

March 2, 1937.

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2,072,078

IMPROVED STOKER AND PROCESS OF BURNING SOLID FUEL

Filed Sept. 13, 1933.

2 Sheets-Sheet 1

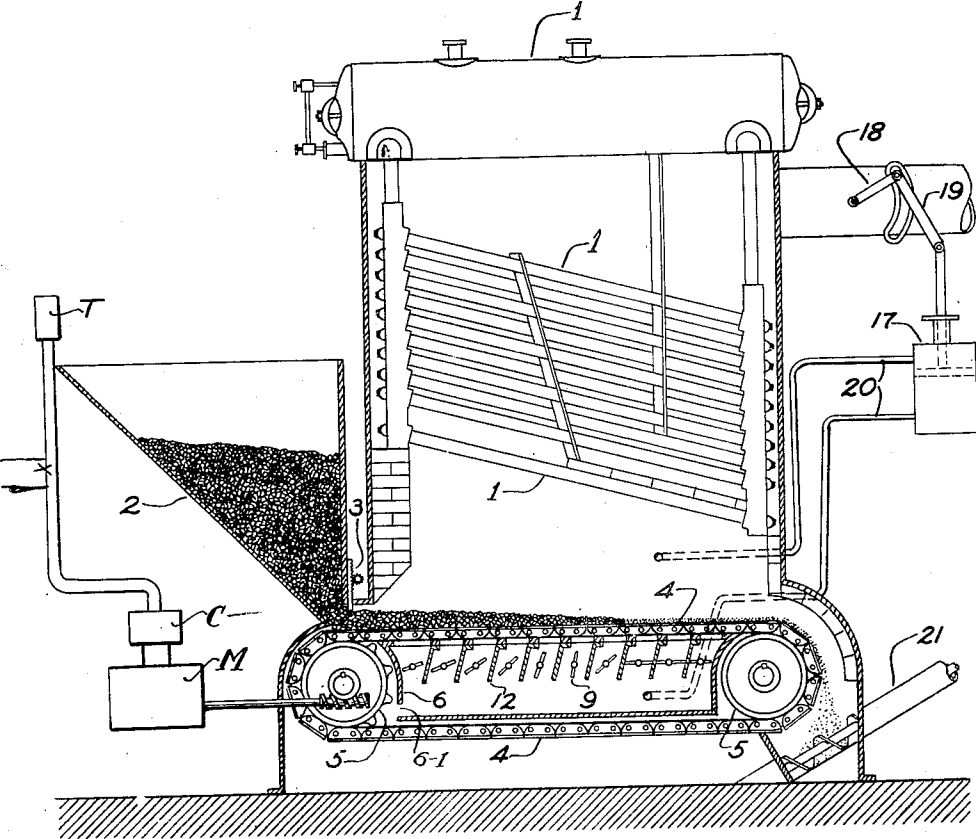


Fig. 1

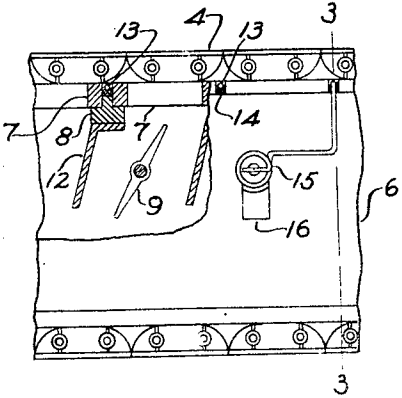


Fig. 2

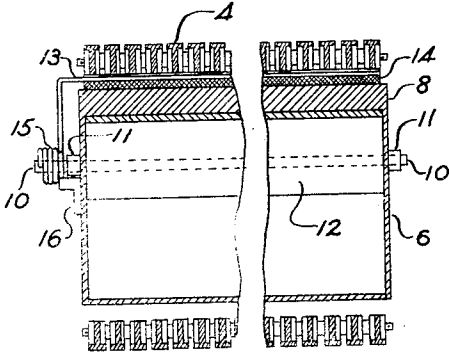


Fig. 3

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2 Sheets-Sheet 2

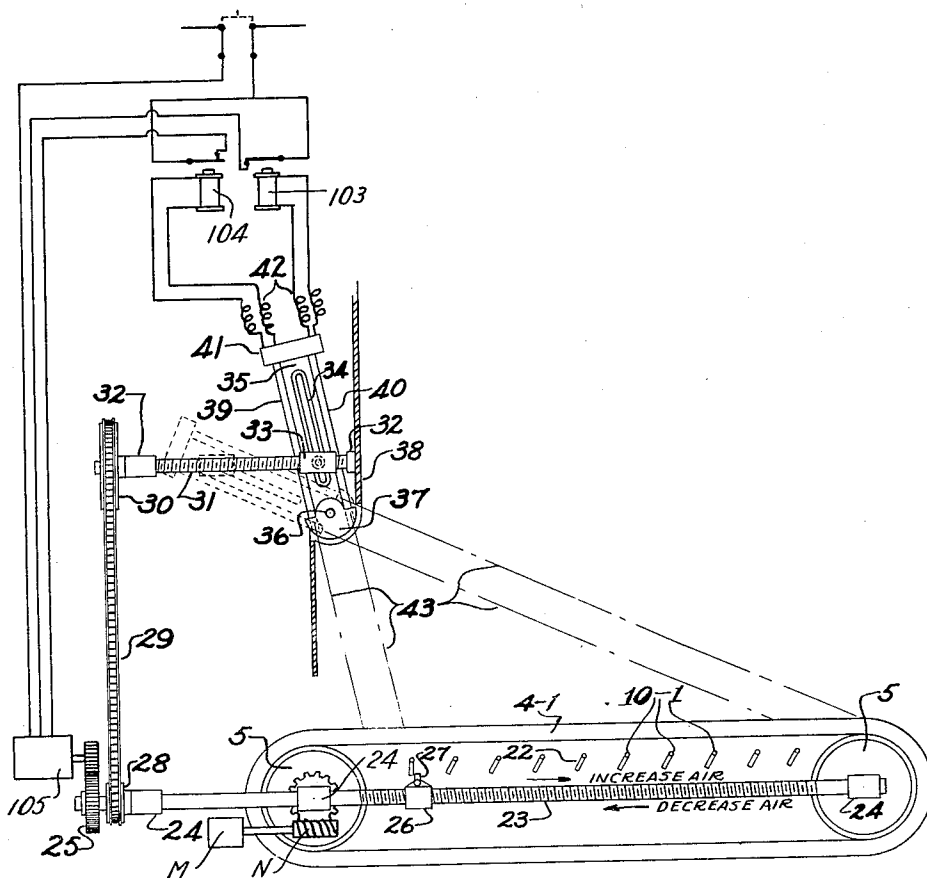


FIG. 4

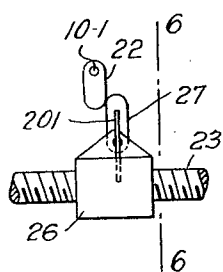


FIG. 5

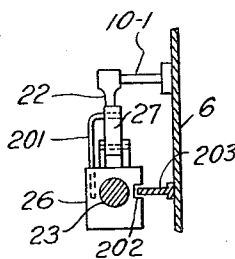


FIG. 6

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2,072,078

IMPROVED STOKER AND PROCESS OF
BURNING SOLID FUELRalph A. Bloomsburg, Albany, N. Y., and Marvin
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Application September 13, 1933, Serial No. 689,222

8 Claims. (Cl. 110—40)

The present invention relates to an improved automatic traveling grate stoker and to a novel method of burning solid fuel whereby an optimum efficiency of combustion of the fuel burned on a mechanical stoker may be secured together with a flexible mode of controlling the heat output of the stoker.

