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(54) **Jewellery assembly**

(57) A item of jewellery includes a support element (92) provided with inner and outer zones, and first and second support surfaces which face one another and taper from the inner to the outer zones, wherein said taper provides a bisector (126) extending along the axis of taper, there being provided on each of said support surfaces first and second spaced recesses or protrusions, said support element (92) having a resilience; said item of jewellery also including a collet (70) for holding a stone or other item, said collet (70) including first and second collet surfaces complementary to the first and second support surfaces, said collet surfaces having a taper substantially corresponding to the taper of the support surfaces, each of said collet surfaces including first and second spaced protrusions or recesses designed to cooperate and fit together with associated recesses or protrusions of the support surfaces, said collet (70) being fittable to said support whereby each of said protrusions includes a surface extending substantially transverse to said bisector.

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Description

Field of the Invention

[0001] The present invention relates to a jewellery assembly, to a kit for a jewellery assembly and a method of manufacturing jewellery assemblies.

Background of the Invention

[0002] Jewellery assemblies, such as rings, are commonly formed by casting a collet and a shank separately. The collet and the shank are generally moulded, cast or otherwise formed from different materials. For example, the collet may be moulded from 18 carat white gold while the shank may be made of 18 carat yellow gold. In order to provide a finished assembly, the collet and the shank need to be held in a predetermined relative position and fixed together for example by soldering. In the case of high value jewellery, for instance rings with precious stones, the item of jewellery is often delicate and formed of small parts. Given their high value, they need to be manufactured accurately to be of acceptable quality. However, owing to the shape of the collet, it is difficult to hold the components in the correct position for the soldering process.

[0003] It is known in the manufacture of high quality rings to provide at the base of the collet a support bar which has extensions either side of the base which in use are made to rest against the inner circumference of the shank. The support bar is used to hold the collet to the shank while solder is applied to fix the two components together. Once the collet and the shank have been soldered together, the support bar can be removed by filing it down.

[0004] In order to perform this procedure, considerable jeweller time and skill is required to place and hold the collet in the correct orientation with respect to the shank. Slight variations in the relative position or orientation of the collet and shank will have a significant effect on the aesthetic appearance of the finished product. If the collet is designed to accept a diamond or other precious stone to make a high quality and expensive item of jewellery, the slightest imperfection can result in rejection of the entire item of jewellery. Thus, a jeweller must expend much time and care to ensure that the ring is manufactured precisely in order to avoid wastage. Even so, given the small nature of the components of the ring (or other item of jewellery) this is a difficult task.

[0005] In addition to the difficulties in manufacturing the ring or other item of jewellery, there is significant wastage in precious material (typically gold or platinum), in particular when the support bar is removed. Although some of the material of the support bar can be recovered, much is lost during filing of this to an aesthetically acceptable condition.

[0006] The wastage in terms of materials and time caused by these problems inevitably also increases the cost of production.

[0007] Problems also occur at the casting stage. In order to cast a component, a sprue needs to be connected to a mould to inject molten material which, when cooled, forms the component. There is always a point at which the sprue connects to the mould, which is generally less well finished and provides an apparent imperfection in the final article. This occurs because the mould is not sealed at the point at which it opens into the sprue and the edge of the moulded article is therefore often poorly defined. Such an imperfection is most noticeable on the collet, since this is the centrepiece of the ring assembly and is specifically designed for aesthetic appeal.

[0008] It is known to provide ring assemblies which are of modular form and which can be connected together by mechanical coupling elements. These may, for instance, provide for replacement of a stone of the ring, allowing the wearer to select one of a variety of different stones. In other cases, a ring may allow for a stone holder to be rotated to show one of a variety of stones fitted to the holder. Such arrangements, while having their uses, are not suitable for precious jewellery. A precious ring generally requires a precise and delicate setting which will last indefinitely and for which bulky mechanical coupling elements of the types envisaged and required by such known modular assemblies are not appropriate or acceptable.

[0009] US-2007/0056321 describes a ring assembly which has interchangeable settings. The setting is provided with laterally extending tabs which can fit into corresponding recesses in angled ends of the circular body to resist this being ejected by the tensile force fit. The tabs and recesses must be of a particular size so as to provide sufficient strength to the fitting in order to seek to prevent its inadvertent loss, as well as to ensure that the fitting sits reasonably well on the ring body, particularly after several or many instances of replacement. The skilled person will appreciate that a ring which must be prized open to release a fitting will loosen every time it is opened, leading to weakening of the fitting and of the assembly itself. Furthermore, the nature of the fitting requires it to be of a certain minimum size which precludes the use with delicate ring structures of the type which are common in precious rings and other jewellery. For these reasons such designs are not considered appropriate for precious jewellery.

[0010] JP-8173222 discloses a ring member and a rotary stone carrying body, wherein the body is rotatably coupled to the annular ring member. The stone carrying body can be rotated such that any one of a plurality of faces is located as the outer-most face of the ring. In one embodiment, this is achieved by having a cuboidal (square) body which is positioned between two parallel square ends of the annular ring member. The cuboidal body is provided with two laterally extending shanks which extend from the rotary body into corresponding bores in the faces of the annular ring member. Four small protrusions are provided around the shanks which align

with recesses in the square ends of the ring to form a ratchet effect by cooperating with corresponding holes in the faces of the annular ring member to allow the rotary body to be clipped into any one of the four positions. Such a design is not suitable for replacement of the fitting and will suffer from weakening of the ring body even upon first assembly in light of the need to open the ring body significantly to accommodate the rotatable fitting and its pins. Such a ring is not suitable for high value jewellery.

[0011] WO 96/33633 discloses a device in which a removable setting for a jewellery item includes a threaded stem and locking pins. US 4220017 discloses a component which can be converted into a ring, a pendant or potentially a brooch, by providing a riveting bar which can be placed through the shank and collet to connect them together. JP 11305671 discloses a device in which a base holding a jewel can be detachably connected to a sample body by magnetic means and by their relative rotation to enable two engaging parts to cooperate. DE 1242030 discloses a retention for a jewel which utilises stamped claws that are then held together with the use of an outer ring. US 5433090 discloses a ring in which the bead or ball is held in position either by the tensile strength of the shank ends, or by being fitted into notches in the end portions.

[0012] US-2006/0288734 discloses an arrangement in which a shank of standard form and dimensions can have fitted thereto one of a variety of heads to which a stone is attached. The arrangement provides a fitting bar or bridge in the shank which supports and fixes the head by a friction fit. The head and shank can be permanently fixed to one another once a head and shank have been selected. It is described that the head could be kept on the shank by a friction fit so as to enable a customer to see and feel the ring prior to fixing of the head to the shank. Different heads can be made to fit on the same shank as a result of the friction fit. The structure includes a common fixing element of predefined form which fixes an aesthetically relevant feature to the ring, in this case a bridge of required diameter and length as well as corresponding head fixings which overlie the bridge. Furthermore, the arrangement relies upon a friction fit between the head and shank in order to be able to demonstrate and allow the handling of the ring and head combination. A friction fit of this nature requires a certain strength to the individual components, such as the pin, and thus a minimum practical size of these components. Moreover, due to manufacturing tolerances, fittings which are too small will provide an unreliable fit, with the result that this also limits the minimum size of these fittings.

[0013] It is to be noted that arrangements which provide a fixing below the collet cause the collet to sit proud of the shank with resultant loss of delicacy of the item of jewellery. It is also to be noted that arrangements which provide a narrow fitting element, such as a support bridge, can be difficult to manufacture, in particular to be cast as a result of the thermodynamics of the casting process.

[0014] It is considered that many of the known devices are not suitable for high value rings which carry precious gemstones. In addition, for rings in which the collet is interchangeable, the features necessary to enable the interchangeability generally impose significant limitations on the possible designs that can be used and are on the whole unsuitable for jewellery items of delicate or sophisticated design. Furthermore, interchangeability in some devices requires distorting parts of the ring which can lead to permanent deformation and weakening of the ring.

Summary of the Present Invention

[0015] The present invention seeks to provide an improved article of jewellery, kit for the manufacture of jewellery and an improved method of manufacturing jewellery.

[0016] According to an aspect of the present invention, there is provided an item of jewellery including a support element provided with inner and outer zones, and first and second support surfaces which face one another and taper from the inner to the outer zones, wherein said taper provides a bisector extending along the axis of taper, there being provided on each of said support surfaces first and second spaced recesses or protrusions, said support element having a resilience; said item of jewellery also including a collet for holding a stone or other item, said collet including first and second collet surfaces complementary to the first and second support surfaces, said collet surfaces having a taper substantially corresponding to the taper of the support surfaces, each of said collet surfaces including first and second spaced protrusions or recesses designed to cooperate and fit together with associated recesses or protrusions of the support surfaces, wherein at least one of said protrusions includes a surface extending substantially transverse to said bisector.

[0017] Advantageously, more than one of said protrusions includes a surface extending substantially transverse to said bisector, preferably at least one on each side of the collet. In the preferred embodiment each protrusion includes a surface extending substantially transverse to said bisector.

[0018] Advantageously, the protrusions have a length or depth of no more than substantially 1 millimetre. In the preferred embodiment, the protrusions have a length in the range of 0.3 to 0.9 millimetres, more preferably 0.4 to 0.8 or 0.75 millimetres and in one embodiment in the region of 0.65 millimetres. Only a portion of each protrusion and associated recess need have a surface extending substantially perpendicularly to the bisector. It has been found that having the correct dimensions for the protrusions or pins can minimise the amount of elastic deformation required of the shank and yet provide a reliable and firm coupling of the collet to the shank, in which the positioning and orientation of the collet to the shank

is precise and fixed, suitable for a high quality jewellery item.

[0019] This arrangement provides a modular jewellery assembly particularly useful for high value jewellery and for the provision of precious gemstones, in particular a modular assembly which can hold the modules together reliably and without imposing upon the design of the jewellery aesthetic restrictions which may adversely affect the design of the jewellery. The arrangement provides a fitting zone on the support, a ring shank for instance, which provides what in effect could be termed a wedged zone into which a correspondingly shaped collet can fit. The support and collet are provided with complementary protrusions and recesses of a structure such that the protrusions will fit in the associated recesses. The arrangement is such that the support surfaces of the support will splay outwardly when the collect is pushed into the wedge opening between the support surfaces, this splaying being resilient and temporary and of a minor extent, allowing the support to spring back to its original position once the collet is in place, thus avoiding any permanent deformation of the support. The provision of transverse support surfaces on the protrusions and recesses plays an important role. These protrusions need in practice to be small to allow for the design of aesthetically delicate items of jewellery. A small protrusion will in practice not give a particularly good coupling. It has been found that providing a transverse surface, which in practice will be transverse to the direction of insertion and required removal of the collet, gives a good and reliable fit even with a protrusion which is very short, that is of less than one millimetre in length. This thus provides a good fit of the collet to the support and still allows the design of delicate items of jewellery. The provision of at least two protrusions and associated recesses on each support/collet surface, ensures that there is no rotation of the collet relative to the support, which can thus ensure precise positioning and holding of this during subsequent fixation of the collet to the support.

[0020] It has been found that as long as the length of the protrusions is appropriate, the collet can fit onto the shank reliably without damaging the shape of the shank or the quality of the fit after assembly. The cross-sectional shape (in the transverse direction) is not critical in such circumstances. In one embodiment, the protrusions and recesses are round in transverse cross-section but it has been found that they could equally be square or rectangular, a half-D shape or any other shape. One embodiment which has been found effective provides for each pair of protrusions one protrusion which is square in axial cross-section and the other which is a half-D shape in axial cross-section, each pair being located on a respective side of the collet or support. Thus, the two protrusions may have the same cross-sectional shape but might have different shapes.

[0021] The protrusions may be rounded at their ends, which can facilitate the fitting of the collet to the support. In another embodiment, the pins may have a narrow or narrowing free end.

[0022] Although the protrusions can be located on either the collet or the shank, it has been found that it is preferable that these be located on the collet as this facilitates assembly and quality of the fit.

[0023] In some embodiments, the support surfaces and the collet surfaces are not flat and preferably curved. Advantageously, they are curved along the axis of the bisector. Such curvature aids in ensuring proper orientation of the collet to the shank, particularly with delicate jewellery designs, as well as in guiding the protrusions to their respective recesses or slots.

