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(54) Thermostat

(57) A thermostat comprises a tube (10) with a switch assembly (12) mounted at a first end of the tube. A rod (14) extends within the tube and is secured to it adjacent its second end (16). The rod (14) has a coefficient of thermal expansion different from that of the tube (10) and is operatively coupled to the switch assembly (12) so as to cause the switch assembly (12) to change state in reaction to a change of temperature of the tube (10). There is carried on the rod (14) a first supporting member (42) formed from a material of a high melting point and a second supporting member (44) formed from a material with a melting point below that temperature which would be dangerous if exceeded in use. A spring (50) is trapped in compression between the first and second supporting members (42,44). An actuating assembly (60,62,64)) is operable under the action of the spring (50) on its release in the event of the second supporting member (44) melting, to cause the switch assembly (12) to change state so as to prevent further heating.

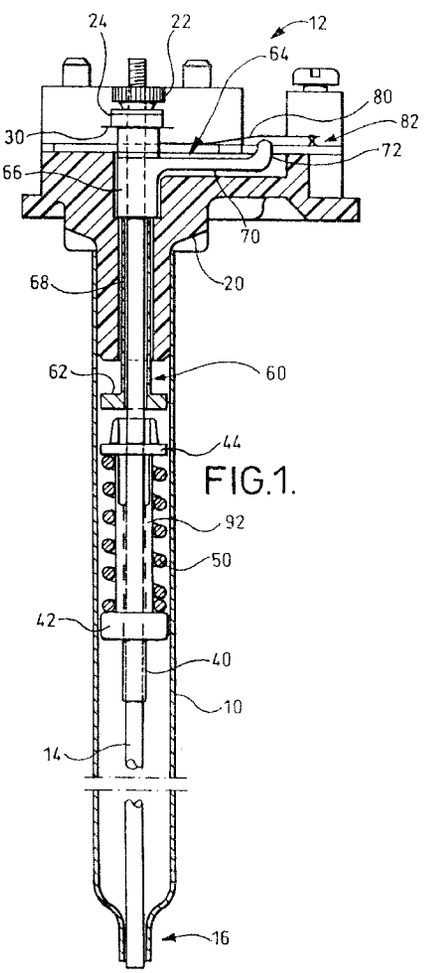

FIG.1.

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Description

The present invention relates to a thermostat, and in particular to a thermostat for liquids, for example, water.

A typical installation for providing a hot water supply comprises a storage tank in which water is heated and stored. A thermostat is provided at the storage tank whereby the temperature of the water can be controlled. The thermostat normally has an electrical switch which changes state as the water in the tank rises above or falls below threshold temperatures. A heating means (electrical or otherwise) is switched on or off according to the state of the thermostat switch.

It is increasingly common (and may soon be compulsory) for a thermostat for hot water to also have a second switching system that operates only in the event that the thermostat ceases to operate normally, in order to protect against the possibility of dangerous overheating occurring due to the heating means being permanently on. The second switching system is triggered by the water reaching a predefined high temperature, and operates to cut off the heating means. The second switching system does not re-activate the heating means when the water cools, since this would most likely cause the hot water system to overheat once again. In a domestic hot water supply system, this has hitherto typically been achieved through providing an entirely separate thermostat on an immersion heater. However, this arrangement requires a suitably modified immersion heater and suitable wiring for the secondary thermostat. This is both inconvenient and costly, and does not permit such a secondary thermostat to be retro-fitted to an existing system without replacement of the immersion heater.

According to a first aspect of the present invention there is provided a thermostat comprising a tube having first and second ends, a switch assembly mounted at first end of the tube; an elongate element extending within the tube and secured to it adjacent its second end, the elongate element having a coefficient of thermal expansion different from that of the tube, and being operatively coupled to the switch assembly so as to cause the switch assembly to change state in reaction to a change of temperature of the tube; there being carried on the rod a first supporting member formed from a material of a high melting point, a second supporting member formed from a material with a melting point below that temperature which would be dangerous if exceeded, a spring trapped in compression between the first and second supporting members, and actuating means operable under the action of the spring on its release in the event of the second supporting member melting, to cause the switch assembly to change state so as to prevent further heating.

