United States Patent

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[54] **METHOD AND APPARATUS FOR MANUFACTURING BEARING RINGS**

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[51] **Int. Cl.**.....**B21d 22/06**

[58] **Field of Search**.....72/354, 370

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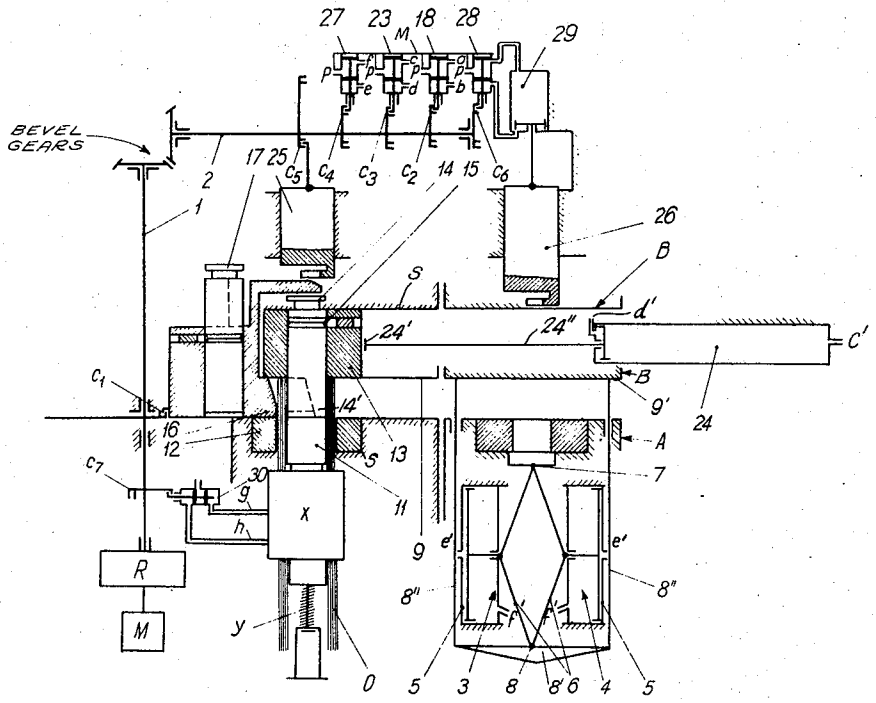
[57] **ABSTRACT**

Method and apparatus for forming ball bearing races from lengths of tubing. A mandrel is inserted into the interior of the7tube. A die having a shape conforming to that of a ball bearing raceway is positioned about the exterior of the tube at approximately its midpoint. The opposite axial ends of the tube are then compressed by jaws to form shoulders on each axial end of the tube to form the raceway.

