March 9, 1943. H. E. MALONE 2,313,083

SWITCHING MECHANISM

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Fig: 2

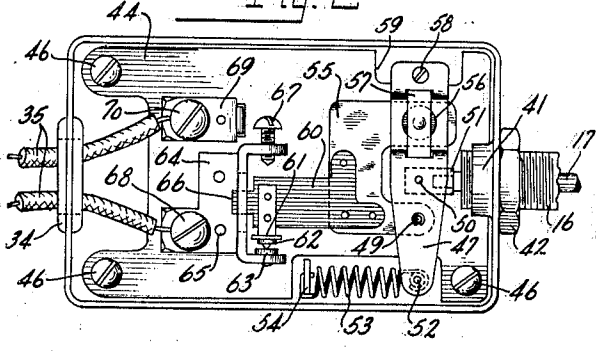


Fig: 5

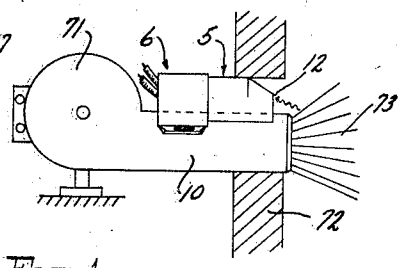
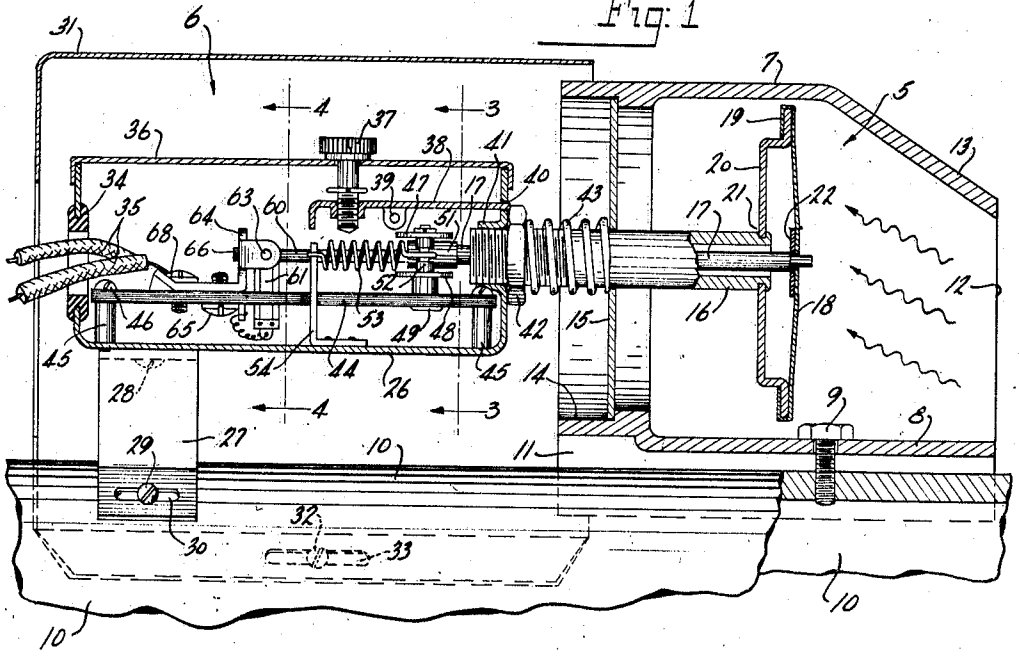


