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A. B. COSGRAVE

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ANTICIPATING THERMOSTAT

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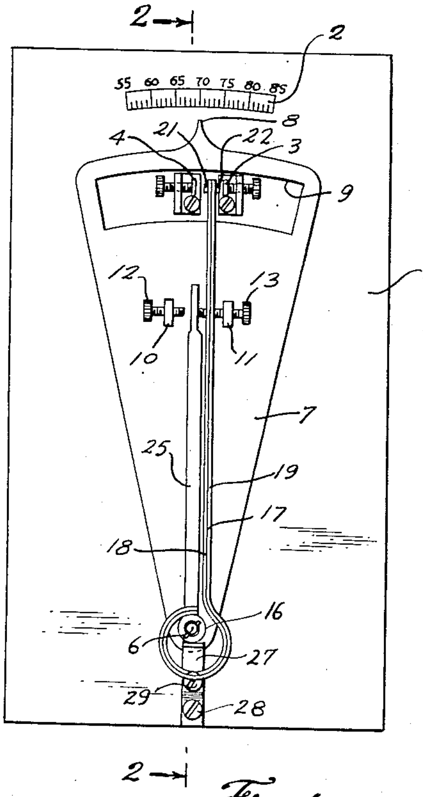


Fig. 1

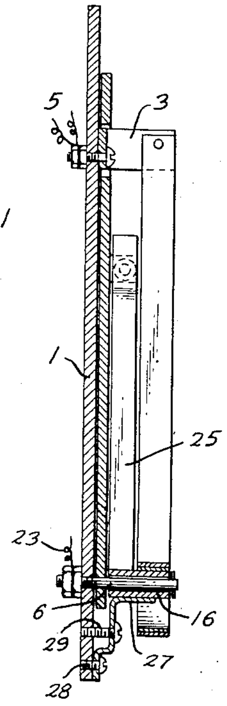


Fig. 2

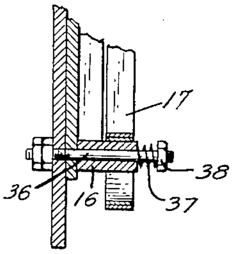


Fig. 3

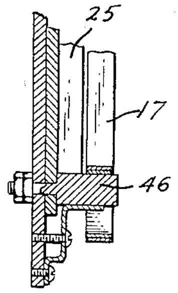


Fig. 4

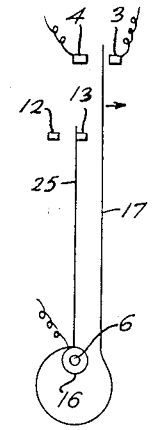


Fig. 5

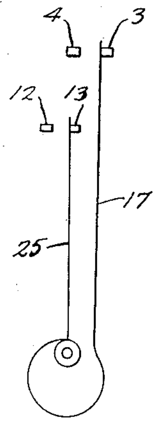


Fig. 6

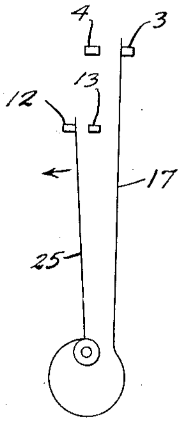


Fig. 7

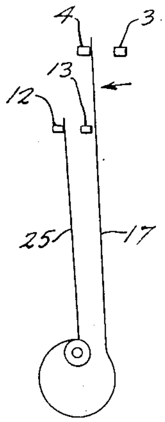
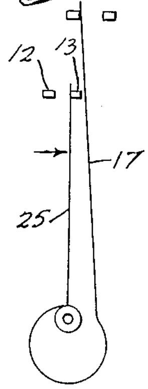


Fig. 8

Fig. 9



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ANTICIPATING THERMOSTAT

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2 Claims. (Cl. 200—138)

This invention relates to anticipating and compensating thermostats.

The ordinary bimetallic strip thermostat is incapable of maintaining temperatures within as close limits as may be desired both by reason of inherent instrumental lag and by reason of inability to anticipate inertia effects in the controlled system. Generally speaking, the effects of instrumental lag are similar to those of the inertia of the controlled system, so that these effects may be lumped together and compensated for by the same anticipation mechanism.

