

July 23, 1940.

W. W. MARTENIS

2,209,298

STOKER CONTROL

Filed Dec. 19, 1938

2 Sheets-Sheet 1

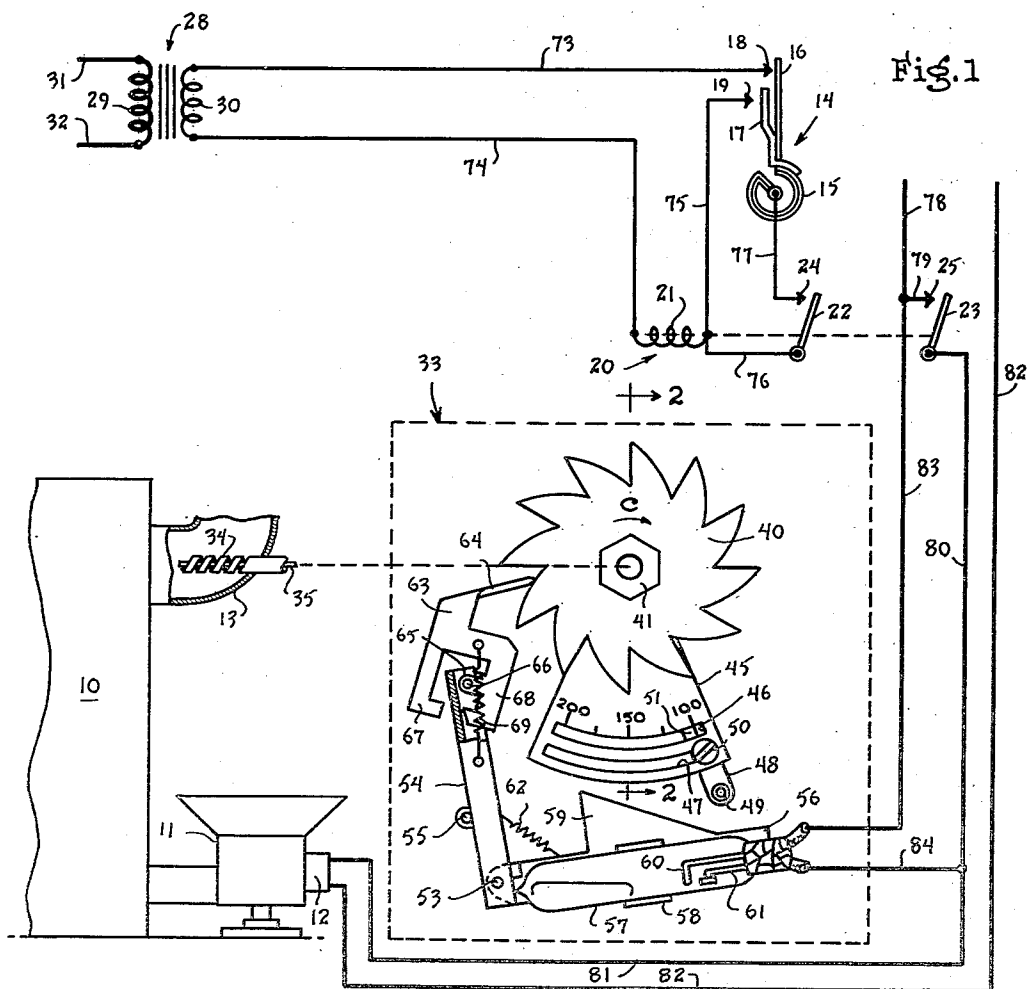
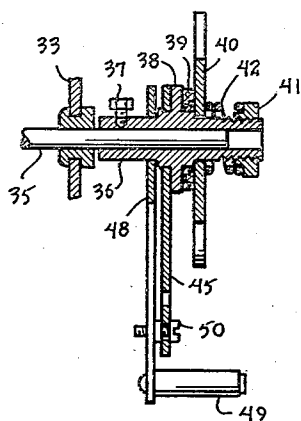


