Aug. 14, 1934. H. F. DEVER 1,969,968

BURNER CONTROL APPARATUS

Original Filed Aug. 5, 1929 2 Sheets-Sheet 1

FIG. 1

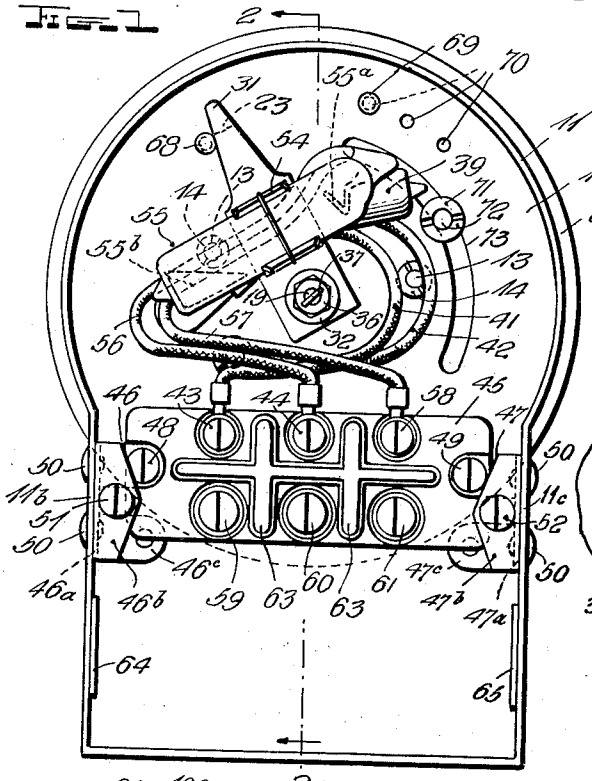
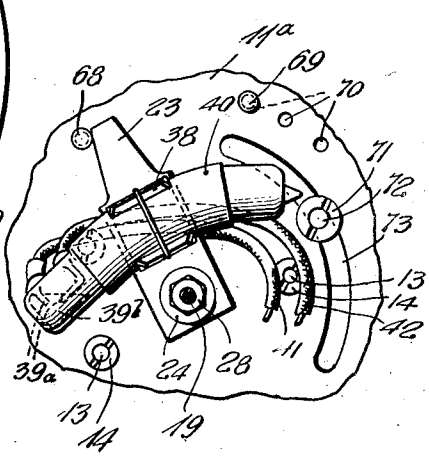


FIG. 3



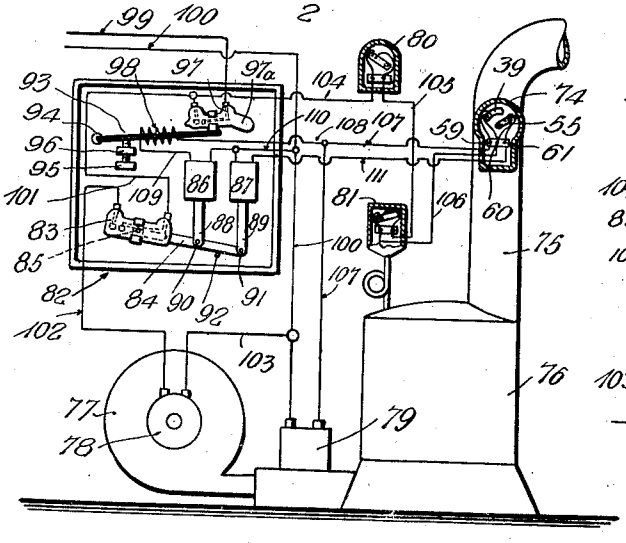
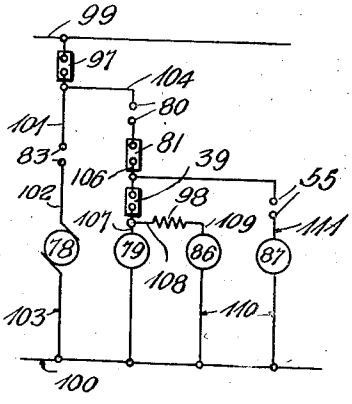


