April 5, 1932. F. J. BAST ET AL 1,852,102

AUTOMATIC CONTROLLER

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Fig. 4.

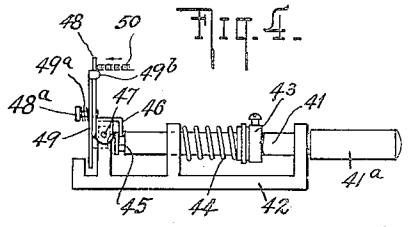


Fig. 1.

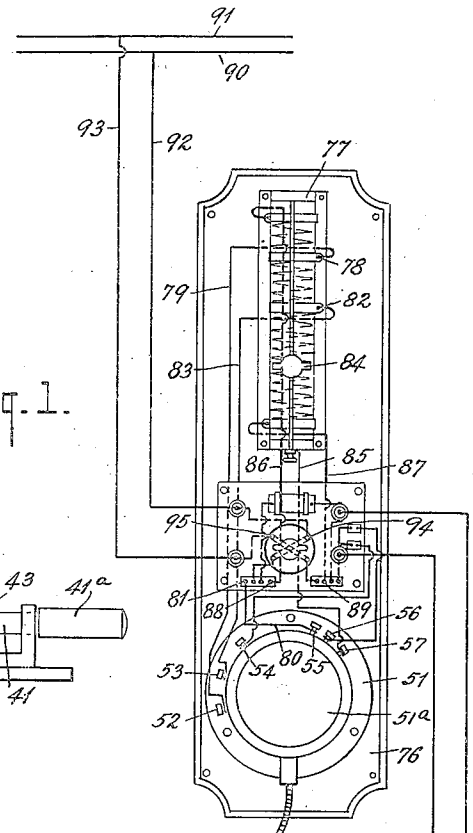
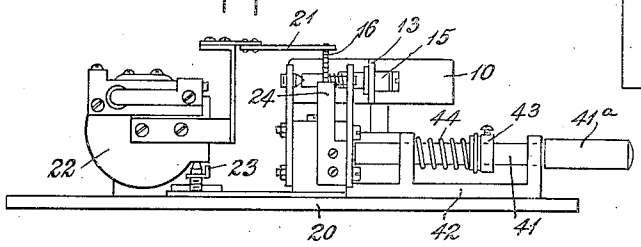
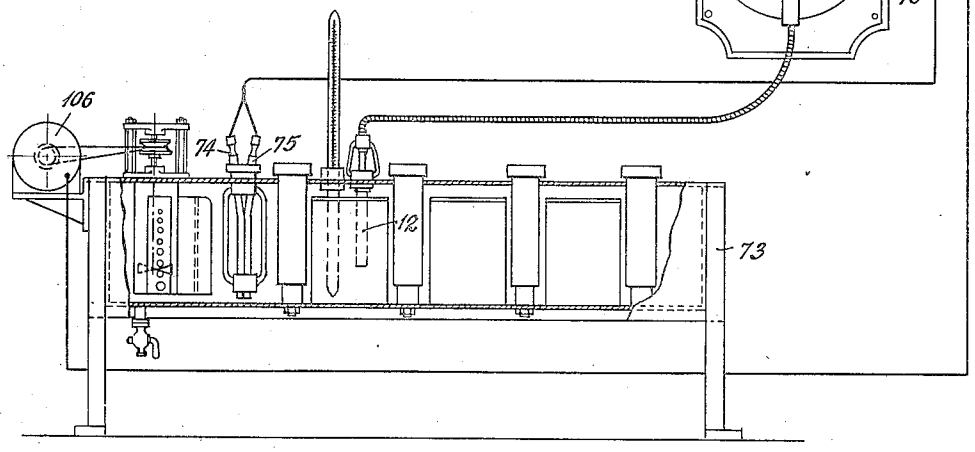


Fig. 5.





