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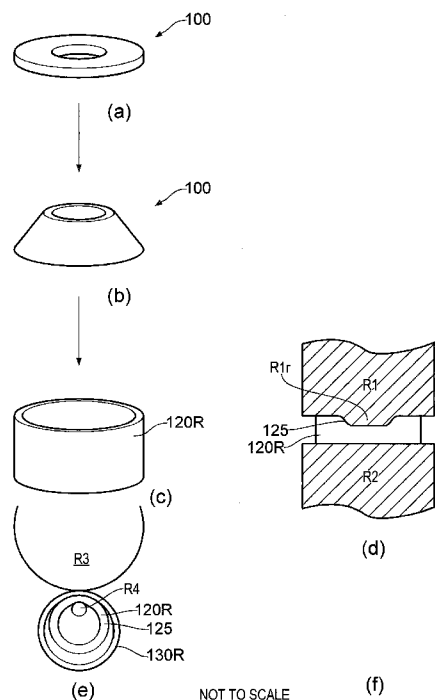
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(54) Title: ARTICLE, METHOD OF FORMING AN ARTICLE AND APPARATUS FOR FORMING AN ARTICLE



(57) Abstract: A method of forming an article such as a jewellery ring or bangle comprising: providing a first substantially annular-sectioned element and a second substantially annular-sectioned element, an outer diameter of the first element being less than an inner diameter of the second element; forming a circumferential groove in one of the first and second elements by a process of rolling; positioning the first and second elements together with the second element positioned circumferentially around the first element; and expanding the first element such that the circumferential groove in the one element receives therein the other of the said elements.

ARTICLE, METHOD OF FORMING AN ARTICLE AND APPARATUS FOR FORMING AN ARTICLE

TECHNICAL FIELD

The present invention relates to articles of jewellery and to a method of formation thereof. In particular but not exclusively the invention relates to articles of jewellery comprising two or more precious metals, further particularly but not exclusively two or more rings or bands of precious metal joined to form a single ring or band.

BACKGROUND

It is known to form a ring or the like from two or more precious metals each in the form of a circular ring element or band to be worn around a finger. The two ring elements may be stacked on top of one another in a side by side arrangement along a common axis, and joined together by soldering or brazing. Alternatively the ring elements may be joined such that one ring element (an outer ring element) surrounds the other ring element (an inner or basal ring element), i.e. one is positioned radially outward of the other.

In the latter case, the ring is typically fabricated by forming a groove in a radially outer surface of the basal ring element by machining on a lathe. The outer ring element is machined to the required axial length and diameter, and is then placed around the basal ring element. The basal ring element is then expanded by stretching to increase its diameter to the final required finger size. The basal ring element is expanded sufficiently to trap the outer ring element in the groove formed in the basal ring element, but care must be taken not to cause fracture of the ring element by expanding by too great an amount.

Bands of larger diameter to be worn around a wrist, such as bangles, comprising two different precious metals may be made in a similar manner to the rings described above.

It is an aim of the present invention to address disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

Embodiments of the invention may be understood with reference to the appended claims.

Aspects of the present invention provide an article and a method.

In one aspect of the invention for which protection is sought there is provided a method of forming an article comprising:

- providing a first substantially annular-sectioned element and a second substantially annular-sectioned element, an outer diameter of the first element being less than an inner diameter of the second element;

- forming a circumferential groove in one of the first and second elements by a process of rolling;

- positioning the first and second elements together with the second element positioned circumferentially around the first element; and

- expanding the first element such that the circumferential groove in the one element receives therein the other of the said elements.

By annular-sectioned is meant that the element has a transverse cross-section substantially in the form of an annulus. By transverse is meant substantially perpendicular to a longitudinal axis of the article, which may for example be a longitudinal axis of symmetry, for example in the case of an element in the form of a tube or toroid. One or more of the annular-sectioned elements may be toroidal in shape. A longitudinal cross-section through a portion of an element may therefore be substantially circular. By longitudinal cross-section is meant a cross-section as viewed substantially perpendicular to the longitudinal axis. Alternatively a longitudinal cross-section of a portion of one or more elements may be substantially lenticular, substantially truncated lenticular, substantially elliptical, substantially truncated elliptical, substantially square, substantially rectangular or any other suitable shape. An inner or outer radial surface of the article may be arranged to be court. That is, an inner or outer radial surface of the article may be arranged to be curved in an axial direction, for example about a generally circular axis in a transverse plane. In the case of an article in the form of a ring for wearing on a finger, forming an inner radial surface of the ring to be court has the advantage of improving an ease with which the article may be slid onto the finger in some embodiments.

The substantially annular-sectioned element may comprise a frustrated cone. Optionally, the substantially annular-sectioned element is in the form of a substantially frusto-conical element.

By rolling is meant that pressure is applied to a surface of the element by a roller, the pressure being applied by relative rolling motion between the element and the roller. The pressure may be applied in a direction generally substantially perpendicular to the longitudinal axis and/or normal to the surface of the element. In some embodiments the element itself may be rotated; in some alternative embodiments the roller may be rotated.

It is to be understood that forming the groove in one of the annular-sectioned elements by rolling has the advantage that loss of material due to cutting does not occur. Furthermore, the cost of providing a cutting tool and replacing worn cutting tools may be eliminated by use of a rolling operation.

Furthermore, in some embodiments a depth of the groove may be controlled by rolling to within a greater tolerance than other methods of forming a groove, such as by cutting, for example using a lathe. In some embodiments, a groove of more shallow and more precise depth may be formed in one of the annular-sectioned elements, allowing the other annular-sectioned element to be of reduced thickness relative to known structures. In some embodiments, the annular-sectioned element to be received in the groove of the other element may be formed by rolling of an annular-sectioned element between rollers. The rollers may be disposed to grip radially inner and outer surfaces at a given circumferential location. The element may be rolled to form an annular-sectioned element of relatively low thickness. This feature has the advantage that substantially annular-sectioned elements may be formed having a thickness that is lower than that of substantially annular-sectioned elements formed using alternative techniques for thinning an annular-sectioned element such as cutting of a tube, for example by turning on a lathe, as in known structures.

In known methods of fabricating double ring structures, the groove is cut in a first ring element to be deeper than is required in methods according to the present invention, and a second ring element of greater thickness employed due to limitations in the minimum thickness of ring element that may be produced by cutting. A mismatch in outer diameters of the first and second ring elements following expansion of the inner ring element to trap the outer ring element inevitably results, requiring a post finishing operation in which trimming of the outer surface of the ring article takes place to substantially eliminate a step in outer diameter of the article due to the difference in outer diameters of the elements. This further finishing operation results in increased cost of manufacture and wastage of material due to trimming. Furthermore, since a radial thickness of the second ring element is relative large this can result in increased cost of manufacture.

Some embodiments of the present invention have the advantage that double ring structures having one or more substantially annular-sectioned elements inset in another substantially annular-sectioned element may be produced with the inset element or elements being of lower thickness than in known structures; this enables a reduction in the amount of material required to form the one or more inset elements. Furthermore, a requirement for post-finishing cutting of the annular-sectioned elements may be reduced or substantially eliminated in some embodiments.

Some embodiments of the present invention permit an article comprising at least two substantially annular-sectioned elements to be formed with one substantially annular-sectioned element inset in the other without any requirement for cutting of the substantially annular-sectioned elements such as turning on a lathe or the like. In some embodiments, substantially the only cutting operation involved in fabricating the article may be cutting of substantially flat discs from a sheet of material and forming an aperture in the discs, to form washer-shaped elements which are subsequently coned to form tube or tube-like elements of substantially annular-section. It is to be understood that, subsequently, cutting of decorative markings may be made in the article if required. However, cutting is not necessarily required in order to provide an article according to an embodiment of the invention for the reasons stated above.

It is to be understood that the annular-sectioned article may be a jewellery item such as a band or ring, or bangle or the like.

The groove may be formed to any required depth. In some embodiments the groove is formed to a depth of from around 0.1mm to around 0.5mm. Smaller depths may be useful in some embodiments, such as 0.05mm. Similarly, in some embodiments greater depths may be useful such as 0.7mm, 1.0mm or any other required depth. In some embodiments, in order to form a jewellery ring article to be worn around a finger, an inner diameter of the first element may be around 9mm and an outer diameter may be around 16mm or less. An axial length of the element may be around 6mm, optionally around 7mm, 8mm or any desired length.

It is to be understood that the inner diameter of the first element may be arranged to be smaller than a smallest required inner diameter of the finished article. Accordingly, the first element may be expanded to the required diameter. Since forming a groove in an annular-

sectioned element such as the first element by rolling may result in expansion of the diameter of the annular-sectioned element, in some embodiments the first annular-sectioned element may be arranged to have the required inner diameter following rolling to form the groove. Alternatively, in some embodiments the diameter of the first annular-sectioned element may be expanded by rolling in which a groove is not formed, for example by rolling between substantially flat roller elements not having a raised portion to form a groove. Subsequently, a rolling operation may be performed to form a groove in the first annular-sectioned element such that a final inner diameter of the first element following rolling to form the groove is substantially equal to the required inner diameter of the final article.

In some embodiments, forming a groove having a depth of substantially 0.5mm in an annular-sectioned element having an inner diameter of 9mm results in expansion of the inner diameter to substantially 10mm.

In some embodiments, in order to form a jewellery bangle article to be worn around a wrist, an inner diameter of the first element may be around 16mm and an outer diameter may be around 22mm or less. An axial length of the element may be around 6mm, optionally around 7mm, 8mm or any desired length.

The method may comprise forming the circumferential groove in a radially outer surface of the first substantially annular-sectioned element.

Alternatively, the method may comprise forming the circumferential groove in a radially inner surface of the second annular-sectioned element.

In some embodiments a circumferential groove may be formed in an inner radial surface and an outer radial surface of the first substantially annular-sectioned element. The second element may be received in the groove formed in the outer radial surface when the first element is expanded. A third substantially annular-sectioned element may be received in the groove formed in the inner radial surface of the first element when a diameter of the third element is expanded.

In some alternative embodiments a circumferential groove may be formed in an inner radial surface and an outer radial surface of the second substantially annular-sectioned element. The first element may be received in the groove formed in the inner radial surface when the

first element is expanded. A third substantially annular-sectioned element may be received in the groove formed in the outer radial surface of the second element when a diameter of the second element, optionally together with the first element, is expanded.

It is to be understood that in some embodiments one annular-sectioned element may be said to become trapped in the groove formed in the other annular-sectioned element when the circumferential groove in the one element receives therein the other of the said elements. By the term trap is meant that the annular-sectioned element is prevented from moving beyond a sidewall of the groove by interference between the first and second annular-sectioned elements.

In the case that the groove is formed at a location spaced apart from opposite edges of one of the substantially annular-sectioned elements, referred to herein as a double sided groove, separation of the first and second substantially annular-sectioned elements by axial translation relative to one another may be substantially prevented by interference. In the case that the groove is formed at one axial end of the element, having one side that is open, the groove may be referred to as a single sided groove. A stepped edge to the element may thereby be provided. Movement of the substantially annular-sectioned elements relative to one another may be substantially prevented in one axial direction by interference between the annular-sectioned element received in the groove and the sidewall of the groove.

However, in such embodiments movement of the second element in the opposite direction, away from the first element, may be permitted in some embodiments unless the second element is expanded sufficiently to prevent separation of the first and second elements by a friction fit or other means. It is to be understood that the first or second elements may be provided with formations such as ridges, bumps or the like in or over a surface in contact with the other element, to provide increased grip between the respective elements to resist separation. Other arrangements for resisting separation may be useful in some embodiments such as diffusion bonding, a mechanical fixing element such as a screw element, an intermediate joining medium such as a solder or brazing material, or any other suitable arrangement.

Optionally, forming the circumferential groove in an element by rolling comprises constraining axial expansion of the element in a longitudinal direction during rolling.

It is to be understood that plastic deformation of the annular-sectioned element typically occurs during rolling of the annular-sectioned element to form the groove. By constraining axial expansion parallel to the longitudinal axis of the annular-sectioned element, an outer diameter of the annular-sectioned element may tend to increase in some embodiments as a depth of the groove formed in the annular-sectioned element increases due to plastic deformation of the element and flow of material from under a roller means or the like used to form the groove. This feature has the advantage that in some embodiments a starting thickness of the annular element may be reduced for a given required groove depth relative to embodiments in which lateral expansion is not constrained during rolling. This in turn allows a reduction in the amount of material required in order to form an article comprising first and second annular-sectioned elements in which one annular-sectioned element is provided in a groove formed in a circumferential surface of the other.

It is to be understood that by axial expansion is meant expansion in a direction parallel to the longitudinal axis of the substantially annular-sectioned element. It is to be understood that a dimension of the annular element in a direction parallel to the longitudinal axis may be referred to herein as a length of the annular element. In the case that the annular-sectioned element is in the form of a tube, the longitudinal axis may be referred to as a cylinder axis.

The method may comprise constraining lateral expansion of the annular-sectioned element during rolling by trapping between clamp members at least a portion of the annular-sectioned element during rolling.

The method may comprise trapping between clamp members the substantially annular-sectioned element across substantially the whole of each axially opposed side of the element.

This feature has the advantage that axial expansion is prevented across substantially the entire radial thickness of the element.

The method may comprise forming the circumferential groove in one substantially annular-sectioned element to have an axial length that is sufficiently large to trap the other substantially annular-sectioned element in the groove when the first element is expanded in diameter.

The method may comprise expanding the first substantially annular-sectioned element by stretching.