[0024] The angle of taper of the support and collet surfaces can range from around 10 degrees to around 140 degrees, more preferably from around 20 degrees to around 90 degrees and most preferably from around 30 degrees to around 80 degrees.

[0025] The protrusions can be of different lengths.

[0026] In the preferred embodiment, the collet includes a plurality of stone supports, which stone supports are located outside an area of the collet surfaces and outside an area of the support surfaces. In the preferred embodiment, the stone supports are in the form of or include support arms. Having the stone supports outside the area of the support and collet surfaces enables the stone supports to be designed to any angle and/or length and/or shape suitable for the stone to be held thereby and aesthetic design of the item, without changing the characteristics of the support surfaces of the support or collet. Thus, the item of jewellery can hold a large variety of stones and have a large variety of designs, while retaining standard characteristics and in particular standardised versions of the support.

[0027] According to another aspect of the present invention, there is provided a kit for the manufacture of an item of jewellery, the kit including a plurality of supports and a plurality of collets as herein specified, wherein at least one of the plurality of supports and the plurality of collets includes at least two different designs.

[0028] In an embodiment, the kit includes supports and collets of valuable and/or non-valuable material, such as of base metal or an alloy or a plastics material. Such a kit can be particularly beneficial where the customer is not able to visit the premises where the jewellery is manufactured or sold. The manufacturer or seller is able to send a plurality of either supports or collets, possibly in a less expensive base material. The customer is then able to select the combination that he or she prefers.

[0029] In the described embodiments, the item of jewellery is a ring, in which case the support will be the ring body or shank.

[0030] Most preferably, the support and collet are fixed to one another, for instance by soldering, welding, bonding or by another permanent fixation method.

[0031] According to another aspect of the present invention, there is provided a method of manufacturing a jewellery assembly, including the steps of:

providing a jewellery item as herein specified, mounting the collet onto the support; and fixing the collet to the support to inhibit their subsequent separation.

[0032] In the preferred embodiments, it will be appreciated, the protrusions fit entirely within their associated recesses, such that they are invisible from the outside of the item of jewellery. This avoids the need to remove any parts of the protrusions, increasing manufacturing yield.

[0033] It has been discovered that many configurations of mechanical locking elements restrict the freedom of design of jewellery and fail in practice to provide a fit of the collet to the shank which is precise and reliable. This is particularly the case when it is desired to have a shank for a very thin ring or a ring in which the shank splits into a plurality of support bars in the region of the collet (Tiffany style for instance).

[0034] Preferably, the protrusions are integrally moulded or cast with the collet or support. This enables the protrusions to be used as an effective connection point for a sprue and runner system during moulding. As described herein, the point at which the sprue and runner system connects to the mould is generally an imperfection of the finished article. The preferred method combines the improvement of the assembly of the collet and support as well as providing an inconspicuous point of entry for moulding the collet or support. This is especially important for the collet, as the collet is the centrepiece of the finished ring assembly.

[0035] Preferably, the collet is first mounted on the support removably, such that different collets can be sequentially mounted on the same support, and then a chosen collet fixed into place, for instance by soldering, to finish the assembly.

[0036] According to another aspect of the present invention, there is provided an item of jewellery including a support element provided with inner and outer zones, and first and second support surfaces which face one another and taper from the inner to the outer zones, said support surfaces having an area, there being provided on each of said support surfaces one or more recesses or protrusions, said support element having a resilience; said item of jewellery also including a collet for holding a stone or other item, said collet including first and second collet surfaces complementary to the first and second support surfaces, said collet surfaces having a taper substantially corresponding to the taper of the support surfaces, said collect surfaces having an area, each of said collet surfaces including one or more protrusions or recesses designed to cooperate and fit together with associated recesses or protrusions of the support surfaces, said collet also including a plurality of stone support elements, wherein said stone support elements are located outside the area of the collet surfaces and outside the area of the support surfaces.

[0037] Preferably, the areas of the support surfaces and the collet surfaces are complementary, that is of substantially the same size and shape.

[0038] This aspect of the present invention can include one or more of the other features of the various embodiments taught herein.

Description of the Drawings

[0039] Embodiments of the invention are described below, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a side view of a prior art collet;
Figure 2 is a side view of the collet of Figure 1 from a direction perpendicular to that of Figure 1;
Figure 3 is a perspective view of the collet of Figures 1 and 2;
Figure 4 is a side view of the top section of an example of prior art ring assembly art, viewed perpendicular to the axis of the shank, comprising a collet according to Figures 1 to 3 and a shank;
Figure 5 is a side view of the entire ring assembly, viewed perpendicular to the axis of the shank;
Figure 6 is a side view of the section of the ring assembly of Figures 4 and 5 viewed parallel to the axis of the shank;
Figure 7 is a side view of the entire ring assembly, viewed along the axis of the shank;
Figure 8 a side view of another example of collet;
Figure 9 is a side view of the collet of Figure 8, viewed from a direction perpendicular to that of Figure 8;
Figure 10 is a perspective view of the collet of Figures 8 and 9;
Figure 11 is a side view of an entire ring assembly, viewed perpendicular to the axis of the shank, to which is fitted a collet as shown in Figures 8 to 10;
Figure 12 is a side view of the ring assembly of Figure 11 viewed along the axis of the shank;
Figure 13 is a side view of an embodiment of collet according to the present invention;
Figure 14 is a side view of the collet of Figure 13, viewed from a direction perpendicular to that of Figure 13;
Figure 15 is a bottom plan view of the collet of Figures 13 and 14;
Figure 16 is a perspective view of the collet of Figures 13 to 15;
Figure 17 is a side view of the top section of an embodiment of ring assembly according to the present invention, including a collet of the type shown in Figures 13 to 16, viewed perpendicular to the axis of the shank;
Figure 18 is a side view of the section of the ring assembly of Figure 17 viewed parallel to the axis of the shank;
Figure 19 is a side view of the ring assembly of Figures 17 and 18 viewed along the axis of the shank;
Figure 20 is a side view of the section of the ring assembly of Figures 17 to 19 viewed parallel to the axis of the shank;

Figure 21 is a side view of the entire ring assembly of Figures 17 to 20;
Figure 22 is a side view of the top section of another embodiment of ring assembly according to the present invention, including a shank and collet, viewed perpendicular to the axis of the shank;
Figure 23 is a side view of the ring assembly of Figure 22;
Figure 24 is a perspective view of the ring assembly of Figures 22 and 23;
Figure 25 is a schematic view of an embodiment of shank;
Figure 26 is a schematic view of part of an embodiment of collet associated with the shank of Figure 25;
Figure 27 is a view of the whole of the collet of Figure 26;
Figures 28A to 28C show different examples of axial cross-sections for the protrusions or pins of the collets and/or shanks of the preferred embodiments;
Figures 29A to 29C show different side elevational views of embodiments of protrusions or pins for the collets and/or shanks;
Figure 30 is a side elevational and schematic view of a part of another embodiment of ring assembly and in particular of a part of the collet;
Figure 31 is a side elevational view of the ring of Figure 30 with an example of entire collet;
Figure 32 is a side elevational view of the ring of Figure 30 with an example of another collet;
Figure 33 is a plan view of a part of the ring assembly of Figure 30;
Figure 34 is a plan view of the ring assembly of Figure 31;
Figure 35 is a plan view of the ring assembly of Figure 32;
Figures 36 to 38 show an example of ring assembly for a round cut gemstone;
Figures 39 to 41 show another example of ring assembly for a round cut gemstone;
Figures 42 to 44 show an example of ring assembly for a square cut gemstone;
Figures 45 to 47 show an example of ring assembly for a pear cut gemstone;
Figure 48 is a side view of an embodiment of collet moulding; and
Figure 49 is a perspective view of the collet moulding arrangement of Figure 48.

Description of the Preferred Embodiments

[0040] The embodiments described herein all relate to a ring assembly. It is to be appreciated, though, that the teachings herein are not limited to ring assemblies but can be applied to other types of jewellery, including for example, necklaces, bracelets, bangles, brooches and so on.

[0041] In the following description, examples and embodiments are described assuming that each of the components is in the orientation as it would be in a ring assembly which is orientated such that a collet is at the top of a shank. However, this is done for facility of description only, the relations between the components being equivalent in any other orientation.

[0042] Figures 1 to 7 depict a prior art example of ring, in which Figures 1 to 3 depict a collet 12 and Figures 5 to 7 depict a ring assembly 10 incorporating the collet 12 of Figures 1 to 3.

[0043] The collet 12 comprises a substantially frusto-conical body 14 and a support bar 16. The collet body 14 is provided with a recessed internal shelf 18 for supporting a jewel stone or precious metal. The support bar 16 substantially follows the arc of a circle and is formed below the base of the collet 12.

[0044] The ring assembly 10 includes a shank 20 is a substantially annular member provided with a gap 22 in which the collet 12 can sit such that the support bar 16 rests against the inner circumference of the shank 20.

[0045] When the collet 12 and shank 20 are to be assembled together, the collet 12 can be held to the shank 20 by support bar 16. While the support bar 16 provides a convenient means by which to hold the two elements to one another, the support bar 16 can slide and rotate against the inner circumferential wall of the shank 20. Accordingly, there can be a problem of tilting and imperfect positioning, leading to a misaligned collet or unwanted gaps in the ring assembly 10. It is sometimes the case that the application of the solder is of sufficient force to tilt or move the collet 12 if it is not held tightly enough to the shank by the jeweller.

[0046] Furthermore, once the collet 12 and shank 20 have been successfully soldered together, the ring assembly, as shown in Figures 6 and 7, still has the support bar 16 at the base of the collet 12, which forms and uncomfortable and unattractive bulge. This therefore needs to be filed away. However, the filing of the support bar 16 can be imperfect, in that it leaves remnants of the support bar on the inside of the shank. Furthermore, the filing process can wear away some of the inner surface of the shank 20 or some of the base of the collet 12. Additionally, since the support bar 16 is moulded integrally with the collet 12, it is composed of the same high-value material. The filing of this support bar 16 is therefore itself a wastage which adds significantly to the cost of production. Meanwhile, the problems of low production yield and the consequent wastage of imperfect products still persist.

[0047] With reference to Figures 8 to 10, another example of a collet 30 is shown. Collet 30 comprises a body 32 which is formed as a hollow frusto-conical element. The body 32 includes a circular top end 34 which tapers to a circular base 36 of smaller diameter. The taper forms a tapered external surface 18. Within the body 32, an inner shelf 40 is provided around the internal circumference of the body 32.

[0048] Extending either side of the body 32 are two locking elements in the form of first and second protru-

sions 42, 44. The protrusions 42, 44 are diametrically opposed on the body 32 and are both displaced from the base 36 by the same distance, being preferably closer to the base 36 than to the top 34. The protrusions 42, 44 have a cross-section which is a square and cooperate with corresponding recesses in a shank (described below).

[0049] With reference to Figures 11 to 13, a shank 50 is depicted with the collet 30 mounted thereon. The top ends of the shank 50 are separated by a gap into which the collet 30 fits. The top ends of the shank 50 are tapered from the outer to the inner surface of the shank 50 to correspond with the frusto-conical shape of the collet 30. The shank 50 may be provided with a decorative coating 60 on the outermost surface. Each of the top ends of the shank 50 includes a recess 62, 64 shaped and positioned to mate with the square protrusions 42, 44. In order to provide adequate locking of the collet 30 to the shank 50, this arrangement can require locking elements 42,44/62,64 which are of a relatively large size. This restricts the design of the ring and can still suffer from imprecise alignment of the collet 30 relative to the shank 50, particularly having regard to manufacturing tolerances. Moreover, large protrusions can cause distortion of the shank. For this purpose, as shown, the shank may be formed of two halves which are then fixed together with the collet 30 in place. This saves having to distort the shank 50 to accommodate the large protrusions.

[0050] Referring now to Figures 14 to 16, there is shown an embodiment of collet 70 according to the invention. The collet 70 includes, in this embodiment, four arms 72 which curve to become substantially parallel to one another at their upper ends to form the four corners of a square, for holding in this instance a gemstone at the four corners. The arms 72 meet at a base point 76 which forms the base of the collet 70.

