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(54) ELECTRICALLY-OPERATED VALVES

(71) We, INTERNATIONAL COLD FORGING COMPANY, a body corporate organised and existing under the laws of Monaco, of "La Ruche", 6 rue de L'industrie, Monaco, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to an assembly of two component members intended to be made fast with one another by fusion bonding into one single pair of two pairs of zones of thermo-bondable plastics material pertaining one pair to each of said two component members. The invention also relates to the assembly obtained in this way. It is most suitable for use in electrically operated valves for distributing water or other fluids.

In such electrically operated valves the internal components, for example the elastic membrane, the magnetic core and the like, are generally enclosed between component members of moulded plastics material one of which is the valve body and the other a cap which contains the magnetic core and which compresses the elastic membrane against the body to produce a tight seal between the two component members.

The cap, or caps, in the case of multiway valves, must be very securely fixed to resist the pressure of the fluid which exists permanently within the valve. For example, the water pressure in mains for drinking water may reach 10 bars, which in a valve of 30 mm diameter results in a permanent wrenching force of some 70 kg.

Normally, the cap is secured by screws which are inserted into the valve body to lock the cap against the body and compress the elastic membrane. The number of screws on the periphery of the valve must be large and the rigidity, that is to say the thickness of the valve body and of the caps must be consistent in order to ensure a sufficiently tight fit over the entire periphery. This must also continue for the entire life of the valve, in spite of the loss of mechanical characteristics of the plastics materials generally employed.

In spite of a large number of screws and a considerable thickness of the component members it frequently occurs after a certain time in use that the electrically operated valves begin to leak which leads to considerable floodings when such valves are employed for example in washing machines.

The electrically operated valve according to the invention comprises a casing which has an inlet and an outlet connection, a seat for a membrane, a magnetically actuated valve shutter, a flexible, impervious membrane, clamped at its periphery, and an insert tightly held in the midportion of said membrane and having a hole therethrough, said membrane being in contact with said seat so as to define with the casing and the insert a control chamber which communicates with the outlet connection by said hole provided in said insert, which hole is normally closed by said valve shutter, said control chamber also communicating with the inlet connection by a restricted passage, and magnetic means for actuating said valve shutter so that it disengages from the hole, and further comprising the improvement which consists in that: said casing is made of a first portion and a second portion both made of the same thermoplastic material, said first portion being shaped as a valve body and said second portion being shaped as a cap for said valve body shape and defining said control chamber with said membrane and said insert thereof and also supporting said valve shutter and said magnetic actuating means; said control cham-

ber, outlet connection, membrane, insert and actuator have an axis common to surface-of-revolution shaping of each of them; said membrane has an annularly cylindrical peripheral rim having at least one cylindrical surface substantially coaxial with said axis and said rim is restrained in a radial direction by a cylindrical surface of one of said casing portions likewise coaxial with said axis; and said first and second portions respectively have opposite stepped portions where they meet which are formed by cylindrical riser surfaces coaxial with said axis offset radially by surfaces perpendicular to said axis, two opposed pairs of said step riser surfaces being overlapped and fused by ultrasonic thermomechanical bonding under axial forcing together of said portions by reason of the diameter of the external riser surface of the casing portion that fits inside the other casing portion at their joint being slightly greater than the internal diameter of the internal riser surface of said outer casing portion at the joint, said two pairs of fused step riser surfaces being separated by an intermediate pair of said step riser surfaces of said respective casing portions which are separated from each other by the width of a pair of said radially offsetting surfaces likewise separated from each other, so that an annular cavity is formed thereby which is at least partially filled with material squeezed out from at least one of the fused overlaps of said adjacent opposed pairs of riser surfaces of said respective casing portions, whereby axially and radially offset tandem sealed annular bonds are provided joining said first and second casing portions and seal said casing peripherally independently of the manner in which said membrane is held therein.

The cylindrical surfaces of the stepped portion of said first casing portion are preferably internal surfaces facing towards said axis and the cylindrical surfaces of the stepped portion of said second casing portion are preferably external surfaces facing away from said axis, so that said second casing portion, of cap shape, is fitted inside said first casing portion, of valve body shape, at their stepped joint providing said offset annular bonds.