Thus, a secondary system is provided whereby the risk of dangerous overheating is reduced.

The second supporting member may comprise a washer disposed, in use, surrounding the elongate member. The first supporting member may have attachment formations to limit axial movement of the washer, so as to maintain the spring in compression.

In a particularly preferred arrangement, the spring and the first and second support members can be assembled into a unit before being fitted onto the rod. This greatly facilitates manufacture of the thermostat.

The first and/or the second support member may be carried on the elongate member, for example, by being crimped to it. Alternatively, they may be supported within the tube, for example, by a constricted section of the tube.

Typically, the switch assembly will cause a circuit to be closed when the temperature falls below a threshold to supply power to a heating means, and to open when the temperature exceeds a threshold to interrupt power to the heating means.

In a preferred embodiment the tube is made of a metal which has a high coefficient of expansion, such as brass, and the rod is made of a metal which has a low coefficient of expansion such as invar.

The spring will typically be a helical metal spring. However, many other types of spring could be used, the main requirement being the ability to store energy under compression. For example, a leaf spring, a disc spring, or a spring disposed as a strip of resilient material in zig-zag form could be used.

A common reason for failure of normal operation of the thermostat is that switch contacts within the switch assembly become welded closed. Therefore, it is highly desirable that the switch assembly comprises a second, independent means on which the spring can act in order to interrupt the supply of power to the heating means. Such independent means may comprise a set of metal conductors normally biased into contact with one another. Such conductors may be provided with contacts.

Suitably, the first supporting member may be formed from plastic material or a metal alloy. The second supporting member may be formed from a low-melting-point alloy. An example of a suitable low-melting-point alloy comprises 57% bismuth, 17% tin and 26% indium, which has a melting point of approximately 79°C. Alternative alloys may be used to provide protection at a lower or a higher temperature.

Within the tube, there is preferably provided a component which is slidable, and which can be urged by the spring towards the switch assembly on melting of the second supporting member.

In a typical application, a thermostat according to the invention will be used to regulate the temperature of water, for example in a domestic hot water supply system.

From a second aspect, the invention provides a water tank onto which is fitted a water heater and a thermostat according to the first aspect of the invention arranged to control the water heater.

In a third of its aspects, the invention provides a rod

thermostat for a hot water supply system for switching a supply current for an immersion heater comprising a thermally-operated set of contacts, arranged to operate to open and close at predetermined temperatures in normal use, and a second set of contacts arranged to open and to remain open in the event that the temperature of the water exceeds a predetermined excess value, the two sets of contacts being connected in series between two terminals of the thermostat.

A rod thermostat according to the last-preceding paragraph can replace directly an existing rod thermostat in order to provide the benefit of protection against overheating.

The rod thermostat of this aspect of the invention suitably embodies the second aspect of the invention.

Embodiments of the invention will now be described in detail, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a sectional view of a rod thermostat embodying the invention;

Figure 2 is a more detailed view of a first supporting member for use in the thermostat of Figure 1; and

Figure 3 is an enlarged sectional view of a spring and its supporting members within the thermostat of Figure 1;

Figure 4 is an end view of a switch assembly of the thermostat of Figure 1, part assembled;

Figure 5 shows an arrangement of a spring and associated supporting members of a first modification of the embodiment of Figure 1; and

Figure 6 shows an arrangement of a spring and associated supporting members of a second modification of the embodiment of Figure 1.

With reference to the drawings, a rod thermostat comprises a brass tube 10, and a switch assembly 12 carried at a first end of the tube 10. Within the tube 10 there is an elongate rod 14. At a second end of the tube 10, remote from the switch assembly 12, there is a crimped region 16 at which the rod 14 is fixed with respect to the tube. The rod 14 also enters the switch assembly 12, and has a free end therein to operate in a manner as will be described below.

The rod 14 is made of a material with a relatively low coefficient of thermal expansion (e.g. Invar), while the brass from which the tube 10 is formed has a relatively high coefficient of expansion. Thus, the free end of the rod 14 moves axially with respect to the second end of the tube 10 as the temperature of the tube 10 changes.

