May 27, 1969 J. MARCOVITCH 3,446,048

PROFILING OF ANNULAR WORKPIECES

Filed Jan. 6, 1967

Sheet 1 of 5

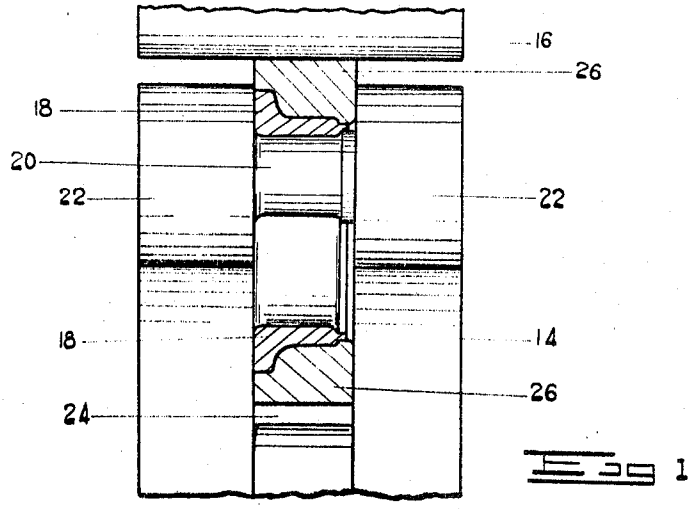


Fig 1

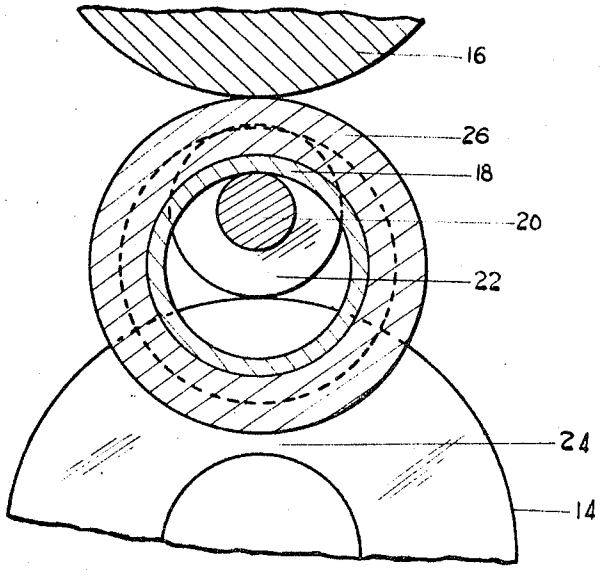


Fig 2

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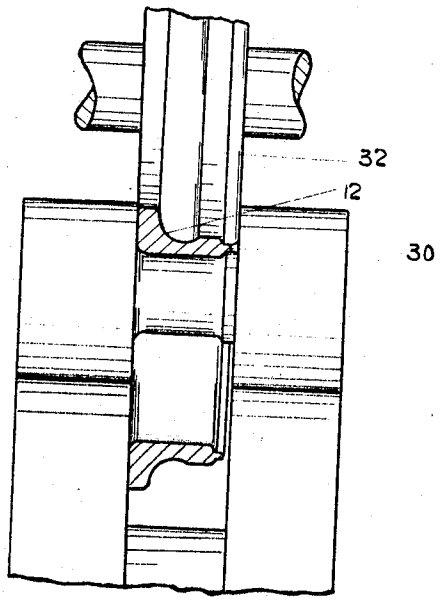


Fig. 3

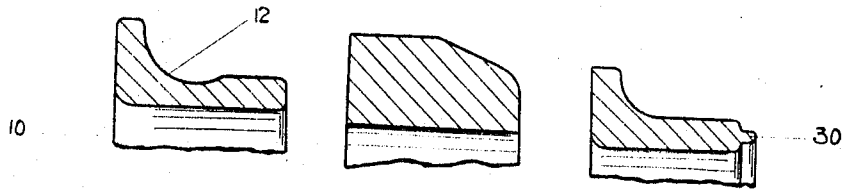


Fig. 4 Fig. 5 Fig. 6

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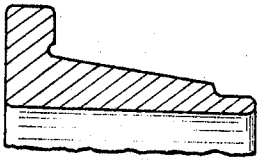


