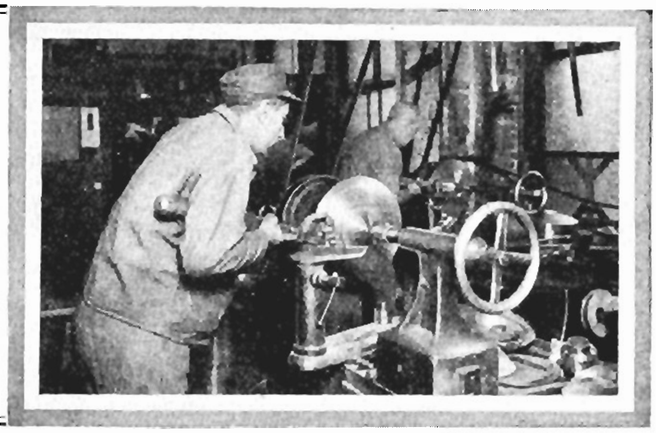
Sheet Metal Spinning and Spinning Tools*

Details of Tool Construction and Explanation of Their Use on Work of Varied Character Where Method Is Less Expensive Than Stamping

By Edward Heller



METAL spinning is employed mainly for two classes of work: (1) for removing wrinkles formed on shells during the drawing process, and (2) for producing shapes that are too difficult to draw by means of dies or that would cost too much when made in that way. Spinning to remove wrinkles from shells is by far the simpler of the two applications. Deep drawn shells made of a comparatively light gage metal such as is used in the making of kitchen utensils and certain kinds of electrical goods, are hard to draw without wrinkling unless the part is cylindrical, and even cylindrical shells are at times slightly wrinkled. The quickest and cheapest way of getting rid of such wrinkles is by a spinning operation. Spinning lathes are made in various sizes for practically all kinds of "automatic" spinning, and as they are standard machine tools, a description is scarcely necessary. The tools used in spinning, however, are of interest.

A plain spinning outfit used for removing the wrinkles on a steel shell having a rounded bottom is shown in Fig. 3. The spinning chuck *A* is made from 0.85 to 0.90 per cent carbon steel, and the tail-piece *B* is an iron casting. Stem C of the chuck is of such size and shape that it is adaptable to many kinds of work and could well be adopted as a standard. The thrust bearing *D* supplied for the tail end could also be standardized, as it may be used with many classes of spinning tools. The bearing proper is held on the tailstock spindle by means of a set-screw. The tail-piece *B* revolves on a projecting stem to which it is held by a set-screw. The projecting stem is stationary, being a pressed fit in bearing *D*, and supports one race of the ball bearing which is provided in back of the tail-piece.

Spinning is done by means of the tool-steel roll *E* mounted on a hardened and ground shaft F which is a pressed fit in the roll and is provided at each end with a roller bearing in bushing K. This entire unit is held in the cast-iron holder *G* by two side plates *H*, which are fastened to the holder by means of flat-head screws. The diameter of roll *E* is usually about 5 in. except when projecting flanges or other obstacles necessitate a larger diameter. The shank of the holder is about 2 in. square, and is finished on the top and bottom sides to insure a good bearing on the lathe carriage.

The space between bushing *K* and shaft *F* is entirely filled with rollers except for an allowance of about 0.001 in. between each roller for lubricant. The shaft and bushings must therefore be made to close dimensions. It is advisable to keep the rollers of a standard size, and so, obviously, the diameters of the shaft and the bushing on the inside will be decimal numbers. The proper shaft diameter can be quickly determined by making use of the formulas and tables of constants given on page 485 of *Machinery's Handbook*. Taking the bearing in question as an example, it was decided to use 1/4-in. diameter rollers, and the requirements of the job necessitated that shaft *F* be at least 1 in. in diameter. By laying out the bearing it was found that sixteen rollers would be required to surround the periphery of a shaft approximately 1 in. in diameter. Then by using the formula for find-

