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THERMOREGULATOR

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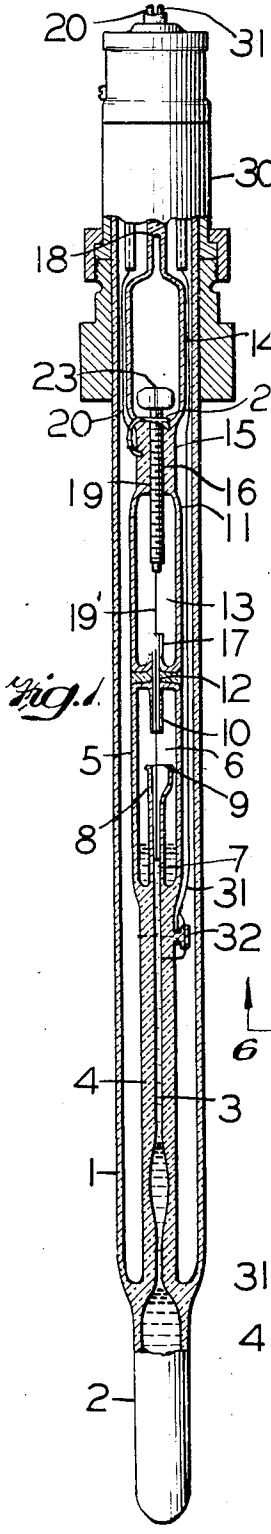



Fig. 1.

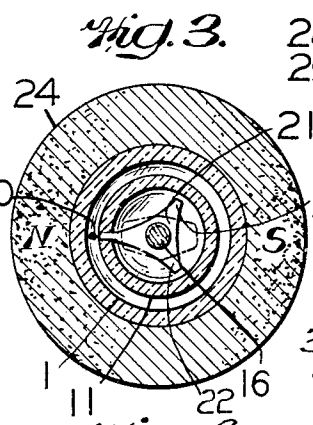



Fig. 3.

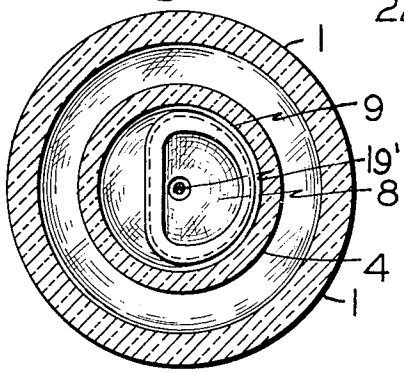



Fig. 4.

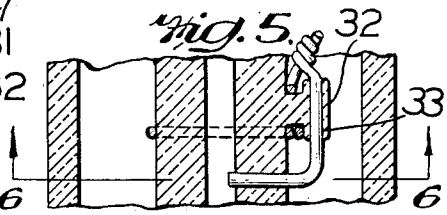



Fig. 5.

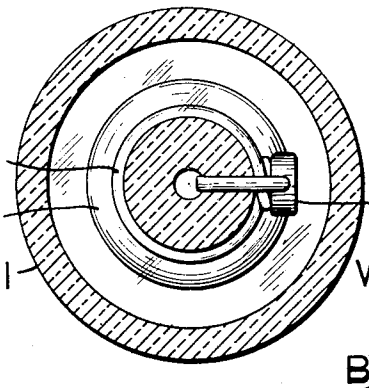



Fig. 6.

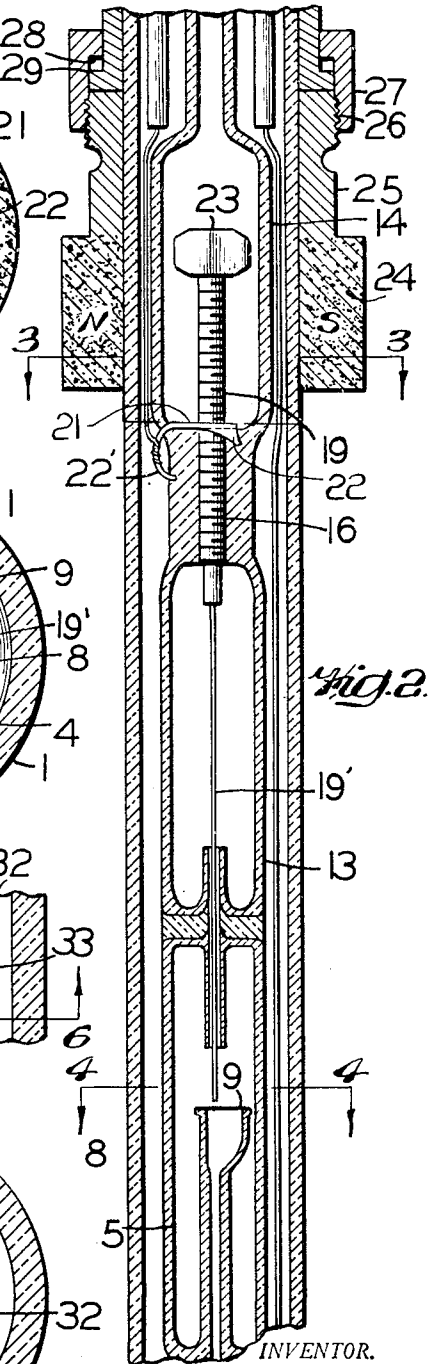



Fig. 2.