[0051] Two support elements 76 and 78, providing what could be described as collet supports, are coupled to respective pairs of adjacent arms 72 and such that the support sides 78 face one another. Each support side 78 includes a semi-circular or D-shaped recess or hole 80 through its centre with an axis perpendicular to the support side 78. The two recesses 80 in the support sides 78 are arranged to be substantially co-axial. Each of the support sides 78 is provided with an internal curved section 82, configured to conform to the surface of an imaginary sphere resting on the top of support sides 78. However, different shapes of the internal sections 82 can be provided in dependence upon the purpose of the collet 70, as explained below.

[0052] Proximate the base 76 of the collet 70, extending in opposite directions and substantially parallel to the axis of the holes 80, the are provided two locking elements 84, 86 between the base 76 and a point 88 at which the arms 72 separate. In the example shown in Figures 14 to 16, the locking elements are protrusions 84, 86.

[0053] The collet 70 is thus provided with two protrusions either side of the collet 70 and aligned with one another in a direction along the longitudinal axis of the collet 70.

[0054] Referring now to Figures 17 to 21, there is shown a ring 90 which includes a shank 92 to which is fitted the collet 70 of Figures 14 to 16. The shank 90 includes first and second facing ends 94, 96 which are, in this embodiment, in the form of split arms 98, 100 and 102, 104 respectively. The inner arms 100, 104 circumscribe a substantially circular shape of the inside of the ring annulus, whereas the outer arms 98, 102 curve upwardly. The upper arms 98, 102 are provided with semi-circular or D-shaped protrusions or pins which correspond in shape and size to the holes 80 in the collet 70. The lower arms 100, 104 of this embodiment are provided with square cross-section recesses corresponding in shape and size to the protrusions 84, 86 of the collet 70. The arms 98-104 form two tapering support surfaces which taper at an angle α as shown, for example, in Figures 25, 26 and 30. This angle α corresponds to an angle of taper of the collet surfaces on which the holes 80 and pins 84,86 are provided.

[0055] The angle α of taper of the support surfaces provided by the shank 90 can be anything from around 10 to around 140°, in the example shown being in the region of 30 to 80°. It will be apparent also from Figures 18 and 20 in particular that the location of two locking elements on either side of the collet 70 (upper locking elements 80 and lower locking elements 84, 86) will fix the collet 70 rotationally relative to the shank 90. The particular design of the locking elements (described in further detail below in connection with Figures 25 to 28) can also provide a secure fixing of the collet 70 to the shank 90 in the manner that the collet 70 can nevertheless be removed from the shank 90, for example while the customer is choosing a particular design of ring. In particular, these features of the locking elements, described in further detail below, enable these to be quite small and thus enables the design of rings and other jewellery having delicate aesthetic features, such as the double arms 98, 100/102, 104 (Tiffany style fittings) as shown in the embodiment of Figures 17 to 24. This is not possible with many of the prior art designs of locking systems for rings of this nature.

[0056] It will be apparent also from Figures 20 and 21 that once the collet 70 is fitted to the shank 92, there is a clean fit of the collet to the shank and thus an aesthetically pleasing product. In some of the embodiments, the shank 92 may fit to the collet 70 in a slightly stressed, expanded, condition, that is the collet 70 may be just slightly wider than the spacing between the support surfaces of the shank 92 so as to keep the shank 92 in slight tension. This can enhance the solidity of the fixing between the collet 70 and the shank 92. However, the provision of the double fixing points can provide more than adequate location and fixing of the collet 70 to the shank 92 even without keeping the shank in tension.

[0057] Referring now to Figures 22 to 24, there is

shown an arrangement of ring very similar to that of Figures 18 to 21. In place of the collet 70 shown in Figures 14 to 16 in particular, there is provided a collet 110 having a narrowed base 112, provided simply for aesthetic purposes. The collet 110 is equally provided with side supports 78 within which there are located recesses 60 as in the collet of Figures 14 to 16. The upper arms 98, 102 of the shank 92 are provided with protrusions 114, 116 which project into the holes 60 in the side supports 78. Similarly, the lower arms 100, 104 are provided with square cross-section recesses 118, 120 which receive the square locking protrusions 84, 86 provided on the collet 110 and equivalent to the same protrusions of the embodiment of Figures 14 to 16.

[0058] Again, the collet 110 provides collet supports, which include the holes 80 and protrusions 84, 86 which are substantially aligned with one another on each side and which alignment tapers by an angle α equivalent to that of the embodiment of Figures 14 to 16, such that the collet 110 can fit the same shank 92 as the embodiment of Figures 14 to 16.

[0059] The shank 92 shown in Figures 18 to 24 can fit a variety of different designs of collet 110, in dependence upon jeweller and customer preferences. It is only necessary for the collets to include locking elements which are substantially identical to those provided for at the ends of the arms 98-104 of the shank 92.

[0060] Although the embodiments of Figures 14 to 24 provide for the collet to have on either side a hole and a protrusion (80 and 84, 86), this specific arrangement is not essential. For instance, protrusions can be provided on the collet only (with appropriate recesses in the shank 92) or vice versa. It is preferred that the protrusions are provided in the collet and the recesses in the shank, for reasons which will become apparent below.

[0061] Referring now to Figure 25, there is shown in schematic form another embodiment of shank 120, of which only the upper part there of is visible in Figure 25. The shank 120 has two ends 122, 124 which provide angled shank support surfaces which taper at angle α about a bisector line 126. The bisector line 126 extends radially towards the radial centre of the shank ring. In the ends 122, 124 of the shank 120, there are provided four recesses 128-124, two on each end 122, 124. The recesses 128, 130 and 132, 134 are aligned with the plane of the shank 120 and are preferably located at the planar centre point of the shank 120. Each recess 128-134 extends, in this embodiment, in a direction substantially perpendicular to the bisector 126 (they may extend substantially perpendicularly thereto but is preferred that they extend precisely perpendicularly to the bisector 126). Although Figure 25 shows the recesses 128-134 being substantially cylindrical along their length, they may be rounded at the ends or may even taper towards their ends. It is, however, preferred that the recesses 128-134 include at least one surface which is substantially perpendicular to the bisector 136. This surface may be the whole of or part of the upper surface of each recess 128-134 (that is the surface of each recess which can be described as being radially outermost relative to the centre point of the shank 120). Thus, the inner surfaces of each recess 128-134 need not necessarily be perpendicular or substantially perpendicular to the bisector 126.

[0062] Referring now to Figure 26, there is shown in schematic form the main portion of an embodiment of collet 140 suitable for fitting to the shank 120 of Figure 25. The collet 140, which is shown in Figure 26 without the stone support arms, includes four protrusions 142-148, two on either side 150 of the collet 140. The sides 150, 152 can be deemed collet support surfaces. The protrusions or pins 142-148 match in terms of spacing, positioning and size the recesses 128-134 in the shank 120. Referring to Figure 27 also, the collet 140 is also provided with arms 154-156 for holding a gemstone 155 in the collet. There may be provided two, three, four or more arms or other support elements 154-156, in dependence upon the design of the arms, the shape of the stone and jeweller/customer preferences.

[0063] It is to be appreciated for all embodiments that the recesses could be slightly wider and/or larger than their associated pins while still maintaining a reliable and precise fit of the collet to the shank, particularly when the shank is kept in tension.

[0064] As will be apparent from Figure 26, the support surfaces 150, 152 of the collet 140 taper at an angle α equivalent to the angle α of the taper of the surfaces 132, 124 of the shank 120.

[0065] Considering the shank and collet of Figures 25 to 27 together, the collet 140 can be fitted to the shank 120 by moving the collet 140 into the shank 120 from above, typically in the direction of arrow 160 shown in Figure 25. In so doing, it will be appreciated, the protrusions 142, 148 will eventually come into contact with the tapering surfaces 122, 124 of the shank 120. As the collet 140 is intended to be a snug fit in the shank 120, the pins or protrusions 142-148 will at some point during the insertion process urge the surfaces 122, 124 of the shank 120 apart until the pins 142-148 become aligned with and slide into their respective recesses 128-134, at which point the shank 120 will spring back to its original position, or substantially to its original position in the case that the shank is kept under tension.

[0066] It will be appreciated that if the protrusions 142-148 are long, as is necessary for instance in a number of prior art designs, these will force the shank 120 to stretch open by a significant amount. In the case in particular of a delicate ring made, for instance, of a relatively soft material such as gold or silver, if the shank 120 is deformed too much, at least a part of that deformation will become permanent, with the result that the shank 120 will not spring back to its original position, leaving the fit of the collet 140 loose within the shank 120. A problem with the prior art designs is that the protrusions have to be relatively long in order to provide a secure footing of the collet 140 to the shank. In this particular embodiment, by contrast, the provision of two pro-

trusions or locking elements either side of the collet and shank and the nature of the surfaces of the protrusions and recesses enables the protrusions 142-148 to be considerably shorter than in prior art devices. In fact, it is preferred that the protrusions 142-148 extend by no more than around 1 mm from the surfaces 150-152 of the collet 140. Preferably, these protrusions 142-148 extend therebetween 0.2 to 0.9 mm, more preferably 0.4 to 0.75/0.8 mm (this being the case for all the embodiments). Various designs have been produced with protrusions in the region of 0.65 mm in length. Such protrusions are very small yet it has been found can still provide very precise, accurate and reliable coupling of the collet 140 to the shank 120. In particular, the provision of surfaces which are substantially perpendicular to the bisector 126 can provide a solid connection holding the collet 140 to the shank 120 preventing this from falling off the shank 120, in particular in a direction opposite that of the arrow 160, even with very short protrusions. This also enables the angle α of taper to be reduced to, for example, 30 or 60° or even less and still provide the easy fitting of the collet 140 to the shank 120 and one which is very precise and reliable. Another important feature of this arrangement of protrusions 142-148 and accompanying recesses 128-134 and in particular the dimensions of these, is that it is possible for a jeweller or customer to pull the collet 140 off the shank 120, for example to fit a different style collet or shank, without damaging either the protrusions 142-148 or the shank 120, such that the shank can still properly hold (precisely and reliably) a collet of another design upon a subsequent fitting of such collet to the shank 120. Thus, this arrangement provides a reliable and repeatable fixation of collets to shanks. This is not in practice possible with designs which require larger protrusions or other locking elements or ones which are necessarily longer as a result of their intended purpose and the design of the ring or other item of jewellery. In such instances, repeated fitting of the collet to the shank will degrade the quality of the fitting, as well as providing significant restrictions to the aesthetic appearance of the jewellery item producible by such prior art methods.

[0067] It will be noticed in particular that the protrusions and recesses of the preferred embodiments described herein have lengths, as described above, preferably less than 1 mm and equivalent widths (that is of preferably less than 1 mm and more preferably in the region of 0.4 to 0.8 mm).

[0068] Referring now to Figures 28A to 28C, there are shown some examples of cross-sectional shapes suitable for the protrusions or pins 142-148 and associated recesses 128-134 of the collet/shank arrangement shown in Figures 24 to 26 and applicable to all of the embodiments of jewellery assembly disclosed in this patent application. Figure 28A shows a cross-sectional shape which is semi-circular or D-shaped, Figure 28B shows one which is circular in cross-section, whereas Figure 28C shows a cross-section which is substantially square. It is important to note that the cross-sectional shape of the pins or protrusions 142-148 and the associated recesses 128-134 is not critical in particular because of the number and arrangement of protrusions and recesses, as well as the collet and shank surfaces upon which these are provided. Any cross-sectional shape can be used and it is not necessary for the pins all to be the same shape, diameter or length, as demonstrated, for instance, with the embodiment shown in Figures 14-21 in particular.

[0069] Figures 29A to 29C show side elevational views of different embodiments of pin or protrusion. Figure 29A shows a protrusion which is substantially cylindrical in shape (for instance of square cross-section and thus having the shape of a rectangular cuboid or being round in cross-section and thus being rod-shaped). The protrusion of Figure 29A could have any desired cross-sectional shape.

