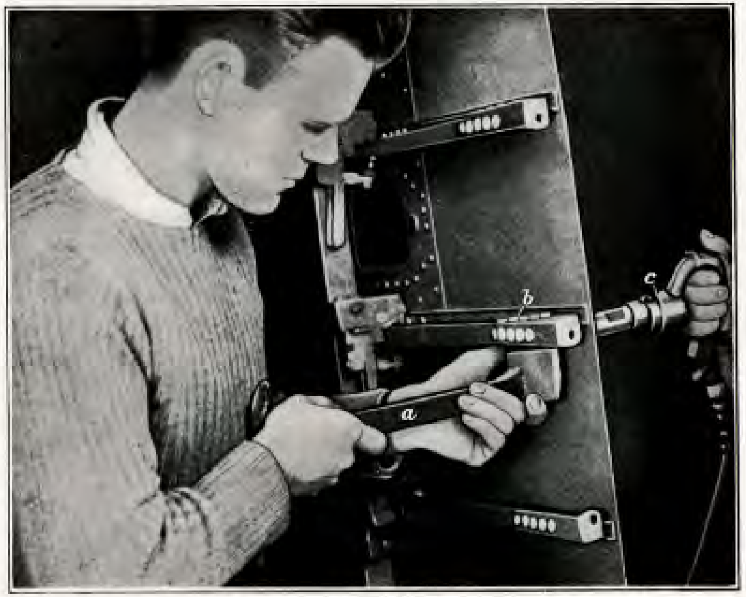

FIG. 20

place that would be inaccessible for a straight tool. Under difficult bucking conditions, such as those illustrated, the bucker works more by feel than sight and must be careful to stay on the rivet, and to exert just enough pressure for an upset of correct size with no dimpling of the sheets. The pressure should be consistent for each rivet driven in order to produce the correct size of upset each time. If the riveter is driving a rivet too flat, the bucking bar should not be removed until the hammer is stopped, or the sheet will buckle. The bad rivet should be replaced, and the riveter on the following rivets should shorten the burst of shots.

31. Riveting Practice.—When aircraft rivets are driven with air-operated hammers, it is almost the universal practice to apply the blow to the head of the rivet while a bucking bar is held against the end of the shank. When two sheets of different thicknesses are being riveted together, the head of the

FIG. 21

rivet should be next to the thinner sheet. When the skin is being riveted in place, however, the rivets are invariably inserted and driven from the outside and bucked from the inside. The riveting may be done by one workman who both operates the hammer and holds the bucking bar, as shown in Fig. 22, or by two workmen, a riveter and a bucker. In the latter case, both workmen must exercise care and work in cooperation for good results. The riveter, for example, must be extremely careful not to mark the skin or the rivet head. The hammer should not be operated until the set is firmly against the rivet head, or removed from the head before the trigger is released; otherwise, both the skin and rivet may be damaged. As an added precaution, masking tape may be placed over the end of the rivet set to prevent its slipping from the rivet head and marring the skin, or the tape may be placed over a row of rivets, thus holding them in place and protecting the surface at the same time. Masking tape should not be used on the face of a bucking bar,

FIG. 22

but it can be used on the sides of a bar to prevent scratching or marring any adjacent structures that the bar might touch.

The hammer should be held at right angles to the part being riveted and enough pressure exerted to prevent the hammer from jumping off the head. Too much pressure will buckle the sheets; whereas too little pressure will slow down the rate of production. Since the weight and strength of the operator and the air pressure that is used effect the riveting operation, only practice can show the operator just the right pressure to exert.

32. **Replacing Rivets.**—When rivets are cracked, bent, marked, overdriven, flashed between the sheets, driven so tightly as to cause buckling of the sheets, or have their heads out of alinement, they will not pass inspection, and must be removed and replaced with new rivets. One method of removing a rivet is to drill through the head for a distance equal to

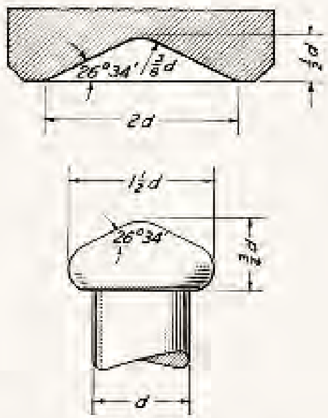

FIG. 23

its height with a drill that has the same diameter as the shank of the rivet. The head is then easily sheared off with a chisel or pried off with a straight punch, and the shank is driven out with the punch while the sheet is bucked up on the other side to prevent dimpling around the rivet hole.