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AUTOMATIC CONTROLLER

Original Filed Sept. 10, 1925 3 Sheets-Sheet 2

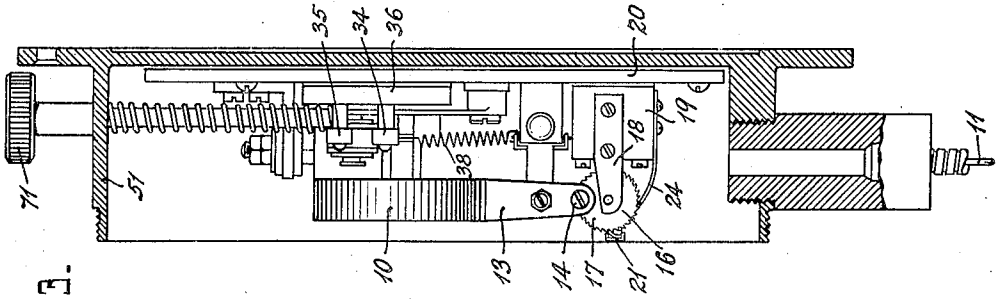

Fig. 1.

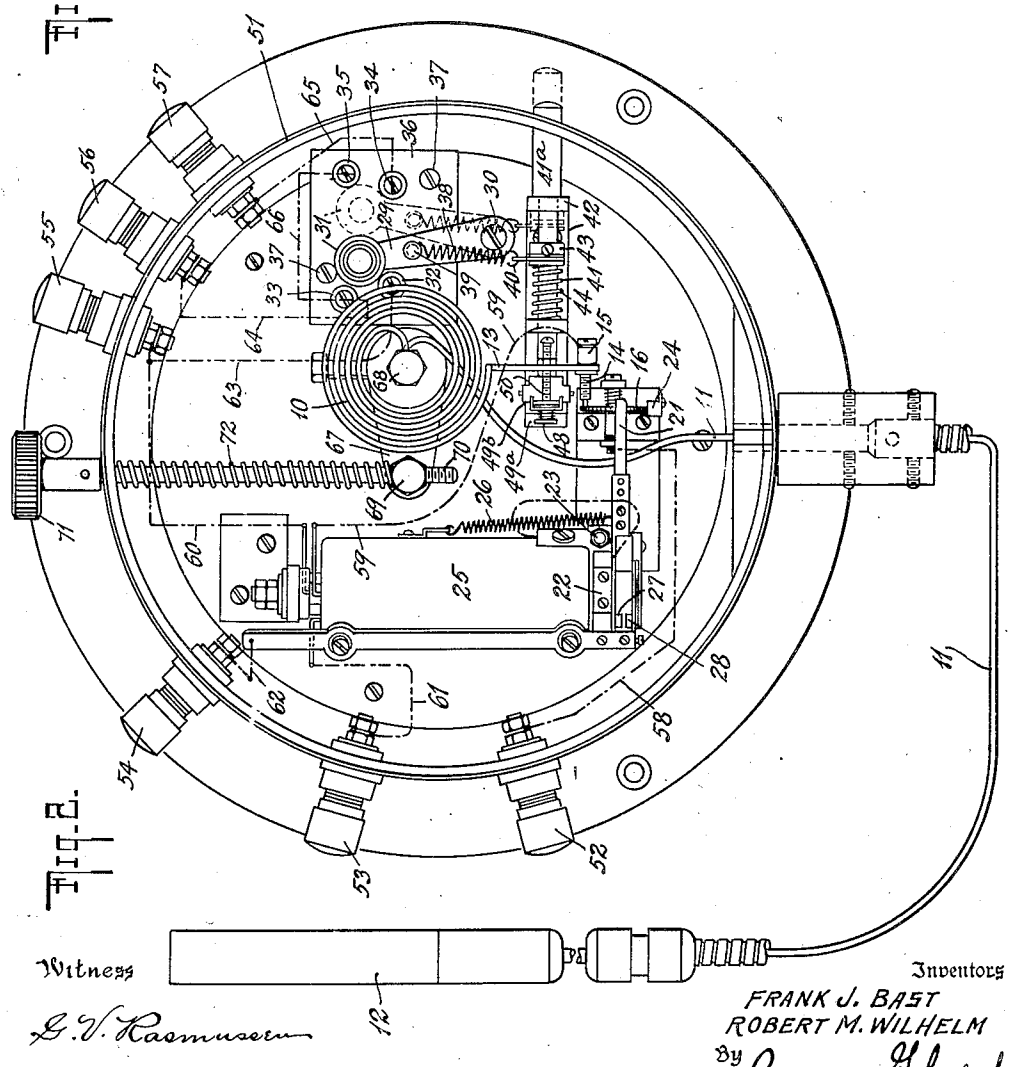

Fig. 2.

