

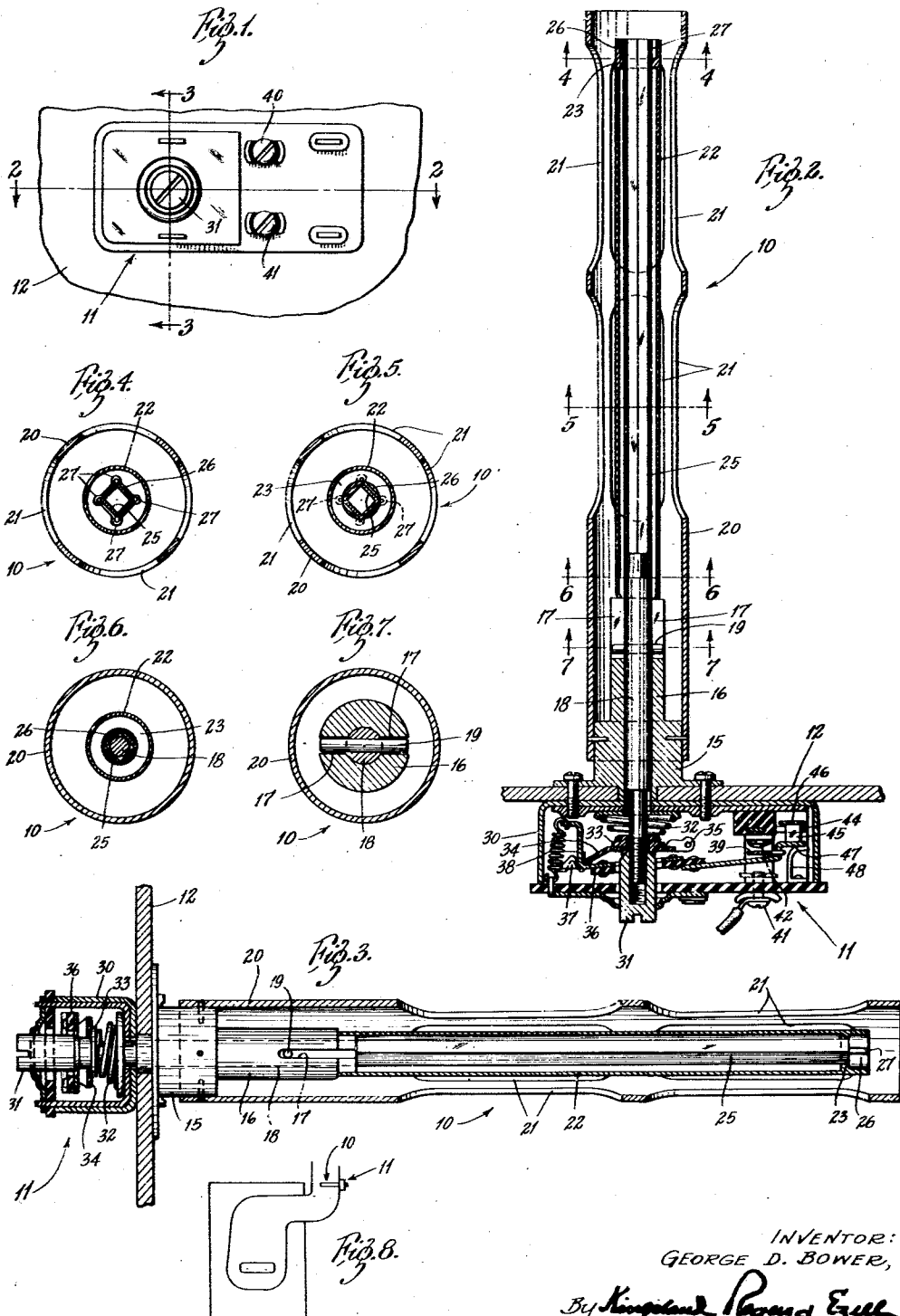
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HEAT-RESPONSIVE ELEMENT

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HEAT-RESPONSIVE ELEMENT

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4 Claims. (Cl. 200—157)

This invention relates to a heat-responsive unit and particularly one that is responsive to certain heat changes occurring at or above a given rate.

In particular, it includes an element adapted to be placed within the range of heat changes, such as within the stack of a furnace where it will be influenced by the flame produced by the burner. It also includes a switch preferably of the snap action type operated by the stack unit.