[0070] Figure 29B shows a protrusion 150 which tapers to a point 152. The protrusion 150 retains a surface 154 which is substantially perpendicular to the bisector 126, as explained above. This surface 154 acts to hold the collet to the shank in a reliable and precise manner. The point 152 can assist in the location of the protrusion 150 into its associated recess.

[0071] Figure 29C shows an embodiment of protrusion 160 which is rounded at its end 162. Again the protrusion 160 includes at least one surface 164 which is perpendicular or substantially perpendicular to the bisector 136, for the purposes stated above. In all instances of protrusion, it is necessary only to have a surface 154, 164 which is substantially parallel to the bisector which is a fraction of a millimetre in length.

[0072] Referring now to Figures 30 to 35, there are shown two other embodiments of ring designs. Referring first to the embodiment of Figures 30 and 31, this embodiment includes a shank 200 and a collet body 202 which is fitted into the shank. In Figure 30 the collet 202 is shown without the gemstone support arms, which are shown in Figure 31. The shank 200 and collet body 202 are provided with locking pins/recesses 204 of the types described above. The collet body 202 is also provided with a plurality of gem support arms 206 (four being shown in Figures 31 and 33 although the number of these will be dependent upon the stone and jeweller/customer preference). The arms 206, as can be seen in particular in Figure 33, lie outside the area encompassed by the shank 200, in particular, and upwardly to suitable fixations (not shown) to fix onto a gemstone 208. The arms 208 thus lie outside the area of the collet and support surfaces which abut one another. This arrangement of arms 206 contrasts with many prior art designs, in which the arms lie at least partially within the area or zone of the shank 200 or shank ends. The advantage of this feature can be seen in particular with the embodiment of Figures 32 and 35. In this embodiment, the collet 202 has arms 306 which spread at an angle β which is substantially greater than the angle α between the faces 150/122, 152/124 of the collet and shank. Having an an-

gle β which is larger is possible because the arms 306 are located outside the area or zone of the shank 200 support surfaces and are therefore not restricted by the structure of the shank 200, in practice being able to extend circumferentially beyond the position of the shank ends. This arrangement can hold a gemstone 308 which is much wider or flatter than the embodiment of Figures 21 and 34 and yet does so by using precisely the same coupling between the collet and shank, thus retaining the ability to provide the same shank 200 with different sizes of stone and design of support arms, and thus a standardised arrangement across a range of different collets and shank designs.

[0073] Figures 36 to 38 show an embodiment of collect structure suitable for a round gemstone. The collet body 202 has standardised collet surfaces, protrusions and size to fit onto a standardised shank 200 (it will be appreciated that there could be provided a variety of shank designs, all having standardised support fitting features). In this embodiment, the collet body 202 is provided with four integral support arms 312 suitably shaped and sized to hold gemstone 314. In practice, given the fact that the support arms 312 are not constrained by the fitting of the collet to the shank 200, the arms 312 could be bent and configured to hold a stone without affecting the quality or nature of the fitting of the collet to the shank 200.

[0074] Figures 36 to 38 in particular also show the support surfaces of the collet body 202, as well as the corresponding support surfaces of the shank 200, with a curvature. This curvature in practice extends as a channel in the radial direction of the ring. The curvature assists in providing a clean tight fit of the collet to the shank and also in ensuring accurate and reliable fitting of the collet to the shank, particularly during assembly of the two components.

[0075] Referring now to Figures 39 to 41, there is shown another embodiment of collet which is provided with a slightly different design of collet body. More particularly, the collet body 202' includes four protrusions 80, 84 which are in axial section part-circular, of a type shown in Figure 28A. The shank 200' will have corresponding bores.

[0076] Referring now to Figures 42 to 44, the collet shown is designed to hold a square shaped gemstone 318. This collet is also provided with a different design of collet body 202", in which the protrusions or pins have rounded ends, of a type shown in Figure 29C. The collet is provided with four gemstone support arms 320, which in this example are internally recessed to hold the gemstone 318. These have an externally rounded shape, chosen for jeweller or customer preference.

[0077] Figures 45 to 47 show another arrangement, in which the collet body 202" is designed for holding a pear-shaped gemstone 322. For this purpose, the collet is provided with first and second collet arms or supports 324, 326, the first of which is in the form of an internally angled or recessed arm 324 shaped and sized to retain the point of the gemstone 322. The second arm or support 326 is rounded and has a shape similar to a part cone, suitable for holding the wider end of the gemstone 322.

[0078] It will be apparent from the examples of Figures 30 to 47 that this arrangement of collet body and corresponding shank can allow a large variety of collet designs to be developed while still retaining a standardised coupling arrangement.

[0079] Referring now to Figures 48 and 49, there is shown a moulding mechanism suitable for moulding the collets taught herein. A similar mechanism can be used in the manufacture of the shanks taught herein. The embodiment shown is particularly designed for the collet 70 of the embodiment of Figures 14 to 16.

[0080] Figures 48 and 49 show a collet mould 400 in a sprue and runner system. The collet mould 400 is a hollow container which conforms to the external contours of the collet and is provided with openings at the distal ends of the protrusions 402. These protrusions connect to the sprue of the sprue and runner system in such a way that the output of the sprue leads into the open ends of the protrusions 402 of the collet mould 400. The two diametrically opposed protrusions provide the advantage that the protrusions can serve as points of connection to the sprue and runner system, thereby providing an effective hold for the mould in the sprue and runner system, as well as providing a point of entry which is inconspicuous in the finished ring assembly.

[0081] The sprues 402 are in fluid communication with a semi-circular delivery tube 404 which is in fluid communication with a runner 406 via a main body 408 of the sprue and runner system.

[0082] Corresponding moulds can be utilised for any of the embodiments herein described. Where the collet is provided with a recess in place of a protrusion for a locking element, a corresponding protrusion is provided on the sprue such that the point of entry into the collet is within the recess.

[0083] After moulding, the collet is suitably polished, with the advantage that the mould inlets are located in components which are not seen by the end user, that it which are exposed in the assembled jewellery piece.

[0084] It will be apparent to the reader that the ring is assembled by pushing the collet into place on the shank, such that the base of the collet faces radially inwards with respect to the shank. The collet is arranged such that the locking elements of the collet engage with the locking elements of the shank. As described, in one embodiment, the locking elements have protrusions on the collet which are diametrically opposed and are the same shape and size, and the locking elements on the shank comprise corresponding recesses. In this embodiment, the collet can be inserted in either of two configurations since it does not matter which of the protrusions cooperates with which of the recesses. However, in other embodiments, the protrusions and recesses can be arranged so that only one configuration is possible. This can be achieved for example by providing one protrusion and one recess on the collet and the corresponding recess and protrusion

on the shank.

[0085] The locking elements hold the collet accurately in place with respect to the shank. The mechanical cooperation of the collet and shank ensures that they are properly fitted and aligned to one another. The collet is at this point held in place with respect to the shank by mechanical cooperation of the locking elements. In the embodiments described, the collet and shank combination forms a ring assembly which can be placed on a user's finger. The user can therefore see the ring assembly as it would appear when finished and can decide whether the design, colour and/or selection of jewel stones or precious metals are what they desire.

[0086] If the user wishes to substitute the collet for one, say, with a different jewel stone, the collet can be removed by pulling the collet from the shank, if necessary by slight twisting of the two relative to one another to prompt the opening of the shank end. A different collet can then be introduced to the shank by repeating the procedure above.

[0087] In addition, the user may wish to substitute the shank for a different shank. The design, arrangement and dimensions of the locking elements are such that the shank may also be of the Tiffany type.

[0088] One way in which this method of selection may be performed is for a remote sale operation. It can be difficult to select jewellery remotely, such as by mail-order or over the internet, since it can be difficult to tell from a picture whether a particular item will suit or fit a customer.

[0089] The embodiments described herein allow a plurality of shanks and/or a plurality of collets to be sent to a customer, possibly in a valuable and/or base metal or other non-valuable material. Owing to the ease with which the shanks and collets with the mechanical locking elements can be interchanged, the customer can interchange the collet and shanks until the preferred combination is identified.

Once the customer has made the selection; the samples can be returned (if desired) and the final item of jewellery manufactured, typically by assembly followed by final fixation, such as by soldering or laser welding, and sent to the customer. In this way, it is not necessary to manufacture finalised assemblies for every different permutation of collets and shanks that a customer may desire.

[0090] Unlike in conventional ring fitting procedures in which the collet needs to be held by an external clamp while the solder is applied, with the arrangements taught herein, the collet is held in place to the shank accurately and precisely. The likelihood of the collet shifting or rotating during the soldering procedure is significantly reduced, typically avoided altogether.

[0091] It will be appreciated that there could be provided more than two locking elements either side of the collet/shank, such as three or more. However, two are preferred as it has been found that these can provide good and precise fitting without compromising on the design options for the ring or other jewellery item.

[0092] The embodiments above have been described with respect to a ring assembly. However, by varying the dimensions and details of the collet and shank, the aspects described above can be used in the manufacture of many sorts of jewellery assemblies, such as bracelets, necklaces, brooches and so on.

[0093] It will also be appreciated that although the embodiments described and shown in the drawings are designed to hold a single stone, this is just one example. The collet can be designed and arranged to hold any number of stones in dependence upon the desires of the jeweller and customer. In many instances this may be by means of the jewel fitting of the collet (number and arrangement of the arms for instance). In other embodiments, there may be provided a wider collet fitting and a correspondingly wider gap between the shank ends, such that two or more stones may be aligned along the circumferential extent of the shank, as in an eternity ring for instance.

[0094] Although it is preferred that the support and collet surfaces taper towards the centre point of the ring, it is envisaged that the taper could be in the opposite direction, that is to widen towards the centre of the ring. This is particularly possible in connection with embodiments in which the stone support arms are located outside the zones of the support and collect surfaces. In this regard it is to be appreciated that the inner and outer zones as specified herein relate to the direction of taper and not necessarily to the jewellery assembly itself.

[0095] The features of the various embodiments can be combined or interchanged as required.

Claims

1. An item of jewellery including a support element provided with inner and outer zones, and first and second support surfaces which face one another and taper from the inner to the outer zones, wherein said taper provides a bisector extending along the axis of taper, there being provided on each of said support surfaces first and second spaced recesses or protrusions, said support element having a resilience; said item of jewellery also including a collet for holding a stone or other item, said collet including first and second collet surfaces complementary to the first and second support surfaces, said collet surfaces having a taper substantially corresponding to the taper of the support surfaces, each of said collet surfaces including first and second spaced protrusions or recesses designed to cooperate and fit together with associated recesses or protrusions of the support surfaces, wherein at least one of said protrusions includes a surface extending substantially transverse to said bisector.

2. An item of jewellery according to claim 1, wherein the protrusions have a length of no more than substantially 1 millimetre.

3. An item of jewellery according to claim 1 or 2, wherein the protrusions and recesses are round in transverse cross-section, square, rectangular, and/or a half-D shape.

4. An item of jewellery according to claim 3, wherein the protrusions are of different shapes.

5. An item of jewellery according to any preceding claim, wherein protrusions have one or more of: substantially flat ends, rounded ends; and narrow or narrowing ends.

6. An item of jewellery according to any preceding claim, wherein the protrusions are located on the collet.

7. An item of jewellery according to any preceding claim, wherein the support surfaces and the collet surfaces are curved.

8. An item of jewellery according to any preceding claim, wherein the angle of taper of the support and collet surfaces ranges from around 10 degrees to around 140 degrees.

9. An item of jewellery according to any preceding claim, wherein the collet includes a plurality of stone supports, which stone supports are located outside an area of the collet surfaces and outside an area of the support surfaces.

10. An item of jewellery according to claim 9, wherein the stone supports are in the form of or include support arms.

11. A kit for the manufacture of an item of jewellery according to any preceding claim including a plurality of support elements each provided with inner and outer zones, and first and second support surfaces which face one another and taper from the inner to the outer zones, wherein said taper provides a bisector extending along the axis of taper, there being provided on each of said support surfaces first and second spaced recesses or protrusions, said support element having a resilience; and a plurality of collets for holding a stone or other item, each collet including first and second collet surfaces complementary to the first and second support surfaces, said collet surfaces having a taper substantially corresponding to the taper of the support surfaces, each of said collet surfaces including first and second spaced protrusions or recesses designed to cooperate and fit together with associated recesses or protrusions of the support surfaces, wherein each of said protrusions includes a surface extending substantially transverse to said bisector; wherein at least one of the plurality of supports and the plurality of collets includes at least two different designs.