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AUTOMATIC CONTROLLER

Original Filed Sept. 10, 1925 3 Sheets-Sheet 3

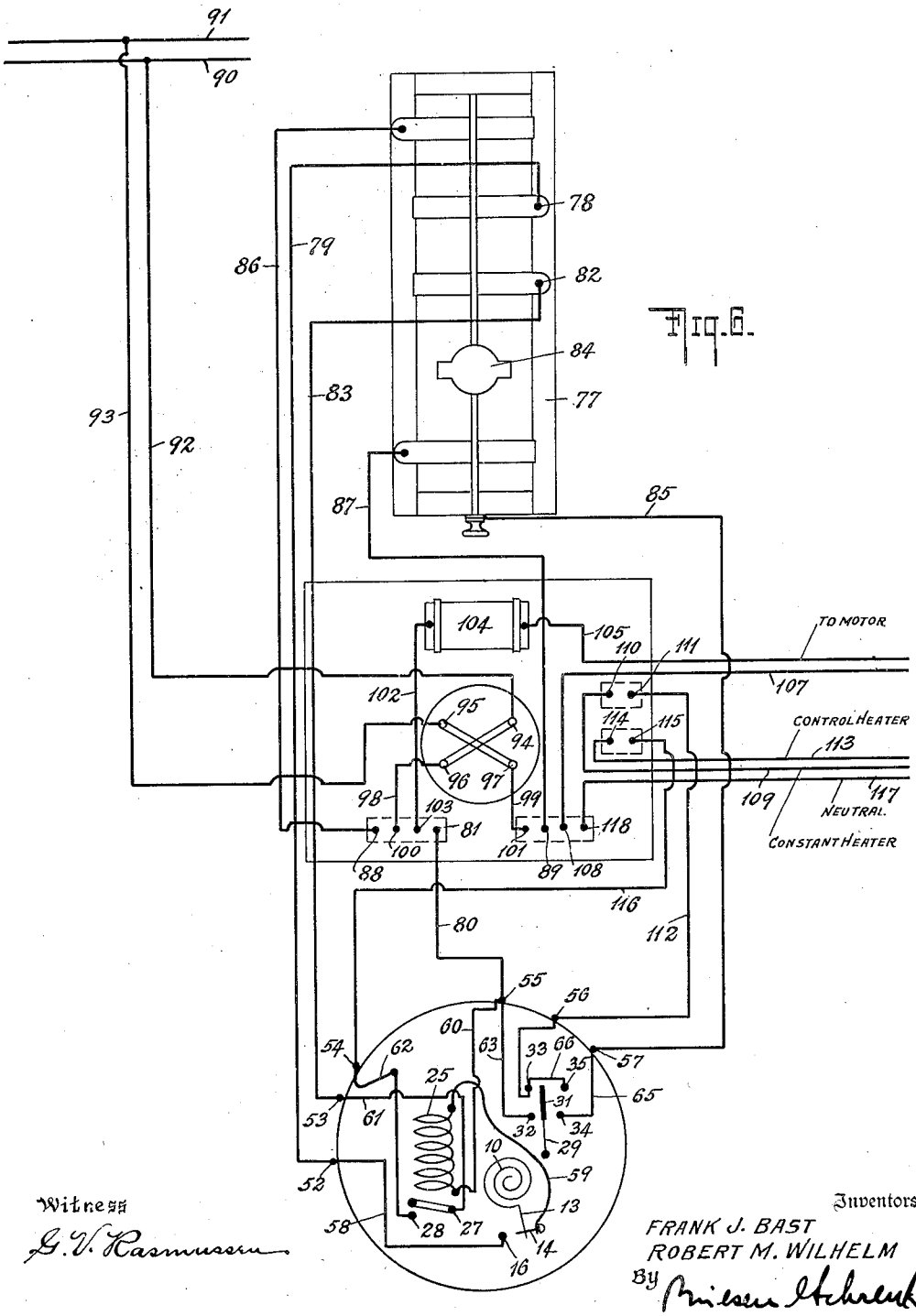

Fig. 6.

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UNITED STATES PATENT OFFICE

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AUTOMATIC CONTROLLER

Original application filed September 10, 1925, Serial No. 55,640. Divided and this application filed April 10, 1928. Serial No. 268,862.