The switch assembly 12 has a body 20 which is firmly secured to the tube 10 adjacent its second end. The body 20 is a plastics moulding on which is carried other components of the switch assembly 12.

A nut 22 is carried in threaded engagement on the rod 14, adjacent its free end. The nut 22 is in contact with a ceramic block 24 which is also carried on the rod 14. The nut 22 is disposed between the ceramic block 24 and the free end of the rod 14.

The switch assembly has two terminals which are connected in series with a power supply to an immersion heater, whereby the switch assembly can control the application of power to the heater. (It is also possible to provide additional contacts, for example to implement two-pole switching.)

The ceramic block 24 acts on a primary switch blade 30 which is carried on the body 20 of the switch assembly 12. The primary switch blade 30 is constructed, in a manner known to those skilled in the art, to rapidly make or break an electrical connection between a first pair of contacts (not shown) by means of an over-centre buckling action. The first pair of contacts are connected between the terminals. In this example, as the temperature of the tube increases, the tube 10 expands causing the rod to be pulled downwards (as shown in Figure 1). The ceramic block 24 is thus pulled downwards (as shown in Figure 1) to push upon the switch blade 30. This eventually causes the switchblade to snap with an over-centre action, so causing the contacts to open.

A first supporting member 42 is provided on the rod 14. The first supporting member 42 comprises an annular collar part 90 which has a central circular aperture in which the rod 14 is a close fit. A tubular part 92 extends from the collar part 90, the tubular part 92 also having a tubular bore which is a close fit over the rod 14.

A plurality of slots extend into an end portion of the tubular part 92 remote from the collar part 90. These slots define a plurality of separate fingers 94 at the said end portion of the tubular part 92. Each of the fingers 94 has a barbed end portion 96 which presents a transverse, axially-directed surface towards the collar part 90, and a radial surface which tapers away from the collar part 90.

Within the tube 10, the rod 14 has a zone of increased diameter 40, formed, for example, by coarse knurling. This region is of diameter larger than that of the bore through the first supporting member 42. The zone of increased diameter 40 thus provides a stop against which a first supporting member 42 rests. The first supporting member 42 therefore can slide along the rod 14 only a limited distance from the switch assembly 12.

A second supporting member in the form of a washer 44 is carried on the first supporting member 42. The washer 44 is formed as an annular disc having a central circular aperture 98. The barbed end portions 96 of each of the fingers 94 of the first supporting member 42 are passed through the aperture 98, the aperture being dimensioned such that as it is pushed onto the first supporting member, the material of the washer acts on the radial surfaces of the fingers 94, whereby the fingers 94 are deflected radially inwardly. Once the washer passes the barbed end portions 96 of the fingers 94, the fingers deflect outwardly, whereupon removal of the washer is resisted by the axial surfaces of the fingers 94.

The washer 44 is made from a material which has a melting point higher than the normal maximum temperature of the liquid, but lower than the temperature which would be considered dangerous. In this example, an alloy of 57% bismuth, 17% tin and 26% indium, which has a melting point of approximately 79°C is used.

A helical spring 50 is maintained in compression between the collar part 90 of the first supporting member 42 and the washer 44. The spring 50 is maintained in place radially by the tubular part 92 of the first supporting member 42.

During assembly, the spring 50 is first positioned on the first supporting member 42. The washer 44 is then applied to supporting member 42, compressing the spring at the same time. This forms a stable assembly which can then be slid into place on the rod 14. Once on the rod, radially inward deflection of the fingers 94 is resisted, so minimising the likelihood of the washer 44 accidentally becoming detached from the first supporting member 42.

A transmission element 60 is slidably carried on the rod 14. The transmission element 60 has a cylindrical portion 68 which projects away from the washer 44 towards the body 20. An end portion of the transmission element 60 next to the washer 44 is formed as a radially extending flange 62.

The switch assembly 12 further comprises a switch actuator 64. The switch actuator 64 has a boss 66 which surrounds the rod 14, and is slidable on it. The boss 66 resides within a cylindrical recess in the body. An arm 70 projects radially from the boss 66. At an end portion, the arm 70 has an axial projection 72 directed away from the second end of the tube 10.