9 Claims, 3 Drawing Figures



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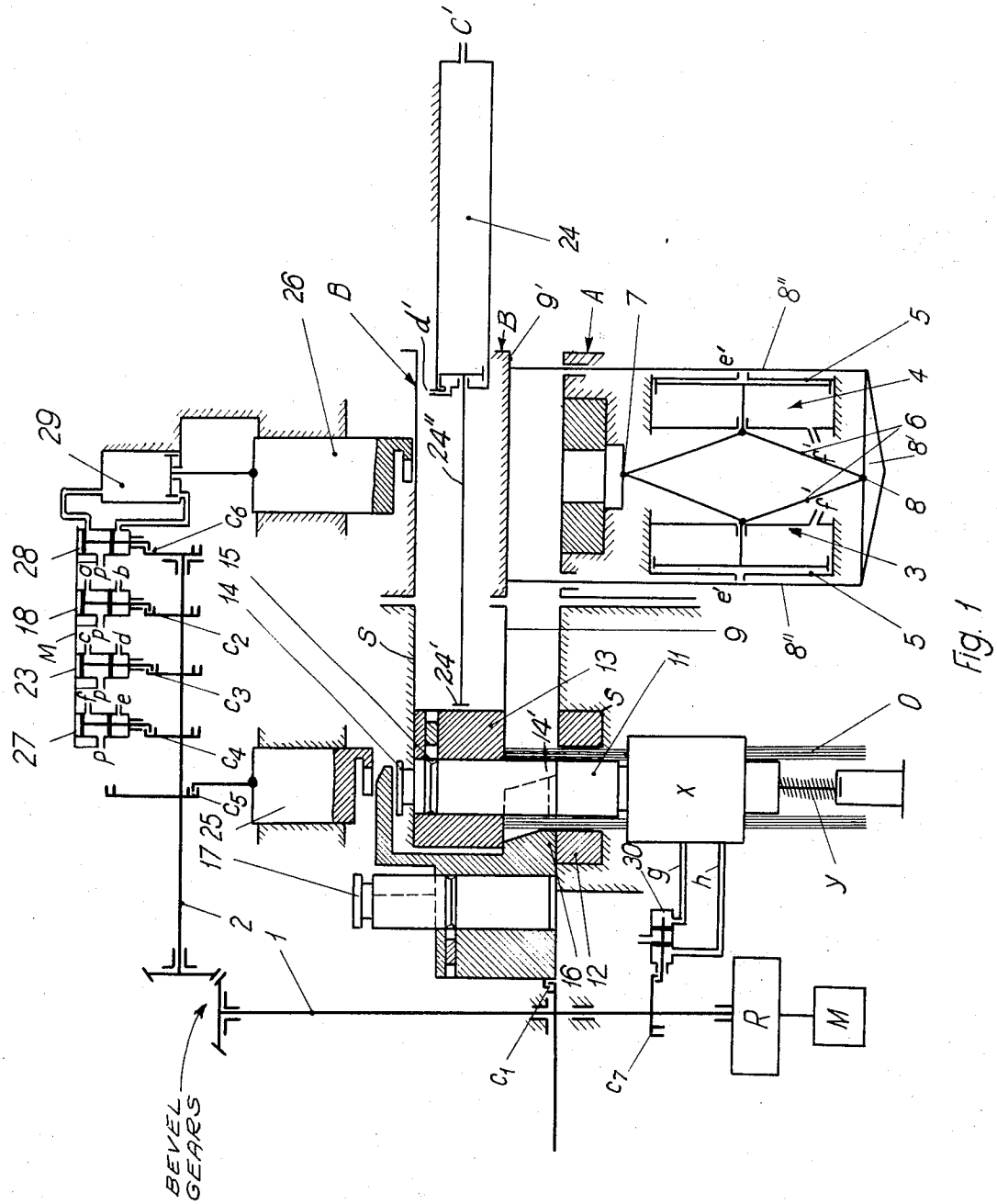