Fig. 2

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2 Sheets-Sheet 2

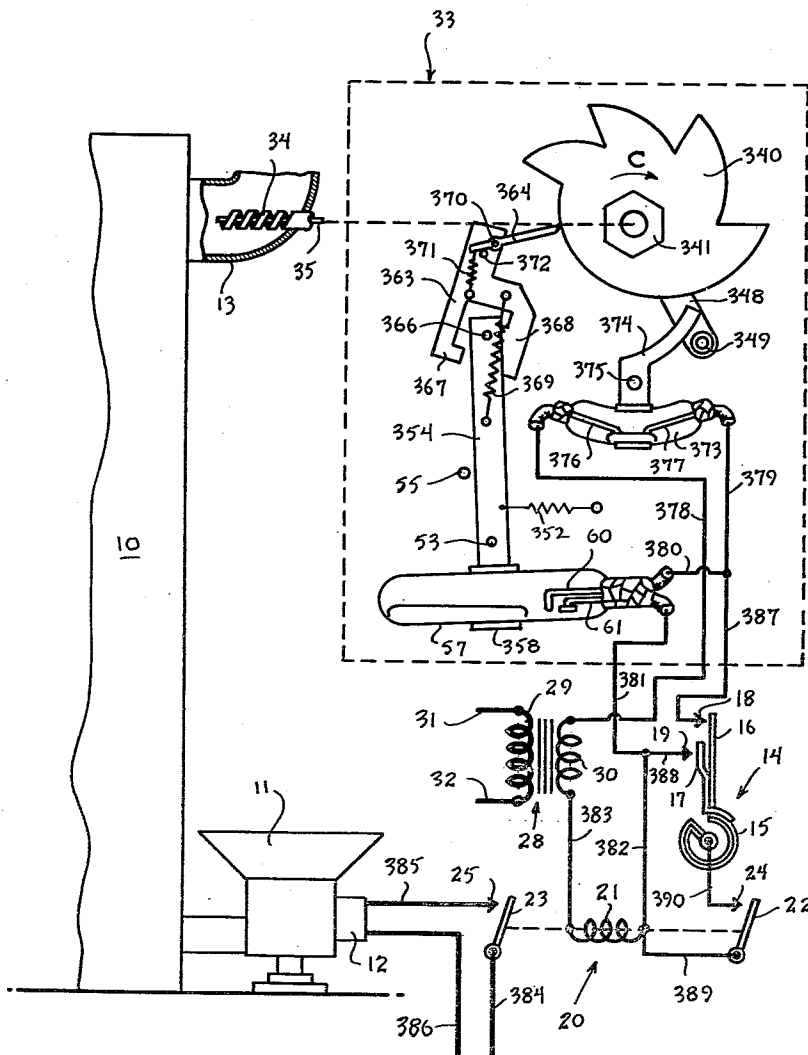


Fig. 3

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UNITED STATES PATENT OFFICE

2,209,298

STOKER CONTROL

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Application December 19, 1938, Serial No. 246,530

12 Claims. (Cl. 236—9)

My invention relates to automatic control of solid fuel fired combustion apparatus and deals particularly with automatic control of solid fuel feeding machinery for fire maintaining purposes.

Specifically my invention is a novel temperature actuated switch mechanism which operates to control an automatic stoker or the like to maintain a fire in a manner whereby a smaller pilot fire will suffice and the danger of accidental extinguishment of the fire is practically eliminated. Stoker control switches are known to the art but they have certain shortcomings in that they do not operate to maintain as small a pilot fire as is desirable in the interests of economy and the minimizing of overheating in mild weather, they cannot be entirely relied on to prevent extinguishment of the fire and at times they produce short cycling of the stoker equipment.

The underfeed type domestic stoker offers a suitable example of equipment for use with which my invention is particularly adapted. With such a stoker the solid fuel is forced upwardly through a retort usually in the form of a more or less conical throat having orifices or tuyères near its upper part to admit air for combustion of the fuel. Combustion of freshly supplied fuel begins where it is in a position to be contacted by air from the tuyères and a fairly well defined line called the ignition line is established between burning fuel and fuel not yet undergoing combustion. The usual stoker control switches are responsive to stack temperature and operate to start the stoker at a low stack temperature. The stack temperature does not always reflect conditions at the ignition line but is influenced considerably by heat from the bed of ashes adjacent the retort and by masses of coke known as "coke trees" which are formed as result of carbonization of the coal and which may jut upwardly from the fire bed and break off. Thus the stack switch may remain off even when the fire at the ignition line has receded to such an extent that it will not recover when fresh fuel is added. It follows necessarily that the stack switch must be set to start the stoker at a higher stack temperature and a larger pilot fire than is desirable is maintained. Also with known stack switches the first holdfire operation after a thermostat operation is delayed by the heat released from the bed of ashes and coke so that during this long off period that portion of the firebed within the retort burns away due to the air drawn thru the tuyères by natural draft until a very thin firebed remains. This thin firebed offers but little restriction to the flow of air thru the tuyères with the result that the fire becomes very sensitive to the presence or absence of forced draft. This results in an abnormally rapid rise in stack temperature when the stoker is started so that the stoker operation is terminated before any appreciable amount of coal can be supplied

and likewise a rapid drop in temperature when the stoker is off due to the lack of body in the fire. The result will be short cycling or undesirably frequent starting and stopping of the stoker.

From the foregoing it is apparent that the previously enumerated shortcomings of known stoker control switches detract markedly from the efficiency and desirability of the systems in which they are used. My invention avoids these shortcomings in a manner which will become apparent as the accompanying detailed specification proceeds, my primary object being to promote the efficiency and economy of stoker control systems without appreciably adding to their first cost.

