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2,512,331

THERMAL RESPONSIVE SWITCH

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Fig. 1.

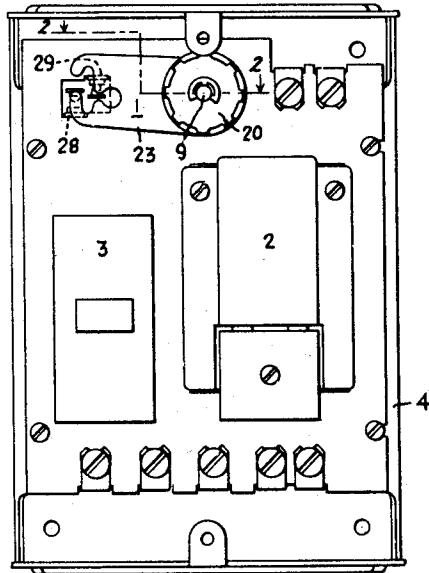


Fig. 3.

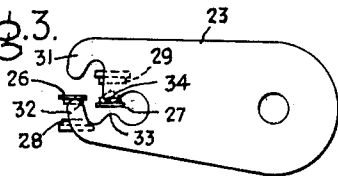


Fig. 2.

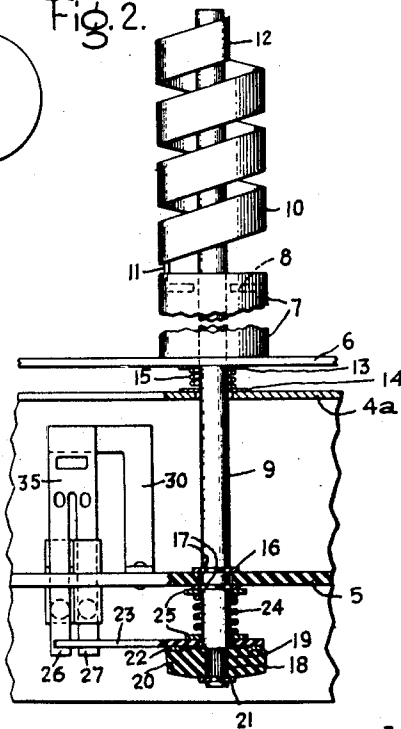


Fig. 4.

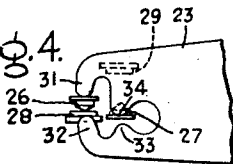
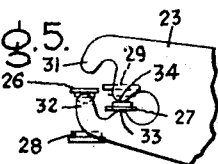


Fig. 5.



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THERMAL RESPONSIVE SWITCH

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My invention relates to thermal responsive switches, and more particularly to such switches having two pairs of switch contacts actuated upon temperature change in opposite directions, with overtravel in temperature permitted in both directions. Switches of this type are particularly suitable for use as flame detectors in fluid fuel burning systems, and the like.

In flame detecting switches having "hot" contacts and "cold" contacts, it is desirable that, although the device is necessarily sufficiently sensitive to discriminate between the presence and absence of flame, it should not be so sensitive that it responds to ambient temperature variations in the absence of flame, or to stack temperature variations as the flame fluctuates slightly. Moreover, it is desirable that the degrees of sensitivity to temperature change on the "hot" and "cold" sides be independent of each other. Both these advantages, as well as various other advantages which will become evident hereinafter, are attained in practicing my invention.

Accordingly, therefore, it is a general object of my invention to provide a new and improved thermal responsive switch mechanism.

It is a more particular object of my invention to provide a thermal switch mechanism of the type having "hot" and "cold" contacts in which the degree of sensitivity on the hot side is independent of the degree of sensitivity on the cold side and vice versa.

It is still another object of my invention to provide, in a thermal switch mechanism responsive to temperature change, an integral spring contact and actuating mechanism which is very simple and inexpensive to manufacture but is effective, reliable and durable in operation.

It is a more specific object of my invention to provide, in a thermal switch mechanism responsive to temperature change, new and novel means for applying and maintaining contact pressure and for wiping in both the high temperature and the low temperature contacts.

