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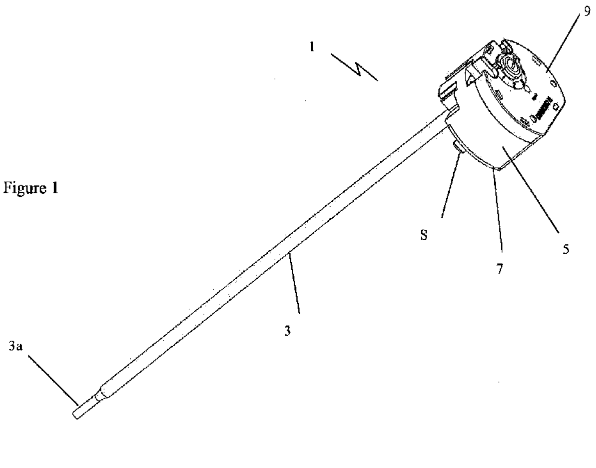

Figure 1

(57) Abstract: The present invention discloses a thermostat (1) of the type having a thermal probe comprising a hollow tube (3) of thermally expansive material having a first coefficient of expansion within which there is provided, fixed thereto at the distal end thereof, a rod (11) of substantially thermally non-reactive material such that when heated a linear displacement between the rod (11) and the tube (3) is utilized to actuate a regulating switch. The thermostat (1) comprises a probe assembly having a base plate (7) to which the tube (3) of the thermal probe is fixed and a switching assembly (5) securable to the base plate (7) and includes a cover element (9). The thermal probe also houses a sensor (45, 47) filled with a thermally expansive fluid in communication with a diaphragm (15) fixed to the base plate (7) and operable to actuate a movement amplifying switch actuator to provide a safety over-temperature cut-out function. The thermal interruption and safety cut-out mechanisms are wholly independent. The present invention also discloses a method of assembling a thermostat (1) which includes the steps of fixing a hollow tube (3) of thermal probe to a base plate (7) having attached thereto mounting points for a movement amplifying switch actuator, forming the thermal probe by positioning within the hollow tube (3) thereof a rod (11) and a fluid-filled sensor (45, 47) disposed adjacent or about the rod (11), mounting the switching assembly (5) to the base plate (7), and testing the temperature points at which thermostatic interruption and over-temperature cut-out functions operate.

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THERMOSTAT WITH INDEPENDENT OVER-TEMPERATURE ACTUATION

Field of the Invention

The present invention relates to the field of thermostats and in particular to electro-mechanical devices for controlling the temperature of a heated water vessel, typically an "immersion tank". More specifically, the invention relates to a thermostat of the kind which comprises a probe tube and a rod located within the tube, the tube and rod being made of materials having different coefficients of thermal expansion.

Background to the Invention

It will be understood that certain terms used in the description which follows are intended to describe specific situations and should not be interpreted as limiting the scope of the invention or its use. The phrase "over-temperature protection", "fail-safe" and "thermo-protection" are used interchangeably so as to be inclusive. Similarly, the term "immersion heater" is used with reference to the predominant use to which the thermostat of the invention is applied.

UK Patent No. 1,098,641 to SATCHWELL CONTROLS LIMITED describes a development of a thermal regulator within which there is provided a probe fitted with a capillary tube containing a thermodynamic fluid to communicate with a diaphragm actuator. As with thermostats having a similar and standard construction, the diaphragm actuates a switch to interrupt an electrical current to the load heating the contents of a cavity or vessel within which the probe is placed. In the SATCHWELL disclosure, a secondary diaphragm is in fluid connection with the primary diaphragm and is adjustably preloaded using a calibration screw to move the operating temperature range of the primary diaphragm which, in the embodiment described, facilitates pyrolytic cleaning of a domestic cooking oven. As with many regulators and thermostats of the time, no fail-safe provision is made.

For the sake of clarity, the normal temperature at which intervention occurs is often referred to as the thermostat regulation temperature. Should the thermostat fail to regulate or intervention does not occur, the temperature within the vessel continues to rise. By providing an interrupter at an elevate temperature beyond the normal operating range of the thermostat but within an acceptable non-hazardous upper limit, a fail-safe system is provided to isolate the load.

Developments of the capillary tube diaphragm actuator thermostat to incorporate a fail-safe system include that illustrated in UK Patent No. 1,352,146 also to SATCHWELL CONTROLS LIMITED. In this construction, a biasing force is applied to the diaphragm which overcomes this force in normal operation. Should the diaphragm actuator fail, for example, by leakage of the thermodynamic fluid from the capillary sensor, the diaphragm collapses to a state of minimum volume under the biasing force and the switch contacts are levered into an open "OFF" position thereby isolating the load.

It will be appreciated by those familiar with the art that the fail-safe system not only acts on the same sets of switch contacts as the primary thermostat function but also uses the operation of the identical sensor or actuating element. Consequently, should the failure be with the actuating mechanism or should the switch contacts become fused or otherwise locked in a closed position, the fail-safe system will not work.

Further development of such linked fail-safe systems moved away from fluid-filled sensors and diaphragm actuators predominantly by replacing the probe with a system incorporating a tube within which is secured a rod having a lower coefficient of thermal expansion than that of the tube. The material most often used for the rod is INVAR (TM), a substantially non-thermoreactive metal. The rod is secured to the probe tube by crimping and/or welding at the remote or distal end thereof, so that when the probe is heated towards the switching temperature of the thermostat, there is a length differential created between the rod and the tube which is used to actuate the thermal control switch.

Exemplary of the use of such arrangements are UK Patent Application Publication Nos. 2 172 749 and 2 201 570 to COTHERM SA and the significantly earlier disclosure of French Patent Application Publication No. 2 369 674 to SNIPELSKI. The COTHERM 2 172 749 publication also discloses a fail-safe actuator disposed coaxially with the rod where, when an over-temperature condition is reached, an actuator element reversibly deforms and mechanically separates the switch contacts to isolate the load. The actuator element comprises a disc retained within a metal dish which is in good thermal contact with the probe tube, so that heat conducted from the fluid within the cavity or vessel gradually elevates the temperature of the disc. When the disc deforms it carries a slide block which opens the switch contacts. As the disc is reversible, a manual reset of the fail-safe is obviated, leading potentially to a cycling of overheating and reliance on the thermo-protection function. Most over-temperature cut-out sensors or actuators are not designed for high cycling.