Fig: 1



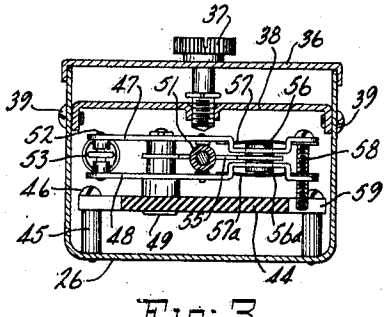


Fig: 3

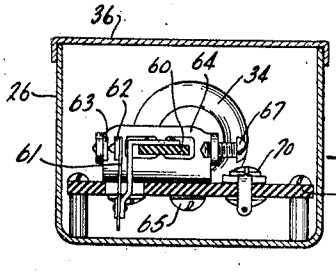


Fig: 4

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SWITCHING MECHANISM

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Fig: 6

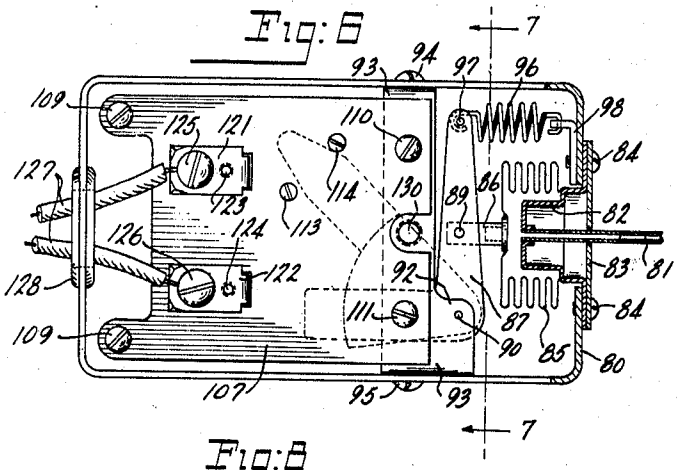


Fig: 7

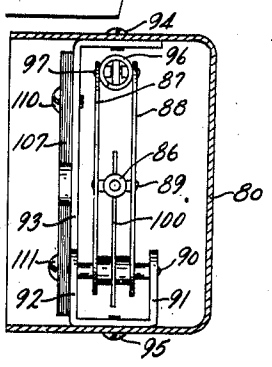


Fig: 8

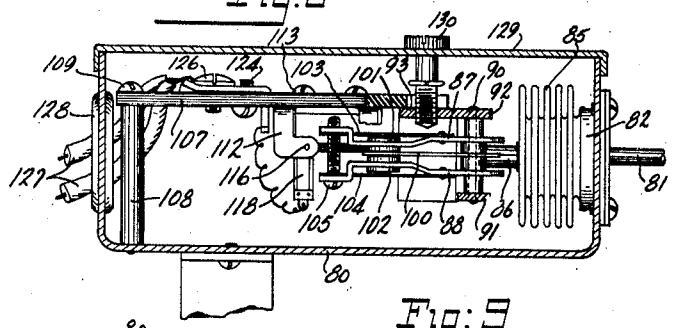


Fig: 9

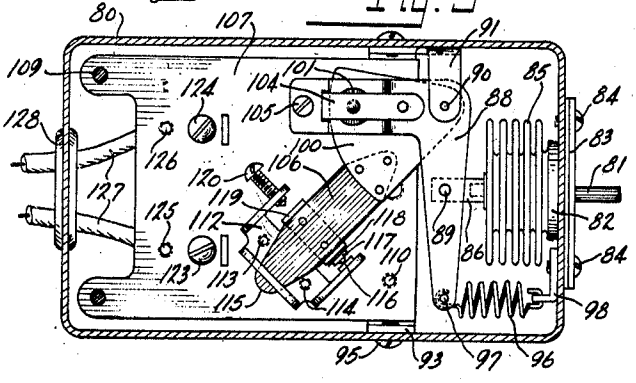
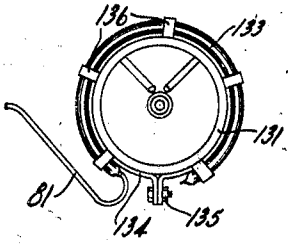


Fig: 11



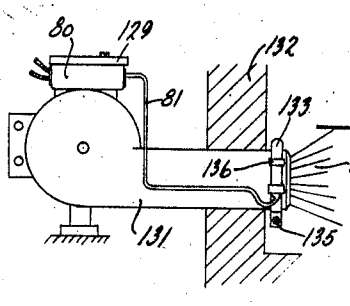


Fig: 10

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UNITED STATES PATENT OFFICE

2,313,083

SWITCHING MECHANISM

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Application October 30, 1940, Serial No. 363,431

14 Claims. (Cl. 200—137)

This invention relates generally to switching mechanisms, and more particularly to the type of device wherein the switching mechanism is actuated by a condition responsive means to control an electric circuit.

The invention has particular utility in connection with the automatic control of a burner for a heating plant for example, where it is desirable that some provision be made for quickly stopping the operation of the burner in the event of combustion or ignition failure, in order that hazardous conditions may be obviated.

It is an object of the invention to provide an improved connection between a thermally responsive member and a circuit controlling mechanism whereby upon motion of the thermally responsive member in response to changes or reversals in temperature affecting the same, the controlling mechanism is operated immediately, and upon continued motion of the thermally responsive member no further motion is imparted to the controlling mechanism.

An object of the invention is to provide an improved slip friction connecting means between a temperature responsive device and the switch elements which is simple and compact in construction, reliable in operation, which is adaptable for operation with various types of temperature responsive devices, and which will produce the desired sequence of operations.

A further object is to devise an improved slip friction switching mechanism which is adaptable for operation with temperature responsive element located at a point remote from the switching mechanism.

A still further object is to provide a slip friction mechanism in which the constituted elements thereof are arranged in a common plane for movement in a linear direction by the thermal device whereby stresses or bending of any of the elements is eliminated and correct operation is insured.

Another object is to provide an improved slip friction mechanism in which the associated elements are always maintained under a state of tension in order that no lost motion may impede the instantaneous reliable operation of the device.

It is a further object to devise an improved slip friction mechanism in which the operating mechanism and the contact elements are all arranged upon a single supporting member or plate so that the assembly, adjustment and accessibility of the elements are facilitated.

A further object is the provision of an improved flame detecting switching mechanism in which a plate-like element is arranged to buckle upon the presence of flame, this member being biased in this buckling direction by the switching mechanism.

Other objects and advantages of the improved slip friction switching device reside in certain novel features of construction, arrangement and combination of the various elements which will be hereinafter more fully described, particularly pointed out in the appended claims, and illustrated in the accompanying drawings in which:

Fig. 1 shows a cross-sectional side elevation of the switching mechanism and the associated thermally responsve device both mounted upon a burner apparatus;

Fig. 2 is a top view of the switching mechanism;

Fig. 3 is an end cross sectional view taken along the line 3—3 of Fig. 1;

Fig. 4 is a similar view taken along the line 4—4 of Fig. 1;

Fig. 5 is a fragmentary view of a gun type of burner installation on a furnace to which the invention is applied;

Fig. 6 is a top view of a modified form of the switching mechanism;

Fig. 7 is a cross sectional end view taken along the line 7—7 of Fig. 6;

Fig. 8 is a cross sectional side view of the modified form of the invention;

Fig. 9 is a bottom view of the mechanism;

Fig. 10 is a fragmentary view of a burner installation to which the modified form of the switching mechanism is applied; while,

Fig. 11 is an end view of the burner illustrating a form of thermal responsive device applicable to the modified switching mechanism.