Fig. 1

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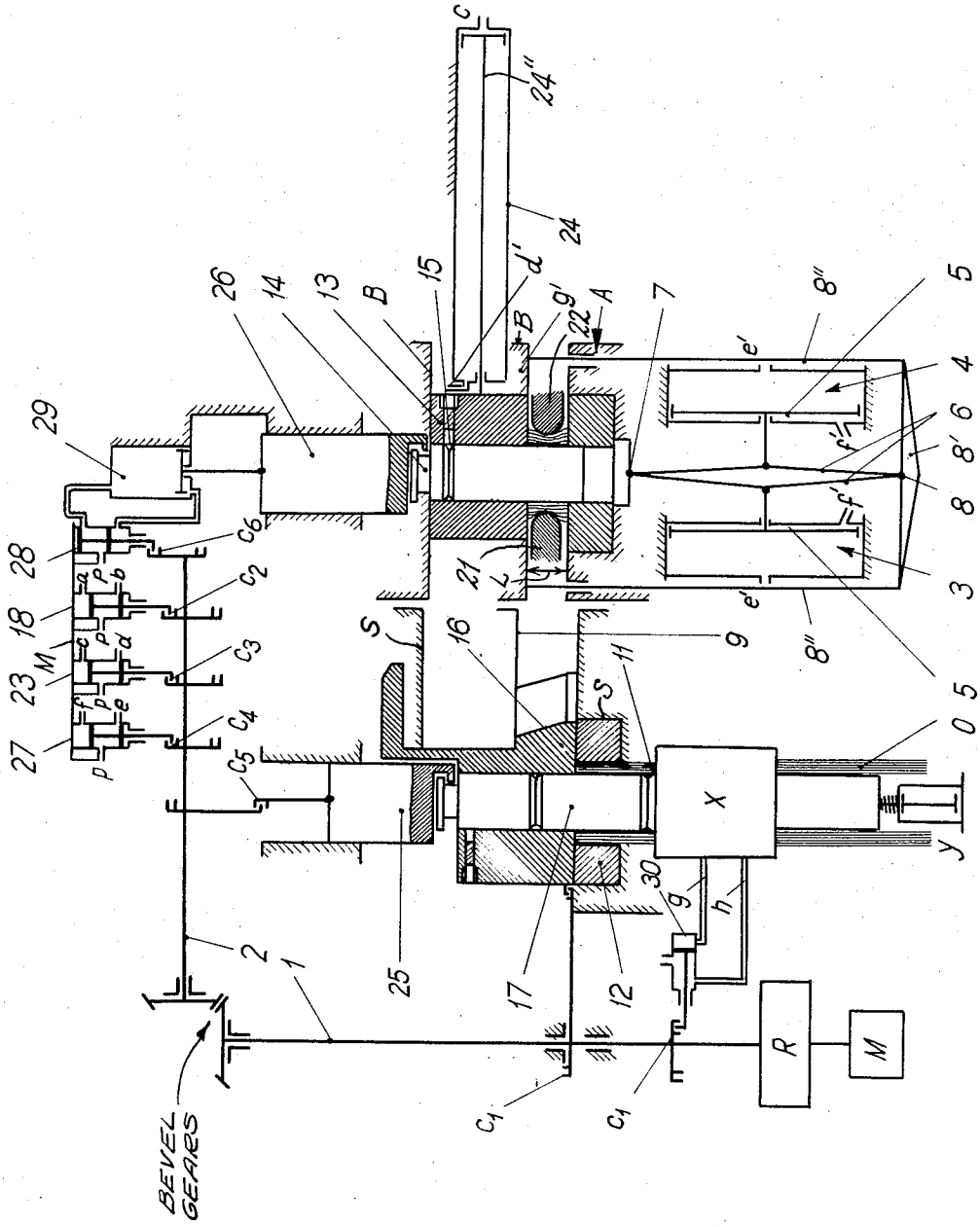