The restricted passage may be formed by a perforation through said membrane located outwardly of said midportion of said membrane.

The cylindrical membrane rim surface by which said rim of the membrane is restrained is preferably a radially outwards facing surface and faces a radially inwards facing cylindrical surface of said second casing portion by which said membrane rim is restrained, but may be a radially inwards facing surface and faces a radially outwards facing cylindrical surface of said second casing portion by which said membrane rim is restrained.

The cylindrical rim of said membrane preferably fits in a groove of one of said casing portions without extending into the full depth of said groove and said restricted passage is a gap in the radially inner wall of said groove, while the outer wall of said groove is provided by a plurality of shoulder segments separated by filtering gaps for admitting fluid from said inlet chamber to said control chamber by way of the portion of said groove unoccupied by said membrane rim and through said restricted passage.

The groove may be provided in said second casing portion.

The casing may have two outlet connections, two said second casing portions of cap shape, and two membranes forming two said control chambers, as well as two said valve shutters, each said outlet connection having an axis of surfaces of revolution in common with one of said second casing portions, one of said membranes, one of said valve shutters and one of said control chambers, said axes of revolution being substantially parallel to each other, and each of said second casing portions is joined to said first casing portion with respect to the axis of surfaces of revolution of the respective second casing portion to form a unitary casing, said second casing portions being also joined together independently of being each joined to said first casing portion.

The casing may have three outlet connections, three said second casing portions of cap shape, and three membranes forming three said control chambers, as well as three said valve shutters, each said outlet connection having an axis of surfaces of revolution in common with one of said second casing portions, one of said membranes, one of said valve shutters and one of said control chambers, said axes of revolution being substantially parallel to each other and disposed so that they traverse planes substantially at the corners of an equilateral triangle, and each said second casing portions is joined to said first casing portion with respect to the axis of surfaces of revolution of the respective second casing portion to form a unitary casing, said second casing portions being also joined together independently of being each joined to said first casing portion.

The casing may have four outlet connections, four said second casing portions of cap shape, and four membranes forming four said control chambers, as well as four said valve shutters, each said outlet connection having an axis of surfaces of revolution in common with one of said second

casing portions, one of said membranes, one of said valve shutters and one of said control chambers, said axes of revolution being substantially parallel to each other and disposed so that they traverse planes substantially at the corners of a square, and each said second casing portions being joined to said first casing portion with respect to the axis of surfaces of revolution of the respective second casing portion to form a unitary casing, said second casing portions being also joined together independently of being each joined to said first casing portion.

The cap is preferably made of the same material as the body and has placed therein a magnetic core and its elastic gasket intended to close a pilot hole in an insert forming said membrane, and a compression spring urges the core in the direction opposite to an electromagnet placed around the cap, the cap having an axis of revolution and comprising on its periphery at least two circular steps, superimposed and of different diameters, coming face-to-face with steps of the body having the same axis of revolution, so that the two steps of the cap each have a part which comes together or coincides with the steps of the body in order to produce a double bond by ultrasonic means or by rotation over the entire periphery of the component members, the forms of the two component members being such that on the one hand the cap is guided diametrically into the body before the bonding is initiated, and that on the other hand gaps of volumes greater than the coincident volumes of the two component members are provided tc accommodate the bonding excesses or burrs.

In this way the cap or caps are affixed to the valve body by a double bond. Since they are bonded the component members may be of less bulk. As a further precaution, a double bond is effected over the entire periphery. Furthermore, the membrane no longer requires to provide, or rather itself to provide, the water-tight seal since this is obtained by the double bonding whilst taking certain precautions as detailed hereinafter. Generally, the body and the cap are of poly (phenylene oxide) or of polyamide (polyamide 66) possible charged with glass fibres.

Since screws, and the operations these involve, are no longer necessary, there is a marked reduction in the cost of manufacture and also in the dimensions of the product so that the possibilities of application are increased.

The invention will be more readily understood from a description of various embodiments which are offered merely as examples of a non-limitative character and are illustrated in the accompanying drawings, in which:

Fig. 1 is a sectional view of an electrically operated valve with one outlet, before welding;

Fig. 2 is an enlargement of a detail of the welded parts;

Fig. 3 is a sectional view of part of a simple valve, showing one embodiment;

Fig. 4 is a view from beneath of the valve cap shown in Fig. 3;

Figs. 5 to 8 illustrate other embodiments; and

Fig. 9 is a part view in section of an electric valve.