Another object of my invention is to enable users of solid fuel fired equipment to maintain a smaller pilot fire.

Another object is to reduce the danger of accidental extinguishment of the fire in solid fuel fired systems having fire maintaining equipment.

Another object is to eliminate short cycling in automatic temperature controlled fire maintaining equipment.

Another object is the provision in a thermostatically controlled stoker system of a combustion responsive switch device for adding a small amount of fuel to the fire at intervals during the ensuing drop in combustion space temperature after a thermostatic operation.

Another object is the provision in a thermostatically controlled stoker system of a combustion responsive switch device for adding a small amount of fuel after predetermined drops in combustion space temperature following a thermostatic operation.

Another object is the provision in a thermostatically controlled stoker system of a combustion responsive switch device for operating the stoker for intervals at the end of predetermined drops in combustion space temperature after a thermostatic operation and for maintaining a predetermined combustion space temperature after it has fallen to that temperature.

Another object is the provision in a thermostatically controlled stoker system of a temperature responsive switch device comprising a cam which is moved in one direction when the temperature is rising and in the opposite direction when the temperature is falling, the cam closing a stoker controlling switch at intervals as the temperature falls after a thermostatic operation, each stoker operation causing appreciable heating and movement of the cam in a direction to open the switch before the temperature resumes its downward trend.

Another object is the provision of temperature actuated switch means wherein an element moved in response to temperature buckles a switch actuator for closing the switch and a relatively small

reverse movement of the element buckles the switch actuator in the opposite direction.

Figure 1 is a view of one embodiment of my invention embodied in a thermostatically controlled stoker system which is diagrammatically illustrated.

Figure 2 is a detail cross section view of a portion of my invention taken along the line 2—2 of Figure 1.

Figure 3 is a view of another embodiment of my invention embodying in a thermostatically controlled stoker system which is diagrammatically illustrated.

Referring to Figure 1 of the drawings, I have shown at 10 a coal fired furnace or boiler to which fuel is supplied in a known manner by a conventional automatic stoker 11 driven by an electric motor having a terminal box 12. The furnace or boiler has a stack or flue 13 for carrying away the gases of combustion.

The stoker may be controlled primarily by a space or room thermostat designated at 14 and which may be of a conventional type comprising a bimetal element 15 arranged to actuate a pair of flexible switch blades 16 and 17 cooperating with fixed electrical contacts 18 and 19, respectively. The thermostat 14 controls a relay 20, the relay 20 comprising a coil winding 21 cooperating with an armature arranged to actuate a pair of switch blades 22 and 23 which are moved to the left when the coil 21 is energized and engage with fixed electrical contacts 24 and 25, respectively. Power for operation of the relay 20 is supplied from a step-down transformer 28 having a primary winding 29 and a secondary winding 30, the primary winding having a greater number of turns than the secondary winding. Power is supplied to the primary winding 29 through line conductors 31 and 32 connected to any suitable source of external power. Relay switch 23 controls the stoker. The various electrical circuits of the thermostat, relay and stoker will be traced later.

Thermostatic control of a stoker as I have shown it is of course well known in the art; my invention resides principally in the stoker control switch which controls the stoker during periods when the room thermostat is not demanding operation of the heating system. My stoker control switch comprises mechanism which is preferably mounted on a panel board 33 which I have indicated by the broken lines on Figure 1. The mechanism of the stoker control switch comprises a helical bimetallic thermostatic element 34 which is mounted in the stack 13 and the inner end of which is attached to a rod or shaft 35 which extends through and is journaled in a suitable bearing in the panel board 33 as may be best seen in Figure 2. The end of the shaft 35 carries a collar 36 which is secured to the shaft by means of a set screw 37 (see Figure 2). The collar 36 has a flange 38 and adjacent one side of this flange is a washer 39 made of cork. Fitted over the collar 36 and adjacent the washer 39 is a saw toothed cam disc 40 the shape of which is best shown in Figure 1. The outer end of the collar 36 is screw threaded and engaged thereon is a spring retaining nut 41 having a suitable shoulder against which a coil spring 42 bears, the other end of the coil spring bearing against the cam 40 and urging it against the cork washer 39. The spring 42 urges cam 40 against the cork washer with sufficient force so that when the collar 36 is rotated the cam rotates with it unless the cam is restrained from rotational

movement. If the cam 40 is restrained the collar 36 may rotate relatively thereto. On the opposite side of the flange 38 the collar 36 carries a segmental member 45 which is securely attached to the collar and rotates therewith. The segmental member 45 as seen in Figure 1 has two arcuate slots 46 and 47, one edge of the slot 46 having graduations etched thereon ranging from 100 to 200, as shown. Carried on the collar 36 to the left of the member 45 is an arm 48 which can be rotated with respect to the collar but normally rotates with the collar. The arm 48 is of greater radius than the segmental member 45 and at its end carries a roller cam follower 49. A small set screw 50 extends through the slot 47 of segmental member 45 and engages the arm 48 in screw threaded relation, there being a small washer interposed between the arm 48 and the member 45. Whenever the set screw 50 is screwed up tight the arm 48 and segmental member 45 are fixed with respect to each other. The arm 48 carries an index 51 which, by loosening the set screw 50 may be set opposite any of the graduations of the segmental member 45.

