

Jan. 12, 1971

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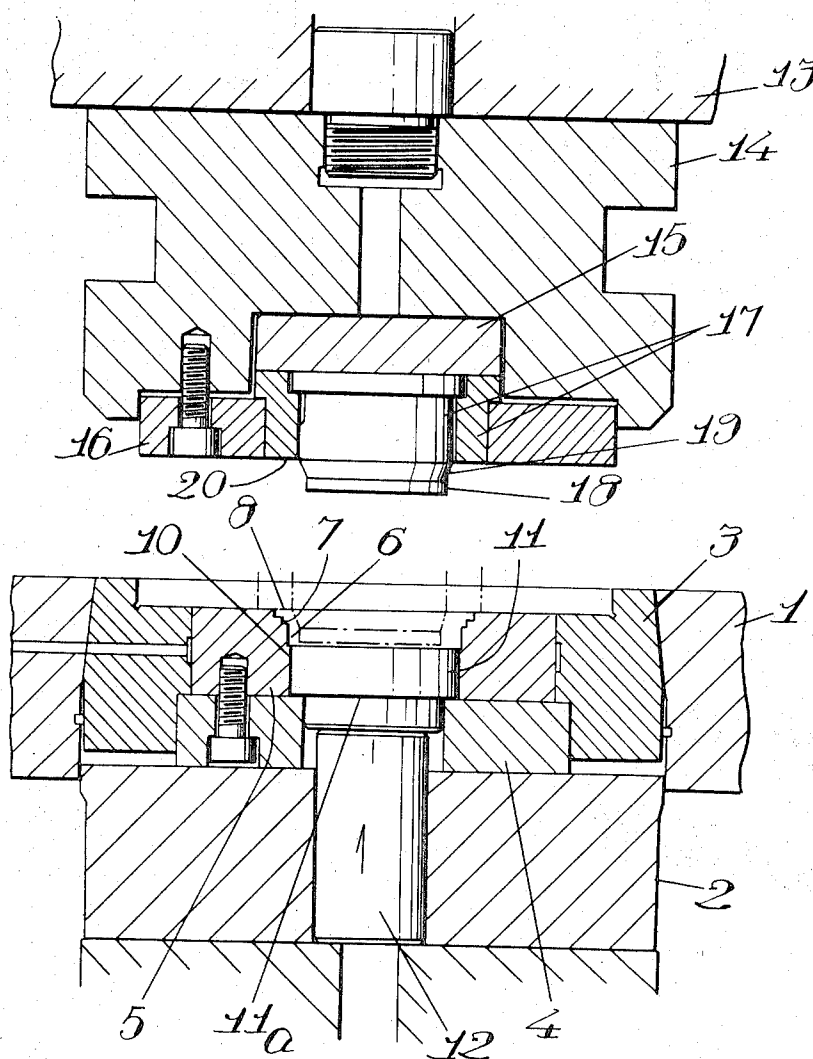
3,553,809

FORGING METHOD FOR PRODUCING A HOLLOW BODY

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4 Sheets-Sheet 1

Fig. 1



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4 Sheets-Sheet 2

Fig. 2

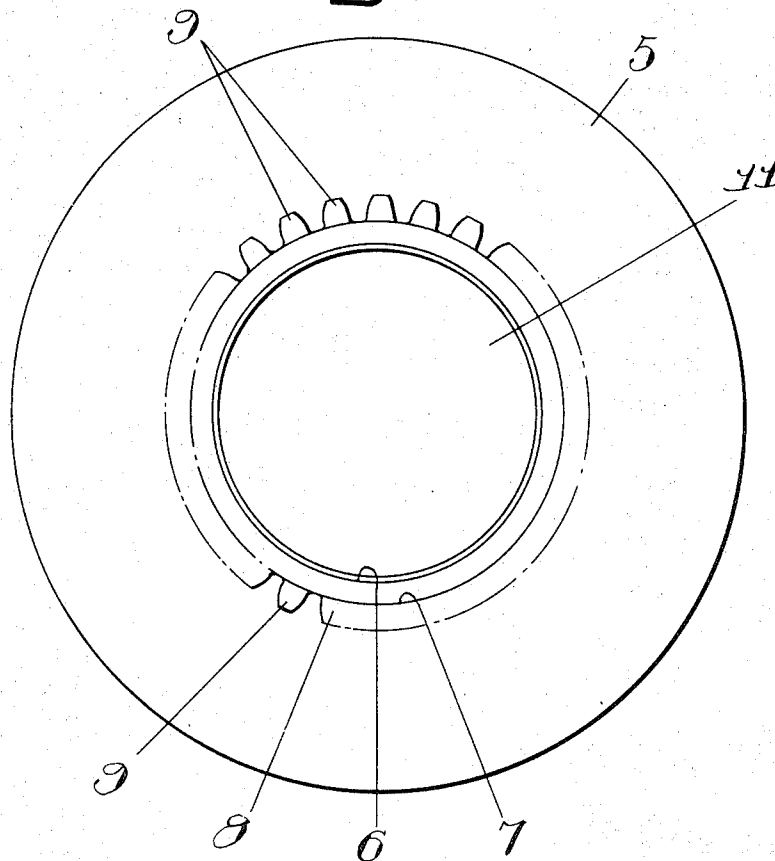
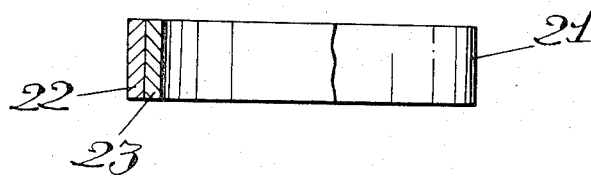