Another method is to drill entirely through the rivet and not to use a punch. This method is satisfactory as long as the drill is centered exactly so that the rivet hole is not enlarged. Since considerable skill is required to drill out the rivet without enlarging the hole, this method is not permissible in most aircraft factories even though it is faster than the first method. If a rivet hole is enlarged during the drilling operation, approval from the engineering department is generally needed before a rivet of greater diameter can be used. Common practice is simply to use a rivet of the same diameter but with a longer shank and to drive it so that it fills the enlarged hole.

33. Shapes of Upsets.—Practically all rivets are driven with a flat, or squash, upset as previously shown in Fig. 3. When appearance is a factor, however, the upset may be of the round, brazier, or cone-point shape of head. The cone-point upset, which is shown with its dimensions in Fig. 23, is often used on rivets of $\frac{3}{16}$ inch or more in diameter when thin sheets are to be riveted and when the cracking tendencies are high. It

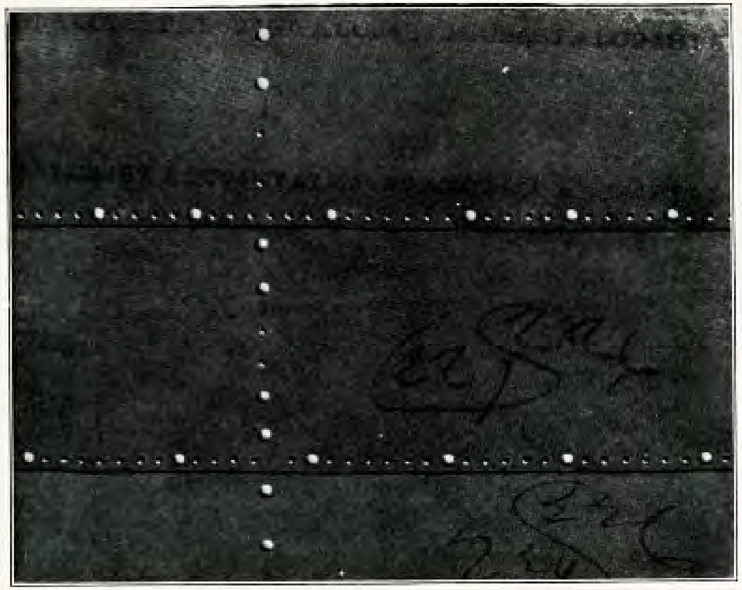

FIG. 24

requires less driving force than does a flat upset, and the flow of metal is such that cracks do not form at the edge as in the case of the flat upset. A cone-point set must be used to form the upset. The amount of driving is controlled by the diameter of the upset, which should be made $1\frac{1}{2}$ times the diameter of the rivet.

34. Riveting Fuselage Skin.—A typical production job that is done by hammer riveting is the riveting of the fuselage skin to the stringers and frames. First, the frames and stringers are assembled in a fuselage fixture and riveted together by squeeze riveters. Then the skin is fitted, drilled, and fastened to the stringers and frames by spring sheet-holders, spaced about 8 inches apart. The holes between the sheet-holders are reamed with a drill of the correct size for the rivets to take care of any slipping of the skin, and the chips are removed from between the parts with a chip remover. A section of the sheet covering about three frames, is tack-riveted with brazier-head rivets about every 5 inches, as shown in Fig. 24, to prevent the sheet from being worked in one direction, thus causing *oil-canning*. In this condition, the riveted section will snap back and forth, in the same manner as the bottom of an oil can, when light pressure is applied.

35. When the tack riveting is completed, the sheet-holders are removed, their holes are reamed out, and the chips are removed from between the members. The riveter then starts in the center of the sheet and rivets out to one end, returns to the center and rivets out to the other end. By holding the gun in one hand and inserting rivets with the other, the riveter can average from five to seven rivets per minute. Rapid teamwork between the riveter and bucker is essential for good production. If the bucker applies a light pressure on the rivet to be driven and raises it slightly above the surface of the skin, the riveter then knows that the rivet is bucked and can push it back against the skin and drive it.