My invention itself will be more fully understood and its various objects and advantages further appreciated by referring now to the following detailed specification, taken in conjunction with the accompanying drawing, in which Fig. 1 is a front elevational view of an oil burner control apparatus including a flame detector embodying the contact actuating mechanism of my invention; Fig. 2 is a top view, shown partly in section, of the flame detector shown in elevation at Fig. 1; and Figs. 3, 4 and 5 are detailed views showing the contact actuator and switch contacts in various operating positions.

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Referring now to the drawing, and particularly to Figs. 1 and 2, a preferred embodiment of my invention is shown by way of illustration as a flame detector 1 forming part of an oil burner control apparatus including also a relay 2 and a timing mechanism 3. While apart from the flame detector 1, the remainder of the oil burner control apparatus illustrated in outline at Fig. 1 is not part of my subject invention, such control apparatus may suitably be of the type described and claimed in the copending application Serial No. 73,293, filed on Jan. 28, 1949, by Jack Witherspoon for Safety Control System for Fluid Fuel Burners and assigned to the same assignee as the instant application.

Referring now more particularly to Figs. 1 and 2, my flame detector is mounted in a housing 4 having a back wall 4a and including a panel 5 disposed in parallel spaced relation with respect to the back wall 4a. Preferably, the panel 5 is formed of a suitable rigid insulating material, such as any well known molded insulating compound. Connected to the casing 4 by brackets (not shown) is a heat shield or plate 6 disposed outside the casing 4 in parallel spaced relation with the back wall 4a. Mounted upon the shield or plate 6, and projecting perpendicularly backward therefrom, is a tube 7 having mounted in the remote end thereof a centrally apertured spider 8. A shaft 9 is mounted concentrically and rotatably in the tube 7 and projects beyond both ends of the tube. The shaft 9 is journaled in the spider 8 and the panel 5, passing through apertures in the casing rear wall 4a, the mounting plate 6 and the panel 5 and extending slightly beyond the front of the panel. The shaft 9 also extends rearwardly beyond the end of the tube 7, and this rear portion of the shaft is encircled by a helical bimetallic strip 10. One end of the bimetallic strip 10 is connected by a bracket 11 to the tube 7. The opposite end of the bimetallic strip is fixed to the shaft 9 at 12. Since the bracket 11 is fixed with respect to the casing 4, and since the bimetallic strip 10 coils or uncoils upon the variations in temperature, the shaft 9 is turned in response to temperature variations. In the illustrated embodiment of my invention, the movement of the shaft is clockwise upon an increase in temperature, as viewed at Fig. 1.

Between the heat shield 6 and the rear wall 4a of the casing 4, the shaft 9 carries a pair of washers 13 and 14 and a helical compression spring 15 between the washers. The spring 15 presses the washer 13 against the rear wall 4a and the washer 14 against the heat shield 6 for the purpose of sealing the shaft apertures in the

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shield and wall against the transmission of excessive heat into the casing 4. Endwise movement of the shaft 9 is prevented by a pair of spring washers or clips 16 seated in annular grooves 17 in the shaft 9 on opposite sides of the insulating panel 5.

The end of the shaft 9, which extends beyond the front side of the panel 5, is provided with a knurled portion 18 of reduced cross section forming a shoulder 19. On the knurled section 18 is mounted a circular clutch plate 20 which is non-rotatably fixed to the shaft 9 by the knurling on the shaft and is held against the shoulder 19 by a spring washer 21 fitting into an annular groove at the outer end of the shaft. The inner surface of the clutch plate 20 is provided with an annular peripheral recess in which is positioned a flat metal ring 22 having a thickness slightly greater than the depth of the recess.

Loosely or rotatably mounted upon the shaft 9 between the panel 5 and the clutch plate 20, is a radially extending actuating arm or plate 23. The actuating arm 23 is formed of insulating material and is held in flatwise engagement with the clutch ring 22 by a helical compression spring 24 encircling the shaft 9 and disposed between a pair of washers 25 on the shaft 9 between the panel 5 and the actuating arm 23.