The invention comprises generally the combination of a thermal responsive device indicated at 5 and a control device or switching mechanism associated therewith indicated at 6, both elements being arranged for example upon a burner installation as indicated in Fig. 5. The thermal responsive device 5 is arranged within an enclosing chamber or casing preferably in the form of a casting 7, having fairly thick walls including a flat bottom wall 8 through which a bolt 9 passes and is threaded into the side wall 10 of the blast tube of a burner for supporting the casting 7. A pair of downwardly projecting legs, one of which is shown at 11, straddle the tube 10 and serve to space the bottom wall 8 from direct thermal contact with the tube 10. The casing 7 has semi-circular side and top walls and is pro-

vided with an opening 12 in the front thereof. The upper portion of the wall extending toward the opening 12 is gradually sloped downward as indicated at 13. The opening 12 is arranged so as to face the combustion chamber of a furnace as shown in Fig. 5. The rear or opposite end of the casing 7 is arranged with a cylindrical wall 14 having a shoulder portion formed therein to provide a seat for a flat metal disc 15 which closes off the end of the casing 7 and lowers the transmission of heat through the casing 7 to the switching mechanism 6. This disc 15 also prevents the escape of the combustion gases through the thermal unit and prevents any drafts of air caused by the chimney drafts in the furnace from entering the thermal unit 5 and affecting the reliable operation of the unit.

The thermal responsive device 5 is supported within the casing 7 by means of a supporting tube 16 passing through an opening in the disc 15. An operating rod or shaft 17 passes axially through the tube 16 and projects outwardly from the front end thereof. The condition responsive or thermal operated device includes a relatively thin flat annular disc member or diaphragm 18 having a rearwardly projecting flange portion 19 formed thereon which engages the periphery of a second relatively flat annular disc member 20. The disc 20 is supported upon the end of tube 16 as shown at 21. The disc 18 is arranged at its front surface to receive and absorb radiant heat waves or energy emanating from the burner flame. These radiant heat waves pass through the opening 12 and impinge upon the front surface of the diaphragm 18. The diaphragm 18 is preferably constructed of a material having a relatively high thermal coefficient of expansion. It is bowed outward toward the opening 12 a slight amount as a result of a shoulder on the shaft 17 engaging the same and applying a slight amount of pressure to the diaphragm. The shaft 17 as will be hereinafter pointed out is normally spring urged in a direction toward the diaphragm 18. The second disc 20 arranged upon the peripheral rear edge 19 of the diaphragm 18 is preferably made of a material having a somewhat smaller coefficient of heat expansion than the material of which the diaphragm 18 is constructed. The disc 20 is thicker than the diaphragm and preferably spot welded at recurring intervals to the periphery 19 of the diaphragm. The diaphragm 18 upon being subjected to elevated temperatures such as caused by radiant heat waves bows or bulges outward while the annular disc 20 expands circumferentially at a somewhat slower rate than the diaphragm. The end of the shaft 17 loosely projects through a hole in the center of the diaphragm so as to guide and support the end of the shaft.

The control device of the invention which is actuated by the operation of the thermal responsive device 5 is shown in the form of a switch actuating mechanism 6. This switching mechanism is suitably enclosed in a rectangular shaped metal casing or housing 26 which is supported by means of an angular U-shaped bracket 27 and screw 28 upon the top of the blast tube 10 of the burner. The bracket 27 comprises a pair of legs, one of which is shown, which straddle the tube 10 and have their lower ends bent to conform to the cylindrical shape of the tube and are secured thereto by screws 29. This screw 29 passes through a slot 30 of each bracket leg 27 so that the bracket and the switching mechanism 6 may be adjustably positioned longitudinally within certain limits along the surface of the blast tube 10. By means of this adjustment the element supporting tube 16 and the thermal device 5 may be laterally positioned within the casing 7 at any desired location either closer or further away from the opening 12 of the casing 6, depending upon the intensity of the burner flame within the combustion chamber so that the correct response of the thermal element may be more accurately and reliably gauged. In the case of a very hot fire the thermal device 5 would be positioned further away from the opening 12, whereas in the type of burner in which a lower flame would exist the thermal device 5 would be adjusted closer to the opening 12.

A sheet metal enclosing cover 31 is provided for protecting the switching mechanism 6. It is adjustably attached to the blast tube 10 by means of a screw 32 on each side riding in a slot 33 so that the cover 31 may be shifted whenever the switching mechanism is adjusted. The casing 26 is provided at one end with an opening in which a conduit connection or a rubber grommet 34 may be inserted as shown. This serves for the purpose of providing an entry for the electrical connecting wires 35. A cover plate 36 for enclosing the casing 26 is provided which is held on the casing by means of a screw 37. The screw 37 threads into a protecting plate 38 arranged immediately above the switching mechanism and which is secured to the sides of the casing 26 by means of screws 39, one of which is shown. A projecting edge of the plate 38 extends through an opening 40 in the side of the casing to further support the plate 38. The plate 38 thereby serves to protect a portion of the mechanism and likewise serves as a securing means for the screw 37. One side wall of the casing 26 has a threaded projecting portion 41 formed integral therewith and into which the end of supporting tube 16 is threaded. A lock nut 42 threaded on the tube 16 and tightened against the side wall of the casing 26 rigidly secures and locks the thermal device 5 and the switching mechanism 6 in associated operative relationship. This threaded engagement provides a calibration or adjustment of the thermal device 5 within the casing 7 and of the switching mechanism to be pointed out. A compression spring 43 encircles the outside of the supporting tube 16 and exerts its force between the lock nut 42 and the rear of the shielding disc 15. The purpose of this spring 43 is to at all times hold and maintain the disc 15 in its set position upon the shoulder formed in the cylinder 14 of casing 7. The disc 15 will remain on its seat and close the end of casing 7 regardless of the position to which the switching mechanism 6 may be longitudinally shifted when an adjustment of the position of the thermal device 5 is made.