Our invention relates to controllers for automatically controlling the functioning of an element and more particularly to instruments of the indicated class in which thermo-sensitive mechanism is the means whereby the control is effected. The invention has for its object to provide an instrument of novel and simple construction whereby the control of electrically operated instrumentalities is effected in an efficient manner. A further object of the invention is to provide a device adapted particularly for controlling electrically operated heating members such as are used, for instance, in connection with viscosimeter baths and the like. Other more specific objects will appear from the description hereinafter and the features of novelty will be pointed out in the claims. The present application is a division of another application filed by us on September 10, 1925, Serial No. 55,640, which has issued as Patent No. 1,689,764.

In the accompanying drawings which illustrate an example of the invention without defining its limits, Fig. 1 is an elevation illustrating a diagrammatic installation of the instrument in combination with a viscosimeter; Fig. 2 is an interior face view of the controller; Fig. 3 is a side elevation thereof with the casing in section; Figs. 4 and 5 are detail views illustrating switching devices forming part of the instrument and Fig. 6 is a diagrammatic illustration of the wiring system.

As shown in the illustrated example, the instrument comprises a thermo-sensitive element 10 which is shown in the form of an expansion coil commonly known as a Bourdon tube, having its inner end connected by means of a capillary tube 11 with a thermo-sensitive bulb 12; the thermo-sensitive element 10 may be of any suitable construction and the illustrated form thereof may be replaced by other equivalent devices. As shown in the drawings, the outer end of the thermo-sensitive element 10 is provided with a member 13 which carries a contact screw 14 insulated from the member 13, for instance by means of a bushing 15 of insulating material as shown in Fig. 2. The contact screw 14 is arranged to cooperate with a contact member 16 preferably constructed in the form of a disc provided upon its periphery with teeth or serrations 17, said disc 16 being mounted rotatably upon a bracket 18 fixed upon a suitable supporting member 19 projecting from a base 20. The teeth or serrations 17 of the contact disc 16 are engaged by an arm 21 suitably constructed and projecting from an armature 22 mounted pivotally upon pivot screws 23 suitably located in the instrument; the arm 21 at its free end, as shown in Fig. 3, is constructed in the form of a pawl adapted to cooperate with the teeth or serrations 17 in a manner to rotate the contact disc 16 in periodic steps as will be more fully described hereinafter. A stop pawl 24 is fixed upon the supporting device 19 and serves to prevent unintentional movement of the contact disc 16 in a backward direction. The armature 22 is located in operative relation to an electro-magnet 25 mounted suitably upon the base 20 as shown in Figs. 2 and 5, a spring 26 being provided for the purpose of retaining the armature 22 in its normal position away from the core of the electro-magnet 25 and returning it thereto after each actuation thereof by the coil 25. The arm 21, or rather the armature 22 thereof, carries a contact 27 arranged to cooperate with a stationary contact 28 located on the base 20 for the purpose to be more fully set forth hereinafter. In addition to the parts so far described, the instrument includes a switch arm 29 pivoted at 30 upon the base 20 and provided at its free end with a contact roller 31; the latter is adapted to cooperate with contacts 32 and 33 in one position and with contacts 34 and 35 in another position, the contacts 32, 33, 34 and 35, being located in cooperating pairs upon a sub-base 36 secured upon the main base 20 by means of screws or the like 37. A spring 38 has its one end connected to a stud 39 on the switch arm 29 and its other end connected at 40 with a plunger 41, which is mounted slidably in a suitable bracket 42 fixed upon the base 20 and terminates at its outer end in the form of a push-member 41a of relatively larger diameter than the plunger itself; the latter is provided with a collar 43