Heretofore, mechanical stokers generally, whether large or small, have had the common fault in that the rate of reaction between the oxygen of the air and the combustible of the fuel was subjected to serious variations and that these variations in the rate of combustion have been essential to the control of the heat output. Such variation of the rate of combustion has serious disadvantages both from the standpoint of efficiency and of operation as is understood by those skilled in the art.

It is the object of the present invention to provide the art with a simple, practical, and efficient means of burning solid fuels so that their heat of combustion may be readily and efficiently available for utilization.

Another object of the invention is the provision of a new principle of heat output control embodying the use of a variable area of firebed while maintaining a substantially constant rate of combustion, or while varying the rate of combustion within such limits that the efficiency and quality of operation are not impaired to any material degree.

A further object of the invention is to provide a stoker which involves the use of a traveling grate and which possesses certain novel features.

It is still another object of the present invention to provide an air shutter control which will admit the proper amount of air according to the immediate requirements of the fuel bed at each section thereof, irrespective of the load or boiler rating, or in other words, it is an object to regulate the air admission at each portion of the fuel bed in relation to the emission of energy at that particular portion and time.

It is a further object to provide an air admission control for a stoker which will prevent the admission of air to the grate at a point which is beyond the burning fuel bed.

It is also within the contemplation of the present invention to provide an air admission control for a stoker which is directly responsive to the temperature effects and energy emission of the fuel bed irrespective of the rate of combustion or the load.

Also within the contemplation of the invention

is the provision of an improved control for stokers which subordinates or eliminates regulation of the heat output by sudden and wide variations in the rates of combustion which produce a reducing atmosphere tending to create a soft, sticky condition of the bed, and too much excess air.

Other objects and advantages of the present invention will become apparent from the following description taken in conjunction with the drawings, in which:—

Fig. 1 is an elevational view, partly in section, of a boiler and a stoker embodying the principles of the present invention;

Fig. 2 depicts a fragmentary view, partly in elevation and in section, of a portion of the stoker shown in Fig. 1;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2;

Fig. 4 is a diagrammatic elevational view of a modified stoker embodying the invention;

Fig. 5 is an enlarged detail view in side elevation, depicting a fragment of the shaft 23, and arms 22 and 27 shown in Fig. 4; and

Fig. 6 illustrates a vertical sectional view taken on line 6—6 of Fig. 5.

Referring to Figs. 1, 2, and 3, the stoker is shown in place under boiler 1, which may be of any suitable type for mounting over the stoker. A coal hopper 2 is a metal hopper of such shape and size that the desired quantity of coal may be stored therein and fed by gravity to the stoker across its entire width through the adjustable coal gate 3. A traveling grate 4 is shown as the conventional "Chain grate" type, although other types of traveling grates may be used. The traveling grate 4 is carried upon and operated by sprocket wheels 5 which in turn receive their rotation from a suitable driving mechanism M. A conventional control box C and the remote thermostatic control T are shown which regulate the grate speed in accordance with the changes in room temperature.

An air box 6 is a metal box interposed between the upper and lower runs of the traveling grate for the purpose of conveying the air for combustion from the source of supply to the underside of the upper run of the grate, and to carry the equipment for regulating the flow of air. The top of this box, referring to Figs. 2 and 3, is composed of a plurality of slotted plates 7 supported on recessed bars 8, which are an integral part of the air box 6. The slotted plates 7 extend under the whole of the grate area which is available between sprocket wheels 5, and they

serve both as a support for the grate and as an outlet for the combustion air from air box 6. An opening 6—1 is provided on air box 6 for the admission of combustion air.

