# BLANKING AND PUNCHING

## BLANKING BY ROUTING

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# BLANKING BY ROUTING

## RADIAL-ARM ROUTER

### ROUTING PROCESS AND EQUIPMENT

1. **Principle of Routing Process.**—In the aircraft industry routing is the most commonly used process for the cutting of aluminum-alloy sheet, when at least one edge of the part, or blank, is curved or irregular. Although most of the material routed is dural or Alclad, other soft metals, such as magnesium, copper, and brass, can also be routed; at present, the process is not adaptable to the cutting of iron or steel.

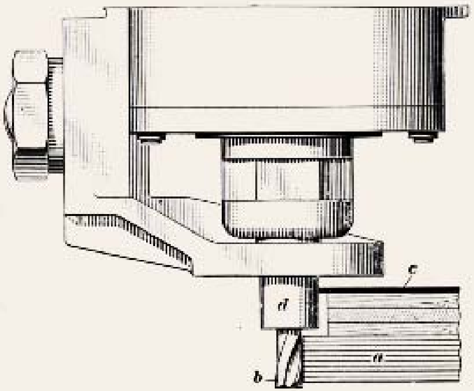



FIG. 1

The basic principle of routing, or profiling, is to stack a number of sheets of standard size, generally 48 by 144 inches, on a table, drill them, and then, with a router bit as the cutting tool, cut them in a single operation to the outline of a pattern. Thus, in Fig. 1, the stack of sheets *a* is cut by the router bit *b* to correspond to the shape of the router pattern *c*. The pattern *c* has the same general shape as the finished part, but is slightly smaller because the router bit is guided around the pattern by a pattern follower, or guide, *d* that is larger than the bit. The follower is $\frac{3}{4}$ inch in diameter, whereas the router bit is $\frac{5}{16}$ inch in diameter. Therefore, the pattern must be made smaller than the finished part to compensate for this difference of $\frac{7}{32}$ inch in radius at all points around its periphery.



2. **Application of Routing Process.**—Routing offers a rapid, yet inexpensive, means of cutting the great variety of complex shapes and sizes required in aircraft production. It is, however, more expensive than square shearing and replaces shearing only when the parts are irregular in outline. Routing is well suited for either large or small quantities, but when as many as ten thousand small parts are to be cut, routing is normally replaced by blanking on a punch press, because of the greater economy and speed of production. Routing, however, is the least expensive method of blanking large, complicated shapes. With good working conditions, a skilled router operator can cut as many as two-hundred parts per hour, but the average production is generally less. The usual speed of routing is about 2 feet per minute or more, depending on the thickness of the stacked sheets and the condition of the router bit.

3. Routing requires little set-up time and is flexible in regards to design changes. The tooling cost is low since only a drill templet and a router pattern are needed for each part. Routing is also economical with material, as small patterns can be arranged on a large layout, so that generally less than ten per cent of the stock is scrapped.

Since the parts are cut to match router patterns, the accuracy of routed parts approaches that attainable with blanking dies. Routed parts also have clean, smooth edges, which are free from burrs that might cause fracture during subsequent forming operations. A burring operation may be necessary on the top and bottom sheets of a stack, as these sheets are not so adequately supported during routing as are the center sheets. Routed edges are especially desirable on parts that are to be formed, since cracking is less likely to result than with parts that have been sheared, sawed, or blanked in dies. The marks and scratches left across the edges of a sheet by



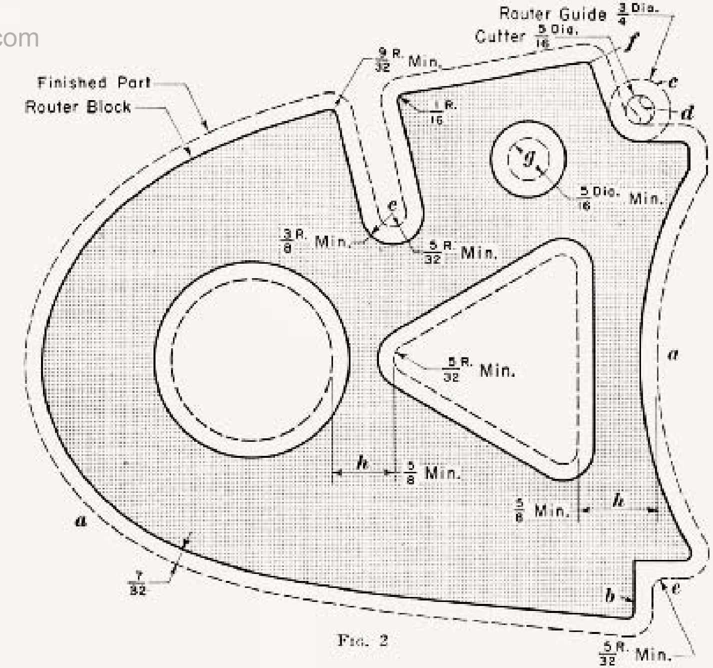



Fig. 2

these other cutting methods may set up stress concentrations and be starting points for cracking; whereas, the tool marks left by a router bit are parallel to the edges and set up no such stress concentrations.

4. **Limitations of Routing Process.**—The limitations of the routing process are illustrated in Fig. 2. Those edges of the part that have large curvatures, such as at *a*, can be routed readily by following the outline of the router pattern *b*. Since the difference between the radii of the pattern follower *c* and the router bit *d* is $\frac{7}{32}$ inch, the part will be uniformly $\frac{7}{32}$ inch larger than the pattern. Square inside corners cannot be routed since the smallest radius, as shown at *e*, is the radius of the router bit, or $\frac{5}{32}$ inch. On an outside corner, the radius

will be at least equal to $\frac{7}{32}$ inch. Since the router pattern will wear rapidly on the corners, if they are left sharp, these corners, as shown at *f*, either wear to or are given a radius of at least $\frac{1}{16}$ inch, thus making the radius on the outside corner of the part at least $\frac{9}{32}$ inch.



**5.** The diameter of the smallest hole *g*, Fig. 2, that can be routed is equal to the diameter of the bit, or $\frac{3}{16}$ inch. Routing holes of the minimum size, however, is often unsatisfactory, because of the danger of damaging the router pattern, either by the router bit or by the pattern follower, as the router head is dropped.

Inside holes are also limited in their position. If the holes are too close together, the router pattern will be so thin between the holes that it cannot withstand the pressure of the pattern follower. Thus, as shown at *h*, the minimum distance between holes, or between a hole and the outside edge of the part, should be at least $\frac{3}{8}$ inch. For the same reason, routing is impractical on parts that have long, thin projections on their outer edges.

**6. Radial-Arm Drills and Routers.**—The machines and methods used for drilling and routing vary somewhat in different aircraft plants, but are all similar in principle. The radial-arm drills and routers are identical in general construction, with the exception of the drilling and routing heads. Each machine consists of a heavy steel base on which one or two arms are pivoted. Each arm is jointed in the middle to permit free movement of its end to any place within its reach. Thus, an arm of 114 inches can cover a table 48 by 144 inches in size, and on a smaller machine an arm of 84 inches can cover a table of 48 by 72 inches.

Some machines have only one radial arm to which either a drilling or a routing head may be attached. Other machines have two arms, one used for drilling and the other for routing, or both arms may be employed for drilling or both for routing. By using a machine for only one operation, the drilling can be done away from the routing. This practice is more efficient



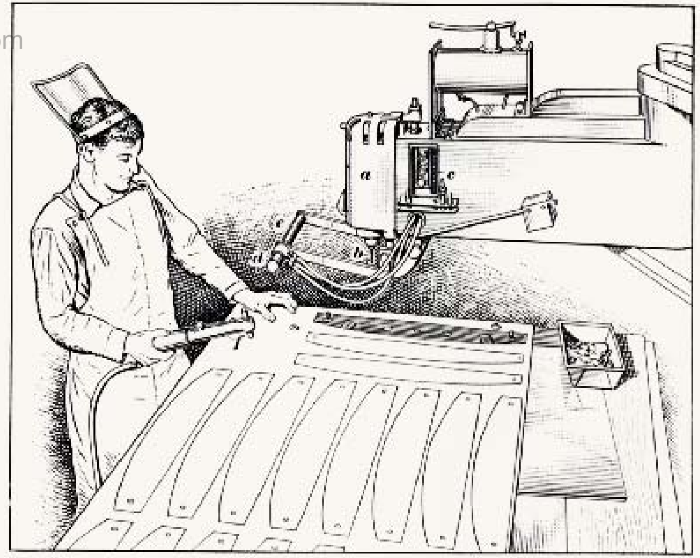


Fig. 3

since routing requires only half as much time as drilling. With a combination machine having one router and one drill, the router is idle a great part of the time. Performing the routing and drilling separately also prevents chips from the router bit from interfering with the drilling operation, as canvas curtains may be hung around each router or pair of routers to localize the chips.