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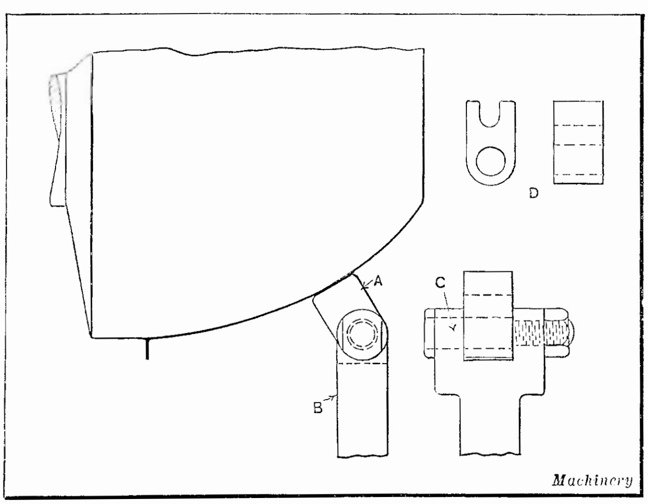


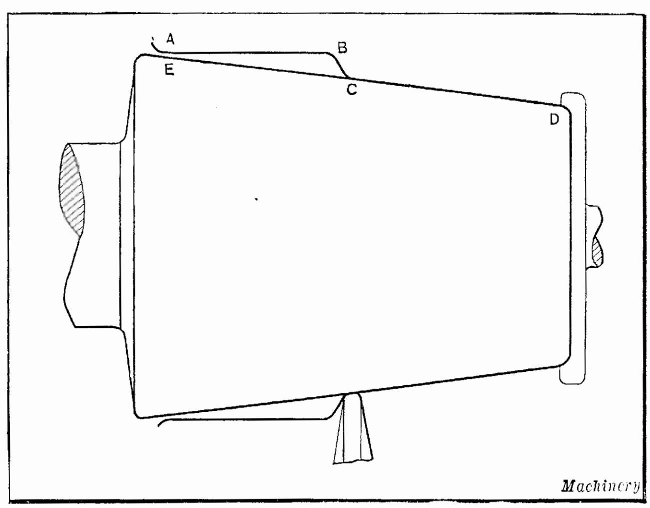


Fig. 1—(Left) Tool Used for Spinning Aluminum Shells; Fig. 2—(Right) Work That Is Partially Shaped by Spinning

ing R on the page referred to, and using the constant given in the extreme right-hand column for sixteen rollers, it was found that the diameter of shaft F would be 1.0314 in. if the rollers touched one another. Next, allowing for a clearance of 0.001 in. between each roller, the actual diameter of the shaft would be

$$1.0314 + \frac{16 \times 0.001}{3.1416} = 1.0365 \text{ in.}$$

The amount of clearance should depend, of course, upon the size of the rollers, the speed at which roll E revolves, and the kind of lubricant used.

To make possible the use of a chuck similar to that shown in Fig. 3 on any spinning lathe, an adapter of the type illustrated in Fig. 4 should be furnished for each lathe. The threads on the extending end of this adapter must agree with those in the head end of the chuck, while the threads in the tapped hole in the adapter should be made to suit those on the machine spindle. By increasing the length of the internally threaded end, the adapter may serve as an extension member.

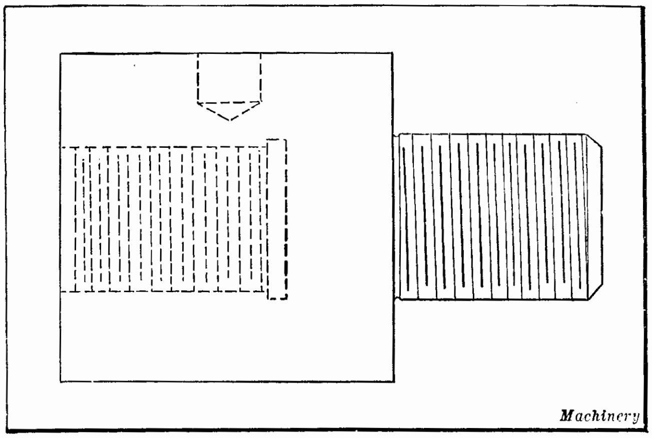


Fig. 4—Adapter Which Enables a Standard Chuck to Be Used on Any Spinning Lathe

Spinning Aluminum Shells

The tooling outfit just described is suitable for use in connection with steel shells only. The tools for shells made of aluminum or other soft metals are similar to those for steel shells so far as the chuck and tail-piece are concerned, but the spinning is done with a shoe instead of a roll. An idea of the way in which the operation is accomplished will be obtained by referring to Fig. 1. Shoe A is made of tool steel, and hardened. It is held in the jaws of the steel forging B by stud C. This stud allows the flat end of the shoe to remain tangent to the work at all times. At D is illustrated a shoe of recent development that is used on shells polished at some later stage. The first prong or tooth on the shoe that makes contact with the work smooths out the wrinkles, while the second, coming in contact with a comparatively smooth surface, acts as a burnisher.