Fig. 2

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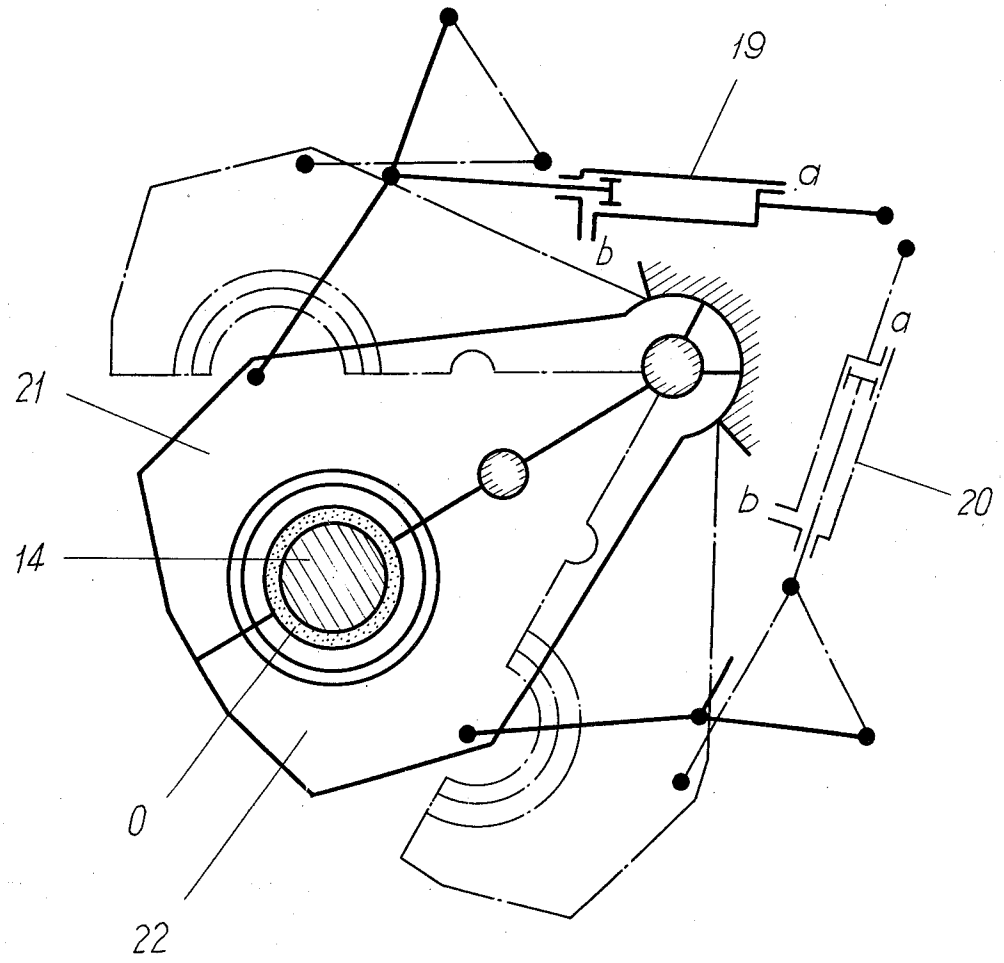

Fig. 3

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METHOD AND APPARATUS FOR MANUFACTURING BEARING RINGS

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for automatically producing inner race rings for rolling-contact bearings. The present method produces the race rings by cold working and uses stock tubing as the input material.

It is well known in the art to form such race rings by plastic-working techniques; as, for example, by the hot rolling of rings whose initial cross section is rectangular. The requisite heating, however, produces a degradation of the rolled surface and subsequent machining requires large material allowances to be made.

It is also know to produce race rings by cold-rolling a workpiece with rollers having an appropriate profile and applied to the workpiece with gradually increasing pressure. The rollers, however, wear rapidly because of the high localized pressures involved.

Both the hot-rolling and cold-rolling processes referred to above have the disadvantage that there are large local displacements of material in the region in the bearing surface. These displacements cause slipping at the grain boundaries with a resulting unfavorable effect on the fatigue properties of the material.

SUMMARY OF THE INVENTION

The problems referred to above are overcome by a process according to the present invention in which the race is formed by a single, axial compression which simultaneously builds up the shoulders of the race groove on either side of a die. This process causes a material to be gradually deformed around the die without being displaced directly by a forming tool.

During the race forming process, the material gradually takes the form of the die.

Lengths of stock tubing constructed from a suitable, known bearing steel are used as the input material. Rolling causes the granular structure of this type of steel to become fibrous. In the method according to the present invention, the initial granular structure improves due to the stretching and the thickness reduction achieved when drawing the tube. This pronounced fibrous structure provides a half-finished bearing ring with certain desirable properties at the raceway due to a desirable orientation of fibers. It has been shown that in order to achieve bearings having a maximum service life, the fibers of the material must be oriented so as not to be cut by the surface of the raceway of the bearing ring.

Orientation of the fibers in the steel to conform with the contour of the surface of the raceway can be achieved by the process according to the present invention.

The inner race of a rolling contact bearing normally fails first during running of the bearing.