**7.** When a combination machine is used, two tables, each measuring 48 by 144 inches, are provided for holding the work during the drilling and routing operations. These tables are fixed to the floor, and the drilling is done on one table while the routing is done on the other. The arms are then swung to change operations. When machines are operated in pairs, however, the work tables should be mounted on casters so that they may be moved successively to one location for loading, to a radial-arm drill for drilling, to a router for routing, and

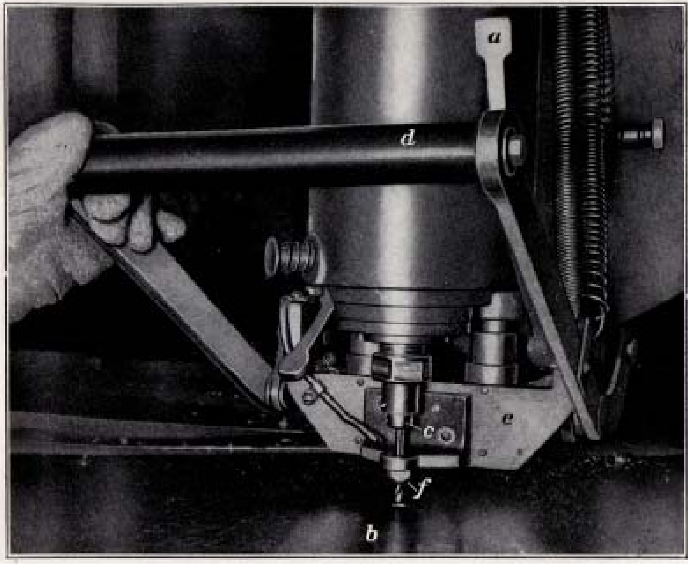



Fig. 4

finally to the unloading station. Steel plates should be set in the floor at the drill and router locations, and quick-acting clamps should be used to hold the table legs firmly and to insure that the table tops will be level.

**8. Drilling Head.**—The drilling head shown in Fig. 3 is used for stack drilling in conjunction with a drill templet, and consists of an electric motor enclosed in the housing *a*, and arranged so that the drill *b* is chucked directly to the end of the motor shaft. There is no intermediate gearing for speed control, but on this particular make of head two speeds, 7,500 and 15,000 revolutions per minute, are obtainable with the speed-selector starter buttons in the switch *c*. On such heads, the drill is fed into the work either by compressed air or by a separate electric motor. On the head illustrated, the feed mechanism is driven by compressed air and is controlled by a valve *d* on the right-hand end of the control bar *e*. Rotation of this valve in a clockwise direction causes the drill head to





move downward. As long as the valve is so held, the drill continues to descend until the end of its travel is reached, or until the valve is turned counter-clockwise to reverse the direction of travel.

**9. Electric Feed Mechanism.**—On a drilling head, such as shown in Fig. 4, on which the feed mechanism is electrically driven, a trigger *a* controls the vertical movement of the drill. When the trigger is pressed, a reciprocating electric motor moves the drill down and up through one complete cycle which, once started, cannot be stopped. Therefore, the reciprocating motor should not be started by its push-button control switch until the hole positioner has been lowered into a templet hole. As soon as the drill head begins to move downward, the trigger should be released so that the drill makes only one cycle. If the trigger is held down, the drill will continue to move up and down, and will finish out the cycle it may have started when the trigger is released. The feed of the drill is controlled by change gearing that can be selected to give 9$\frac{1}{2}$, 15, or 23 complete strokes per minute. Small drills should be fed at higher speeds than the larger drills, but a feed suitable for the whole job should be selected since frequent gear changes are impractical.

**10. Hole Positioners.**—To enable the drill to be centered quickly over holes in the drill templet *b*, Fig. 4, the drill is provided with a hole positioner *c* that is operated by the control bar *d*. The positioner *c* is attached to a slide bracket *e* that is adjustable vertically by the control bar. A small projection *f* on the bottom of the positioner is tapered so that it can center exactly in the templet holes. These templet holes are not of the same size as the holes to be drilled in the stock, but are made larger so that the positioner can quickly and accurately be centered in them. On other makes of drilling heads, the positioners may be constructed somewhat differently, but all of them are tapered so as to center in the templet holes.

**11. Drill Chucks.**—Since the drills on drilling heads of the type shown in Figs. 3 and 4 operate at high speeds, the chucking arrangement is unlike that for ordinary drills. A cross-section of the chuck is shown in Fig. 5. The drill *a* is held by a set screw in a drill holder *b*, which in turn is gripped in a tapered and slotted collet *c*. The collet is wedged in the spindle by the upward pressure exerted by the chuck as it is tightened on its threads. The drill holder *b* cannot be used for any drill except one of the exact size for which it is made, since a smaller drill would be thrown off center by the set screw. Therefore, when it is necessary to change drill sizes, the drill holder must be installed with the drill in place. The hole positioners must also be changed with the drills.

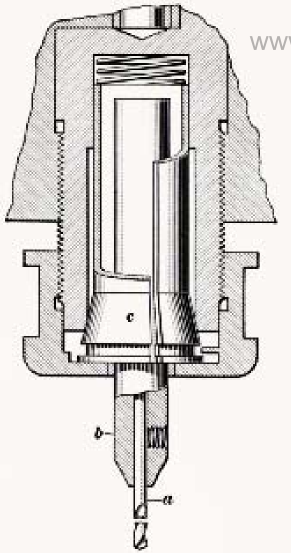


Fig. 5



The drilling heads shown in Figs. 3 and 4 can use drills up to $\frac{1}{4}$ inch, but drill holders and hole positioners for only two sizes, No. 10, or .1935 inch, and No. 41, or .096 inch, are standard equipment. The No. 10 holes are the tool holes drilled to receive the $\frac{3}{16}$ inch hold-down lag screws, and the No. 41 holes are the assembly pilot holes. To drill holes of other sizes, different holders and positioners are necessary.

**12. Routing Head.**—The routing head, one type of which is shown in Fig. 6, is similar in appearance to the drilling head, but differs in the controls and cutter assemblies. A drill cuts downward only, whereas the router bit, as *a*, cuts both downward and sidewise. The router motor is controlled by push buttons and runs at 15,000 revolutions per minute. A brake *b* is provided to stop the spindle quickly after the motor is turned off, and a spindle lock *c* on the left side of the head keeps the spindle from turning while the router bits are being changed. The vertical movement of the motor and bit is controlled by



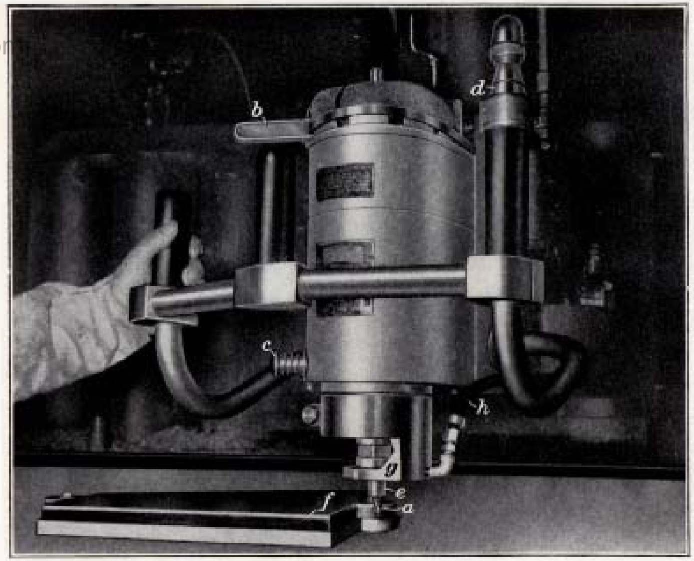


Fig. 6

an air valve *d*. Turning the valve to the left lowers the bit to the work, and turning it to the right raises the bit. On some heads, the vertical movement is controlled by two separate buttons on the control handles.