The axial projection 72 is disposed adjacent a second switch blade 80. A second pair of electrical contacts 82 (connected in series with the first pair)is controlled by the second switch blade 80. The first and second pair of contacts are electrically connected in series with one another, such that if either pair enters an open-circuit state, flow of electrical current through the switch assembly 12 is broken.

In the normal operating condition, as shown in the figure, there is a clearance between the washer 44, the flange 62 of the transmission element 60, and the boss 66 of the switch actuator 64. The clearances are sufficiently large that they will not close up, even under the coldest conditions encountered by the thermostat (when the tube 10 is shortest).

In the event that the first pair of contacts fails to open under the action of the thermostat (for example, if arcing has caused them to weld closed) and the temperature of the liquid in which the thermostat is immersed continues to rise, eventually the washer 44 will melt. When this happens, the spring 50 will be released to move towards the switch assembly 12. The spring then pushes against the flange 62 of the transmission element 60 which, in turn, comes into contact with the switch actuator 64. The switch actuator 64 moves axially along the rod 14, its axial projection 72 coming into contact with the second switch blade 80. The switch blade is then moved upwardly (in Figure 2) thereby opening the second pair of contacts 82. Power to the heating means is thereby removed.

It will be appreciated that power will not be restored once the liquid cools. The washer 44 has been destroyed, so the spring 50 is permanently released, such that the second pair of contacts 82 is permanently open.

With reference now to Figure 5, there is shown a first alternative configuration of the spring and its supporting members. The switch assembly is not shown in Figure 5. However, it should be understood that it will be carried at the end of tube 10 near to the top of the figure. This is also the case for the embodiment of Figure 6, to be described below.

In this modified embodiment, a first supporting member for the spring 50 comprises a first eyelet 100 which surrounds the rod 14 and is crimped at 104 so as to prevent it from sliding along the rod 14. The eyelet 100 includes a flange 106 radially projecting from and surrounding the rod 14.

A first washer 102 is disposed around the rod 14 and is supported on the flange of the eyelet 100. The washer 102 has a through hole of diameter less than that of the flange 106. Thus, movement of the washer 102 along the rod 14 in a direction away from the switch assembly 12 is prevented by the first washer 102. The eyelet 100 and the first washer 102 are formed from a material of a melting point higher than would be experienced by the thermostat in use. (In an alternative construction, the flange 106 could be formed with a larger diameter, so obviating the need for the washer 102.)

A second supporting member for the spring 50 comprises a second eyelet 110, substantially identical to the first eyelet 100. The second eyelet is disposed between the first eyelet 100 and the switch assembly 12. A second washer 112 is located against the flange 116 of the second eyelet 110. The second washer is formed of a material which has a melting point higher than the normal maximum temperature of the liquid, but lower than the temperature which would be considered dangerous.

The spring 50 is confined under compression between the first and second washers 102,112.

It will be seen that the present embodiment operates in a similar manner to the first embodiment in the event that overheating occurs. The second washer 112 will melt, so allowing the spring 50 to expand towards the switch assembly, thereby opening the circuit through the switch.

In the embodiment of Figure 6, the first and second supporting members are constituted by formations of a one-piece supporting sleeve 200.

The sleeve 200 comprises a disc portion 202 which surrounds the rod 14 within the tube 10. A tubular collar portion 204 extends from the disc portion 202, surrounding the rod 14, towards the switch assembly 12. The collar portion 204 has an outer diameter less than that of

the disc portion 202. A tapered portion 206 extends from the collar portion 204 towards the switch assembly 12. The tapered portion 206 has an outer diameter which increases to substantially span the tube 10 in a direction away from the collar portion 204. Slots extend axially into the tapered portion 206, to divide it into four circumferentially spaced segments.

A recess 208 is formed centrally of an end face of the sleeve 200, directed towards the switch assembly 12. A washer 210 of material which has a melting point higher than the normal maximum temperature of the liquid, but lower than the temperature which would be considered dangerous is located within the recess surrounding the rod 14.

The spring 50 is contained in compression between the disc portion 202 (a first supporting member) and the tapered portion 206 (a second supporting member) of the sleeve 200.