Arranged in spaced relation to the bottom wall of the switch casing 26 is a flat insulating plate 44, the general shape of which is shown in detail in Fig. 2. The plate 44 is supported by means of a number of bushings 45 riveted at one end to the bottom of casing 26 and screws 46 threading into the bushings.

The switching mechanism 6 is of the so-called "slip friction" type, that is, the contact structure is operated immediately upon initial movement of the mechanism and upon continued progressive movement a slipping action takes place between the elements while the contacts remain

closed. By this arrangement the contact mechanism is actuated immediately upon reversals of the switching mechanism caused by temperature changes. The slip friction mechanism comprises generally a lever means including a pair of identically shaped and oppositely disposed lever arms 47 and 48 which are pivoted together for movement about a pivot pin 49 which is supported on the insulating plate 44. A second pivot pin 50 connecting the lever arms 47 and 48 together passes through a movable element or link 51. The link member 51 is adapted to freely rotate a limited amount about the pin 50 between the two lever arms and is provided with an axial bore into which the operating shaft 17 loosely projects. The lever arms 47 and 48 are connected together at one end by a pin 52 to which one end of a tension spring 53 is connected. The other end of spring 53 is connected to a supporting bracket 54 suitably secured to the bottom of casing 26 as shown. The foregoing arrangement of elements is such that the spring 53 normally exerts a pull upon the lower end of levers 47 and 48 as viewed in Fig. 2 and tends to urge the lever arms about pivot pin 49 so that the link 51 transmits this spring force longitudinally to the operating shaft 17. The shaft 17 as a result urges its shoulder against the rear side of diaphragm 18 thereby bulging it slightly outward at its center. From this arrangement it is seen that the diaphragm 18 upon being subjected to heat and as a result bowing outward permits the lever arms 47 and 48 to swing their upper ends in a clockwise direction as viewed in Fig. 2 and upon a drop in temperature affecting the diaphragm 18 the diaphragm forces the shaft 17 in a left hand direction to rotate the lever arms 47 and 48 clockwise against the action of the spring 53. Since the spring 53 maintains the foregoing elements under a constant state of tension at the pivot points and link members, it is seen that the possibility of lost motion existing in the linkage is extremely remote. All moving parts therefor are actuated together simultaneously insuring the instantaneous reliable operation of the contact switching mechanism.

The slip friction mechanism proper includes a relatively thin steel blade 55 pivoted at one end to pin 49 and having a polished surface on both sides which is in intimate contact with separate graphite discs or blocks 56 and 56*a* arranged on each side of the blade 55 as seen in Fig. 3. Each graphite disc 56 and 56*a* is held in position on the blade 55 with tension by means of a thin spring blade 57 and 57*a* respectively which is supported at each end in oppositely disposed slotted openings in each lever 47 and 48. In order to adjust the degree of friction between the friction discs 56 and 56*a* and the blade 55, an adjusting screw 58 threads between the ends of the lever arms 47 and 48. By turning this screw the desired friction or compressive effort of the friction discs upon the blade 55 is obtained. The adjusting screw 58 is of sufficient length so as to serve as a stop for the lever arms by engaging the sides of a recess 59 formed in the insulating plate 44. The adjusting screw 58 also passes through one end of each spring blade 57 and 57*a* to hold it in position on the friction blocks 56 and 56*a*.

A switching arm 60 made of insulating material is secured to the friction plate 55 by means of rivets as shown. The switch arm 60 at its free end carries a bracket arranged to support a movable contact 62 supported upon a thin press-back spring blade 61, as shown. The movable contact 62 is arranged in cooperative relationship with a fixed contact 63 which in turn is carried upon an angular metal bracket 64 attached to the insulating plate 44 by screws 65. The bracket 64 has a slotted opening in its turned up portion as seen in Fig. 4 through which a reduced portion 66 of the switch arm 60 projects. This slotted opening serves as a guide and slidable support for the end of the switch arm 60. An adjusting and stop screw 67 threaded through a projecting end of the bracket 64 is adapted to engage one edge of the switch arm 60 when the arm is in contact opening position. The adjusting screw 67 enables the switch arm to be adjusted to operate with any desired degree of movement. The bracket 64 is also provided with a terminal screw 68 to which one of the wires 35 is attached to establish a circuit path for the fixed contact 63. A second bracket 69 is supported as shown to the insulating plate 44 and carries a terminal screw 70 for attachment of the other connecting wire 35. The bracket 69 has a pig tail connection passing underneath the insulating plate 44 and connecting with the spring blade 61 of the movable contact 62. The irregular shaped bracket because of its particular construction serves for a multiplicity of purposes; it functions as a terminal screw support, a guide for the switch arm 60, a support for the fixed contact, and a support for the adjusting screw 67.