FIG. 4

FIG. 5



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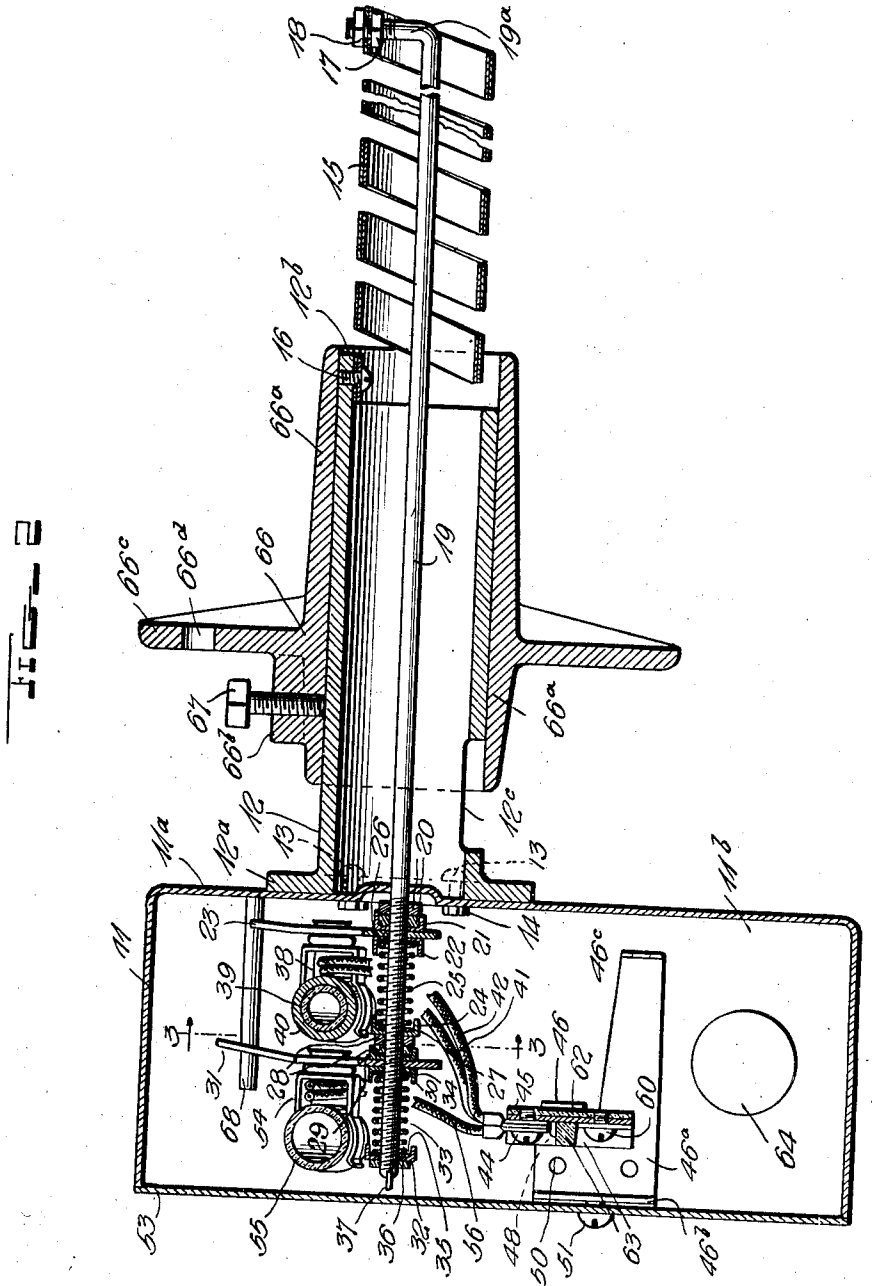
BURNER CONTROL APPARATUS

Original Filed Aug. 5, 1929 2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

1,969,968

BURNER CONTROL APPARATUS

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Original application August 5, 1929, Serial No. 383,728. Divided and this application August 22, 1931, Serial No. 558,652

11 Claims. (Cl. 200—138)

This application is a division of my co-pending application Serial No. 383,728, filed August 5, 1929, for Burner control apparatus and systems.

This invention relates to burner control apparatus and has particular relation to electrical apparatus for controlling the operation of oil burners and the like.

The primary object of the invention is to provide new and improved apparatus for controlling the operation of oil burner systems or the like in accordance with conditions of combustion in such systems.

A specific object of the invention is to provide apparatus for controlling the ignition and fuel supply means of an oil burning system or the like in accordance with conditions of combustion in such system.

A further object of the invention is to provide apparatus which may be utilized to control systems of the above indicated character in such manner that, upon a failure of combustion, the fuel supplying apparatus of the system will be rendered inoperable for a predetermined interval of time, whereafter an attempt to re-establish combustion will be made by re-energizing the fuel supplying and ignition apparatus, this attempt being made without sacrificing the desired features of safety whereby continued operation of the fuel supplying means is prevented if combustion fails to be established.

Other objects and advantages of the invention will appear from a consideration of the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a front elevational view of a control device designed and constructed in accordance with the invention, the cover of the casing for such device being removed;

Fig. 2 is a vertical sectional view taken on the line 2—2 of Figure 1, with the cover of the casing in place;

Fig. 3 is a fragmentary view, partly in front elevation and partly in vertical section, taken on the line 3—3 of Fig. 2;

Fig. 4 is a diagrammatic representation of an oil burner system or the like, illustrating one way of connecting a control device embodying the present invention in circuit relation to certain other devices comprising other essential or desirable controlling elements of such a system;

Fig. 5 is a simplified schematic representation of the electrical circuits and devices shown in Fig. 4.

Referring to the drawings, the control device shown in Figs. 1, 2 and 3 comprises a suitable housing or casing 11 within which the operative parts of the device are disposed, as will presently appear. A sleeve member 12 projects rearwardly from the rear wall of the casing 11, to which said sleeve is secured by means of screws 13 extending through suitable apertures or slots in an annular flange portion 12a of said sleeve, and also through corresponding openings in the rear wall of the casing 11. Nuts 14 cooperate with the screws 13 to secure the sleeve member 12 in the position shown. The rear extremity of the sleeve member 12 has a protruding portion 12b to which the forward extremity of a coiled bi-metallic or other thermostatic element 15 is secured by means of a screw 16. The rear extremity of the thermostatic element 15 is secured between nuts 17 and 18 on the screw-threaded extremity of an angularly bent portion 19a of a rod or spindle 19 extending axially of the thermostatic element 15 and the sleeve 12 and through a suitable opening in the rear wall of the casing 11.

The forward extremity of the rod or spindle 19, which projects into the interior of the casing 11, is screw threaded for substantially the entire length of said portion and a pair of nuts 20 are placed in mutually locking relation on this screw threaded portion near the rear wall of the casing 11. A cup-shaped metallic friction washer 21 is placed on the forward extremity of the rod 19 with the lip portions thereof overlying the nuts 20 as shown. A similar cup-shaped washer 22 is placed in opposing relation to the washer 21 and between these two washers a switch-carrying arm 23 is disposed, this arm being apertured to permit the rod 19 to extend therethrough in freely rotatable relation. A third cup-shaped washer 24 is placed on the forward extremity of the arm 19 in opposed relation to the washer 22 and between the two washers 22 and 24 a coiled compression spring 25 is disposed around the rod 19. Flat friction washers 26 and 27 are disposed between the inner surfaces of the cupped washers 22 and 24 respectively and the corresponding extremities of the spring 25. The parts 21, 22, 23, 24, 25, 26 and 27 are held longitudinally of the rod 19 in the positions shown, by the locked nuts 20 and a similar pair of locked nuts 28 that are located on the screw-threaded foremost portion of the rod 19 immediately in front of the cupped washer 24.