A pivot pin 53 extends outwardly from the panel board 33 and carried on this pivot pin is a channel bar 54 which in the position shown in Figure 1 is in engagement with a stop pin 55. Also pivoted on the pin 53 between the sides of the channel bar 54 is an arm 56 forming a carriage for a mercury switch 57. The arm 56 has an integral spring clip 58 for attaching the mercury switch thereto and also a fin 59 forming a cam surface for cooperation with the cam follower 49. The mercury switch 57 has the usual globule of mercury therein and a pair of electrodes 60 and 61 at one end. The channel bar 54 and arm 56 are biased towards each other about the pivot pin 53 by a coil spring 62. At the free end of the channel bar 54 a cam follower 63 is pivotally attached, the cam follower having an extending finger 64 arranged to follow the contour of the cam 40. The cam follower 63 has a small lug 65 which engages a pivot pin 66 extending through the sides of the channel bar 54 and also has extending portions 67 and 68 disposed on opposite sides of the bottom of the channel bar so as to act as stops to limit the amount of rotation of the cam follower 63 in either direction about the pivot pin 66. A coil spring 69 is attached to the cam follower 63 and the channel bar 54 in a manner to form an over center mechanism, the coil spring being so attached that when the cam follower 63 is rotated to the left about its pivot to its extreme position the coil spring 69 is slightly to the left of the pivot pin 66. As is well known in the art the spring 69 will snap past its dead center position wherein its ends and the pin 66 lie in a straight line.

In operation the thermostat 14 may at any time start the stoker in response to a demand for heating. The thermostat is arranged so that the blade 16 will engage contact 18 at a predetermined temperature of 72°, for example, and the blade 17 will engage the contact 19 at a predetermined temperature which may be 1° and 2° lower, for example, 70°. When the temperature adjacent thermostat 14 has fallen to 70° both pairs of contacts will be made and a circuit for coil 21 will be completed as follows: from blade 16 through contact 18, wire 73, secondary winding 30 of transformer 28, wire 74, coil 21, wire 75, contact 19, blade 17, and back to blade 16 of the thermostat. Immediately upon completion of

this circuit coil 21 is energized and blade 22 is moved to the left into engagement with contact 24 completing a maintaining circuit for coil 21 as follows: from blade 16 through contact 18, wire 73, winding 30, wire 74, coil 21, wire 76, blade 22, contact 24, wire 77, thermostatic element 15 back to blade 16. It will be seen that this maintaining circuit is independent of blade 17 and therefore once the relay has been energized it will remain energized until the temperature rise above 72° causing blade 16 to disengage from contact 18. Thus the thermostat has a positive operating differential and chattering of the relay due to insecurely made contacts is eliminated. Whenever relay 20 is energized bringing blade 23 into engagement with contact 25, a circuit for energizing and starting the stoker is completed as follows: from line wire 78 to wire 79, contact 25, blade 23, wire 80, wire 81, terminal box 12 back to wire 82. Wires 78 and 82 may be connected to any suitable source of power. The stoker of course operates as long as the thermostat is demanding heating.

With the parts in the position shown the thermostat has been satisfied for some time and the fire has died down considerably but is still larger than the pilot fire normally maintained. If now the thermostat should indicate a need for heating and energize the relay 20 to start the stoker the temperature of stack 13 would of course rise and the heating effect at the element 34 would move shaft 35 and collar 36 in a counter-clockwise direction. This would tend to begin to move cam 40 in a counter-clockwise direction also but the cam tooth just above finger 64 would engage that finger and restrain the cam from rotation inasmuch as with the cam follower 63 and channel bar 54 in the position shown neither of the latter elements are free to rotate in response to the force exerted on them by the cam. Thus the arm 48 and segmental member 45 will be rotated in a counter-clockwise direction to a position wherein the arm 48 may be vertical for example while the cam 40 remains in practically the same position.