From the foregoing, it will be evident that the actuating arm 23 is connected to the shaft 9 by a slipping clutch connection constituted by the arm 23, the plate 20 and ring 22, and the compression spring 24. Thus, the arm 23 is turned with the shaft 9 in response to variations in temperature of the bimetallic strip 10 and the slipping clutch provides for overtravel of the shaft 9 in both directions if the arm 23 is stopped. This slipping clutch arrangement provides quick response to temperature reversals in that, while the clutch permits overtravel of the shaft 9 in either direction, it effects movement of the arm 23 immediately upon reversal of the direction of movement of the shaft. Thus, a high degree of sensitivity to temperature change is provided by the slipping clutch connection of the arm 23 to the shaft 9.

While the high degree of sensitivity to temperature change which is provided by the slipping clutch connection of the actuating arm 23 is highly desirable in a flame detector, it is also frequently desirable to provide different degrees of sensitivity of the detector in its "hot" and its "cold" positions. For this purpose, I provide a pair of movable spring contact fingers 26 and 27 arranged to engage, upon opposite directions of movement of the actuating arm 23, separate stationary contacts 28 and 29. The spring fingers 26 and 27 are connected by separate lost motion connections to the actuating arm 23, so that the amounts of lost motion on the hot and cold sides are independently determinable.

The spring contact fingers 26 and 27 are mounted in cantilever fashion at one end upon a mounting bracket 30 attached to the panel 5, and the free end of each contact finger is disposed between a separate pair of juxtaposed actuating fingers or abutments formed at the end of the actuating arm 23. More specifically, the free end of the spring contact finger 26 is disposed between a pair of spaced apart actuating fingers 31 and 32 formed at the end of the arm 23, and the free end of the spring contact finger 27 is disposed between a pair of spaced apart actuating fingers 33 and 34 formed on the arm 23 adjacent the fingers 31 and 32. It will be evident that the spac-

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ing between each pair of actuating fingers on the arm 23 determines the sensitivity to temperature change of the particular contact finger disposed therebetween. Since these spacings are independent of each other, it follows that the sensitivity of each of the two contacts can be separately predetermined. To permit this independent sensitivity response, the movable contact fingers 26 and 27 are each biased to their contact engaging positions, as will appear more fully hereinafter.

In the preferred embodiment of my invention, the spring contact fingers 26 and 27 are formed by slotting longitudinally a single strip 35 of spring material, the slot being somewhat shorter than the length of the strip. The strip 35 is mounted in cantilever fashion at its integral end on the mounting bracket 30 with an integral portion of its end overhanging the bracket. Since a portion of the integral end of the spring strip 35 extends beyond its point of mounting on the bracket 30, any deflection of one of the spring fingers, 26, 27 produces a somewhat lesser deflection, or bias, of the other spring finger. With this arrangement of the spring fingers 26, 27, my dual contact device is made self-biasing by so positioning the oppositely disposed actuating fingers 32 and 34 of the actuating arm 23 that they maintain the free ends of the contact fingers 26 and 27 in offset relation, the offset being in a direction to bias both contact fingers toward their contact engaging position. This offset is shown in Fig. 3, where the actuating arm 23 is in a position intermediate its hot and cold positions. In Fig. 3, the actuating arm is in the position which it would take if the clutch spring 24 were removed, so that the arm 23 would be completely free on the shaft 9.

In operation, if it be assumed that the thermal responsive switch shown in the drawings is mounted with the bimetallic helix 10 in the exhaust stack of a furnace, and if it further be assumed that the furnace is not in operation, so that the stack is cold, the shaft 9 will be in its extreme counter-clockwise position, as viewed at Fig. 1, and the actuating arm 23 will be in the position shown at Fig. 4. In this position of the actuating arm 23 (Fig. 4) the movable contact finger 26 is in engagement with its cooperating stationary contact 28 and is held in such engagement by deflection of the spring finger 27 by the actuating finger 34. The actuating arm 23 is in its "cold" limiting position with the actuating finger 31 engaging the back of the contact finger 26 to stop movement of the arm 23.