The pattern follower *e* is kept in contact with the pattern *f* during the routing operation, and is surrounded by a bracket *g* that has inside of it a mixing nozzle for cutting oil and compressed air. This mixture is blown on the router bit to cool and lubricate it and to wash the chips away from the bit. The oil hose *h* leads to the coolant tank in the forearm segment, and an air hose in the rear of the bracket leads to a compressed-air line.

**13. Router Bits.**—Router bits are special single or double helical-fluted end mills that differ from ordinary end mills in that they have a slightly concave face, and require a greater rake and clearance because of their high cutting speeds. Two kinds of double-fluted bits are used, the up-cut bit shown in

Fig. 7 (*a*) and the down-cut bit shown in view (*b*). The up-cut bit, having a right-hand helix, can cut straight down into sheet metal, whereas the down-cut bit, having a left-hand helix, cannot drill through the metal, but must enter the work from the side and can therefore be used only for outside cutting. The latter type of bit has the advantage of pushing down, rather than pulling up, on the sheets being cut. However, to avoid the necessity of changing bits during the routing operation, up-cut bits are generally used.

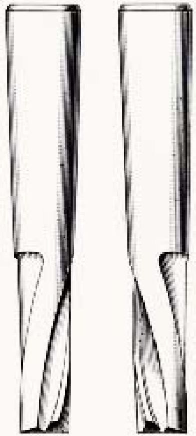



Fig. 7

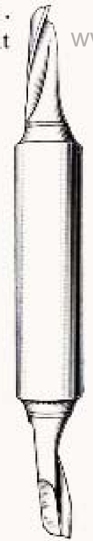


Fig. 8

Single-fluted bits of the up-cut type are used to a greater extent than are double-fluted bits. A double-end bit of the single-fluted type that has been correctly ground is shown in Fig. 8. Some plants use only single-fluted bits, having either one or two cutting ends, whereas other plants use single-fluted bits for *SO* material and double-fluted bits for *ST* material.

**14. Use of Resharpened Bits.**—The quantity of work that can be routed with a bit depends on its sharpness. As soon as its cutting edge is dulled, the cutting speed must be decreased and, furthermore, there is the possibility that the tool will jam in the cut and break. For routing aluminum alloys, the bits should be resharpened after approximately 2 hours of use by removing just enough material to renew the cutting edge. When a bit is resharpened, its diameter is reduced. For most work the reduction in diameter is unimportant, but when close tolerances must be maintained, this difference must be taken into account, especially if the bit has been sharpened several times.





The only way in which adjustment can be made for the reduction in diameter of the bit is by the use of a new pattern follower with a correspondingly reduced diameter. Since the original difference between the radii of the follower and bit was $\frac{7}{32}$ inch, that difference must be retained with the resharpened bit and its follower. General practice is to mark bits that have been reduced in diameter by a certain amount, usually $\frac{1}{64}$ inch, and to use them with followers that have been made undersize by the same amount. Care should be taken not to use a standard $\frac{5}{16}$-inch bit with an undersize follower, since the parts would then be cut undersize and possibly spoiled.

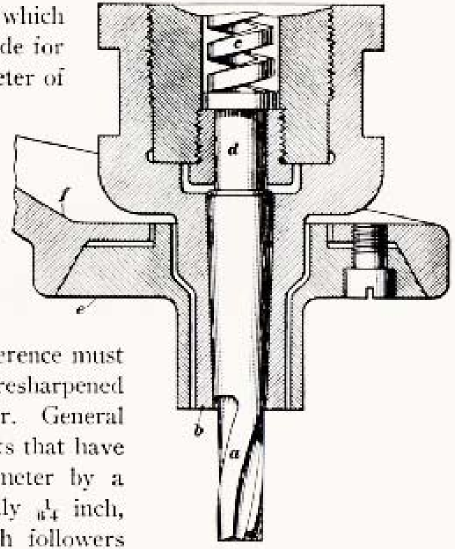



Fig. 9

**15. Router Checks.**—Since router bits, although similar to drills, are used entirely differently in that the cutting pressure is applied in a horizontal direction, the router chuck should be made so as to prevent, as much as possible, the bits from breaking because of the leverage effect of the cutting pressure. The type of router chuck shown in Fig. 9 is intended for single-end bits and utilizes an inverted taper-shank bit *a* and a taper chuck *b* to permit gripping the bit as near to the cutting point as possible. A spring *c* and a piston *d* exert enough pressure against the bit to cause the tapered surface to grip so tightly that the bit will twist off before it will slip.

To change bits, the pattern follower *e* and its bracket *f* must first be removed so that the chuck *b* can be unscrewed. The bit can then be passed up through the chuck and replaced by a sharp bit. If the new bit has been resharpened and is shorter

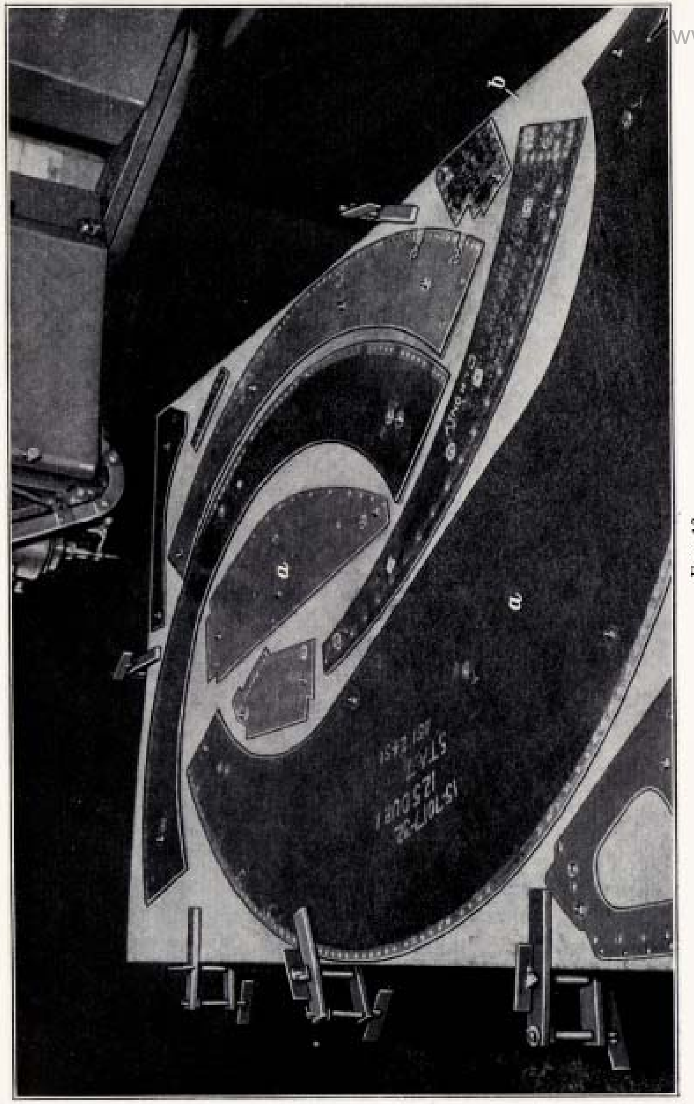



FIG. 10





than the old bit, its vertical adjustment should be changed by means of a set screw underneath the arm so that the tip of the bit will come about $\frac{1}{16}$ inch below the bottom sheet to be routed. If the bit is set too low, it will cut too deeply into the crating plywood panel that is placed under the sheets to protect the top of the work table.