Fig. 2 shows how spinning may be done on water pails or other shells having the open end larger in diameter than the closed end. In drawing a long taper shell of this class it is often necessary to finish the shell partly in one of the operations, perhaps the third or fourth, and then completely finish it in another. The shell, when partly drawn, may follow the outline $ABCD$, and when it is finally drawn the outline may be like that shown at ED.

A shell of this type will wrinkle no matter how carefully the different drawing steps are proportioned, and therefore must be spun. If the preliminary and intermediate draws are so proportioned that the step BC is not more than about ½ in. high it is possible to eliminate the final draw by spinning the cylindrical part near the open end to the desired shape and dimensions after the wrinkles in the lower part of the shell have been smoothed out. This method not only eliminates the time required for an additional draw, but also saves the cost of a set of drawing dies.

In spinning to develop shapes that cannot be drawn readily or at a reasonable cost, the work is generally of the type that is larger in diameter at the bottom, or some place intermediate between the bottom and the open end, than at the open end. One way of spinning such work is from the inside, in which case the operation really consists of stretching the metal. However, the general principles of spinning apply in these instances as well. Inside spinning is often resorted to when the difference between the largest and smallest diameters of the finished work is too large to enable spinning to be done from the outside. The shell is then drawn to a diameter about midway between the two extremes, and one section is spun from the outside while the other is spun from the inside.

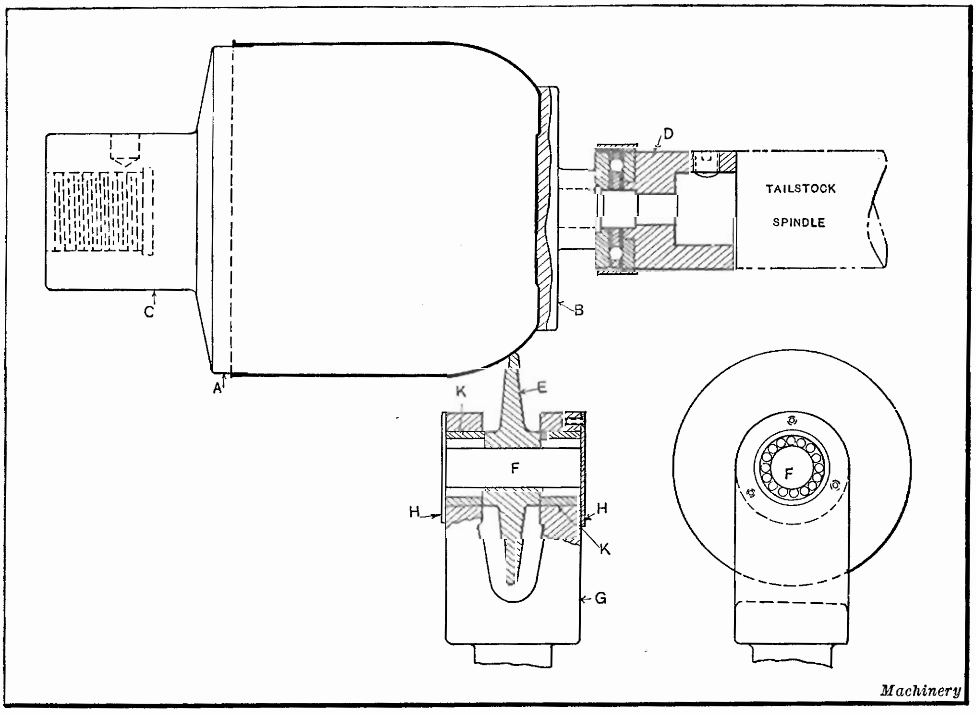


Fig. 3—Plain Tooling Equipment for Removing the Wrinkles from Drawn Shells by Spinning

