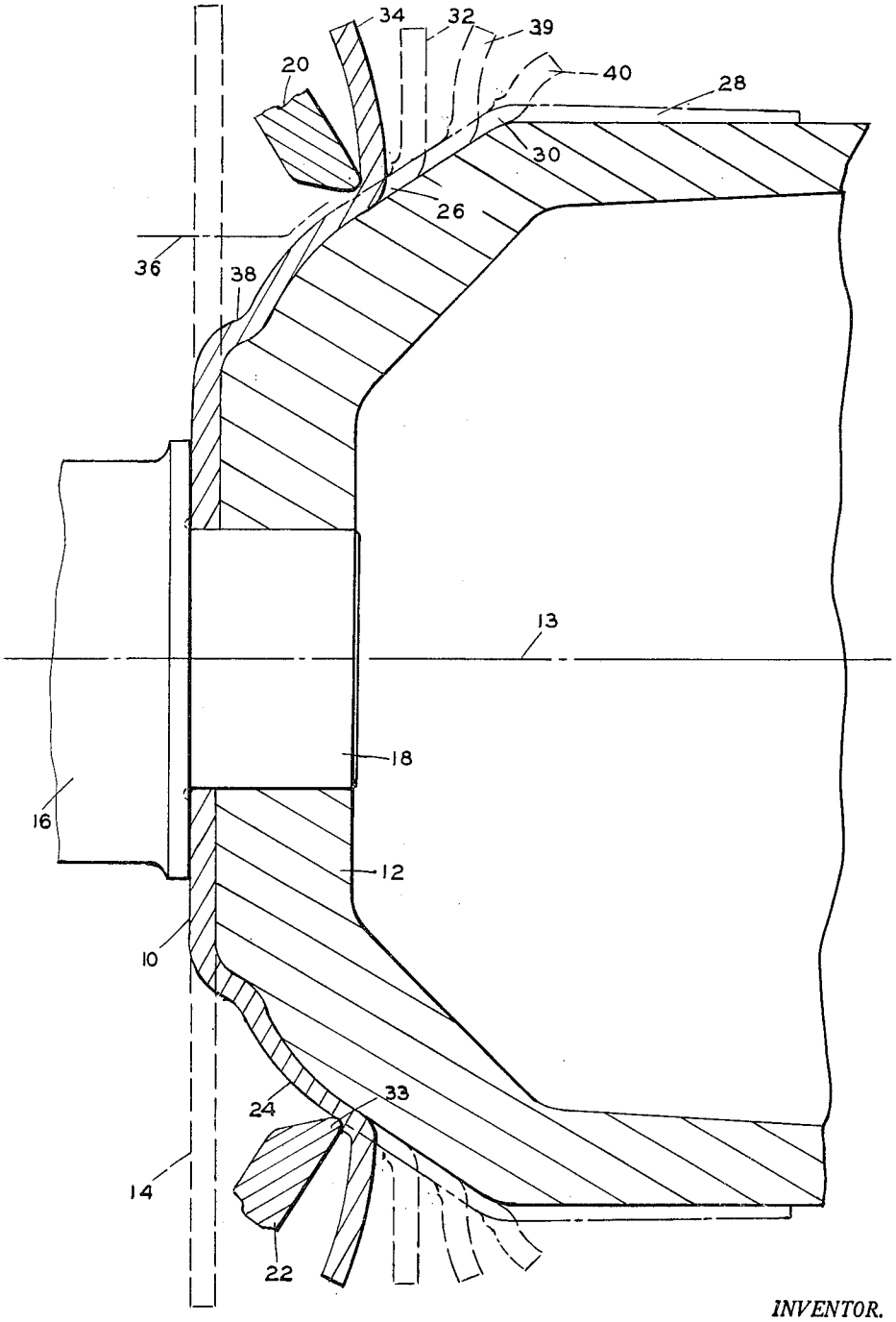
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METAL SPINNING METHOD

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INVENTOR.
RICHARD A. PAULTON

BY
Howard A. Kaiser
& John F. Verhoeven

ATTORNEYS

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METAL SPINNING METHOD

Richard A. Paulton, Phelps, Wis., assignor to The Cincinnati Milling Machine Co., Cincinnati, Ohio, a corporation of Ohio

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This invention relates to a new method of spinning a flat metal blank onto a mandrel which has a generally conical portion followed by a generally cylindrical portion.