French Patent Application Publication No. 2 149 242 to BDM ITALIA discloses a bimetallic actuator exposed to radiated heat independently of the immersion tube and axially off-set therefrom. When the over-temperature condition is reached, the bimetallic disc inverts moving a rod adapted to carry independent serially connected switch contacts to the "OFF" position. The extremity of the rod protrudes from the thermostat case to present a manual reset button.

In all devices utilising a bimetallic disc or similar over-temperature actuator, detection occurs remotely from the probe and requires efficient thermal communication between the fluid being heated and the disc, which is normally secured to or constrained within the base plate of the thermostat and thus thermal losses affect the rapidity with which the over-temperature condition is detected and reacted to. The physical distance the bimetallic actuator deflects is also a consideration and a number of other solutions, including a spring memory actuator as exemplified by International Patent Publication No. WO 2005/119720 to COTHERM SA, attempts to address the disadvantages associated with remotely disposed over-temperature cut-out actuators. It will be appreciated that once selected or fitted, the cut-out temperature at which the actuator deflects is fixed and cannot be adjusted.

French Patent Publication No. 2 707 424 to VASCO discloses a special function thermostat which, in addition to performing a single pole thermostatic intervention of a water heater resistance load using a conventional probe and rod arrangement, utilises a capillary tube to monitor possible temperature losses from the water being heated. With minimal thermal inertia, the fluid contained in the capillary tube deforms a spherical strip from a concave to a convex shape to separately disconnecting power to the load. The capillary is wound in a spiral at its distal end.

United Kingdom Patent Publication No. 2 295 490 to DIAMOND H CONTROLS LTD discloses a thermostat having a thermal probe including a thermally expansive rod of the known type eccentrically disposed within the hollow tube of a modified probe adapted to accommodate a fluid-filled sensor within the tube to provide a safety cut-out function. The cut-out function is operable via a diaphragm coupled to the sensor by a capillary tube. When the temperature of the fluid in the sensor expands, the corresponding movement of the diaphragm ensures that the switch actuator mounted on the rod forces the switch contacts into the open position.

As neither the embodiments described in the VASCO nor DIAMOND H disclosures were realised or tested in the market, their respective disadvantages are not well known. The challenges calibrating deformable strips and discs are well appreciated and it is essential to isolate the return movement of the cut-out actuator if cycling is to be avoided. In the DIAMOND H disclosure, the probe is of a non-standard shape to accommodate the sensor phial, increasing the cost of the device and eliminating the retrofit market as a larger bore is required to accommodate the probe in the vessel containing the liquid to be heated. It will also be seen that despite addressing some of the major disadvantages associate with certain prior art devices, neither the VASCO or DIAMOND H disclosure address the issues of thermal dead spots or temperature gradients arising from water stratification within the vessel.

The technical literature indicates that the use of capillary and diaphragm systems was overlooked thereafter as developments in thermostatic controls followed and alternative path. It was not until the push towards the integration of electronic controls with electro-mechanical devices that capillary and diaphragm systems made a resurgence. An example of such an electronic control system governing a domestic electrical appliance is illustrated in United States Patent Application Publication No. 2008/0230617 to COTHERM SA. It will also be seen by the skilled addressee that the preponderance of devices having a thermal fail-safe or over-temperature cut-out function seeks to integrate rather than separate the regular thermal intervention and cut-out function. Clearly, where a mechanical failure of the device occurs and the intervention and cut-out functions are linked or closely associated, the likelihood of total failure of the device is greater.

There is a perceived need to provide a thermostat having independent over-temperature protection in which detection and reaction to elevated temperatures are independent of the primary sensor and the resultant thermal intervention. Furthermore, the cut-out actuating mechanism and isolation of the electrical load heating the fluid in the subject cavity or vessel ought also to be wholly independent of the thermostat function to provide reliable and fail-safe over-temperature protection.

One scenario where thermo-protection must be assured is in the instance where the crimp and/or weld securing the INVAR rod to the distal end of the probe tube fails, resulting in total loss of the thermostatic function.

It will also be observed from the prior art that the construction and assembly of thermostats involves the assembly and calibration of a number of discrete components which must operate together reliably, repeatedly and predictably over many cycles for many years. There is continuous cost pressure on such control devices and any improvement in cost, reduced component count or ease of assembly is to be lauded.

The positioning of the over-temperature sensor has already been discussed above with respect to sensitivity and rapidity of response, however, the known problems with thermal dead spots and temperature gradients within the vessel, as a result of water stratification or thermostat probe positioning, are not addressed by the prior art devices having over-temperature cut-out actuators.

It is an object of the present invention to seek to alleviate the disadvantages associated with prior fail-safe protection of thermostats and to provide an improved thermostat construction with independent over-temperature protection.

It is also an object of the present invention to provide a thermostat that is easily assembled from standardised modules.

It is a further object of the present invention to seek to obviate the primary disadvantages associated with prior art thermostats and methods of assembly.

A further object of the present invention is to decouple the previously linked detection and interruption of current to a heating load during over-temperature conditions from the standard thermal intervention function of a thermostat.

It is a yet further object of the present invention to obviate the measurement of over-temperature conditions by inference (that is, by detecting remotely at the base plate of the thermostat, over-temperature conditions at the probe), and to provide thermal detection for the thermostat function and over-temperature function within and along the length of the probe. Furthermore, adjustment of the temperature at which the over-temperature cut-out function actuates is facilitated.

It is an additional object of the invention to provide thermal protection to a rod type thermostat in event of catastrophic failure of rod, including where the rod breaks away from the weld/crimp.

Summary of the Invention

Accordingly, the present invention provides a thermostat of the type having a thermal probe comprising a hollow tube of thermally expansive material having a first coefficient of expansion within which there is provided, fixed thereto at the distal end thereof, a rod of thermally expansive material having a second coefficient of expansion such that when heated a linear displacement between the rod and the tube is utilised to actuate a switch, the thermostat comprising:

a probe assembly having a base plate to which the tube of the thermal probe is fixed; and

a switching assembly securable to the base plate and adapted to receive a cover element;

in which the thermal probe also houses a sensor filled with a thermally expansive fluid in communication with a diaphragm fixed to the base plate and operable to actuate a movement amplifying switch actuator to provide a safety over-temperature cut-out function.