Upon an increase in stack temperature and consequent clockwise rotation of the shaft 9, the actuating arm 23 begins to move immediately upon movement of the shaft 9 by reason of the slipping clutch connection between the shaft and the arm 23. In this movement, the contact finger 26 does not leave the contact 28 until the actuating finger 32 engages the under side of the finger 26 and positively opens the contact. During the lost motion interval between the time when the actuating finger 31 leaves the contact finger 26 and when the actuating finger 32 engages the contact finger 26, the contact 26 is biased into engagement with the fixed contact 28 by reason of the fact that the actuating finger 34 maintains the contact fingers 27 and 28 in offset relation. Thus, a temperature change sufficient to move the actuating arm 23 far enough to take up the lost motion between the fingers 31 and 32

is required in order to separate the contacts 26 and 28.

The contacts 26, 28 are separated before closing of the contacts 27, 29, as illustrated at Fig. 3. If the increase in temperature continues, so that the shaft 9 continues to rotate clockwise, the actuating finger 34 eventually permits the movable contact finger 27 to engage its cooperating stationary contact 29. In this position of engagement, contact pressure between the contacts 27 and 29 is maintained by deformation of the contact finger 26, which is held in offset relation with respect to the finger 27 by the actuating finger 32. After engagement of the contact finger 27 with the fixed contact 29, the actuating arm 23 continues to rotate clockwise as the temperature increases, thereby to take up the lost motion between the actuating fingers 33 and 34. When the actuating finger 33 engages the back side of the spring contact finger 27, the actuating arm 23 is stopped, and any further increase in temperature and consequent rotation of the shaft 9 effects slippage between the actuating arm 23 and the clutch plate 20.

Operation of my thermal responsive switch in the reverse direction upon a decrease in temperature of the bimetallic helix is entirely similar in all respects to the operation just described in connection with an increase in temperature. Thus, any decrease in temperature of the helix 10 below its maximum temperature immediately initiates counter-clockwise movement of the actuating arm 23, but separation of the contact 27 from the contact 29 does not take place until the lost motion between the actuating fingers 33 and 34 is first taken up.

It will now be evident that, with the actuating arm 23 in either its "cold" position of Fig. 4 or its "hot" position of Fig. 5, a predetermined temperature change is required to effect opening of the engaged contacts. Thus, the sensitivity of the switch on both the "hot" and the "cold" contacts is independently determined by the amount of lost motion between the actuating arm and each of the contact fingers. With the "hot" contacts 27, 29 closed, this permits a certain amount of flame fluctuation, or temperature variation in the stack, within the sensitivity range without effecting opening of the hot contacts. Similarly, on the "cold" side with the contacts 26, 28 closed, a certain amount of ambient temperature variation within the sensitivity range is permitted without opening of the cold contacts. Moreover, by forming both spring contact fingers 27 and 28 from a single spring with an interconnection at the integral end of the spring strip, the contacts are self-biasing, so that each contact wipes in the other during the lost motion in each direction. By this latter arrangement also, manufacturing problems are considerably simplified in that the single flat spring requires the holding of no close manufacturing tolerances, while at the same time, the coupling of this spring to the actuating arm 23 with the parallel fingers 26 and 27 in offset relation, ensures positive and permanent wiping force for each of the contacts.

While I have described only a preferred embodiment of my invention by way of illustration, many modifications will occur to those skilled in the art, and I, therefore, wish to have it understood that I intend in the appended claims to cover all such modifications as fall within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A thermal responsive switch mechanism comprising, a rotatable shaft, thermal responsive means connected to turn said shaft, an actuating member rotatably mounted on said shaft, said actuating member being formed to provide two pairs of actuating fingers, the fingers of each said pair being radially equidistant from said shaft and being circumferentially spaced apart, a slipping clutch coupling said actuating member to said shaft, a pair of cantilever spring contact fingers having their free ends disposed between said pairs of actuating fingers respectively thereby to provide separate lost motion connections between said contact fingers and said actuating member, and a pair of stationary contacts disposed to be engaged by said contact fingers respectively upon movement of said actuating member in opposite directions.