**16. Drill Templets.**—To save time and still maintain high accuracy in stack-drilling the holes required in the finished part and the tool holes required for subsequent operations, drill templets are used with the radial-arm drills. The templets are generally made of sheet iron or steel, from $\frac{1}{16}$ to $\frac{3}{32}$ inch thick, which is cut to the exact shape and size of the developed surface of the part. They are made from the master templet, which was laid out in the lofting department, by any of the reproduction processes in use, among which are the photographic, photo-drawing, photo-print, electrolytic, and X-ray processes. Previous to the development of these processes, the drill templets were laid out from the shop drawings by careful measurements, or by scribing and transfer punching from a master or layout templet. The hand methods, however, were too slow and not nearly so accurate as those now being used.

**17.** After the outline has been transferred to the drill templet, its shape is cut out. If the drill templet is to be used in making the router pattern, the templet must be carefully cut, ground, and filed to shape. However, if a master, or layout, templet is used in making the router pattern or if a separate router templet has been made, the drill templet need not be made so accurately. All holes in the drill templet must be center-punched and drilled with the greatest possible precision. The templet holes, as previously explained, are larger than the holes in the finished work; thus, the diameter of the templet hole for a $\frac{1}{8}$-inch rivet or bolt hole in the part is made $\frac{3}{8}$ inch, the templet hole for a No. 41 hole in the part is $\frac{3}{16}$ inch, and the templet hole for a No. 10 hole in the part is $\frac{3}{8}$ inch.

In addition to these holes, rivet or bolt holes of the exact size must be drilled if the templet is to be riveted or bolted to a plywood backing sheet on which several drill templets are combined. For easy identification of the hole sizes, colored  rings may be painted around the templet holes, each color indicating a certain size of drill to be used. The holes required for riveting or bolting the templet to a backing sheet are not identified by paint as the operator does not drill these holes and, therefore, requires no identification for them.

**18. Master Drill Templets.**—Drill templets may be used individually in laying out the sheets to be drilled, or several may be combined to make a master drill templet, such as shown in Fig. 10. The master drill templets are made in two ways. By one method the individual drill templets *a* are riveted or bolted to a plywood backing sheet *b*, about $\frac{1}{4}$ inch thick and of the same size as or half the size of the sheets of stock. As many drill templets as possible are placed on the plywood sheet in such a way as to obtain the maximum efficiency in using the material, and to reduce as much as possible the amount of scrap metal. A minimum distance of $\frac{3}{8}$ inch must be left between templets for router-bit clearance.

In selecting the templets to be mounted together, the number of finished parts required must be considered, because, for all templets mounted on the plywood, an equal number of parts will be produced. For example, a templet for parts of which five are required per production unit, would not be grouped with templets for parts of which twenty are required. Instead, combinations are made of templets for parts that are needed in the same quantities.

**19.** When the templets have been grouped on the plywood sheet, their outlines should be drawn with a pencil on the plywood in order to fix their positions and to aid in replacing them after the rivet or bolt holes are drilled. With a center punch that fits loosely in the templet rivet or bolt holes, the corresponding holes may be marked on the plywood. The templets are then removed and the holes are drilled in the plywood sheet. The templets are replaced on the plywood by locating them in their marked outlines, and are riveted or bolted



in place. The ends of the rivets or bolts should be set deeply enough in the plywood that they will not scratch the top sheet of the stack. With the templets fastened in place, the complete sheet, now called the master drill templet, is ready for use, even though none of the other holes has been drilled in the plywood. The first time the templet is used in production work, these holes will be drilled in the plywood, as well as in the stack of sheet metal, without an extra operation.

**20.** Master drill templets may also be made of sheet steel with no plywood backing. The individual templets are grouped together on a sheet of steel, $\frac{1}{8}$ inch thick and of the same size as the stock. The holes required in the finished part and the tool holes are then drilled in the large steel sheet, and the outlines of the individual templets are marked on this sheet. These outlines later aid the operator in locating the router patterns in their proper positions on the sheet-metal stack. The individual templets are then removed, and the holes in the master drill templet are identified with colors to indicate the size of hole to be drilled at any location.

**21. Router Patterns.**—Router patterns, or blocks, are generally made of masonite or plywood, and either with or without a top facing of $\frac{1}{16}$-inch sheet steel or $\frac{1}{8}$-inch dural. Masonite is considered the better material for patterns, since it does not become soaked with oil as quickly as does plywood. The tops of some patterns, as shown in Fig. 6, are entirely covered with metal plates, whereas, on the larger patterns such as shown in Fig. 11, only the bearing edges require reinforcement to prevent distortion from the pressure of the pattern follower. The patterns are usually made in thicknesses of $\frac{1}{2}$ to $\frac{3}{4}$ inch, and are smaller in area than the drill templet or finished part by a differential of $\frac{7}{32}$ inch on its radius. This set-back on the router pattern can be obtained accurately in the lofting department by careful measuring and scribing on a router templet. The pattern may be made directly from this router templet.

**22.** A more common procedure, however, is not to make a router templet, but to cut the router pattern of either dural

FIG. 11

or masonite on a pin router by using a master or layout templet or a carefully cut drill templet as a guide. Since on the radial-arm router the bit is $\frac{5}{16}$ inch in diameter and the pattern follower is $\frac{3}{4}$ inch in diameter, this ratio must be reversed on the pin router to obtain the $\frac{7}{32}$-inch set-back that is required. Thus, as shown in Fig. 12, a $\frac{3}{4}$-inch bit *a* and a $\frac{5}{16}$-inch guide pin *b* are used. The router pattern *c* that is being cut to shape is fastened securely to the templet *d*, the layout templet being usually used for this purpose. The pattern and templet are separated by plywood spacers *e* to provide clearance for the end of the router bit. The pattern is then cut to its exact shape and size by keeping the templet *d* in close contact with the guide pin while moving the pattern to the cutting bit.

This method of utilizing the pin router cannot be employed to cut patterns directly from sheet steel. Steel patterns may be laid out, cut, ground, and filed to shape, or a masonite or plywood pattern may first be cut on a pin router and then used as

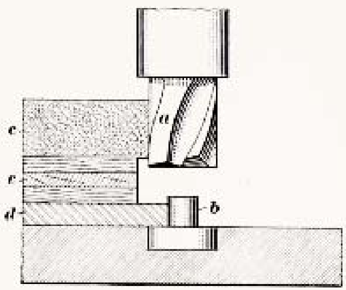



FIG. 12





a guide for scribing the outline on the steel sheet. Using a masonite or plywood pattern to obtain the outline of the steel pattern eliminates the layout operation, which takes considerable time.

**23.** As in the drill templets, holes must be provided in the router patterns for fastening them to the table. These tool, or hold-down, holes must be located and drilled accurately. When a pattern is to undergo severe service, the holes may be equipped with steel bushings. In addition to the tool holes, sheet-steel patterns must be drilled for the rivets or wood screws that are to hold them to their plywood backing sheets. Each router pattern must have its own backing sheet and the patterns cannot be grouped together, as can drill templets on a master drill templet, since the router bit must pass completely around each pattern. The backing sheets should be undercut approximately $\frac{1}{8}$ inch to eliminate any danger of chips getting between the pattern follower and the pattern. When the pattern is made of a solid piece of masonite, a setback of $\frac{1}{4}$ inch along the bottom edge of the pattern can be made by using a shaping cutter in the pin router, or by tilting the router table. Masonite patterns should be painted to increase their resistance to the cutting fluids.