Fig 8

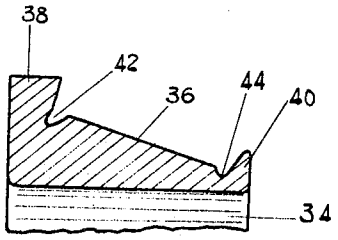


Fig 7

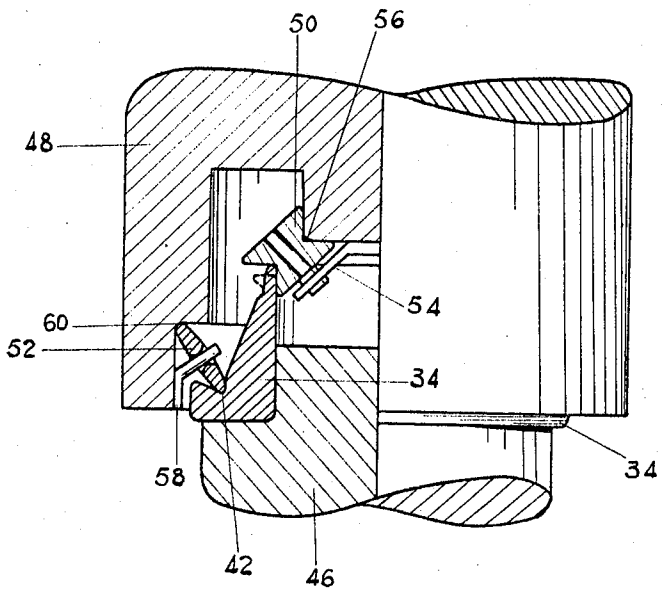


Fig 9

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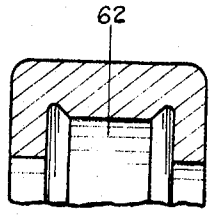


Fig 10

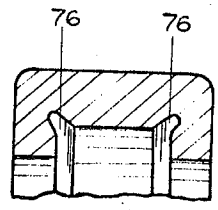


Fig 11

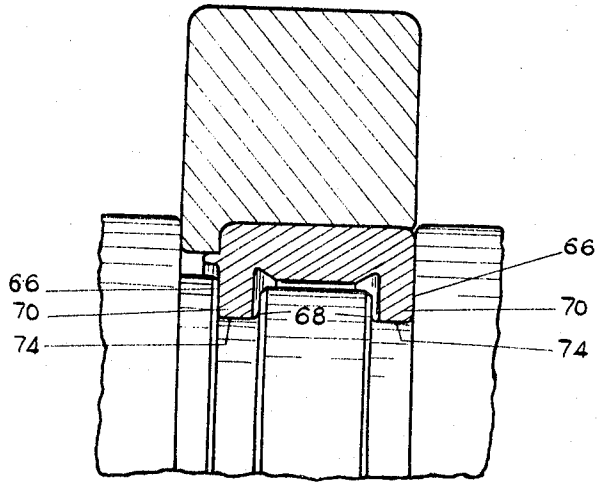


Fig 12

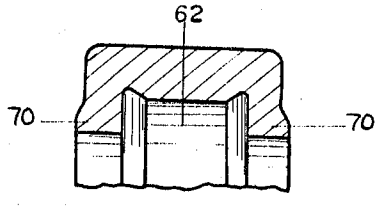


Fig 13

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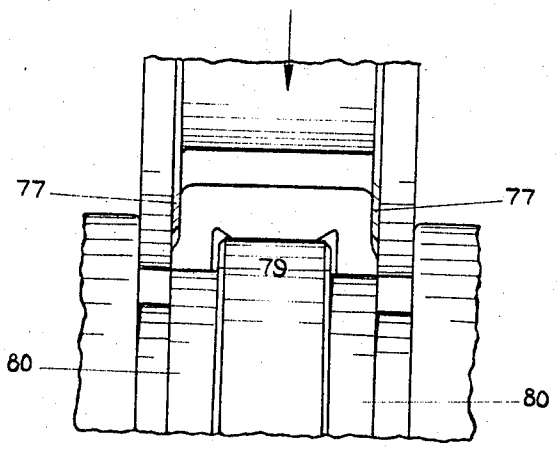