2. A thermal responsive switch mechanism comprising, a longitudinally slotted elongated spring plate mounted in cantilever fashion at its integral end to form a pair of adjacent and normally coplanar movable spring contact fingers, a thermal responsive actuating member formed to provide two adjacent pairs of spaced apart actuating fingers so disposed that each said pair of actuating fingers embraces the free end of one of said contact fingers thereby to provide separate lost motion connections between said actuating member and said contact fingers, said actuating fingers being positioned to maintain said contact fingers in normal prestressed non-coplanar position and providing lost motion in opposite directions from said positions between said contact fingers and said actuating member, and a pair of stationary contact members disposed to be engaged by said contact fingers respectively upon movement of said actuating member in opposite directions, whereby contact pressure between each of said contact fingers and its cooperating stationary contact is maintained by deformation of the other contact finger while the lost motion associated with the engaged contact finger is being taken up.

3. A thermal responsive switch mechanism comprising, a longitudinally slotted elongated spring plate mounted in cantilever fashion at its integral end to form a pair of adjacent and normally coplanar movable spring contact fingers, a thermal responsive actuating member loosely coupled to both said fingers, said actuating member maintaining said fingers in normal prestressed non-coplanar positions and providing lost motion in opposite directions from said positions between said fingers and said actuating member, and a pair of stationary contact members disposed to be engaged by said contact fingers respectively upon movement of said actuating member in opposite directions, whereby contact pressure between each of said fingers and its cooperating stationary contact is maintained by stress in the other finger while the lost motion associated with the engaged contact finger is being taken up.

4. A thermal responsive switch mechanism comprising, a rotatable shaft, thermal responsive means connected to turn said shaft, a radially projecting actuating member rotatable upon said shaft, a slipping clutch coupling said actuating member to said shaft, a longitudinally slotted elongated spring plate fixedly mounted in cantilever fashion at its integral end to form a pair of adjacent normally coplanar movable spring contact fingers, separate lost motion connections between the free ends of said contact fingers and

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said actuating member, said lost motion connections maintaining the free ends of said contact fingers in off-set relation and providing lost motion of each of said fingers in a direction to increase the off-set between said ends, and a pair of stationary contact members disposed to be engaged by said contact fingers respectively upon movement of said actuating member in opposite directions and providing stops for said contact arms to take up said lost motion in each direction of movement of said actuating member.

5. A thermal responsive switch mechanism comprising, a base, a shaft rotatably mounted upon said base, a helical bimetallic thermally deformable member connected between said base and said shaft, a radially extending actuating arm loosely mounted upon said shaft, said actuating arm being formed to provide two adjacent pairs of spaced apart actuating fingers, the fingers of each said pair of actuating fingers being radially equidistant from said shaft and circumferentially spaced apart, a slipping clutch coupling said actuating arm to said shaft, a longitudinally slotted elongated spring plate fixedly mounted in cantilever fashion at its integral end to form a pair of adjacent normally coplanar movable spring contact fingers, the free ends of said contact fingers being disposed between said pairs of spaced apart actuating fingers respectively thereby to provide separate lost motion connections between said contact fingers and said actuating arm, said actuating fingers maintaining the free ends of said contact fingers normally in non-coplanar off-set relation and providing lost motion between each of said contact fingers and said actuating arm, said lost motion being in a direction to increase the off-set between said

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contact fingers, and a pair of cooperating stationary contact members disposed to be engaged by said contact fingers respectively thereby to stop said contact fingers and take up said lost motion upon movement of said actuating arm in opposite directions, whereby contact pressure between each of said contact fingers and its cooperating stationary contact is maintained by deformation of the other contact finger while the lost motion associated with the engaged contact finger is being taken up.

6. A thermal responsive member comprising, a longitudinally slotted elongated spring plate mounted in cantilever fashion at its integral end to form a pair of adjacent and normally coplanar movable spring contact fingers, a thermal responsive movable actuating member having lost motion connections with the free ends of said contact fingers, said lost motion connections being relatively positioned to hold said fingers continuously in offset relation and permit movement of either finger from a position of minimum offset to a position of greater offset and a pair of fixed contacts disposed on opposite sides of said spring plate for engagement each by one of said spring fingers upon movement of said actuating member in opposite directions.

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REFERENCES CITED

The following references are of record in the file of this patent:

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35	Number	Name	Date
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