Another cupped washer 29 is positioned on the rod 19 in front of the locked nuts 28 and with its lip portions overlying said nuts. Another such cupped washer 30 is placed on the rod 19 in opposed relation to the washer 29 and be-

tween these two washers 29 and 30 a second switch-carrying arm 31 is placed on the rod 19 in a manner similar to that in which the switch-carrying arm 23 is so disposed, that is, with the rod 19 extending through a suitable aperture in said switch arm in freely rotatable relation thereto. Still another cupped washer 32 is placed on the rod 19 with the lip portions thereof facing rearwardly in opposed relation to the washer 30 and between the two washers 30 and 32 a second coiled compression spring 33 is disposed around the rod 19. Between the inner faces of the cupped washers 30 and 32 respectively, and the corresponding extremities of the spring 33, flat friction washers 34 and 35 are disposed. The parts 29, 30, 31, 32, 33, 34 and 35 are held in position longitudinally of the rod 19 between the locked nuts 28 and a nut 36 that is screwed onto the forward extremity of the rod 19 in front of the cupped washer 32. The foremost extremity of the rod 19 is flattened or mutilated as indicated at 37 to prevent the nut 36 from coming off by reason of vibration or other causes.

With the above described construction it will be seen that the switch-carrying arm 23 is pressed between the flat outer surfaces of the cupped washers 21 and 22 by means of the spring 25 and that the switch-carrying arm 31 is similarly pressed between the washers 29 and 30 by means of the spring 33. This method of holding the arms 23 and 31 provides a frictional slip connection between the rod 19 and each of said arms whereby said arms will be rotated in accordance with the rotation of the rod or spindle 19 as long as such movement of the arms is unrestrained. When such movement is restrained, however, the rod 19 is permitted to rotate freely without imparting any further movement to the switch-carrying arms. The structural details of the frictional slip connections, as herein described, do not constitute a part of the present invention but are described herein because these frictional connections are utilized in combination with certain other elements as will hereinafter appear.

The rearward switch-carrying arm 23 has secured thereto a clip 38 which embraces the tubular container of a mercury electric contactor 39 whereby said contactor may be tilted in accordance with the rotative movement of the arm 23. The container of this contactor 39 is of curved or humped formation, as shown in Fig. 3, for a purpose which will appear hereinafter. By reason of the curved formation of the container of the contactor 39, it is preferable to provide a section of soft rubber tubing 40 or the like around said container and between the latter and the clip 38. The contactor 39 comprises a pair of electrodes 39*a* that are disposed in the left-hand extremity of the container for said contactor as the latter is viewed from the front, as shown. A body of mercury 39*b* is also disposed within the container of this contactor and is adapted to be moved between the extremities of said container to make and break the electrical circuit between the electrodes 39*a* in accordance with the angle of inclination of the container.

Two insulated flexible conductors 41 and 42 are individually connected to the two electrodes 39*a* of the contactor 39 and extend therefrom to terminal posts 43 and 44, respectively, located on a terminal board 45 which is made of insulating material and which is secured within the casing 11 by means of bracket members 46 and 47 and cooperating screws 48 and 49, respectively. The bracket members 46 and 47 respectively project inwardly from flat securing portions 46*a* and 47*a* which are secured to the inner surfaces of side walls 11*b* and 11*c* of the casing 11 by rivets 50 or other suitable means. The forward extremities of the portions 46*a* and 47*a* of the bracket members 46 and 47 are bent inwardly to form ear portions 46*b* and 47*b* having screw-threaded openings therein for the reception of screws 51 and 52 which are adapted to pass through corresponding openings in a cover member 53 for the casing 11 which is shown in its normal position with respect to said casing in Fig. 2. The bracket members 46 and 47 also preferably comprise portions extending rearwardly and bent inwardly at their rearmost extremities to form another pair of bracket portions 46*c* and 47*c* which may be utilized, if desired, to secure the terminal board 45 in a different position within the casing 11.

The forward switch-carrying arm 31 has secured thereto a clip 54 embracing the container of a mercury electric contactor 55 which has a pair of electrodes 55*a* disposed in the right-hand extremity thereof for cooperation with a body of mercury 55*b* which is also disposed within the container of said contactor. Two insulated flexible conductors 56 and 57 are individually connected to the two electrodes 55*a* of the contactor 55 and respectively extend therefrom to the terminal post 44 on the terminal board 45 and to another terminal post 58 on said terminal board. It will be seen, therefore, that one electrode of the contactor 39 and one electrode of the contactor 55 are electrically connected together, since the conductors 42 and 56 are connected to the common terminal post 44.

The terminal posts 43, 44 and 58 are provided for receiving the connecting leads of the two contactors 39 and 55 and the external connections to said contactors are adapted to be made through terminal posts 59, 60 and 61 which are respectively connected to terminal posts 43, 44 and 58. The internal connections between the two sets of terminal posts are made by conducting straps 62 which are preferably constituted by metallic inserts molded into the insulating material of the terminal board 45 as shown in Fig. 2. The front face of the terminal board 45 is preferably provided with integral forwardly projecting portions 63 which serve as partitions between the several terminal posts to prevent accidental short circuiting therebetween. The external connections for the contactors 39 and 55 may be made by means of conductors entering the casing 11 through suitable apertures which may be readily made by removing either or both of two knockout portions 64 and 65 which are respectively provided in the side walls 11*b* and 11*c* of the casing in the space below the terminal board 45.

The thermostatic element 15 is adapted to be disposed within the stack or flue for conducting the gaseous products of combustion away from the combustion chamber of the heating system to be controlled, and for this purpose a securing member 66 is provided, which comprises a sleeve portion 66*a* surrounding the sleeve member 12 and having a bore of such diameter as to be freely slidable over said sleeve member 12. A boss portion 66*b* is provided on said sleeve portion 66*a* near the forward extremity thereof, and a screw-threaded opening in the boss portion 66*b* is adapted to receive a set-screw 67 which may be tightened to cause its extremity to engage the outside of the sleeve 12 whereby the members 12 and 66 may be secured in fixed relative positions. An integral annular flange portion 66*c* of the member 66 surrounds the sleeve portion

66a at an intermediate point thereof and is suitably apertured as indicated at 66d to receive bolts or screws for securing the member 66 to the wall of the stack or flue. Since such stacks or flues are ordinarily made of metal of cylindrical formation, the flange portion 66a is preferably curved as indicated in Fig. 2 to conform to the external surfaces of such stacks or flues.