Example of Inside Spinning

An arrangement of tools for the inside spinning of the lower part of a steel pitcher is shown in Fig. 5. The shell is held in an internal chuck A by a tail-piece B. The spinning is done by a small roll *D* mounted on a long, stiff holder *E*. The holder is fastened to the top of the lathe carriage in the regular manner. Lubricant is supplied to the bushing of roll *D* through a hole drilled along the center of holder *E*, an oil-cup being located near the right-hand end of the holder. The work is shaped by spinning the metal against a large roll *F* mounted on a cast-iron bracket *G* at the front of the machine. The shaft of roll *F* is mounted in roller bearings. Bracket *G* is fastened to a stationary part of the lathe and should be doweled or tongued so that when it is removed, it can readily be replaced in the proper position. This equipment can be used for a variety of shapes by simply changing roll *F*.

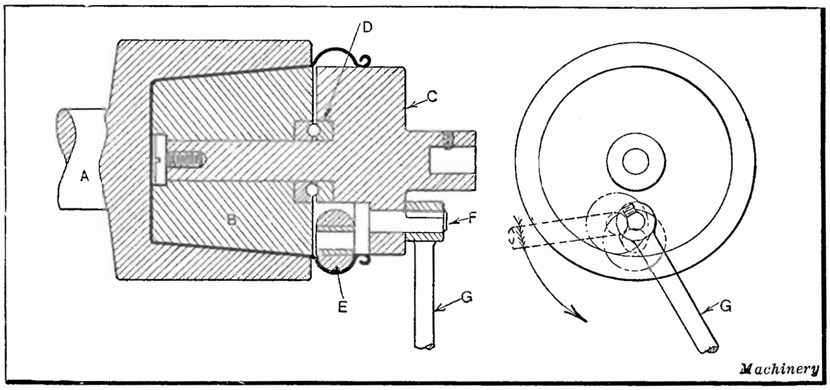


Fig. 6—Producing a Bulge Near the Open End of a Drawn Shell

In designing tools of this class, care must be exercised to insure that there is sufficient space to permit roller *D* to be conveniently inserted and withdrawn from the work and to see that the roll is large enough to do the work efficiently. If the space allowed is too limited for the tool design described, one way of overcoming the difficulty is by using an arrangement similar to that shown at *X*. Here a plate *H* with a ball embedded in the center is substituted for the tail-piece *B*. One end of the offset holder *K* bears against this ball and holds plate *H* in place against the work, while the other end is connected to the tailstock spindle by a sleeve. With such an arrangement there is plenty of room to bring the spinning roll against the inside of the work. The offset bar should be made of medium carbon steel and should be as heavy as possible; it should be hardened on the end bearing against the ball in plate *H*.

In using the tools in Fig. 5, roll *F* should be set up so that its axis will be parallel with that of chuck *A* and it should practically touch the chuck, as the slightest gap between the two members will cause pronounced marks on the finished work. This tooling is also intended for steel shells only. On aluminum work roll *F* will do more harm than good. For this reason the spinning of aluminum shells is performed without an outside support, the desired shape being produced by means of a cam. The screw in the cross-slide of the carriage is removed or released, and the slide linked rigidly to a roller or rollers traversing the guiding surface of the cam. As in the case of the roll bracket *G*, the member holding the form cam must be rigidly held to the machine, in such a way that an exact replacement is always possible.

Bulging the Open End of a Shell

Another application of internal spinning may be made in cases where one part of a shell is to be bulged out as shown in Fig. 6. It will be seen that the shell is held in a pot chuck *A*. The tail-piece has a live part *B* which revolves with the chuck, and a stationary part *C*, which is fastened to the tailstock spindle. A ball bearing *D* is placed between the live and stationary parts, and these two parts are held together by a screw that engages the threads of a tapped hole in the end of a stem on part *C*. The head of the screw seats against the end of the stem and allows part B to revolve freely on the stem.