The method may comprise expanding the first substantially annular-sectioned element by rolling.

The method may comprise joining the first and second substantially annular-sectioned elements by fusing.

The method may comprise joining the first and second elements by fusing substantially in the absence of an intermediate joining medium.

By joining medium is meant a material arranged to bond to the first and second elements to substantially permanently bond the first and second elements together such as a solder, a brazing material or the like.

It is to be understood that, when two materials are fused together, diffusion of material from at least one material to the other typically takes place, forming a bond between the materials.

The performing of a fusing operation has particular advantages when a substantially annular-sectioned element of relatively low radial thickness is received into the circumferential groove formed in the other element. By fusing the elements, joining of the elements typically takes place over substantially the whole of the areas of the elements that face one another. Accordingly, if further fabrication steps are applied such as cutting the element received in the groove to pattern the element, islands or similar otherwise fragile regions of the element formed as a result of cutting typically remain adhered to the element in which the groove is formed. In the case of joining methods other than fusing such as soldering or brazing, gaps between areas in contact with intermediate joining material such as solder may exist, resulting in decohering of the islands or regions that are otherwise fragile.

Optionally, the first and second substantially annular-sectioned elements are of a diameter in the range from substantially 5mm to substantially 300mm.

Further optionally the article is arranged to be worn around one selected from amongst a finger and a wrist.

The method may comprise forming the first substantially annular-sectioned element from a first material and the second substantially annular-sectioned element from a second material.

Optionally the first and second materials are the same material.

Alternatively the first and second materials may be different respective materials.

The first and second materials may each comprise a precious metal.

The first and second materials may comprise gold, silver, platinum or palladium.

Optionally the step of positioning the second substantially annular-sectioned element around the first element comprises positioning a plurality of substantially annular-sectioned elements around the first element.

Optionally, forming a circumferential groove in one of the first and second elements comprises forming a plurality of circumferential grooves in the element.

The method may comprise providing an annular element in each of the plurality of grooves in said one of the elements.

The method may comprise forming one or more of the annular-sectioned elements by cutting from a tube.

Alternatively or in addition the method may comprise forming one or more of the annular elements by pressing a blank from a sheet, the blank being formed in the shape of an annulus, subsequently forming a tube element from the blank.

Optionally, forming the tube element from the blank comprises forming the tube element by coning.

In a further aspect of the invention for which protection is sought there is provided an article formed by a method according to another aspect.

The article may comprise a jewellery ring suitable for being worn on a finger.

The article may comprise a jewellery bangle suitable for being worn around a wrist.

In an aspect of the invention for which protection is sought there is provided a method of forming an article comprising

- providing a first annular element comprising a substantially flat disc having an aperture formed therein;
- forming a groove in a surface of the annular element;
- placing a second element in the groove formed in the first element; and
- coning the first element to form a tube element comprising the first and second elements.

The method may comprise subjecting the tube element to a drawing operation.

Optionally, the groove may be provided in the form of an endless loop around an axis of rotation the first annular element.

The may comprise forming the second element to be of a shape corresponding substantially to the groove, the second element being arranged to fit at least partially within the groove.

Optionally, the second element is in the form of a substantially endless loop.

Optionally, the first and second annular elements are substantially circular.

In one aspect of the invention for which protection is sought there is provided a method of forming a substantially annular article comprising:

- providing a first annular element;
- forming a circumferential groove in the first annular element by means of a roller in a rolling process;
- providing a second annular element having an inner diameter that is greater than an outer diameter of the first element;
- positioning the second annular element around the first annular element; and

expanding the first annular element with the second annular element positioned therearound until a diameter of the first annular element has increased sufficiently to trap the second annular element in the circumferential groove of the first element.

In a further aspect of the invention for which protection is sought there is provided apparatus for forming a groove in an annular element comprising:

element support means for supporting a substantially annular-sectioned element;

roller means supported by roller support means, the roller means being rotatable relative to the roller support means about a roller axis;

means for applying pressure between the roller means and an annular-sectioned element supported by the support means; and

means operable to allow relative movement between the annular-sectioned element and the roller support means such that the roller means is caused to roll around the annular-sectioned element in contact therewith to form a groove in the annular-sectioned element.

It is to be understood that in some embodiments the roller support means may remain substantially stationary whilst the element support means permits the annular-sectioned element to rotate relative to the roller support means whilst the groove is being formed. In some alternative embodiments the element support means may hold the annular element substantially stationary whilst the roller support means is caused to rotate about the annular element, whilst the groove is being formed. In some embodiments the element support means may be configured to cause rotation of the annular element and in addition the roller support means may be configured to rotate about the annular element to form a groove in the annular element.

The apparatus may further comprise means for constraining axial expansion of the annular-sectioned element in a direction parallel to a longitudinal axis thereof whilst the roller means is rolling therearound to form the groove.

It is to be understood that plastic deformation of the annular-sectioned element typically occurs during rolling of the element to form the groove. By constraining axial expansion of the annular-sectioned element, an outer diameter of the annular-sectioned element will tend to increase in some embodiments as a depth of the groove formed in the element increases. This feature has the advantage that a starting thickness of the element may be reduced for a given required groove depth relative to embodiments in which axial expansion is not constrained during rolling. This in turn allows a reduction in the amount of material required

in order to form an article. In some embodiments, post-rolling finishing of the annular-sectioned element to trim unsightly deformation of opposite axial edges of the annular-sectioned element due to axial expansion during rolling may be rendered unnecessary due to the fact that axial expansion has been constrained.

By constraining is meant that axial expansion is substantially prevented or at least reduced relative to rolling in which axial expansion is substantially unconstrained.

Optionally the means for constraining lateral expansion comprises clamping means having first and second clamp portions arranged to be positioned on opposite sides of the annular-sectioned element.

It is to be understood that one or both of the clamp portions may be provided by a portion of a component of the apparatus such as a portion of a base, a housing or other portion of the apparatus. Alternatively, separate clamp portions in the form of clamp elements may be provided.

It is to be understood that the annular-sectioned element may be provided in the form of a tube element having a tube length. The annular-sectioned element may comprise a ring element. The ring element may comprise a relatively short tube element. By relatively short is meant that an axial length of the tube element in a direction parallel to a cylinder axis thereof may be less than a radius of the tube element, optionally less than or substantially equal to substantially 50% of a radius of the tube element, optionally less than or substantially equal to substantially 40% of a radius of the tube element, further optionally less than or substantially equal to substantially 30% of a radius of the tube element, still further optionally less than or substantially equal to substantially 20% of a radius of the tube element. The length of the tube element may be greater than or equal to substantially 5% of the radius of the tube element.

Further optionally, the means for supporting the annular-sectioned element comprises a shaft member around which the annular-sectioned element may be positioned.

It is to be understood that the first and second clamp portions may be arranged to be coupled to the shaft member, optionally with the shaft member passing therethrough.

The apparatus may comprise roller support means for supporting the roller means for rotation about the roller axis.

The apparatus may be configured to cause the roller support means to describe a substantially circular path about the annular-sectioned element, in use.

Optionally, the element support means is configured to support the annular-sectioned element in a substantially fixed position, in use.

The apparatus may comprise means for rotating the annular-sectioned element relative to the roller support means.

Optionally, the element support means is configured to cause rotation of the annular-sectioned element relative to the roller support means.

The apparatus may be operable to cause translation of the roller support means towards and away from the element support means whereby pressure may be applied between the roller means and an annular-sectioned element supported by the element support means.

The apparatus may comprise at least one powered actuator, the apparatus being configured automatically to cause relative movement between the substantially annular-sectioned element and the roller support means by means of the powered actuator such that the roller means is caused to roll around the substantially annular-sectioned element in contact therewith to form the groove in the element.

In an aspect of the invention for which protection is sought there is provided a method of forming a groove in a substantially annular-sectioned element comprising:

- supporting the annular element by means of element support means;

- applying pressure between roller means supported by roller support means and the annular element; and

- causing relative movement between the annular element and the roller support means such that the roller means is caused to roll around the annular element in contact therewith to form a groove in the annular element, the roller means being caused to rotate relative to the roller support means about a roller axis.

In one aspect of the invention for which protection is sought there is provided a method of forming an article comprising:

- providing a first substantially cylindrical element;
- forming a circumferential groove in a radially outer surface of the first cylindrical element by a process of rolling;
- providing a second substantially cylindrical element having an inner diameter that is greater than an outer diameter of the first element;
- positioning the second annular element around the first annular element; and
- expanding a diameter of the first annular element with the second annular element positioned therearound.

The article may be substantially ring-shaped.

In one aspect of the invention for which protection is sought there is provided a method of forming a substantially annular article comprising:

- providing a first annular element;
- forming a circumferential groove in the first annular element by rolling;
- providing a second annular element having an inner diameter that is greater than an outer diameter of the first element;
- positioning the second annular element around the first annular element; and
- expanding the first annular element with the second annular element positioned therearound until a diameter of the first annular element has increased sufficiently to trap the second annular element in the circumferential groove of the first annular element.

In one aspect of the invention for which protection is sought there is provided a method of forming a substantially annular article comprising:

- providing a first annular element;
- providing a second annular element having an inner diameter that is greater than an outer diameter of the first element;
- positioning the second annular element around the first annular element; and
- rolling the first annular element with the second annular element positioned therearound until a diameter of the first annular element has increased sufficiently to trap the second annular element in the circumferential groove of the first element.

The use of rolling to increase the diameter of the first annular element and trap the second has the advantage that an article such as a double ring may be formed more quickly and/or

with less damage compared with alternative methods of forming an article such as by stretching without rolling or by crimping.

Furthermore, a more uniform expansion of the first annular element may be enabled by the rolling process compared with other expansion methods. In addition, in some embodiments rolling of the first annular element causes rolling of the second annular element also, with a corresponding reduction in thickness of the second annular element. This can enable double rings to be produced in which the second annular element is thinner than in known double rings. This can reduce the amount of precious metal required to form the second annular element, and therefore reduce the cost of the double ring, in some embodiments.

Some embodiments of the present invention have the advantage that a second annular element of reduced thickness (in a radial direction) may be employed. This is because the groove may be formed to a more precise depth and in some embodiments a more shallow depth by rolling compared to cutting. Thus, the first annular member may be formed to be thinner than prior art members because it is not required to support as deep a groove. The second annular element may be formed to have a thickness lower than that of known articles since the groove may be made to a more precise depth, eliminating the requirement to finish the article by trimming a thickness of the second element (typically by turning and cutting in a lathe) so that it does not stand proud of the first element, following expansion of the first element.

The ability to employ a second annular element (and/or a first annular element) of reduced thickness has the advantage that the amount of precious metal required to be used to form the article may be reduced, reducing in turn a cost of materials required to form each article.

The annular element may be an element having a substantially annular section. The annular element may be in the form a ring such as a short section of tube. The annular element may be formed by coning a substantially flat disc with an aperture formed therein, the disc being in the shape of an annulus.

Advantageously the method comprises forming a circumferential groove in a radially outer surface of the first element prior to positioning the second element around the first element.

Further advantageously the method comprises forming the circumferential groove by rolling.

This feature has the advantage that loss of material due to turning and cutting the first annular element may be avoided. This reduces wastage of valuable material, which is typically recycled. By avoiding cutting, the step of recycling may be avoided. Use of cutting equipment may also be avoided.

The method may comprise forming the circumferential groove to have a length parallel to a cylinder axis of the first element that is sufficiently large to trap the second annular element in the groove when the first annular element is subsequently rolled.

It is to be understood that in some embodiments when the first element is expanded by rolling to trap the second element, the groove shrinks in length parallel to the longitudinal axis of the element to trap the second element. The second element may be arranged to be trapped by an interference fit within the groove. Other arrangements are also useful.

The annular article may be arranged to be worn around one selected from amongst a finger or wrist.

Optionally, the first annular element is of an inside diameter in the range from substantially 10mm to substantially 25mm, optionally in the range from around 14mm to around 22mm. This size range is found to be suitable for manufacturing rings to be worn on fingers.

Thus, the annular elements may be ring elements for forming a ring to be worn on a digit of a person, such as a finger or thumb. Such rings typically have an inside diameter in the size range from 13.370mm (inside circumference 42mm) to 23.877mm (inside circumference 75mm). Other sizes are also useful.

Alternatively the first annular element may have an inside diameter in the range from around 70 to 75mm. This size range is found to be suitable for manufacturing bangles to be worn around a wrist.

The bangles may have an inside diameter in the range from 54mm (inside diameter 169.7mm) to 75mm (inside diameter 235.7mm).

The method may comprise forming the first annular element from a first material and the second annular element from a second material.

The first and second materials may be substantially the same material.

The first and second materials may be different respective materials.

For example, the first and second materials may comprise different elements, or comprise alloys of different respective compositions.

The first and second materials may comprise a precious metal.

For example, the first and second materials may comprise gold, silver or platinum.

Other materials and other non-precious metals and combinations thereof may also be useful.

The precious metal may be a coloured gold such as a white gold, a yellow gold or a red gold. Other types of gold may also be useful. It is to be understood that coloured gold may be formed by alloying gold with silver and/or copper in various proportions to produce white, yellow, green and/or red golds. In some embodiments intermetallic compounds, producing blue and purple golds, as well as other colours, may be employed. The production of coloured golds is well understood by persons skilled in the art.

It is to be understood that the first and second annular elements may be formed from respective different precious metals. For example the first element may be formed from yellow gold and the second element may be formed from white gold or red gold. Other arrangements are also useful.

The step of positioning a second annular element around the first annular element may comprise positioning a plurality of annular elements around the first annular element.