When the thermostat becomes satisfied the stoker will of course stop and the element 34 will begin to cool tending to rotate the shaft 35 and collar 36 in a clockwise direction. The finger 64 will now follow out the contour of one of the cam teeth as seen on Figure 1, the curved surface of the cam tooth tending to rotate the cam follower 63 in a counter clockwise direction about its pivot. Before the finger 64 overrides the extremity of the adjacent tooth of cam 40 the channel bar 54 will strike stop 55 causing the cam follower 63 to rotate relative to the channel bar 54 until the coil spring 69 will snap past its dead center position to a position slightly to the left of pin 66 the extremity of portion 67 of cam follower 63 engaging channel bar 54. This snap movement of the cam follower will momentarily move the finger 64 away from the cam tooth but the weight of mercury switch 57 will immediately rotate arm 56, channel bar 54 and cam follower 63 in a clockwise direction bringing finger 64 back into contact with the cam tooth. Finger 64 will continue to follow out the surface of the cam tooth until it overrides the extremity of the cam tooth, the weight of the mercury switch then rotating the arm 56, channel bar 54 and cam follower 63 in a clockwise direction so that the finger 64 moves in to the shorter radius of the cam 40. This latter movement will be sufficient to cause the mercury of the mercury switch to

engage the contacts 60 and 61 whereupon a circuit for the stoker motor will be completed as follows: from wire 78 through wire 83, contact 60, contact 61, wire 84, wire 81, terminal box 12 back to the wire 82. The stoker will now operate and will replenish the fire with fuel so that the stack temperature begins to rise causing element 34 to again begin to rotate shaft 35 and collar 36 in a counter-clockwise direction. The flat surface of the cam tooth which finger 64 has just overridden will now move toward and engage the finger 64 and will rotate the cam follower 63 in a clockwise direction about its pivot so as to snap the spring 69 past its dead center position with the cam follower 63, channel bar 54 and arm 56 now assuming the position shown in Figure 1. It will be understood that the buckling action when cam follower 63 snaps into the position in which it is shown will cause a leftward reaction to be exerted upon the pivot pin 66 at the upper end of channel bar 54 which will cause sufficient counter-clockwise movement of channel bar 54 and arm 56 to open the mercury switch 57, as shown. After opening of the mercury switch the stack temperature will resume its fall. In the manner just described the finger 64 of the cam follower 63 will progressively override the extremities of successive cam teeth so as to intermittently close the mercury switch 57 and start the stoker, upon each starting of the stoker the cam 40 moving back in a counter-clockwise direction just sufficiently to cause opening of the mercury switch. As the stack temperature continues to fall, eventually the segmental member 45 and arm 48 carrying roller cam follower 49 will reach a position as shown in Figure 1. After finger 64 overrides the cam tooth with which it is shown in contact in Figure 1 the roller cam follower 49 will be close to the cam surface of the fin 59. As the stack temperature continues to fall the next tooth of the cam will cause the cam follower 63 and spring 69 to snap over center with the spring 69 taking a position to the left of pin 66. However before finger 64 has an opportunity to override the extremity of this cam tooth the roller cam follower 49 will engage the fin 59 and move the arm 56 clockwise with respect to the channel bar 54 tending to stretch the spring 62. Thus in this manner the mercury switch will be closed before the finger 64 has an opportunity to override the extremity of the cam tooth with which it is in contact at this time. The stoker will now start as before tending to rotate the cam and arm 48 in a counter-clockwise direction. The tension of spring 62 biasing the cam surface of fin 59 against roller cam follower 49 will move arm 56 in a counter-clockwise direction as the temperature rises until mercury switch 57 opens stopping the stoker. Upon the ensuing fall in temperature roller cam 49 will again move the fin 59 to close the mercury switch in a manner just described, the apparatus now continuing to cycle in this manner, the stoker control switch maintaining a minimum stack temperature determined by the temperature at which arm 48 is in a position with respect to fin 59 to close the mercury switch.

From the foregoing it is apparent that I have provided a novel stoker control switch wherein after the room thermostat becomes satisfied the stoker is operated at intervals while the stack temperature is falling. This intermittent replenishment of the fuel prevents the fire from dying out in the vicinity of the point of supply sooner than it does at regions more remote from the

source of supply. In other words, with my system the effect of heat from a large bed of ashes or coke formations which would normally keep a stoker control switch open while the fire has receded beyond recovery in the vicinity of the point of supply, that is, the ignition line is counteracted. In my system when the fire has receded to a minimum size the heat remaining for actuating the element 34 emanates primarily from the central point of the retort, that is, the vicinity of the point of supply where combustion is first initiated. There is no danger as happens frequently with ordinary stoker control switches that at the time the stoker control switch first closes the fire is out at the fire line, the stoker control switch having been kept open by heat emanating from a large bed of ashes or the like. My invention enables the user to maintain a lower minimum stack temperature and a smaller pilot fire while at the same time considerably reduces the danger of accidental extinguishment of the fire for the reasons pointed out. It should be understood that with my device that during the temperature drop after the thermostat is satisfied the mercury switch is closed after predetermined drops in temperature and is then opened in response to only relatively small rises in temperature so that the operation of the stoker merely acts to keep the fire within the retort alive and does not materially add to the total heat input to the heated space.