The entire device as above described is mounted on the outside of the stack in a manner which will be readily apparent, namely, by cutting a suitable hole in a wall of the stack through which the thermostatic member 15 and the part of the sleeve portion 66a behind the flange portion 66c may extend. The device is then placed in this position and suitable securing means are passed through the apertures 66d and corresponding holes which will have been provided in the wall of the stack around the main opening for receiving the parts 15 and 66a. When the device is so mounted the entire assembly, with the exception of the member 66 and set-screw 67, may be rotated within the sleeve portion 66a until the casing 11 is properly leveled, and may also be moved axially of the sleeve 66a to secure the proper position of the thermostatic member 15 within the stack, whereafter the set-screw 67 may be tightened to hold the device securely in the position desired.

The sleeve member 12 is preferably apertured as indicated at 12c to permit a certain amount of cold air to be drawn through the inside of said sleeve member for the purpose of ventilating or cooling the thermostatic member 15. The amount of air drawn in through the aperture 12c by reason of the draft inside the stack may be regulated by sliding the sleeve member 12 inwardly or outwardly within the sleeve portion 66a of the securing member 66 until the desired cooling effect of the thermostatic member 15 is obtained, since the forward extremity of the sleeve portion 66a is thus caused to overlap a greater or less portion of the aperture 12c.

This regulation or adjustment is so made that the thermostatic member 15 responds in the desired manner to the conditions of combustion within the combustion chamber of the heating system, which response is effected by reason of the expansion and contraction of the member 15 in accordance with the temperature of the gaseous products of combustion that are being conducted away from said combustion chamber through the stack or flue within which said member 15 is disposed. The construction of the sleeve member 12 with the aperture 12c therein, whereby the above described regulation or adjustment may be effected, does not constitute a part of the present invention and therefore this feature is not claimed herein.

It will be seen that as the thermostatic member 15 expands and contracts in response to changes of temperature within the stack or flue, the rearmost extremity thereof will be rotated and this rotation will be transmitted directly to the rod 19. The corresponding rotative movements of this rod are imparted to the contactors 39 and 55 through the heretofore described frictional slip connections between the rod 19 and the carrying members 23 and 31, respectively, for said contactors.

When the thermostatic member 15 is relatively cool, as, for example, after a substantial period of inactivity of the heating system, or, in other words, after the termination of a period of combustion, this thermostatic member is in a condition which results in the contactors 39 and 55 occupying the positions shown in the drawings. This means that the rearward extremities of the member 15 and the rod 19 have been turned to their extreme positions in a counter-clockwise direction, as viewed in Figs. 1 and 3, and that the carrying members 23 and 31 for the contactors 39 and 55 have been likewise turned in the same direction. The extreme positions of the members 23 and 31 in this direction are limited by engagement of both of said arms with a stop member or pin 68 that is suitably secured in the rear wall 11a of the casing 11 and projects forwardly from said wall within the casing a sufficient distance to arrest the movements of said arms. Under the conditions illustrated it will be seen that the bodies of mercury within the contactors 39 and 55 will have flowed to the left-hand extremities of the containers of these contactors, since each of these containers is then tilted downwardly to the left, as shown. The electrodes 39a of the contactor 39 are therefore in electrically connected relation to complete the circuit between the conductors 41 and 42, which are respectively connected through the terminal posts 43 and 44 to the terminal posts 59 and 60, as heretofore described. The electrodes 55a of the contactor 55, however, are disconnected from each other and the circuit between the conductors 56 and 57 is therefore interrupted at this point.

When the temperature of the thermostatic member 15 is increased, as in response to the establishment of combustion in the heating system, the resultant movement of this member causes the rod or spindle 19 to be rotated in a clockwise direction, as viewed in Figs. 1 and 3, with the result that the contactors 39 and 55 are similarly moved toward the positions in which the containers of said contactors are tilted in the reverse direction of that shown. In a relatively short time after such movement of the members 15 and 19 and the contactors 39 and 55, the latter contactor attains a position in which its inclination is reversed so that the body of mercury therein flows to the opposite end of the container and completes the electrical circuit between the electrodes 55a. The result accomplished by the making of this circuit will appear hereinafter in the description of the system shown in Figs. 4 and 5.

Shortly after the contactor 55 has been actuated to the position in which its circuit is closed, the upper extremity of the switch-carrying arm 31 for said contactor engages a stop member or pin 69, which projects forwardly within the casing 11 from the rear wall 11a thereof in a manner similar to that described with respect to the stop pin 68. It may be noted, however, that since the pin 68 is adapted to occupy one position only it may be permanently secured in its desired position, as by extending a reduced diameter portion thereof at its rearmost extremity in closely fitting relation through a suitable hole in the rear wall of the casing and thereafter riveting or heading over the rear end of this portion which projects through the rear wall of the casing. It is desired, however, that the other extreme position of the contactor 55 may be adjustably limited and for this reason the stop pin 69 is removably held in place, as by means of a screw or screw-threaded portion which is adapted to extend through any one of several holes 70 in the rear wall 11a of the casing 11. After the upper extremity of the carrying arm 31 engages the stop pin 69 in any one of its several possible

positions, further movement of said arm and of the contactor 55 carried thereby is precluded, but continued rotation of the rod 19 in a clockwise direction in response to further heating of the thermostatic member 15 is readily permitted by reason of the frictional slip connection between the rod 19 and the arm 31.