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2,498,212

## THERMOREGULATOR

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8 Claims. (Cl. 200—141)

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Our invention is an improved thermo-regulator comprising a sealed tube containing a magnetically adjustable solid conductor and a liquid conductor of variable mass forming a thermally expansible and contractible column making and breaking contact with the solid conductor to make and break an electric circuit.

Our invention provides improved means for varying the effective mass of the liquid conductor and for thermally varying the length of the column and means for magnetically adjusting the solid conductor rectilinearly and relatively to the column so as to effect relatively coarse and fine adjustments of the setting of the instrument without opening the tube and with a minimum of frictional resistance, without impairing the electrical conducting path, and without permitting contact between the conducting liquid and the means for adjusting the solid conductor.

Our improvements provide an instrument which may operate under super-atmospheric or sub-atmospheric pressures and which is accurately adjustable over a wide working range without danger of corroding, deteriorating or displacing the mechanism for adjusting the solid conductor, without contaminating the liquid conductor, and without stopping the passages through which the conductors move.

The principles and characteristic features of our invention, and the manner of making, constructing and using our improved thermo-regulator will further appear from the accompanying drawings and the following description explaining the best mode in which we have contemplated applying such principles.

In the drawings, Fig. 1 is a longitudinal sectional view of a thermo-regulator embodying our improvements with a magnet locking nut in locking position; Fig. 2 is an enlarged fragmentary view of a longitudinal section of the thermo-regulator shown in Fig. 1 with the magnet locking nut in unlocking position; Fig. 3 is a transverse sectional view taken on the line 3—3 of Fig. 2; Fig. 4 is a transverse sectional view taken on the line 4—4 of Fig. 2; Fig. 5 is an enlarged fragmentary view of the longitudinal section of the portion of the instrument containing a fixed contact complementary to the adjustable solid conductor; and Fig. 6 is a transverse sectional view taken on the line 6—6 of Fig. 5.

In the embodiment of our invention illustrated in the drawings, an outer tube 1 of glass or the like has a bulb or reservoir 2 integrally formed on the bottom thereof and communicating with a capillary bore 3 of an inner tube 4 having an

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enlarged upper section 5 forming a chamber 6. A hollow quill or sleeve 7, integrally formed on the tube 4 and containing an extension of the capillary bore 3, projects upwardly from the bottom of the chamber 6 and terminates in a cup 8 having an eccentric rim 9 having a portion of its perimeter in sufficiently close proximity to the inner surface of the wall of the chamber 6 to prevent passage of mercury between such perimeter portion and the adjacent wall surface.

A hollow quill or sleeve 10 is formed integrally on the top of the tube section 5 and depends into the chamber 6 to a point adjacent to but spaced from the top of the cup 8. The bore of the quill 10 is aligned with the capillary bore 3.

A tubular shell 11 is positioned in the tube 1 above the section 5 and may be formed integrally therewith or cemented thereto by a suitable connecting and sealing member 12 containing an aperture aligned with the capillary bore 3.

The shell 11 comprises hollow sections 13 and 14 connected by an intermediate neck 15 containing a longitudinal aperture 16 connecting the interiors of the sections 13 and 14. The bottom wall of the section 13 is turned upward to form a hollow quill or sleeve 17 projecting substantially above the bottom of the section 13 and containing a longitudinal passage aligned with the capillary 3. The upper wall of the section 14 is drawn to a tip 18 through which the chambers in the members 5, 13 and 14 may be exhausted or gas under pressure introduced into such chambers and the tip 18 then sealed in any usual manner.

The passage 16 provides a smooth walled slideway for a threaded stem or conducting screw 19 which has a conducting rod or wire 19' fixed to the bottom thereof and extending through the apertures in the members 17, 12 and 10 into the cup 8 and capillary bore 3.

A triangular plate 21 is seated on top of the neck 15 and is secured thereto by downturned prongs 22 embedded in the neck and by a tail 22' which extends through the wall of the section 14 and into the side of the neck 15 to form a loop terminal on which is wrapped the end of a conducting wire 20 which enters the instrument through the cap 30.