5 The thermostatically controlled air shutters and the accessory equipment may be of a number of different designs using a multitude of different types of thermostats located so as to operate as a function of the temperature of definite portions 10 of the firebed. The embodiment shown in Figs. 1, 2, and 3 is merely an example of the air shutters which may be controlled by thermostats actuated by the variation in the temperature of the fuel bed. A plurality of the air shutters 9 are of the 15 butterfly type and extend entirely across the air box 6 and make a close fit at the sides. Stub shafts 10 on the shutters are supported in bearings 11 attached to the air box and thus serve as pivots for the shutters. The seats for the 20 closing of the shutters are formed by plates 12 attached to the undersides of bars 8 and extending the entire width of the air box 6. These plates are inclined to the vertical and away from the opening edge of the shutter in order to make the 25 openings of the shutter more nearly proportional to the angle of rotation while at the same time maintaining a close degree of control at the lower angles of rotation.

The thermostatic control shown in Figs. 2 and 30 3 is composed essentially of two portions, to wit:—the thermostatic element and the actuating element. Thermostatic element 13 consists of a small bore tube of some metal, preferably an alloy steel, filled with mercury, diphenyl, diphenyl 35 oxide, or some other expansive or volatile element or compound. This tube is embedded in a heat insulating cement 14, such as the alundum types, with its upper surface not quite touching the underside of grate 4 and protected from wear 40 by the adjacent grate supporting plates 7.

The temperature effect of the burning fuel, or in other words, the emission of energy, heats the tube containing the expansive or volatile material to some temperature which will be a function 45 of the temperature of the firebed. The expansion or vapor pressure of the filling material will, therefore, also be a function of the firebed temperature and this pressure will be transmitted to the actuating element 15, which is a small bore 50 metal tube wound in a helix and possessing a certain degree of spring temper.

Where the expansion of such a liquid as mercury is utilized, the actuating element 15 will contain a sufficient quantity of inert gas to prevent 55 excessive pressures from being built up, and where the vapor pressure of a liquid is used, the actuating element will be so constructed as to prevent the vapor from reaching it.

The helix of tubing 15 is rigidly supported by 60 bracket 16 which is fastened to the coil leading to the thermostatic element. The sealed-off end of the coil is connected to shaft 10 of an air shutter. The action of the helix is similar to the mechanism used in pressure gages, that is, the 65 tubing will endeavor to straighten out with increases in pressure and this will result in the helix partially unwinding and rotating the shutter through a given angle. A thermostatic element 13 may be provided for each of a number of 70 shutters 9.

The thermostatic control will be used on each shutter according to requirements. In some cases it may be desirable to use adjustable volume devices in the pressure circuit for the proper setting of the control. 75

The thermostatic control will cause the shutters to be wide open when the temperature of the bed is at some predetermined value and entirely closed when the temperature of the bed is at some value below the minimum at which combustion can exist with the exception, of course, of when it is found desirable to use stops to prevent the full opening or closing of the shutters.

The last shutter at the rear of the grate may be arranged so that when it opens it operates a switch or clutch which stops or slows up the motion of the fuel bed thus preventing the dumping of the unburned fuel into the ashpit.

The thermostatic shutter controls being acted upon by individual portions of the firebed will distribute the air to the various portions of the bed in much the same way as this is done manually in the multi-pressure air box system.

The automatic draft control 17 is shown in Fig. 1 as being of the piston type, but obviously any other type may be used with similar results. The control is shown diagrammatically in Fig. 1 as operating damper lever 18 of a natural draft unit through linkage 19. Pressure tubes 20 which connect the control with the air box and the firebox are shown running to their respective destinations.

An ash removal conveyor 21 is shown as the screw type, but any other suitable type may be used or the conveyor dispensed with entirely in favor of some form of ash pan.