An object of the invention is to provide a mechanism of this kind that will operate a switch or like mechanism when a reversal of heat conditions occurs at a rate above a critical one. A further object is to provide a unit of this kind that will not operate the switch when the heat changes occur at rates lower than the critical one.

A further object of the invention is to provide a mechanism that will operate from any temperature of starting, and which will not operate upon casual temperature changes, either modulating or ambient.

A further object of the invention is to provide a mechanism that will fail safe, and more particularly one that will shift to safe position upon collapse of the flame-receiving parts.

Another object is to provide a unit that is adapted for use with a snap action switch while responsive to such heat changes above the predetermined rate.

In the drawing:

Fig. 1 is a broken front elevation showing the switch mechanism;

Fig. 2 is a horizontal middle section through the mechanism taken on the line 2—2 of Fig. 1;

Fig. 3 is a similar vertical section taken on the line 3—3 of Fig. 1;

Fig. 4 is a vertical section through the tip of the stack unit taken on the line 4—4 of Fig. 2;

Fig. 5 is a vertical section through a middle point of the stack unit taken in the line 5—5 of Fig. 2;

Fig. 6 is a vertical section taken on the line 6—6 of Fig. 2;

Fig. 7 is a vertical section taken on the line 7—7 of Fig. 2; and

Fig. 8 is a diagrammatic view of the device installed on a furnace with a burner.

This application is a continuation in part of co-pending application Serial No. 328,177, filed April 6, 1940.

The mechanism includes generally a stack unit 10 and a switch unit 11 mounted on a housing or other suitable support 12. The unit 10 is adapted to be inserted into a stack or other part

of a furnace or like heat change producing device so as to be influenced upon the production of a heat change at the burner.

The stack unit includes a base portion 15 having an extension 16 thereon of lesser diameter. The extension has diametrical slots 17 at its outer end for a purpose to be described. The member 15 has a hole through the axis thereof to receive an actuating member 18. This actuating member has a pin 19 extending transversely therethrough and engaging within the slots 17 to prevent rotation between the member 15 and the actuating member 18, but to permit axial displacement.

An open-ended guard member 20 is secured about the larger part of the supporting member 15 and has a plurality of openings 21 to permit free flow of gases through it adjacent its outer portion.

A first and outer heat-responsive tube 22 is secured at one end to the outer end of the supporting member 15. At its outer end the tube 22 is formed with a guide 23 extending from the inner surface thereof.

Within the tube 22 there is located a second or inner tube 25 which preferably is square in cross section. This tube is secured over an end of the actuating member 18 so that they move together. At its outer end it is guided by the guide ledge 23. Also, at its outer end it has a collar 26 secured to it beyond the ledge 23. This collar has projections 27 (Fig. 4) at the corners thereof which engage over the ledge 23 so that upon movement of the end of the outer tube 22 outwardly the inner tube may be carried with it. This, of course, carries the actuating member 18 and shifts the switches, as will be explained.

The switch is of any suitable type, such as is shown in copending application Serial No. 203,020, filed April 20, 1938, or Patent 2,180,018, both in the name of L. M. Persons. This switch includes a casing 30 attached to the back of the housing 12 and it may be attached by the screws that hold the stack unit to the housing. The actuating member 18 extends within the casing 30 and is threaded at its end to receive an adjustment sleeve 31. There is a spring 32 that maintains a collar 33 toward the sleeve 31. This collar acts upon a primary lever 34 pivoted at 35 to the casing 30. This primary lever, in turn, acts upon a secondary lever 36 pivoted on a pair of knife edge pivots 37 on to the casing.

The secondary lever has a return spring 38 adjacent one end and a switch contact 39 at its

other end; and, as may be seen, it has an insulating portion between its ends. The switch has two terminals 40 and 41 from which extend contacts 42 that are adapted to be bridged by the contact element 38 on the secondary lever 36. Details of this mechanism are disclosed in the previously mentioned copending application or patent. It also may act with two-way contacts alternately closed, as is also shown therein, in which case it will close with one set of contacts in one position and the other set in its other position.

Supported on the casing in a molded insulating block is a magnet 44 adapted to attract an armature 45 on the end of the secondary lever 36. The armature 45 has two armature elements 46 and 47 held on opposite sides of the projecting magnet legs. One armature element is attracted with the switch in one position and the other element is attracted with the switch in the other position. A stop member 48 may be employed to limit the movement of the secondary lever away from the contact.