An eyelet 220, substantially similar to that described above, is provided to resist movement of the sleeve away from the switch assembly 12.

In the event that the thermostat is subject to an unacceptably high temperature, the washer 210 will melt. This allows the tapered portion 206 to collapse radially inwardly, the segments moving together thereby allowing the spring 50 to expand towards the switch assembly 12 to break the circuit as has been described above.

In this last embodiment, only a fractional part of the spring's force is carried by the washer. This is advantageous because the spring force can be greater than is the case with the other embodiments without the result that the washer becomes subject to deflection over time through creep.

Claims

1. A thermostat comprising:

a tube having first and second ends, a switch assembly mounted at the first end of the tube;
an elongate element extending within the tube and secured to it adjacent its second end, the elongate element having a coefficient of thermal expansion different from that of the tube, and being operatively coupled to the switch assembly so as to cause the switch assembly to change state in reaction to a change of temperature of the tube;
there being within the tube a first supporting member formed from a material of a high melting point, a second supporting member, at least part of which is fusible being formed from a material with a melting point below that temperature which would be considered dangerous if exceeded, and a spring trapped in compression between the first and second supporting members, in which event, the second supporting part being rendered unable to withstand compressive force of the spring; and there being
actuating means operable under the action of the spring on its release in the event of at least part of the fusible melting, to cause the switch assembly to change state so as to prevent further heating.

2. A thermostat according to claim 1 in which the fusible part comprises a washer disposed, in use, surrounding the elongate element.

3. A thermostat according to claim 2 in which the first supporting member has attachment formations to limit axial movement of the washer, so as to maintain the spring in compression.

4. A thermostat according to any claim 2 or claim 3 in which the spring and the first and second supporting members can be assembled into a unit before being fitted within the tube.

5. A thermostat according to claim 2 in which a component is mounted on the rod and spaced from the first supporting member to limit axial movement of the washer, so as to maintain the spring in compression.

6. A thermostat according to any one of claims 2 to 5 in which the spring bears directly against the washer.

7. A thermostat according to any one of claims 2 to 5 in which on melting of the washer, a part of the second supporting member becomes deflectable by the spring, such that compressive force of the spring cannot be retained by the second supporting member.

8. A thermostat according to any preceding claim in which the first supporting member is carried on the elongate element.

9. A thermostat according to any one of claims 1 to 7 in which the first supporting member is carried on formations of the tube.

10. A thermostat according to any preceding claim in which the switch assembly causes circuit to be closed when the temperature falls below a threshold to supply power to a heating means, and to open when the temperature exceeds a threshold to interrupt power to the heating means.

11. A thermostat according to any preceding claim in which the tube is made of a metal which has a high coefficient of expansion, such as brass, and the rod is made of a metal which has a low coefficient of

expansion such as invar.

12. A thermostat according to any preceding claim in which the spring is a helical metal spring, a leaf spring, a disc spring, or a spring disposed as a strip of resilient material in zig-zag form.

13. A thermostat according to any preceding claim in which the switch assembly comprises a second, independent means on which the spring can act in order to interrupt the supply of power to the heating means.

14. A thermostat according to claim 13 in which the said independent means comprises a set of metal conductors normally biased into contact with one another.

15. A thermostat according to any preceding claim in which the first supporting member is formed from plastics material or a metal alloy.

16. A thermostat according to any preceding claim in which the fusible part of the second supporting member is formed from a low-melting-point alloy.

17. A thermostat according to any preceding claim 16 in which the low-melting-point alloy approximately comprises 57% bismuth, 17% tin and 26% indium.

18. A thermostat according to any preceding claim which comprises within the tube, a component which is slidable, and which can be urged by the spring towards the switch assembly on melting of the second supporting member.

19. A thermostat substantially as herein described with reference to the drawings.

20. A water tank onto which is fitted a water heater and a thermostat arranged to control the water heater, in which the thermostat is in accordance with any preceding claim.

21. A rod thermostat for a hot water supply system for switching a supply current for an immersion heater comprising a thermally-operated set of contacts, arranged to operate to open and close at predetermined temperatures in normal use, and a second set of contacts arranged to open and to remain open in the event that the temperature of the water exceeds a predetermined excess value, the two sets of contacts being connected in series between two terminals of the thermostat.