The general operation of the stoker is as follows:—

The fuel from hopper 2 flows by gravity, as may be seen from Fig. 1, onto the endless traveling grate 4, the rate of feed being determined by the height of the fuel gate 3 and the speed by which the traveling grate 4 is moved by sprocket wheels 5. The fuel, as it is carried away from the point of feed, is raised to its ignition temperature by the burning fuel immediately preceding it. Combustion is initiated by the air flowing through the fuel bed from air box 6 under the influence of the difference in pressure existing between the air box and the upper surface of the fuel bed. The combustion of the fuel proceeds as the grate moves slowly toward the rear of the furnace and it is completed at some point determined by the character of the fuel, the rate of air supply, the thickness of the fuel bed, and the rate of travel of the grate. Any portion of the grate beyond the point of complete combustion will have its supply of air cut off by the thermostatically controlled shutters. The ash residue from the fuel is carried to the rear of the furnace and dumped into the ash pit as the grate bends over the sprockets.

Now suppose that with the stoker operating at its rated capacity, the temperature of the room containing the customary remote control thermostat or temperature regulator rises above the value for which the regulator has been set. The regulator then makes contact and through suitable relays, etc., reduces the grate speed to the predetermined value. There is no instantaneous effect upon the stoker beyond the decrease in grate speed. However, as the fuel at the rear end of the grate begins to burn out and the area of the firebed decreases, the air shutters in this region through their thermostatic control commence to close and cut off the air to the burned out area. As the shutters close the draft control comes into action and compensates for the reduced air flow through the furnace by maintaining a constant pressure differential across 75

the active portion of the fuel bed. The reduction in the area of the firebed continues until either the load changes or the area corresponding to the minimum load, which may be called the equilibrium point, is reached.

It is to be noted that by means of the thermostatically controlled air shutters it has been possible to supply air to the residue of the fuel remaining in that area which is to become inactive by reason of a decrease in load, while at the same time these shutters have made it possible to cut off the air to this area when combustion is complete. The draft control, on the other hand, has made it possible to supply air to all active portions of the firebed at a constant rate per unit area irrespective of changes in load. This latter accomplishment means that a particle of fuel is swept by the combustion air at a constant rate at all loads and it will, therefore, have an essentially constant burning time or combustion rate. With a fixed time of combustion of the fuel particle, the net result of the decrease in grate speed has been to reduce the distance the particle will move before being consumed and thereby to reduce the area of the firebed.

It is obvious that a reduction in firebed area with a constant rate of combustion will result in less fuel being consumed and a lower heat output being obtained.

This demonstrates that the combination and correlation of a traveling grate, suitable thermostatically controlled air shutters, and an automatic draft control makes it possible to reduce the heat output of the stoker by reducing the area of the firebed while maintaining a constant rate of combustion of the fuel, and at the same time accomplishing this without undue air leakage into the furnace through the inactive area of the grate.

Now then, assume that the temperature of the room containing the remote control thermostat falls below the desired point and that the thermostat acts to speed up the traveling grate. Subsequent to this increase in grate speed, the burning fuel will commence to move into that area which was formerly inactive with the result that the temperature of this burning fuel will cause the thermostatically controlled air shutters to open and admit the necessary air for combustion. The opening of the shutters and the resulting increase in air flow will be compensated for by the automatic draft control and the rate per unit area maintained constant. The firebed being at a comparatively high temperature as a result of the constant rate of combustion, a favorable condition is present for the quick ignition of the increased feed of fresh fuel. The area of the firebed will continue to increase until either a change in load occurs or the whole available surface of the grate is again active.

It is to be observed that the thermostatically controlled air shutters have provided for the admission of combustion air to the firebed as it progressed into the formerly inactive area of the grate, and also, that the automatic draft control has made it possible to maintain a constant rate of combustion in the increased area of the firebed. The constant burning time of the fuel particle, together with the increased grate speed, has resulted in the particle traveling a greater distance before being consumed and thereby increasing the area of the firebed.

An increase in the area of the firebed at a constant rate of combustion will result in the

combustion of more fuel per unit time and therefore, in a greater heat output.

It is thus demonstrated that the combination and correlation of a traveling grate, thermostatically controlled air shutters, and an automatic draft control makes it possible to increase the heat output of a stoker by increasing the area of the firebed while maintaining an essentially constant rate of combustion, and at the same time accomplishing this without undue air leakage into the furnace through the inactive area of the grate.