Optionally the step of forming a circumferential groove comprises forming a plurality of circumferential grooves in the first element.

Optionally the method may comprise providing an annular element in each of the plurality of grooves in the first element.

The method may comprise forming one or more of the annular elements by cutting from a tube.

The method may comprise forming one or more of the annular elements by pressing a blank from a sheet, the blank being formed in the shape of an annulus, subsequently forming a tube element from the blank.

Optionally, forming the tube element from the blank comprises forming the tube element by coning.

Thus, optionally, the blank may be subject to one or more coning operations whereby the blank is 'coned' to form a slug in the form of a relatively short length of tube. The coning operation involves forcing the blank through a die in order to deform the blank into a cone shape (a frusto-conical shape). The slug may then be subjected to one or more drawing operations in a die until the slug is of a substantially uniform wall thickness and substantially constant diameter along a length thereof.

Thus, the one or more drawing operations will typically ensure that sides of the slug are substantially parallel and of substantially constant thickness along a length of the slug.

It is to be understood that the coning operation effectively twists the sheet of material from which the blank is formed by substantially 90 degrees, to form a relatively short length of tube.

Forming the slug in this manner has the advantage that a jewellery maker is not required to keep substantial lengths of tube of precious metal in stock, with tubes of different size for different article diameters.

In a further aspect of the invention for which protection is sought there is provided an article formed by a method according to any preceding aspect.

In a still further aspect of the invention for which protection is sought there is provided a method of forming an article comprising:

- providing a first annular element substantially in the shape of a substantially flat washer or annulus;
- forming a groove in a surface of the annular element;
- placing a second element in the groove formed in the first element; and

coning the first element to form a substantially cylindrical slug comprising the first and second elements.

The substantially cylindrical slug may be in the form of a right cylinder having a substantially constant inner diameter. Alternatively the slug may be frusto-conical in shape, having an inner diameter that decreases in a direction parallel to a longitudinal axis thereof.

The method may comprise subjecting the slug to a drawing operation.

Optionally, the groove is provided in the form of an endless loop around an axis of the first annular element.

The method may comprise forming the second element to be of a shape corresponding substantially to the groove, the second element being arranged to fit at least partially within the groove.

The method may comprise joining the first and second elements, for example by means of soldering or brazing, to retain the second element within the groove. In some embodiments the first and second elements may be joined by fusing. That is, the elements may be joined without the use of an intermediate joining medium or material such as a solder. The fusing process may involve heating of the first and second joining elements to a temperature at which interdiffusion of material from one element to the other, optionally from each element to the other, may occur.

The second element may therefore be combined with the first element on a substantially flat surface of the blank pre-coning. Some embodiments of the invention have the advantage that a rolling operation to increase a diameter of the first element may be eliminated since the coning operation (and optionally the drawing operation in addition) may be sufficient to cause the first and second elements to be of a snug fit together.

Optionally, the second element is in the form of a substantially endless loop.

Alternatively the second element may be discontinuous. The second element may be formed by joining ends of a length of material to form a substantially continuous, endless element.

The second element may be oriented radially rather than circumferentially in some embodiments. For example the second element may be provided with a longitudinal axis thereof substantially parallel to a radial direction, for example in the manner of a spoke of a wheel.

A plurality of second elements may be provided.

The first and second annular elements may be substantially circular.

As noted above, in an alternative embodiment the second annular elements may be non-circular. The second annular elements may be substantially linear. Other arrangements are also useful.

The first and second elements may be formed from a similar or different metal. The second element may be formed to have a corrugated profile. Other arrangements are also useful.

In a further aspect of the invention for which protection is sought there is provided an article formed by a method according to a preceding aspect.

The article may be an article of jewellery, optionally a finger ring, a wrist band, a bracelet or a bangle or like article.

Within the scope of this application it is envisaged that the various aspects, embodiments, examples and alternatives, and in particular the individual features thereof, set out in the preceding paragraphs, in the claims and/or in the following description and drawings, may be taken independently or in any combination. For example features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

For the avoidance of doubt, it is to be understood that features described with respect to one aspect of the invention may be included within any other aspect of the invention, alone or in appropriate combination with one or more other features.

Within the scope of this application it is expressly envisaged that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features

thereof, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying figures in which:

FIGURE 1 illustrates a process of forming a double ring according to an embodiment of the present invention;

FIGURE 2 illustrates a structure of a double ring according to an embodiment of the present invention (a) before and (b) after rolling of inner and outer ring elements to form a single double ring;

FIGURE 3 shows first and second ring elements according to an embodiment of the present invention in (a) plan view, (b) front view and (c) perspective view;

FIGURE 4 shows a triple ring according to an embodiment of the present invention;

FIGURE 5 shows a cross-sectional view of (a) a double ring structure and (b) a triple ring structure according to an embodiment of the present invention, and (c) a process of forming a single sided groove in a ring element for forming a double or triple ring structure according to an embodiment of the present invention;

FIGURE 6 shows a cross-sectional view of a double ring structure in which an inner ring element is inset in a double sided groove formed in an inner radial surface of an outer ring element;

FIGURE 7 shows a cross-sectional view of a double ring structure in which an inner ring element is inset in a single sided groove formed in an inner radial surface of an outer ring element;

FIGURE 8 is a schematic view of apparatus according to an embodiment of the present invention for forming a groove in a ring element;

FIGURE 9 is an enlarged view of the apparatus of FIG. 8 showing the manner in which a ring element is gripped;

FIGURE 10 illustrates a process of forming a double ring according to a further embodiment of the invention;

FIGURE 11 illustrates (a) a blank assembly formed from first and second blanks, and (b) the assembly following coning to form a tube element; and

FIGURE 12 illustrates (a) a tube element formed by a method according to an embodiment of the present invention, (b) a blank assembly according to an embodiment of the invention having a second blank element of substantially spiral form inset in a first blank element in the form of a substantially flat disc, and (c) a tube element formed by coning the blank assembly shown in (b).

DETAILED DESCRIPTION

Some embodiments of the present invention are directed to providing an article of jewellery comprising two or more ring elements that are combined in a single article.

FIG. 1 shows part of a process of forming an article according to one embodiment of the invention in the form of a double ring 140 shown in FIG. 2(b). In the present embodiment illustrated the article 140 is a finger ring, in particular a finger ring of the 'double ring' type in which two ring elements are combined to form a single article 140. Double rings are typically formed such that each ring element is formed from a different precious metal, for example a yellow gold and a red gold, a white gold and a red gold, or any desired combination of red, yellow and white gold. In some embodiments of the present invention other precious metals may be used in addition or instead, such as platinum or silver or any other suitable metal.

In the present embodiment an annular blank of material 100 (FIG. 1(a)) is first formed by pressing from a sheet of material. The blank 100 may be described as being substantially in the shape of a 'washer'. In other words, the annular blank 100 is in the form of a substantially flat, circular disc with a circular hole therethrough. In the present example the circular hole through the disc (which may also be described as an aperture) has a geometric

centre substantially coincident with that of the disc. That is, the disc and aperture or hole therein are substantially coaxial.

The material may be any suitable material but in the present embodiment the material is a precious metal. The metal may be any suitable precious metal such as gold, silver, platinum, a coloured gold in the form of an alloy of gold with silver and/or copper such as white gold, yellow gold or red gold, or any suitable metal.

It is to be understood that gold of different colours such as white, yellow or red gold is typically produced by alloying gold with one or more of silver or copper. A reddish coloured gold may be formed by alloying with copper, whilst a whitish gold may be formed by alloying with silver. Mixtures of gold, copper and silver may be employed depending on the colour or shade of colour required.

After forming the blank 100, the blank 100 is coned in a coning operation whereby the sheet of metal from which the blank is formed is rotated or twisted through substantially 90 degrees from the substantially flat initial shape shown in FIG. 1(a) through a cone-like shape (frusto-conical shape) shown in FIG. 1(b) through to a slug 120 having a substantially tubular shape as shown in FIG. 1(c).

The process of starting from a sheet, producing a washer and then forming a short section of tube by a series of coning processes (which involve drawing of the blank 100 by means of a die) may be referred to as the Klink process in some embodiments. The short section of tube produced is referred to herein as a 'slug' but may also be referred to as a 'do-nut' or 'donut'. It is to be understood that one or more annealing processes may be performed between coning and drawing operations to relieve mechanical stress due for example to work hardening. An annealing process may be performed at any stage of the process of fabricating an article, as required.

The slug may then be subject to a drawing process in which the slug is drawn by means of a die to ensure that the wall of the slug is of substantially uniform thickness and substantially constant diameter along a length thereof. The resulting structure may be referred to as a ring element 120R as shown in FIG. 1(c).

The ring element 120R is then placed between first and second rollers R1, R2 as shown in FIG. 1(d). Roller R1 has a ridge portion R1r formed around a peripheral surface thereof

shaped to form a recess or groove 125 in the outer circumferential surface of the ring element 120R when the ring element 120R is placed between the rollers R1, R2. The second roller R2 is substantially flat around the peripheral surface. The ring element 120R is 'rolled' between the rollers R1, R2 which are urged together under pressure until the recess 125 is sufficiently deep to receive a second ring element 130R (FIG. 1(e) and FIG. 2) therein such that a radially outer surface of the second ring element 130R is substantially flush with a radially outer surface of the first ring element 120R. The ring element 120R may be subject to an annealing treatment before, during and/or after rolling to form the recess or groove 125.

It is to be understood that in some embodiments the first roller R1 may have two or more ridge portions R1r thereby to form a corresponding two or more recesses 125 in the ring element 120R.

In some embodiments, in addition or instead the second roller R2 may have one or more ridge portions formed in the radially outer surface facing the radially inner circumferential surface of the ring element 120R so as to form a groove in the radially inner surface of the ring element 120R.

After forming the recess 125 in the first ring element 120R, the second ring element 130R is formed in a similar manner to the first 120R and presented to the first ring element 120R. The second ring element 130R has an internal diameter greater than an outer diameter of the first ring element 120R, allowing the first ring element 120R to be positioned concentrically with respect to the second ring element 130R.

The second ring element 130R is of a length L parallel to a cylinder axis thereof that is sufficiently small to fit within the recess 125 formed in the first ring element 120R. As noted above, in the present example a thickness t of the second ring element 130R is substantially equal to the depth d of the recess or groove 125 formed in the ring element 120R. In some alternative embodiments the second ring element 130R may be of a thickness t greater than the depth d of the recess 125 formed in the first ring element. In some further alternative embodiments the second ring element 130R may be of a thickness t lower than the depth d of the recess 125 formed in the first ring element.

FIG. 3 illustrates the second ring element 130R being offered to the first ring element 120R. FIG. 3(a) shows a view from above whilst FIG. 3(b) shows a front view, parallel to a cylinder

axis CA of the ring elements 120R, 130R. FIG. 3(c) is a 3D view of the configuration shown in FIG. 3(a).

It can be seen that in the present embodiment the second ring element 130R is arranged to have an inside diameter that is sufficiently large to allow it to fit over the first ring element 120R. The inside diameter of the second ring element 130R may be substantially the same as an outer diameter of the first ring element 120R in some embodiments, provided the second ring element 130R may be slid or otherwise provided around the first ring element 120R.

In the present embodiment, the first and second ring elements 120R, 130R are then placed between a further pair of rollers, third and fourth rollers R3, R4 as shown in FIG. 1(e) such that the second ring element 130R is held securely within the recess 125 formed in the first ring element 120R. The first and second ring elements 120R, 130R are then rolled between the rollers R3, R4, pressure being applied by the rollers to cause the first ring element 120R to increase in diameter.

In the present embodiment roller R3 has a diameter of around 100mm whilst roller R4 has a diameter of around 8mm. Other sizes and relative sizes are also useful.

It is to be understood that the second ring element 130R may also increase in diameter during rolling between the rollers R3, R4 in some embodiments, in addition to the first ring element 120R. However in such a case the first ring element 120R is arranged to increase in diameter at a faster rate than the second ring element 130R such that the first ring element 120R expands to capture the second ring element 130R snugly within the recess 125 around substantially the entire diameter of the first ring element 120R. The second ring element 130R is thereby constrained such that it cannot become detached from the first ring element 120R. It is to be understood that the groove 125 formed in the first ring element 120R may contract in length parallel to the cylinder axis CA thereof during the rolling process, gripping the second ring element 130R and preventing relative movement once the fabrication process is complete. It is to be understood that a thickness of the first ring element 120R in a radial direction will reduce as a consequence of the rolling process, which results in an increase in circumference of the ring element 120R. The ring element 120R is therefore formed initially to have a radial thickness that is greater than the intended thickness at the end of the rolling operation.

It is to be understood that deforming the first and second ring elements 120R, 130R by rolling facilitates the formation of an article for which little or no further processing is required in respect of the addition of the second ring element 130R to the first 120R. That is, an outer diameter of second ring element 130R may become substantially the same as the outer diameter of the first ring element 120R. As such, trimming of the second ring element 130R by cutting in a lathe or other means is not required in some embodiments. For example, in the prior art example described above, stretching of the first ring element without rolling is performed until the second ring element becomes securely embedded in the groove formed in the first ring element 120R by cutting. The second ring element 130R may therefore not increase in diameter at all, or at least not by any significant amount. It is therefore important to ensure that a depth of the groove formed in the first ring element will correspond substantially to the thickness of the second ring element when the first ring element has been stretched to grip the second ring element. This is not an easy task to achieve, and trimming of the second ring element to reduce the radial thickness thereof is typically required. In contrast, rolling of the first and second ring elements 120R, 130R together may be arranged to have the effect that the first and second elements 120R, 130R have substantially the same outer diameter at the end of the rolling process, eliminating the need to trim either of the elements 120R, 130R.