## ROUTING PRACTICE

**24. Stacking Sheets for Drilling and Routing.**—The first step in the drilling and routing cycle is to stack the metal sheets on a work table, which has previously been covered with a plywood panel about $\frac{3}{16}$ inch in thickness to prevent the router bit from cutting into the top of the table. The thickness of the stack varies from $\frac{3}{8}$ to $\frac{5}{8}$ inch, depending on the practice being followed, and the number of sheets in the stack depends on the thickness of the individual sheets. In some plants, no more than $\frac{3}{8}$ inch is used, since the claim is made that with a stack of material of greater thickness the routing speed is so reduced that the efficiency is lessened. In other plants, however, the stacks are piled to thickness of $\frac{7}{16}$, $\frac{1}{2}$, or even $\frac{5}{8}$ inch. The use of a stack thickness of $\frac{7}{16}$ inch seems to be the most common

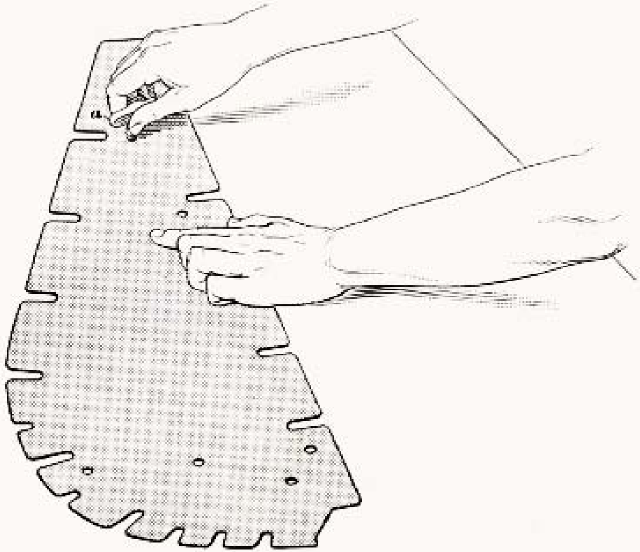



FIG. 13



practice. The thickness of the stack depends to a large extent on the length of the router bit. A bit that has been resharpened several times and is considerably shorter than a new bit cannot be used to rout a thick stack.

**25. Drilling Stacked Sheets.**—The method of making the drilling set-up depends on whether the intention is to use individual drill templets or a master drill templet. When a master drill templet is available, it is laid on top of the stacked sheets and the whole assembly is clamped tightly to the table either by C-clamps or by quick-acting clamps that are mounted at each end of the table. When C-clamps are used, they should be spaced around the whole table. All holes of the same size, as shown by the color code, should be drilled in one operation; after which the drill, drill holders, and hole positioners should be changed for each succeeding size of holes, until all the required holes are drilled in the stack. The templet is then removed so that the router patterns can be placed on the sheets.



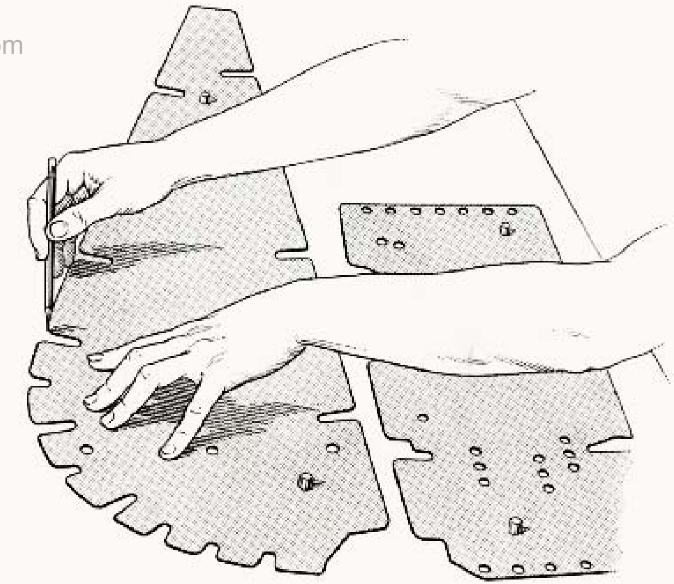


FIG. 14

**26.** When individual drill templets are used, the procedure is different. After the sheets are placed on the table, they are fastened to the plywood panel with either nails or $\frac{1}{4}$ inch lag screws. Next, a sheet of layout paper is spread over the stack and the templets are placed on the paper and nested together as closely as possible in order to save material. A clearance of from $\frac{3}{8}$ to $\frac{1}{2}$ inch must be allowed between the patterns for the router bit. The tool holes for each templet are then drilled. The usual practice is to drill one tool hole first, insert a lag screw or a plug, as shown at *a*, **Fig. 13**, and then to drill the second tool hole and insert its screw or plug. The outline of the templet is drawn with pencil on the layout paper, as shown in Fig. 14. Next, the holes are drilled by the radial-arm drill, Fig. 15. As in the case of a master drill templet, holes of all one size should be drilled at one time, the drills changed, and the next series then drilled.

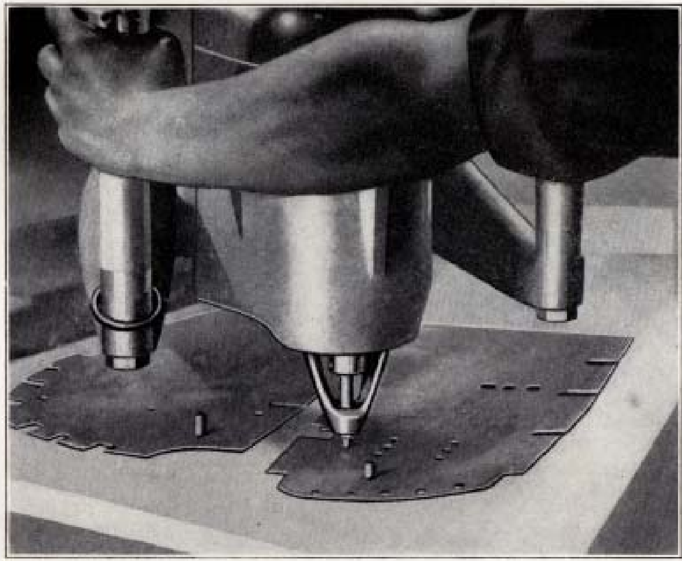


FIG. 15

**27. Routing Stacked Sheets.**—After all holes are drilled, the templets are removed and the router patterns are fastened to the stacked sheets by lag screws. If a master drill templet has been used, the individual templets or their outlines marked on the master drill templet may be used as a guide in locating the router patterns. In some plants, master drill templets made of sheet steel are marked with identification numbers instead of drawn outlines; the router patterns bearing corresponding numbers can then be located in their proper positions. If individual drill templets have been used, their outlines marked on the layout sheet indicate the positions of the router patterns. After all the patterns have been located, the lag screws are started in the tool holes. To prevent buckling of the material, the screws should be tightened by starting at the center of the table and working out toward the edges. The lag screws can be conveniently tightened by an electric nut-runner *a*, Fig. 16, or by one that is air operated, as shown at *f*, Fig. 3.





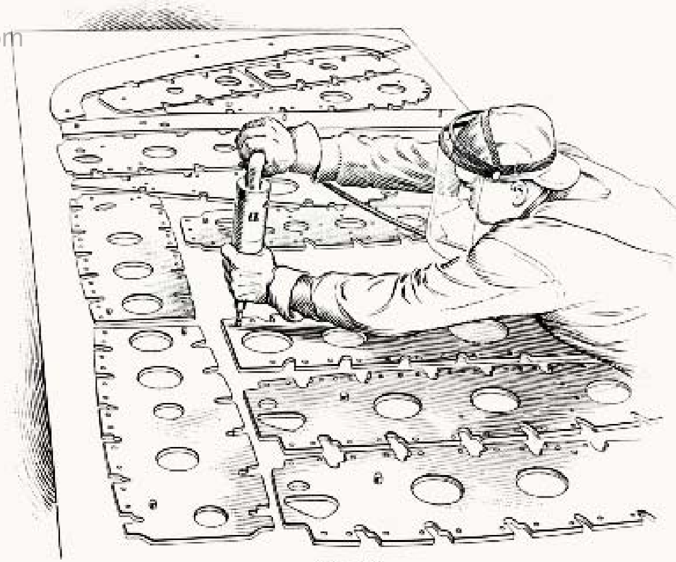



FIG. 16

28. After the router patterns have been screwed fast, the table is moved to the router. The usual practice is to cut out inside contours first, by boring into the work in such a position that the pattern follower will be about $\frac{1}{4}$ inch away from the inside pattern edge. Then the routing head is swung to bring the follower against the pattern and the contour is cut out. At the end of the cut the bit should be carried on for an inch or so to insure a clean surface, and then swung away from the pattern and raised. The outside contours are cut last. In routing the outside contours, the bit is generally kept down and moved from one pattern to the next. When the head must be raised and lowered again, it should not be lowered into places where the patterns are close together as the patterns may be damaged by the follower; instead, the bit should be lowered into a clear spot and fed into the close places. When all cutting has been done, the table is moved to the unloading station. Here the lag screws are removed and the blocks taken off,

