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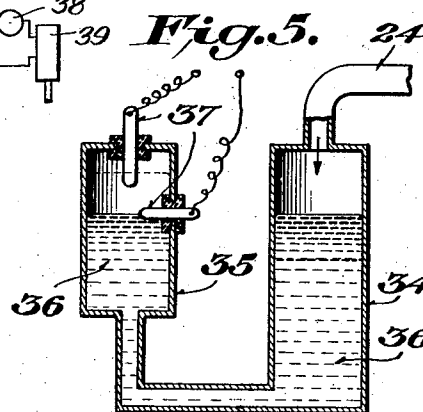
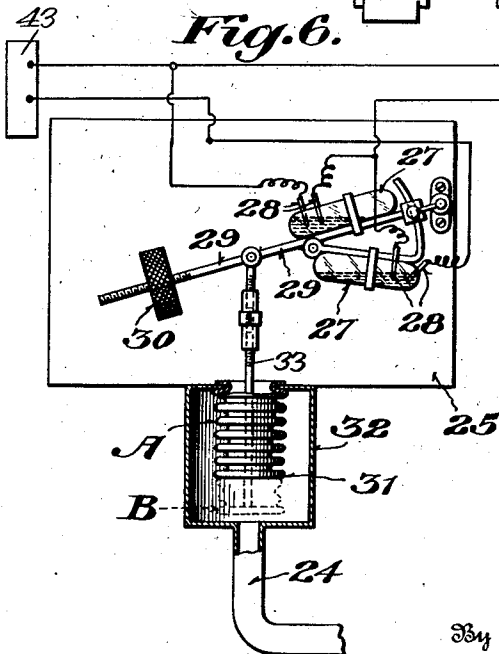
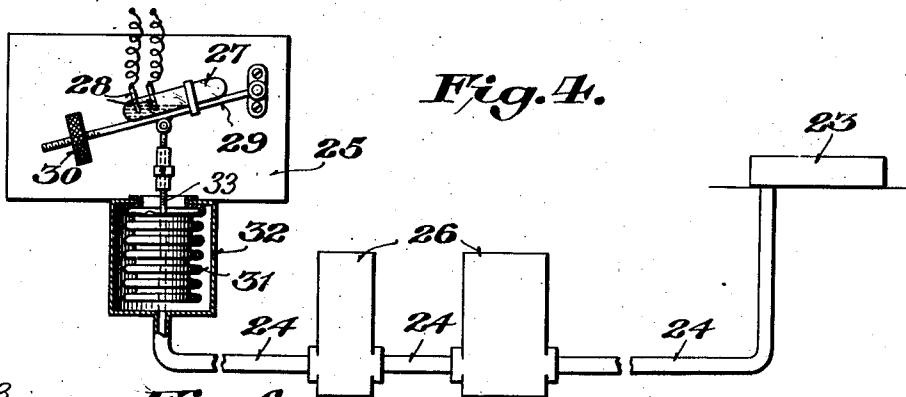
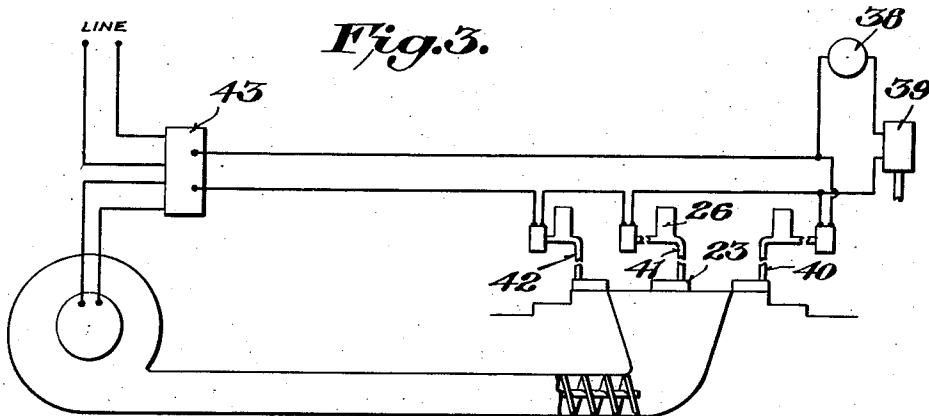
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THERMOSTATIC STOKER CONTROL