Furthermore, because both the first and second ring elements 120R, 130R will typically experience some increase in circumference and therefore reduction in radial thickness as a consequence of the rolling process, some embodiments of the present invention allow the second ring element 130R to be formed to have a lower thickness than would otherwise be achievable reliably and reproducibly using known techniques. By way of example, in some embodiments of the present invention the first and second ring elements 120R, 130R may be arranged to increase in diameter by at least a factor of from around 1.5 to around 2 or 3, as required. Larger or smaller increases in diameter may be useful in addition or instead in some embodiments.

It is to be understood that the first and second ring elements 120R, 130R may be subject to an annealing treatment before, during and/or after the rolling operation in order to ensure adequate softness of the ring elements 120R, 130R during rolling and any subsequent processing.

In some alternative embodiments, the first and second ring elements 120R, 130R are formed using the process described above with respect to FIG. 1(a) to (c) and a groove

formed in the outer circumferential surface of the first ring element 120R as described with respect to FIG. 1(d). Subsequently, the first ring element 120R is stretched to trap the second ring element 130R in the circumferential groove 125 formed in the first ring element 120R.

It is to be understood that the second ring element 130R may be held within the groove 125 formed in the first ring element 120R without any further joining processes being required in some embodiments, such as soldering. Alternatively, the first and second ring elements 120R, 130R may be joined by soldering or brazing. Alternatively, the first and second ring elements 120R, 130R may be joined by fusing the elements together. The article 140 may be heated to allow interdiffusion of metal between the elements 120R, 130R to form a bond between them. In the case of an article 140 having ring elements 120R, 130R formed from gold or silver, the article 140 may be heated to a temperature of around 600C to 700C for a sufficient period of time to cause fusion, for example a period of around 30s, 60s, 120s or any other suitable period of time. It is to be understood that the use of diffusion bonding processes not requiring the addition of an intermediate material to join the elements 120R, 130R has the advantage of simplifying manufacture and/or reducing cost. Furthermore, in some embodiments a requirement to undertake a post-joining finishing operation, for example so as to remove excess intermediate material such as excess solder or other joining material, may be eliminated in some embodiments.

The article 140 formed by combining the first and second ring elements 120R, 130R as illustrated in FIG. 1 to FIG. 3 may be referred to as a 'double ring' structure. As noted above, a triple ring structure may be formed by combining a third ring element with the first and second ring elements. FIG. 4 illustrates an example of a triple ring structure 240 in which a first ring element 220R has second and third ring elements 231R, 232R provided in respective recesses 225 formed in the first ring element 220R. Other arrangements are also useful.

It is to be understood that in some embodiments the groove or recess 225 may be formed at an edge of the first ring element 220R such that a side edge 230Re of the second ring element 230R at a first end 220R1 of the first ring element is visible when the first and second ring elements 220R, 230R are combined. Examples of such structures are illustrated schematically in FIG. 5. Such a groove 225 may be referred to as a 'single sided' groove in contrast to the 'double sided' groove 225 of the embodiments of FIG. 1 to 4.

FIG. 5(a) is a cross-sectional view of a portion of a double ring structure according to an embodiment of the present invention in which a single sided groove or recess 225 is formed along or around one free edge of the first ring element 220R prior to expansion of the first ring element 220R. The second ring element 230R has been inserted into the groove 225 by sliding from free end 220R1 of the first ring element 220R. The second ring element 230R was formed such that an inner diameter of the second ring element 230R was sufficiently large to allow the element 230R to be placed in the groove 225 such that a side edge 230Re on one side thereof is in abutment with shoulder or sidewall 225S of the recess 225. The opposite side edge 230Re is exposed and substantially flush with side edge 220Re of the first ring element 220R. It is to be understood that the first ring element 220R has been caused to expand in diameter with the second ring element 230R so held, causing a friction fit to be established between the second ring element 230R and the first ring element 220R. It is to be understood that the friction fit may in some embodiments be formed to be sufficiently constraining of movement of the second ring element 230R to prevent separation of the first and second ring elements 220R, 230R in normal use. That is, the diameter of the first ring element 220R may be cause to expand so as to cause sufficient radial pressure to be exerted between the first and second ring elements 220R, 230R such that separation of the first and second ring elements 220R, 230R does not occur in normal use.

In some embodiments, complementary interengaging formations may be provided on radially facing surfaces of the first and second ring elements 220R, 230R such that separation of the first and second ring elements 220R, 230R is resisted, and substantially prevented in normal use. In addition or instead, in some embodiments one or both surfaces may be roughened so as to increase resistance of the elements 220R, 230R to separation.

In some embodiments, the first and second ring elements 220R, 230R may be bonded together in order to reduce the risk of separation of the ring elements 220R. The elements may be bonded by means of a diffusion bonding process, for example by annealing at a sufficiently high temperature to allow interdiffusion of material from one ring element to the other, optionally from each ring element 220R, 230R to the other 230R, 220R. In some alternative embodiments an intermediate joining material may be employed such as a solder material.

FIG. 5(b) is a cross-sectional view of a portion of a triple ring structure 1240 according to a further embodiment of the present invention. Like features of the embodiment of FIG. 5(b) to those of the embodiment of FIG. 5(a) are shown with like reference signs prefixed

incremented by 1000. In the embodiment of FIG. 5(b) a groove or recess 1225 has been formed along or around opposite free edges of the first ring element 1220R. Second and third ring elements 1231R, 1232R have been provided in the respective recesses 1225 and the diameter of the first ring element 1220R subsequently expanded to trap the second and third ring elements 1231R, 1232R in the respective recesses 1225. It is to be understood that in some embodiments the first, second and third ring elements 1220R, 1231R, 1232R may each be of a different respective composition. In some embodiments the ring elements 1220R, 1231R, 1232R may be of different respective coloured metals. The ring elements 1220R, 1231R, 1232R may have different respective amounts of one or more of the elements gold, silver and copper. One ring element may be formed from a red gold, one formed from a yellow gold and one formed from a white gold in some embodiments.

FIG. 5(c) illustrates a method of forming a single sided groove in the first ring element 1220R. It can be seen that the first ring element 1220R is rolled between first and second rollers R1, R2, roller R1 having a ridge portion R1r at one end thereof for forming the single sided groove 1225. Roller R1 is caused to rotate about roller axis R1A whilst roller R2 is caused to rotate about roller axis R2A.

It is to be understood that the relative lengths of the first and second and any further ring elements may be of any required values. In some embodiments the second ring element provided in the groove may be approximately 50% of the length of the first element although any other suitable value may be employed such as 90%, 80%, 70%, 60%, 40%, 30%, 20%, 10% or any other suitable value.

In some embodiments, a recess or groove may be formed in the second ring element 130R on a radially inner, circumferential surface instead of the radially outer circumferential surface of the first ring element 120R as per the embodiments of FIG. 1 to FIG. 5. This may be accomplished by reversing the relative positions and optionally the relative sizes of the first and second rollers R1, R2 in FIG. 1(d) to form the groove on the radially inner surface of the second ring element 130R. The first ring element 120R may then be placed on an inside of the second ring element 130R and the first and second ring elements 120R, 130R rolled to reduce the difference in diameter between the first and second ring elements 120R, 130R. The diameter of the first ring element 120R is increased at a rate greater than the first 130R to cause the second ring element 120R to expand to sit within the groove formed in the second ring element 130R. Alternatively, the first ring element 120R may be expanded

by stretching to cause the first ring element 120R to be received within the groove formed in the second ring element 130R.

FIG. 6 illustrates a double ring structure 1340 according to a further embodiment of the present invention. Like features of the embodiment of FIG. 6 to those of the embodiment of FIG. 5 are shown with like reference signs incremented by 100. In the embodiment of FIG. 6 a groove 1325 has been formed in a radially inner surface 1330Ri of second ring element 1330R. A first ring element 1320R of complementary shape to the groove 1325 has been expanded by stretching to substantially fill the groove 1325. A fusion bonding process has then been performed in which the structure 1340 is heated to cause fusion of the first and second ring elements 1320R, 1330R together.

FIG. 7 illustrates a double ring structure 1440 according to a further embodiment of the present invention. Like features of the embodiment of FIG. 7 to those of the embodiment of FIG. 6 are shown with like reference signs incremented by 100. In the embodiment of FIG. 7 a groove 1425 has been formed in a radially inner surface 1430Ri of second ring element 1430R. A first ring element 1420R of complementary shape to the groove 1425 has been expanded by stretching to substantially fill the groove 1425. A fusion bonding process has then been performed in which the structure 1440 is heated to cause fusion of the first and second ring elements 1420R, 1430R together.

It is to be understood that, in some embodiments, prior to performing the fusion bonding process, axial pressure may be applied to the structures 140 described herein in order to reduce or substantially eliminate any gap between the first and second ring elements 120R, 130R. This has the advantage that an improved bond may be formed between the first and second ring elements 120R, 130R. Application of axial pressure may be performed in a stamping, crimping or 'squashing' operation, with force being applied to compress the structure 140 parallel to the longitudinal axis thereof.

It is to be understood that, in some embodiments, expansion of a first ring element according to an embodiment of the invention (such as element 120R, 220R and so forth) may be performed by stretching of the first ring element 220R rather than rolling of the first, second and optionally one or more further ring elements together in a rolling operation. The stretching operation may be performed using known ring stretching devices. For example in some embodiments a ring stretching device may be provided in the form of a known split

shaft arrangement in which a hollow split shaft is provided that is arranged to allow an expansion member such as a tapered rod to be driven axially at least partially through the split shaft, causing radial expansion of the split shaft in a known manner. By placing the first ring element 220R around the split shaft with the second ring element 230R around the first 220R, the first ring element 220R may be expanded to trap the second ring element 230R within the groove 225 when the tapered rod is driven through the split shaft, or to trap a first ring element 1320R in a groove 1325 formed in the second ring element 1330R.

FIG. 8 and FIG. 9 illustrate an apparatus 460 according to an embodiment of the present invention for forming a groove 425 in a ring element 420R by means of a rolling process. The apparatus 460 has a base portion 462 having a threaded shaft portion 462S having a longitudinal or cylinder axis A. The shaft portion 462S projects from the base portion 462 in a direction substantially normal to a basal face 462F of the base portion 462. In the embodiment illustrated in FIG. 6 the shaft portion 462S is shown projecting substantially vertically upwards. Other orientations of the shaft portion 462S may be useful in some embodiments. In some embodiments the shaft portion 462S may instead be mounted in a substantially horizontal orientation.

The shaft portion 462S is arranged to receive first and second bearing portions 462B1, 462B2 thereon. The bearing portions 462B1, 462B2 have threaded bores corresponding to the external thread of the shaft portion 462S. A diameter D of the shaft portion 462S is arranged to allow insertion of the shaft portion 462 through the ring element 420R.

In use, the first bearing portion 462B1 is screwed to the threaded shaft portion 462S such that it is substantially in abutment with the basal face 462F of the base portion 462. One or more washers may be provided between the base portion and first bearing portion 462B1 in some embodiments. The ring element 420R is then passed over the shaft portion 462S and into abutment with the first bearing portion 462B1. The second bearing portion 462B2 is subsequently screwed to the threaded shaft portion 462S such that the ring element 420R is trapped between the first and second bearing portions 462B1, 462B2. The ring element 420R is held firmly between the first and second bearing portions 462B1, 462B2 substantially without deforming the ring element 420R due to the pressure applied by the bearing portions 462B1, 462B2 thereto.

The apparatus 460 also has a roller element 465R mounted for rotation about an axle 465A that is supported at opposed ends thereof in a recess 465CR provided in a carriage portion

465C. In the present embodiment the axle 465A is oriented substantially parallel to the shaft portion 462S.

The carriage portion 465C is coupled to and supported by a carriage support portion 465CS that is configured for rotary movement about the base portion 462, about an axis substantially coincident with the longitudinal axis A of the shaft portion 462S. The carriage support portion 465CS has a handle portion 466 that projects radially outwardly from the carriage support portion 465C, allowing an increased moment to be applied to cause rotation of the carriage support portion 465CS, and thereby the carriage portion 465C, about the base portion 462.

The carriage support portion 462CS is configured to be movable with respect to the carriage portion 465C radially towards and away from the shaft portion 462S by means of a screw adjuster 465CA, allowing the roller element 465R to be moved in a corresponding manner towards and away from the ring element 420R mounted between the bearing portions 462B1, 462B2. The axial position of the ring element 420R may be adjusted by adjusting the axial positions of the bearing portions 462B1, 462B2. In the present embodiment the screw adjuster 465CA is configured to actuate a wormscrew mechanism in order to cause movement of the carriage portion 465C relative to the carriage support portion 465CS.