After the skin is completely riveted, it is inspected for oil cans. If any are present, the rivets in that section must be drilled out, the holes re-reamed, and the skin tack riveted in such a manner as to relieve the former strain. The rivets are then replaced. It may even be necessary to straighten a twisted bulb angle that is causing the oil-canning, or to insert a shim to take up an excess of improperly-fitted skin.

36. Self-Bucking Riveting Hammer.—A special self-bucking riveting hammer has been developed by one aircraft company in its effort to attain uniform riveting and to speed up its production. As shown in Fig. 25, the unit consists of a pneumatic hammer *a* held in one arm of a U-shaped frame *b*. On the end of the other arm of the frame, a bucking bar *c* is supported on a rod along which it can slide toward the rivet set in the hammer. When the air valve *d* is opened, air is admitted to a line running around the frame to an actuating cylinder *e*. As the piston of the cylinder *e* is moved down, it causes the

FIG. 25

bar *c*, through a lever arrangement, to move forward, as shown in Fig. 26, until it contacts the shank of the rivet. At the same time, air is admitted to the cylinder of the hammer and the rivet is upset in a few blows.

The self-bucking hammer is shown in these illustrations as being used in the riveting of side panels of Panelyte to aluminum-alloy ribs. It is used as well for riveting aluminum-alloy sheets, on other parts such as inner-wing panels, and for dimpling operations on parts that are to be flush-riveted. To make the unit easily handled, it is supported on an overhead monorail and counterbalanced by a spring-loaded reel. Production estimates are that one operator with this type of hammer can do faster riveting than a riveting team consisting of riveter and bucker.

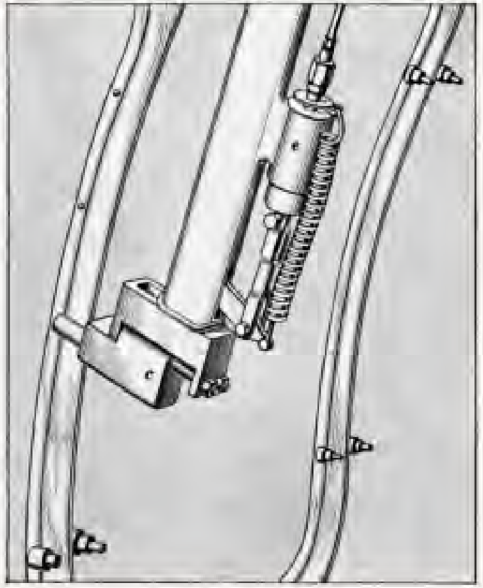

FIG. 26

SQUEEZE RIVETING

37. Squeeze, or Compression, Riveting.—Squeeze, or compression, riveting differs from hammer riveting in that it forms the upset by a squeezing action, rather than by a series of blows. Each rivet is driven in a single stroke between two dollies mounted in the squeezer. The driving stroke is comparatively slow and permits a maximum amount of plastic deformation, or flow of the metal, with the proper amount of work-hardening. Once a squeezer is adjusted for the correct pressure and stroke, it drives rivets with greater uniformity than is possible with hammer riveting, and is more economcial since only one man is required for driving the rivets.

Although squeeze riveters are available in a variety of sizes and shapes and are capable of driving all sizes and types of rivets, their use is limited by the structural design of the work and the location of the rivets to be driven. They are restricted

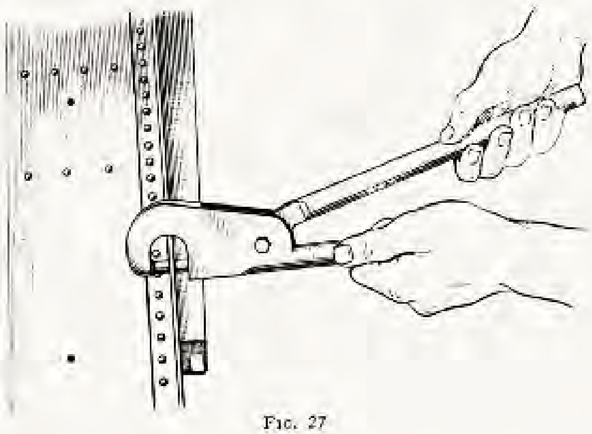

FIG. 27

to riveting parts small enough to pass between the dollies, and may be used to drive rivets only in locations where the rivets are not further from an edge of the part than the maximum throat depth of the riveter. The versatility of squeeze riveters makes them well suited for most sub-assembly riveting operations.