Advantageously, the thermostat has a modular construction comprising two standard modules and one module provided in a plurality of switching configurations, in which the first standard module comprises said base plate and probe, the base plate carrying the diaphragm and movement amplifying switch actuator, thereby presenting two actuator elements to the switching assembly.

The relatively small linear movement of the diaphragm is translated into a step movement by a movement amplifying mechanism which presents a switch actuator to be received by the switching assembly in a manner similar to the reception of the threaded end of the rod actuator within the switching assembly.

The switch actuator of said movement amplifying mechanism comprises a grub screw to facilitate calibration. The grub screw acts on an actuator follower in the switching assembly which has a pair of radial arms which engage respective blades of the switches to provide single throw, double pole isolation. Due to the linear characteristics of expansion of the thermodynamic fluid and the movement of the diaphragm, the combination of the movement amplifying mechanism and grub screw actuator, allows for the cut-out temperature not only to be adjusted but also moved significantly to provide preselected cut-out temperatures anywhere between 0C and 300C.

The second standard module comprises the cover for the switching assembly which is configured to push fit therewith and to provide pre-set adjustment for the temperature at which thermostatic interruption occurs.

As will be appreciated by the skilled addressee, the switching assembly incorporates a thermostat switch operable by said rod and further incorporates an over-temperature safety cut-out switch operable in response to said movement amplifying switch actuator.

Advantageously, the switching assembly is configured so that thermostatic interruption of the connection of electrical current to a water heater resistance load is in series with the over-temperature cut-out function.

Preferably, the thermal interruption occurs on the supply phase and the cut-out function provides double-pole isolation.

In one construction, the switching assembly includes insulated terminals, adapted to penetrate apertures provided in the base plate, for supplying electric current to a water heater resistance load.

In the preferred embodiment of the invention, the actuation means and switching associated with thermostatic interruption of electrical current is wholly independent of both the actuation means and switching associated with the safety over-temperature cut-out function, whereby failure of any single component cannot prevent both thermal interruption and cut-out function.

Advantageously, the sensor comprises at least one helically coiled section which can be accommodated within the thermal probe and having an inner diameter capable of accepting the rod.

Preferably, the sensor is provided along substantially the entire length of the probe, so as to eliminate the effects of thermal dead spots and temperature gradients.

The provision of the sensor within the probe overcomes all the major disadvantages associated with over-temperature detection by sensors located on the base plate or within the head of the thermostat. By providing the sensor along the operational length of the probe, in either helically coiled, straight length or almost any other configuration, eliminates the effects of water stratification or localised temperature variations and dead spots associated with point sensing of temperature.

The invention further provides a method of assembling a thermostat as defined hereinabove, the method including:

fixing a hollow tube of a thermal probe to a base plate having attached thereto mounting points for a movement amplifying switch actuator;

forming the thermal probe by positioning within the hollow tube thereof a thermally expansive rod and a fluid-filled sensor disposed adjacent or about the rod, both being positioned and configured to provide efficient thermal reaction;

selecting a switching assembly according to desired switching function;

mounting the switching assembly to the base plate;

testing the temperature points at which thermostatic interruption and over-temperature cut-out functions operate; and

fixing a cover to the switching assembly.

Brief Description of the Drawings

The present invention will now be described more particularly with reference to the accompanying drawings which show, by way of example only, one embodiment of thermostat and a method of assembly in accordance with the invention. In the drawings:

Figure 1 is a perspective view of an assembled thermostat having a thermal probe, a switching module and a cover for the switching module;

Figure 2 is an exposed perspective elevation of a thermostat base plate to which the thermal probe is attached, illustrating the movement amplifying mechanism associated with a diaphragm;

Figure 3 is a detailed perspective elevation of the thermostat base plate, thermal probe, diaphragm and movement amplifying mechanism;

Figure 4 is a detailed perspective elevation of a switching assembly module; and

Figure 5a and 5b are exposed side elevations of first and second configurations of thermal probe in which the rod element is held coaxially. In the first configuration the over-temperature capillary tube is disposed parallel to the rod. In the second configuration, the capillary tube is arranged as a helical coil and disposed about the central rod.

Detailed Description of the Drawings

Referring to the drawings and initially to Figure 1, the thermostat assembly 1 of the invention includes a thermal probe comprising a cylindrical hollow tube 3 which has disposed therein, along its central longitudinal axis, a rod of substantially thermally non-reactive material. The rod is secured at the free end 3a of the tube 3 by crimping and/or welding. At the other end of the rod, an actuator is provided to be operably movable with the rod and is disposed within and forms part of a switching module or assembly 5. The switching module 5 is screwed or otherwise fixed to a base plate 7 to which the probe tube 3 is bonded and a cover element 9 sealingly clips to switching module 5.

Referring now to Figures 2 and 3, the probe tube 3 constrains the rod 11 so that its limited thermal expansion is confined to the longitudinal axis of the probe. As the probe tube has a greater coefficient of thermal expansion to that of the rod and the rod 11 is bonded to the tube 3 at the free end 3a thereof, the length differential at the thermostat operating range is presented at the base plate 7. When a switching assembly 5 is fixed to the base plate, the differential is used to engage an actuator to open a set of contacts interrupting current to a heating load in a manner well-known to the skilled addressee.

Centrally disposed within the inner surface of the base plate 7 there is secured a diaphragm 15 connected to a capillary system (described in more detail with reference to Figures 5a and 5b) to constrain and communicate expansion of a thermal fluid between an independent sensor located within the probe tube and the diaphragm. The sensor can comprise a phial positioned at a convenient point along the length of the tube to gain an optimal measure of the temperature of the heated fluid or may simply comprise a length of capillary tube along the length of the probe tube and ideally in thermal connection therewith. By providing the sensor along the operational length of the probe, the problems associated with thermal dead spots and temperature gradients, most notably arising from water stratification, are eliminated. In a preferred construction, the sensor comprises a helically arranged coil of capillary tube defining a central passage within which the rod 11 is free to move. The coiled capillary has a larger volume of thermal fluid therein and consequently provides a greater differential volume at elevated temperatures to increase corresponding movement at the head 17 of the diaphragm 15. Optionally, the sensor is provided with a number of discrete coiled sections along the length of the probe. It will be readily appreciated by the skilled addressee that the thermodynamic fluid within the capillary system may be a gas.