The principles of anticipation in control systems generally are well understood and a variety of anticipating devices for thermostats and thermostatically controlled systems have been proposed. Such devices, however, have not been adapted to incorporation in bimetallic strip thermostats in general, and have not been of sufficiently cheap, simple and reliable construction as to warrant their general use.

It is an object of the present invention to provide an improved anticipating thermostat.

Another object of the invention is to provide an anticipating thermostat capable of compensation for overshoot in the control system both in the downward and upward direction, and capable of eliminating either of these overshoots.

A further object of the invention is to provide an anticipating thermostat comparable in cheapness and simplicity to thermostats of conventional construction.

Still another object of the invention is to provide anticipation mechanism adapted to be incorporated in instruments of conventional construction without modifying the casing and other parts.

With these and still other objects which will appear in the following full description in mind, the invention consists in the combinations and arrangements of parts and details of construction which will now be fully described in connection with the accompanying drawing and then be more particularly pointed out in the appended claims.

In the drawing:

Figure 1 is a front elevation of a thermostat embodying the invention in a preferred form;

Figure 2 is a section on the line 2—2 of Figure 1;

Figures 3 and 4 are fragmentary views corresponding to a portion of Figure 2, and showing modified forms of the invention; and

Figures 5 to 9 are schematic views illustrating successive stages in the operating cycle of the thermostat.

Referring now to Figures 1 and 2, the thermostat is mounted on a support plate or frame 1 which bears a temperature scale 2 and also carries adjustable contacts 3 and 4, to which connection may be made at the rear of the frame 1, as indicated by the conductor 5 shown in Figure 2. A stub shaft 6 is fastened to the frame 1 and carries the movable thermostat parts. These parts include a sector plate 7 carrying a pointer 8 and having a cutout 9 to accommodate the contacts 3 and 4, previously referred to. The brackets 10 and 11, mounted on the sector plate 7, carry thumb screws 12 and 13 which are threaded therein so as to form adjustable stops for an element later described. A bushing 16 rotatably mounted on the shaft 6 carries a bimetallic strip 17 which includes an inner strip 18 of metal such as Invar, having a low temperature coefficient, and an outer strip 19 of metal, such as brass, having a high temperature coefficient, these strips being brazed or similarly fastened together in the usual way and brazed to the sleeve 16 or otherwise attached thereto in any convenient manner. Contacts 21 and 22 are carried by the upper end of the strip 19. When contact 22 touches contact 3 a circuit is established therefrom through the strip 17 to shaft 6 and to connection 23 thereof, while a similar circuit may be established from contact 4 to connection 23 by the contact 21.

The hub 16 also carries a stop arm 25, the upper end of which is positioned between the adjustable stops 12 and 13 carried by the sector plate 7. Hub 16 is rotatable on shaft 6 and is yieldably restrained from rotation by the friction of spring 27 which is mounted on frame plate 1 by means of a screw 28 and is adjustable by means of a screw 29. Turning screw 29 in one direction will force spring 27 against hub 16 more strongly, thus increasing the frictional resistance to turning of the hub 16, while turning it in the other direction will lessen the pressure, thus permitting the hub 16 to turn more easily.

Plate 7 should engage shaft 6 and support plate 1 with sufficient friction to prevent movement of plate 7 during the operation of the device, while permitting manual movement of plate 7 for adjusting the temperature to be maintained. A friction spring or other friction device for plate 7 may be used wherever necessary.

The frame 1 and sector plate 7 may be made of insulating material, in which case the remaining elements may be mounted directly on the frame and sector as shown in the drawing. If preferred, the frame 1 and sector 7 may be of metal, in which case the remaining parts will be suitably insulated therefrom wherever necessary.

As will be apparent, the bimetallic strip 19 and stop element 25 may assume a variety of forms without departing from the spirit of the invention, and these elements may be mounted in a variety of ways, as is found convenient. Two alternative mountings are shown by way of example in Figures 3 and 4. In Figure 3, the shaft 6 is replaced by a somewhat elongated shaft 36, and a coil spring 37, carried thereon and adjustable by means of a nut 38, is substituted for the spring 27. This spring acts against the end of hub 16, the effect being otherwise the same as in the embodiment of Figures 1 and 2. Figure 4 illustrates a construction in which the bimetallic strip 17 and stop element 25 are carried on a shaft 46, rotatable in the plate 1 and sector 7, and which replaces the shaft 6 and sleeve 16 of Figures 1 and 2, the operation being otherwise the same.