During the above-described movement of the contactor 55 in accordance with the rotation of the rod 19, the other contactor 39 partakes of similar movement, but owing to the curved formation of the container for this latter contactor the body of mercury therein does not move to the right-hand extremity of said container as soon as such movement takes place within the contactor 55. It is necessary, therefore, that the contactor 39 be permitted to move a substantial distance beyond the position which it occupies when the body of mercury within the contactor 55 flows to the right-hand extremity of the container for said contactor. Also, the extreme right-hand or clockwise position of the contactor 39 is ordinarily considerably beyond that of the contactor 55, but whether or not this is the case, it is desired that this extreme position of the contactor 39 be adjustable independently of the extreme position of the contactor 55. Accordingly, a separate stop member 71 is provided for limiting the extreme clockwise position of the contactor 39. This member 71 is in the form of a nut engaging the screw-threaded shank of a screw 72, which shank is extended through an arcuate slot 73 in the rear wall 11*a* of the casing 11, with the head of said screw 72 engaging the rear surfaces of said wall along the sides of said slot. The stop nut 71 extends forwardly a sufficient distance to be engaged by the upper extremity of the arm 23 which carries the contactor 39 and therefore the extreme clockwise position of this arm and contactor is limited to a position in which said arm engages said stop nut. It will be apparent that this position may be adjusted as desired by loosening the nut 71 on the screw 72 and moving these two elements to the desired position along the slot 73, where the nut 71 may again be tightened.

When movement of both of the arms 31 and 23 has been arrested by engagement between these arms and the stop members 69 and 71, respectively, the rod 19 is still permitted to be rotated freely in a clockwise direction, as viewed in Figs. 1 and 3, because the arm 23, as well as the arm 31, is provided with a frictional slip connection with the rod or spindle 19. Such movement of the rod 19 will continue as long as the temperature of the thermostatic member 15 continues to rise. When this rise in temperature stops, the rotation of the rod 19 is likewise stopped and as soon as this temperature starts to fall in response to termination or failure of combustion, the rod 19 begins to turn in the reverse direction. By reason of the two frictional slip connections heretofore described, the reverse movement of both of the contactors 39 and 55 also begins immediately. This immediate reversed movement of the contactors 39 and 55 upon a drop in the temperature of the member 15 is a very important result following from the use of the two frictional slip connections. It is during this reverse movement that the curved formation of the container of the contactor 39 performs its essential function, which is to delay the reclosing of the circuit between the electrodes 39*a* of said contactor. The extent of this delay is determined by the position of the stop member 71 which, as previously stated, determines the extreme clockwise position of the arm 23 and the contactor 39 that is carried thereby. In any event, the interval of this delay is of substantial duration after the time when the circuit between the electrodes 55*a* of the contactor 55 is broken by reason of the reversal in the inclination of the latter contactor, which occurs in a relatively short interval of time after the reverse movement thereof is initiated. It will appear hereinafter that the opening of the circuit through the contactor 55 causes the operation of the fuel supplying apparatus of the heating system to be stopped. The substantial interval of time between the stopping of this operation and the reclosing of the circuit through the contactor 39 is made amply sufficient to allow the combustion chamber of the heating system to be entirely purged of the highly inflammable or explosive gases which may remain in said combustion chamber at the instant that the actual combustion ceases.

When the combustion chamber has been purged of this matter, it is desirable that the operation of the fuel supplying means and of the ignition means of the system be resumed in an attempt to re-establish combustion where the latter was interrupted otherwise than in response to the normal conditions requiring complete shut-down of the system. It will appear hereafter in connection with the description of Figs. 4 and 5 that the device including the contactors 39 and 55 causes such attempt at re-establishment of combustion to be made in every case where combustion was interrupted in other than a normal shut-down manner. If combustion is reestablished following such an abnormal failure thereof, the contactors 39 and 55 resume their normal operating positions and so remain until combustion is again terminated. In the event that the apparatus fails to re-establish combustion, a safety device described hereinafter functions to lock the system entirely out of operation until manual restoration of such safety device following an inspection of the system and correction of the abnormal condition which made it impossible for combustion to be maintained. During this locked-out condition, and also during the normal periods of inactivity of the heating system, the thermostatic member 15 is relatively cool and the contactors 39 and 55 occupy the positions corresponding to this condition, which are the positions in which these contactors are shown in the drawings.

Reference may now be had to Figs. 4 and 5 for a full understanding of one advantageous manner of utilizing the device shown in Figs. 1, 2, and 3 and above described with reference to said figures. Such a device is designated generally in Figs. 4 and 5 by the reference character 74 and is mounted on the side of a stack 75 which is adapted to conduct the gaseous products of combustion away from the combustion chamber within a furnace 76. Fuel is supplied to the furnace 76 by a pump or blower 77 operated by a motor 78, and a device for igniting such fuel to establish combustion within said combustion chamber is indicated at 79. This latter device may be constituted by either an ignition coil having its high tension terminals connected to a suitable spark gap within the combustion chamber, or an electromagnetically-controlled valve for expanding a

gas pilot flame, or by any other suitable means of like character.

The operation of the system is normally and primarily controlled by a room thermostatic device 80 of any suitable well-known type in which a switch or pair of contacts is controlled in accordance with the temperature of the space to be heated. A secondary control device 81 is also shown as being associated with the boiler of the furnace 76 and may be of any suitable well known type for controlling the system in accordance with the temperature or pressure of such boiler. The devices 74, 80 and 81 cooperate to control the operation of the heating system through the instrumentality of another control device 82 which embodies a mercury electric contactor 83 or other suitable switch for controlling the energization of the motor 78.

The contactor 83 is suitably carried by an arm 84 that is pivotally mounted at 85, and the angle of inclination of said contactor, which inclination controls the opening and closing of the circuit therethrough, is controlled by two solenoid coils 86 and 87 respectively having core members 88 and 89 pivotally connected to the arm 84 at 90 and 91. When neither of the coils 86 and 87 is energized, the arm 84 is maintained against a suitable stop 92, as shown, by the action of gravity on said arm and on the core members 88 and 89. In this position the contactor 83 is tilted downwardly to the right, and, since the electrodes of this contactor are located in the left-hand end of the container therefor, the circuit between said electrodes is interrupted.