The relatively small linear movement of the diaphragm 15 is translated to a step movement by an amplifying mechanism 20 via a calibration grub screw 21 held in position over the diaphragm head 17 by an actuator pivot plate 22. The movement of the plate is triggered by a leaf spring 23 held between the free end of the plate 23 and a first control surface 24 which is fixed to the base plate 7 and has a stop 25 disposed over the pivot plate. The pivot plate 22 is held by the biasing force of the leaf spring 23 against a pair of edge receivers 26 which engage pivot edges 27 on the pivot plate. The edge receivers 26 are formed on uprights of a second control surface 29 fixed to the base plate.

Figure 4 shows one embodiment of switching assembly/module 5 in which positive and negative terminals T are connected to corresponding spade connectors S located on the underside of the switching module and are positioned so as to penetrate apertures A formed in the base plate 7 (as detailed in Figure 3) of the thermostat for connecting to corresponding receiving connectors of an immersion heater element (not shown). Between each of the terminals T and the corresponding connectors S, normally ON switches are provided. The switch associated with the interruption by the thermal regulation function of the thermostat comprises an over-lever blade switch arm 30 which is deflected from its corresponding static contact 31 by a follower surface 32 secured to the threaded end of the rod 11 by a nut adjuster N. In the illustrated embodiment, a pair of switches 33 are opened by the action of the actuator associated with the over-temperature sensor and diaphragm (and is described below in more detail). It will be appreciated that the safety cut-out function may be effected using a single throw, single-pole isolation.

In another embodiment of switching module, the terminals T are provided for connecting in series with a phase of the power supply provided to the load (the heating element). In this instance, the spade connectors S are not required or are removed. Phase interruption occurs when the switch is forced open into the "OFF" position by the corresponding actuator. Ideally, all switching occurs under the thermostat function of the rod actuated switch with the over-temperature diaphragm actuated switch being used only where the thermostat function fails.

Figure 4 particularly illustrates the position of the movable switch spring blades 33 and their corresponding static contacts 34 which operably form part of the terminals T. The action of an over-temperature actuator follower 35, which is constrained to move in a vertical plane under the influence of the grub screw 21 held by the actuator plate 22 of the amplifying mechanism 20, is also illustrated. When the diaphragm head 17 moves a pre-selected amount, triggering the snap-action of the leaf spring 23, the uppermost part of the grub screw 21 abuts the underside of the follower 35 pushing it upwardly. The follower has a pair of radial arms 36 over which the spring blades 33 of the normally ON switches are disposed. As the follower 35 is urged upwardly it carries the spring blades 33 on each of its radial arms 36, separating the contacts and breaking the switches, thereby providing single-throw, double-pole isolation. A head portion 35a of the actuator protrudes through a hole provided in the cover 9 of the switching module 5 to indicate over-temperature actuation and to provide a reset switch. An automatic reset function can be provided by positioning a helical spring over the head portion 35a of the follower to urge it downwardly to reposition the actuator plate 22 and re-arm the leaf spring 23.

Also illustrated in Figure 4, the switch actuation associated with the thermostat function communicates the relative movement of the rod 11 to the over-lever blade 30 carrying the first contact of the primary thermostat switch away from the second static contact 31. The switch actuator has a pivot tab 40 which engages a tab receiver 41 in the body of the switching module 5 and a through-hole adjacent the tab to accommodate the threaded section 11a of the rod. The threaded nut N tightened onto the rod ensures the actuator follower 32 is correctly positioned and deflects the switch arm 30 at the point where the length differential of the rod with respect to the tube exceeds a switching pre-set, thereby affecting the thermostatic function.

As noted above, the over-temperature switch actuator follower 35 responds to the movement amplifying mechanism 20 via the grub screw 21 which facilitates calibration but also allows for adjustment of the temperature at which the cut-out function engages. Due to the linear characteristics of expansion of the thermodynamic fluid and the movement of the diaphragm, the combination of the movement amplifying mechanism, grub screw and actuator follower, allows for the cut-out temperature not only to be adjusted but also moved significantly to provide preselected cut-out temperatures anywhere between 0C and 300C.

Referring now the Figures 5a and 5b, a first construction of over-temperature sensor 45 comprises a length of capillary which is accommodated in the probe tube 3 substantially the entire operating length of the probe adjacent the rod 11.

The sensor 45 optionally includes a flattened section for accommodating a greater volume of thermodynamic fluid at one or more selection positions along the length of the probe. The movement of the rod 11 with respect to the tube 3 is not affected. A second construction of over-temperature sensor 47 comprises a capillary formed as a helical coil adapted to fit within the probe tube 3 and to accommodate the rod 11 therewithin without interference. The capillary is ideally coiled along the entire length of the tube to maximise the volume of thermoreative fluid exposed to an elevated temperature thereby maximising the diaphragm deflection. Optionally, coiled sections are provided for positioning at selected regions along the length of the probe tube.

As will be appreciated from the foregoing, the method of assembly of the thermostat is made more reliable and easier using standardised modules which can be calibrated separately as assembly does not alter their respective performance characteristics.

Securing of the tube 3 to a base plate 7 and the provision of a crimped and/or welded INVAR™ rod 11 at the remote end 3a thereof is well-appreciated so will not be discussed further here. The addition of an over-temperature sensor 45, 47 with capillary and diaphragm 15 is straight-forward in that a tubular sensor or plain capillary length may be passed into the probe tube adjacent the rod without interfering therewith. A sensor in the form of a helically coiled section of capillary having a passage within to accommodate the rod (again without interference) may also be positioned within the standard configuration of probe tube without difficulty. The diaphragm ideally includes a securing stud on the underside thereof to facilitate fixing the diaphragm to the base plate. On the upper surface of the diaphragm 15, a diaphragm head 17 acts against a threaded grub 21 in the movement amplifying mechanism 20 described hereinabove with reference to Figures 2 and 3. The mechanism is fixed to the base plate 7 and forms an integral part of the probe module.

The switching module 5, in whatever configuration desired, is secured to the base plate 7 by a pair of screws which penetrate screw holes 49 provided in the base plate and engage threaded receivers in the body of the switching module 5. The threaded section 11a of the rod 11 passes through the module unimpeded and the threaded nut N is screwed down onto the actuator follower 32 which breaks the main thermostat contact by pushing downwardly on the over-lever blade switch 30.