When the actuating member 18 moves toward the upper part of Fig. 2 the sleeve 31 and the washer 33 move with it. This releases the primary lever, and the secondary lever pivots under influence of the spring 38. The secondary lever is more or less resilient, and the effect of the armature 45 and the magnet 44 acts with great leverage relative to that of the primary lever. Hence under the force of the spring 38, the secondary lever flexes until it has stored enough energy to overcome the magnetic attraction. The secondary lever then withdraws the armature 46, in a snap action manner, because the magnetic effect lessens exponentially with increasing withdrawal. When the movement of the secondary lever subsequently brings the armature 47 within range of the magnet, after a dead center position, this armature moves in rapidly under an increasing magnetic force to close the contacts with a snap action, usually accompanied by some early flexing of the secondary lever.

Upon reverse movement of the actuating member 18, the sleeve 31 is moved downwardly to withdraw from the primary lever 35 so that the spring 32, acting upon the washer 33, shifts the primary lever, and in turn the secondary lever to open the contacts.

The sleeve 31 is adjusted preferably so that at the start the switch could assume a neutral position, in which the armatures are balanced on opposite sides of the magnet, and with the tubes producing no force of displacement either way.

The stack unit 10 is adapted to be projected into the stack or the heating zone at a suitable distance such as to approximate the section line 6-6 on Fig. 2. This may be called the depth of immersion. The parts below this line will therefore be somewhat cooler than the parts above the line when heat is applied to the unit.

The operation

At the start the tubes will have given relative lengths, which may mean that either is longer or that they are equally long. This is called the starting length differential. At the start the length differential will be such as to cause the secondary lever to be capable of assuming a mid position with each armature 46 and 47 equidistant from the magnet. Owing to the resiliency of the members of the switch, the secondary lever

will, however, actually remain in a previously adopted position upon return of the tubes to starting length differential.

When a heat change is rapidly applied to the immersed parts of the tubes, as when flame is produced at the burner, the outer tube receives a large quantity of heat, and expands, being located so as to receive heat from the flame. The rapidity of expansion is enhanced by the thinness of the tube walls. Some heat flows from the outer tube to the inner, but the outer tube is constantly drawing from what, in effect, is an infinite heat reservoir, so that its heat losses are negligible insofar as concerns any effect on its expansion.

During this time the inner tube is receiving heat from only two sources. Some is derived at its outer end from the flame, but this is of little effect. Most of its heat is derived from the outer tube, by radiation, convection, and conduction through the end, as at 23. The resistance of these paths to heat flow is so great that the inner tube receives less heat than the outer, and expands much less, in a given time, producing a changed or plus length differential.

The inner tube is constantly discharging its heat through its end and into the member 18, the switch housing, and associated parts, all of which comprise a cold reservoir. Under usual operating conditions, the amount of heat discharged into the cold reservoir is a substantial part of the heat received by the inner tube. As a result, the inner tube has a lower heat content at its inner end than at its outer, whereas the outer tube, throughout its immersed length, is subjected to infinite heat.

The discharge of heat from the inner tube into the cold reservoir means that even though the outer end of the inner tube becomes as heated as the outer tube, the inner end of the inner tube will be cooler, and the inner tube will always permit the outer tube to maintain the plus length differential.

Even if the inner tube should become as hot as the outer, so that it attains the starting length differential, this will not shift the switch, because at the starting length differential, the switch is not urged beyond dead center of the magnetic snap action, and as noted the switch will remain in its previously assumed position.

After the heat applied has caused the switch to shift, and this normally occurs in from one to three seconds after flame occurs, a further increase in heat of the flame will have no additional effect, because the most it could do would be to increase the plus length differential.

Normal burner fluctuations occurring during operation of the burner do not cause the device to shift the switch, because they occur at rates below the critical rate of the device. Among the factors determining the critical rate are the capacity of the heat flow paths into the inner tube, relative to those of the outer, and the corresponding capacities of the heat flow paths out of the inner tube. There is also a lag in the switch mechanism itself. Whenever the quantity of heat added to the outer tube within a given time is as great as or greater than the quantity of heat flowing into and retained in the inner tube during the same time, the plus length differential will be maintained.