12. An item of jewellery or a kit for the manufacture of an item of jewellery according to any preceding claim, wherein the item of jewellery is a ring, the support being the ring body or shank.

13. An item of jewellery or a kit for the manufacture of an item of jewellery according to any preceding claim, wherein the support and collet are fixed to one another to inhibit their subsequent separation, optionally by one or more of: soldering, welding or bonding.

14. An item of jewellery including a support element provided with inner and outer zones, and first and second support surfaces which face one another and taper from the inner to the outer zones, said support surfaces having an area, there being provided on each of said support surfaces one or more recesses or protrusions, said support element having a resilience; said item of jewellery also including a collet for holding a stone or other item, said collet including first and second collet surfaces complementary to the first and second support surfaces, said collet surfaces having a taper substantially corresponding to the taper of the support surfaces, said collect surfaces having an area, each of said collet surfaces including one or more protrusions or recesses designed to cooperate and fit together with associated recesses or protrusions of the support surfaces, said collet also including a plurality of stone support elements, wherein said stone support elements are located outside the area of the collet surfaces and outside the area of the support surfaces.

15. An item of jewellery according to claim 14, wherein the areas of the support surfaces and the collet surfaces are complementary.

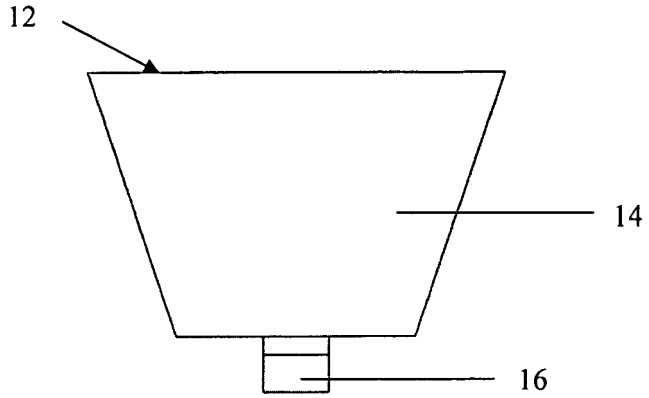


Figure 1

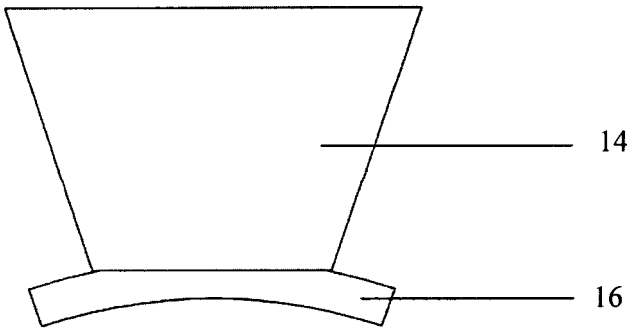


Figure 2

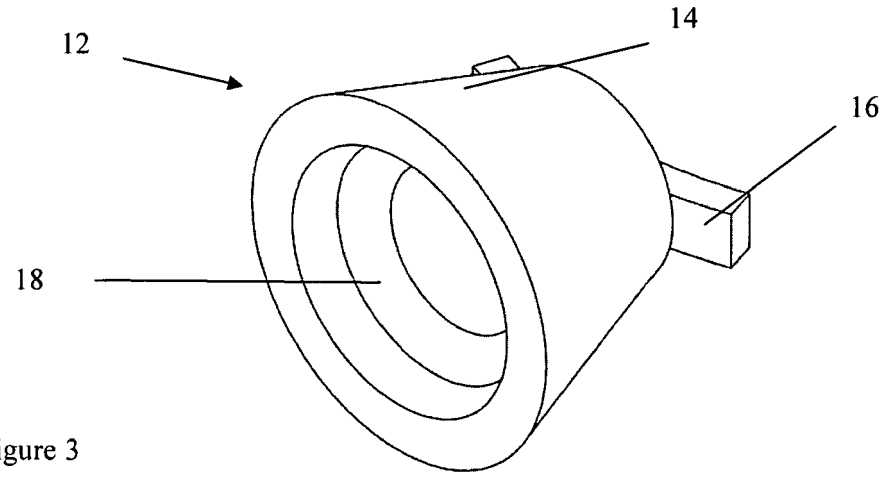


Figure 3

Prior Art

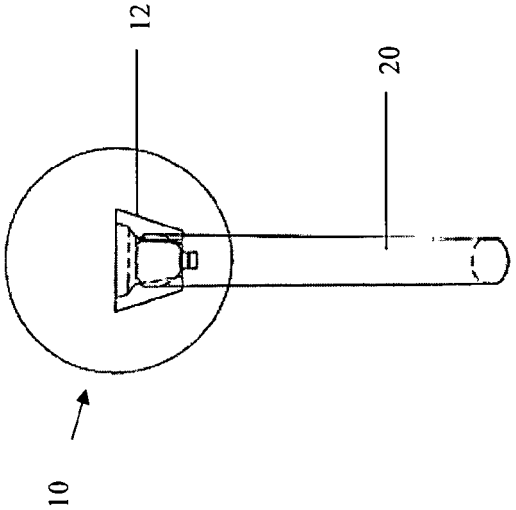
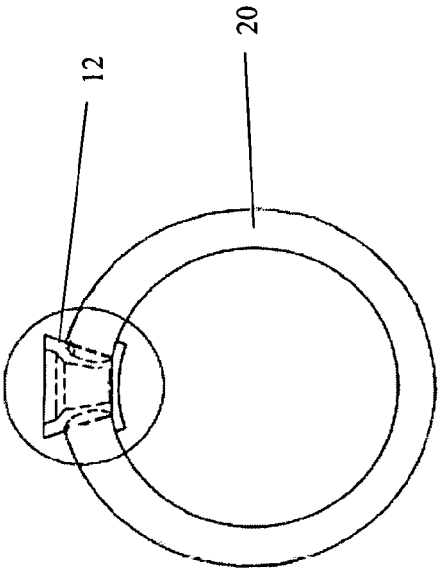