Referring now to the drawings, Fig. 1 is a cross-section of a simple, one-way valve with piloted aperture, the valve being here shown before the fusion of the cap to the body.

The body 1 of the valve, which is of plastics material, essentially thermoplastics material, has one face serving as seat for the rubber membrane 2 and its insert 3 of a plastics material which is impervious to the fluid passing through the valve. The insert 3 is integral with the membrane 2.

The cap 4 carries the magnetic core 5 with rubber sealing joints 6 and also the compression spring 7. The electromagnetic coil 8 is not shown in detail in the figure but is simply indicated symbolically. The manner of working is known of this type of electrically-operated valve which is normally closed when no current passes to the coil 8. When the magnetic core 5 and its sealing gasket 6, under pressure of the spring 7, close the centre hole 10 in the insert 3, the pressure of the mains to which the electrically-operated valve is linked by the inlet connection 9 is exerted through the control aperture 12 of the membrane into the closed control chamber, which is limited by the membrane 2 and cap 4, thus pressing the membrane 2 firmly against the seat 11 of the valve body 1. If current is passed to the coil 8, the magnetic core 5 is raised to meet and compress the spring 7, thus disengaging the seal 6 of the hole 10 in the insert 3. The pressure in the control chamber limited by the membrane 2 and cap 4 falls, since the hole 10 communicates between the control chamber and the outlet connection 13, so that the membrane rises upwards disengaging from the seat 11 and allowing the fluid to flow towards the valve outlet 13.

According to the invention the cap 4 is secured to the valve body 1 by the bonding of these two pieces at the peripheral zone of the cap 4 which has a vertical axis of revolution, whilst the part of the body 1 situated opposite this zone also has a vertical axis of revolution.

The bonding is preferably ultrasonic,

that is to say ultrasonic vibrations are applied to the upper plane surface 14 of the cap before positioning the electromagnet 8, the valve body resting upon a rigid base (not illustrated). The shocks imparted to the contacting parts of the two pieces 1 and 4 produce a very rapid local heating which causes the pieces to fuse and to bond together in the zone of contact by reason of the pressure exerted on the cap 4.

In order to ensure that the bond is secure, a second bonding is effected, as will be seen in Fig. 2 which is an enlargement of Fig. 1 around a bonded part of the two pieces after the bonding, there being provided on each side of the bonds vacant spaces in which the burrs from the bonds can be accommodated. In this connection, the burr from one bond should not be allowed to infiltrate into the other bond since this in the long term might endanger the tightness of the seal. It is also necessary for the excess material to find a space to receive it in order to avoid restricting the descent of the cap in relation to the body during bonding. The cap 4 comprises two parts 15 and 16 which are common (coincident) with the body 1 in the position assumed after bonding. It is these two common parts which fuse on the two pieces during the ultrasonic treatment which produces the double bond. The excess material is equivalent to the surface of the common areas 15 and 16 tnd infiltrates from both sides of the bonding zones. For this reason vacant spaces 17 and 18 are provided which have volumes greater than those of the parts 15 and 16 so that they can accommodate the entire excess material.

When the cap is lowered towards the body for the bonding, axial guidance is provided by the cylindrical parts 19 and 20 of these two pieces, the cap fitting into the valve body before the bonding begins.

Also shown in Fig. 2 is the peripheral part of the membrane 2, the diameter and the height of which are determined by formations within the cap and valve body.

Fig. 9 shows a modified form of that shown in Fig. 2 which may be employed in order to render such valves more compact. Here, the membrane 2 is no longer maintained in the cap by its outer portion but by the interior of its thickened peripheral portion which is lightly tensioned against a projection or circular rib 28 on the cap 4 whereby the membrane is integral with the cap 4 before this latter is positioned in the body for the bonding.

The membrane however is not intended to act as a seal between the valve body 1 and the cap 4 as is the case in valves which are screwed together. The membrane may for example be secured to the cap as shown in Fig. 3. Here a modification is shown of the membrane which is rendered possible by utilising the bond between the cap and the body. The membrane 2 no longer has the control aperture 12 shown in Fig. 1, this being replaced by a system of slots in the cap, as will be seen in Fig. 4 which is a view of the cap from beneath.