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THERMOSTATIC STOKER CONTROL

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12 Claims. (Cl. 236—15)

This invention relates to thermostatic stoker controls; and it comprises in combination with an automatically stoked furnace having means, including a fire pot, adapted for the establishment and maintenance of a fire bed of substantial depth, of a temperature responsive element mounted in heat receiving relationship to said fire bed at a point where the normal fire temperature is around 1400° F. in combination with control switches controlling the operation of the stoking means; all as more fully hereinafter set forth and as claimed.

Automatic coal stokers of the under-feed type have recently come into considerable use. In these furnaces combustion is effected in a bed of coal of substantial depth contained in a chamber variously called a fire pot and a retort. Furnaces of this automatically stoked type are used in various sizes and for various purposes; the larger sizes being used in boiler firing and for general heating purposes. These under-feed stokers are particularly adapted for heating buildings and for burning cheap and low-grade fuels; mine screenings, slack coal, etc. Their employment results in an average fuel saving, as compared with hand stoking using sized coal. With hand stoking, if smoke is to be eliminated the use of anthracite or semi-anthracite is necessary, whereas with automatically stoked furnaces of the type described smokeless firing can be secured with bituminous fuels.

In a particularly advantageous form of these automatically stoked furnaces, there is a fire pot adapted for the establishment and maintenance of a body of burning fuel of substantial depth with a conveyor for supplying it with coal from a suitable source; the conveyor supplying the coal to the bottom of the fire bed.

In under-feed stokers of this type it is usual to employ an electric motor as a source of power both for the conveyor and for the operation of a fan or a blower supplying air to the furnace. The upper portion of the fire pot is provided with tuyères for admitting air from the blower to the fire. In these furnaces the fire pot is smaller in lateral extent than the fire box of the furnace and it is usually provided with a tuyère grate. Some of the air from the blower is sent upwardly through this grate and through the bed of burning fuel. In smaller sizes, the tuyère grates are sometimes omitted. In operation the conveyor feeding coal into the fire pot is adapted for a slow feed at a uniform rate. The rate is adjustable and is usually set for the maximum heating requirements to be met by the furnace. As ordi-

narly operated, the rate of air feed below the fire pot is usually more or less fixed; a supply of 225 cubic feet of air per pound of fuel burnt being common, while the flow of air to the tuyères beyond the fire pot is adjustable by means of a damper. In cases where the furnace requirements are constant and the fuel supply is of unvarying characteristics no particular controls are necessary. But ordinarily these conditions do not obtain; and in particular in the case of equipments used for heating buildings where the requirements for heat are quite irregular; varying with the time of day, the weather, etc. Sometimes room thermostats are provided adapted to start the stoker functioning when the room temperature falls below a certain level and to stop it when the temperature rises above another certain point. These do not provide for any regulation of the speed of operation; the stoker is either operating or not. In the case of the heating equipment including a boiler there may be a boiler pressure control adapted to cut in or cut out the stoker as the case may be; this control being in series with the room thermostat. With these devices there is the obvious difficulty that if the stoker is out of function for more than a very short period, the fire goes out and must be rekindled before the stoker again goes into operation. Otherwise, green coal is fed into a cold fire box. To rectify these difficulties controls have been proposed in which the stoker is put into intermittent operation from time to time in order to maintain the fire in being irrespective of the setting of the room thermostat. In their best form these proposed controls comprise, in a general way, temperature responsive means placed in the flue or stack or in the path of the hot gases in the fire box above the fire; and adapted to start the stoker functioning when the furnace temperature drops below a predetermined minimum. These devices take care of one difficulty, that of the fire becoming extinguished, but they afford no remedy when the fire becomes too hot, either by failure of the room temperature or of the pressure control or by reason of excessive demands on the stoker. To prevent over-heating, however, a maximum temperature control device is often placed in series with the room temperature control and is adapted to break the stoker motor circuit when the flue temperatures rise above a predetermined point.