Fig. 3



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3,553,809

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4 Sheets-Sheet 3

Fig. 4

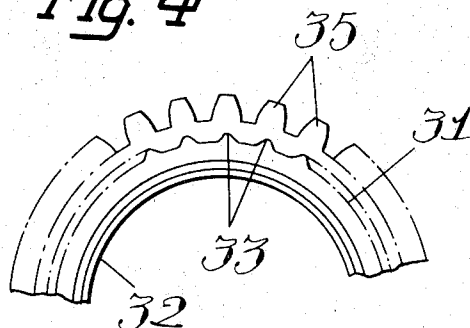


Fig. 5

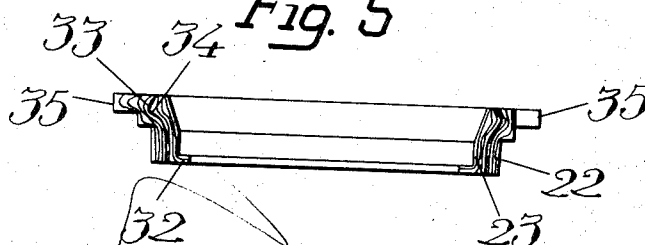
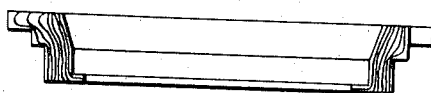


Fig. 6



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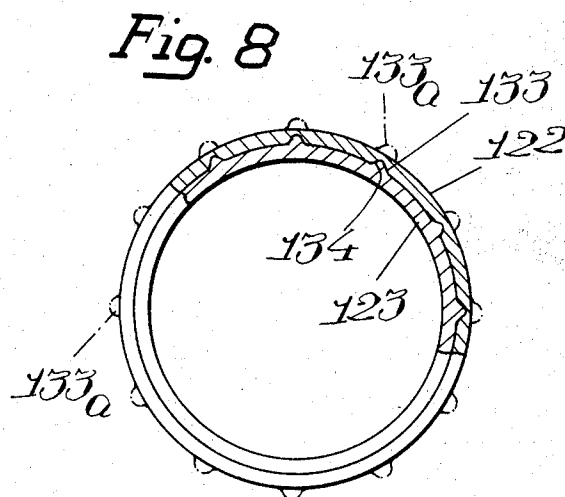
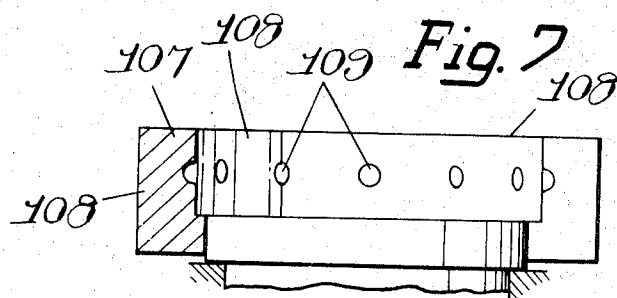
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4 Sheets-Sheet 4



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1

3,553,809

**FORGING METHOD FOR PRODUCING A
HOLLOW BODY**

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42/4,907, 42/6,538

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U.S. Cl. 29—159.2

10 Claims 10

ABSTRACT OF THE DISCLOSURE

A compound annular body is produced by a forging operation. Inner and outer annular bodies are telescopically engaged one within the other, and are placed within an annular die having radially outwardly extending peripherally spaced recesses. The material of the inner annular member has a higher malleability than that of the outer annular member. Axial pressure is applied to the closely fitted annular members in the die to force the material of the outer member into the recesses to form projections, and to force the material of the inner member into recesses in the inner periphery of the outer member, these latter recesses resulting from the radially outwardly deformation of the outer member. The inner and outer members are thus interlocked against both axial and angular relative displacement. The two materials may be metallic materials or the outer member may be a metallic material and the inner member a synthetic resin material. The forging operation may be either a hot forging operation or a cold forging operation.