The roller element 465R has a circumferential ridge portion 465RR disposed centrally with respect to a circumferential face 465RF of the element 465R. In the present embodiment the roller element 465 has a length LRL that is similar to that of the length LR of the ring element 420R. The length LRL of the roller element 465 and the diameters of the first and second bearing portions 462B1, 462B2 are sized to allow the roller element 465R to be positioned between the first and second bearing portions 462B1, 462B2 and in relatively close proximity thereto with the circumferential ridge portion 465RR in abutment with a radially outer surface of the ring element 420R. This has the advantage that correct positioning of the roller element 465R with respect to the ring element 420R may be made in a more reliable and convenient manner, reducing the risk that a groove or recess 425 formed in the radially outer surface of the ring element 420R is formed at an undesirable location with respect to a length LR of the ring element 420R. In the present embodiment, the circumferential ridge portion 465RR of the roller element 460R is located substantially centrally between opposed major faces of the roller element 460R, so that a groove or recess 425 is formed substantially equidistant between opposed edges 420Re of the ring element 420R. Other positions of the ridge portion 465RR may be useful in some

embodiments, such as substantially at one axial end of the circumferential face 465R. In some embodiments a roller element 465R may be provided with a plurality of ridge portions. A roller element 465R provided with a plurality of ridge portions 465RR may be used to form a plurality of grooves 425 in a ring element 120R, 130R enabling two or more ring elements to be joined to that ring element.

In use, the ring element 420R is positioned between the first and second bearing portions 462B1, 462B2 and held securely therebetween. The position of the carriage portion 465C relative to the carriage support portion 465CS (and therefore the ring element 420R) is then adjusted by means of the screw adjuster 465CA to cause the roller element 465R to move towards the ring element 420R until the circumferential face 465RF of the roller element 465R is in abutment with the radially outer circumferential face 420RF of the ring element 420R. In this position, lateral radial faces 465RL of the roller element 465R directly face opposed faces 462B1L, 462B2L of the first and second bearing portions 462B1, 462B2 respectively. In the embodiment shown in FIG. 6 and FIG. 7, a gap between the lateral radial faces 465RL of the roller element 465R and opposed faces 462B1L, 462B2L of the first and second bearing portions 462B1, 462B2 is approximately 0.1mm although other values are also useful in some embodiments.

In the embodiment illustrated in FIG. 6 and FIG. 7 the roller element 465R has a diameter of 25mm and a length LRL of substantially 7mm although other values may be useful in some alternative embodiments. A length LRR of the ridge portion 465RR of the roller element 465R is substantially 3mm in the present embodiment, with the ridge portion 465RR being provided substantially midway between lateral faces 465RL of the roller element 465R. Again, other lengths and relative positions of the ridge portion 465RR may be useful in some embodiments. A plurality of ridge portions 465RR may be provided in some embodiments.

The ridge portion 465RR is arranged to protrude a radial distance HR of 2mm beyond the portion of the circumferential face 465RF either side of the ridge portion 465RR. Other values are also useful in some embodiments.

The first and second bearing portions 462B1, 462B2 are each of diameter 50mm in the present embodiment, in which the ring element 420R is formed to be suitable for wearing around a finger. The ring element 420R shown in FIG. 6 and FIG. 7 (not to scale) has an inner diameter of 9mm and an outer diameter of 16mm although in some embodiments

other values may be useful. In the case of the formation of a bangle to be worn around a wrist, the inside diameter of the element 420R may be around 16mm and the outer diameter may be around 22mm. Again, other sizes may be useful in some embodiments. The diameters of the first and second bearing portions 462B1, 462B2 may be selected accordingly.

It is to be understood that other values are useful in some embodiments. In particular, it is to be understood that the relative diameters of the roller element 465R and first and second bearing portions 462B1, 462B2 may be of any suitable diameter to enable gripping therebetween of a ring element 420R of the required size and the forming of one or more grooves 425 therein by means of the roller element 465R.

In some embodiments, during rolling of the ring element 420R to form the groove therein the ring element 420R may expand in diameter due to displacement of material during rolling. Accordingly, lateral movement of the ring element 420R may occur due to pressure applied by the roller element 465R since the ring element 420R may remain gripped between and in contact with the shaft portion 462S and roller element 465R during the rolling operation. Accordingly, the first and second bearing portions 462B1, 462B2 may be sized to accommodate such movement during groove formation. In use the roller element 465R is urged against the ring element 420R with sufficient pressure to cause grooving when the roller element 465R rolls around the ring element 420R. The carriage support portion 465CS is then caused to rotate about the base portion 462 by manipulation of the handle portion 466, causing the roller element 465R to travel in a corresponding manner around the ring element 420R. The roller element 465R rotates about axle 465A as the roller element 465R describes a circular path about the axis A as the carriage support portion 465CS is caused to rotate about the base portion 462. By controlling the amount of pressure between the roller element 465R and ring element 420R, a groove 425 of suitable depth may be formed in the ring element 420R.

In some methods of use, the amount of pressure between the roller element 465R and the ring element 420R is increased in steps, with the roller element 465R typically being caused to describe one or more revolutions of the base portion 462 between respective increases in the amount of pressure applied, until a groove 425 of sufficient depth is formed in the ring element 420R. In some alternative embodiments the amount of pressure between the roller element 465R and ring element 420R may be increased in a substantially continuous,

gradual manner as the roller element 465R revolves around the ring element 420R. Other arrangements may be useful in some embodiments.

As will be apparent from the above description, the apparatus 460 shown in FIG. 8 is a manually operated apparatus. It is to be understood that in some alternative embodiments one or more actuators such as one or more electric motors may be provided for causing rotation of the carriage support portion 465CS about the base portion 462. Similarly, in some embodiments translation of the roller element 465R towards and away from the ring element 420R may be driven by means of one or more actuators, such as one or more electric motors. For example, in some embodiments one or more motors may be provided for driving screw adjuster 465CA.

In some embodiments the roller element 465R may itself be arranged to be driven by one or more actuators such as an electric motor, in addition to or instead of the carriage support portion 465CS. In some embodiments, the ring element 420R may be rotated with respect to the base portion 462 instead of the carriage support portion 465CS, the carriage support remaining in a substantially fixed position relative to the base portion 462. For example, in some embodiments the ring element 420R may be rotated by rotation of the shaft portion 462S. In some embodiments the first and second bearing portions 462B1, 462B2 may be arranged for rotation about the shaft portion 462S thereby to cause rotation of the ring element 420R relative to the base portion 462, the bearing portions 462B1, 462B2 not being tapped and screwed to the shaft portion 462S. Accordingly in some embodiments the first and second bearing portions 462B1, 462B2 may be arranged to be rotate about the shaft portion 462S with the ring element 420R gripped therebetween, thereby causing rotation of the ring element 420R and facilitating formation of the groove 425.

It is to be understood that the apparatus 460 illustrated in FIG. 6 and variations thereof described herein may have a number of advantages. For example, it is noted that the first and second bearing portions 462B1, 462B2 are arranged to abut the side edges 420Re of the ring element 420R and constrain axial expansion of the ring element 420R in the direction of cylinder axis A. This feature has the advantage that the amount of post-fabrication finishing of the ring element 420R that may be required may be reduced relative to embodiments in which such expansion is not constrained. The present inventors have found that the side edges 420Re of the ring element 420R can develop unsightly markings such as steps unless lateral expansion is constrained across substantially the entire radial thickness of the side edges 420Re, as in the illustrated embodiment of FIG. 8.

Furthermore, the radial thickness of the ring element 420R before the groove 425 is formed therein may be reduced in some embodiments. This may be at least in part because the prevention of axial expansion of the ring element 420R in a direction parallel to the cylinder axis A may reduce the amount by which the radial thickness of the ring element 420R in the region of the groove 425 decreases during the process of forming the groove 425.

It is to be understood that forming the roller element 465R to have a length LRL corresponding substantially to the length LR of the ring element 420R, and causing the circumferential face 465C of the roller element 465R to be extend substantially from one bearing element 462B1 to the other 462B2 during rolling such that axial movement of the roller element 465R in a direction parallel to axis A is constrained, has the advantage that a precision with which a groove may be formed at a required location between opposed circumferential edges of a ring element 420R may be enhanced.

FIG. 10 illustrates a method of fabricating an article according to a further embodiment of the present invention. In the embodiment shown the article is also in the form of a double ring.

In the embodiment of FIG. 10, a first blank 300 is formed by pressing from a sheet of precious metal. The blank 300 is substantially in the form of a washer-shaped element. That is, the blank 300 is in the form of a substantially circular disc 300 with a substantially circular aperture 302 formed therein substantially coaxial with a rotational centre of the disc 300. In some embodiments the blank 300 is formed by a one or two-step pressing operation. In a one-step operation, a disc 300 is pressed from a sheet of material and, substantially simultaneously, a second disc, coaxial with the first disc 300, is pressed from the first disc 300 to form the aperture 300A in the first disc 300. In a two-step operation, a disc 300 not having an aperture 300A therein is pressed from the sheet. Subsequently, the aperture 300A is formed in the disc 300 by pressing a second disc therefrom, substantially coaxial therewith.

It is to be understood that other methods of forming the blank 300 may be useful in some embodiments, such as by drilling, casting or any other suitable method.

After forming the blank 300, a substantially circular groove or recess 325 is formed in the blank 300 substantially coaxial with a centre of rotation thereof. In the present embodiment

the groove 325 is also formed by pressing. Other methods of forming the groove 325 are also useful, for example by cutting, e.g. by means of a lathe, by rolling or any other suitable means for forming a groove. In the present embodiment the groove 325 is in the form of a substantially flat bottomed, parallel-sided channel which may also be described as having a shape in the form of a substantially square U-shaped channel.

Once the groove 325 has been formed, a second blank 330 is inserted into the groove 325 to form a blank assembly 300A as shown in FIG. 10(a). The second blank 330 is shaped and sized in a complementary manner to the groove 325 such that a radial width w of the groove is greater than or substantially equal to the radial width of the second blank 330. In the present embodiment, the second blank 330 is soldered to the first blank 300 to retain the second blank 330 in the groove formed in the first blank 300. In some alternative embodiments the second blank 330 may be joined to the first blank 300 by means of a fusion process without the use of an intermediate joining material such as a solder or brazing material.

The assembly 300A is then subject to a coning operation in a similar manner to the blank 100 illustrated in FIG. 1. The assembly 300A is thus transformed through an intermediate frusto-conical shaped structure as shown in FIG. 10(b) to a substantially tubular structure 300T as shown in FIG. 10(c). The tubular structure 300T may be considered to be composed of a first ring element 320R (formed from blank 300) having a second ring element 330R (formed from second blank 330) embedded in an outer circumferential surface thereof. The tubular structure 300T is then subject to a drawing operation in which the structure is drawn to ensure that a wall thickness and a diameter of the structure is substantially uniform along a length LR thereof.

It is to be understood that in the embodiments described herein, the grooves 125, 225, 325 and second elements 130R, 231R, 232R, 330R may be formed to be of any desirable shape. Thus the second ring elements may have a corrugated shape, a helical or other curved shape, or any other suitable shape.

FIG. 11(a) shows an example of a blank assembly 500A according to a further embodiment of the present invention. Like features of the embodiment of FIG. 11 to those of the embodiment of FIG. 10 are shown with like reference signs incremented by 200. In the embodiment of FIG. 10(a) a second blank 530 in the form of a substantially flat, corrugated or zig-zag shaped element has been formed and inserted into a correspondingly shaped

recess formed in a major face of a first blank 500. The first and second blanks have been fused together by heating to a sufficiently high temperature for a sufficiently long period. FIG. 10(b) shows the assembly 400A following the coning operation to form tubular structure 400T in the form of a double ring 500T having first and second ring elements 420R, 430R, the second ring element 430R being inset in the first 420R.

FIG. 12(a) shows a tubular structure 600T in the form of a double ring according to a further embodiment of the present invention. Like features of the embodiment of FIG. 12(a) to those of the embodiment of FIG. 11 are shown with like reference signs incremented by 100. The tubular structure 600T has been formed by coning a blank assembly to form a structure in which the second ring element 630R is of a meandering form in a circumferential direction, being curved or softly zig-zag shaped rather than relatively sharply zig-zag shaped as in the embodiment of FIG. 11.

FIG. 12(b) shows a blank assembly 700A according to an embodiment of the invention and FIG. 10(c) shows a tubular structure 700T formed by coning the assembly 700A. Like features of the embodiment of FIG. 12(b) and (c) to those of the embodiment of FIG. 10 are shown with like reference signs incremented by 400.

The blank assembly 700A includes a first blank 700 and a second blank 730. The first blank 700 is also in the form of an open annular disc, i.e. a disc having a substantially circular, concentric aperture formed therein.

It is to be understood that in some alternative embodiments the aperture may not be concentric with the centre of rotation of the disc forming the first blank 700.

In the embodiment of FIG. 12(b) a spiral-shaped groove or channel 725 has been formed in a major face of the first blank 700, substantially coaxial with a centre of circular symmetry of the first blank 700 prior to groove formation. A second blank 730 in the form of a spiral-shaped element 730 of corresponding, complementary shape to channel 725 has been fused into the channel 725.

FIG. 12(c) shows the blank assembly 700A following the coning operation to form the tubular structure 700T. It can be seen that the spiral-shaped second blank 730 has deformed to form a substantially helical-shaped element 730. The second blank 730 may be

described as a ring element 730 since it has a substantially circular form when viewed along a cylinder axis of the tubular structure 600T.

It is to be understood that, in respect of any of the embodiments of FIG. 10 to 12, the dimensions of the channel (such as channel 725) and second blank (such as second blank 730) may be varied along a length thereof so as to obtain a second element 730, following the coning operation, that has a desired shape and appearance. In other words, the radial width RW and depth of the channel 725 and second blank 730 may be varied to compensate for distortion of the channel 625 and second blank 630 during the coning operation.

For example, the radial width RW and depth as a function of radial coordinate (R, θ), such as radial width RW of the channel 725 and second blank 730, and depth of the channel 725 and second blank 730, may be varied to compensate for distortion during the coning operation.