Fig 14

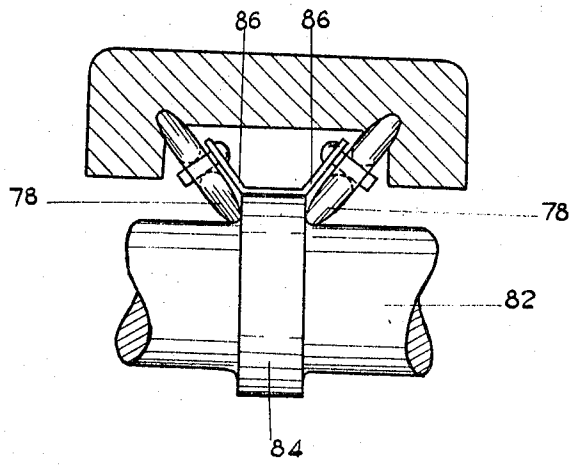


Fig 15

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United States Patent Office 3,446,048
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3,446,048

PROFILING OF ANNULAR WORKPIECES

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Int. Cl. B21d 3/02
U.S. Cl. 72—126
4 Claims

ABSTRACT OF THE DISCLOSURE

An annular workpiece is profiled by means of juxtaposed rollers defining a profiling space of diminishing extent in which the workpiece is contained, with a cylindrical mandrel threaded through it, the ends of the mandrel rolling on one of the rollers and pressing the workpiece towards the other roller; the workpiece having first imposed on it an intermediate profile and being then subjected to a second operation to complete the profile; at least one of the two operations being a profiling operation as above set out.

This invention relates to the profiling of annular workpieces. The operation may be effected by means of juxtaposed surfaces defining between them a profiling space of diminishing extent, to which the workpiece is offered, threaded over a cylindrical mandrel which projects from the workpiece at each side, the projecting mandrel ends rolling on at least one of the surfaces, and, as the profiling space diminishes, pressing the workpiece towards the other surface to impose on it the profile of the mandrel and of the other surface, or of a surface with which the outer surface of the workpiece is in contact and which separates it from the other surface.

In the vast majority of cases, the juxtaposed surfaces will be the peripheries of rollers defining a profiling space between them, and this specification will hereinafter refer to rollers only. However, it must be understood that rectilinear surfaces are equivalent to rollers of infinite and very large radii, and are included in the ambit of the invention.

There may be two rollers, defining a convergent throat between them to which the workpiece, with its mandrel, is offered; and the rollers may be juxtaposed externally, or one may be hollow with the other contained within its cavity. On the other hand there may be three or more rollers which define the profiling cavity between them and which are moved relatively inwardly to diminish the size of the cavity.

There may be and usually is a control ring surrounding the workpiece and which provides the surface in contact with the outer surface of the workpiece, the ring being present to limit the diametral spread of the workpiece as it is being profiled.

The necessity to withdraw the finished workpiece from the control ring imposes the condition that the profile imposed on the workpiece must not increase in diameter across the width of the ring in the direction of axial movement of the workpiece relatively to the control ring, which for convenience' sake may be called the withdrawing direction. If there is any such increase, the finished workpiece is incapable of withdrawal without destruction of the control ring, unless the ring is split, which increases the complexity of the machine. This limits the versatility of the profiling process. One object of the present invention is to propose an improved process, which enables profiled rings to be fabricated in spite of diametral increase in the withdrawing direction.