BACKGROUND OF THE INVENTION

The present invention relates to a forging method producing a hollow or annular body, such as a synchronizer ring, by a forging process. The present invention, further in details, relates to a method producing a hollow or annular body, such as a synchronizer ring, consisting of two components of respectively different materials, which are combined in an exact and close fit and of which the outer and inner components are made from two different materials having respectively different malleability.

A hollow or annular body, of which the outer and inner components are made from different materials, has been commonly produced by such processes as bonding, welding, compressing and shrink fitting procedures, and there have been only a few suggestions to form such an annular body by combining a forging process and taking advantage of the plastic deformation characteristics of the materials.

A certain type of annular body, for example, a synchronizer ring for an automobile transmission, has been produced from a pipe made from metal alloys of an expensive bronze group, by a welding process or a cutting process, due to the necessity for meeting the required high abrasion resistance and mechanical strength and the required appropriate coefficient of friction of such ring. In spite of these requirements, one of the expensive materials to be employed for these inner and outer components can be very often substituted by an inexpensive material without any problem. It has been extremely difficult, however, to prepare inner and outer annular components individually and precisely formed by a preliminary process such as forging, cutting and other processes, which should be selected depending upon the materials to be employed, so that they can be exactly fitted in the succeeding bonding and other manufacturing processes as afore-mentioned. This has also caused an increase in manufacturing proc-

2

esses. Moreover, another problem has been encountered in that the thus obtained annular body has not ample strength in the axial and peripheral directions of the composite or compound body, and especially in that, when, contacting surfaces at which two hollow or annular components are joined together are tapered, it is very difficult to increase the strength in the combined surfaces of the components as high as that of a hollow or annular body made from a single material.

SUMMARY OF THE INVENTION

In accordance with the present invention, an annular forging die is provided with a plurality of peripherally spaced radially outwardly extending depressions which may be in the form of either a tooth-disc or gear wheel or may be in the form of hemispherical depressions, for example. An annular piece, consisting of two components having an exact telescoping interfit with each other, is placed into the die. The outer component is made of metallic materials having a relatively large resistance to deformation as compared to the materials used for forming the inner component, which latter may be, for example, a malleable and deformable plastic or synthetic resin material. By applying axial pressure to the composite annular body, the material of the outer component is partly distorted or extruded into the depressions of the annular die, the axial pressure being provided, for example, by a punch member of a press. Successively, the material of the inner component is distorted or radially extruded to flow into recesses resultantly created around the inner periphery of the outer material by such distortion of the latter, so that materials of the outer and inner components are united in partial abutment in the peripheral direction, whereby a hollow or annular body having improved composite strength can be obtained.

An object of the invention is to provide an improved method for producing a composite annular body.

Another object of the invention is to provide such a method in which the starting member comprises two or more telescoped and closely interfitting annular bodies having a relatively short axial length.

A further object of the invention is to provide such a method in which there are a pair of such annular bodies with the material of the outer annular body being less malleable than the material of the inner annular body.

Another object of the invention is to provide such a method in which the starting piece or body is axially compressed in a forging die member in the form of an annular ring having radially outwardly extending recesses formed in its inner periphery in peripherally spaced relation.

A further object of the invention is to provide such a method in which the starting body, engaged in the annular die ring, has pressure exerted thereon by a punching member movable in axial alignment with the die ring and projectable into the annular body.