The final module in the assembly comprises the switching assembly cover 9 which has a plurality of snap-fit receivers to engage with shaped tabs on the switching module body. Temperature adjustment of the operational temperature of the thermostat is provided by a push fit connector which engages the fluted periphery of the threaded nut N located on the rod 11. Adjustment rotates the nut with respect to the actuator follower 32 altering the amount of differential length of the rod with respect to the probe tube required to deflect the thermostat switch 30.

An entirely different switching function can be provided by selecting from a number of switching modules so that the assembly of the thermostat remains identical in all respects.

It will of course be understood that the invention is not limited to the specific details described herein, which are given by way of example only, and that various modifications and alterations are possible within the scope of the appended claims.

CLAIMS:

1. A thermostat of the type having a thermal probe comprising a hollow tube of thermally expansive material having a first coefficient of expansion within which there is provided, fixed thereto at the distal end thereof, a rod of thermally expansive material having a second coefficient of expansion such that when heated a linear displacement between the rod and the tube is utilised to actuate a switch, the thermostat comprising:

a probe assembly having a base plate to which the tube of the thermal probe is fixed; and

a switching assembly securable to the base plate and adapted to receive a cover element;

in which the thermal probe also houses a sensor filled with a thermally expansive fluid in communication with a diaphragm fixed to the base plate and operable to actuate a movement amplifying switch actuator to provide a safety over-temperature cut-out function.

2. A thermostat as claimed in Claim 1 having a modular construction of two standard modules and one module provided in a plurality of switching configurations, in which the first standard module comprises said base plate and probe, the base plate carrying the diaphragm and movement amplifying switch actuator, thereby presenting two actuator elements to the switching assembly.

3. A thermostat as claimed in Claim 2, in which the switching assembly incorporates a thermostat switch operable by said rod and wherein said assembly further incorporates an over-temperature safety cut-out switch operable in response to said movement amplifying switch actuator.

4. A thermostat as claimed in any one of Claims 1 to 3, in which the switching assembly is configured so that thermostatic interruption of the connection of electrical current to a water heater resistance load is in series with

the over-temperature cut-out function.

5. A thermostat as claimed in Claim 4, in which the thermal interruption occurs on the supply phase and the cut-out function provides double-pole isolation.

6. A thermostat as claimed in any one of the preceding claims, in which the switching assembly includes insulated terminals, adapted to penetrate apertures provided in the base plate, for supplying electric current to a water heater resistance load.

7. A thermostat as claimed in any one of the preceding claims, in which the actuation means and switching associated with thermostatic interruption of electrical current is wholly independent of both the activation means and switching associated with the safety over-temperature cut-out function, whereby failure of any single component cannot prevent both thermal interruption and cut-out function.

8. A thermostat as claimed in any one of the preceding claims, in which the sensor comprises at least one helically coiled section which can be accommodated within the thermal probe and having an inner diameter capable of accepting the rod.

9. A thermostat as claimed in any one of the preceding claims, in which the sensor is provided along substantially the entire operating length of the probe, so as to eliminate the effects of thermal dead spots and temperature gradients.

10. A thermostat as claimed in any one of the preceding claims, in which the movement amplifying switch actuator comprises an adjustable movement amplifying mechanism, calibration means and actuator follower which together allow for the cut-out temperature not only to be adjusted marginally but also to provide a range of preselected cut-out temperatures.

11. A thermostat as claimed in Claim 10, in which the range of preselected cut-out temperatures is selected from between 0C and 300C.

12. A method of assembling a thermostat as defined in Claim 1, the method including:

fixing a hollow tube of a thermal probe to a base plate having attached thereto mounting points for a movement amplifying switch actuator;

forming the thermal probe by positioning within the hollow tube thereof a thermally expansive rod and a fluid-filled sensor disposed adjacent or about the rod, both being positioned and configured to provide efficient thermal reaction;

selecting a switching assembly according to desired switching funtion;

mounting the switching assembly to the base plate;

testing the temperature points at which thermostatic interruption and over-temperature cut-out functions operate, and

fixing a cover to the switching assembly.