The bulging is done by a roll *E* mounted on a crank-

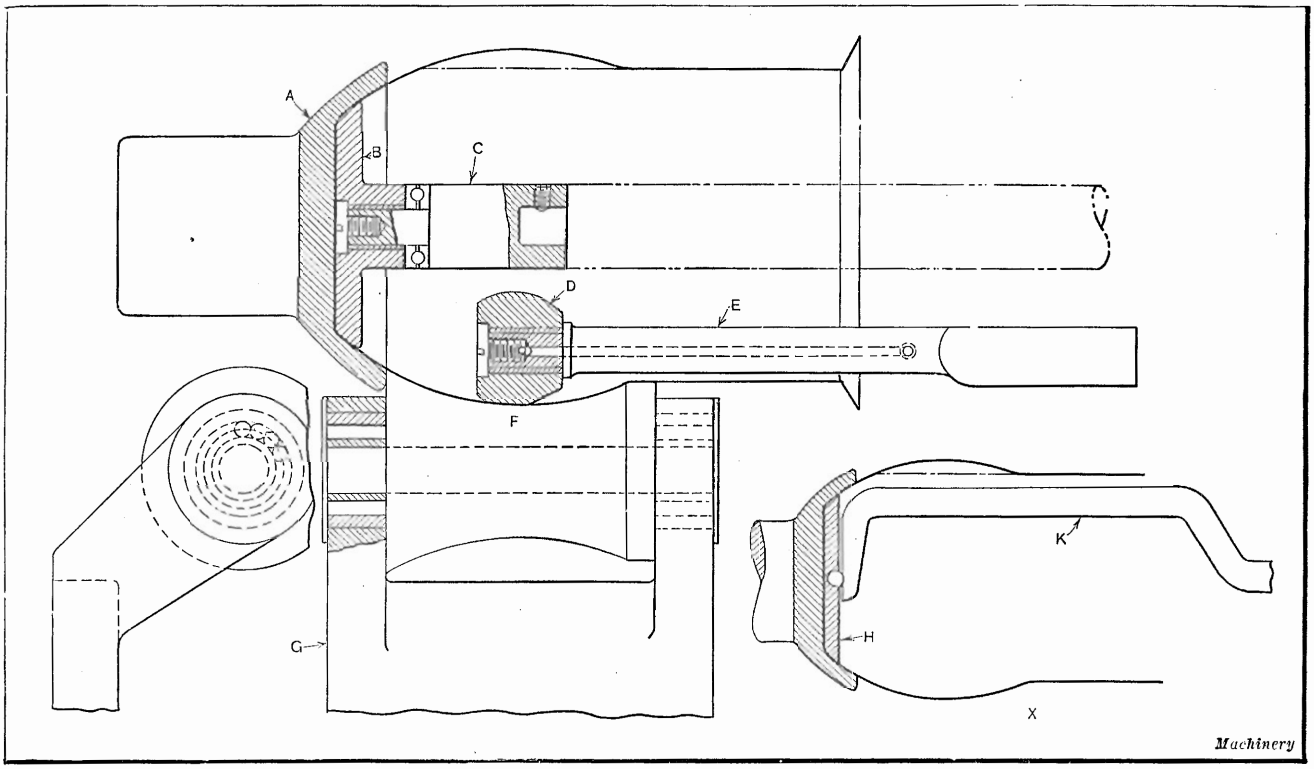
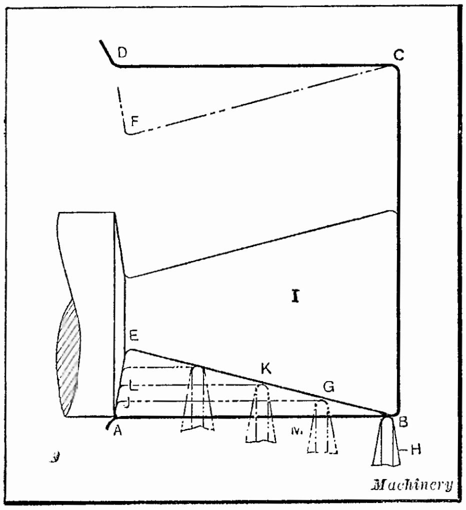


Fig. 5—Tooling Arrangement for Spinning the Lower Part of a Steel Pitcher from the Inside