38. Types of Squeeze Riveters.—Squeeze riveters are made in several different types to meet the requirements of the variety of jobs encountered in aircraft construction. They are made in portable, semiportable, and stationary types and are operated by various means. Hand squeezers, such as the one shown in Fig. 27 riveting nut plates on a floor beam, are operated manually. These nut plates have a central, internally-threaded body and two wings drilled to receive the rivets. Hand squeezers are seldom used and then usually in places not accessible to other riveters. A plier-type hand squeezer, which is operated through a series of levers and toggles to the arms of the tool, may be used to drive rivets in places where there is little room parallel to the rivet shank, but enough space perpendicular to the shank to permit access of the tool. One advantage of hand squeezers is that their cost is so low that special yokes can be made economically, even for only one application on an airplane.

FIG. 28

39. Portable Power Squeezers.—Portable power squeezers are particularly adaptable for riveting large assemblies where the tool must be moved in relation to the work. They are operated by compressed air and are made with two general types of jaws, the C yoke and the alligator yoke. The squeezer shown in Fig. 28 has a C yoke and is operated by depressing the valve lever *a* to cause the plunger *b* to move downward and drive the rivet. The force is obtained by a piston-and-cam arrangement that provides a fast initial and a slow final travel; thus, the maximum power of the stroke is developed near its end and the squeezer should be adjusted, on scrap material of the same thickness as the job, to take advantage of the maximum power during this part of the stroke. An air pressure of from 90 to 100 pounds per square inch gives the best results.

Fig. 29

40. Alligator-yoke squeezers may be used by hand in the same way as the C-yoke squeezers, or they may be mounted in a bench vise or in a special clamp, if the parts to be riveted are small and easily handled. For example, in Fig. 29, the squeezer *a* is clamped in a bench vise and is being used to rivet together two sections of an air filter *b*. The squeezing action, which is approximately 1,000 pounds per square inch, is obtained by depressing a valve lever at the end of the air cylinder *c*. The extension *d* on the air cylinder is a cylinder that receives the retracting piston attached to the end of the piston rod leading to the power piston.

A similar squeezer, but one having a smaller throat depth, is shown, in Fig. 30 riveting a nose shelf assembly *a*. This squeezer is mounted in a special clamp *b* that has been made for that purpose. Its operation and application are to a great extent the same as the squeezer previously shown.