13. A thermostat substantially as herein described, with reference to and as show in the accompany drawings.

14. A method of assembling a thermostat substantially as herein described, with reference to the accompanying drawings.

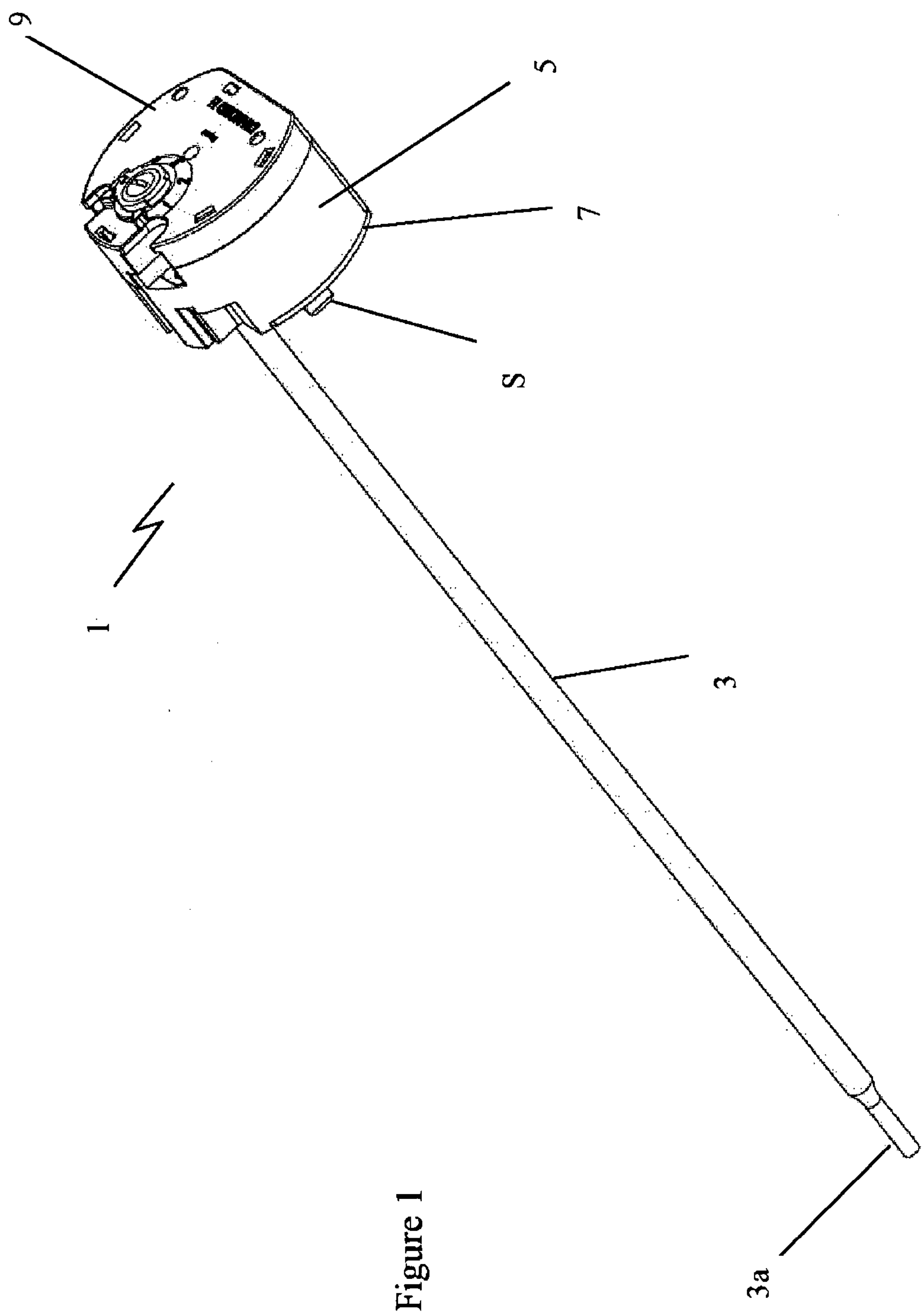

Figure 1

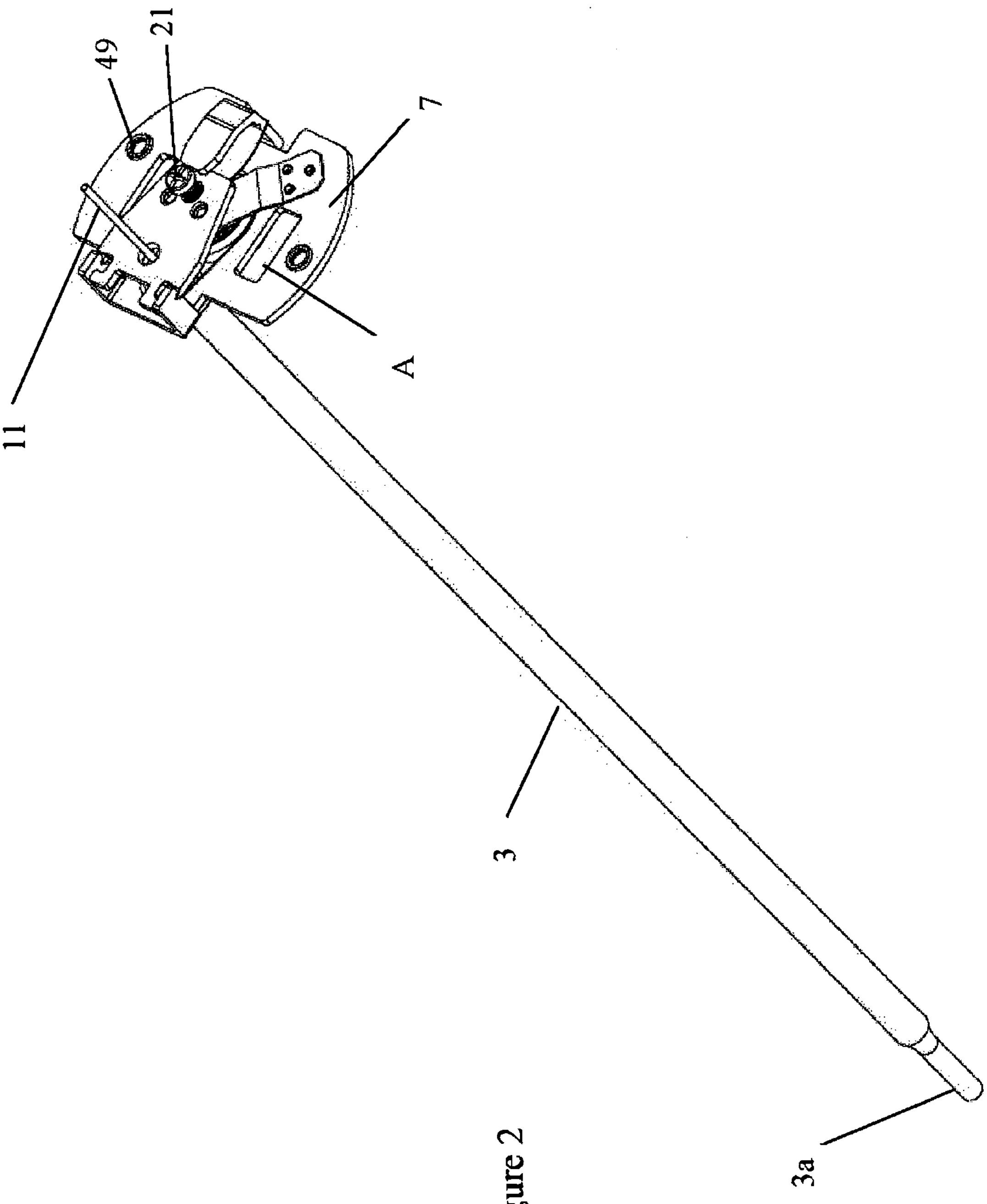

Figure 2

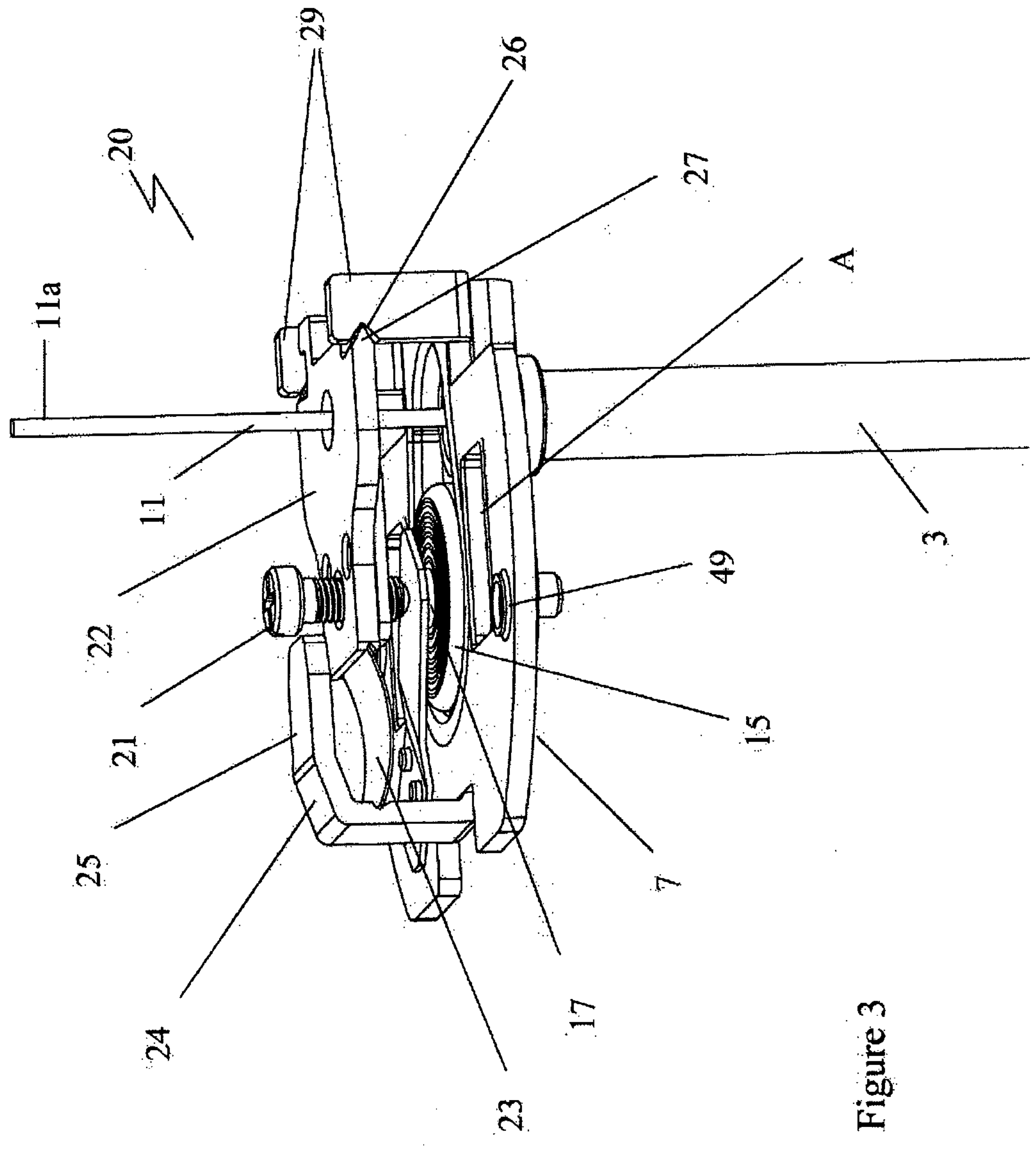

Figure 3

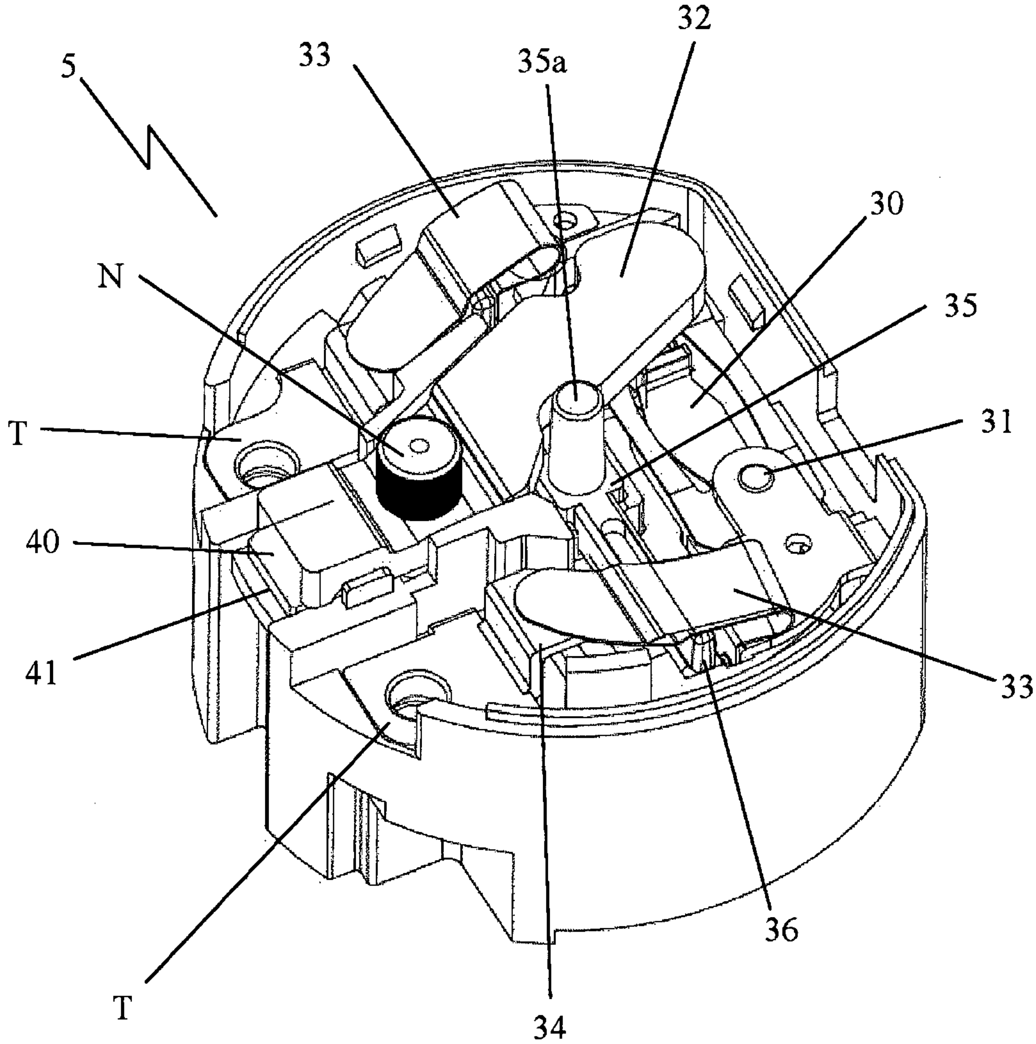

Figure 4

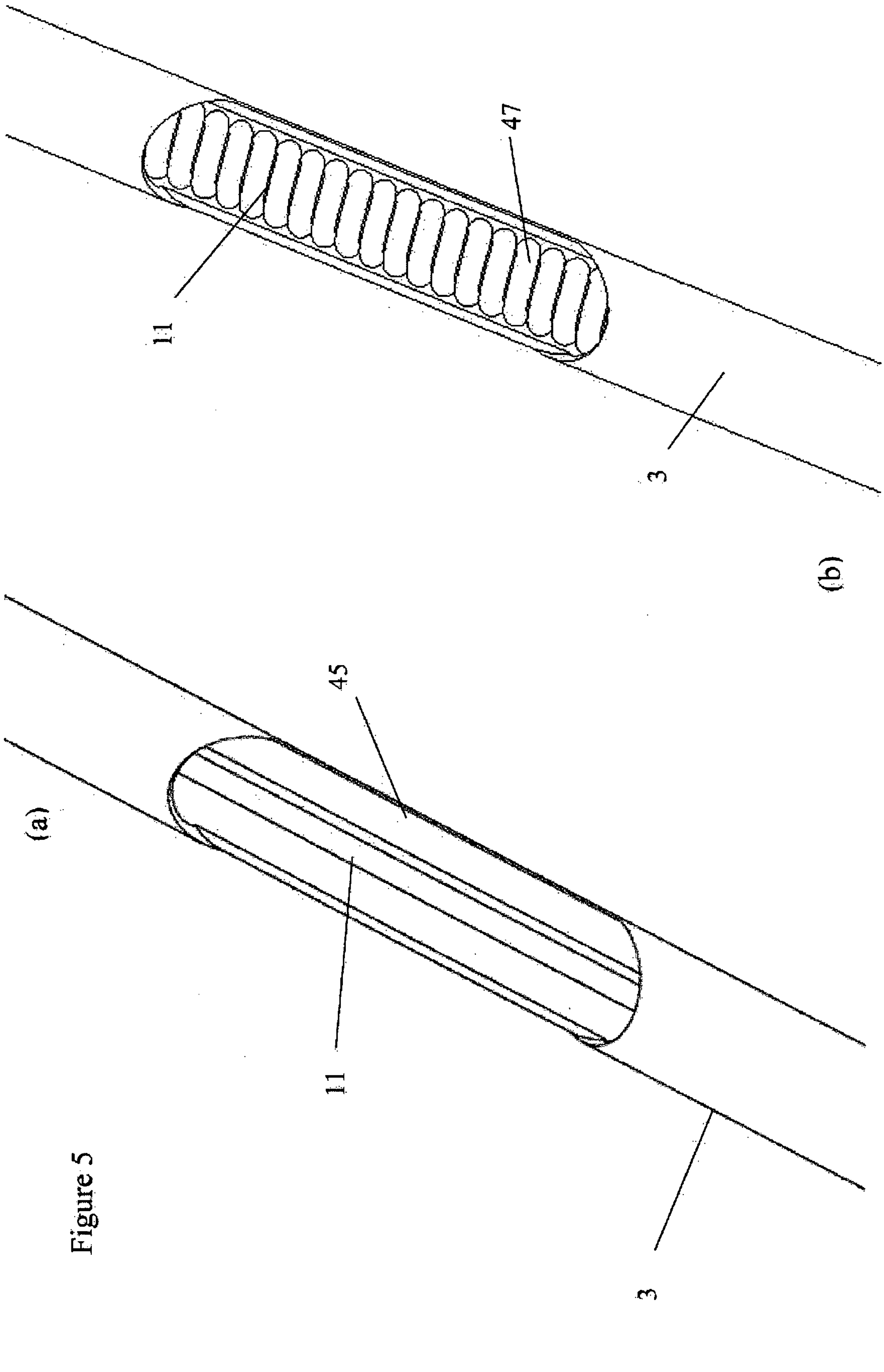

Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2016/001497

A. CLASSIFICATION OF SUBJECT MATTER

H01H 37/46(2006.01)i； H01H 37/48(2006.01)i； H01H 37/40(2006.01)i； H01H 