Operation

The combination control, including the thermal responsive device 5 and the switching mechanism 6, is arranged as a unitary structure supported as has been pointed out, upon the sides of a cylindrical blast tube 10 of an oil burner installation 71 in the position indicated in Fig. 5. The unit is supported in such a manner that the opening 12 will be exposed and point into the combustion chamber of a furnace indicated generally at 72. The flame 73 produced by the operation of the burner 71 projects into the fire pot of the furnace in the general manner indicated and the opening 12 is so arranged that radiant heat emanating from the flame can pass through the opening 12 and impinge upon the front surface of the diaphragm 18. The diaphragm 18 is therefore so positioned in the assembly of the device as to be directly exposed to the temperature of the flame to which it is arranged to respond. Fig. 2 shows the switching mechanism including contacts 62 and 63 in their closed or "cold" position and if the fire is now started by the burner 71 in the well known manner, and combustion is produced in the furnace 72, the diaphragm 18 will rapidly become heated by radiant heat from the flame and tend to expand. Circumferential expansion of the diaphragm 18 is restricted because of its intimate association with the disc 20 which does not heat up as fast as the diaphragm and which also expands a lesser amount than the diaphragm even when heated to the same temperature as the diaphragm. As a result the center portion or apex of the diaphragm 18 bulges outwardly. This action takes place almost immediately in response to combustion conditions in the furnace because the diaphragm is constructed of relatively thin material and absorbs the heat instantly. The outward movement of the apex of the diaphragm 18 permits the shaft 17 to follow this movement due to the follow-up movement of the levers 47

and 48 caused by the tension of the coil spring 53. The spring 53 at all times maintains a relatively close intimate relationship between the levers 47 and 48, the rod 17 and the diaphragm 18 so that no lost motion can exist in the linkage. Upon the initial movement of the levers 47 and 48 about the pin 49 the friction blade 55 is caused to effect a movement also about pivot pin 49 by reason of the force exerted upon the blade by the friction discs 56 and 56a which carry the blade along when the levers are rotated. The switch arm 60 is thereby swung in a clockwise direction as viewed in Fig. 2 so that the normally closed contacts 62 and 63 are immediately opened. The action of opening the contacts 62 and 63 produces a change in the circuit operating conditions of the oil burner 71 in a manner well understood in the art for permitting the burner to continue to operate.

As the operating arm 60 rotates in a clockwise direction after opening the contacts 62 and 63 it encounters the adjustable stop screw 67. When this point is reached further rotation of the switch arm 60 and the friction blade 55 is halted and the contacts remain in their open position. The diaphragm 18 however may continue to buckle outward as a consequence of greater elevated temperatures to which it may be subjected as the flame in the combustion chamber acquires greater intensity. As a result the spring 53 continues to exert a pivoting movement of the lever arms 47 and 48 about pivot pin 49. The friction blocks 56 and 56a on each side of friction blade 55 can now frictionally slip across the surface of the blade 55 without causing further motion of the blade 55 and without straining any of the mechanism. Since the movement of all of the actuated elements is in a straight linear direction due to their arrangement in substantially a unitary plane, there can be no stresses set up in any of the elements which may cause them to bend or flex in any manner. The diaphragm 18 is practically instantaneously responsive to radiant heat while the disc 20 arranged on the rear of the diaphragm being of a greater mass responds somewhat at a slower rate and lags behind the response of the diaphragm.

When the burner 71 is shut down or in the event of combustion failure during a running period, the flame 73 in the combustion chamber ceases to exist. The drop in temperature is immediately manifested upon the diaphragm 18 which senses the reversal or change in temperature and because of its thinness begins to move immediately to a substantially flat position, as shown in Fig. 1. This movement of the diaphragm 18 is passed to the shaft 17 by means of the washer 22 engaging the rear of the diaphragm. The shaft 17 causes levers 47 and 48 to rotate against the tension of spring 53. The initial movement of levers 47 and 48 causes the friction blade 55 to move the switch arm 60 into contact closing position away from stop screw 67. Continued inward buckling of the diaphragm 18 causes the friction blocks 56 and 56a to slip on the blade 55 after contacts 62 and 63 establish contact so that the mechanism can continue to move without straining the same.

In the event that the thermal responsive device 5 should develop a defect, burn off or become affected by any abnormal conditions the device is arranged to move into a "fail safe" position. That is, upon the automatic operation of the burner the device would operate under control of the tension spring 53 to cause opening of contacts 62 and 63 which would enable the burner 71 to start, but upon the automatic stoppage of the burner and the consequent extinguishment of the flame in the burner, the diaphragm or associated mechanism which is disabled, would fail to restore the contacts to their closed position with the result that a lock-out condition would occur in the burner circuit in the well known manner and prevent the further operation of the burner. The device therefore is arranged to provide for this "fail safe" feature in a simple and reliable manner.

It is contemplated in the present structure that the device may be utilized in a circuit arrangement in which the contacts 62 and 63 may be normally opened instead of closed as shown. This may be accomplished by simply reversing the position of the contacts and adjusting stop screw 67. Under certain conditions an arrangement of this type is desirable and to produce a "fail safe" condition with this arrangement, similar conditions would prevail as pointed out.