In the metal spinning art, two basically different techniques are employed to form a workpiece into a desired shape. According to one of these, known as "hand spinning," the metal workpiece is pressed onto a rotary mandrel by use of a hand tool. This method requires a high degree of skill on the part of the workman and cannot ordinarily be employed where precise and accurate results are required. In the other method, usually referred to as "shear spinning," the metal in the blank or preform is translated or "sheared" axially onto the mandrel. This action is in accordance with the law

$$T_2 = T_1 \frac{\sin M}{\sin B}$$

where T_1 is the thickness of the blank or preform; T_2 is the thickness of the finished part; M is one-half the included angle of the mandrel, and B is one-half the included angle of the blank. This method is carried out on machines in which the spinning tool is power driven along a predetermined path relative to the mandrel. These machines are capable of spinning the workpieces to the desired shape and size with a high degree of accuracy. When the shear spinning process is applied to contoured parts in which the cone angle varies along the length of the part, it is necessary to start either with a preform made by a preliminary metal forming step, or with a sculptured blank in which the thickness of the metal is varied as necessary to permit sine law shear spinning to be performed. In either case, the manufacturing cost is increased over what it would be if a flat blank of uniform thickness could be used to spin the part. In some cases, it is possible to spin contoured parts from a flat blank provided the departure from sine law reduction is of a moderate nature. However, it has heretofore been believed impossible to shear spin a precision part having the form of a conical section followed by a cylindrical section without first preforming the blank into the approximate shape of the final part. This was because all previous attempts to shear spin a part of this nature using known techniques resulted in the blank being severed from the part at the corner where the conical section joins the cylindrical section. This action is due to the severe stress induced in the metal when the tool ring reaches the corner and attempts to force the upstanding flange onto the cylindrical portion of the mandrel. Due to the stiff and unyielding nature of the flange, the nose of the tool ring tends to cut or dig into the metal and sever the flange from the part.

It has now been found that a part having a conical section followed by a cylindrical section can be successfully spun on a machine having a pair of tool rings located on opposite sides of the mandrel by advancing one tool ring ahead of the other by a small amount with the leading ring set out from the mandrel a distance approximately equal to the thickness of the blank. In this way, the leading tool ring will be applying only bending pressure to the blank at the corner and will not tend to dig or cut into the metal as in the case of conventional shear spinning where the tool ring is also attempting to reduce

the thickness of the blank to that of the finished part. The trailing tool ring is thereby able to reduce the blank to the desired thickness and to tube spin it onto the cylindrical portion of the mandrel without exceeding the elastic limit of the material.

Accordingly, it is an object of the present invention to provide a new method of metal spinning in which a flat metal blank is spun onto a mandrel having a diverging conical section followed by a cylindrical section connected thereto.

Another object of the invention is to provide a method for spinning parts of the type mentioned in the preceding object wherein the spinning is effected by two tool rings disposed on opposite sides of the mandrel with one of the rings displaced slightly ahead of the other ring in the axial direction.

Another object of the invention is to provide a spinning method of the type recited in the preceding object in which the leading tool ring is displaced from the mandrel a distance approximately equal to the thickness of the blank while the trailing tool ring is displaced therefrom by a distance equal to the final thickness of the part.

The novel aspects of the present spinning method which are believed to be characteristic of the invention, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawing in which one embodiment of the invention is illustrated for the purpose of explanation.

In the drawing is shown a cross-sectional view of a mandrel with a partly spun part thereon and with subsequent stages in the formation of the part shown in dashed outline.