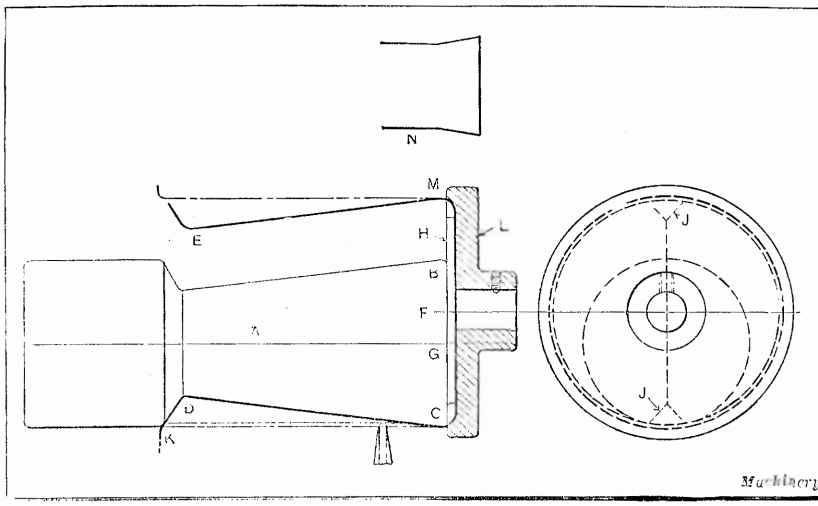


Fig. 7—(Left) Principle of True Spinning; Fig. 8 (Right) Arrangement Employed for an "Offset" Spinning Operation

shaft F, which is swiveled by means of handle G. The crankshaft and roller can be made to such dimensions that the work will be finished to the desired diameter when the highest point of the crank is brought directly toward the work, in which position an additional pressure on the handle will move the roll away from the work. On the other hand, these parts could be so arranged that the entire throw of the crank is not utilized in producing a bulge of the desired diameter, but then it becomes necessary to provide an adjustable stop on part C for the handle to prevent too great a diameter of the bulged section. The first arrangement is more customary, as it enables a uniform product.

Different shapes and diameters of bulges can be formed by changing roll E to suit. The tail-piece C should be attached in such a manner to the tailstock spindle that convenient operation of handle G will be possible. A peculiarity found in work of this kind is that the open end of the shell becomes smaller in diameter after the bulging operation. This fact must be carefully considered in designing the tools.

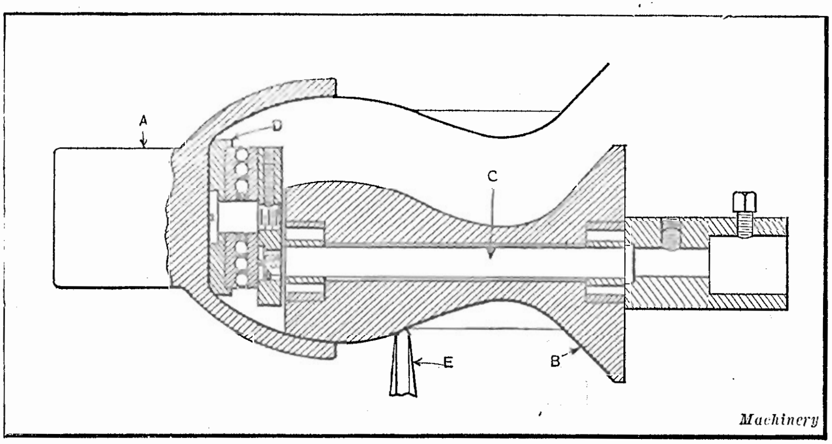


Fig. 9—Spinning a Pitcher by Supporting the Form Roll on the Tailstock

Principle of Spinning

Thus far, the spinning tools described have been used for either smoothing out wrinkles or for stretching the metal, and while these operations may be classed under the general heading of "spinning," they are not true examples of spinning. The principle of true spinning is illustrated diagrammatically in Fig. 7. A cylindrical shell having the outline $ABCD$ is required to be spun to the conical shape $EBCF$. To produce this shape, the spinning roll H is first pushed over the spinning chuck I along the line BG until a dent is made in the shell that resembles a saw tooth. The depth to which this dent can be made depends on a number of conditions, including the diameter of the shell after the final drawing operation, and the gage and quality of the metal from which the shell has been produced. A few trials will suffice to determine to what depth the dent should be made. When point G has been reached the roll is traversed by means of the lathe carriage parallel to the center line of the work, that is, along line GJ.