Figure 5



Prior Art

Figure 7

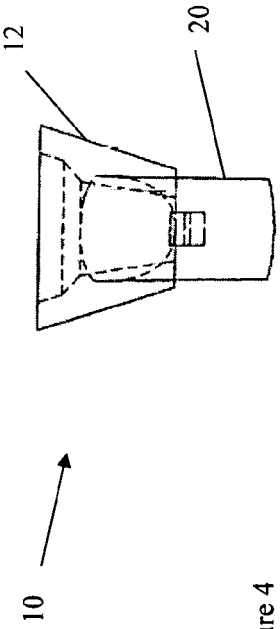


Figure 4

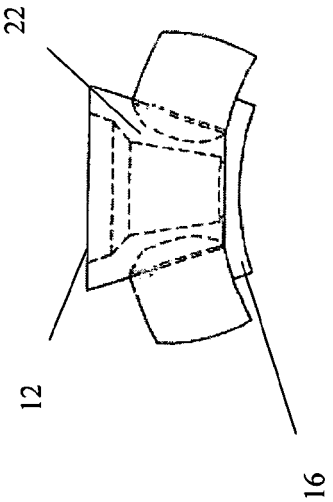


Figure 6

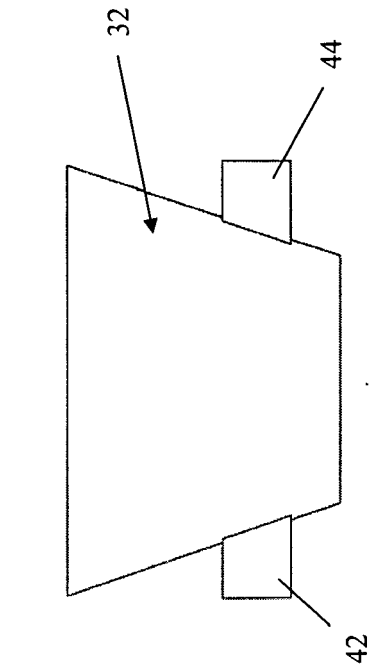


Figure 9

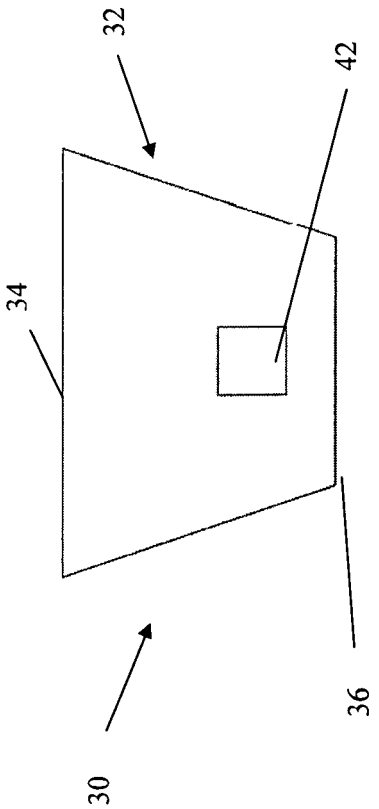


Figure 8

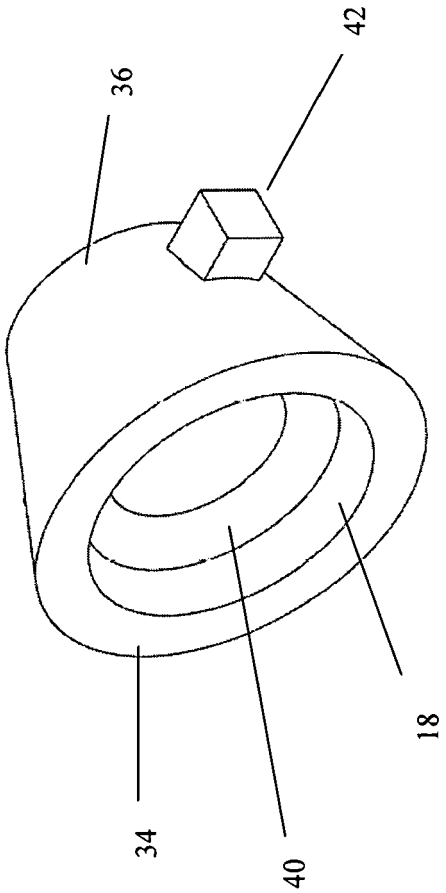


Figure 10

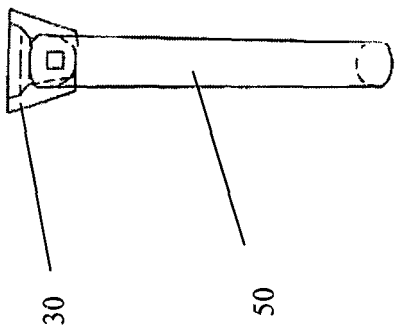


Figure 11

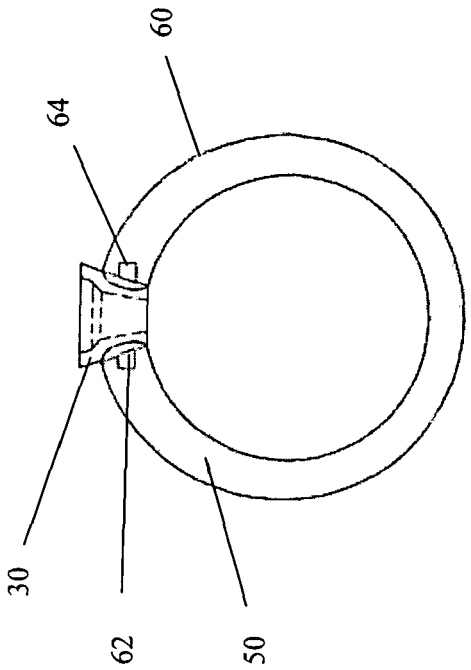


Figure 12

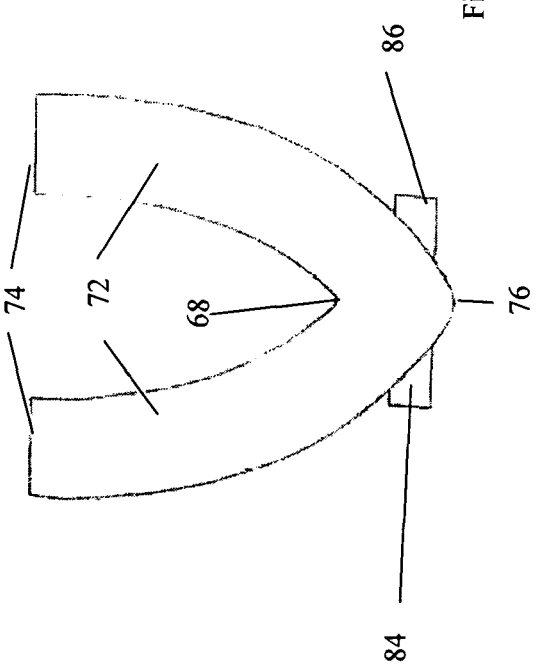
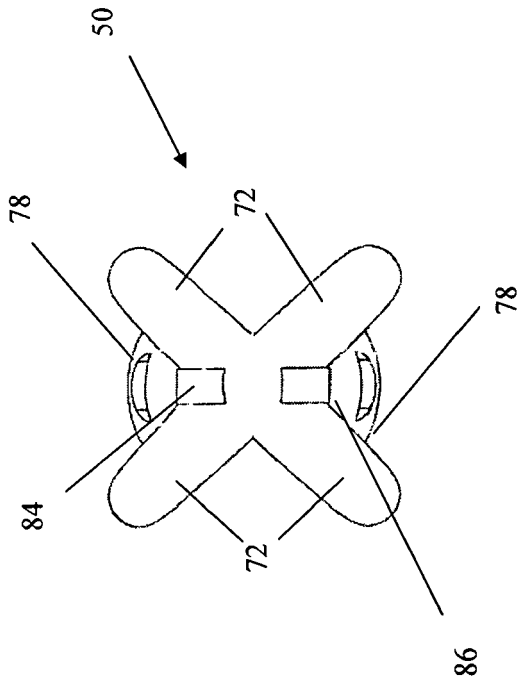


Figure 13



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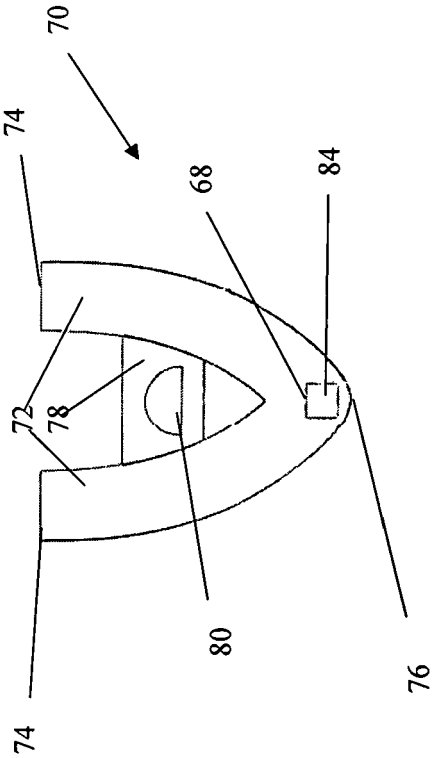

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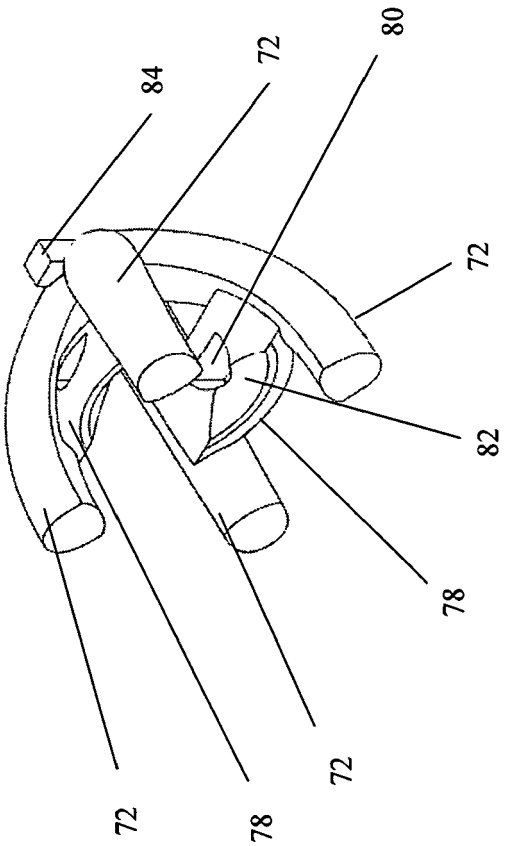

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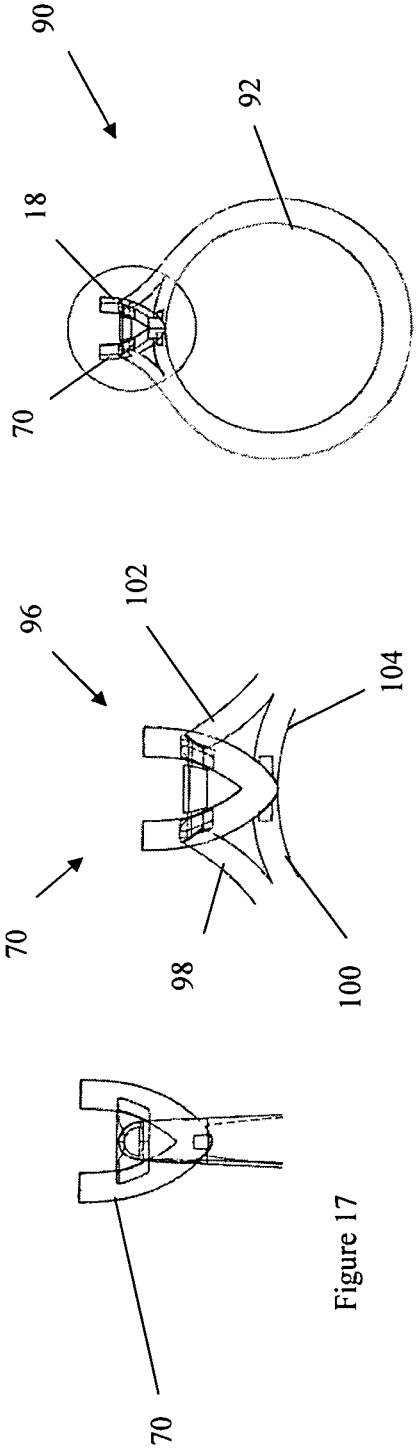
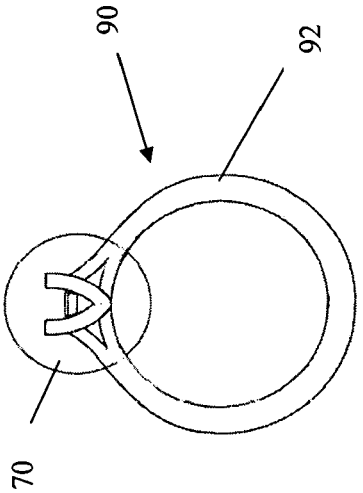


Figure 17

Figure 18

Figure 19



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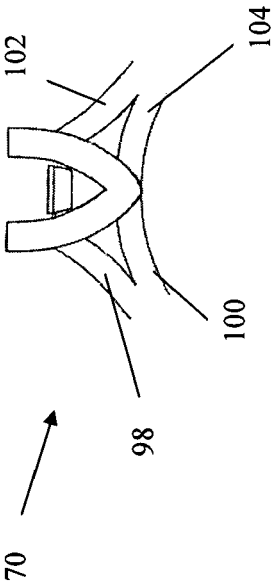

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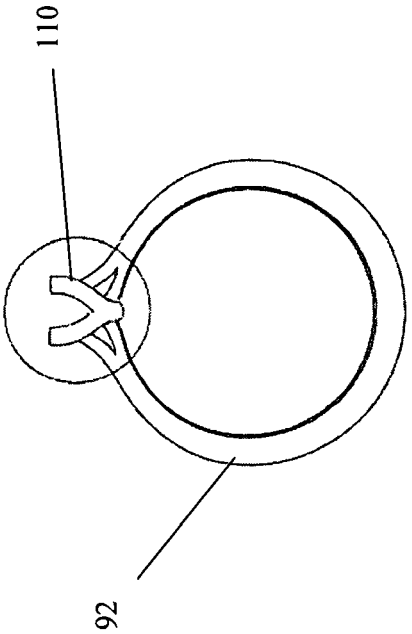

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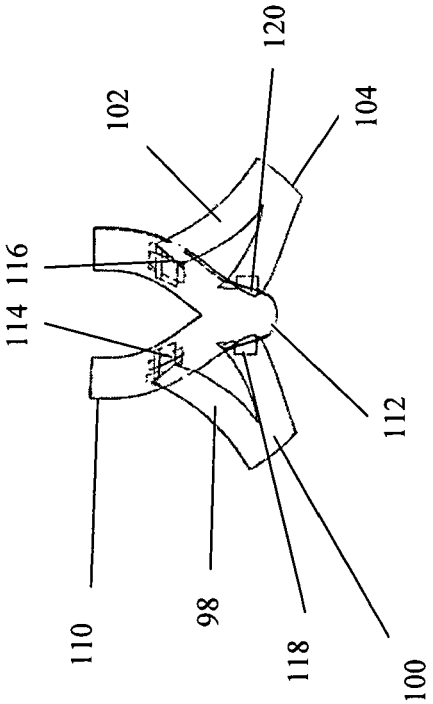

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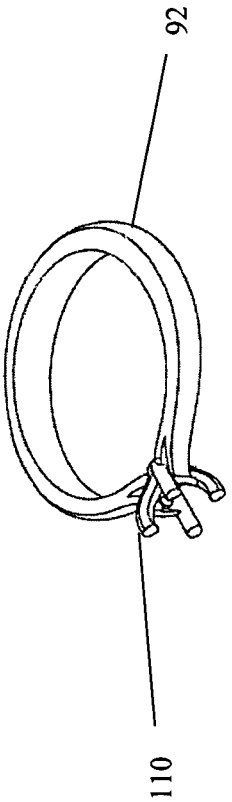

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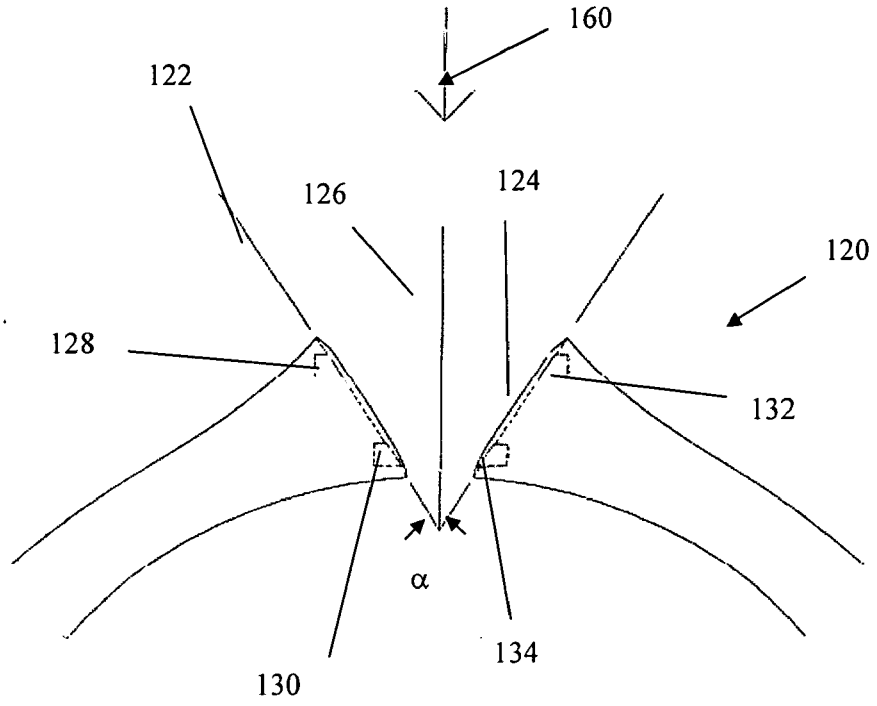