In cases where extreme ranges in loading are to be encountered or where there is need for quicker responses to load changes, it may be desirable to sacrifice some of the advantages of combustion at the constant optimum rate and substitute a variable rate of combustion with such limits on the variation of the rate that the efficiency and quality of operation will not be materially affected.

The clinkering and sealing-over of the firebed can be eliminated, for with a properly selected rate of combustion and the absence of wide variations in the rate of combustion the sources of these troubles have been removed.

The use of the traveling grate stoker to carry out the new principle of heat output control eliminates the necessity for excessively high combustion rates, difficulties with feeding mechanisms, and troubles due to the lack of positive motion of the fuel during combustion.

The collection of soot on the boiler surfaces is minimized due to the fact that with relatively high firebed temperatures at all loads and a comparatively constant rate of air flow, the complete combustion of the carbon-containing volatiles is assured.

The use of thermostatically controlled air shutters make it possible to regulate the distribution of air to the various parts of the firebed and they can, therefore, be substituted for the manually controlled, multi-pressure air boxes now in use. The shutters can also be used to limit the maximum temperature of the firebed.

The automatic air shutter also makes it possible to bank fires more economically than it is done with present methods. This is because it is possible to reduce the banking fire to a small area with a comparatively high temperature instead of using the usual large, inefficient, slow-burning fire.

The description of the principle of heat output control embodied in this invention and the apparatus by which it is to be carried out has been confined to the idea of obtaining the best possible efficiency and operating results over the range of operation. There are, however, other conditions of operation and other apparatus which, because of certain factors of installation and manufacture, it might be desirable to use. The following modifications which do not affect the basic ideas involved are suggested:—

Although, certain requirements of scattered installations may make it necessary to operate the stoker either at a constant rate of combustion or over a range of rates that are widely removed from the optimum values, the present invention may be installed advantageously as long as the principle of a variable area of firebed is present for it is to be noted that the conditions of operation would be much worse were a constant area of firebed used.

As a matter of illustration, a control which de-

pend upon either the radiation of light or of heat from the fuel bed is shown diagrammatically in Fig. 4.

For purposes of clarity, the same types of stoker and air shutters which were used in Figs. 1, 2, and 3 have been retained. Of course the shutters are without the control used in Figs. 1, 2, and 3.

In Fig. 4 the chain grate is indicated diagrammatically by the belt 4-1 which is carried on sprocket wheels 5 and is driven by motor M through a worm and gear drive N. The air shutters themselves are not shown, but the arms 22 are shown attached to shafts 10-1 of Fig. 3 instead of the coil 15. These arms 22 serve to rock the shutters.

The right-hand threaded shaft 23 is supported by bearings 24 and is capable of being rotated in either direction by means of gear 25 and reversible electromotor 105. The direction of rotation of electromotor 105 is controlled by relays 103 and 104 as it will be more fully explained hereinafter. As it clearly appears from Fig. 4 and particularly from detail views Figs. 5 and 6, threaded shaft 23 carries a nut 26 having a pivoted arm 27 mounted thereon which is normally held in a vertical position by the wire spring 201. Nut 26 is provided with a slot 202 adapted to be engaged by a guiding strip 203 attached to and extending along the length of air box 6 whereby rotation of the nut is prevented. The spring retained arm 27 on the top of nut 26 serves to engage arms 22 and thereby to open or close the air shutters in accordance with the direction of motion of nut 26. When the limit of travel of one of the arms 22 is reached, spring 201 allows the arm 27 to pivot slightly and to clear arm 22 whereafter it will be returned to its upright position and is ready to engage the next shutter arm. Also attached to shaft 23 is a sprocket wheel 28 which operates chain 29. Chain 29 in turn rotates another sprocket wheel 30 on the left-hand threaded shaft 31. Shaft 31 is supported in bearings 32 and carries and operates nut 33. A suitable attachment to nut 33 engages and slides in slot 34 of the control head 35. The control head is pivoted at 36 and its rounded end 37 makes a close fit with a correspondingly shaped, slotted portion of furnace wall 38.