preferably mounted adjustably on the plunger 41 and constituting an abutment for one end of a coil spring 44, the other end of which engages a stationary portion of the bracket 42. At its inner end the plunger 41 is notched or grooved as indicated at 45 in Fig. 4 for the reception of a detent 46 whereby the plunger is locked in its inner position as shown in Figs. 2 and 4. The detent 46 is pivoted at 47 upon a suitable portion of the bracket 42 and is continued in the form of an upright member 48 as shown in Fig. 4; an actuating member 49 is mounted in surface engagement with said member 48 and depends beyond the same into the path of the plunger 41 for the purpose to be more fully set forth hereinafter. The connection between the members 48 and 49 is such that the latter member is capable of yielding relatively to the member 48 under certain conditions; for this purpose the member 49 may be loosely mounted upon a headed stud 48*a* which is fixed upon the member 48, a spring 49*a* being provided to yieldingly maintain the member 49 in proper position upon the member 48. At its upper end the member 49 may be provided with lugs 49*b* which project over and beyond the opposite edges of the member 48 and thereby maintain the members 48 and 49 in registry with each other. The detent 46 is actuated to release the plunger 41, in the manner to be described hereinafter, by means of a screw 50 adjustably fixed upon the member 13 which is carried by the thermo-sensitive element 10. In the preferred arrangement, the instrumentalities so far described are contained in a suitable casing 51 which may be normally closed, for instance by means of a removable cover 51*a* (Fig. 1) and is provided at suitable points with binding posts 52, 53, 54, 55, 56, and 57 to facilitate the installation of the instrument. The binding post 52 is connected by means of a wire 58 with the contact member 16, a wire 59, in turn leading from the contact screw 14 to one terminal of the electro-magnet 25; the other terminal of the latter is connected by means of a wire 60 with the binding post 55. The binding posts 53 and 54 are connected by means of wires 61 and 62 with the contacts 27 and 28 respectively. Wires 63 and 64 lead from the binding posts 55 and 56 respectively to the contacts 32 and 33 while the binding post 57 is connected with the contact 34 by means of a wire 65; a wire 66 extends between and connects the contacts 33 and 35. The remainder of the electrical circuits forming part of the illustrated installation will be more fully set forth hereinafter. In the preferred arrangement, the thermo-static element 10 is carried by an arm 67 pivoted at 68 upon the base 20 and provided at its free end with a projection 69 into which an adjusting screw 70 is screw-threaded. The adjusting screw 70 projects through the casing 51, and is provided with an operating knob 71 exteriorly of said casing to facilitate the actuation of said screw 70; a coil spring 72 surrounds the latter and with one end abuts against the casing and with the other end against the projection 69, to assist the adjustment of the arm 67 in one direction as will appear more fully hereinafter.

For the purpose of illustrating and describing the invention, it has been shown installed in cooperative combination with a viscosimeter of any conventional construction, for the automatic control of which the invention is particularly adapted. In such case, the bulb 12 is located upon the viscosimeter 73 so as to extend into the same, the arrangement being such that the bulb is affected by the temperature of the viscosimeter bath. The latter includes a primary heating element 74 and a secondary heating element 75 both of which may be of any conventional construction and arrangement, the primary heating device carrying a sufficient constant current at all times to maintain the bath at a temperature a few degrees below the desired control point; the secondary heating device 75 on the other hand carries only a relatively light current sufficient to provide the difference between the temperature of the bath as maintained by the heating device 74 and the aforesaid control point. For instance, if the desired control point is 100 degrees F., the primary heating device 74 will maintain the bath at a temperature of approximately 98° while the secondary heating device 75 will supply the current necessary to provide the two degrees necessary to raise the temperature to 100° F. In practice, the casing 51 with the instrumentalities therein is mounted upon a panel 76 on which a suitable device for regulating the desired electric currents may be also mounted; as shown in Fig. 1, this device may comprise a potentiometer 77 which is tapped at various points to obtain the desired voltages. For instance, the tap at 78 is connected by means of a wire 79 with the binding post 52 and is thus in electrical circuit with the contact disc 16, the latter, as shown in Fig. 2 and as previously stated, being connected with the binding post 52 by means of the wire 58 and the contact screw 14 being connected by means of the wire 59 with one terminal of the electro-magnet 25, from the other terminal of which, the wire 60 leads to the binding post 55; the latter, in turn, is connected by means of a wire 80 to a terminal 81 on the panel 76 as shown in the diagram of Fig. 6. The voltage fed to the aforesaid contacts 14 and 16 in the illustrated example is about six volts. The tap 82 is connected by means of a wire 83 with the binding post 53 and is thus in electrical circuit with the contacts 27 and 28, the voltage supplied to these contacts in the illustrated example being about thirty volts. The adjustable tap 84 is con-