In Figure 3 of the drawings I have shown a second embodiment of my invention wherein the construction of the switch is modified in several respects. The elements of Figure 3 which are identical with corresponding elements of the previous embodiment are numbered the same and need not be described again. The elements of Figure 3 which take a different form than elements shown in the previous embodiment are numbered over 300. The teeth of the cam 340 in the present embodiment are not uniform but are of progressively less circumferential extent in a counter-clockwise direction. The cam 340 always rotates with the shaft 35 in the present embodiment but both the cam and the arm 348 may be adjusted on the shaft 35 by loosening the nut 341. The channel bar 354 is pivoted on a pivot pin 53 and at its lower end carries a spring clip 358 in which the mercury switch 57 is mounted. The cam follower 363 is similar to the cam follower of the previous embodiment but the finger 364 is pivoted at 370 and a coil spring 371 is attached to the end of the finger 364 normally biasing it against a stop 372. The spring 371 forms a strain release mechanism operative when the teeth of the cam engage the finger 364 but only after the overcenter snap has occurred. The cam follower 363 is pivoted at 366 and has extending portions 367 and 368 corresponding to and operative in a similar manner to that described in connection with the previous embodiment. The channel bar 354 is biased in a counter-clockwise direction by a coil spring 352 this biasing being great enough to cause finger 364 to follow the cam surface but not great enough to operate the over center snap action.

In the present embodiment a mercury switch comprising a curved tube 373 is carried on a switch actuating arm 374 pivoted at 375 and having a portion engageable by the roller cam follower 349 carried on arm 348. The mercury switch 373 has two electrodes 376 and 377 which extend to the center portion of the tube where they are engaged by a globule of mercury, the mercury

tube normally being in the position shown in the drawings. The mercury switch 373 acts both as an outfire switch and a high limit switch as will presently become apparent.

The stoker control switch 57 of the present embodiment is shown in the position which it assumes when fire in the combustion chamber has died down to pilot fire proportions. The finger 364 is contacting a portion of the longest curved surface of the cam and upon slight further cooling of element 34 and consequent slight further rotation of cam 340 in a clockwise direction cam follower 363 and channel bar 354 will move in a clockwise direction about pivot pin 53 to cause the mercury in mercury switch 57 to engage the contacts 60 and 61. This will occur at the minimum combustion temperature which is to be maintained. Closure of the mercury switch will complete a circuit for energizing the relay 20 as follows: from secondary winding 30 through a wire 378, contacts 376 and 377 of mercury switch 373, wire 379, wire 380, contacts 60 and 61 of mercury switch 57, wire 381, wire 382, winding 21, and wire 383 back to secondary winding 30. Energization of winding 21 moves switch blade 23 into engagement with contact 25 energizing the stoker through wire 384, switch blade 23, contact 25, wire 385, terminal box 12 back to wire 386, the wires 384 and 386 being connected to any suitable source of power. The stoker will now operate causing a rise in stack temperature which will result in counter-clockwise movement of cam 340 which after a predetermined stack temperature rise will again cause mercury switch 57 to be moved substantially into the position shown wherein the switch is open. Control of the pilot fire will be maintained as just described and the minimum temperature to be maintained may be varied by adjusting the cam 340 on the shaft 35.

Whenever the thermostat 14 indicates a need for heating the relay 20 is energized through the following circuit from blade 16 through contact 18, wire 387, wire 379, mercury switch contacts 377 and 376, wire 378, secondary winding 30, wire 383, winding 21, wire 382, wire 388, fixed contact 19 and blade 17 back to blade 16 of the thermostat. Energization of the relay closes switch 22 and completes the maintaining circuit as follows: from blade 16 through contact 18, wire 387, wire 379, mercury switch contacts 376 and 377, wire 378, secondary winding 30, wire 383, winding 21, wire 389, switch blade 22, contact 24, wire 390, element 15 back to blade 16. While the stoker is operating in response to the thermostat cam 340 will rotate in a counter-clockwise direction. The cam teeth will successively engage the finger 364 which will urge channel bar 354 against stop 55 and the cam teeth will force the finger 364 downwardly stretching the spring 371, the resiliency of the spring permitting the cam teeth to pass the finger 364 without moving cam follower 363 on its pivot. When the thermostat becomes satisfied the finger 364 will be contacting the curved surface of one of the cam teeth and the cam will then begin to rotate in a clockwise direction. As in the previous embodiment before the finger 364 overrides the extremity of a cam tooth it will first snap follower 363 and spring 369 past dead center to a position with the spring 369 slightly to the left of pivot pin 366. Upon the finger 364 then overriding the extremity of a cam tooth it will move in to the shorter radius of the cam causing closure of mercury switch 57

and starting of the stoker. Counter-clockwise movement of the cam will cause the flat surface of the tooth which has just been overridden by the finger 364 to engage the finger 364 and snap the cam follower 363 past dead center in the opposite direction to the position in which it is shown in Figure 3 and thus opening the mercury switch. This operation is similar to that described in the previous embodiment. As the stack temperature then resumes its fall the finger 364 will eventually override the next succeeding cam tooth. It will be seen that the cam teeth are of progressively less circumferential extent in the direction of temperature fall so that after the thermostat becomes satisfied there will be a relatively great increment of temperature drop before the stoker is first started and the increments of temperature drop which cause subsequent starting of the stoker will be progressively smaller. In this manner the number of stoker operations during the time that the stack temperature is falling to its minimum value is reduced and they are spaced more widely apart while the fire in the combustion chamber is larger.