This device is useful in governing the normal operation of the stoker as well as in serving as a safety device. Stokers are designed to operate at such rates of coal and air feed that the zone of active combustion of the fire is kept up above

the retort or fire pot proper. If the high heat zone of the fire bed is allowed to descend lower in the retort for any length of time, the metal of the retort may melt or be injured. In addition, if the stoker be run too fast with firing at pick-up load rate for a considerable length of time, the excess air sweeping through the fire pot may burn the retort or even the tuyère grate. The maximum temperature control, properly set, prevents such an occurrence regardless of any attempts on the part of the attendant to force the firing.

The controls described are complicated in operation and moreover make no provision for contingencies when a fire becomes extinguished. With a cold fire pot the stoker will keep on working since the minimum temperature control remains in the "on" position; green coal being fed in.

The invention relates in part to a control adapted to shut off the stoker when the fire goes out; as explained post.

Temperature responsive devices in the flues, in the stack breeching or water compartment of the boiler, and even those in the fire box near the fire, have the common disadvantage that they are not directly responsive to the temperature in the fire bed itself; there is a time lag. A sudden rise or fall in the fire bed temperature affects the temperature responsive device only after a time which may be several minutes if the device is located at a distance from the fire, as in the stack for instance. A further difficulty occurs in shifting to a coal having different coking characteristics; burning differently. Heavy-coking coals maintain fire longer than free burning coals. In changing coal, readjustment of controls is usually necessary.

In installing a stoker, with these types of control there must be individual adjustment for each installation, for the coal, etc. The temperatures vary over a wide range in the stack breechings of various types of furnaces and boilers.

I have found that all the disadvantages of the variability of temperature in stacks, etc. can be avoided, and new advantages secured, by placing the temperature responsive element under the thermal control of the fire bed itself. I have determined the region in the fire where temperatures are most constant during normal combustion, and where any change in firing temperature is reflected most quickly and find it to be the zone where the temperature fluctuates around 1400° F. In the present invention I locate the temperature responsive element in thermal relationship to this zone. Changes in fire temperature are immediately registered, without lag, and the stoker is promptly cut on or off when the temperatures rise or sink and the controls go into or out of action. The result is to maintain a fire under all conditions since this zone is maintained at its normal temperature in firing (about 1400° F.). Thereby, all other zones are maintained at their respective normal temperatures. The fire cannot go out and remains, so to speak, in a standardized condition whatever the heating demands. I may mount other and separate temperature responsive elements for all desired controls at appropriate locations in the fire box.

In the accompanying drawing I have shown, more or less diagrammatically, my temperature controls embodied in an automatic stoker of the under-feed screw-conveyor type. In this showing,

Fig. 1 is a view in vertical section, some parts being shown in elevation, of an automatic stoker fitted in a boiler and embodying a single temperature control;

Fig. 2 is an enlarged view in vertical section taken along line 2—2 of Fig. 1;

Fig. 3 is a diagrammatic view in elevation of an automatic stoker embodying three controls depending on fire temperature;

Fig. 4 is a diagrammatic view showing vapor bulb expansion vessels and one type of control switch;

Fig. 5 is a view showing another type of switch useful in my invention; and

Fig. 6 is a view of a control circuit showing a third type of switch which may be used in my invention.