It is further contemplated that the unitary structure comprising the thermal responsive device 5 and the slip friction mechanism 6 be mounted in other positions than the top of the blast tube as illustrated in Fig. 5. For example it may be mounted on the side of the blast tube 10 or any other position. Under these conditions and that in which it is shown in Fig. 5 the sloped portion 13 on the casing 7 is arranged to intercept the radiant heat which emanates from the edge of the flame within the burner. This portion of the flame does not produce a stable condition but wavers considerably and if it were permitted to transmit its heat rays to the diaphragm 18 erratic operation may result. Therefore the opening 12 of the casing 5 is so arranged as to point toward the most intense or most stable portion of the flame in the combustion chamber and permit only the rays from this portion of the flame to pass to the diaphragm 18.

In the modified form of the invention illustrated in Figs. 6 to 11 inclusive a casing or housing 80 similar to that shown in Fig. 1 is provided for housing the switching mechanism. In this form of the switching mechanism the elements comprising the same are constructed and arranged in a somewhat different manner from the elements of Fig. 1, but they function and operate in a somewhat similar manner. Extending outwardly from the casing 80 is a small tube 81, one end of which is connected as shown in Fig. 6 to the bottom of a cup-shaped member 82 arranged upon the wall of the casing 80. A plate member 83 encloses the end of the cup member 82. Both the cup member 82 and the plate 83 are fastened to the side wall of the casing 80 by a plurality of screws 84. Arranged within the casing 80 and having one end sealed against the outside wall of the cup member 82 is a condition responsive device shown in the form of an expansible and contractible bellows 85. The other end of the bellows is connected with a link member 86. The bellows 85 communicates with the tube 81 and may contain a volatile gas or liquid having the properties of expanding when subjected to elevated temperatures. The bellows 85 when expanded moves the link member 86 in a left hand direction as viewed in Fig. 6 and is adapted to rotate a pair of bell crank lever arms 87 and 88 which are connected by a pin 89 to the bellows link 86. The bell crank arms 87 and 88 are pivoted for rotation about a pin 90 which is supported between a pair

of projecting bracket members 91 and 92 formed in a supporting bracket member 93, the general shape of which is more clearly seen in Fig. 7. The supporting member 93 is supported in the casing 80 by screws 94 and 95 passing through opposite walls of the casing and into the supporting member 93.

A coil tension spring 96 arranged within the casing 80 has one end connected to the free ends of both the bell crank arms 87 and 88 by means of a pin 97. The other end of the tension spring 96 is connected to a bracket 98 held onto the casing 80 by screw 84. The spring 96 is arranged to exert its tension upon the free end of the bell crank arms and normally urge them about pivot 90 against the vapor tension of the bellows 85 so as to function as a restoring force for the bell crank arms when the bellows is contracted. The spring also functions to eliminate any lost motion at any of the pivot points.

A friction spring blade 100 in the form of a thin leaf spring having a polished surface is loosely pivoted upon the pin 90 and arranged between the bell crank arms 87 and 88. Arranged for sliding frictional contact with the friction blade 100 is a pair of friction elements or blocks 101 and 102 arranged on opposite sides of the friction blade. The friction blocks 101 and 102 are held in resilient intimate engagement with the friction blade 100 by means of leaf springs 103 and 104 engaging the friction blocks as shown in Fig. 8. One end of the leaf springs 103 and 104 is rigidly secured to the respective bell crank arms 87 and 88 while the opposite end extends through slotted openings in the free end of the bell crank arms. In order to adjust the correct amount of tension and therefore the frictional engagement of the friction blocks with the friction blade, an adjusting screw 105 is threaded through the ends of the bell crank arms 87 and 88 and passes through the free end of the leaf springs 103 and 104 to hold them in position. A switch arm 106 preferably made of insulating material is riveted as shown to the friction blade 100 and projects outwardly therefrom.

All of the foregoing elements are arranged within the casing 80 in a position below a flat insulating plate 107 which is supported in spaced relation from the bottom of the casing by means of a pair of studs 108 and screws 109 passing through the plate 107 and into the studs 108 at one side of the plate, while the opposite side is supported on top of the supporting member 93 by a pair of screws 110 and 111 as seen in Fig. 6. Supported on the bottom side of insulating plate 107 is a contact bracket 112 of irregular shape having a number of extensions formed thereon. This bracket 112 is supported by screws 113 and 114 from the plate 107. A projecting portion of the bracket 112 is provided with a slot through which an end 115 of switch arm 106 projects. This slot serves for the purpose of guiding and slidably supporting this switch arm at its end. Another projecting portion of bracket 112 carries a fixed contact point 116. Fixed contact 116 engages a movable contact 117 which is carried upon the free end of a press back spring 118 in turn supported from a bracket 119 arranged on switch arm 106 as shown. The opposite end of bracket 119 is adapted to engage an adjustable stop screw 120 carried from a projecting portion of bracket 112. The screw 120 serves as a stop for the switch arm 106 when it moves from one position to another to open the contacts 116 and 117.

Arranged upon the top side of insulating plate 107 is a pair of terminal plates 121 and 122 which are supported on the plate 107 by means of screws 123 and 124 respectively. Wire attaching screws 125 and 126 carried by terminal plates 121 and 122 serve for the attachment of the connecting wires 127 which pass into the casing 80 through a rubber grommet 128. An enclosing cover 129 for the mechanism within the casing 80 is held on the casing by means of removable screw 130 threading into the supporting member 93.