The solenoid coil 86 is designated as the "pull" coil because it is so designed that energization thereof will exert sufficient attraction upon its core member 88 to actuate the arm 84 upwardly whereby the inclination of the contactor 83 is reversed and a circuit is completed between the electrodes of said contactor. The coil 87 is designated as the "hold" coil because it is so designed that energization thereof will maintain the arm 84 in raised position with the contactor 83 closed after said arm and contactor have been initially actuated by the pull coil 86. The magnetic effect of the coil 87 is not sufficient, however, to effect initial actuation of the arm 84 to close the contactor 83.

A thermal cut-out device is embodied in the control device 82 for the purpose of effecting a desired feature of safety in the operation of the heating system and comprises a bimetallic or other thermostatic element 93 that is freely pivoted at 94. The thermostatic member 93 is adjustably supported by a thumb screw 95 carried by a suitable fixed bracket member 96. The free right-hand extremity of the thermostatic member 93 carries an electrical contacting device 97, which is preferably of the mercury electric contactor type as shown, embodied in a container comprising a well portion 97*a* at its right-hand extremity for a purpose hereinafter described. An electrical heating element or coil 98 is disposed around or adjacent the thermostatic member 93 for the purpose of heating said element to deflect the same in a desired manner in accordance with the length of time during which current is permitted to traverse the circuit in which said heating element or coil is connected.

The thermostatic member 93 is so designed that an increase in the temperature thereof causes its free right-hand extremity to be deflected downwardly, and a predetermined degree of such deflection results in the contactor 97 being so inclined that the body of mercury therein flows into the well 97*a* to interrupt the circuit between the electrodes of said contactor, which are located in the left-hand end of the container as shown. The thermal cut-out embodying the elements just described is provided for the purpose of interrupting the operation of the heating system in response to predetermined abnormal conditions and precluding further operation until said cut-out has been manually restored. It is for the purpose of accomplishing this result that the container of the contactor 97 is provided with the well portion 97*a*, because when the body of mercury within said container has been caused to flow into said well in response to the predetermined abnormal condition, it will remain there after the thermostatic member 93 has returned to its normal position and until the contactor 97 has been further inclined downwardly to the left, which is accomplished by manually raising the free right-hand extremity of the thermostatic member 93, during which movement said member moves freely about the pivot 94. When the member 93 and the contactor 97 are manipulated in this manner, the body of mercury within the container of said contactor is caused to return to the left-hand extremity of said container to reestablish the circuit between the two electrodes located at said extremity.

The circuit connections of the apparatus above described include two supply conductors 99 and 100 which supply energy to the system from any suitable source to which they may be connected. The conductor 99 extends to one terminal of the contactor 97 and to no other part of the system, and therefore this contactor controls the supply of energy to all of the operating and control devices of the system. The opposite terminal of the contactor 97 is connected through a conductor 101 to one terminal of the contactor 83, the other terminal of which is connected through a conductor 102 to one terminal of the motor 78. The other terminal of the motor 78 is connected through a branch conductor 103 to the other supply conductor 100, thus completing the energizing circuit for the motor 78.

The terminal of the contactor 97 opposite that to which the conductor 99 is connected is also connected through a conductor 104 to one terminal of the switch or contactor of the room thermostatic device 80. The other terminal of the switch or contactor of the room thermostatic device 80 is connected through a conductor 105 to one terminal of the switch or contactor of the secondary control device 81, the other terminal of which latter switch or contactor is connected through a conductor 106 to the terminal post 60 of the control device 74. It will be remembered that this terminal post 60 is connected in common to one terminal of each of the contactors 39 and 55 of the device 74. The other terminal of the contactor 39 is connected through the terminal post 59 and a conductor 107 to one terminal of the ignition device 79, the other terminal of which ignition device is connected directly to the other supply conductor 100. A branch conductor 108 extends from the conductor 107 to one terminal of the electrical heating element 98 of the thermal cut-out embodied in the control device 82, and the other terminal of said heating element 98 is connected through a conductor 109 to one terminal of the pull coil 86. The opposite terminal of this pull coil, as well as one terminal of the hold coil 87, is connected to the other supply conductor 100 through a branch conductor 110. The terminal

of the contactor 55 other than the one which is connected in common to one terminal of the contactor 39, as above described, is connected through the terminal post 61 and a conductor 111 to the remaining terminal of the hold coil 87, thus completing the energizing circuit of said coil.

All of the above-described circuit connections are illustrated in simplified schematic form in Fig. 5 and reference to this figure will give a clearer understanding of such circuit connections and the operation of the entire system which will be described forthwith.

It will be understood that the operation of the heating system is normally controlled in accordance with the temperature of the space to be heated through the instrumentality of the room thermostat 80, the secondary control device 81 being normally in a condition to permit the control circuit to be completed therethrough. Assuming a condition in which the parts of the control device 74 occupy the positions indicated, which condition is that existing after a period of inactivity of the heating system, a demand for heat in the room or other space to be heated will be evidenced by closing of the switch or contactor embodied in the room thermostatic device 80.

The closing of this switch or contactor completes the energizing circuits for the ignition device 79 and for the pull coil 86, since all of the switches connected in series with these devices between the supply conductors 99 and 100, namely, the switches 97, 80, 81 and 39, are then closed. Accordingly, the ignition device 79 establishes the ignition flame or spark and at the same time the contactor 83 is closed in response to the energization of the pull coil 86. The closure of the contactor 83 completes the energizing circuit of the motor 78 and thereupon said motor initiates the operation of the fuel supplying means 77. In the absence of abnormal conditions, therefore, ignitable fuel will be supplied to the combustion chamber of the furnace 76 and will there be ignited because of the energization of the ignition device 79.