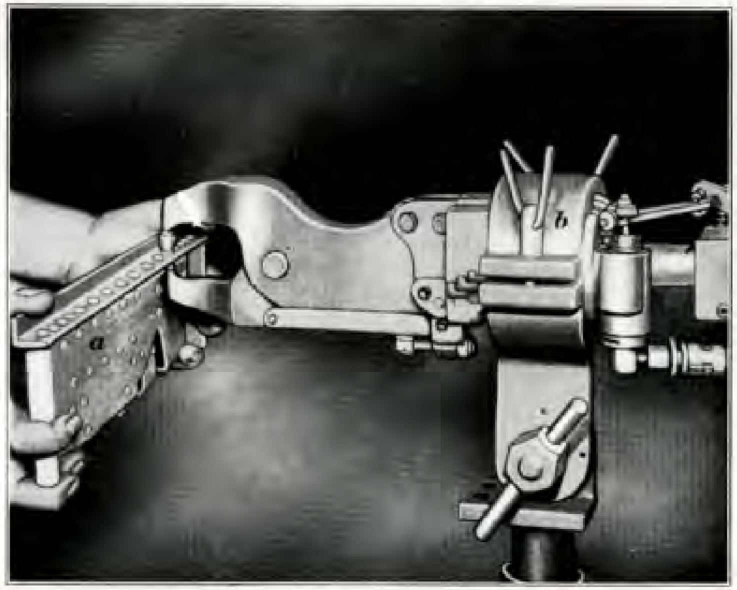

FIG. 30

41. **Semi-Portable Squeezers.**—Semi-portable squeezers are operated by hydraulic pressure produced either by an electric motor or by compressed air. A pneumatic-hydraulic squeezer, commonly known as a pneudraulic squeezer, is shown in Fig. 31, being used to rivet an end fitting to the rear spar and skins of a stabilizer with $\frac{1}{4}$-inch *DD* rivets. Two hoses *a* leading from a separate power plant carry the oil under high pressure to the cylinder *b* of the squeezer. This particular squeezer has a C-type yoke, but pneudraulic squeezers are also made with alligator-jaw yokes. They are lighter than ordinary air-operated portable squeezers and can be used more readily in close quarters. The squeezer is operated by depressing the trigger on the handle, and an automatic return cycle valve returns the plunger to its open position after the stroke. Since the pressure throughout the stroke is constant, the riveter automatically compensates for any difference in thickness of the parts being riveted.

FIG. 31

42. A hydraulic semi-portable squeezer that is capable of exerting a pressure of 10,000 pounds is shown in Fig. 32. Squeezers of this type are used for heavy riveting jobs that require a high squeezing pressure. In this case, a wing attach fitting *a* is being riveted to a front wing spar *b*. Since flat-head rivets are being used, both the plunger *c* and dolly *d* have flat surfaces. Because of the structural design of the parts, the plunger is placed against the rivet head instead of against the shank, as customary. When the trigger is depressed and the squeezer is drawn backward as the plunger advances, care must be taken that the plunger does not jump off the rivet head and possibly injure the work. Operating the squeezer in this manner is slow, but it permits upsetting the rivets in the inside of the part and leaving the rivet heads on the outside. Since the squeezer is to heavy for a woman operator, it is suspended by a cable from a spring-loaded reel and the

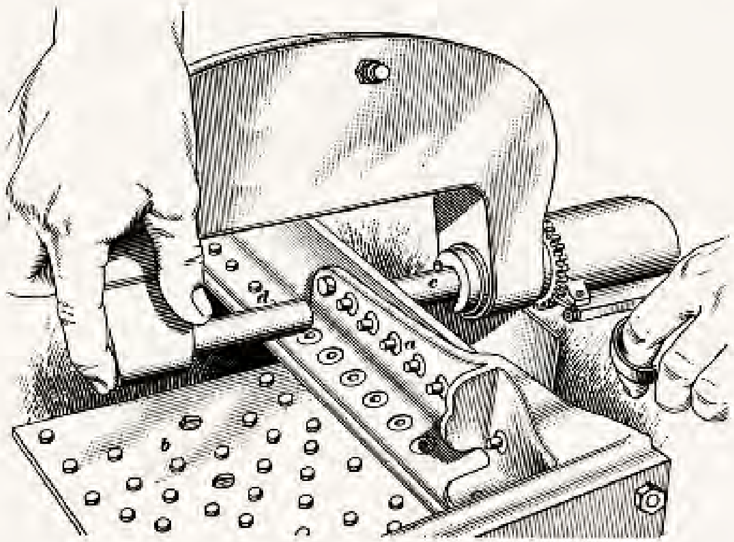

FIG. 32

entire fixture can be rolled freely along the spar on an overhead monorail.

43. Dolly Sets for Squeeze Riveters.—Dolly sets for squeeze riveters are made of steel and have the same cupping dimensions for round-head and brazier-head rivet sets for hammers. They are also made with flat surfaces for forming flat upsets and for driving flat-head and flush rivets. For round-head or brazier-head rivets, a cupped dolly is generally used in the stationary member of the squeezer and a flat dolly is used in the plunger, or in the moving jaw in the case of an alligator squeezer. Most squeezers are made with three styles of plungers: flat-face solid, cupped solid, and hollow to receive a dolly. The cupped plunger or a cupped dolly in the hollow plunger is used for forming round-head or brazier-head upsets, or when the plunger must be placed on the rivet head and the upsetting is done by the dolly on the yoke of the squeezer.