The means for operating the switching mechanism in this modified form of the invention differs from the thermal element 5 of Fig. 1 in that no positive mechanical connection between the combustion responsive device and the switching mechanism exists. The usual gun-type of burner 131 illustrated diagrammatically in Fig. 10 is shown arranged with its blast tube projecting through the body of the furnace 132 and the switching mechanism casing 80 is preferably mounted in close proximity to the burner 131. The condition responsive element is here shown in the form of a ring shaped bulb 133 sealed at one end and connected at the other end with the tube 81. The bulb 133 may be filled with a temperature responsive gas or fluid. The bulb 133 is positioned and encircles the end of the blast tube 131 of the burner in a position within the furnace 132. It is held on the blast tube by means of a metal strap 134, the ends of which are clamped together by a bolt 135. A number of clips 136 formed in the strap 134 support the bulb 133 in position within the furnace 132 so as to be subjected to the flame 137 when the burner is operating.

Operation

In the operation of this modified form of the invention the contacts 116 and 117 are normally in their closed position and upon establishment of combustion conditions by the burner 131 within the furnace 132 the heat from the flame 137 causes the vapor within the bulb 133 to expand. The expansion of the vapor manifests itself through the tube 81 within the bellows 85 causing an expansion of the same. With this arrangement the connecting tube 81 may be of an indefinite length and therefore the casing 80 containing the switching mechanism may be positioned at any desired remote point from the thermal element 133 or at a location where the heat of the furnace would not have any effect upon the switching mechanism. The expansion of the bellows 85 causes the link member 86 to move in a left hand direction as viewed in Fig. 6, causing the bell crank arms 87 and 88 to rotate counterclockwise against the tension of spring 96 and about the pivot pin 90. Upon the initial rotation of the bell crank arms the slip friction blocks 101 and 102 exert sufficient frictional tension upon the friction blade 100 to carry it along, thereby effecting a movement of the switch arm 106 and immediately opening the contacts 116 and 117. As the bellows 85 expands further the switch arm 106 eventually engages its bracket 119 with the adjustable stop screw 120. When this point is reached further motion of the switch arm 106 is halted. The friction blocks 101 and 102 are thereby caused to slip along the friction blade 100. The bellows thereby can continue to expand without building up stresses in any of the elements. The amount of frictional effort of the friction blocks upon the friction blade is

readily adjusted by means of the screw 105. It will be observed that the motion of the bell crank arms 87 and 88, the friction blade 100, and the switch arm 103 takes place in a linear direction and all elements are operated in the same common flat plane. This prevents any strain upon the mechanism and eliminates lost motion caused by pulling or bending of the elements. In addition, all of the elements are supported in a protected position below the insulating plate 107.

Upon the cessation of combustion conditions within the furnace the thermal element 133 cools off resulting in the contraction of the bellows 85. The coil spring 96 immediately takes over the function of restoring the elements to their "cold" position. Upon the initial movement of the crank arms the friction blocks carry along the friction blade 100 and move the switch arm 106 out of engagement with the stop screw 120. Upon the closure of contacts 116 and 117 the motion of switch arm 106 and friction blade 100 is halted and the friction blocks slip on the blade 100 as the bellows 85 continues to collapse.

From the foregoing it is perceived that the improved slip friction mechanism in combination with the associated thermal responsive means is of simple construction, reliable in operation and is arranged to safeguard the operation of a burner in a reliable manner. By combining the switching mechanism 6 with a thermal element into a single unitary structure as illustrated in Figs. 1 to 5, or remotely associating the switching mechanism 6 with the thermal element as illustrated in the modified form of the invention, a reduction in the wiring and installation cost is effected as well as a simplification of the testing, assembling, and matching of the units.

While a preferred form of the invention is illustrated as well as a modified form, it is contemplated that various modifications of the same may be made without departing from the general spirit of the invention, and it is therefore to be understood that the invention is not limited to the precise construction illustrated and described but only by the scope of the appended claims.

What is claimed is:

1. In a switching mechanism, in combination, a condition responsive element, a supporting base, a lever arm on said base actuated to one position by said condition responsive element, spring means on said base for restoring said lever arm after having been actuated, a friction blade pivoted to said base independently of said lever arm and having a limited movement on said base, slip friction means connecting said friction blade and said lever arm, and control means on the base operated by the movement of said friction blade.

2. In a switching mechanism, in combination, a condition responsive element, a supporting base, a lever arm and a friction blade independenly pivoted upon said base, slip friction means connecting said friction blade and said lever arm, means connecting said condition responsive element with said lever arm for causing said friction blade to be operated to one position through said slip friction means when the condition responsive element moves in one direction, means on said base connected to said lever arm for causing said friction blade to be operated to another position through said slip friction means when the condition responsive element moves in another direction, and control means operated differently by said friction blade in each of its positions.

3. In a flame detecting control mechanism, the combination of, a plate-like member adapted to receive radiant heat from the flame, confining means associated with opposite edges of said member for causing said member to buckle when heated, a lever, direct connecting means between said lever and member, a spring for biasing said lever and member in one direction, said spring determining the direction in which the member buckles when heated and taking up lost motion between the parts, a friction blade, slip friction means connecting said friction blade with said lever, and control mechanism actuated by said friction blade.

4. In a control mechanism, in combination, a condition responsive element, a lever arm connected thereto, a pivot about which said lever arm is rotated by said condition responsive element, a friction blade independently rotatable about said pivot, a control arm carried by said friction blade, stops for said control arm, slip friction means arranged between said friction blade and said lever arm whereby said control arm is operated by the movement of said lever arm until the stops are encountered, said lever arm, said friction blade and said control arm all arranged in a common plane for pivotal movement about said pivot.