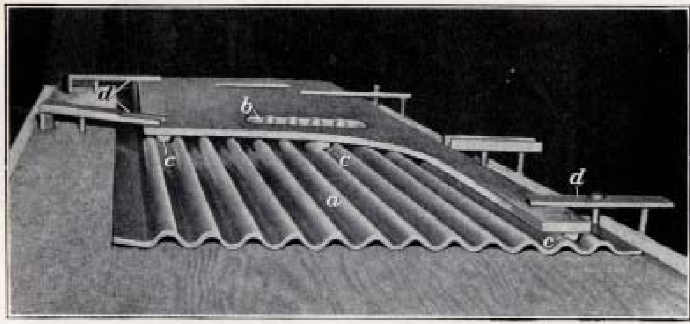



FIG. 17

and finally, the finished blanks are burred, if the subsequent forming operations require extremely smooth edges.

**29. Cutting Fluids for Drilling and Routing.**—During the drilling and routing operations, the drill or bit should be flooded with a suitable cutting fluid. One commonly used cutting fluid consists of a half-and-half mixture of kerosene and S.A.E. 10 lubricating oil. Another is made of 20 per cent of lard oil and 80 per cent of kerosene. Both of these mixtures are fairly expensive and cause annoying smoke and fumes; therefore, a soluble oil consisting of about one part of oil to from twelve to twenty parts of water is often preferred. The soluble-oil mixture should be removed soon after the routing is completed, to prevent corrosion of the sheet metal by any alkali that may be in the water. Special coolants that have been compounded by the oil companies for routing eliminate the foregoing troubles and are very satisfactory.

**30. Routing Corrugated Sheets.**—Routing may be done on corrugated sheets as well as on flat stock, and is well adaptable to cutting out sections of corrugated inner skin. A number of corrugated sheets *a*, Fig. 17, are nested together for the routing operation, but their overall depth cannot exceed the length of the cutting edge of the router bit. The router pattern *b* is then placed over the sheets. Since it is difficult to clamp corrugated sheets firmly without adequate bearing surface, the pattern





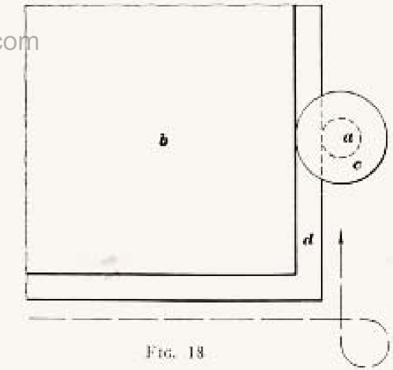



FIG. 18

has three long projections *c* that fit into corrugations. Clamps *d* over the side projections can then hold the stock and the pattern firmly enough to the table top that there will be no danger of their shifting during the routing operation. Since routing of corrugated sheets leaves the edges sharp and rough, all such stock should be burred after routing.

**31. Routing Square Corners.**—Although outside corners are generally routed to a minimum radius of $\frac{9}{32}$ inch, they can be cut square with fairly good results by the method illustrated in Fig. 18. The router bit *a* is simply carried beyond the pattern *b* in a continuous straight line and then circled back to start a new cut on the next side of the pattern. The follower *c* is out of contact with the pattern while the corner of the sheets *d* are cut, but by careful manipulation the corners of the sheets can be cut approximately square.

32. A more accurate method of making square outside corners with the router provides for the use of strips that guide the pattern follower beyond the limits of the pattern. Two such guide strips *a* and *b*, Fig. 19, are fastened to the corner of the pattern, and are hinged so that either one may be extended beyond its edge. Thus, when the router bit *c* is cutting along the front edge of the sheets *d*, the strip *a* is swung open to act as a guide for the fol-

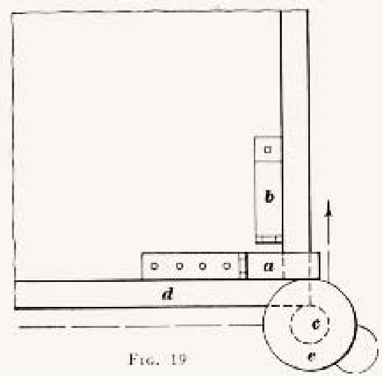



FIG. 19

lower *c* to the end of the routing cut on that side of the stack. The strip *a* is then closed, the strip *b* is swung open, and the router bit is circled back to begin its new cut in the direction indicated. The use of the two strips in this manner provides a positive guiding action for the bit and the results obtained are more accurate.

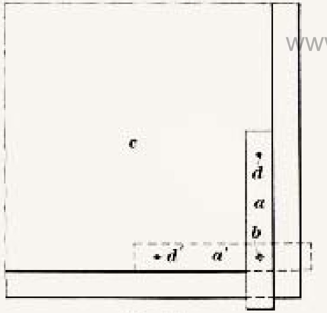



Fig. 20

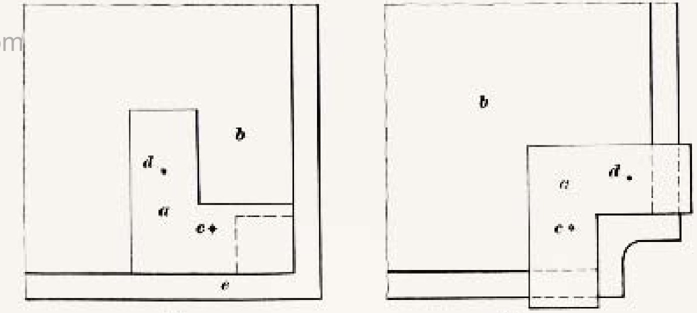


**33.** Instead of two hinged strips, a single guide strip may be used by setting it on a pivot so that it can be swung at right angles after one edge of the sheet has been cut. In Fig. 20, the strip *a* is pivoted at *b* and is held parallel to the side edge of the router pattern *c* by a removable pin *d*. The strip can then guide the pattern follower beyond the point at which it leaves the pattern. After the side edge is routed, the pin *d* is removed, the strip is swung to its second position *a'*, and the pin is inserted at its second position *d'*. The upper edge of the sheets may then be routed with the strip in position *a'* guiding the pattern follower.

To obviate the necessity of having a removable pin that might get lost, the end of the guide strip can be cut to a tongue shape so that it can bear against either of two stop pins set near the edges of the router pattern. These pins should be located in the pattern in such positions that, when the strip bears against either pin, it will be held parallel to that side of the router pattern. As soon as one edge of the stack is routed, the strip is swung until it makes contact with the other pin, and the second edge is then routed.

**34. Routing Notched Corners.**—When a notched corner must be routed in a stack of sheets, a pivoted guide plate *a*, Fig. 21, may be set in one corner of the router pattern *b*. In view (*a*), the guide plate, which is pivoted at *c* and held in






(a) (b)

Fig. 21

position by a removable pin *d*, is set so as to present a square corner to the pattern follower, in order that the corner of the stack *e* can be routed approximately square. Then the guide plate is swung to the position shown in view (*b*), and the corner of the stack is notched. The radius of the inside corner of the notch is equal to that of the router bit. The outside corners of the notch, however, are square, since the two legs of the plate *a* guide the pattern follower beyond the limits of the router pattern. If the outside corners of the notch can be given a radius of at least $\frac{7}{32}$ inch, no guide plate is needed as the router pattern can be made square on these corners to obtain the minimum radius of $\frac{7}{32}$ inch.