37/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01H37/-;F24H1/-;F24H9/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC,WPI,CNPAT,CNKI:SHEL,NIBE,thermostat,probe,hollow,tube,tubular,pipe,rod,coefficient,expans???,actuat???, switch???,base,plate,cover,shell,sensor?,capillary,helix,helical+,coiled,spiral,flat,flattened,diaphragm,amplify???,cut w out

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2707424 A3 (LORENZI VASCO S.P.A.) 13 January 1995 (1995-01-13) abstract， claims 1-6， description page 3 line 2-page 7 line 8， figures 1-3	1-12
X	GB 2295490 A (DIAMOND H CONTROLS LIMITED) 29 May 1996 (1996-05-29) abstract， claims 1-9， description page 3 line 1-page 4 line 2 ， figure 1	1-12
A	GB 2172749 B (S A COTHERM) 21 June 1989 (1989-06-21) the whole document	1-14
A	WO 2008093051 A1 (CERAMASPEED LIMITED) 07 August 2008 (2008-08-07) the whole document	1-14
A	GB 2474238 A (HEATROD ELEMENTS LIMITED) 13 April 2011 (2011-04-13) the whole document	1-14
A	CN 203218177 U (SHENZHEN XINFUDA ELECTROMECHANICAL CO.， LTD.) 25 September 2013 (2013-09-25) the whole document	1-14

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 February 2017	**15 March 2017**

Name and mailing address of the ISA/CN	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**LI,Jiarui**
Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)62413476**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101996819 A (E.G.O.ELEKTRO-GERAETEBAU G.M.B.H.) 30 March 2011 (2011-03-30) the whole document	1-14

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2016/001497

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