nected by means of a wire 85 with the binding post 57, the circuit in which the potentiometer 77 is located being completed by means of wires 86 and 87 which lead respectively to terminals 88 and 89 on the panel 76 as shown in Figs. 1 and 6; the adjustable tap 84 supplies current to the primary heating device 74 at a voltage sufficient to maintain the bath at a point slightly below the predetermined control point as hereinbefore set forth. The instrument is connected with a source of electricity by means of the main wires 90 and 91 from which wires 92 and 93 lead to terminals 94 and 95 on the panel 76; the terminals 94 and 95 are in electrical connection with terminals 96 and 97 from which wires 98 and 99 lead to terminals 100 and 101. The electrical circuits of the illustrated example further include a wire 102 leading from a terminal 103 to a coil 104 from which a wire 105 leads to the motor 106 which forms part of the viscosimeter equipment as shown in Fig. 1; a wire 107 in turn leads from said motor to a terminal 108. The primary heating element 74 is connected by means of a wire 109 with a terminal 110, the cooperating terminal 111 being connected by means of a wire 112 with the binding post 56. A wire 113 leads from the second heating element 75 to a terminal 114 and the co-operative terminal 115 is connected by means of a wire 116 with the binding post 54. To complete the circuit a neutral wire 117 leads from a terminal 118 to the viscosimeter.

By means of the adjusting screw 70, the instrument may be adjusted to the desired temperature setting point, the actuation of said screw 70 in the illustrated example, shifting the member 13 of the thermo-sensitive element 10 relatively to the member 48 of the detent 46 in a circular path about the center 68. If the temperature of the bath is materially below the desired control point, which as previously stated may be 100° F., the plunger 41 is pushed inwardly whereby the lower end of the spring 38 is shifted inwardly beyond the point 30 of the switch arm 29 and the latter is accordingly pulled over to bring the roller 31 into engagement with the contacts 32 and 33; as the plunger 41 is thus adjusted inwardly, its inner end will engage the depending portion of the actuating member 49 and thereby swing the detent 46 into the notch 45 whereby the plunger 41 is locked in its inner position and the roller 31 is accordingly held in engagement with said contacts 32 and 33. If the inward movement is greater than is required to seat the detent 46 in the notch 45, the member 49 will yield against the tension of the spring 49*a* and thus prevent injury to or disarrangement of the detent and its associated parts. When the roller 31 is in engagement with the contacts 32 and 33, a current of full voltage will be sent through the primary heating device 74, thereby bringing the bath to within approximately one degree of the desired temperature in a comparatively short period of time. When this temperature, that is 99° F. is reached, the action of the thermo-sensitive element 10, under the influence of the fluid contained in the bulb 12 which is affected by the aforesaid temperature of the bath, causes the screw 50 to engage the member 48 above its pivot 47 and to pivotally actuate said member 48 in a manner to lift the detent 46 out of the groove 45 of the plunger 41. The latter is thereby released and under the influence of its spring 44 is shifted slidably to the right in Figs. 2, 4, and 5 of the drawings so that the end 40 of the spring 38 is shifted to the opposite side of the pivot 30; the pull of the spring upon the lever 29 is thereby shifted and causes the lever 29 to be actuated pivotally in a manner to bring its roller 31 into engagement with the contacts 34, 35 and out of engagement with the contacts 32 and 33. This causes a current of lower voltage to be sent through the primary heating device 74, said current being sufficient to maintain the temperature of the bath at about 98° F. At the same time, as contacts 27 and 28 are normally closed, sufficient additional current is passing through the secondary heating device 75 to bring the temperature up to the desired control point, that is in the present case to 100° F. As the temperature of the bath passes beyond this point, the effect of this rise upon the thermo-sensitive bulb 12 will be transmitted to the thermo-sensitive element 10 and will cause the latter to expand or unwind, thereby bringing the contact screw 14 into engagement with the contact disc 16 and closing the circuit whereby the electro-magnet 25 is energized. As soon as this happens, the armature 22 is attracted by the electro-magnet. This actuation of the armature 22 separates the contacts 27 and 28 and thereby breaks the circuit in which the secondary heating device 75 is located and consequently cuts off the electric current flowing therethrough. The heating action of this secondary heater thus temporarily ceases until the temperature of the bath drops to the aforesaid control point or in other words to 100° F. As soon as this happens, the thermo-sensitive element 10 will contract and thereby withdraw the contact screw 14 from engagement with the contact disc 16 and thus de-energizes the electro-magnet 25; as a result of this, the spring 26 will swing the armature 22 away from the electro-magnet 25 and cause the contacts 27 and 28 to engage each other to again close the circuit in which the secondary heating device 75 is located with the result that electric current again passes through the latter which again functions as a heating element. At the same time, the aforesaid return of the armature 22 to its normal position swings the arm 21 back to its

initial point, this arm during such return movement engaging a tooth 17 of the contact disc 16 to rotatably shift the disc one step or a distance sufficient to bring a new point of said contact disc 16 into alignment with the contact screw 14; with this arrangement the life and efficiency of the contacts 14 and 16 is increased and a perfect electrical contact between the two is assured for an indefinite period without having any operative effect thereon. The instrument may be utilized in any installation where it is desired to control a given temperature in a predetermined manner and is particularly adapted for use in connection with viscosimeters for measuring the viscosity of oils or other fluids. It will be understood, however, that the instrument may be used to advantage in many other fields.