## SPECIAL ROUTERS AND SHAPERS



**35. Pin Routers.**—Another type of router that is used in the aircraft industry is the pin, or fixed-spindle, router, which was adapted from the type used for wood working. As shown in Fig. 12, these routers are used in making patterns for radial-arm routers. They are also employed for trimming formed aluminum-alloy parts and for cutting small, flat, blanks that cannot be satisfactorily secured to router tables for radial routing. Pin routing is a convenient method of cutting a large quantity of identical parts, since any desired number can be cut without the necessity of coordination with the number of other parts being produced. Another advantage of pin routing is that outside corners can be cut square without special equipment, as the router pattern is made of the same size as the blanks, and provides positive guiding action throughout the entire cut. However, as in the case of radial-arm router patterns, a radius of $\frac{1}{16}$ inch is desirable on the outside corners of the pattern. The radius of the outside corners of the blanks would be the same as the radius on the pattern, or $\frac{1}{16}$ inch.

**36. Operation of Pin Router.**—The pin router, Fig. 22, consists of a metal table *a*, which may be either of the fixed or tilting type, and a routing head *b*, which is supported above the center of the table. The routing head, which is similar in construction to the radial-arm head, is mounted on a slide and can be moved vertically by a foot treadle. Stops are provided to limit the downward movement of the head to prevent the router bit *c* from damaging the guide pin *d*, which is set in the center of the table directly below the center of the router spindle. The guide pin is generally made with the same diameter as the router bit. The part to be routed, in this case the formed part *e*, is located on the router pattern, or fixture, *f* by means of two tool holes that fit over pins in the pattern. No clamps are needed when only one such part is being cut. The part is then trimmed to shape by pressing the pattern against the guide pin, and holding it in contact with the pin as the work is fed along the router bit. During the routing opera-




FIG. 22

tion, the bit must be lubricated with cutting fluid. The bits used for pin routing are of the same as those used in the radial-arm router, except that various sizes are employed in pin routing. The pin routers are operated at two speeds, namely, 21,600 revolutions per minute for the smaller cutters, and 14,400 revolutions per minute for the larger cutters.

**37. Cutting Blanks on Pin Router.**—The method of cutting blanks on a pin router is illustrated in Fig. 23. Sheets *a* that have been sheared to approximately the desired shape are stacked on top of the router pattern *b*, and are held securely by means of clamps *c* that are tightened by the thumb screws *d*. The outside contour is then cut out by feeding the work along the router bit *e*, while the pattern is held in contact with the guide pin directly below it.

In case holes are to be routed in the material, as shown, the contour of the hole is cut out of the bottom surface of the

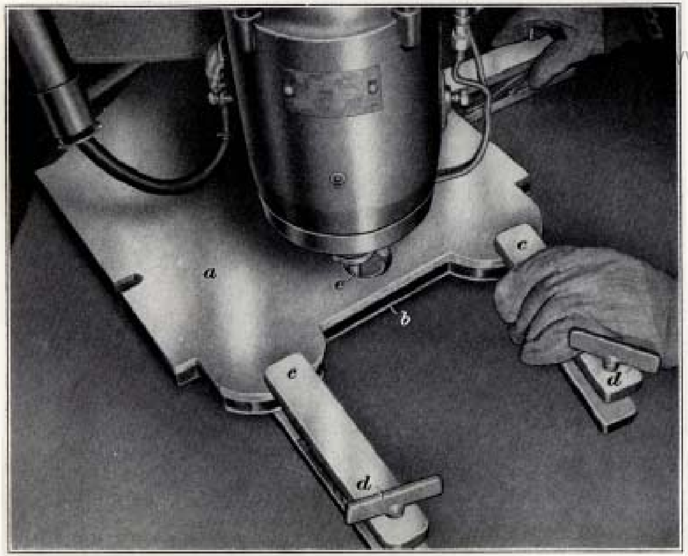



Fig. 23

router pattern. With the router head raised, the work and the pattern are slid over the pin so that the pin projects into the cut-out part of the pattern. The head is then lowered and the hole is routed to size by again keeping the pin and pattern in contact as the work is fed to the router bit. This method of cutting the contour in the bottom of the router pattern, or in a templet fastened to the bottom of the router pattern, may also be employed for routing outside contours of blanks. The sheets, however, would not be laid directly on the router pattern; instead, a $\frac{1}{8}$-inch metal plate somewhat smaller than the finished blanks would be placed between the sheets and the pattern to provide end clearance for the router bit.

**38. Shapers.**—The use of a standard wood-shop shaper is regarded as the most accurate method available for trimming irregular edges of parts that have been formed from aluminum-alloy sheet by drop hammer, hydro-press, or other methods. The shaper, as shown in Fig. 24, consists of a flat table *a* with





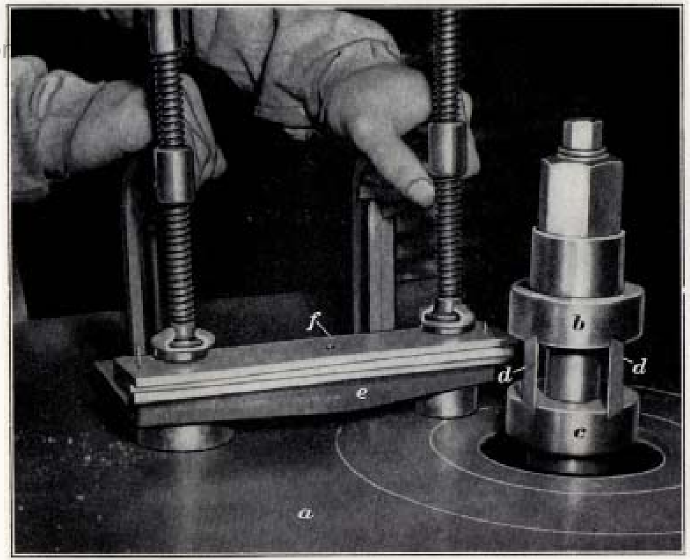



Fig. 24

a spindle projecting up through its center from an electric motor in the base. On the spindle are mounted two collars *b* and *c* that are about 3 inches in diameter. Each collar has two parallel slots in which the two knife blades *d* are clamped. These knives, which are about $\frac{1}{4}$ inch thick, are set between the collars in such a position that their sharp edges project slightly beyond the collars in opposite directions.

The lower collar *c* acts as a guide for the shaper block, or pattern, *e*. The block *e* is similar to the pattern used on a pin router in that it is of the same size as the finished part, and the work *f* is clamped to its top surface. On a shaper, however, a stack of parts up to $1\frac{1}{4}$ inches in thickness can be trimmed safely and at a greater speed than is possibly on a pin router. The cut cannot be deep, usually not more than $\frac{1}{8}$ inch, since deeper cuts when feeding by hand are too dangerous. Therefore, parts that are to be finish trimmed on a shaper, must be rough trimmed fairly close to the required outline.