Beginning with the greatest diameter, a system of ribs 23 is seen which define a plurality of slots 24, the purpose of which is to act as a filter preventing particles from entering the control chamber 26. A groove 22 is also provided which receives the peripheral rib of the membrane 2 and grips it tightly in position. A part of the groove 22 is not occupied by the membrane so that it may receive and collect the fluid passing through the slots 24. There is also a circular rib 21 at the radially inward side of the groove 22, the rib 21 being interrupted by a slot 25 which transmits the pressure of the fluid supply to the control chamber 26.

It is evident that the same result might be obtained by securing the membrane to the valve body and not to the cap, in which case the body then contains the relevant system of slots and ribs.

Modified forms are illustrated in Figs. 5 to 8 which are views from above of the electrically-operated valves according to the invention, of simple one-way, two-way, three-way and four-way type before mounting of the electromagnets in the caps.

On the bodies of the valves, which are in one piece in each drawing, each way has an axis of revolution which coincides with that of the cap. Moreover, the caps of two or more ways in juxtaposition to each other may be linked together by ribs 27, for example, to form one single piece whereby assembly is facilitated. The distances between the axes of revolution of ways in juxtaposition are constant, the axes of the ways of a three-way valve lie on the apices of an equilateral triangle, and those of a four-way valve lie on the corners of a square.

WHAT WE CLAIM IS:

1. An electrically-operated valve comprising a casing which has an inlet and an outlet connection, a seat for a membrane, a magnetically actuated valve shutter, a flexible, impervious membrane, clamped at its periphery, and an insert tightly held in the midportion of said membrane and having a hole therethrough, said membrane being in contact with said seat so as to define with the casing and the insert a control chamber which communicates with the outlet connection by said hole provided in said insert, which hole is normally closed by said valve shutter, said control chamber

also communicating with the inlet connection by a restricted passage, and magnetic means for actuating said valve shutter so that it disengages from the hole, and further comprising the improvement which consists in that: said casing is made of a first portion and a second portion both made of the same thermoplastic material, said first portion being shaped as a valve body and said second portion being shaped as a cap for said valve body shape and defining said control chamber with said membrane and said insert thereof and also supporting said valve shutter and said magnetic actuating means; said control chamber, outlet connection, membrane, insert and actuator have an axis common to surface-of-revolution shaping of each of them; said membrane has an annularly cylindrical peripheral rim having at least one cylindrical surface substantially coaxial with said axis and said rim is restrained in a radial direction by a cylindrical surface of one of said casing portions likewise coaxial with said axis; and said first and second portions respectively have opposite setepped portions where they meet which are formed by cylindrical riser surfaces coaxial with said axis offset radially by surfaces perpendicular to said axis, two opposed pairs of said step riser surfaces being overlapped and fused by ultrasonic thermomechanical bonding under axial forcing together of said portions by reason of the diameter of the external riser surface of the casing portion that fits inside the other casing portiton at their joint being slightly greater than the internal diameter of the internal riser surface of said outer casing portion at the joint, said two pairs of fused step riser surfaces being separated by an intermediate pair of said step riser surfaces of said respective casing portions which are separated from each other by the width of a pair of said radially offsetting surfaces likewise separated from each other, so that an annular cavity is formed thereby which is at least partially filled with material squeezed out from at least one of the fused overlaps of said adjacent opposed pairs of riser surfaces of said respective casing portions, whereby axially and radially offset tandem sealed annular bonds are provided joining said first and second casing portions and seal said casing peripherally independently of the manner in which said membrane is held therein.

2. An electrically-operated valve as claimed in claim 1 in which the cylindrical surfaces of the stepped portion of said first casing portion are internal surfaces facing towards said axis and the cylindrical surfaces of the stepped portion of said second casing portion are external surfaces facing away from said axis, so that said second casing portion, of cap shape, is fitted inside said first casing portion, of valve body shape, at their stepped joint providing said offset annular bonds.

3. An electrically-operated valve as claimed in claim 1 in which said restricted passage is formed by a perforation through said membrane located outwardly of said midportion of said membrane.