Fig. 1 shows the fire end of a boiler 1 provided with water tubes 2 and a fire box 3. The boiler is fired by an automatic stoker, comprising a fire pot 4, coal conduit 5, screw conveyor 6 and fuel hopper 7. The conveyor is rotatable by a motor 8 through a mechanical speed reducing transmission (not shown), conveying coal from the hopper to the fire pot. A blower 9 operated by the same motor, furnishes air through air conduit 10 to the air chamber 11 between the outside of the fire pot and a casing 12. Air enters the fire pot through orifices 13 in the walls thereof. An orifice 14 is provided in the walls of the casing 12 to admit air into the ash-pit space 15. This orifice is regulable by a sliding damper 16 operable by rod 17. In the horizontal space between the rim of the casing 12 and the walls 18 of the furnace fire box is a stepped tuyère grate 17A having a plurality of orifices 19 in the vertical risers, the grate terminating slightly below the top of the fire pot 4. Air, issuing from orifice 14 in the stoker casing into the space 15, emerges through these orifices in the grate into the fire bed.

The stoker is provided as shown with a dust and back smoke preventive device adapted to maintain a slight suction on the fuel hopper, carrying away dust and back smoke therefrom. The device comprises an injector 20 mounted on the hopper, an air conduit 21 leading from the injector to the blower, and a second, larger air conduit 22 leading from the injector to the stack of the boiler as shown. Air under slight pressure is forced into the injector by the blower pressure, producing a slight suction in the hopper and carrying dust or smoke therefrom to the stack as shown.

In Figs. 1 and 2 I have shown diagrammatically the conditions which exist in a normal fire in a stoker-operated furnace, as determined from pyrometric tests. Combustion may be considered as taking place in three zones. In zone A, the temperatures are those associated with the heating of green coal to the point where gases and vapors are evolved. The top of this zone usually shifts more or less during each firing period. This zone represents conditions preliminary to coking. In the course of time, the green coal may go higher in the bed if the air supply is at all deficient. Conversely, this level may sink deeper into the retort if there is a considerable excess of air with pressure sufficient to penetrate the coke bed and thus draw the hot coke level lower.

Zone B is the coking and gas producing zone of the bed and has a temperature varying from 1400° F. in the center to a maximum combustion

temperature of approximately 2800° F. at a point on the lip of the fire pot corresponding approximately to the edges of the first tuyère grate on each side. The temperature of this zone is lower in the area directly above the fire pot, due to the low ignition temperatures of the volatile matter that is rising through the bed. As the coal cokes in the lower part of zone B a shrinkage occurs and the fuel draws away from the walls. This allows air to by-pass over the lip of the fire pot and out in a substantially horizontal direction into the sides of the fire bed. Here is where the highest temperatures exist, when measured in the coke. Here coke and some volatiles are burning under an excess of air. It is in this zone that clinker is heaviest. Peculiarly enough, the temperature readings taken immediately on top of the fire pot tuyère blocks, that is, at the lip of the fire pot (as indicated at 13, Fig. 1), are sometimes as low as 800° F. This is probably due to excess air by-passing under the bed. Immediately above the lip are found temperatures of approximately 2800°.

Zone C shows an average temperature varying from 2200° up. The temperature variations apparently depend upon blow-hole formation in the bed.

The boundaries between these zones are usually not particularly well defined, and they may shift up and down somewhat in normal operation of the stoker.

In determining just which section of the entire fire remains most nearly at constant temperature during normal burning, I find that this section is just above the top of the fire pot, in the lower layers of the zone B. The temperature here is around 1400° F. I place my temperature responsive element in heat receiving relation to the portion of the fire bed at this temperature.