If for any reason the fire should accidentally go completely out or practically out the stack temperature will fall to such a value that roller cam follower 349 will engage member 374 rotating it about its pivot and causing the mercury in switch 373 to disengage from contacts 376 and 377. As this switch is in the circuit of both the thermostat and the mercury switch 57 further fuel cannot be added until an operative has manually restarted the fire. If the stack temperature should rise to an unusually high value the arm 348 may make practically a complete revolution and engage the member 374 on the opposite side so as to rotate it about its pivot in the opposite direction and correspondingly open the mercury switch 373. Similarly when the mercury switch has been opened in this manner no fuel can be added while the stack temperature is above the predetermined value at which arm 348 causes opening of the mercury switch 373.

From the foregoing it is apparent that the present embodiment has the novelty and utility pointed out in connection with the previous embodiment and has the further advantage that the number of stoker operations are reduced while the stack temperature is falling to its minimum value and they are more widely spaced during the time when the fire remaining in the combustion chamber is of larger proportions. It will be understood by those skilled in the art that in the present embodiment the cam 340 itself provides a cam surface which serves the purpose of the cam surface of fin 59 of the previous embodiment. My improved switch is comprised of sturdy elements not requiring minute adjustments but yet capable of producing a marked increase in efficiency in the operation of solid fuel fired equipment.

In accordance with the patent statutes I have disclosed in detail two representative embodiments of my invention. These embodiments are illustrative of different forms and modifications which my invention may take. My invention is not to be limited by my disclosure but its boundaries are to be determined only in accordance with the subject matter encompassed by the appended claims.

I claim as my invention:

1. In combination, means forming a combustion chamber, an automatic stoker for feeding

solid fuel into the combustion chamber, combustion responsive means for controlling said stoker to maintain a fire in the combustion chamber, said combustion responsive means comprising a device constructed and arranged to operate the stoker after predetermined drops in combustion temperature while the fire is receding during a period when combustion is not required, and means for operating the stoker whenever the combustion temperature falls to a predetermined minimum value so as to maintain a pilot fire corresponding to said minimum combustion temperature value.

2. In combination, means forming a combustion chamber, an automatic stoker for feeding solid fuel into the combustion chamber, combustion responsive means for controlling said stoker to maintain a fire in the combustion chamber, said combustion responsive means comprising a device constructed and arranged to start the stoker after predetermined drops in combustion temperature while the fire is receding during a period when combustion is not required, said device stopping the stoker upon a relatively small rise in temperature after each start, and means for operating the stoker whenever the combustion temperature falls to a predetermined minimum value so as to maintain a pilot fire corresponding to said minimum combustion temperature value.

3. In combination, means forming a combustion chamber, an automatic stoker for feeding solid fuel into the combustion chamber, combustion responsive means for controlling said stoker to maintain a fire in the combustion chamber, said combustion responsive means comprising a switch device, means actuable by heat for closing the switch device upon a fall in temperature, said means opening the switch device upon a relatively small rise in temperature of less magnitude than said fall in temperature and again closing the switch device upon a further fall in temperature and means whereby said switch device controls said stoker to prevent the combustion temperature from falling below a predetermined minimum value.

4. In combination, means forming a combustion chamber, an automatic stoker for feeding solid fuel into the combustion chamber, combustion responsive means for controlling said stoker to maintain a fire in the combustion chamber, said combustion responsive means comprising cam means actuable by heat, cam follower means cooperating with said cam means and a switch actuable by said cam follower means, said cam means having a contour engaging with said cam follower means so as to close said switch in response to a fall in temperature, said cam means engaging said cam follower so as to open said switch in response to a rise in temperature of less magnitude than said fall in temperature, and said cam means causing successive closing and opening of the switch.

5. In combination control system, in combination, an automatic stoker for feeding fuel into a combustion chamber, thermostatic means controlling said stoker for regulating heating in a space, combustion responsive means controlling said stoker when heating of the space is not required, said last means comprising a heat actuable device for starting the stoker at intervals during the fall in combustion temperature after the thermostatic means is satisfied, each starting of the stoker causing a relatively small rise in combustion temperature, said device being responsive to said small rise in temperature for

stopping the stoker before the fall in temperature is resumed.