The plate 21 contains an aperture through which the stem 19 is screwed so that the plate 21 makes good electrical contact with the faces of the thread of the stem 19 and acts as an elastically mounted single thread nut therefor.

When the stem 19 is rotated it is screwed up or down through the plate 21 and is thereby moved longitudinally to move the conducting rod or wire 19' rectilinearly without impairing the circuit through the wire 20.

The threaded stem 19 has fixed to the upper end thereof a magnetically permeable head 23 of oblong or elliptical cross section forming an armature for an annular magnet 24 which encircles and makes a close slip fit with the periphery of the tube 1. The magnet 24 has diametrically opposite north and south poles of sufficient axial length to embrace a desired field of rectilineal movement of the armature 23 for varying the setting of the instrument without moving the magnet axially to any substantial degree.

The magnet 24 is suspended from a non-magnetic hub 25 having its upper end 26 exteriorly threaded for engagement by the threaded inner surface of a lock nut 27. The lock nut has a lip 28 overlying a flange 29 of the cap 30 which forms a closure for the top of the tube 1 and through which the lead-in wire 20 emerges for incorporation in a desired electric circuit to be controlled by the instrument.

A complementary lead-in wire conductor 31 enters the instrument through the cap 30, passes downward between the tube 1 and the inner tubular members, is wrapped around the tube 4 and around the radial headed boss 32 thereon, is twisted on itself, it passed through the aperture 33 of the boss 32, and sealed in the wall of the tube 4 with its end exposed in the capillary 3. The exposed end of the wire 31 is below the lowest level to which the column of mercury or other conducting, thermally responsive, liquid in the bore 3 recedes and hence there is continuous contact between the conducting column and the conductor 31. The circuit through the conductors 20 and 31 is therefore closed when the meniscus of the mercury column contacts the bottom of the solid conductor or wire 19'.

The temperature at which a given mass of mercury in the bulb 2 and bore 3 will cause the meniscus of the column to contact the wire 19' may be varied by varying the penetration of the wire 19' into the bore 3 and the temperature at which the solid and liquid conductors make contact may also be varied by varying the mass of liquid conductor in the capillary.

When it is desired to change by some small fraction of a degree the setting point or temperature at which apparatus in the circuit containing our improved instrument is actuated, the rod 19' is moved relative to the meniscus of the liquid in the capillary tube 3. The magnetically permeable head 23 is held by the lines of magnetic force emitted from the permanent magnet 24 in a fixed position relative to said magnet. Hence, when the magnet 24 is turned, the head 23 is turned, and when the magnet 24 is held stationary the head 23 is also held stationary though the thermometer tube be turned. If the tube is turned while the magnet is held stationary and the nut 27 is loose, the stem 19 is fed through the plate 21, thus varying the position of the rod 19' relatively to the meniscus of the liquid in the capillary tube. Slight turning will produce, accurately, extremely small variations in the actuating temperature.

If a greater change in the setting point of the instrument is desired than is attainable by adjustment of the solid conductor 19', this may be effected by reducing or increasing the mass of the liquid conductor in the bore 3. To reduce the mass, the bulb may be heated in a bath of appropriate temperature until a desired amount of mercury is discharged from the capillary into the cup, from which it may then be emptied.

To increase the mass of liquid conductor in the bore 3 without entrapping gas in the capillary, the rod 19' is withdrawn from the capillary by magnetically turning the armature 23, and the bulb 2 is heated until the capillary is completely filled or overflows slightly into the cup. The instrument is then turned on its side so that some of the excess conducting liquid in the spill chamber 6 fills the cup 8 at the head of the capillary tube and merges with the mercury in the capillary; the weight to mercury in the cup being sufficient to break the interfacial tension between such liquid and the surface of the liquid flush with the top of the capillary.

In filling the cup, the instrument is turned substantially horizontally, with the flat edge of the rim 9 downward so that the liquid readily passes between it and the inner surface of the member 5. By turning the instrument on its axis 180° some of the liquid is trapped by the proximity of the eccentric curved portion of the rim 9 with the inner surface of the member 5, so that when the instrument is again turned upright such trapped liquid flows into and fills the cup 8. The instrument may be then subjected to a cooling bath or other cooling means having a temperature of one degree, or some other known increment, below the desired operating temperature and the liquid on contracting creates a suction which, together with the weight of the liquid in the cup surmounting the capillary tube, forces the liquid into the capillary tube and completely fills the same. The tube is then tilted so as to displace any excess liquid from the cup 8 and allow it to fall into the spill chamber 6. The capillary bore being filled, the temperature of the bath or other heat source is now raised, say, two degrees, or any known increment, above the desired datum temperature. This forces a small amount of the liquid from the capillary bore into the cup 8 and the spill is then emptied therefrom so that, when the bulb is subjected to the desired datum temperature, the meniscus of the column is slightly below the top of the capillary bore and the rod 19' may be lowered in the manner described into contact with the meniscus in the bore to complete a circuit.