There are several types of temperature responsive elements suitable for use in my invention, e. g. pyrometer elements, liquid bulbs employing mercury for instance, and vapor bulbs. Ordinarily I use vapor bulbs, comprising a container filled with volatile matter, conveniently a gas such as air, and placed in the desired zone. The bulb is connected by a vapor line with a pressure operated switch outside. The bulb may take the form of a small cylinder or vessel of any suitable shape. Sometimes I make the bulb in the form of a complete ring encircling the fire pot. This design eliminates the effect of local variations in temperature in the fire. With slight modifications in the vapor bulb and vapor line, mercury may be used. Mercury is sometimes convenient. For the sake of concreteness, I have illustrated my invention using vapor bulb temperature controls. In Figs. 1 and 2 the control illustrated is a minimum temperature control, adapted to turn on the stoker when the temperature of the fire drops near the lowest at which combustion can be maintained.

A vapor bulb 23 containing air is mounted slightly above the edge of the fire pot in the position shown. A vapor line 24 leads from the bulb outside the fire box to a pressure operated switch 25. One or more expansion vessels 26 are advantageously interposed in the vapor line, the size of the vessels depending upon the pressure necessary to operate the switch and on the temperature at which it is desired that the switch operate. By using one or more expansion chambers of suitable size, the switch may be made to

operate at any desired temperature. The vapor bulb, vapor line, expansion vessel and pressure operated switch form a sealed system.

The switch in Fig. 1 is shown in detail in Fig. 4. It is adapted to remain open at normal fire temperatures and to make circuit at a predetermined low fire temperature. It comprises a mercury bulb rocker tube 27 of a well-known type, having a pair of electrodes 28 adapted to be submerged in mercury in one position of the tube and to be removed from the mercury, breaking the circuit, in another position of the tube. The tube is mounted on a rod 29 pivoted at one end as shown and carrying an adjustable screw weight 30 on the other end. By adjusting this weight, the pressure necessary to throw the switch is changed. Hence the switch can be set to operate at any desired fire bed temperature. The pressure responsive element comprises a bellows 31 mounted in a chamber 32 and adapted to be acted upon by pressure in vapor line 24. A rod 33 connects the bellows with the switch rod.

In Fig. 4 the control is shown in "on" position, the temperature at the bulb 23 in the fire being low, and hence the pressure in vapor line 24 being low. As shown in Fig. 1, the switch is connected in parallel with the room thermostat and the boiler pressure control, hence in the "on" position the stoker will be put in operation whatever the demands of the room thermostat. Upon increase in fire temperature, pressure is developed in the bulb and vapor line, and the bellows is compressed, throwing the switch off.

Sometimes, a differential control is used, embodying springs rather than weights, and adapted to permit the switch to be moved on or off at one pressure on the bellows, and then to be moved back to the original position at a different pressure; thereby allowing the length of the stoker operating period to be varied. Inasmuch as this differential adjustment forms no part of the present mechanism, I have chosen for the sake of clarity in illustration a simple weight operated control.

A minimum temperature control ordinarily is effective in preventing the fire from going out. But if the fire should go out for some reason, the minimum temperature control switch remains in "on" position, and the stoker goes on feeding green coal into the fire box indefinitely. This is, of course, undesirable. According to the present invention, I provide a control for turning off the stoker when the fire temperature goes below a predetermined very low point, a point below that at which combustion can be maintained. This control is highly advantageous in automatic stokers. Choking of the fire box with green coal upon accidental extinction of the fire is prevented. Also, if the coal hopper should become empty, the stoker will be shut off. The pressure system is advantageously similar to that of the minimum temperature control described, and the vapor bulb is advantageously mounted in the same region of the fire. But the switch is of a different type—one adapted to go off on decrease of temperature and pressure, rather than on.

In Fig. 5 is shown a suitable switch, comprising a reservoir 34 and a chamber 35, both partly filled with a body of mercury 36. A pair of electrodes 37 insulated from each other are mounted in chamber 35 as shown. The mercury level in chamber 35 is as shown in dotted lines, when the fire is burning and pressure is high in reservoir 34, but drops, breaking the circuit, when

pressure falls. This switch is in series with the room thermostat and other controls, hence when it breaks the circuit upon extinction of the fire the stoker remains off, whatever the demands of the other controls.