The necessity to withdraw the workpiece from the mandrel at the end of the profiling operation makes it impossible to form a recess with undercut grooves in a single rolling operation, because the mandrel would be inextricably engaged with the workpiece against separation. Thus far, to the best of applicant's knowledge, no method of rolling this kind of ring has been known. Another object of this invention is to provide a technique which will enable it to be achieved wholly or mainly by rolling and thereby minimise the need for any machining operation.

According to the invention, the profile to be applied to the workpiece is produced by first applying to the workpiece a profile which is intermediate in a profile of the original workpiece and the profile of the finished article, and then subjecting the intermediately profiled workpiece to a further profiling operation to produce the final profile; at least one of the operations being a rolling operation as above described; that is to say, a rolling operation comprising the steps of threading the workpiece over a loose cylindrical mandrel which projects from it at each side, and locating the mandrel and the workpiece within a profiling space of diminishing extent, defined between juxtaposed rollers on one of which the projecting ends of the mandrel roll, diminution of the space causing the workpiece to be pressed by the mandrel towards a second of the juxtaposed rollers to impose on the workpiece the profiles of the surfaces with which its inner and outer faces are in contact.

Further according to the invention, the first operation is carried out on the external face of the workpiece, by rolling, with the workpiece surrounded by a control ring to limit diametral spread, and the intermediate profile is such as to offer no obstruction to withdrawal of the ring from the workpiece by relative axial movement.

Also according to the invention, the second profiling operation is carried out by rolling the partly finished workpiece in contact with a profiled roller. Since the second profiling operation is carried out with the workpiece rolling free—that is to say, without control of the diametral dimension—the profiled workpiece can be withdrawn from the machine merely by extracting the mandrel from its cavity. If the major profiling operation is carried out in the first stage, the diametral increase imposed during the second, and lighter, stage, is inappreciable or at least insignificant and in any case consistent.

Apparatus according to the invention is illustrated in the accompanying drawings, by way of example. In the drawings:

FIGURE 1 is an elevation, partly sectioned, of rotary profiling apparatus suitable for carrying out one technique of the invention,

FIGURE 2 is a sectioned side view of the apparatus of FIGURE 1,

FIGURE 3 shows the final operation being carried out,

FIGURE 4 is a fragmentary view in section of a finished component,

FIGURE 5 is a fragmentary view in section of a suitable blank,

FIGURE 6 is a similar view of the shape imposed upon the blank in the initial stage of rolling,

FIGURE 7 is a fragmentary view in section of another component,

FIGURE 8 is a similar view showing the intermediate shape of the component,

FIGURE 9 is a sectional view of a machine to convert the intermediate workpiece of FIGURE 8 into a finished component,

FIGURE 10 is a fragmentary sectional view of another workpiece in the intermediate stage,

FIGURE 11 is a similar view of the finished component,

FIGURE 12 is a fragmentary sectional view of a machine to transform the intermediate workpiece of FIGURE 10 into the finished component of FIGURE 11,

FIGURE 13 is a fragmentary sectional view of another intermediate form of workpiece,

FIGURE 14 is a fragmentary sectional view of a machine to convert the intermediate form of FIGURE 13 into the component of FIGURE 11, and

FIGURE 15 is a fragmentary view of another machine to finish the component.

The technique of the invention is particularly well suited to the fabrication of the inner races of ball and roller bearings of the kind commonly known as angular contact bearings, the profile of which is shown in FIGURE 4. The race is characterised by a cylindrical bore **10** and a periphery including a groove **12** to receive the balls.

The diameters of the component must be precise, so that, when it is formed by rotary profiling, it is necessary to use a control ring to limit diametral spread of the blank. In FIGURES 1 and 2 the apparatus illustrated comprises juxtaposed rollers **14, 16,** which are two in number to define between them a convergent throat, but may be three which are movable inwardly relatively to one another to diminish the profiling spaced defined between their peripheries. The workpiece **18** has a mandrel **20** passed through its cavity, and projecting from it at each side, the projecting ends **22** of the mandrel rolling on the roller **14**, or on two rollers. The lands of the roller upon which the mandrel ends roll are separated by a circumferential groove **24**, into which the workpiece extends. The workpiece is surrounded by a control ring **26** and the outer surface of the workpiece is pressed into profiling contact with the inner face of the control ring by the mandrel, as the width of the profiling space diminishes, either by the mandrel being translated along the convergent throat defined between two rollers, or by the profiling space being diminished in size by the rollers being moved inwardly.