As will be apparent, setting the stop screws 12 and 13 so as to hold the stop arm 25 against any movement will prevent rotation of the hub 16, so that the thermostat will operate in the conventional way and without anticipation. Under such conditions, the narrowest range within which temperature can be maintained may be arrived at by adding the upside overshoot and the downside overshoot of the controlled system to the range resulting from the instrumental lag.

A second extreme condition of adjustment may be considered (although it does not represent the practical or intended operation of the device) as clarifying in the simplest way possible some of the essential principles of operation. In this condition of adjustment, it may be assumed that the stops 12 and 13 are set so far apart as to be ineffective. Under these conditions, once contact is made with contact 3 for turning on the heating plant, the continued expansion of the strip 17 will cause the hub 16 to be rotated backward (counterclockwise) as long as the temperature continues to fall and for a short time thereafter, corresponding to the lag in response of the instrument. This means that the strip is at all times in a condition to respond to a rise in temperature regardless of what the temperature may be at the time it ceases to drop and starts rising. Accordingly, if, for example, the thermostat when so adjusted turned on the heating plant at 71° and the downside overshoot were 2°, the temperature would continue to fall to about 69° and then as the heating plant became effective would start to rise. Since, however, the retrograde motion of the hub 16 maintained the bimetallic strip in readiness for breaking contact, the heating plant would be turned off as soon as the temperature began to rise and at about 69°. The high side overshoot of the heating plant might raise the temperature to some such value as 71° and, meanwhile, the strip having engaged contact 4, further tendency to contract would cause the hub to move backwardly (this time clockwise) to maintain the strip in constant readiness for making contact to start the heating plant as soon as the temperature started to fall. The thermostat if so operated would, of course, not maintain the temperature within any set or adjusted range, but would hunt and possibly find a condition of stability depending upon the thermostat construction and the controlled system. The point which is to be noted, however, is that when so operated the thermostat is capable of turning on the heating plant at a higher value (with a falling temperature) than the temperature at which the heating plant is turned off (when the temperature is rising) and that these two temperature values are separated by a number of degrees of temperature determined by the inertial effect or overshoot of the heating system itself.

By suitably adjusting the stops 12 and 13, the range of temperature variation may be centered about the temperature indicated by pointer 8 on scale 2 and the width of this range may be adjusted for the most uniform temperature consistent with efficient operation of the heating plant. If the stops 12 and 13 are spaced far enough apart so that the turning on and off of the heating plant occurs at the same temperature of the controlled system, it will be apparent that lag of the instrument has been anticipated and compensated for. Where the stops 12 and 13 are set more widely than this, the temperature at which the heating plant is turned on will be higher than that at which it turns off. The range of temperature variation will now be less than the sum of the upside and downside overshoots, so that the lag of the controlled system has been anticipated.

For purpose of explaining the operation, arbitrary figures will be assumed for definiteness by way of example, and an oil burner and steam radiator household heating plant will be considered by way of illustration. In such a system, a rise of temperature in the air after the oil burner has been turned off, due to the steam remaining in the boiler and radiators may be considerable, and an upside overshoot of 2 degrees will be assumed. Similarly, the time required for the oil burner to get up steam and for the steam to fill the radiators and commence to warm the air may also be considerable and a downside overshoot of 2 degrees will be assumed.