22. A rod thermostat for a hot water supply system substantially as herein described with reference to Figures 1 to 4 of the drawings.

23. A rod thermostat according to claim 19, as modified substantially as described with reference to Figure 5 or Figure 6 of the drawings.

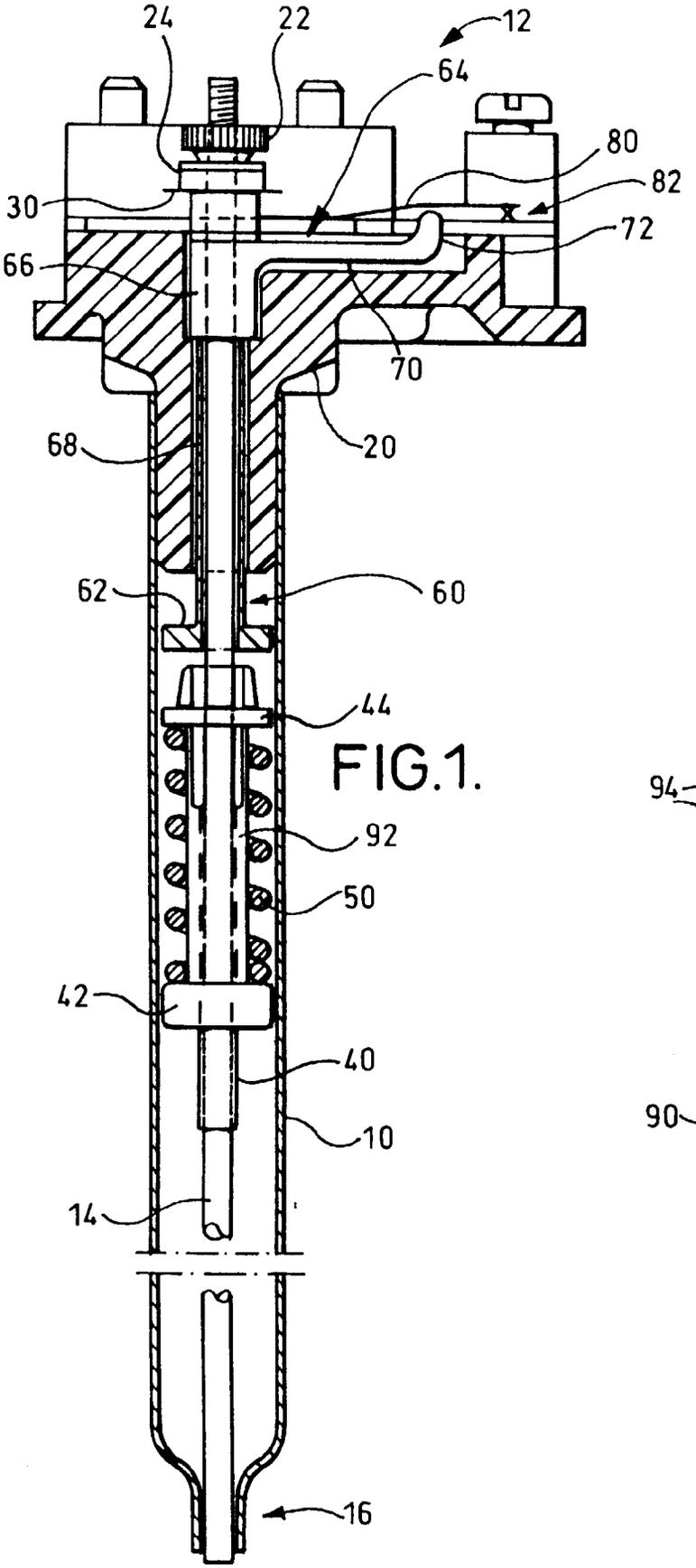
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FIG.1.