Fig. 3 shows diagrammatically a stoker provided with five controls: a room thermostat 38 of an ordinary type, a boiler pressure control 39, a minimum temperature or fire maintenance control 40, a maximum temperature control 41, and an out-fire control 42. This diagram illustrates the wiring connections for the several controls. It is seen that controls 40, 41 and 42 are in series with the relay switch 43 controlling the motor circuit. The room thermostat and the boiler pressure control are in series, and are in parallel with the fire maintenance control. The other controls are in series with the latter control. The vapor bulbs are all shown mounted in the position corresponding to a fire box temperature of around 1400° F.

Fig. 6 shows a control circuit embodying a modification of the switch shown in Fig. 4, this control embodying both a minimum temperature control and a control for stopping the stoker at a predetermined low temperature. As will be seen in Fig. 6, in normal operation of the stoker while running, the bellows is collapsed; the bottom of the bellows taking a position indicated at A. In that position the upper mercury switch is open, the lower one closed. The stoker is started and stopped at the demands of the room thermostat and boiler pressure control, the circuit between these controls and the motor starting switch 43 being completed through lower switch 28. Upon decrease in fire temperature to a point corresponding to the lowest point at which combustion can be maintained, the bellows takes the position shown in full lines. In this position both switches are on, as shown, and hence the stoker is put into operation. Upper switch 28 completes a circuit through starting switch 43 and (closed) lower switch 28. This takes place irrespective of the demands of the room thermostat and boiler pressure controls. Upon further decrease in temperature as by extinction of the fire, the bellows expands to the limit, the bellows bottom taking a position as shown in dotted lines at B. In this position the upper mercury switch is on, but the lower one is off, hence the stoker switch circuit is broken and remains so whatever the demands of the room thermostat and boiler pressure controls.

In some cases I incorporate the maximum temperature control in the same housing. This simply requires the addition of a third mercury switch to the control in Fig. 6, adapted to break contact upon high pressure on the bellows corresponding to undesirably high fire temperatures.

Mounting of the temperature responsive devices in the fire pot, in the position shown, presents many advantages. The controls can be built into the stoker, and adjusted at the factory, whereas when stack or boiler temperatures are used for controlling the operation of the stoker, each stoker installation presents a new problem. Individual adjustments must be made. Furthermore, the stoker is controlled according to the temperatures in the fire itself, rather than by secondary temperatures, so to speak; temperatures of flue gases, boiler water, or the like. Sensitive quick control is assured. There is no lag. There is the additional advantage that a built-in control is cheaper to make.

While I have found it better to locate my heat

control in heat receiving relationship to the zone of the fire with a temperature fluctuating around 1400° F., it can, of course, be placed in heat receiving relationship to other zones of the fire, as, for instance, zones where the temperature is higher or lower. It may be used, for example, in connection with a zone where the temperature is as low as 800° F. However, the best results are obtained by having the heat control related to a zone of the fire where the average temperature is around 1400° F. This is the fire bed temperature and is not necessarily the temperature of the heat control device; allowance being made for drop in temperature of heat passing through the walls of the fire pot.

My method of controlling stoker operation according to fire bed temperatures may be applied successfully to stokers of other types, for instance plunger-feed stokers and overfeed stokers of the automatic type. In all applications of my method, the temperature responsive elements are placed in heat-receiving relationship to a suitable layer in the fire bed, and are arranged to control the operation of the stoker through suitable relays. By suitably adjusting the setting of the maximum temperature control, the furnace temperature may be limited to a point below that at which slag and clinker formation occurs.

What I claim is:

1. In a stoker-fed furnace having a fire pot adapted for the establishment and maintenance of a fire bed of substantial depth with a zone therein of substantially constant temperature, this temperature being above the ignition point of the fuel, a conveyor supplying solid fuel to the pot, power means adapted to operate the conveyor, control means comprising a temperature responsive element located in direct heat receiving relationship to said zone and a switch actuated by said temperature responsive element and adapted to control the operation of the power means.