The mandrel may be supported and driven by a machine of the type shown in U.S. Patent No. 2,960,951 granted November 22, 1960, on an application filed by Charles Bierman, Jr. The spinning machine shown in this patent includes a large base plate on which is mounted a head stock having a spindle driven by an electric motor through a suitable speed reducing transmission. Secured to one end of the spindle is a large face plate on which is fastened a mandrel conforming to the desired size and shape of the part which is to be spun. A workpiece blank or preform is held against the end of the mandrel by a power operated footstock. Also mounted on the base plate on opposite sides of the mandrel are two similar tool units each comprising a main slide movable along the length of the mandrel, a cross slide mounted on the main slide for movement at right-angles to the direction of movement of the main slide, and a tool head on the cross slide for supporting the tool ring for rotation by the workpiece as it is rotated by the mandrel. The machine for practicing the present invention should also include a contouring mechanism which is capable of moving the tool rings along a preselected path as they advance along the mandrel in the course of the spinning operation. One type of mechnism which is suitable for this purpose is disclosed in my copending patent application Serial No. 809,156 filed April 27, 1959, for Spinning Method Using Offset Tool Rings now Patent No. 3,109,400 granted November 5, 1963. In accordance with this disclosure, the tool rings are caused to follow a path determined by a template which is sensed by a tracing finger mounted on the cross slide.

In the machine shown in Patent No. 2,960,951, the mandrel has a uniform, straight taper so that a tracing mechanism is not necessary in order to cause the tool rings to follow the outline of the mandrel, the main slides merely being positioned on the base so that the tool rings will move in a direction parallel to the sides of the man-

drel. Also, since the taper is straight and the thickness of the part wall is uniform, a flat workpiece blank may be shear spun onto the mandrel. This, of course, would not be possible in the case of a part having a wall of variable thickness. To shear spin a part of this nature it would be necessary to make use of a sculptured blank.

The present invention is concerned with a method of spinning a part of variable contour from a flat blank of a suitable material such as AISI 1020 steel. The shape of the part is such that the first portion to be spun is generally conical in form while the final portion is generally cylindrical . The part may also involve a tapered wall which decreases in thickness from the start of the part to the finish thereof. Such a part **10** is shown in the drawing as it is being spun on a mandrel **12** which is shaped to conform to the desired configuration of the part and is mounted on the face plate (not shown) of the spinning machine for rotation about an axis **13**. The part is spun from a flat blank **14** of suitable material which is held in place against the end of the mandrel by a clamping element **16** operated by the tailstock. A pilot **18** extends through a hole in the blank and in the mandrel and holds the part centered on the mandrel. The blank is spun into shape by a pair of tool rings **20** and **22** supported on the cross slides of the machine. The tool rings are staggered in the direction of the axis **13** so that one lies slightly ahead of the other for a purpose hereinafter to be described. This offsetting of the rings may be accomplished by the means shown in Patent No. 3,109,400 referred to above or it may be effected by a purely mechanical arrangement such as is shown in U.S. Patent Number 376,167 granted January 10, 1888. As shown herein, the tool ring **20** is the leading tool ring and the tool ring **22** is the trailing tool ring. The tool rings are caused to follow the contour of the surface **24** of the mandrel but at a predetermined spacing therefrom as they proceed from the left-hand end of the mandrel to the right-hand end thereof as viewed in the drawing. This may be accomplished by a tracer mechanism, as mentioned earlier herein, with the template shaped to correspond to the desired outline of the part on its outside surface.

It will be observed from the drawing that the part includes a generally conical section **26** and a generally tubular or cylindrical section **28** which sections are joined to one another by an arcuate section **30**. Heretofore, it has been considered impossible to spin parts of this nature by the shear spinning method. This was because of the severe stresses induced in the material at the corner between the conical and the cylindrical sections as the tool attempted to cause the metal in the upstanding flange to flow along the cylindrical face of the mandrel. This flange, using conventional shear spinning methods, would have the appearance of the flange **32** shown in the drawing but would, of course, be somewhat shorter by the time the corner **30** was reached. The size of the flange at the corner might be in the neighborhood of two inches in length or more, depending of course, on the length of the cylindrical portion **28**. Due to the stiffness of the flange, the tool rings, using conventional spinning methods, will tend to cut into the material at the corner and sever the flange from the part. Even if it were possible to negotiate the corner successfully, it would be found difficult to tube spin the part onto the cylindrical portion of the mandrel using tool rings of the shear-spinning type as shown in the drawing. It will be noted that the rings have a rather small radius nose **33** as is required for shear spinning a workpiece blank onto a cone-shaped mandrel and such rings will tend to form a burr on the part immediately ahead of this nose whenever tube spinning is attempted. For this reason, a special form of tool ring is normally used in tube spinning to prevent the formation of this burr. Such a burr is, of course, undesirable since it tends to weaken the part and to spoil the surface finish.