To impose the contour of the outer face of the component shown in FIGURE 4 on the blank, the inner face of the control ring must, of course, be complementally contoured, but it is clear that if the contour were that of the finished component, the control ring would extend into the groove **12** and the two would be interlocked against separation. It is, therefore, not possible to roll the component in one operation. For this reason, the control ring is internally contoured to approximate to the contour of the finished component as closely as possible while not transgressing the rule that there must be no increase of diameter of the workpiece in the withdrawing direction. The closest approximation is seen in FIGURE 6, which diverges from the finished component only in that it does not include the groove **12**. The control ring is accordingly shaped to produce this contour in the workpiece, as is seen in FIGURE 1, while lateral spread is prevented by the presence of the control ring and the radial wall **28** of the mandrel. Slight surplus material is extruded into an annular escape gap and appears on the rolled workpiece seen in FIGURES 1 and 6 as a flash **30** which is ground away.

The workpiece and its control ring and mandrel are then withdrawn from the machine and the control ring is separated from the workpiece to which the workpiece offers no resistance as its diameter does not increase in the withdrawing direction.

The workpiece, in its intermediate state, is then subjected to a second rolling operation. This is conveniently carried out in apparatus which is the same or similar to that shown in FIGURE 1 and is seen in FIGURE 3. However, no control ring is used, the component being rolled in a "free" state in the sense that diametral spread is not controlled. The workpiece, with its mandrel, is inserted into the machine (FIGURE 3) and the outer face of the workpiece is pressed directly into profiling contact with the periphery of a roller **32**, which is profiled to impose the groove **12** on the workpiece. The finished component is recovered merely by withdrawing it from the machine and removing the mandrel.

By far the majority of the deformation imposed on the workpiece takes place in the first stage, when the workpiece is constrained against overspread in all dimensions, and the diametral increase in the second, lighter, stage, is either inappreciable or at least acceptable in the sense that the component remains within the permitted tolerance, or the small increase is sufficiently consistent to be allowed for.

Another example of the technique of the invention is seen in FIGURES 7 to 9. Here, the component to be manufactured is a ring **34** having a cylindrical bore and an outer face with an inclined surface **36**, flanked by flanges **38, 40** separated from the inclined surface by grooves **42, 44**, one, **42**, being undercut. The component will be recognised as the inner roll of a conical roller bearing.

The blank used is much the same as is seen in FIGURE 5. The initial profiling stage is exactly the same as that described above, the blank being surrounded by a control ring into intimate contact with which it is rolled by diametral spread due to the profiling of the outer surface of the blank. This operation produces the intermediate form shown in FIGURE 8 in which it will be observed that there is no diametral increase in the withdrawing direction, so that there is no difficulty about dislodging the blank from the ring.

"Free" rolling is not competent for this type of component because of the undercut groove **42**. Therefore, the second rolling operation is carried out by other means, which are illustrated in FIGURE 9. In the machine partially shown in that figure, the blank, shaped in the initial rolling operation, is inserted into a chuck **46**, and is introduced into the cavity of an annular backing member **48**. In the annular gap between the chuck and the member there is arranged a spool roller **50**, and a disc roller **52**. The spool roller is mounted on a bracket **54** and is backed by a shoulder **56** on the member **48**. The disc roller is similarly mounted on a bracket **58** and is backed by being engaged within a corner **60** in the member **48**. Relative rotation of the backing and the chuck, accompanied by relative axial movement towards each other to cause diminution in the size of the annular gap between them, causes the spool roller to fold over the end of the workpiece to form the flange **40**, and the disc roller to indent the workpiece to form the undercut groove **42**. It will be noticed from FIGURE 9 that the disc roller **52** is free to tilt on the shank of the bracket **58**, since the bore in the roller **52** is convex and the roller fits loosely on the shank. As the operation proceeds, such tilting takes place progressively during the relative axial approach of the chuck **46** and backing member **48**.