5. In a control mechanism, in combination, a condition responsive element, a lever arm connected thereto and operable thereby, a friction blade, a control arm carried by said friction blade, slip friction means arranged between said friction blade and said lever arm, and a common pivot point for said lever arm and said friction blade about which said slip friction is operated and said control arm is actuated, said lever arm said friction blade and said control arm all arranged in a common operating plane, and control means operated by said control arm.

6. In a control mechanism, in combination, a condition responsive means, a lever arm operable thereby, pivot means arranged between the ends of said lever arm and about which said lever arm is rotated, biasing means on one end of said lever arm for restoring the lever arm after having been operated by said condition responsive means, a slip friction means arranged at the other end of said lever arm, a friction blade cooperating with said slip friction means and independently rotatable about said pivot means, a control arm connected to said friction blade and operated thereby, and control means actuated by the operation of said control arm, said lever arm said friction blade and said control arm all arranged in a common operating plane rotatable about said pivot means.

7. In a slip friction control mechanism, a lever arm, means for pivoting said lever arm for rotation, a friction blade pivoted to said pivoting means for independent rotation thereabout, slip friction means arranged on said lever arm, resilient means on said lever arm for resiliently engaging said slip friction means with said friction blade, means on said lever arm for adjusting the degree of frictional engagement of the slip friction means with the friction blade, stops for limiting the rotation of said friction blade, and control means actuated by said friction blade.

8. In a slip friction control mechanism, a lever means comprising a pair of oppositely disposed lever arms, pivot means arranged between the ends of said arms and about which said lever arms are rotated, a friction blade pivoted to said

pivot means and having a portion arranged between said lever arms, slip friction means arranged upon each of said lever arms and engaging said friction blade, means on each arm engaging said slip friction means for resiliently holding said slip friction means against the friction blade, adjusting means between said lever arms for adjusting the degree of friction with which said slip friction means engages said friction blade, and a control device actuated by said friction blade.

9. In a slip friction control mechanism comprising, in combination, a condition responsive element, a linearly movable shaft actuated thereby, a base, a lever arm pivoted to said base and rotated by said movable shaft, a friction blade pivoted to said base, said lever arm comprising two portions thereof between which said friction blade is arranged, friction means on said lever arm engaging opposite sides of said friction blade, means on said lever arm for resiliently holding said friction means in engagement with said friction blade, stops on the base for limiting the rotation of said friction blade, said lever arm arranged to slip said friction means across the surface of said friction blade after the friction blade encounters one of said stops, and a control arm connected to said friction blade and operated by the movement thereof, said lever arm, said friction blade, said control arm, said movable shaft and said slip friction means all arranged to operate in a single common plane upon said base.

10. In a control mechanism, in combination, a condition responsive element, a rotatable lever arm, a pivot pin on said lever arm to which said condition responsive element is connected, a supporting base, a pivot pin for said lever arm mounted on said supporting base and about which said lever arm is rotated by said condition responsive element, a friction blade pivoted to said last mentioned pivot pin, slip friction means arranged upon one end of said lever arm and engaging said friction blade for operating the same, a spring connected to the opposite end of said lever arm for rotating said lever arm back to its initial position after having been operated by said condition responsive element, and control means actuated by the movement of said friction blade.

11. In a control mechanism, in combination, a condition responsive element, a rotatable lever arm, a pivot pin arranged between the ends of said lever arm and to which said condition responsive element is connected, a second pivot pin arranged between the ends of said lever arm for supporting said lever arm upon the base for movement by said condition responsive element, a spring connected to said lever arm at a point remote from said second pivot pin, slip friction means carried by said lever arm at a point remote from said second pivot pin, a friction blade having one portion engaged by said slip friction means and another portion connected to said second pivot pin for rotation thereabout, and a control arm supported by said friction blade and operable thereby.

12. In a switching mechanism, a supporting plate, a switch arm pivoted for movement on said supporting plate, an angular shaped bracket supported upon said plate and having a plurality of projections formed thereon, means on a first one of said projections for supporting and guiding the free end of said switch arm, means on a second one of said projections for adjustably limiting the movement of said switch arm, contact means on a third one of said projections actuated by said switch arm, and wire terminal connecting means for said contact on a fourth one of said projections.

13. In a control mechanism, in combination, a lever, a fixed pivot for said lever, condition responsive means for rocking the lever about said pivot upon change in the condition to which the condition responsive means responds, a friction blade independently pivoted upon said pivot adjacent said lever, control means operated by said friction blade between predetermined limits of movement, and slip friction means carried by said lever and engaging said friction blade, said slip friction means tending to cause rocking of the friction blade about said pivot upon rocking of the lever about said pivot.

14. In a flame detecting switching mechanism, the combination of, a plate-like member adapted to receive radiant heat from the flame, confining means associated with opposite edges of said member for causing the member to buckle when heated, a movable member, connecting means between said movable member and said plate-like member for transmitting all buckling or unbuckling movement of said plate-like member to said movable member whereby the movable member assumes various positions corresponding to various positions of said plate-like member, said connecting means including a spring for positively biasing said movable member and plate-like member in one direction to determine the direction in which the plate-like member buckles when heated and for taking up lost motion between the parts, a second movable member, control mechanism operated by said second movable member, and slip friction means interposed between said first and second movable members, said slip friction means being separate from and independent of said spring whereby the tension of said spring does not affect the action of said slip friction means.

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