A novel spinning method has now been discovered, however, which overcomes the above-mentioned difficulties and enables a part of this nature to be spun from a flat blank. This method involves a staggering of the tool rings so that the leading ring **20** is from 3/16 to 5/16 of an inch in advance of the trailing ring **22**. It also involves controlling the spacing of the leading ring from the mandrel so that there is no significant reduction in the thickness of the blank by this ring. The function of reducing the blank to a predetermined thickness is left to the trailing ring. It has been found that the process may be carried out successively with the leading ring set for a spacing equal to the thickness of the blank at all points along the conical and cylindrical portions. However, it is unnecessary to maintain this spacing exactly in order to obtain acceptable parts, so long as the departure from this dimension is in the minus direction along the conical portion of the part and in the plus direction along the cylindrical portion thereof. For example, it has been found that the spacing may be as much as .010 inch less than the original thickness of the blank on the conical portion, and as much as .060 inch greater than the thickness thereof on the cylindrical portion.

The effect of the staggered tool rings on the spinning process is shown in the drawing where the part being spun is illustrated in its partly finished condition with the flange **34** shown curving rearwardly as it tends to do at this particular location. Although the stagger of the tool rings is held constant throughout the spinning operation, the leading ring **20** is preferably held away from the mandrel until the conical portion of the part is reached by the trailing ring. For example, the ring **20** may be brought in along the path **36**, the ring serving to stabilize the part on the mandrel during this portion of the spin. Since the portion **38** of the part is formed with a reverse curve and since the part is tapered throughout its length, the operation does not conform strictly to a shear spinning process but the departure therefrom is small and, in any event, is not great enough to cause any difficulty in the spinning operation. The metal of the blank is sufficiently plastic to flow along the mandrel under the influence of the trailing ring **22** to the extent necessary to produce a part of the specified size and thickness.

As the operation proceeds along the conical portion **26**, the flange will straighten out as indicated by reference numeral **32** and then commence to curve forwardly as the corner is approached as indicated at **39**. At the corner, the effect of the leading ring **20** is to bend the flange still further forward as shown at **40**. As the corner is negotiated, the flange is bent still further forward until it is finally forced down against the mandrel as the trailing ring reaches the beginning of the cylindrical portion **28**. At this point, the leading ring is bearing against the surface of the part sufficently in advance of the trailing ring to prevent the formation of a burr by the latter ring. Thus, tube spinning may be effected without the necessity of stopping the operation and changing to a different form of tool ring. It will be seen, therefore, that the leading ring performs the function of preparing the way for the trailing ring by laying down the metal ahead of the trailing ring so that it will not dig in and cut off the flange. It also permits the use of a shear spinning type of tool ring for spinning the cylindrical portion of the part thereby enabling the part to be formed in a single, continuous spinning operation.

It is to be understood, of course, that the foregoing disclosure is intended to be illustrative only and that changes and modifications may be resorted to without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. The method of spinning a flat metal blank over a mandrel by a pair of tool rings engaging with the blank as they move along the mandrel to form in a single, continuous operation a part having a generally conical section

followed by a generally cylindrical section which comprises:

(a) rotating the mandrel and the blank as a unit relative to the tool rings,

(b) moving one of the tool rings along the mandrel with a predetermined spacing between the ring and the mandrel which is approximately equal to the original thickness of the blank to press the blank against the mandrel without any significant reduction in the thickness thereof, and,

(c) simultaneously moving the other tool ring a preselected distance behind the first-mentioned tool ring and at a spacing from the mandrel equal to the desired thickness of the finished part to thereby effect a substantial reduction in the thickness of the blank material and spin the part to its final shape and size.

2. The spinning recited in claim 1 wherein said preselected distance between the tool rings lies within the range of from 3/16 inch to 5/16 inch.

3. The spinning method recited in claim 1 wherein said part has a reversely curved portion preceding the conical section, and wherein the separation between said one tool ring and the mandrel is considerbly greater than said

predetermined spacing during traversal of said reversely curved portion of the part.

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CHARLES W. LANHAM, *Primary Examiner.*

NEDWIN BERGER, *Examiner.*