However, when the quantity of heat added to the outer tube during a given time becomes less than that flowing into and retained in the inner

tube during the time, a minus length differential will result. During normal operations, even with fluctuation of the burner, the quantity of heat from the burner is so much greater than the heat capacity of the stack unit that the unit is not influenced by the fluctuations. Further, these fluctuations ordinarily occur at relatively slow rates; i. e., the aggregate rate of heat change influencing the stack unit is low.

However, any sharp decrease in heat applied to the outer tube, as when the flame stops, immediately produces a very rapid reduction in the heat supplied to the outer tube. This tube can then dissipate its heat not only to the inner tube as before, but to a greater or lesser degree to the air in the furnace. In any case, it can lose heat more rapidly than can the inner tube, the flow paths of which are restricted. When the outer tube loses heat more rapidly than the inner, it contracts more rapidly and produces a minus length differential, returning the switch to starting position. This shifting of the switch can occur from any temperature.

Thereafter, the tubes cool down gradually, with the inner again approaching the outer, until the starting length differential is obtained. At this point the switch will remain in its starting position, owing to the previously mentioned balanced setting of the snap action means.

Ordinary fluctuations of ambient temperature when the burner is off occur at rates too slow to produce a reversal of the length differential to shift the switch.

What I claim is:

1. In a mechanism of the kind described, a heat-responsive unit having two relatively movable members expansible and contractible in response to heat changes, and adapted to have a starting length differential, the heat-flow capacity of the first member being greater than that of the second, whereby upon application of heat to the unit at rates greater than the heat-flow capacity of the second member the first will expand more rapidly to provide a plus length differential, and upon the discharge of heat from the unit at rates greater than the heat-flow capacity of the second member, the first member will contract more rapidly to provide a minus length differential upon cessation of heat, an actuated means adapted to be displaced to a first position upon production of the plus length differential, and adapted to be displaced to a second position upon production of the minus length differential and means causing said actuated means to remain in either position to which it has been displaced upon subsequent production of the starting length differential.

2. In a mechanism of the kind described, a heat-responsive unit having two relatively movable members expansible and contractible in response to heat changes, means causing the first member to have a heat flow path into and out of it of greater capacity than the heat flow path of the second, whereby upon application of heat changes to it at rates greater than the heat-flow capacity of the second, it will expand or contract more rapidly than the second, said members hav-

ing a starting length differential, the application of heat to the unit at rates greater than the heat-flow capacity of the second member providing a plus length differential, and the discharge of heat from the first member at rates greater than the heat-flow capacity of the second member providing a minus length differential, a switch having a blade movable to two positions by the production of said plus and minus length differentials, snap-action means urging the blade into each of said two positions, and said heat-responsive unit being adapted, at said starting length differential, to produce insufficient blade displacement to move the switch from the position previously assumed.

3. In a mechanism of the kind described, a base member adapted to be secured to a support, an outer tube projecting from the base member, an inner tube within the outer tube, means attaching the remote ends of the tubes together so that upon expansion of the outer tube the inner may be displaced, an actuating rod attached to the rear end of the inner tube and slidably passing through the base member, switch means on the support opposite the base member, said switch means including a primary lever astride the actuating member, a sleeve adjustably threaded into the actuating member on one side of the primary lever against the sleeve, a secondary lever adapted to be displaced by the primary lever, contact means associated with the secondary lever, a magnet adjacent one end of the secondary lever, and a pair of armatures on the lever alternately co-operable with the magnet to operate the lever.

4. In a mechanism of the kind described, a pair of elements adapted to change in length upon application of heat changes thereto, said elements being adapted to have a starting length differential at starting temperature, the first of said elements having a relatively rapid rate of heat absorption and heat dissipation, the second element being shielded to receive heat at a slower rate than the first, heat-absorbing means connected to the second element to absorb heat transmitted thereto, said connection being disposed to insure flow of heat through the second element, said heat-absorbing means being adapted normally to continuously absorb heat from the second element whenever it attains a temperature above its starting temperature, said shielding and heat-absorbing means being adapted to provide slower rates of expansion of the second element than the first upon application of heat to the first, and slower rates of contraction of the second upon sharp reduction of heat applied to the first, and said heat-absorbing means being adapted normally to prevent the second element from attaining the starting length differential during application of heat to the first element, means connecting the elements for displacement of one of them upon increase in length of the first one at a rate greater than that of the second, and reverse displacement of the one upon decrease in length of the first one at a rate greater than that of the second, and means adapted to be operated upon such displacements.

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