Various changes in the specific form shown and described may be made within the scope of the claims without departing from the spirit of our invention.

We claim:

1. The combination of a primary electric heating device adapted normally to develop heat within a predetermined number of degrees of a predetermined constant temperature, a secondary electric heating device, a first electric circuit connected with the primary heating device and carrying a current sufficient to develop heat rapidly to raise the temperature quickly to approximately the predetermined temperature, a second electric circuit connected with said primary heating device and with a source of current at a lower voltage than said first circuit for maintaining the temperature at a degree slightly below said predetermined temperature, a switch for closing one of said circuits at a time, said switch initially closing said first circuit, thermo-sensitive means controlled by the temperature developed at said heating devices whereby said switch is automatically operated to open the first and close the second circuit when said temperature approximates said predetermined temperature, and a heating circuit for said secondary heating device adapted continuously to develop heat corresponding to the deficiency between the temperature developed by said primary heating device and said constant temperature.

2. The combination of a primary electric heating device adapted normally to develop heat within a predetermined number of degrees of a predetermined constant temperature, a secondary electric heating device arranged to develop heat corresponding to the deficiency between the temperature developed by said primary heating device and said constant temperature, a first electric circuit connected with the primary heating device and carrying a current sufficient to develop heat rapidly to raise the temperature quickly to approximately the predetermined temperature, a second electric circuit connected with said primary heating device and with a source of current at a lower voltage than said first circuit, a switch for closing one of said circuits at a time, said switch initially closing said first circuit, thermo-sensitive means controlled by the temperature developed at said heating devices whereby said switch is automatically operated to open the first and close the second circuit when said temperature approximates said predetermined temperature, and means whereby the secondary heating device is temporarily cut out when the temperature rises above said predetermined temperature.

3. In a viscosimeter including a viscosimeter bath, a heating apparatus for maintaining a predetermined temperature in such bath, comprising a primary electric heating device adapted normally to heat the bath to a temperature below said predetermined temperature, a secondary electric heating device for supplying a predetermined degree of additional heat to said bath to raise the same to said predetermined temperature, an electric circuit at high voltage connected with said primary heating device for developing heat rapidly to raise the temperature quickly to approximately the predetermined temperature, an electric circuit of lower voltage connected with said primary heating device, a switch for closing said first mentioned circuit, electro-magnetic means controlling the circuit of said secondary heating device, thermo-sensitive means controlled by the temperature of said bath and arranged to operate said switch to open said first-mentioned and close said second-mentioned primary circuit when the temperature of the bath approximates said predetermined temperature, and an electric circuit for said electro-magnetic means controlled by said thermo-sensitive means, whereby said secondary heating device is cut out when the temperature of the bath rises beyond said predetermined temperature and cut in when said temperature is restored to said predetermined temperature.

4. The combination with an electric heating device, of a first electric circuit connected with such device and carrying a current at high voltage for developing heat rapidly, a second electric circuit connected with said heating device and with a source of current at a lower voltage than said first circuit, a switch for closing one of said circuits at a time, said switch initially closing said first circuit while the other circuit remains open, thermo-sensitive means controlled by the temperature developed by said heating device and operative upon said switch to open the first circuit and close the second circuit, whereby a predetermined temperature is rapidly reached with current at high voltage and maintained with current at low voltage.

5. The combination with an electric heat-

ing device, of a first electric circuit connected with such device and carrying a current at high voltage for developing heat rapidly, a second electric circuit connected with said heating device and with a source of current at a lower voltage than said first circuit, a manually operable switch associated with both circuits and movable initially to close the first-mentioned circuit, the second circuit remaining open, a spring urging said switch in such manner as to open the first circuit and close the second circuit, latching mechanism operative to hold said switch in the position in which it closes said first circuit, thermo-sensitive means controlled by the temperature developed by said heating device and operative to trip said latching device to cause opening of the first and closing of the second circuit, whereby a predetermined temperature is rapidly reached with current at high voltage and maintained with current at low voltage.

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