The sight tubes 39 and 40 attached to the side of control head 35 serve to conduct the light or heat waves from the surface of the firebed to the radiation sensitive elements contained at the end of each tube in the housing 41. These elements are of the thermoelectric type, but photoelectric cells and other like conventional radiation-responsive elements may be used with similar results, as those skilled in the art will readily understand.

The radiation sensitive elements contained in housing 41 are connected by wires 42 to relays 103 and 104. The relays serve to set the driving mechanism 105 in motion in the direction called for by the effect of the firebed radiation on the radiation sensitive elements. Driving mechanism 105 imparts motion to shafts 23 and 31 through the gear train 25. This arrangement is of a conventional character and is well known to those skilled in the art.

The lines 43 indicate the center line of sight of tubes 39 and 40 when in their extreme positions.

The operation of the control is as follows:—

It is fundamentally necessary that the ratios

of the sprocket wheels 28 and 30 and the threads on shafts 23 and 31 be such that the limits of travel of nuts 26 and 33 coincide. Under these conditions, the geometric laws applying to the similar triangles with bases consisting of the motions of the two nuts and with common apexes at pivot 36 make the motion of nut 26, and hence the opening or closing of the air shutters, correspond with the impingement of the lines of sight of the tubes 39 and 40 upon the surface of the firebed.

The position of the control in Fig. 4 indicates a minimum of area of the firebed with all shutters except the first one closed.

Assume now that the load demand increases and the grate speeds up with the result that the length of the firebed increases. When the burning fuel comes into the field of sight of tube 40, the radiation from its surface causes the radiation element of this tube, through wires 42 and relay 103, to set the driving mechanism 105 and gears 25 into motion in such a direction that nut 33, and therefore the control head 35, is moved to the left by virtue of the rotation of sprocket wheels 28 and 30, chain 29, and threaded shaft 31. This motion of the control head 35 causes the line of sight of tube 40 to move to the right and follow the progress of the firebed. The nut 26 has at the same time been moving to the right and opening the air shutters at such a rate that it keeps pace with the line of sight of tube 40 and the burned out front of the firebed.

The control will continue to operate until the load demand has changed or until the control has overtaken and passed the advancing firebed. The latter condition will exist because it is desirable that the control move at some speed greater than that of the firebed. When this happens, the control simply pauses until the radiation from the firebed sets it in motion once more.

Assume next that there is a decrease in load demand and the grate slows down. The firebed will then commence to decrease in length and will pass from the line of sight of tube 39. As the radiation through tube 39 decreases, the radiation sensitive element for this tube reduces the current flowing through wires 42 and the spring loaded relay 104, causing the spring to close the relay contacts, and the driving mechanism 105 and gears 25 are set into motion in such a direction that nut 33, and therefore control head 35, is caused to move to the right. This causes the line of sight of tube 39 to move to the left and follow the decreasing length of firebed. The control continues to move until tube 39 once again receives the radiation from the burning fuel and then it will stop. A further marked decrease in the radiation received by this tube will again set the control in motion.

Meanwhile the nut 26 has also been moving to the left and closing the air shutters under the burned out portion of the firebed and moving at such a rate that it has kept pace with the line of sight of tube 39 and the burned out front of the firebed.

This description shows that this control makes it possible to vary the area of air admittance to the grate in accordance with the area of the firebed.

It is to be observed that although the present invention provides a means whereby a constant rate of combustion may be maintained, the shutter control is independent of the rate of combustion and can be used successfully in conjunction with any system of control. Thus, it is quite pos-

sible, as in cases where great changes in loading are required, to change the combustion rate according to the load as in the conventional stokers, and then to permit our apparatus to automatically distribute the draft over the sections of the fuel bed which need air, and cut off the air to those parts which do not need air. This distribution of air is independent of the load, draft, grate speed or other factors, with the exception, of course, of the temperature effects of the fuel.