4. An electrically-operated valve as claimed in claim 1 in which said cylindrical membrane rim surface by which said rim of membrane is restrained is a radially outwards facing surface and faces a radially inwards facing cylindrical surface of said second casing portion by which said membrane rim is restrained.

5. An electrically-operated valve as claimed in claim 1 in which said cylindrical membrane rim surface by which rim of said membrane is restrained is a radially inwards facing surface and faces a radially outwards facing cylindrical surface of said second casing portion by which said membrane rim is restrained.

6. An electrically-operated valve as claimed in claim 1 in which said cylindrical rim of said membrane fits in a groove of one of said casing portions without extending into the full depth of said groove and said restricted passage is a gap in the radially inner wall of said groove, while the outer wall of said groove is provided by a plurality of shoulder segments separated by filtering gaps for admitting fluid from said inlet chamber to said control chamber by way of the portion of said groove unoccupied by said membrane rim and through said restricted passage.

7. An electrically-operated valve as claimed in claim 6 in which said groove is provided in said second casing portion.

8. An electrically-operated valve as claimed in claim 7 in which the cylindrical surfaces of the stepped portion of said first casing portion are internal surfaces facing towards said axis and the cylindrical surfaces of the stepped portion of said second casing portion are external surfaces facing away from said axis, so that said second casing portion, of cap shape, is fitted inside said first casing portion, of valve body shape, at their stepped joint providing said offset annular bonds.

9. An electrically-operated valve as claimed in claim 1 in which said casing has two outlet connections, two said second casing portions of cap shape, and two membranes forming two said control chambers, as well as two said valve shutters, each said outlet connection having an axis of surfaces of revolution in common with one of said second casing portions, one of said membranes, one of said valve shutters

and one of said control chambers, said axes of revolution being substantially parallel to each other, and each said second casing portions is joined to said first casing portion with respect to the axis of surfaces of revolution of the respective second casing portion to form a unitary casing, said second casing portions being also joined together independently of being each joined to said first casing portion.

10. An electrically-operated valve as claimed in claim 1 in which said casing has three outlet connections, three said second casing portions of cap shape, and three membranes forming three said control chambers, as well as three said valve shutters, each said outlet connection having an axis of surfaces of revolution in common with one of said second casing portions, one of said membranes, one of said valve shutters and one of said control chambers, said axes of revolution being substantially parallel to each other and disposed so that they traverse planes substantially at the corners of an equilateral triangle, and each said second casing portion is joined to said first casing portion with respect to the axis of surfaces of revolution of the respective second casing portion to form a unitary casing, said second casing portions being also joined together independently of being each joined to said first casing portion.

11. An electrically-operated valve as claimed in claim 1 in which said casing has four outlet connections, four said second casing portions of cap shape, and four membranes forming four said control chambers, as well as four said valve shutters, each said outlet connection having an axis of surfaces of revolution in common with one of said second casing portions, one of said membranes, one of said valve shutters and one of said control chambers, said axes of revolution being substantially parallel to each other and disposed so that they traverse planes substantially at the corners of a square, and each said second casing portions is joined to said first casing portion with respect to the axis of surfaces of revolution of the respective second casing portion to form a unitary casing, said second casing portions being also joined together independently of being each joined to said first casing portion.

12. An electrically-operated valve constructed substantially as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.

13. An electrically-operated valve constructed substantially as hereinbefore described with reference to Figures 3 and 4 of the drawings.

14. An electrically-operated valve as claimed in claim 6, constructed substantially as hereinbefore described with reference to Figure 5 of the drawings.

15. An electrically-operated valve as claimed in claim 6, constructed substantially as hereinbefore described with reference to Figure 6 of the drawing.

16. An electrically-operated valve as claimed in claim 6, constructed substantially as hereinbefore described with reference to Figure 7 of the drawing.

17. An electrically-operated valve as claimed in claim 6 constructed substantially as hereinbefore described with reference to Figure 8 of the drawing.

18. An electrically-operated valve constructed substantially as hereinbefore described with reference to Figure 9 of the drawing.