The amount of excess liquid normally contained in the chamber 6 is preferably insufficient to reach the opening in the quill 10 when the instrument is horizontal or inverted, and the bores of the quills 10 and 17 are too small for the passage of liquid therethrough with the conductor 19' therein, even though the liquid should inadvertently reach a level above the mouth of the quill 10. Hence no free liquid can enter the hollow member 13 or passage 16 to contaminate or corrode the threaded stem 19', or nut 21, or amalgamate therewith.

The instrument may thus be adjusted to within a tenth of a degree or within some other known increment of a degree, of the desired temperature, and still more accurate operation may be obtained by turning the tube or magnet so as to raise or lower the rod 19' as above described.

By means of the conductors piercing but sealed in the inner shell, the one being connected with the stem 19' and the other with the liquid, the meeting of the rod and the meniscus of the liquid will close an electric circuit while communication

between outside and inside of the instrument other than by means of the wires is entirely cut off because the inner shell is hermetically sealed.

By adjustments of the liquid mass and of the rod, coarse or fine adjustments of the instrument may be effected with extreme accuracy for controlling the closing and opening of an electric circuit through the rod and liquid column by making and breaking contact between them at predetermined temperatures, which may be varied widely.

Having described our invention, we claim:

1. A sealed instrument comprising a tubular member containing an apertured partition, a straight stem having a threaded surface and slidable through said aperture and guided by said partition, a nut having a member extending through the wall of said tubular member, said nut engaging said stem and coacting with the thread thereof to effect rectilineal movement of said stem, a liquid conductor complementary to said stem, and means for rotating said stem to effect the rectilineal movement thereof.

2. A sealed instrument comprising a tubular structure containing a plurality of chambers spaced by apertured partitions, one of said partitions having hollow quills projecting therefrom in alignment with the aperture therein, a solid conductor movable through and guided by said last named partition and quills, a threaded member connected with said conductor and movable through and guided by the other of said partitions, magnetic means for operating said threaded member, a capillary tube projecting into one of said chambers and containing a liquid column in alignment with said solid conductor, and a surplus supply of conducting liquid in said last named chamber and excluded from said means by said quills and partitions.

3. A sealed instrument comprising a tubular member forming a bulb, a chamber and a capillary tube leading from said bulb and projecting into said chamber, said tube terminating in a cup having a perimeter partly in close proximity to and partly spaced substantially from the wall of said chamber above the bottom thereof, and a liquid pool in said chamber and movable past said cup in one position of said instrument and obstructed by said cup in another position of said instrument.

4. A sealed instrument comprising a tubular member forming a chamber, a capillary tube terminating in a cup and a hollow quill projecting into said chamber in opposite directions and in alignment with one another, and a conducting liquid partly in said capillary tube and partly forming a pool in said chamber, said quill having a mouth free of said pool in all positions of said instrument and sealed to the passage of the liquid, and a solid straight conductor movable through said quill into contact with the liquid in said capillary tube.

5. A sealed instrument comprising a tube forming a bore containing liquid, means forming a spill chamber for receiving liquid from and supplying liquid to said bore to vary the effective mass of liquid therein, a rod rectilineally adjustable in said instrument relatively to said bore, magnetically operable mechanism for moving said rod rectilineally, and a partition having a quill projecting therefrom and encircling said rod and preventing access of liquid in said spill chamber to said mechanism.

6. A sealed instrument comprising a tube forming a bore surmounted by a cup and containing liquid, a wall forming a spill chamber containing liquid and from which chamber liquid may enter said cup to vary the volume of liquid in said bore, said cup having a peripheral section close to the inner wall of said chamber and a peripheral section spaced substantially from said wall to permit passage of said liquid, a rod in said instrument and adjustable relatively to said bore, means within said instrument for moving said rod, and a shield for shielding said operating means from the liquid in said spill chamber.

7. An instrument comprising an outer sheath, a tube and a hollow shell within said sheath, said shell being interiorly partitioned to form a plurality of chambers, a liquid in said tube means forming a partition having oppositely extending quills through which one of said chambers communicates with an end portion of said tube, a rod adjustable through said means and quills aforesaid toward said tube, and means in the other of said chambers for moving said rod.

8. A sealed instrument comprising a structure containing a plurality of chambers with partitions between them, one of said partitions being apertured and having a hollow quill projecting therefrom, a capillary tube having an open end housed in one of said chambers, a liquid in said tube magnetically operable means housed in another of said chambers, and a rod rectilineally movable by said means through said aperture and quill into said tube.

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