The method of the present invention includes the steps of inserting a mandrel into the interior of a length of tube, placing a die about the exterior of the tube at approximately its midpoint, and compressing the opposite ends of the tube while the mandrel and die are so positioned to form shoulders on each axial end of the tube for retention of ball bearings. Before the above steps are carried out, the length of tube is prepared by the steps of placing the mandrel within the end of a tubular extensive length so that the mandrel end is positioned at a distance from the tube end equal to the length of tube required to shape one ball bearing raceway, and cutting the tube with the mandrel therein at the point to which the end of the mandrel extends.

Apparatus for carrying out the method of the present invention is also provided. This apparatus has a support structure, sleeve means having an axial end mounted on the support structure for holding a tube to be processed within it with one end of the tube extending past the axial end, a mandrel having an axial end and arranged to be inserted within the tube, means mounting the mandrel on the support to move the mandrel into the tube with the axial end of the mandrel positioned and aligned with the end of the sleeve, a cutting tool having a cutting edge for cutting the portion of the tube projecting beyond the axial end of the sleeve means, means mounting the cutting tool for movement of the cutting edge in engagement with the axial end of the sleeve to thereby cut the portion of the tube projecting beyond the axial end of the sleeve from the remainder of the tube, a die having a shape corresponding to the exterior of the ball bearing raceway to be pressed, means mounting the die on the support structure for movement about the exterior of a cut section of the tube, a pair of jaws for pressing opposite axial ends of the cut section of the tube, and means mounting the jaw on the support structure for movement to axially compress the opposite tube ends to thereby form shoulders at each axial end of the tube to form a groove in the central region of the tube and thereby form a ball bearing raceway.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic showing, partly in cross section, of a first operating position of apparatus for performing the method according to the present invention.

FIG. 2 is a schematic showing similar to FIG. 1 with the apparatus in a second operating position.

FIG. 3 is a partly schematic top plan view of the die for forming the bearing ring, together with the die actuating device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The pressing apparatus according to the present invention is arranged on a support structure S, as can be seen in FIGS. 1 and 2 of the drawings. The partial top-right-to-bottom-left hatching indicates the various segments of this support structure S.

Pressing jaws A and B are mounted on the structure S in opposed relationship for movement toward and away from one another. The jaws A and B are represented in FIGS. 1 and 2 by the partial top-left-to-bottom-right hatching.

The apparatus is actuated by a suitable, known motor M. Motor M rotates a pair of cam shafts 1 and 2. Cams C_1 and C_7 are mounted on cam shaft 1 and cams C_2 through C_6 are mounted on cam shaft 2. Rotary motion is transferred from cam shaft 1 to cam shaft 2 by means of a pair of suitable, known bevel gears.

The jaws A and B are mechanically actuated — that is, hydraulically or pneumatically — through piston and

cylinder arrangements 3 and 4. Each piston and cylinder arrangement 3 and 4 contains a respective piston 5. Each piston 5 has a piston rod connected to respective, opposed pivot points of a four-bar linkage 6 in the form of a parallelogram. This linkage 6 has pivot points 7 and 8 in addition to those connected to pistons 5. Pivot point 7 is connected to jaw A, and pivot point 8 is connected to a rod 8'. Rod 8' is in turn connected to bars 8'' which are fixed to jaw B. A spacer or intermediate member 13 is provided and arranged to slide between an area 9 and an area 9'. These areas are configured in any conventional manner to accommodate the spacer 13 and the cut section of tube O as they are translated therebetween in still another conventional manner to be described hereinafter.

The purpose of the apparatus according to the present invention is to intermittently feed an extensive length of tubing, or pipe, a distance from an end of the tube which is equal to the length of a tube section required to shape one ball bearing raceway, to cut the tube, to transfer the blank or cut tube section to a position between jaws A and B, to place a die 21, 22 having a cross section corresponding to the desired final shape — toridial in the case of ball bearing races — around the cut tube section, to axially compress the cut tube section, to a predetermined length "L" (FIG. 2), to engage the bore of the sheered pipe at the cut end thereof, to retract the jaws A and B, to separate the component segments 21 and 22 of the die, to remove a pin on which the pressing was obtained, and to reject the previously pressed bearing ring and initiate a new cycle. As mentioned above, the cams C_1 to C_7 mounted on cam shafts 1 and 2 are provided for this purpose. These cams act in conjunction with suitable, known actuators 18, 23, and 27 through 30 to actuate the various elements of the press in their proper sequence. The actuators are supplied from a pressure source through a manifold arrangement shown schematically at M.