Another object of the invention is to provide such a method in which, in response to the axial pressure on the starting body, the material of the outer body is forced radially outwardly into the depressions in the die ring and the material of the inner body is forced radially outwardly into the resulting depressions in the inner surface of the outer body member.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings showing preferred embodiments of the present invention;

FIG. 1 is a longitudinal sectional view of one form of

3

forging apparatus used in the method of the present invention, wherein dotted lines show a punching member when fitted into a die member,

FIG. 2 is a plan view of the die member,

FIG. 3 is a side elevation view, partly in radial section, illustrating a starting body comprising two annular members having a close interfitted telescopic fit with each other and having a short axial length,

FIG. 4 is a partial plan view of another example of a hollow or annular body obtained by the method of the present invention,

FIG. 5 is an explanatory sectional view especially showing flow of materials used in producing the body of FIG. 4,

FIG. 6 is an explanatory sectional view showing flow of a material used in producing a hollow or annular body of which the outer and inner component are made from a single material,

FIG. 7 is an elevation view, partly in radial section, of another embodiment of annular die ring usable with the invention method, and

FIG. 8 is an end elevation view, partly in section, of a composite annular body produced using the die shown in FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. 1 and 2, fixed by supporting members 1 through 4 is a forging die member 5, which has a diametrically reduced part 6, a diametrically medium part 7 and a tooth-like form depression forming part 8, these parts being arranged in a step-like state upwardly from the bottom. On tooth form depression forming part 8, as shown in detail in FIG. 2 are arranged a plurality of depressions 9 arranged in spaced relation in a peripheral row, in which a plurality of peripherally spaced tooth form radial projections are to be formed. The bottom surface of the diametrically reduced part 6 of the forging die member 5 is defined by the upper surface of an ejector 11, which has a peripheral shoulder 11a supported in abutment with a support member 4, and which is pushed upwardly into die member 5, for ejecting a finished annular body, in coaction with a cylindrical stem. 17 is a punching member which is fixedly supported by supporting members 14 through 16 mounted fixedly on a ram 13. Punching member 17 has a diametrically reduced part 18, whose peripheral edge is slightly tapered in the upward direction in substantial correspondence with the reduced part 6 of the die member 5 and whose bottom surface confronts, at a slightly spaced distance, the upper surface of the ejector 11 when member 7 is pushed into die 5, a tapered part 19 corresponding to the diametrically medium part 7 and the tooth form depression forming part 8 of die member 5, and a bottom end surface 20 confronting, at a slight distance and/or in a close contact, the upper surface of die member 5 including the open upper ends of depressions 9.

FIG. 3 shows one example of a compounded hollow or annular piece 21 to be processed, of which inner component 23 is made from soft steel and outer component 22 is made from an alloy of a bronze group, for example, cobalt-bronze. In hollow piece 21, the material of outer component 22, having a higher softening point has far higher deformation resistance in comparison with the material of inner component 23.

The inner diameter of the compounded piece 21 must be larger than the diameter of the under part of the punching member 17, and it must be noted that the difference between these diameters will have a great influence on the flow of materials during heat working.

The compound annular piece 21, during the forging operation, is shortened in an axial direction, and the thicknesses of the outer component 22 and the inner component 23 are correlatively decided depending upon

4

the configurations of the die member 5 and the punching member 17 which is pushed into the interior thereof.

Accordingly, a dimension of the annular piece 21, that is, in detail, an outer diameter, an inner diameter, a longitudinal or axial length and a ratio of the thicknesses of the outer component 22 and the inner component 23 must be decided taking into consideration the difference in deformation resistance between materials of the outer component 22 and the inner component 23 and the configurations of the die member 5 and the punching member 17.

FIGS. 4 and 5 illustrate a synchronizer ring for an automotive transmission formed by the forging operation performed upon the starting body shown in FIG. 3, the forging operation being a hot forging operation using the apparatus shown in FIGS. 1 and 2. When punching member 17 is projected into the interior of starting body 21 positioned in annular die 5, the metallic material of inner component 23 is, by the forging and contacting pressure of the punching member 17, caused to flow downwardly in that portion confined between the outer periphery of part 18 of the punching member 17 and the inner peripheral surface of annular piece 21. The displaced material is forced into the gap formed between the bottom end of part 18 and the upper surface of the ejector 11 to form a flash directed radially inwardly of the annular piece. The upper end of annular piece 21 is impacted, under pressure, by surface 20 of the punching member 17, when the member 17 is pushed into piece 21. Meanwhile, the material of the outer component 22 having relatively high deformation resistance, without following the aforementioned flow of the material of the inner component 23, forced radially outwardly, as at 33, into depressions 9 to form plastic deformed protrusions 35, due to the pressure of punching member 17. The material of inner component 23 is, in turn, caused to flow into the recesses 33, formed on the inner periphery of the outer member opposite each depression 9, as a result of the distortion of the material of the outer member. Thereby, a uniting of the inner and outer components and a compound of these materials in the annular piece 21 are created by close abutment and fusion of particles of these materials. Such conjugation and compounding extend throughout the entire engaging surfaces of the outer component 22 and the inner component 23, and the contact of these materials inside the aforementioned radially distorted protrusions especially serves to increase the compounded strength of the finished body 31 in the axial and peripheral directions thereof.