It is to be understood that computational methods may be employed to calculate the required radial width RW and depth of the channel 725 and second blank 730 for forming the blank assembly 700A based on data describing the required form of the final tubular structure 700T. Finite element methods or the like may be employed in order to perform this calculation.

In the embodiment shown in FIG. 10, instead of a single second ring element 330R that is in addition to the first ring element 320R, two or more second ring elements may be provided. In some alternative embodiments one or more letters, indicia or other elements may be embedded in corresponding grooves or recesses formed in the first blank 300. The elements may be shaped such that following the coning operation (and/or a subsequent drawing operation if required) the elements have a desired shape. Thus, the elements as inserted into the grooves or recesses may be of a shape (and optionally a thickness) that is distorted relative to the final desired shape (and optionally thickness) such that following the coning operation and/or drawing operation the elements have the desired visual appearance and thickness.

It is to be understood that a trimming and/or polishing operation may be performed following the coning or drawing operation, to reduce a thickness of the second ring element 130R, 231R, 232R, 330R if desired.

Some embodiments of the present invention provide a method of forming an article such as a finger ring, bracelet, bangle or other wrist or arm-worn article that enables the article to be formed with a reduced amount of wastage and/or a reduced amount of starting material.

Some embodiments enable a ring or bracelet or bangle or the like to be formed having a required size with each of the ring elements fitting sufficiently tightly whilst avoiding distortion or breakage.

Throughout the description and claims of this specification, the words “comprise” and “contain” and variations of the words, for example “comprising” and “comprises”, means “including but not limited to”, and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

CLAIMS:

1. A method of forming an article comprising:
 - providing a first substantially annular-sectioned element and a second substantially annular-sectioned element, an outer diameter of the first element being less than an inner diameter of the second element;
 - forming a circumferential groove in one of the first and second elements by a process of rolling;
 - positioning the first and second elements together with the second element positioned circumferentially around the first element; and
 - expanding the first element such that the circumferential groove in the one element receives therein the other of the said elements.
2. A method according to claim 1 comprising forming the circumferential groove in a radially outer surface of the first substantially annular-sectioned element.
3. A method according to claim 1 comprising forming the circumferential groove in a radially inner surface of the second annular-sectioned element.
4. A method according to any preceding claim wherein forming the circumferential groove in an element by rolling comprises constraining axial expansion of the element in a longitudinal direction during rolling.
5. A method according to claim 4 comprising constraining lateral expansion of the annular-sectioned element during rolling by trapping between clamp members at least a portion of the annular-sectioned element during rolling.
6. A method according to claim 5 comprising trapping between clamp members the annular-section element across substantially the whole of each axially opposed side of the element.
7. A method according to any preceding claim comprising forming the circumferential groove in one substantially annular-sectioned element to have an axial length that is sufficiently large to trap the other substantially annular-sectioned element in the groove when the first element is expanded in diameter.

8. A method according to any preceding claim comprising expanding the first substantially annular-sectioned element by stretching.
9. A method according to any one of claims 1 to 7 comprising expanding the first substantially annular-sectioned element by rolling.
10. A method according to any preceding claim comprising joining the first and second substantially annular-sectioned elements by fusing.
11. A method according to claim 10 comprising joining the first and second elements by fusing substantially in the absence of an intermediate joining medium.
12. A method according to any preceding claim wherein the first and second substantially annular-sectioned elements are of a diameter in the range from substantially 5mm to substantially 300mm.
13. A method according to any preceding claim wherein the article is arranged to be worn around one selected from amongst a finger or wrist.
14. A method according to any preceding claim comprising forming the first substantially annular-sectioned element from a first material and the second substantially annular-sectioned element from a second material.
15. A method according to claim 14 wherein the first and second materials are the same material.
16. A method according to claim 14 wherein the first and second materials are different respective materials.
17. A method according to any one of claims 14 to 16 wherein the first and second materials comprise a precious metal.
18. A method according to claim 17 wherein the first and second materials comprise gold, silver, platinum or palladium.

19. A method according to any preceding claim wherein the step of positioning the second substantially annular-sectioned element around the first element comprises positioning a plurality of substantially annular-sectioned elements around the first element.
20. A method according to claim 19 wherein forming a circumferential groove in one of the first and second elements comprises forming a plurality of circumferential grooves in the element.
21. A method according to claim 20 comprising providing an annular element in each of the plurality of grooves in said one of the elements.
22. A method according to any preceding claim comprising forming one or more of the annular-sectioned elements by cutting from a tube.
23. A method according to any preceding claim comprising forming one or more of the annular elements by pressing a blank from a sheet, the blank being formed in the shape of an annulus, subsequently forming a tube element from the blank.
24. A method according to claim 23 wherein forming the tube element from the blank comprises forming the tube element by coning.
25. An article formed by a method according to any preceding claim.
26. An article according to claim 25 comprising a jewellery ring suitable for being worn on a finger.
27. An article according to claim 25 comprising a jewellery bangle suitable for being worn around a wrist.
28. A method of forming an article comprising
 - providing a first annular element comprising a substantially flat disc having an aperture formed therein;
 - forming a groove in a surface of the annular element;
 - placing a second element in the groove formed in the first element; and
 - coning the first element to form a tube element comprising the first and second elements.

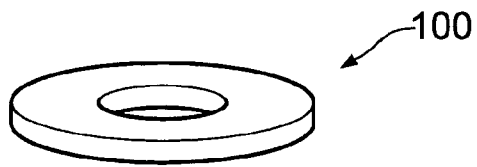
29. A method according to claim 28 comprising subjecting the tube element to a drawing operation.
30. A method according to claim 28 or claim 29 whereby the groove is provided in the form of an endless loop around an axis of rotation the first annular element.
31. A method according to any one of claims 28 to 30 comprising forming the second element to be of a shape corresponding substantially to the groove, the second element being arranged to fit at least partially within the groove.
32. A method according to claim 31 whereby the second element is in the form of a substantially endless loop.
33. A method according to any one of claims 28 to 32 whereby the first and second annular elements are substantially circular.
34. Apparatus for forming a groove in an annular element comprising:
element support means for supporting a substantially annular-sectioned element;
roller means supported by roller support means, the roller means being rotatable relative to the roller support means about a roller axis;
means for applying pressure between the roller means and an annular-sectioned element supported by the support means; and
means operable to allow relative movement between the annular-sectioned element and the roller support means such that the roller means is caused to roll around the annular-sectioned element in contact therewith to form a groove in the annular-sectioned element.
35. Apparatus according to claim 34 further comprising means for constraining axial expansion of the annular-sectioned element in a direction parallel to a longitudinal axis thereof whilst the roller means is rolling therearound to form the groove.
36. Apparatus according to claim 35 wherein the means for constraining lateral expansion comprises clamping means having first and second clamp portions arranged to be positioned on opposite sides of the annular-sectioned element.

37. Apparatus according to claim 36 wherein the means for supporting the annular-sectioned element comprises a shaft member around which the annular-sectioned element may be positioned.
38. Apparatus according to any preceding claim comprising roller support means for supporting the roller means for rotation about the roller axis.
39. Apparatus according to claim 38 configured to cause the roller support means to describe a substantially circular path about the annular-sectioned element, in use.
40. Apparatus according to any preceding claim wherein the element support means is configured to support the annular-sectioned element in a substantially fixed position, in use.
41. Apparatus according to any one of claims 38 or 39 comprising means for rotating the annular-sectioned element relative to the roller support means.
42. Apparatus according to claim 41 wherein the element support means is configured to cause rotation of the annular-sectioned element relative to the roller support means.
43. Apparatus according to any preceding claim operable to cause translation of the roller support means towards and away from the element support means whereby pressure may be applied between the roller means and an annular-sectioned element supported by the element support means.
44. Apparatus according to any preceding claim comprising at least one powered actuator, the apparatus being configured automatically to cause relative movement between the substantially annular-sectioned element and the roller support means by means of the powered actuator such that the roller means is caused to roll around the substantially annular-sectioned element in contact therewith to form the groove in the element.
45. A method of forming a groove in a substantially annular-sectioned element comprising:
supporting the annular element by means of element support means;
applying pressure between roller means supported by roller support means and the annular element; and

causing relative movement between the annular element and the roller support means such that the roller means is caused to roll around the annular element in contact therewith to form a groove in the annular element, the roller means being caused to rotate relative to the roller support means about a roller axis.

46. Apparatus, an article or a method substantially as hereinbefore described with reference to the accompanying drawings.

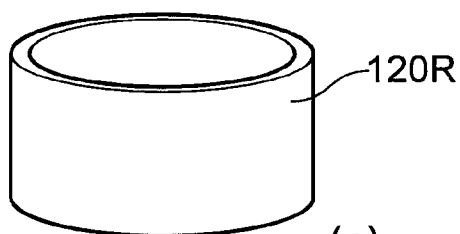
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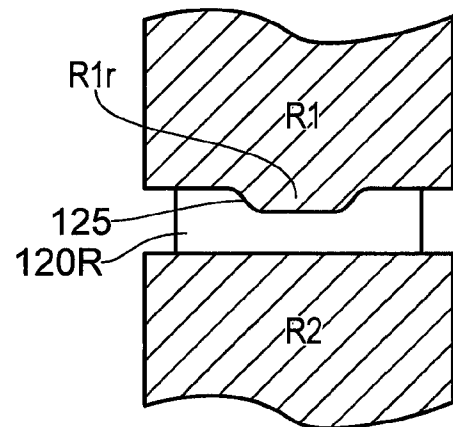
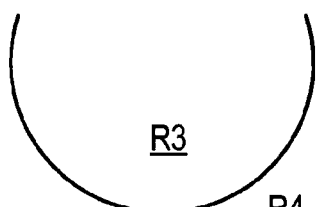
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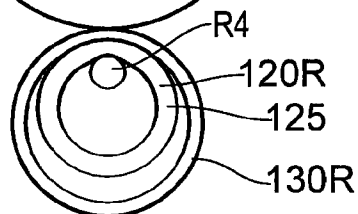
(b)



(c)



(d)



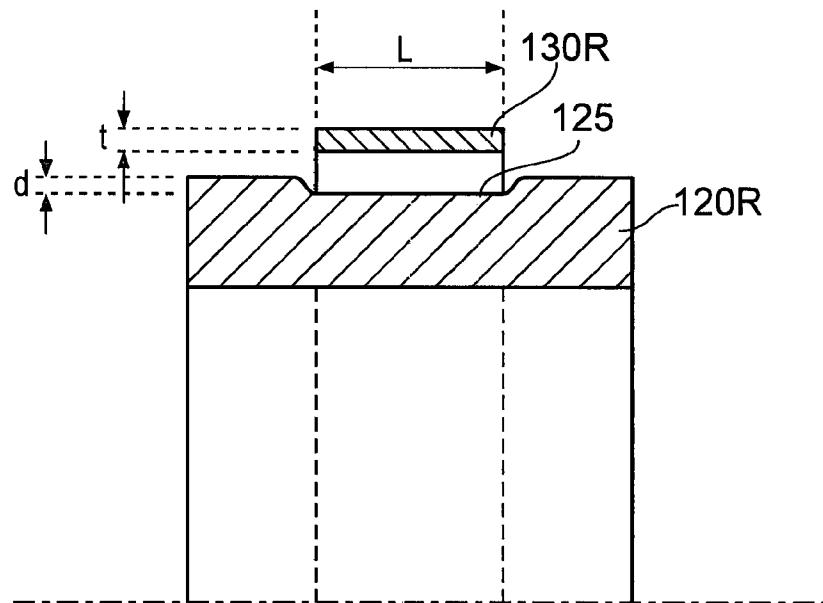
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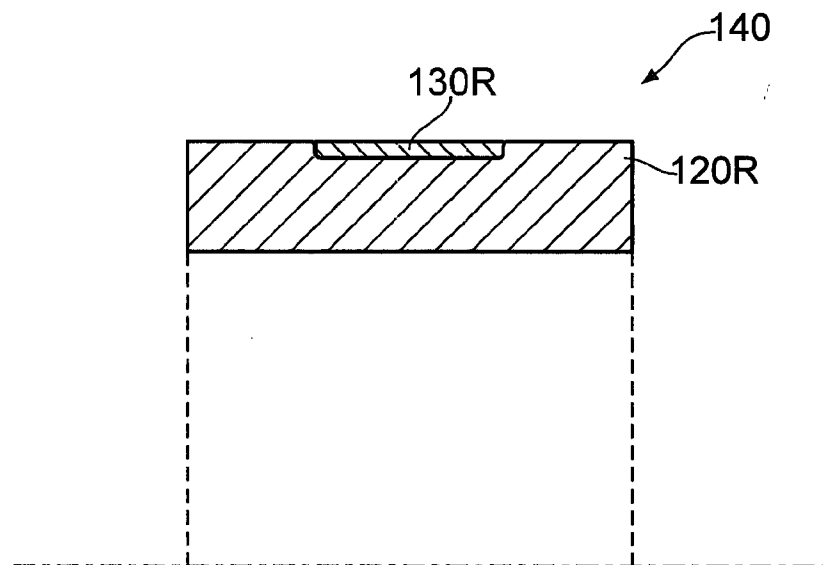
(f)