After the work has been shaped along this line, the spinning roll is returned to point G and manipulated along line GK until another saw tooth has been produced, after which the roll is traversed along line KL. This process is repeated until the spinning roll reaches point E. Finally, the spinning roll is returned to point B and fed the entire distance along line BE in order to smooth the conical surface produced by the preceding steps. One of the absolute requirements of such work is that edge A of the shell rest slightly on the shank of the chuck so as to form a support while the first notch BGM is being formed. After that step, there is a sufficient flange formed by the spinning to support the work firmly throughout the remainder of the operation.

Fig. 8 illustrates the method of spinning a tapered shell intended for use as a coffee pot. The completed shell is represented by the heavy solid line and the prelminary shapes by the dotted lines. This method is known as "offset" spinning. Chuck A is made of 0.90 carbon steel and is formed to the shape of the finished part, with the diameter BC of the large end slightly smaller than the diameter of mouth DE of the work. The tailstock of the lathe is moved off center a distance FG, so as to be in line with the center of the shell when the latter is in contact with the front end of the spinning chuck. A plate H, ¼ or ⅜ in. thick, is placed at the bottom of the shell prior to mounting the shell on the chuck. This plate fills the bottom of the shell and forms a support over this entire end. The plate is made in two halves which have the corners J cut away to facilitate their removal from the shell after it has been spun down.

In order to have edge K of the shell supported by the shank of the chuck, the diameter of the chuck shank must be about the same as diameter *BC*. This is an instance in which a standardized chuck might not be convenient, at least not so far as the large diameter is concerned. The tail-plate *L* is of a standard type; it consists of an iron casting, held on a thrust bearing of the style shown in Fig. 3. When the difference between diameters *CM* and *DE* is a trifle larger than can be spun down successfully under average conditions, and when the quantity of work warrants it, the spinning operation may be facilitated by a preliminary shaping of the work, as shown at *N*, with an expanding die. Shells from 4 to 6 in. in diameter, when annealed after the final draw, can be expanded about ½ in. on a side or 1 in. in diameter without difficulty.

A modification of offset spinning is "hot" offset spinning; this method is resorted to when the difference between the largest and smallest diameters of the finished work is great, and the length of the shell comparatively short. Fig. 10 shows this method applied to the spinning of a large steel tea kettle, and it will be seen that it is quite similar to the method shown in Fig. 8. In this case, however, a semicircular gas burner *A* has been added to the equipment. This burner is made of cast iron. It is about 2 in. deep radially and of a width to suit the work. The interior is cast hollow to form a chamber for the gas and air, which is admitted through a 1¼-in. pipe screwed into the tapped hole *B*. The face of the burner next to the shell is practically covered with holes 3/64 in. in diameter, spaced from ⅜ to ½ in. apart. The inside radius of the burner should be about 1 in. larger than the outside radius of the drawn shell.

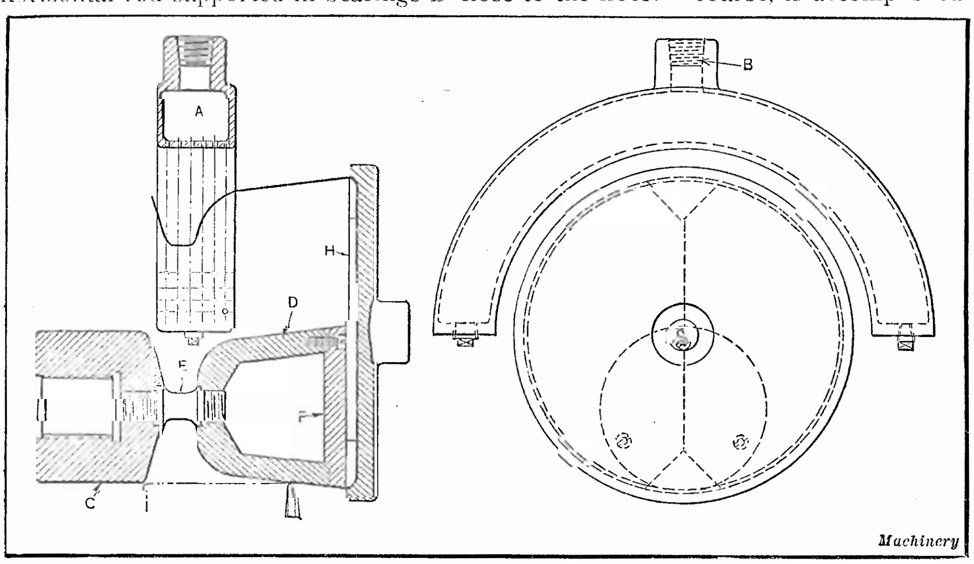
The chuck is made in four parts, shank *C* being made of machine steel and the forming end *D* of 0.90 per cent carbon steel. End *D* is made hollow so that it will not conduct the heat away from the shell too rapidly; this construction also reduces the weight hanging on the connecting stud *E*. Stud *E* cannot be hardened, and so is made of a high-grade tough steel. The end cover *F* is also made of carbon steel. Both cover *F* and plate *H* can be replaced as they become worn, but the cover can be shimmed up and refaced a number of times before replacement is necessary.