2. The apparatus of claim 1 wherein the temperature responsive element is a bulb containing vapor mounted on the fire pot and the switch is a pressure operable switch in operative, pressure tight connection with the vapor bulb.

3. A control for automatic motor-operated stokers, comprising a temperature responsive element located in direct heat receiving relationship to the fire pot in a zone of approximately constant temperature in the fire bed, this temperature being above the ignition point of the fuel and a control switch in series with the stoker motor circuit adapted to be operated by the element, the element being adapted to keep the control switch closed at temperatures corresponding to normal combustion of the fire and to open the switch when the temperature falls below a predetermined low value, whereby the control serves to shut off the stoker immediately when the fire goes out.

4. The apparatus of claim 3, wherein the temperature responsive element is a vapor bulb mounted on the fire pot and the control switch is a pressure operated switch in operative communication therewith.

5. A method of controlling automatic stokers having a fire pot and power driven means for feeding solid fuel to the fire pot comprising measuring the temperature at points in the fire bed, and cutting off the stoker when the temperature rises above a predetermined maximum safe value, turning on the stoker when the temperature drops to a value corresponding to the

minimum at which combustion can be maintained, and cutting off the stoker when the temperature drops below a predetermined value corresponding to the temperature at which combustion cannot take place, the cutting on and cutting off of the stoker closely following the changes in the fire bed temperature.

6. In a furnace provided with a stoker having a fire pot, a conveyor adapted to feed solid fuel into the fire pot from below, power means for driving the conveyor, a tuyere grate surrounding the fire pot, and means for feeding a draft of air to the fire pot and through the grate, whereby a fire bed can be established and maintained in the fire pot and on the grate, a control for the stoker comprising a temperature responsive element in heat receiving relationship to an interior section of the fire bed at which the temperature fluctuates around 1400° F., and a switch adapted to be operated by the element and to control the operation of the stoker.

7. The apparatus of claim 6, wherein the control is adapted to turn on the stoker when the fire bed temperature drops to a predetermined point corresponding to the lowest temperature at which combustion can be maintained.

8. The apparatus of claim 6, wherein the control is adapted to turn off the stoker when the fire temperature drops below a predetermined point below the temperature at which combustion can be maintained.

9. The apparatus of claim 6, wherein the control is adapted to turn off the stoker when the fire temperature rises above a predetermined maximum value.

10. In a stoker-fed furnace, a fire pot of a substantial but limited depth and having an upper lip, a conveyor supplying solid fuel to the fire pot and adapted to establish and main-

tain a bed of fuel of substantial depth in said pot extending above said lip, power means adapted to operate the conveyor, a temperature responsive element mounted adjacent the lip of the fire pot and a switch actuated by the temperature responsive element adapted to control the operation of the power means.

11. In a stoker-fed furnace having a fire pot adapted for the establishment and maintenance of a fire bed of substantial depth, a conveyor supplying solid fuel thereto, power means adapted to operate the conveyor, control means comprising a temperature responsive element mounted on the fire pot at a position intermediate the top and the bottom of the fire bed during normal operation thereof and corresponding to a zone of approximately constant temperature of the fire bed and in direct heat receiving relationship with respect to this zone and a switch actuated by said temperature responsive element and adapted to control the operation of the power means.

12. In a stoker-fed furnace having a fire pot adapted for the establishment and maintenance of a fire bed of substantial depth extending above the lip of the pot, a conveyor supplying coal thereto, power means adapted to operate the conveyor, control means comprising a temperature responsive element mounted adjacent the lip of the fire pot at a position intermediate the normal top and the normal bottom of the fire bed and corresponding to a zone of approximately constant temperature of the fire bed around 1400° F. and in direct heat receiving relationship with respect to this zone and a switch actuated by said temperature responsive element and adapted to control the operation of the power means.

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