FIG. 1

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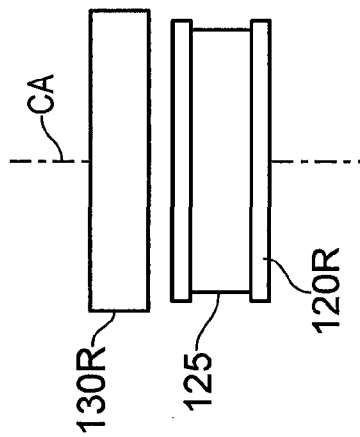
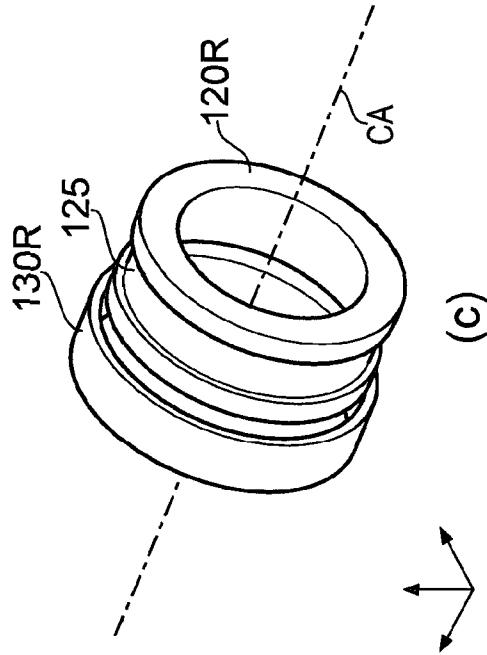
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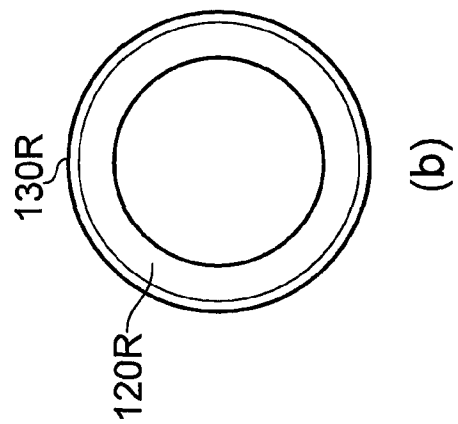
(b)

FIG. 2

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(a)



(b)

FIG. 3

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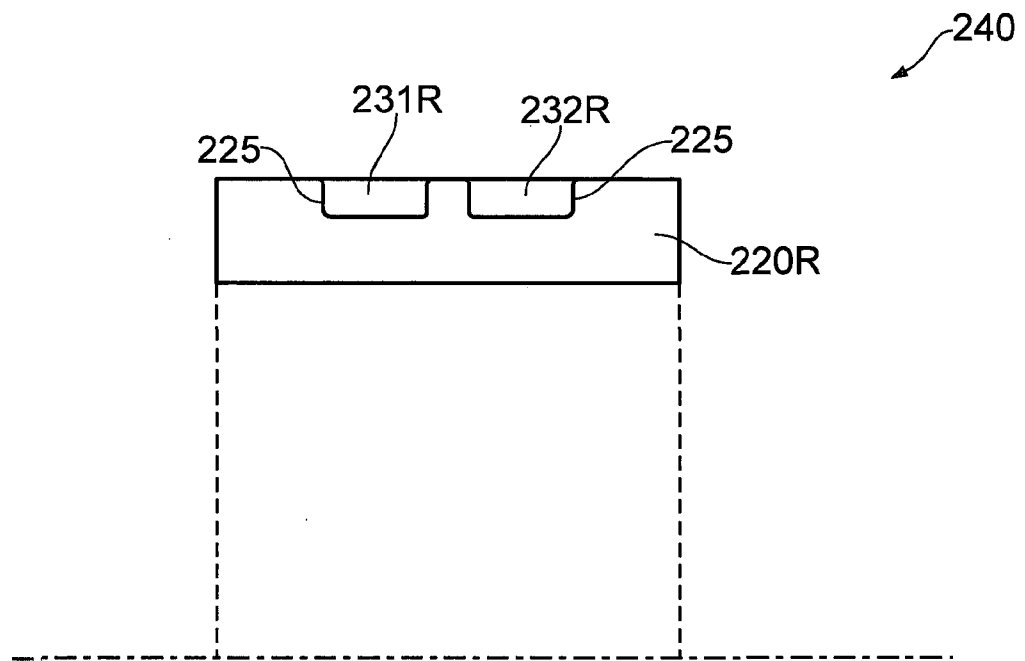


FIG. 4

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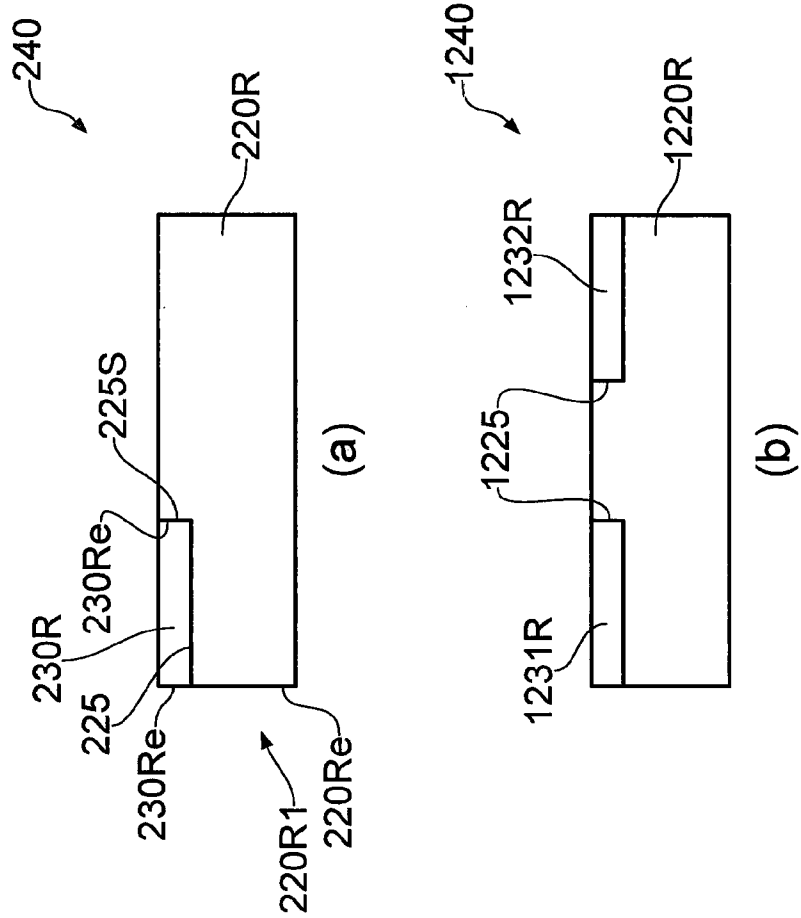
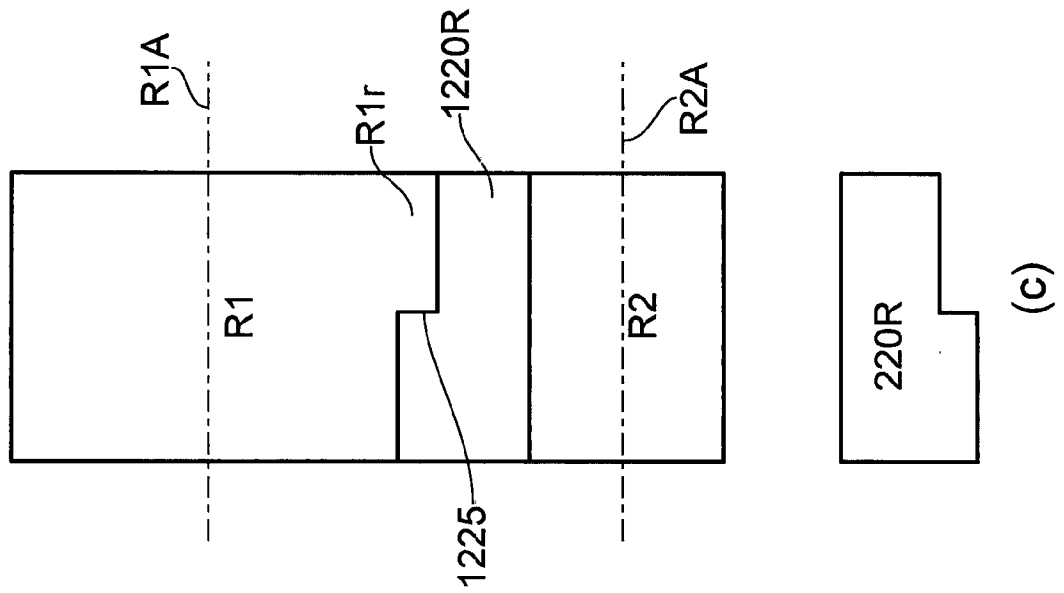


FIG. 5

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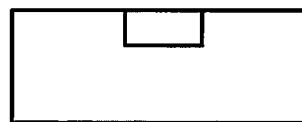
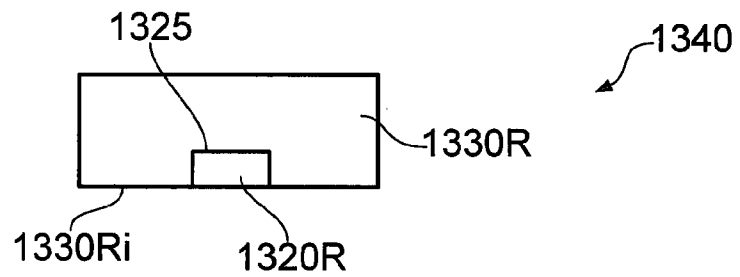


FIG. 6

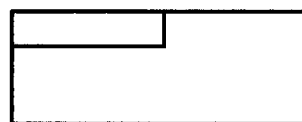
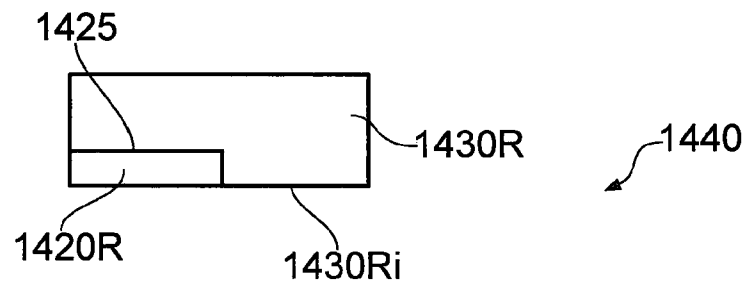
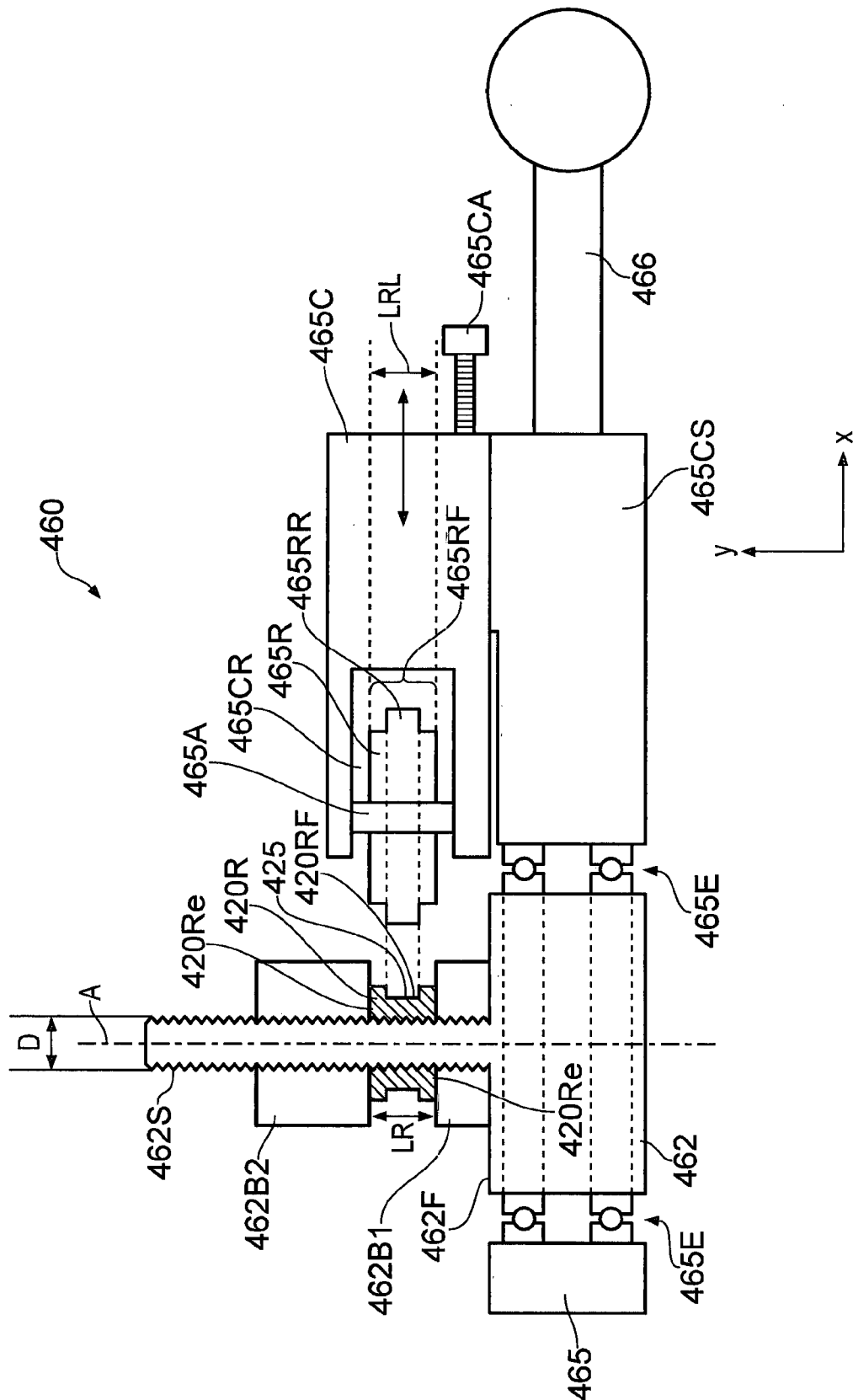


FIG. 7

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G.
F.