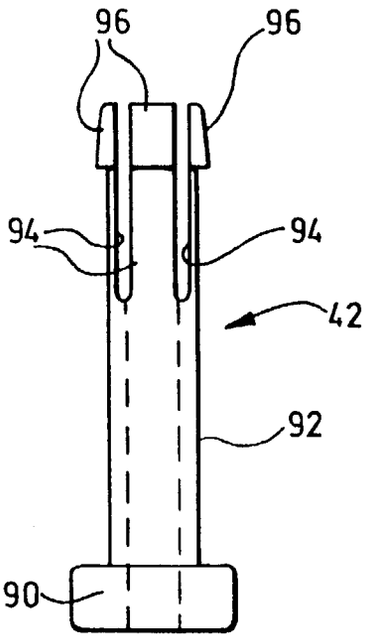
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FIG.2.

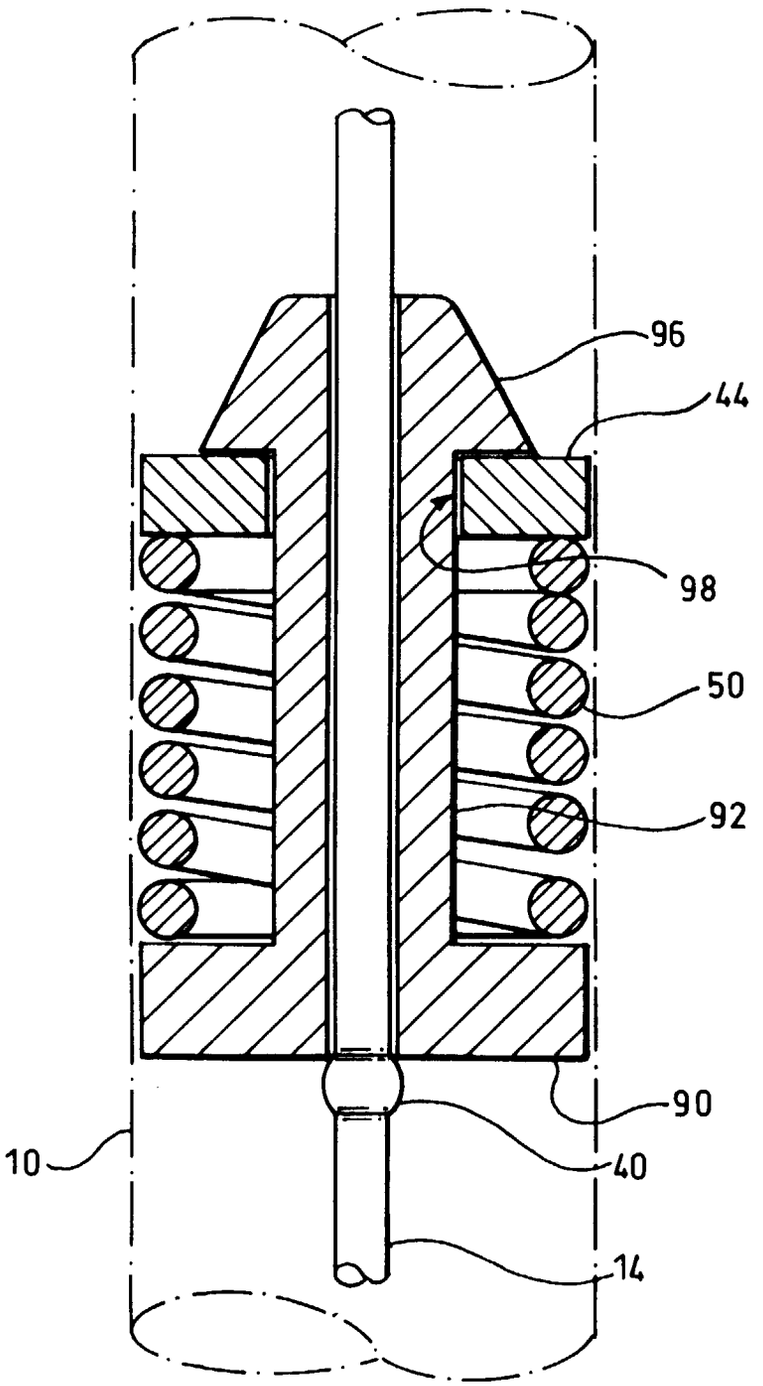

FIG.3.