No obstruction is offered to separating movement of the chuck from the backing member, when the chuck is moved away from the member. The disc roller **52** tilts back on the bracket **58** to permit this separating movement.

Another technique according to the invention relates to components having recesses with undercut grooves at the corners. These are made by first profiling the workpiece to an intermediate form.

In FIGURE 10 the workpiece, in the intermediate state, has been profiled preferably by rolling into its inner face an annular recess **62**, the corners **64** of which are flared. This operation is carried out by a machine such as is illustrated in FIGURE 1. However, the workpiece could be intermediately shaped by an operation other than rolling, such as by machining.

The mandrel is readily withdrawable from the recess it has formed in the workpiece. Thereupon, the workpiece is returned to the machine, but with another mandrel, as seen in FIGURE 12. This mandrel is shaped to enter the recess **62** in the workpiece with two flanges

66, 68 bracketing each wall 70 of the recess. As the profiling space diminishes, the formations 72 on the mandrel come into contact with the face 74 of the workpiece. The face 74 is increased in diameter and plastic flow of the material of the workpiece causes the walls 70 to bulge inwardly until they come into contact with the flanges 68 of the mandrel. Flow in the opposite lateral direction is prevented by the presence of the flanges 66.

The effect of this second rolling operation is to produce an undercut groove 76 (FIG. 11) at each corner of the recess. A similar result is produced by profiling the workpiece initially to the shape shown in FIGURE 13, where the walls 70 of the recess 62 are bulged outwardly. By pressing the bulged walls inwardly in the direction of the axis of the workpiece, by rollers 77 (FIGURE 14) that bear on the sides of the workpiece, and constraining the inward flow of the material by walls 79 on a mandrel 81, the undercut corners are produced.

If the shape of the undercut grooves is critical, it may be necessary to subject the workpiece to a final operation; illustrated in FIGURE 15, in which the corners are shaped by oblique disc rollers 78 mounted on brackets 86 on a mandrel 82 and backed up by a collar 84 on the mandrel, which are rotated relatively to the workpiece, and are simultaneously pressed into the corners to finish the component. The disc rollers 78 are tiltable on the brackets 86 to increase the extent of the undercut with closer relatively radial approach of the mandrel 82 towards the workpiece.

I claim:

1. A method of profiling an annular workpiece to form a profile which includes a recess on one of the faces of the workpieces, with an undercut at at least one end corner of the recess, consisting in forming the recess in a first operation, and thereafter forming the undercut in a second operation, the second operation consisting in locating a disc roller obliquely in the recess to bear on the end corner of the recess, juxtaposing a backing member to the recess, the backing member having a shoulder which in the juxtaposed position supports the disc roller,

and moving the backing member relatively to the workpiece to cause the disc roller to roll around the circumference of the recess and impress the undercut into its end corner, the movement of the backing member relatively to the workpiece including movement which causes the disc roller to tilt progressively during such rolling to increase the extent of the undercut.

2. The method of claim 1 in which, in said first operation, the recess is formed with a flared end corner.

3. The method of claim 1 in which the undercut recess is formed on the outer face of the workpiece and in which, in said second operation, the backing member is annular and surrounds the workpiece, rotating the backing member about an axis coincident with that of the workpiece to cause the disc roller to roll around the recess, and moving the backing member axially towards the end corner of the recess during such rotation to cause tilting of the disc roller.

4. The method of claim 1 in which the undercut recess is formed on the inner face of the workpiece and in which, in said second operation, the backing member is a mandrel extending loosely into the workpiece, rotating the mandrel relatively to the workpiece, and moving the mandrel relatively radially towards the recess during such rotation to cause tilting of the disc roller.

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U.S. Cl. X.R.

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