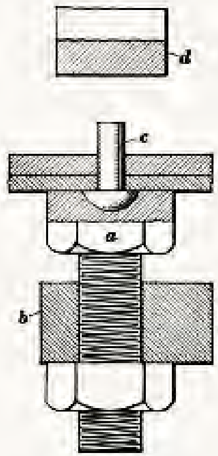

FIG. 33

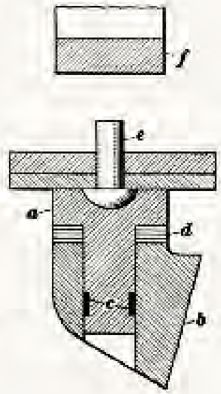

FIG. 34

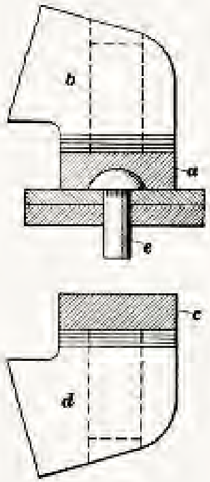

FIG. 35

44. The dollies are made in different lengths to accommodate different thicknesses of material, and are retained in the yoke or plunger either by a spring clip or by a threaded shank. In Fig. 33, the cupped dolly *a* is screwed into the yoke *b* of the squeezer, and, in use, is placed on the head of the rivet *c*. The plunger *d* is flat and upsets the shank of the rivet as the force is applied. The dolly can be screwed in or out of the yoke to obtain the correct height and diameter of upset. One disadvantage of this type of dolly, which is generally used on large C-yoke squeezers, is that it cannot be changed quickly when a change in rivet size or style of head is made.

In Fig. 34, the dolly *a* is retained in the yoke *b* by a spring clip *c*. Metal shims *d* are placed under the dolly to adjust it for the size of opening required to give an upset of the correct dimensions. As in the previous case, the cupped dolly is placed against the head of the rivet *e* and the rivet shank is upset by the plunger *f*.

45. The arrangement of dolly sets in an alligator-type squeezer is shown in Fig. 35. The cupped dolly *a* is placed in the stationary jaw *b*, and the flat dolly *c* is placed in the

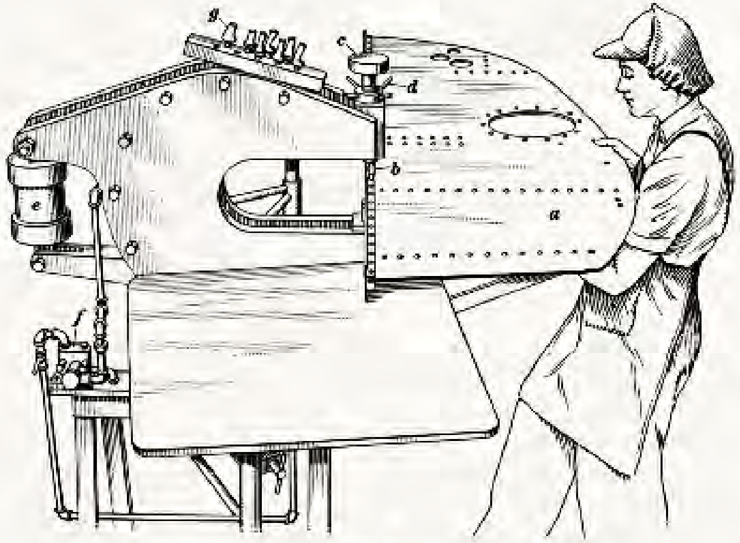

FIG. 36

moving jaw *d*. The dollies are adjusted for size of opening by shimming under either one or both. After the adjustment is made, the dollies must be shimmed so that their faces are parallel when the jaws are closel. The rivet *e* is driven by placing the cupped dolly on the rivet head and upsetting the shank with the flat dolly on the moving jaw. During the operation, the cupped dolly should be held firmly against the rivet head to avoid bending the rivet.