FIG. 6 shows an explanatory sectional view of an annular body forged, in a forging apparatus as shown in FIGS. 1 and 2, from an annular piece of a single metallic material for the outer and inner component made in a configuration identical to that of the annular body as shown in FIG. 3, wherein the plastic fluidity of the metallic material is completely equal, so that distorted flow of the metallic material is minimized in depressions 9 where the material protruded. It will be apparent that the efficiency of the compounded materials having different flow characteristics is clearly proven by comparison of this figure and FIG. 5.

FIG. 7 illustrates another embodiment of the invention wherein an annular die member 107 is divided into three arcuate sections 108 whose inner surfaces are circular arcs. Die member 107 is not designed to form tooth type projections around the outer periphery of a finished composite annular body, as in the embodiment of the invention shown in FIGS. 1 and 2, but is formed with a plurality of peripherally spaced hemispherical recesses or depressions in its inner annular surface, all being centered on a common diametric plane of member 107 intermediate the axially opposite ends thereof. The punching member used with the die 107 can be a simple type of punch. An annular piece 121 to be processed in this example is a composite hollow piece consisting of an

5

outer component 122, made from aluminium alloy, and an inner component 123, made from poly-carbonate plastics which is subject to plastic deformation by forging pressure.

FIG. 8 shows a sectional view of a compounded hollow body forged in cold working in the forging apparatus as shown in FIG. 7. In this example, the material of the outer component 122 is compressed to be distorted and flowed into depressions 109, as indicated at 133 by pressure applied to the upper end of the piece to be processed by the punching member, and the material of the inner component 123 is forced into recesses 134 formed inside of depressions 109, whereby the materials of the outer component and the inner component are sealed in close meshing interfitting with one another. Verruci-form projections 133a, formed around the outside of part 133, can be cut off in practical use of the product, depending upon application thereof.

What is claimed is:

1. A forging method for producing a compound annular body, comprising the steps of providing an annular forging die having peripherally spaced, radially outwardly extending recesses in its inner periphery; forming a composite starting body by inserting an axially short inner annular member into an axially short outer annular member with a close telescopic fit, the two members being substantially equal in length and the material of the outer member having a higher resistance to deformation than that of the inner member; positioning the starting body in the forging die; and advancing a forging punch into pressure exerting engagement within the inner annular member while exerting forging pressure axially against the outer end of the starting body to axially compress the starting body while deforming material of the outer member into the die recesses with subsequent plastic flow of the material of the inner member into resulting peripherally spaced recesses in the inner surface of the outer member each substantially aligned with a die recess; whereby the inner and outer members are interlocked against relative angular and axial displacement.

2. A forging method for producing a compound annular body, as claimed in claim 1, including the step of subsequently removing the resulting radially outwardly extending projections from the outer periphery of the outer member.

3. A forging method for producing a compound annular body, as claimed in claim 1, in which both the inner annular member and the outer annular member are metallic annular members.

6

4. A forging method for producing a compound annular body, as claimed in claim 1, in which the material of the outer annular body is metallic and the material of the inner annular body is a plastic composition.

5. A forging method for producing a compound annular body, as claimed in claim 1, in which the radially outwardly extending recesses in the inner periphery of said die produce gear-tooth-like projections from the outer periphery of the outer annular member.

6. A forging method for producing a compound annular body, as claimed in claim 5, in which the die recesses open through the outer axial end surface of the die.

7. A forging method for producing a compound annular body, as claimed in claim 1, in which the die recesses are substantially hemispherical recesses.

8. A forging method for producing a compound annular body, as claimed in claim 7, including the step of providing an annular forging die comprising plural arcuate separable sections conjointly defining the annular forging die; the die recesses being intermediate the axially opposite ends of the die.

9. A forging method for producing a compound annular body, as claimed in claim 6, including the step of providing a starting body seating member within the annular die; and limiting the advance of the forging punch to a position in which its inner end is spaced slightly from the seating member; whereby, under the forging pressure, there is a plastic flow of the material of the inner member radially inwardly into the space between the end of the forging punch and the surface of the seating member.

10. A forging method for producing a compound annular body, in which the forging operation is a hot forging operation.

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U.S. Cl. X.R.

29—523; 74—457

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