Under such conditions the following type of operation may be obtained: the parts may be set so that the contact for turning on the oil burner (Fig. 6) is made at 71° or very slightly under this temperature. The assumed downside overshoot of two degrees will cause the temperature to continue to fall to about 69°. In the ordinary thermostat this would mean an expansion or attempted expansion of the bimetallic strip corresponding to 2 degrees (of temperature). In other words, the bimetallic strip would attempt to continue to move as the temperature fell, but being prevented from moving by the contact 3, would be flexed to a corresponding extent, the strain being proportional to the stress, as is obvious. Before the contact could be broken in an ordinary thermostat, the temperature would therefore have to rise so as to eliminate this flexing or stressing of the bimetallic strip, and only thereafter would the temperature variation be effective for breaking the contact. In a conventional thermostat, under the assumed conditions, there would therefore be the equivalent of four degrees of temperature variation consumed in stressing and eliminating the stress of the bimetallic strip, thus delaying the action. However, in the thermostat of the present invention, as soon as the bimetallic strip has engaged the contact 3, further tendency toward expansion will create a torque on the hub 16, and as soon as this torque becomes sufficient to overcome the frictional resistance to movement of the hub 16, which may be very slight, the hub will rotate in the retrograde direction (counterclockwise) until arm **25** engages stop **12**, as shown in Fig. 7. Stop **12** may be so adjusted that this occurs at just about the temperature (69°) at which the downside overshoot has finished. Since the bimetallic strip **17** is pressed against the contact **3** with a pressure which may exceed the amount required to overcome the friction of hub **16** by only a very small amount, if at all, the bimetallic strip is in instant readiness to break contact as soon as the temperature starts to rise. This will occur at 69° under the assumed condition so that the heating plant is turned off. The upside overshoot will cause the temperature to rise to 71° and, meanwhile, the bimetallic strip having engaged contact **4** (Fig. 6), which is functioning merely as a stop, tendency of the strip to contract further as the temperature rises will again cause a retrograde motion of the hub **16** (this time in the clockwise direction, as indicated by the arrow in Fig. 9, until the stop arm **25** comes against the stop **13**, as shown in Fig. 9. The stressing of the bimetallic strip by stops **4** and **13** may be similar to the stressing of the strip by contact **3** and stop **12**, as discussed in connection with Fig. 7, and for reasons there discussed, a total stressing to four degrees of temperature change may be eliminated, making a total, under the assumed conditions, of eight degrees of ineffective flexing of the bimetallic strip which has been eliminated, by comparison with conventional thermostats. The parts are now in position for reacting to a drop in temperature and as soon as the temperature starts to fall, the bimetallic strip **17** will move, as indicated in Fig. 5, until it comes against the contact **3**, as indicated in Fig. 6, for turning on the heater. This cycle will be repeated indefinitely, maintaining the temperature very closely within a range from 69° to 71° when the temperature is set for 70°.

With some heating plants, such close temperature regulation may be inconsistent with the most efficient operation of the heating plant itself, and in such cases the stops **12** and **13** may be set closer together, providing a regulated amount of anticipation anywhere between zero anticipation, which of course will ordinarily not be desired, and the full extent of anticipation as obtained in the example just discussed.

As will now be apparent, the invention provides, in a thermostat of the type in which control is obtained by an expansible element carried on the support, such as plate **7**, and having an upper contact with contacts **21** and **22** which cooperate with stationary contacts or stop elements **3** and **4**, a frictionally slidable connection which permits the elimination of overstressing of

the bimetallic strip beyond the stress necessary to make efficient contact.

While the invention has been shown in a preferred form in which this frictionally slidable connection is embodied in the hub **16** or similar rotatable elements, it will be apparent that, when considered more broadly, the same type of operation can be obtained by inserting such a frictionally slidable connection at any suitable point between the bimetallic strip movable contacts **21—22** and the plate **7** or other support for the strip.

The invention has also been discussed with reference to single contact operation, in which case the contact **4** functions merely as a stop. The contact **4** may, however, also be active, and may be used, as is common in three-wire systems, for controlling auxiliary equipment, or for turning off the heating plant. Contacts **3** and **4** may also control the heating plant indirectly wherever desired.

What is claimed is:

1. An anticipating thermostat comprising in combination, a frame, opposed contacts carried by the frame, a thermo-responsive expansible strip, a rotatable support member attached to one end of the strip and holding the same with its other end between the contacts, means frictionally resisting rotation of the said rotatable support, and a member adjustably carried on the said frame and carrying stops for limiting rotation of the said support.

2. An anticipating thermostat comprising in combination, a frame, opposed contacts carried by the frame, a thermo-responsive expansible strip, a rotatable support member attached to one end of the strip and holding the same with its other end between the contacts, means frictionally resisting rotation of the said rotatable support, a plate carried by the frame and pivotally adjustable about the rotatable support member, opposed adjustable stops on said plate and a stop arm fixed to the rotatable support member and positioned between the stops for limiting rotation of the support member.

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