If combustion is properly established in this manner, the hot gaseous products of combustion which will be conducted away through the stack or flue 75 will so raise the temperature of the thermostatic element 15 of the control device 74 that the heretofore described clockwise movement of the contactors 39 and 55 will be initiated. Continued normal operation of the system will cause the temperature of the thermostatic member 15 to be raised to such a point that the contactor 55 will be closed to complete the energizing circuit of the hold coil 87, which thereafter will maintain the motor switch or contactor 83 closed. A short time after this operation takes place, the contactor 39 is opened to de-energize the ignition device 79 and the pull coil 86, continued energization of these devices being no longer required. The contactor 55 will then remain closed and the contactor 39 will remain open as long as combustion continues. If such combustion continues until the temperature of the space to be heated is raised as much as is desired, the room thermostatic device 80 will open its switch or contactor to de-energize the control circuit including the hold coil 87 and thereupon the motor switch 83 will be permitted to open to de-energize the motor 78 and consequently to terminate the operation of the heating system in the normal shut-down manner.

In the event that combustion is not properly established in response to the closure of the switch or contactor of the room thermostatic device 80, the ignition device 79 and the pull coil 86 will remain energized for an undue length of time. It will be observed that the heating element 98 for the thermostatic member 93 is connected in series with the pull coil 86 and that, therefore, said heating element is energized whenever the pull coil is energized. This heating element is so designed that after a predetermined period of energization thereof, the switch or contactor 97 will be opened in the manner heretofore described. The opening of this switch or contactor disconnects all of the operating and control devices of the system from the supply conductor 99 and therefore precludes any further operation of the system until said switch or contactor is manually restored to its closed position. The thermal cut-out device embodying the thermostatic member 93, the switch or contactor 97 and the heating element 98 therefore affords complete protection to the system against the hazardous condition which would arise if operation of the fuel supplying means 77 were permitted to continue after combustion failed to be established within a reasonable interval of time.

The thermal cut-out device referred to also affords the same degree of protection in precluding operation of the fuel supplying means for an undue length of time following a possible failure of combustion after the same is initially established, but the control device 74 cooperates with said thermal cut-out under such conditions to provide a further advantageous feature of operation which has been previously mentioned. This feature is the attempt to re-establish combustion a predetermined interval of time after the same has failed following proper initial establishment thereof. This interval of time before the attempt to reestablish combustion is obtained by reason of the time delay in the reclosing of the contactor 39, which time delay results from the curved or humped formation of the container for said contactor as previously described.

It will now be seen that the opening of the contactor 55, almost immediately following a decrease in temperature of the thermostatic element 15 of the control device 74 in response to the extinguishment of the flame in the combustion chamber, interrupts the energizing circuit for the hold coil 87 and therefore permits the motor switch 83 to be opened to deenergize the motor 78 and thereby to stop the operation of the fuel supplying means 77 in the same manner as in the normal shut-down operation. The motor switch or contactor 83 cannot then be reclosed until the pull coil 86 has been re-energized and the re-energization of the said pull coil cannot occur until the contactor 39 has been reclosed after the desired predetermined interval of time. When the contactor 39 is thus reclosed, the pull coil 86 is again energized and the ignition device 79 is likewise re-energized to cause the operation of the fuel supplying means and the ignition means to be restarted. If combustion is successfully re-established, the same events will occur as in the normal initiation of operation of the system, but if it is not established, the thermal cut-out device will function also in its normal manner to open the switch or contactor 97 whereby the heating system is locked entirely out of operation until said switch or contactor 97 is manually restored to its closed position.

From a consideration of the above description of operation of the system it will appear that every abnormal failure of combustion, after

proper initial establishment thereof, will result in an attempt to re-establish combustion in the normal manner, but only after the lapse of the predetermined interval of time required for the contactor 39 to be returned to its closed position in response to the relatively slow cooling of the thermostatic element 15 of the control device 74. During this interval of time the combustion chamber is entirely purged of the highly inflammable or explosive gases which may be present for a few moments immediately following extinguishment of the flame in the combustion chamber. It has already been pointed out that the provision of this interval of time before an attempt to re-establish combustion can be made, constitutes the major feature of the present invention, and it will be seen that the provision of this interval of time is made possible by reason of the novel features of construction of the control device designated generally by the reference character 74, these novel features residing in the provision of two separate frictional slip connections, or the equivalent thereof, between the thermostatic actuator of said device 74 and the two contactors 39 and 55, respectively, which are actuated thereby.

It is to be noted that the operations of attempting to re-establish combustion are performed only when combustion has been terminated or interrupted in an abnormal manner, as the termination of combustion in a normal manner in response to the opening of either of the switches or contactors of the devices 80 and 81 interrupts the energizing circuits for the ignition device 79 and the pull coil 86, as well as that for the hold coil 87, so that under these conditions the motor switch or contactor 83 is not reclosed when the contactor 39 normally returns to its closed position.

While only one specific embodiment of the present invention has been disclosed herein, it will be apparent to those skilled in the art that many changes and modifications may be made in the details of construction and arrangement of parts of the device constituting such embodiment, without departing from the spirit and scope of the invention as set forth in the appended claims. It will likewise be understood that said device may be utilized in conjunction with any suitable cooperating devices and circuit connections other than those herein illustrated by way of example.

Having thus described this specific embodiment of the invention, what is claimed as new and is desired to secure by Letters Patent is:

1. An electric control device comprising thermal responsive actuating means adapted to respond to predetermined temperature conditions, two electric switches actuable by said means, operative connections comprising non-positive transmission means between said means and one of said switches, partly separate operative connections comprising another non-positive transmission means between said means and the other of said switches, a fixed common stop means for limiting the movement of both of said switches in response to a decrease in the temperature of said means, and separately adjustable stop means for limiting the movements of said two switches in response to an increase in the temperature of said means.

2. An electric switching device comprising an actuator, two tiltably mounted mercury electric switches, means whereby said actuator tilts said switches in unison, and means for limiting the tilting movements of both of said switches in both directions to predetermined arcs of different lengths, said switches being angularly displaced relatively to each other whereby when they are tilted in one direction the electric circuit through one switch is closed before the electric circuit through the other is opened and when they are tilted in the opposite direction the electric circuit through said first switch is opened before the electric circuit through said other switch is closed.