All of the members which are directly attached to the body of the press, as well as those arranged adjacent the cams, are directly actuated. The most remote parts, namely those mounted for movement with the jaws A and B, are remotely controlled through suitable linkages from the manifold and actuators to piston and cylinder arrangements to be described hereinafter. A rod provided with a mandrel 11 on its end is introduced into a tube, or pipe, O of extensive length to prevent flattening thereof. Tube O is inserted into a known feeding system X. This feeding system X is hydraulically or pneumatically actuated. Mandrel 11 is coupled to a dismountable, moving elastic link-coupling Y, which is in turn attached to the supporting structure forming the press body.

A special sleeve 12 is arranged about the end of the tube O. This sleeve 12 is integral with the supporting structure S.

Spacer 13 in the position shown in FIG. 1 acts as a stop for tube O and thereby determines the length of tube O to be cut.

A pin or mandrel 14 is inserted into the end of tube O to cooperate with mandrel 11 and prevent the deformation of the tube O in the shear plane during the cutting step. Pin 14 along with spacer 13 functions to transfer the cut tube section, or blank, into position to have a raceway pressed thereinto. The pin 14 has an axial end 14' arranged to be inserted within the tube O so that the end 14' is positioned at a distance from the tube end equal to the length of tube required to shape one ball bearing raceway. An elastic latch 15 is provided to hold pin 14 in position. A cutting-off tool 16 shears the tube O by a left-to-right movement in FIGS. 1 and 2. The movement of tool 16, which defines a bore for receiving a pin 17 which is similar to pin 14, is controlled by cam C_1. This cam pushes tool 16 with great force from the position shown in FIG. 1 to the position shown in FIG. 2, thus performing the shearing of tube O. The shape of the cutting edge of the tool 16 can be any desired shape suited for the purpose which is within the expertise of the ordinarily skilled artisan. At the end of the stroke of the cutting-off tool 16 (FIG. 2) the axis of pin 17 is aligned with the axis of sleeve 12. In the following description of the positioning of the actuators 18, 23, and 27 through 30 by cams C_2 through C_7, respectively, the letter p is always used to designate the incoming medium under pressure. This pressure p is derived from a known source which is not shown in the drawings.

Cam C_2 positions actuator 18 to direct pressure p to the piston and cylinder arrangements 19 and 20 (FIG. 3). These piston and cylinder arrangements 19 and 20 open and close the die 21, 22 by manipulating respective ones of the die segments 21 and 22. The die segments 21 and 22 define the groove of the raceway to be formed in the cut tube section. Piston and cylinder arrangements 19 and 20 are actuated by means of pressure from outlets a and b of actuator 18 being alternatively directed to the corresponding openings in the cylinders of arrangements 19 and 20. That is, outlets *a* and *b* are connected to corresponding openings *a'* and *b'* respectively.

The cut tube section is now transferred to a position between jaws A and B of the press. For this purpose, cam C_3 positions actuator 23 which is provided with channels *c* and *d*. Channels *c* and *d* are connected to respective openings, which are designated *c'* and *d'*, in the cylinder of a piston and cylinder arrangement 24. Arrangement 24 is arranged to positively displace spacer 13, along with pin 14 and the cut tube section. For this purpose a connection 24' is made between the spacer 13 and the rod 24'' of the arrangement 24. As is clearly evident from FIGS. 1 and 2, the connection 24' is preferably of a sliding type which permits the spacer 13 to move with jaw B during compression of tube O.