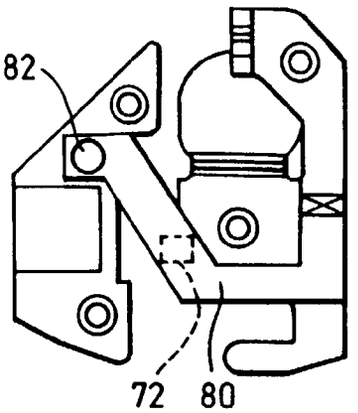

FIG.4.

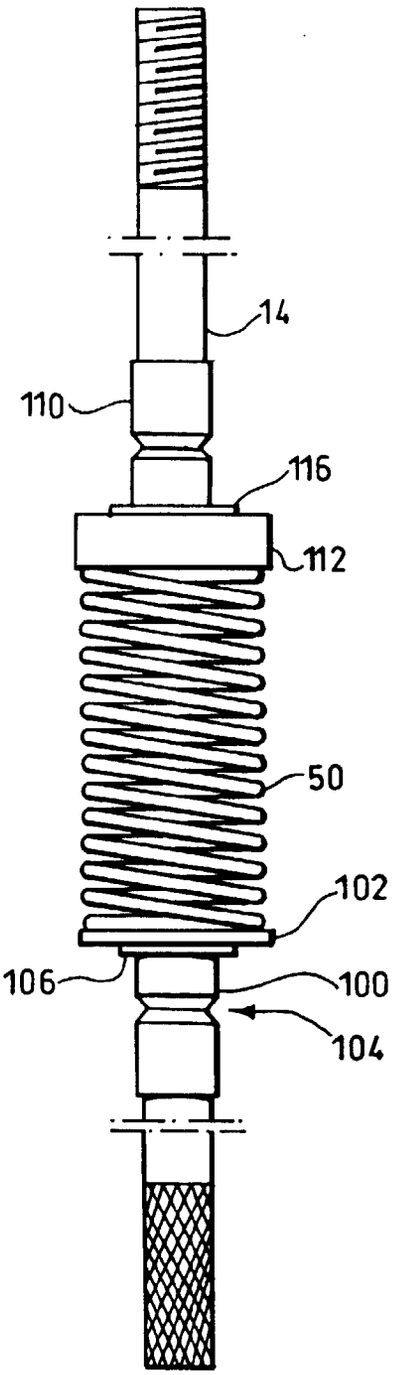

FIG.5.

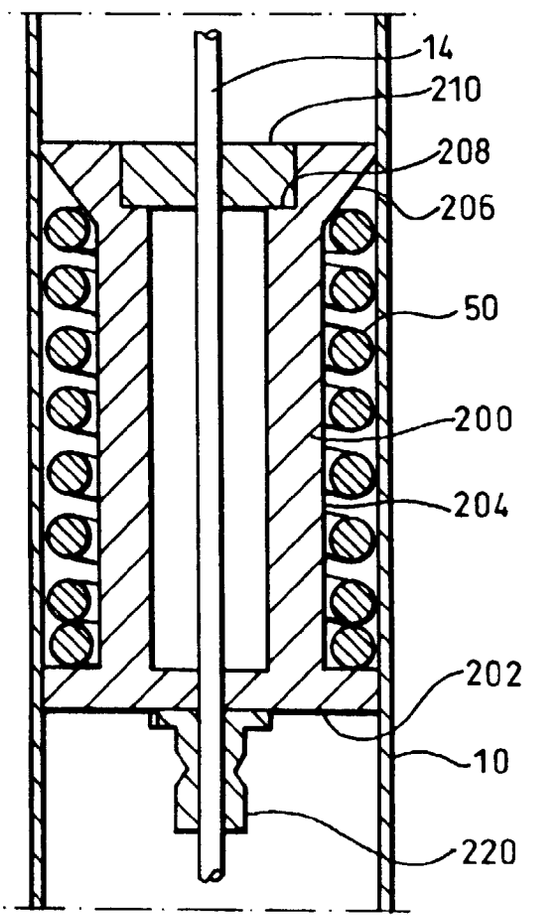

FIG.6.