46. **Pedestal-Type Squeezers.**—Pedestal-type, or stationary, squeeze riveters are used principally in sub-assembly departments for riveting small parts that can be handled easily. They may be operated by compressed air, by hydraulic pressure, or mechanically. In Fig. 36, a bulkhead *a* is shown being riveted on a stationary squeezer that is capable of exerting a pressure of 10,000 pounds. The upper dolly *b* is screwed through the yoke of the machine, and can be adjusted vertically by a hand wheel *c* for the proper size of

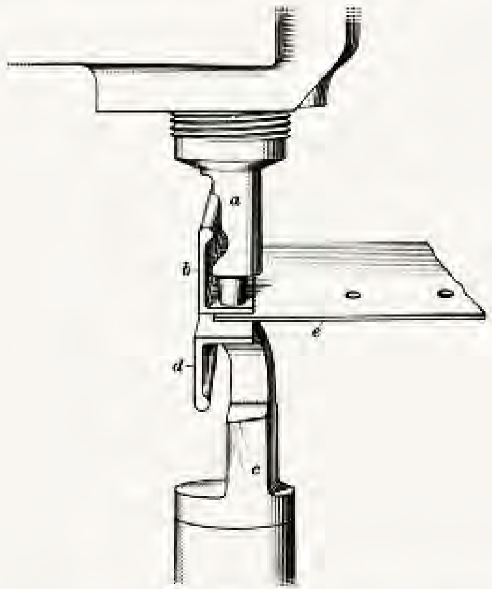

FIG. 37

opening between the upper and lower dollies and then locked in place by a lock nut *d*. The plunger, which carries the lower dolly, is operated by a lever arrangement from an air cylinder *e* that is controlled by a foot pedal through a valve *f*. This arrangement leaves both hands of the operator free to handle the work. Additional dollies *g* are provided to adapt the machine to a variety of jobs.

The shapes of the dollies are shown in Fig. 37. The upper dolly *a* is cut out to clear the bulb of the bulb-angle *b*, and the lower dolly *c* is offset to clear the lower bulb angle *d*. The sheet *e* of the bulkhead is riveted between the two bulb angles, the rivets being inserted from the top and upset on the bottom. Both dollies are cupped, the upper one to fit the head of the rivet and the lower one to form a round-head upset.

47. Nut-Plate Squeezer. — The pedestal-type squeezer shown in Fig. 38 was designed especially for attaching nut plates to parts. The moving jaw *a* of the machine is operated

FIG. 38

by a foot pedal through a compound-lever arrangement. The rod *b* leading to the foot pedal is attached to a lever *c* that is pinned to the stationary yoke of the machine. When the foot pedal is depressed, the lever *c* forces the free end of the moving jaw to rise by means of a roller extending through a slot in the jaw, and thus closes the jaw over the rivets in the nut plate *d*. Since, with this arrangement, the initial travel of the jaw is rapid and the final travel is slow, the maximum pressure is obtained when it is actually needed to upset the rivets. A spring *e* on the rod *b* is compressed as force is applied on the pedal, and thus provides a uniform pressure throughout the squeezing operation. To rivet a nut plate in place, two rivets are inserted from the bottom through previously drilled holes in the flange of the part, which is then moved along to bring the rivets over the lower dolly. The nut plate is slipped over the rivets, and the pressure is applied to form the upsets. The upper dolly is separated in the middle to clear the body of the nut plates.

48. Multiple Squeezers.—Multiple, or gang, squeezing can be used effectively on a large variety of aircraft work, such as riveting stiffeners on skin sub-assemblies, wing shear webs, wing spars, and bulkhead assemblies. Upsetting rivets in multiple, that is, several at one time, produces uniform upsets, holds warping to a minimum, and is fast and efficient. One particular machine with an air pressure of 90 pounds per square inch, develops sufficient pressure in one squeeze to upset sixteen $\frac{1}{8}$-inch rivets, twelve $\frac{5}{32}$-inch rivets, eight $\frac{3}{16}$-inch rivets, or four $\frac{1}{4}$-inch rivets. Under ordinary working conditions an average operator is able to upset as many as 1,100 rivets per hour in attaching stringers to wing skins, and 500 per hour on more complicated work, such as wing-spar riveting. With highly-developed handling methods, rivets can be upset at the rate of 2,000 per hour on large assemblies. Roll-top tables are considered to be the best and simplest means of supporting large, flat assemblies, such as wing and stringer sections. For wing-spar and web riveting, roll-top stands may be used.