Simultaneously with the cutting of tube or pipe O, cam C_3 positions actuator 23 to direct pressure into channel *d*. This pressure moves the piston of arrangement 24 from the position shown in FIG. 1 to the position shown in FIG. 2, and positively displaces spacer 13 and pin 14 to move the cut tube section into the position shown in FIG. 2. Now the compressing step can begin.

When spacer 13 and pin 14 are moved to the position shown in FIG. 2 of the drawings, the free end of pin 14 comes into engagement with and is coupled to a retaining section of member 26. Simultaneously, the movement of tool 16 and pin 17 into the position shown in FIG. 2 moves pin 17 into a position to be coupled to the retaining section of a member 25.

Members 25 and 26 are mounted for reciprocating movement along their vertical axes in FIGS. 1 and 2,

and are actuated by cams C_5 and C_6, respectively. Cam C_5 acts directly on member **25**, while cam C_6 positions an actuator **28** which actuates a piston and cylinder arrangement **29** to reciprocate member **26**.

Once the elements are in the positions shown in FIG. **2** of the drawings, cam C_2 positions actuator **18** to direct pressure *p* through channel *a* and opening *a'* to actuate arrangements **19** and **20** and close and lock the die segments **21** and **22**. Cam C_4 now positions actuator **27** to direct pressure *p* through channel *e* to openings *e'* of cylinders **3** and **4**. The pistons **5** of cylinders **3** and **4** move toward one another and, thus, cause jaws A and B to move toward one another. As jaws A and B move toward one another, the cut tube section, or blank, is upset to the required length L.

Cam C_2 then positions manifold **18** to direct pressure *p* through channel *b* and opening *b'* to unlock and open die segments **21** and **22**.

Next, Cam_4 positions actuator **27** to direct pressure *p* through channel *f* to opening *f'* and moves jaws A and B away from one another into their position shown in FIG. **1**.

When this is accomplished, cam C_5 moves member **25** from its position shown in FIG. **1** into its position shown in FIG. **2** and inserts pin **17** into the tube O. Thus, possible irregularities in the cross section of tube O at the sheared section thereof are dressed. Then cam C_5 returns member **25** to its FIG. **1** position and withdraws pin **17**.

Now cam C_6 positions actuator **28** to direct pressure *p* to arrangement **29** such that member **26** is moved upwardly as seen in FIGS. **1** and **2**, and pin **14** is removed from the pressed bearing ring. The bearing ring then drops down off the press. A further rotation of cam C_6 replaces pin **14** in its initial position with respect to spacer **13**.

After the pin **14** has been returned to its initial position, cams C_3 and C_1 act to return spacer **13** and tool **16**, respectively, to their initial position shown in FIG. **1**. Cam C_7 positions actuator **30** to position system X through channels *g* and *h*. System X then moves tube O a length L in the upward direction of FIG. **1**, and the process set out above is then repeated. Cam shafts **1** and **2** are arranged such that one cycle is completed within a 360° revolution of these cam shafts **1** and **2**, so that further rotation of the cam shafts **1** and **2** will start a new cycle.

When compared with the known processes, the new cold working technique according to the present invention demonstrates the following advantages:

a perfect material structure is obtained in that the direction of the fibers is parallel to the groove of the pressed bearing rings;

rolling-contact bearing rings are produced which require low machining allowances; that is, the material and labor consumption is very low;

forming by cold-pressing results in lower tool wear and less thermoenergy consumption than a hot working technique would require.

deformation is achieved with only compression stresses being produced in the workpiece and the tool, and occurs little by little throughout the material. As a result, slip and faults at the grain boundaries of the material are avoided;

special extra machines to precut the material are not required;

bearing rings are obtained by the method according to the present invention efficiently and without the material waste which would occur if the rings were turned.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. A method of manufacturing ball bearing races, comprising, in combination, and in any desired order:

a. placing a mandrel within the interior of a tube section,

b. placing a die about the exterior of the tube section at approximately its midpoint, and

c. compressing the opposite ends of the tube section while said mandrel and die are so positioned to form shoulders on each axial end of the tube section for retention of ball bearings.