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1576288 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

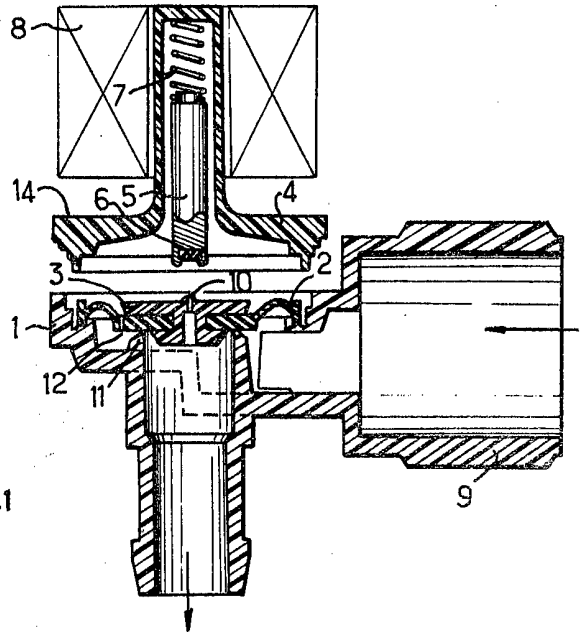

FIG.1

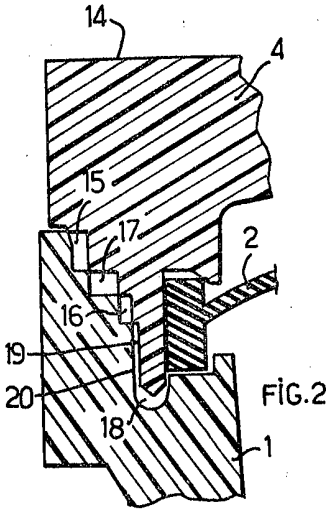

FIG.2

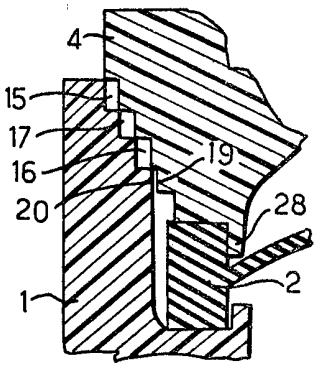

FIG.9

1576288 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

FIG.3

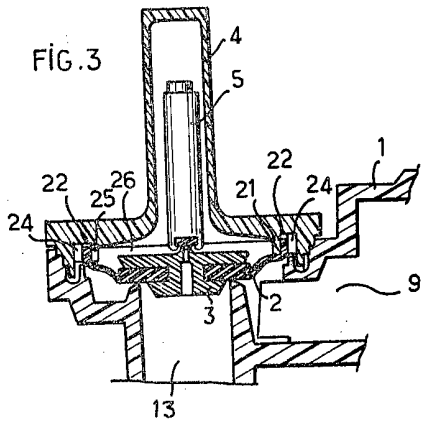

FIG.4

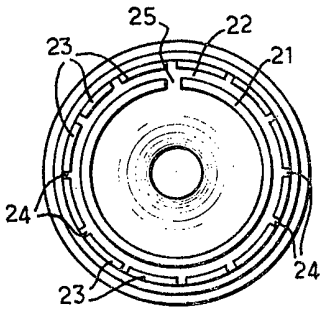

FIG.5

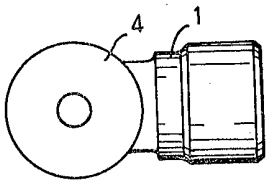

FIG.6

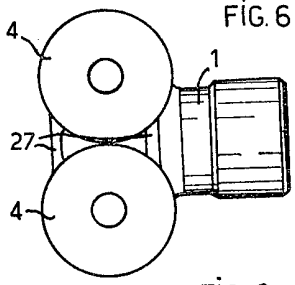

FIG.7

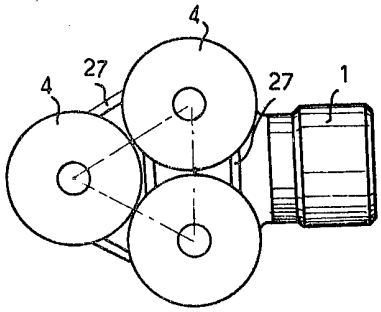

FIG.8