6. In a combustion control system, in combination, an automatic stoker for feeding solid fuel into a combustion chamber, thermostatic means controlling said stoker for regulating heating in a space, combustion responsive means controlling said stoker when heating of the space is not required, said last means comprising an element movable in response to falling combustion temperature, means comprising a switch actuable by movement of said element for starting the stoker, said element being movable in response to heat resulting from starting of the stoker to actuate said switch to stop the stoker after a relatively small rise in combustion temperature, said element being repeatedly moved to start and stop the stoker whereby after the thermostatic means is satisfied the combustion temperature falls by stages to a predetermined minimum value.

7. In combination, a stoker, a control device for the stoker comprising a combustion responsive element, switching means actuable by said element controlling said stoker, said element actuating said switching means in response to a fall in combustion temperature to start said stoker and said element actuating said switching means in response to a smaller subsequent rise in combustion temperature to stop said stoker whereby combustion temperature is reduced in stages under control of said control device.

8. In a stoker control system, in combination, means forming a combustion chamber, a stoker for feeding fuel into said chamber, means for controlling said stoker when heating is not demanded of said combustion chamber, said last means comprising a temperature responsive element and a cam having a plurality of projections actuable thereby, a cam follower for said cam and a switch actuable by said cam follower, each of said projections being operable to move said cam follower so as to close said switch when said element is cooling, each closure of said switch starting said stoker and causing sufficient heating of said element to cause said element to move in heating direction, each of said projections being arranged so that when moved in heating direction they engage said cam follower and cause opening of said switch for stopping said stoker, said projections passing said cam follower progressively, each projection causing starting of the stoker and subsequent stopping of the stoker after a relatively small rise in combustion temperature.

9. In a stoker control system, in combination, means forming a combustion chamber, a stoker for feeding fuel into said chamber, means for controlling said stoker when heating is not demanded of said combustion chamber, said last means comprising a temperature responsive element and a cam having a plurality of projections actuable thereby, a cam follower for said cam and a switch actuable by said cam follower, each of said projections being operable to move said cam follower so as to close said switch when said element is cooling, said projections having extremities which the cam follower overrides to actuate said switch, each closure of said switch starting said stoker and causing sufficient heating of said element to cause said element to move in heating direction, each of said projections being so formed that when moved in heating direc-

tion they engage said cam follower and cause opening of said switch for stopping said stoker, said projections passing said cam follower progressively, each projection causing starting of the stoker and subsequent stopping of the stoker after a relatively small rise in combustion temperature.

10. In combination, a stoker, a control device for the stoker comprising a combustion responsive element, switching means actuable by said element controlling said stoker, said element actuating said switching means in response to a change in combustion temperature to start said stoker and said element actuating said switching means in response to another change in combustion temperature of different magnitude to stop said stoker whereby the size of the fire is progressively varied by increments.

11. In a stoker control system, in combination, means forming a combustion chamber, a stoker for feeding fuel into said chamber, means for controlling said stoker when heating is not demanded of said combustion chamber, said last means comprising a temperature responsive element and a cam having a plurality of projections actuable thereby, a cam follower for said cam and a switch actuable by said cam follower, each of said projections being operable to move said cam follower so as to close said switch when said element is cooling, each closure of said switch starting said stoker and causing sufficient heating of said element to cause said element to move in heating direction, each of said projections being arranged so that when moved in heating direction they engage said cam follower and cause opening of said switch for stopping said stoker, said projections passing said cam follower progressively, each projection causing starting of the stoker and subsequent stopping of the stoker after a relatively small rise in combustion temperature, and said projections being of progressively less extent as the cam follower rides over them when the cam is progressing in cooling direction.

12. In a stoker control system, in combination, means forming a combustion chamber, a stoker for feeding fuel into said chamber, means for controlling said stoker when heating is not demanded of said combustion chamber, said last means comprising a temperature responsive element and a cam having a plurality of projections actuable thereby, a cam follower for said cam and a switch actuable by said cam follower, each of said projections being operable to move said cam follower so as to close said switch when said element is cooling, said projections having extremities which the cam follower overrides to actuate said switch, each closure of said switch starting said stoker and causing sufficient heating of said element to cause said element to move in heating direction, each of said projections being so formed that when moved in heating direction they engage said cam follower and cause opening of said switch for stopping said stoker, said projections passing said cam follower progressively, each projection causing starting of the stoker and subsequent stopping of the stoker after a relatively small rise in combustion temperature, and said projections being of progressively varying circumferential extent.

WILLIAM W. MARTENIS.

CERTIFICATE OF CORRECTION.

Patent No. 2,209,298.

July 23, 1940.

WILLIAM W. MARTENIS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, second column, line 63, claim 5, for the word "combination" read --a combustion--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of October, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)