2. The method of claim **1** including the steps of:

a. placing said mandrel within the end of a tube of extensive length so that the mandrel end is positioned at a distance from a tube end equal to the length of the tube section required to shape one ball bearing raceway.

b. cutting the tube with the mandrel therein at the point to which the end of said mandrel extends

c. thereafter performing said die placing and said compressing steps while the mandrel remains within said cut tube section.

3. The method of claim **2** including the step of reshaping any of the portions of the interior of the tube which are deformed during said cutting operation by inserting a pin of larger dimensions than expected deformations within the tube bore, and moving said pin axially past said deformed regions.

4. The method of claim **1** including performing said die placing step by simultaneously moving segments of a die together on radially opposite outer surfaces of the tube section and bringing the edges of said segments into engagement with each other to thereby form a complete die surrounding the tube section.

5. Apparatus for the manufacturing of ball bearing races from tubes, comprising, in combination:

a. support structure,

b. sleeve means having an axial end mounted on said support structure for holding a tube to be processed within it with one end of the tube extending past said axial end,

c. mandrel means for inserting within the tube, said mandrel means having an axial end,

d. means mounting said mandrel means on said support structure to move said mandrel means into the tube with said axial end of the mandrel means positioned in alignment with the end of said sleeve means,

e. cutting tool means having a cutting edge for cutting the portion of the tube projecting beyond said axial end of said sleeve means,

f. means mounting said cutting tool for movement of said cutting edge in engagement with said axial end of said sleeve means to thereby cut the portion of the tube projecting beyond said axial end of the sleeve means from the remainder of said tube,

g. die means having a shape corresponding to the exterior of a ball bearing raceway to be pressed,

h. means mounting said die means on said support structure for movement about the exterior of a cut section of the tube,

i. a pair of jaw means for pressing opposite axial ends of said cut section of the tube, and

j. means mounting said jaw means on said support structure for movement to axially compress the opposite tube ends to thereby form shoulders at each axial end of the tube bordering a groove in the central region of the tube and thereby form a ball bearing raceway.

6. The combination of claim **5** in which said means mounting said jaws move the jaws simultaneously and at the same speed during said axially compression movement.

7. The combination defined in claim **6** wherein said jaw moving means include two pressure cylinder means mounted on said support structure and a parallelogram linkage system connecting the two cylinder means with the two jaw means to provide said simultaneous movement.

8. The combination defined in claim **5** including pin means having exterior dimensions larger than the expected dimensions of portions of the tube which are distorted during said cutting action, and means mounting said pin means for axial movement within the interior of one of said tubes after cutting and past any distorted regions to thereby reshape regions of the tube distorted by cutting.

9. The combination of claim **5** including:

a. a bore within said cutting tool and means mounting said pin within said bore and said cutting tool to bring said bore in co-axial alignment with the end of the bore of uncut portions of the tube,

b. a spacer member, means mounting said mandrel within said spacer member for movement from a first position in which said bore is coaxial with said uncut tube to a second position in which said bore is co-axial with a bore in one of said jaws, said means further mounting said mandrel for movement of a portion thereof into said jaw bore while the remaining portion remains within said spacer bore and the cut tube bore whereby during movement from said first position to said second position the mandrel moves said cut section of said tube to said jaw means said mandrel then moves into said jaw bore and said spacer engages one of said axial ends of said jaw and is itself engaged by the other of the said jaws to transmit compressing forces from said other jaw to said tube section,

c. means carried by said support structure for moving said mandrel out of said jaw bore and the cut tube section after said ball bearing race is formed,

d. means carried by said support structure for moving said pin out of said uncut portion of the tube after said reshaping action is completed, and wherein

e. said jaw moving means includes two pressure cylinders and a parallelogram linkage system connecting the two cylinders with the two jaws to provide simultaneous movement of said jaws at the same speed during said axial compressure movement, and

f. said die is formed of a plurality of segments and means on said support structure for moving said segments together to form a complete die surrounding the tube.

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