The method of attaching the burner on the spinning lathe is represented diagrammatically in Fig. 11. The burner is held on bar *A*, which, in turn, is fastened to a horizontal rod supported in bearings *B* close to the floor. A foot-lever *C* and a second lever having a counterweight *D* are mounted on this horizontal rod. The air and gas lines are brought close to the burner, and are connected to it through flexible hose. Shut-off cocks are placed in a convenient position for the operator.

While the operator is placing a shell on the chuck, the burner is held in the position indicated by the dot-and-dash lines by the action of counterweight *D*. When he has finished putting the shell in place, he brings the burner into the working position by depressing foot-lever *C* and securing it under a hook fastened to the floor; this counteracts the tendency of weight *D* to swivel the horizontal rod. The gas and air are then turned on sufficiently to produce a good blue flame. After revolving the work a short time, it becomes red-hot and remains so until the flame is turned off at the end of the operation. The final smoothing-out touches are given to the work after it is again cold.

The limiting factor of hot offset spinning is the difference between the maximum and minimum diameters of the finished part. Since the largest diameter of the chuck member *D*, Fig. 10, must be slightly smaller than the smallest diameter of the finished work, and its shape must be similar, it is obvious that if the difference in the diameters mentioned is great, the diameter of stud *E* may be so small that the stud will not have sufficient strength to sustain the job. The smallest diameter of neck that has been found satisfactory in practice is about 1 in.

Another offset spinning operation is shown in Fig. 9. This differs from the others that have been dealt with in that the spinning form is mounted on the tailstock spindle. The headstock spindle is again utilized for driving the shell through chuck *A*. This operation is the second one performed on the water pitcher, the first operation on which was shown in Fig. 5. Tools of the type used in Fig. 9 are employed when the shell is rather long, and consequently the driving means must be positive. The details of construction were decided upon after many trials and tests. The chuck is made of cast iron and the form roll *B* of chrome-nickel steel. The roll is provided at each end of its bore with a roller bearing, the inner race of which seats on the round bar *C*. On the left-hand end of this bar is mounted a member that supports a ball bearing having three circles of balls, so that the revolving work and tail-piece *D* have no effect on the supporting arrangement. The spinning operation, of course, is accomplished by the spinning roll *E*.



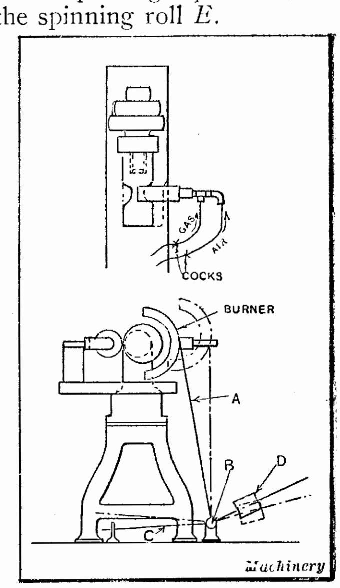


Fig. 10 (Left) Hot Offset Spinning Operation in which the Work Is Heated by Means of a Gas Burner; Fig. 11—Burner Arrangement