When the grate speed changes, the fuel bed does not necessarily change immediately in accordance therewith. The fuel bed area does not always change directly with the load or grate speed. There is a variable time lag. The actual length of the burning fuel bed may be registered as the result of the temperature effects of the fuel bed including particularly the effects at or near the zone where combustion is completed.

With regard to the temperature effects of portions of the fuel bed, these may be recorded and harnessed in various ways, all being a function of the emission of energy by the fuel bed which is mathematically related to its absolute temperature.

The present invention provides the art with a method of controlling the air admission to the actively burning fuel bed so that full advantage may be taken of the benefits of varying the actively burning area of fuel bed. Inefficiencies owing to unburned fuel or excess air admitted through completely burned fuel, are minimized.

There are, of course, many other mechanical devices capable of accomplishing the same results as the heretofore described automatic mechanical air shutter control, but it is to be noted that their success will depend upon the adherence to the fundamental principles which we have laid down for the proper operation of the control.

We claim:—

1. In a stoker having an advancing fuel bed, the combination which comprises a plurality of air inlet compartments, each adapted to supply air to a corresponding section of the fuel bed, and means associated with each inlet compartment for controlling the air supply to its corresponding section, said means being responsive to the emission of energy of its corresponding section of fuel bed.

2. The method of controlling the heat output of a mechanical stoker which comprises establishing a moving fuel bed, controlling the rate of fuel admission to said bed in response to room temperature changes, and varying the admission of air to various sections of the fuel bed in response to the temperature of the corresponding sections of the fuel bed.

3. The method of controlling the heat output of a mechanical stoker which comprises establishing a moving fuel bed, controlling the rate of fuel admission to said bed in response to room

temperature changes, and varying the admission of air to various sections of the fuel bed in response to the energy emission of the corresponding sections of the fuel bed.

4. The method of controlling the heat output of a mechanical stoker which comprises establishing a moving fuel bed, controlling the rate of fuel admission to said bed in response to room temperature changes, and varying the air admission to the firebed in proportion to its length.

5. In a stoker having an advancing fuel bed, the combination which comprises a plurality of air inlet means located underneath said bed and adapted to be actuated to admit and to shut off air to sections of said fuel bed, and means responsive to the temperature of said sections of said bed for actuating said air inlet means.

6. In a stoker having a moving grate, the improvement comprising an air box located below the grate, an air shutter mechanism for said air box, means for maintaining on said grate a firebed having an area varying in accordance to room temperature changes and having a constant rate of combustion, said means including an automatic pressure control for maintaining a constant pressure differential between the air box and the fire box above the fuel bed, and thermostatic means responsive to the emission of energy of the fuel bed for regulating the air shutter mechanism to admit air only to the burning and energy-emitting part of the fuel bed.

7. In a stoker having an advancing fuel bed, the combination comprising a moving grate adapted to introduce fuel into a furnace commensurate with room temperature changes, a plurality of air inlet compartments located below the grate of said stoker, each of said compartments being adapted to supply air to a corresponding section of said fuel bed, an air shutter mechanism for each of said compartments, and actuating means for said shutter mechanism for controlling the air supply to its corresponding section, said actuating means being responsive to the emission of energy of said corresponding section of the fuel bed.

8. In a stoker having an advancing fuel bed, the combination comprising a moving grate adapted to introduce fuel into a furnace commensurate with room temperature changes, a plurality of air inlet compartments located below the grate of said stoker, each of said compartments being adapted to supply air to a corresponding section of said fuel bed, an air shutter mechanism for each of said compartments, and actuating means for said shutter mechanisms, said actuating means including a sight tube having a radiation sensitive element therein responsive to the emission of energy of said corresponding section of the fuel bed.

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