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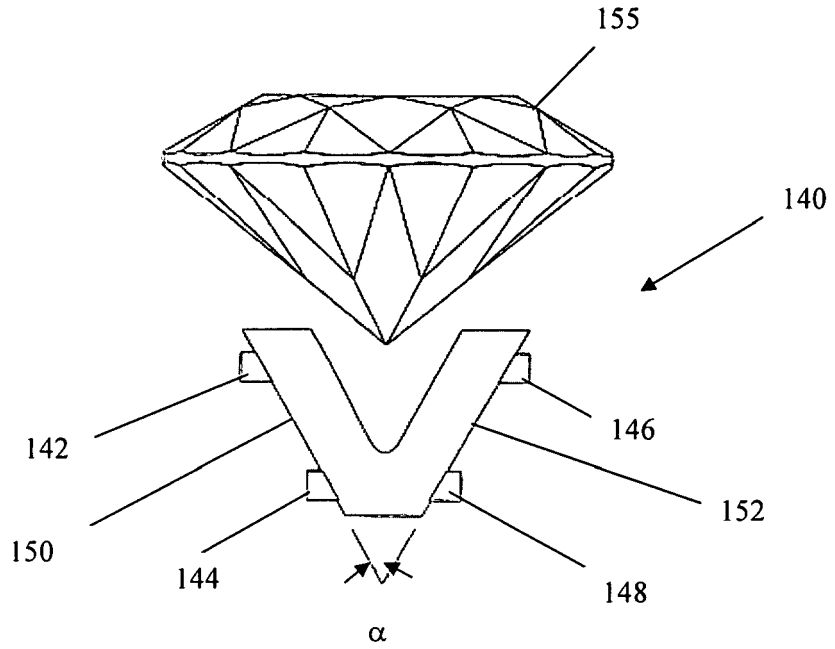

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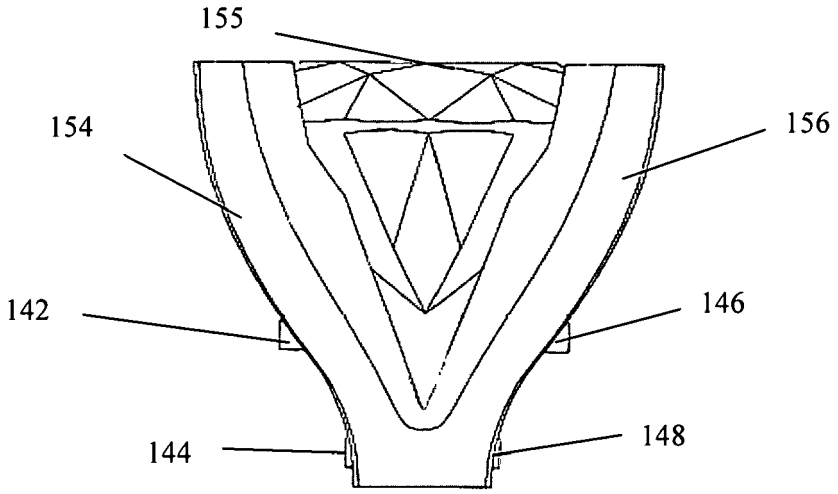

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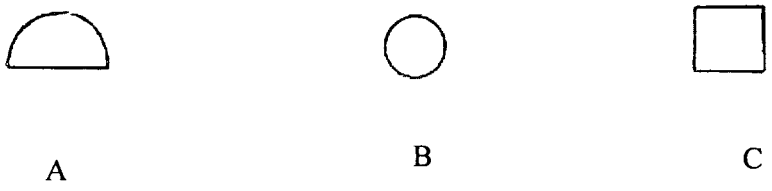

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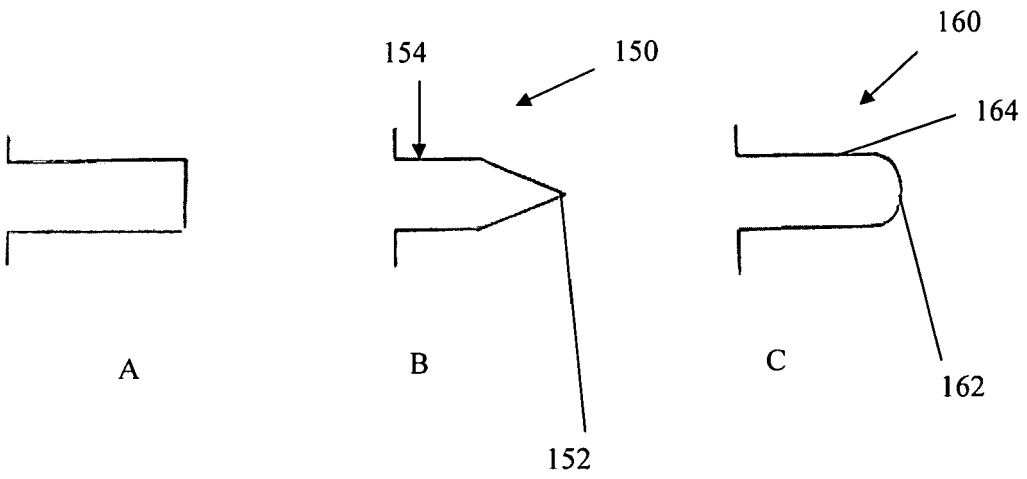

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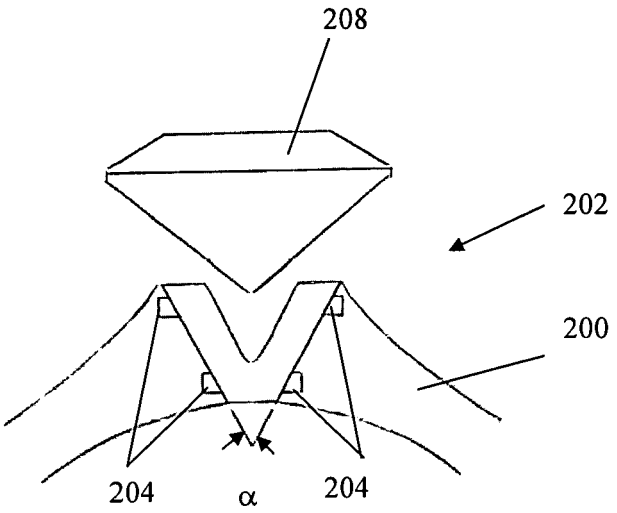

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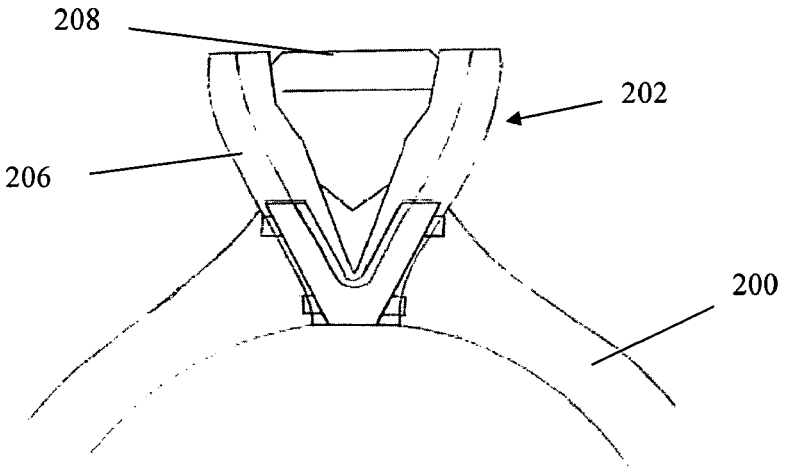

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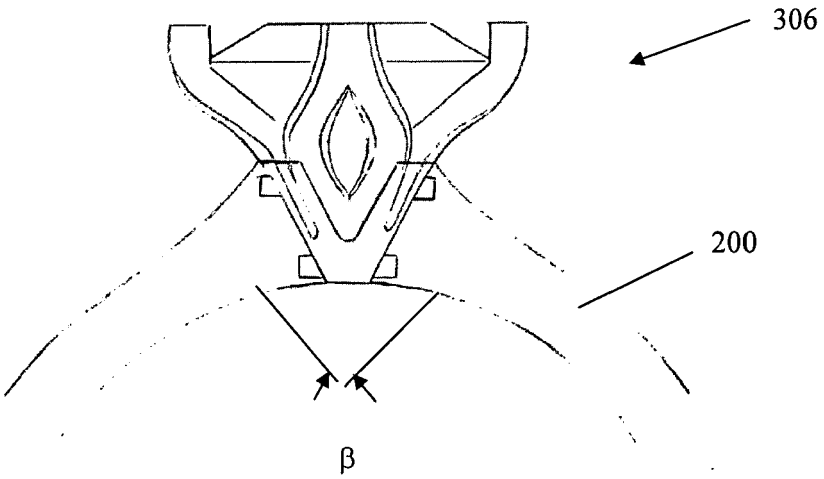

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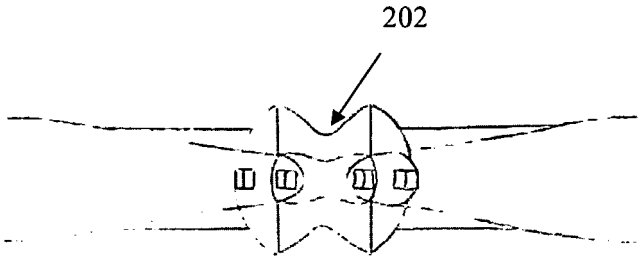

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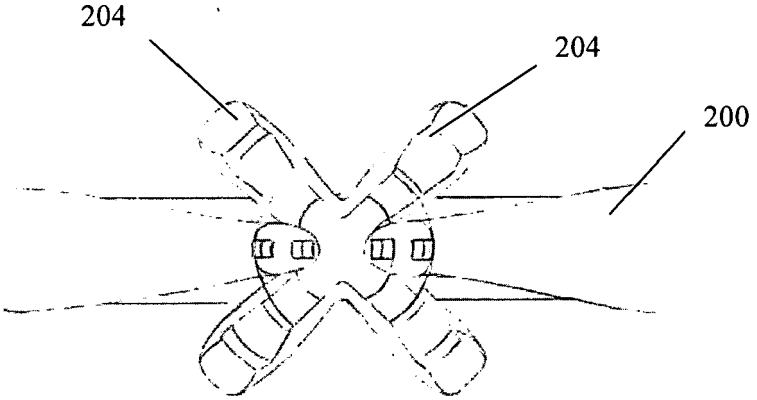

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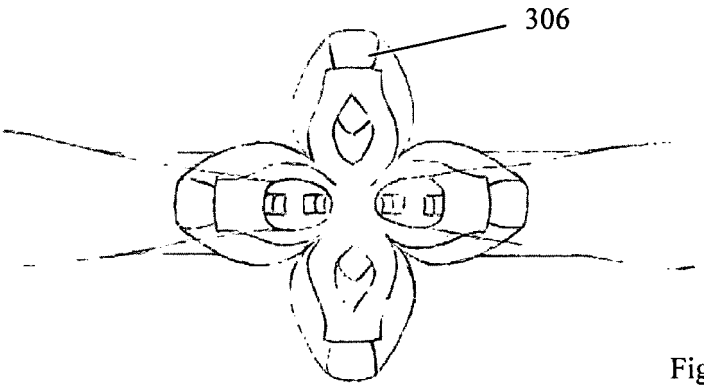