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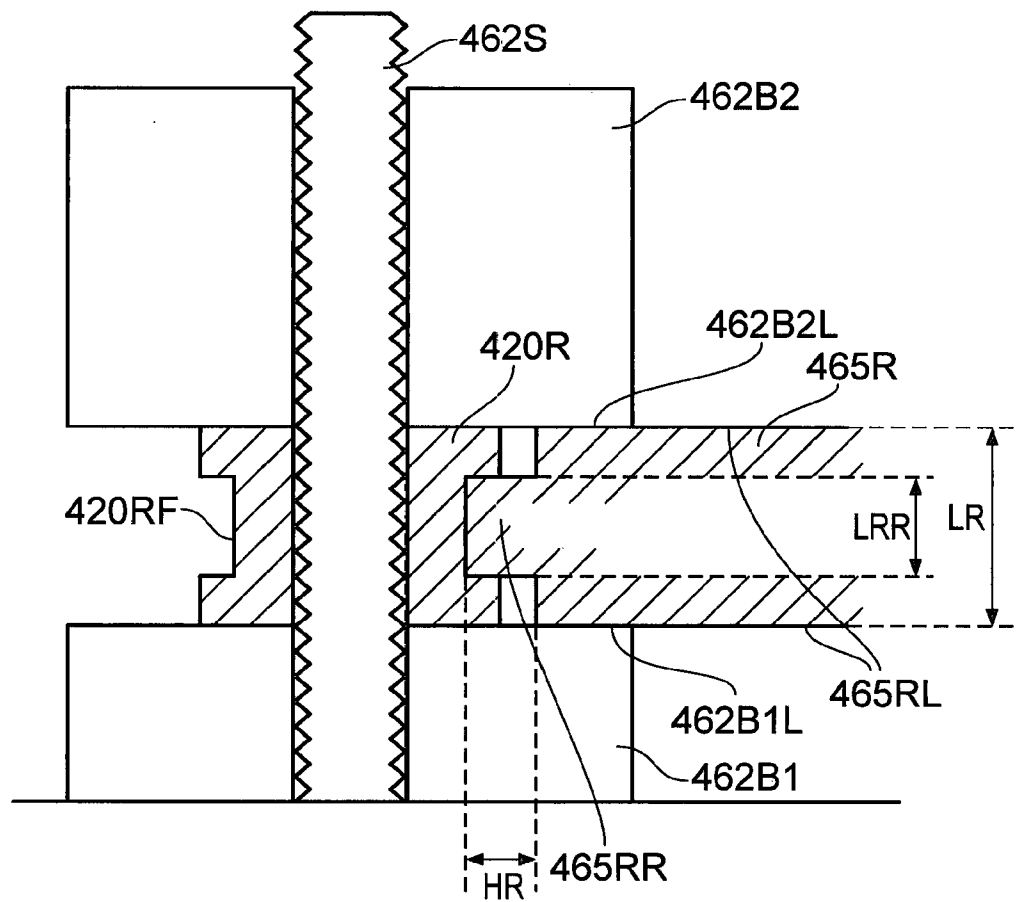


FIG. 9

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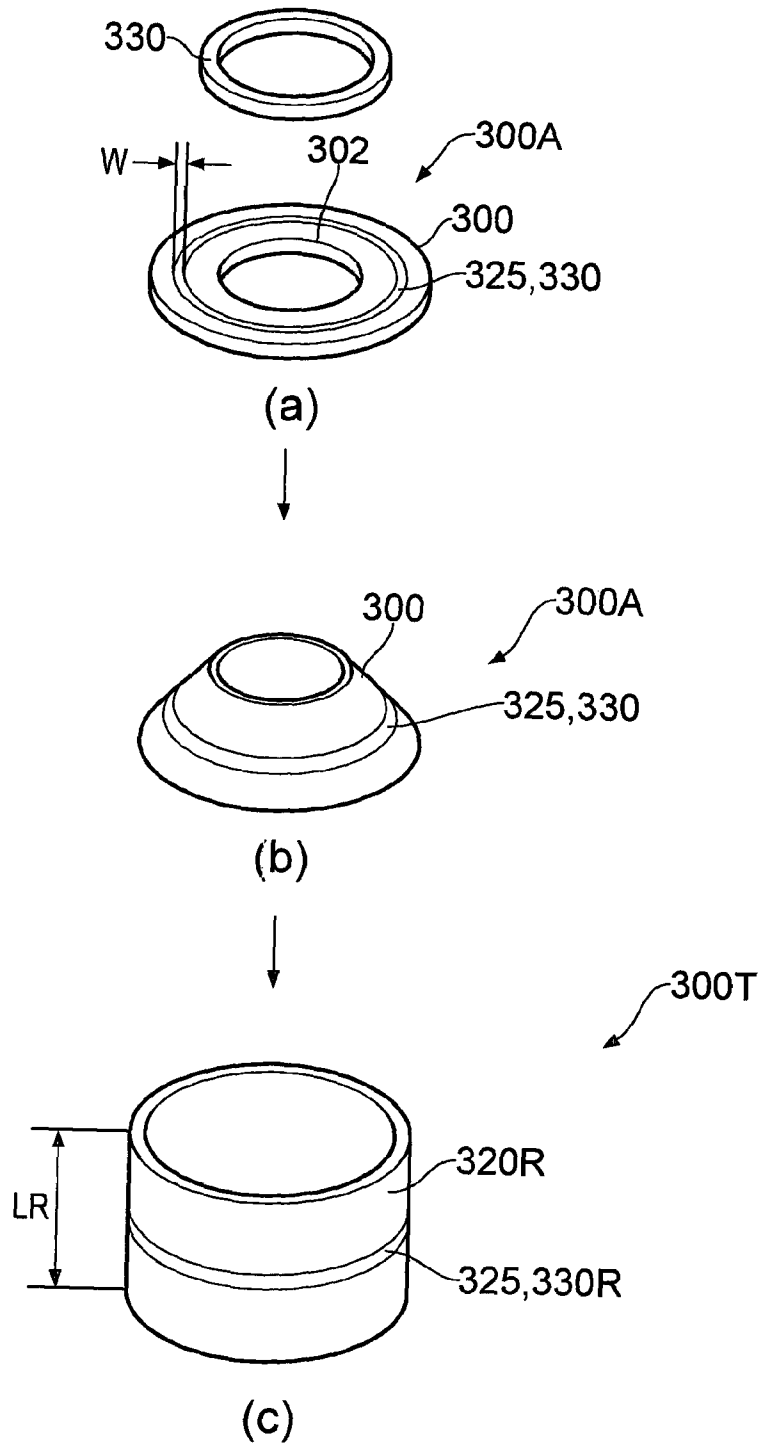


FIG. 10

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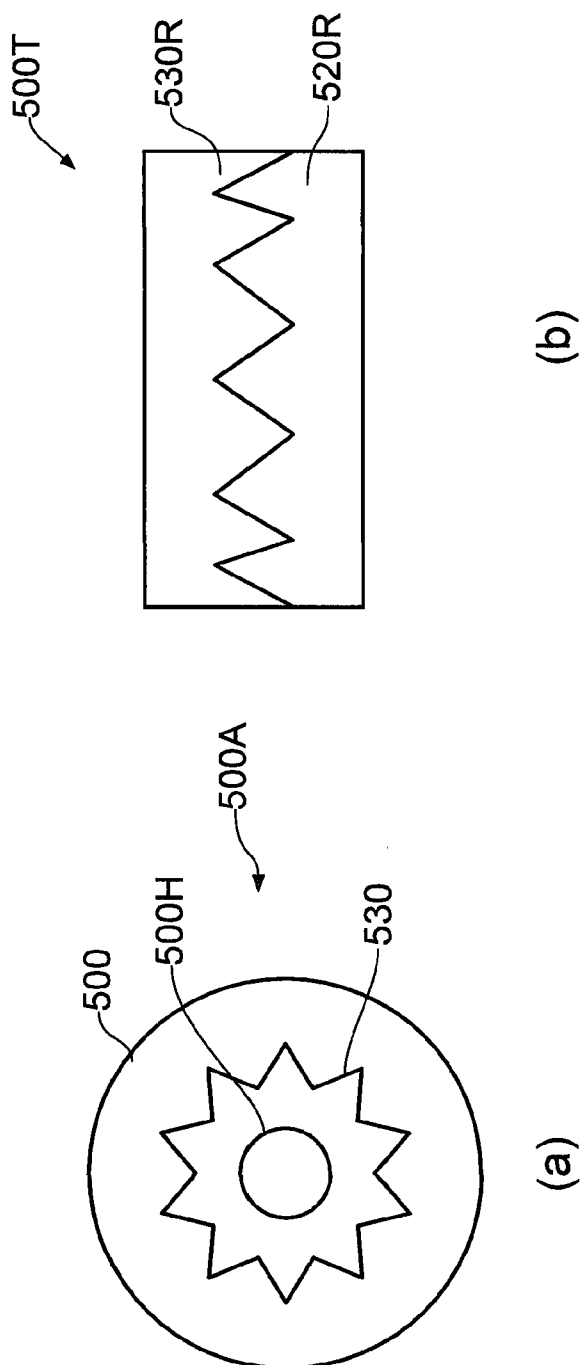


FIG. 11

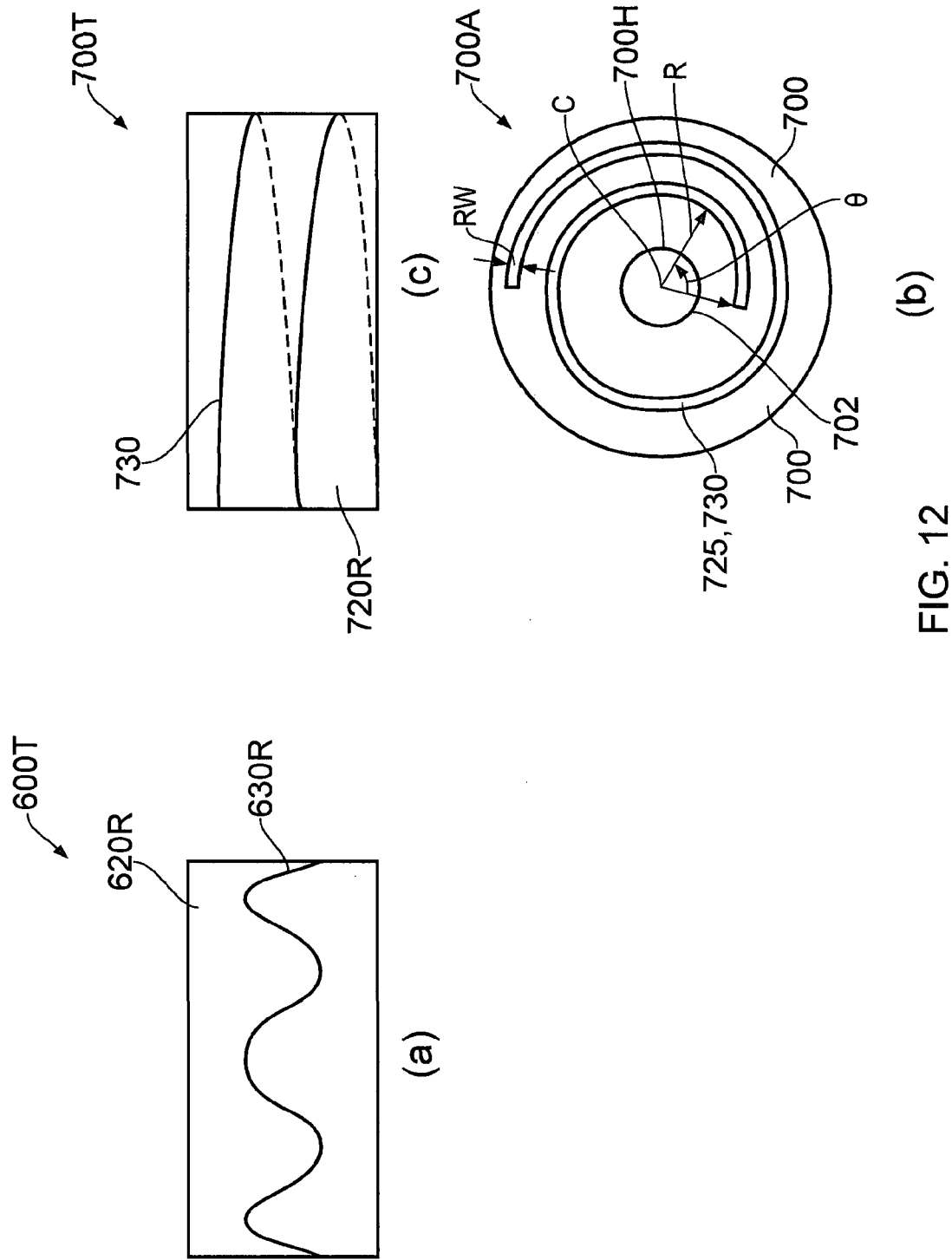


FIG. 12