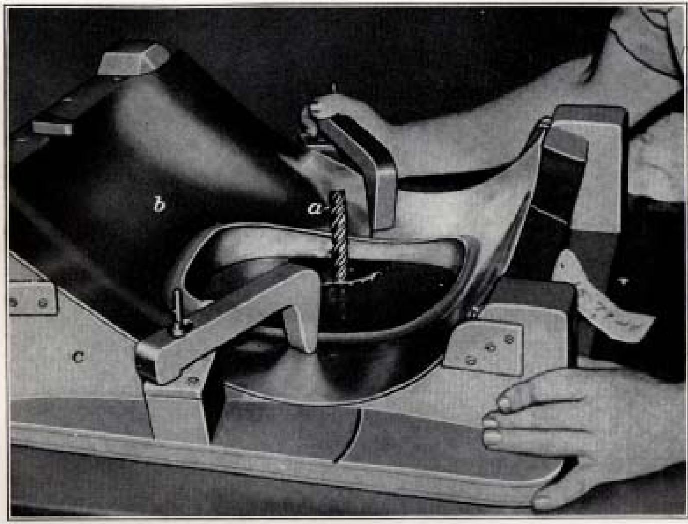



Fig. 25

**39.** The knife-blade cutter can be replaced with a slab milling cutter for other operations, such as for milling soft-metal castings or heavy extrusions, or for trimming parts that are too deep for a knife cutter. A trimming operation is shown in Fig. 25. The mill *a*, which is about 4 inches long, is being used to trim the inside contour of the formed sheet-metal part *b*. A block *c*, on which the formed part is clamped, bears against the smooth shank of the cutter, so that the inside contour is milled out to the same shape as that of the block. The minimum inside radius that can be cut is equal to the radius of the milling cutter.

**40. Horizontal Trimming Router.**—A router specifically designed for the trimming of formed parts having flanges is shown in Fig. 26. The routing head *a* is air-operated and is supported horizontally on an arm *b*, that permits the head to swing up and down as the pattern follower is guided by the contour of the router block. The formed part *c*, a lower nose window-frame, that is to have its end flanges trimmed, is placed





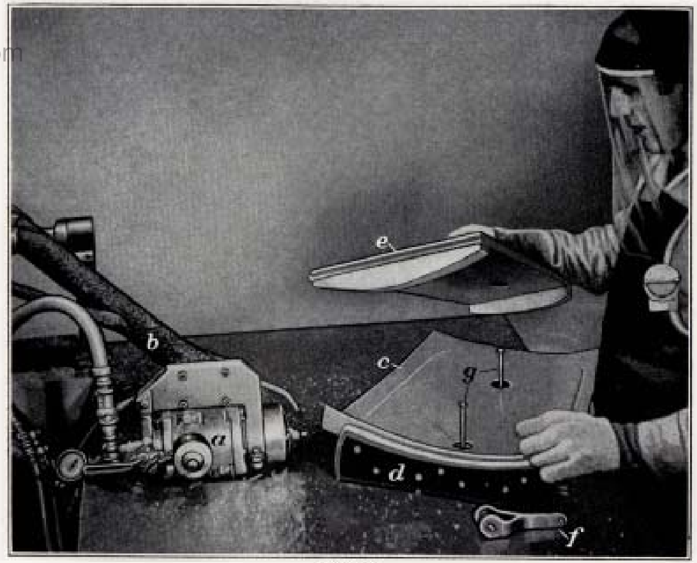



Fig. 26

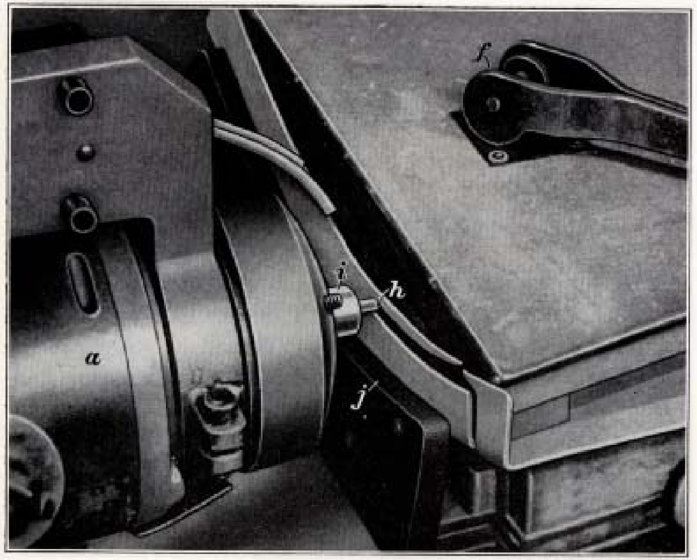



Fig. 27

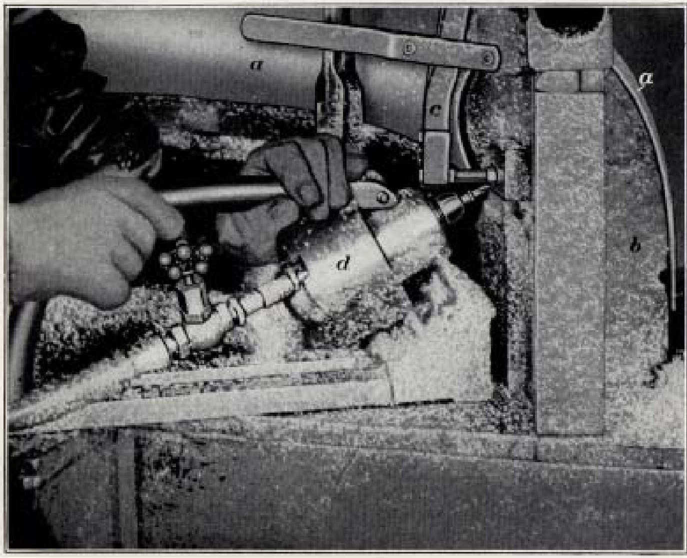


FIG. 28

in the base *d* of the router block and held by the top *e*. Two clamps, similar to the one shown at *f*, fasten to the bolts *g* to provide clamping pressure on the top of the block.

In Fig. 27, the top of the block is shown fastened down on the frame by the clamp *f*. To trim the flange of the part, the operator grasps the router block in both hands, and moves it slowly past the router bit *h*. Since the routing head *a* is free to move in a vertical direction, the pattern follower *i* keeps in contact with the curved edge *j* of the router block, and causes the router bit to cut the flange to its correct height above the block. The weight of the routing head is sufficient to maintain contact between the follower and the edge of the router block.

**41. Double Trimming Routers.**—A method whereby both edges of a nose-cowl skin can be trimmed simultaneously is illustrated in Figs. 28 and 29. The nose-cowl *a* fits down over





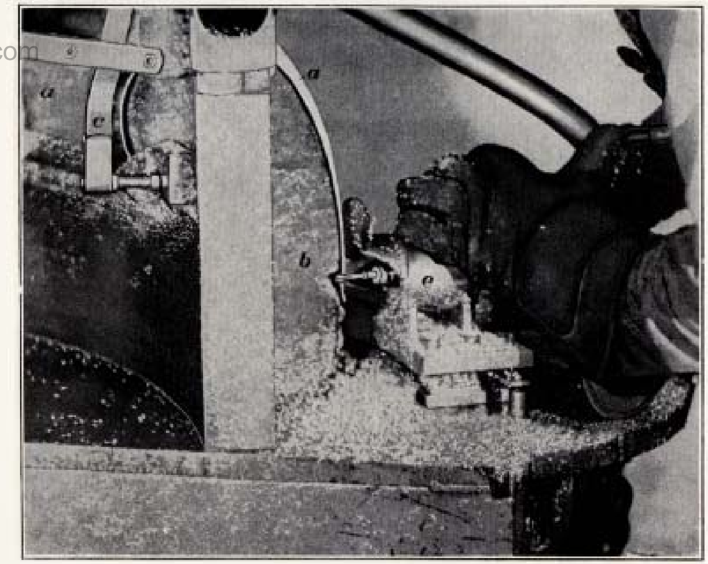


FIG. 29

a form *b* and is clamped in place on the form by a framework *c*, which is supported on an overhead crane arm. When the cowling is placed on the form, the framework is pulled down against the action of a counterweight and fitted over the part. Then as soon as the part is trimmed, the framework on being released lifts out of the way. This arrangement permits fast and convenient loading and unloading.

With the cowling in place, one operator starts trimming with the air-operated routing head *d* at one end of the part and a second operator starts with the other routing head *e*, Fig. 29, at the other end. Thus, the head *d*, Fig. 28, is shown finishing its cut, whereas the head *e*, Fig. 29, is just beginning its cut. Both routing heads swing in an arc horizontally in order to follow the curvature of the skin, and are so adjusted on their supports that the router bits follow the trim lines and require no pattern followers, or guides.