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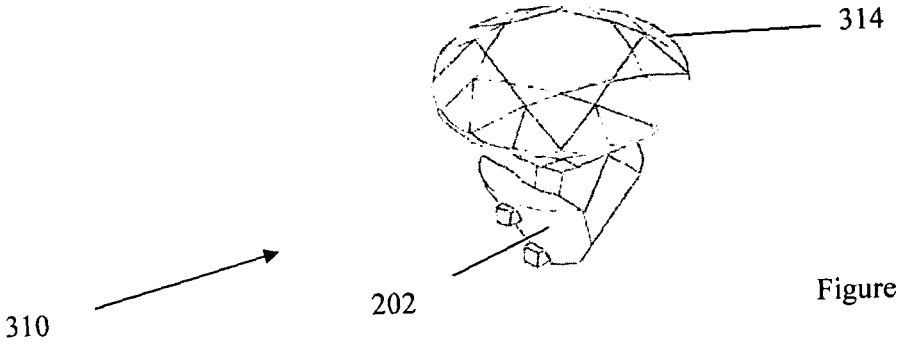

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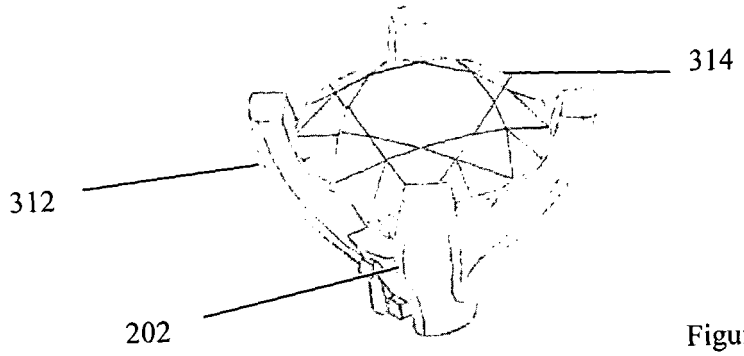

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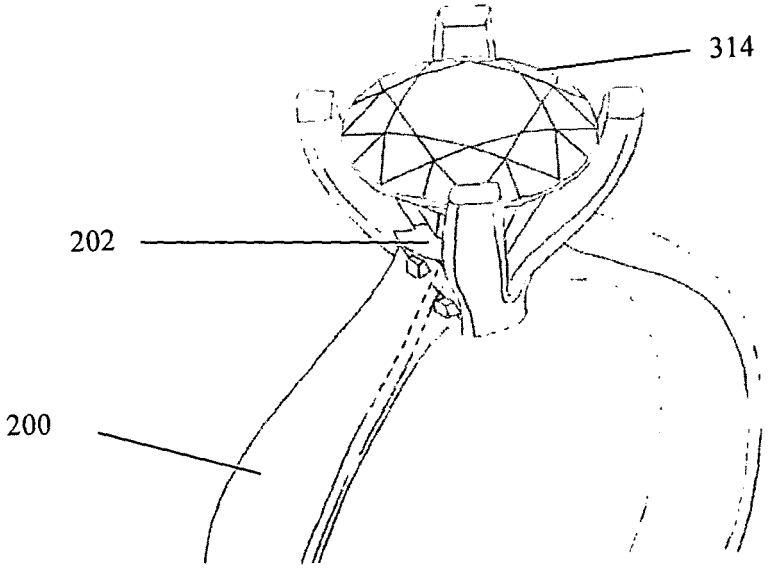

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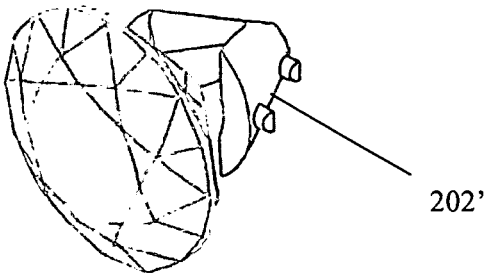

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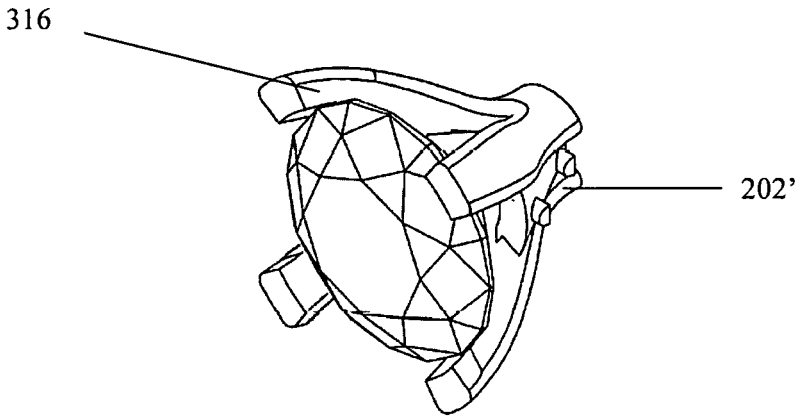

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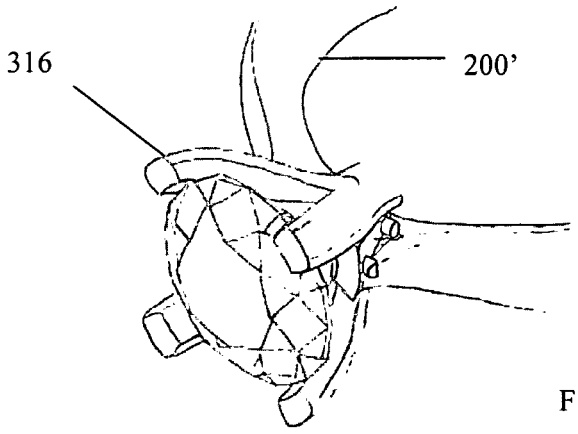

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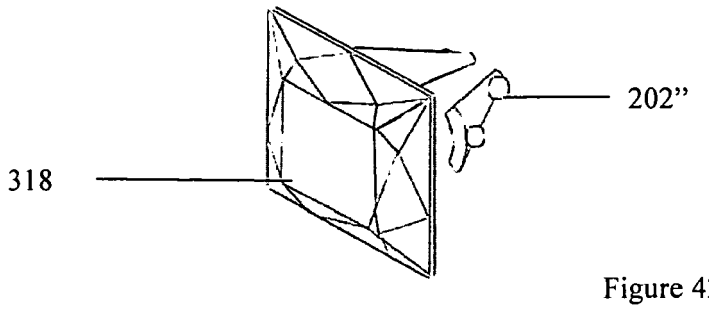

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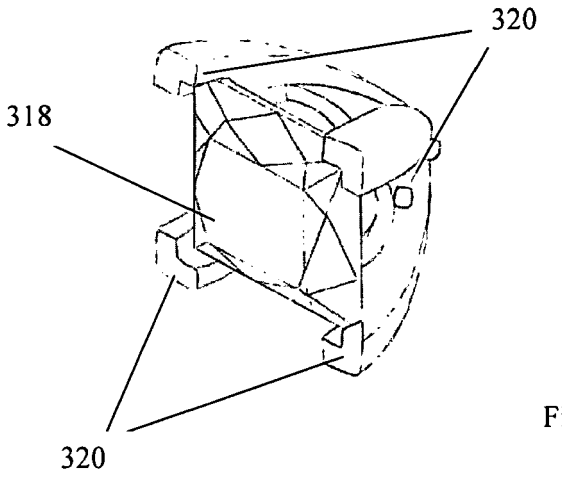

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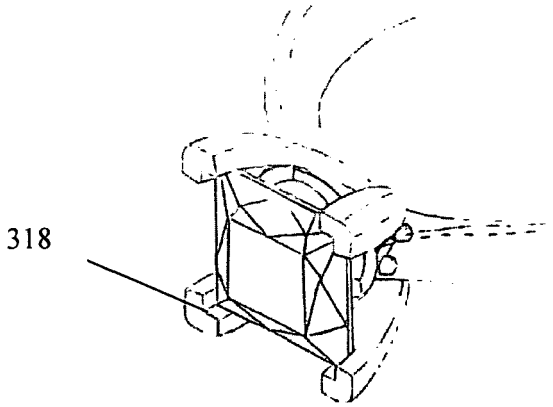

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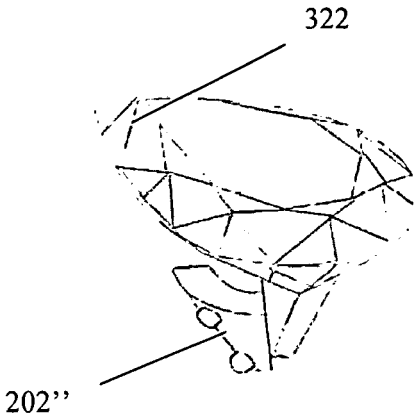

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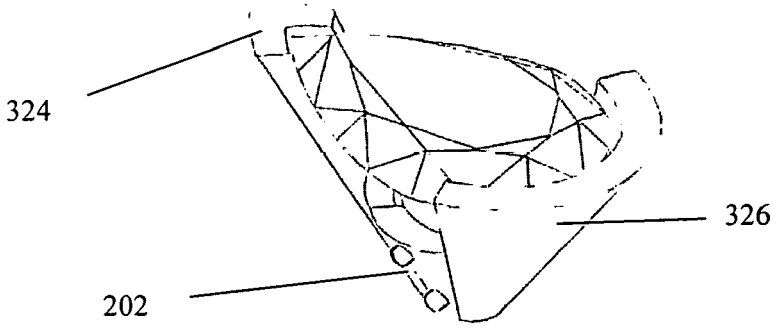

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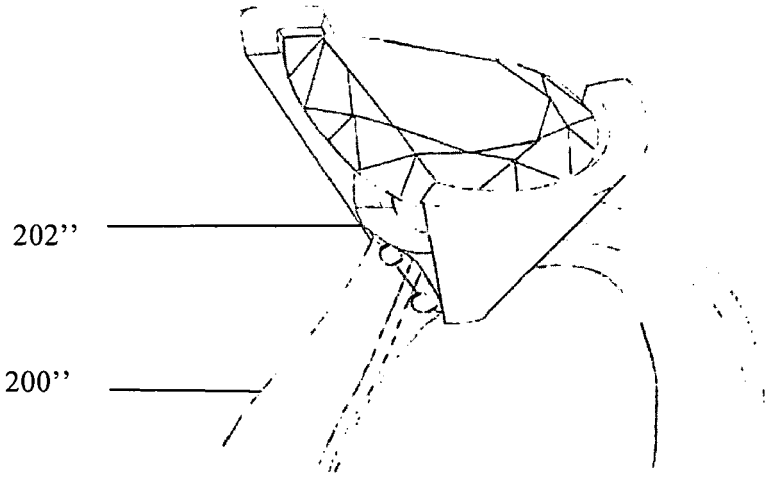

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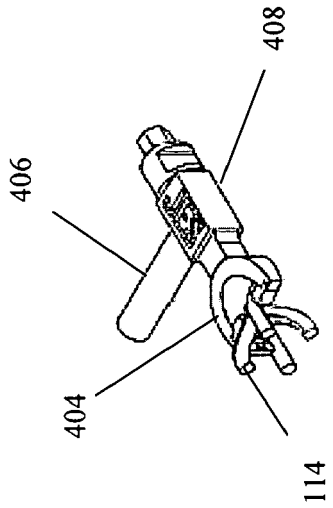

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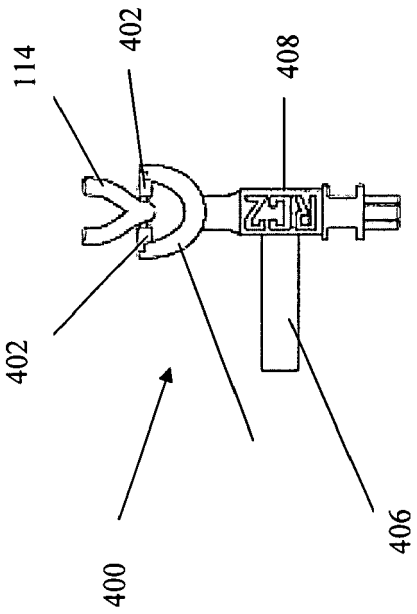

Figure 48

REFERENCES CITED IN THE DESCRIPTION

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