3. An electric switching device comprising a thermal responsive actuator movable under temperature variations, two tiltably mounted electric switches, means whereby said actuator tilts said switches in the same direction in unison, and means for limiting the tilting movements of both of said switches in both directions to predetermined arcs of different lengths, said switches being angularly displaced relatively to each other whereby when the actuator responds to increased temperature conditions the electric circuit through one of said switches is closed before the electric circuit through said other switch is opened and when the actuator responds to decreased temperature conditions the electric circuit through said first switch is opened before the electric circuit through said other switch is closed.

4. An electric switching device comprising an actuator, two tiltably mounted mercury electric switches, the electrodes contained in the separate switches associated in the same circuit being positioned at opposite ends in the respective containers of said switches, means whereby said actuator tilts said switches in unison, and means for limiting the tilting movements of both of said switches in both directions to predetermined arcs of different lengths, said switches being angularly displaced with respect to each other whereby when they are tilted in one direction the electric circuit through the electrodes of one switch is closed before the electric circuit through the electrodes of the other switch is opened and when said switches are tilted in the opposite direction the electric circuit through the electrodes of said first switch is opened before the electric circuit through the electrodes of said other switch is closed.

5. An electric switching device comprising an actuator, two mercury electric switches tiltably mounted upon a common axis of rotation, means for limiting the tilting movements of both of said switches in both directions to predetermined arcs of different lengths, said switches being angularly displaced upon the common axis of rotation relatively to each other whereby when they are tilted in one direction the electric circuit through one switch is closed before the electric circuit through the other is opened and when they are tilted in the opposite direction the electric circuit through said first switch is opened before the electric circuit through said other switch is closed.

6. An electric switching device comprising an actuator, electric switches adapted to open and close circuits through tilting actions imparted thereto by said actuator, means for limiting the tilting movements of both of said switches in both directions to predetermined arcs of different lengths, whereby said switches may severally control circuit conditions by their respective tilting movements through said arcs of different lengths, said switches being positioned relatively to each other whereby when they are tilted in

one direction the electric circuit through one switch is closed before the electric circuit through the other is opened, and when they are tilted in the reverse direction the electric circuit through said first switch is opened before the electric circuit through said other switch is closed.

7. An electric switching device comprising a thermal responsive actuator, two electric switches actuated by tilting movements imparted thereto by said actuator, said electric switches being mounted upon a common tilting axis, means for limiting the tilting movements of both of said switches in both directions to predetermined arcs of different lengths, whereby said switches may severally control circuit conditions by their respective tilting movements through said arcs of different lengths, said switches being positioned relatively to each other whereby when they are tilted in one direction the electric circuit through one switch is closed before the electric circuit through the other is opened, and when they are tilted in the reverse direction the electric circuit through said first switch is opened before the electric circuit through said other switch is closed.

8. A device of the class described, comprising, in combination, a first switch control member, a second switch control member, means for limiting movement of said switch control members in a first direction, a first switch movable to closed position by said first switch control member upon predetermined movement thereof in a second direction away from its limit of motion in the first direction, a second switch movable to open position by said second switch control member upon a predetermined larger movement thereof in said second direction away from its limit of motion whereby said first switch is closed prior to opening of said second switch upon simultaneous movement of said switch control members away from their limits of motion, means for preventing further substantial movement of said first switch control member after said first switch has been closed and means for preventing further movement of said second switch control member only after the same has moved a substantial distance beyond the point at which said second switch is opened, whereby simultaneous reverse movements of said switch control members open said first switch substantially immediately upon initiation of such reverse movements and delays reclosure of said second switch, a common actuator movable in reverse directions, and a nonpositive transmission means connecting said actuator and switch control members whereby said actuator may continue to move unrestrictedly after said switch control members have reached their limits of movement in either direction.

9. A device of the class described, comprising, in combination, a first switch control member, a second switch control member, means for limiting movement of said switch control members in a first direction, a first switch movable to closed position by said first switch control member upon predetermined movement thereof in a second direction away from its limit of motion in the first direction, a second switch movable to open position by said second switch control member upon a predetermined larger movement thereof in said second direction away from its limit of motion whereby said first switch is closed prior to opening of said second switch upon simultaneous movement of said switch control members away from their limits of motion, means for preventing further substantial movement of said first switch control member after said first switch has been closed and means for preventing further movement of said second switch control member only after the same has moved a substantial distance beyond the point at which said second switch is opened, whereby simultaneous reverse movements of said switch control members open said first switch substantially immediately upon initiation of such reverse movements and delays reclosure of said second switch, a common thermal actuator movable in reverse directions in response to temperature changes, and non-positive transmission means connecting said thermal actuator and switch control members whereby said thermal actuator may continue to move unrestrictedly after said switch control members have reached their limits of movement in either direction.

10. An electric switching device comprising a single actuator, first and second tiltably mounted mercury electric switches, separate slip frictional connecting means between said single actuator and said switches to tilt the latter in unison, said second switch being of such formation as to increase the normal impedance to the flow of mercury therein, whereby when the switches are tilted in one direction the electric circuit through said second switch is maintained until after the electric circuit through the first switch is closed and when they are tilted in the opposite direction the electric circuit through said first switch is opened before the electric circuit through said second switch is closed.

11. An electric switching device comprising a single actuator, first and second tiltably mounted mercury electric switches, separate slip frictional connecting means between said single actuator and said switches to tilt the latter in unison, said second switch being of such curved formation as to require the switch to be tilted to a greater angle than would otherwise be necessary to cause the flow of mercury therein, thereby delaying such flow so that when the switches are tilted in one direction the electric circuit through said second switch is maintained until after the electric circuit through the first switch is closed and when they are tilted in the opposite direction the electric circuit through said first switch is opened before the electric circuit through said second switch is closed.

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