Jan. 11, 1938. H. S. MORTON 2,104,883

METHOD AND APPARATUS FOR CONTROLLING FUEL BEDS

Filed April 7, 1934 3 Sheets-Sheet 1

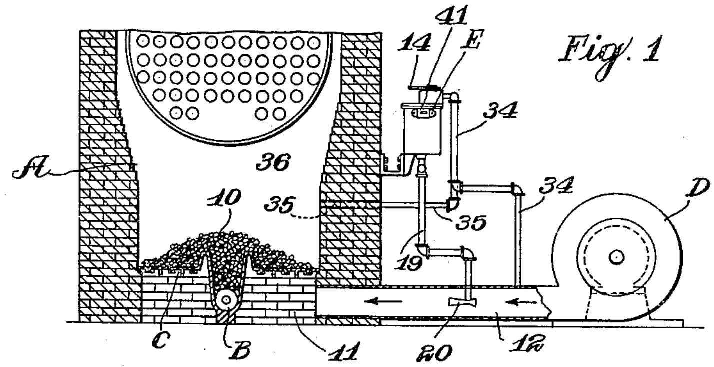

Fig. 1

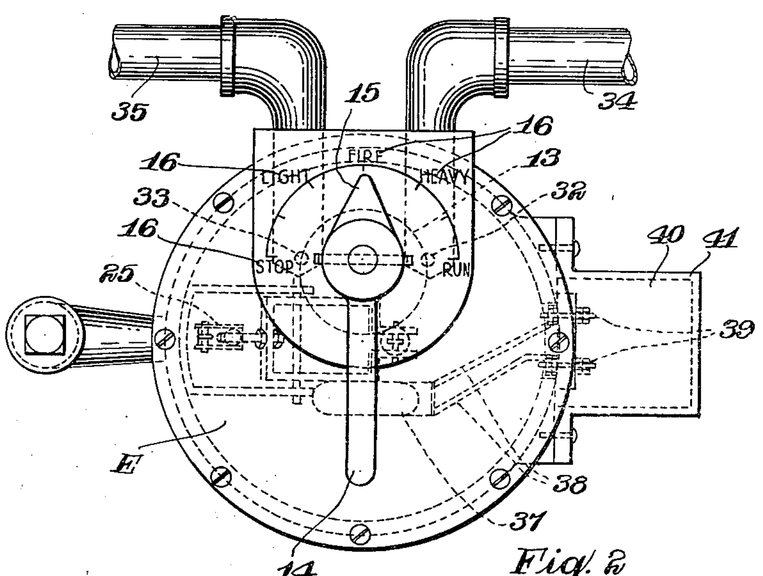

Fig. 2

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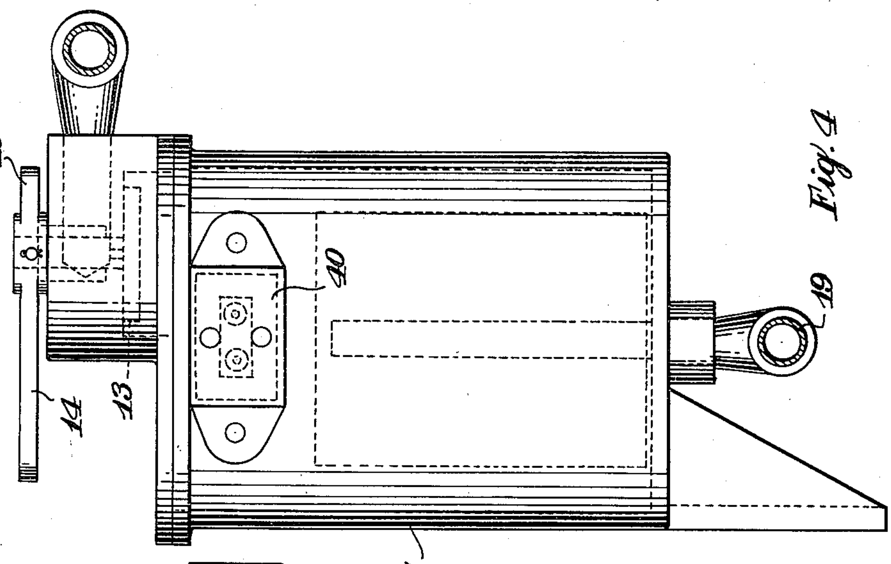

Fig. 4

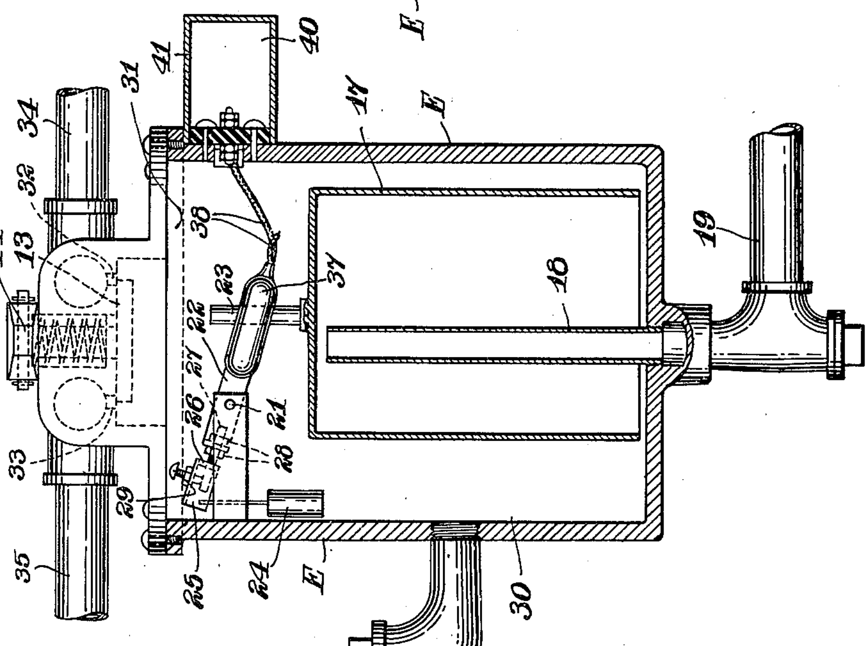

Fig. 3

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METHOD AND APPARATUS FOR CONTROLLING FUEL BEDS

Filed April 7, 1934 3 Sheets-Sheet 3

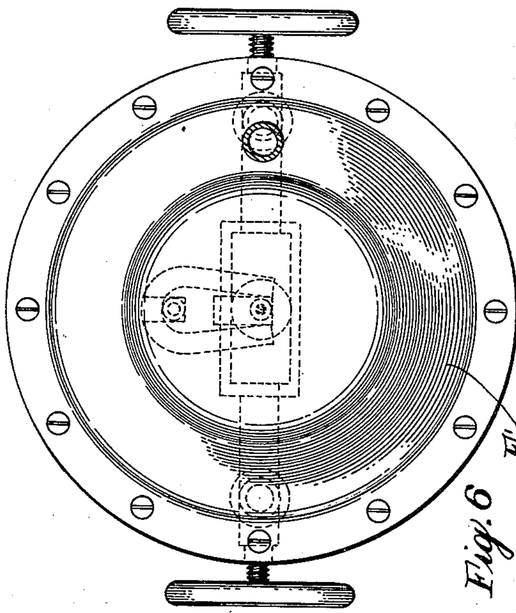

Fig. 6

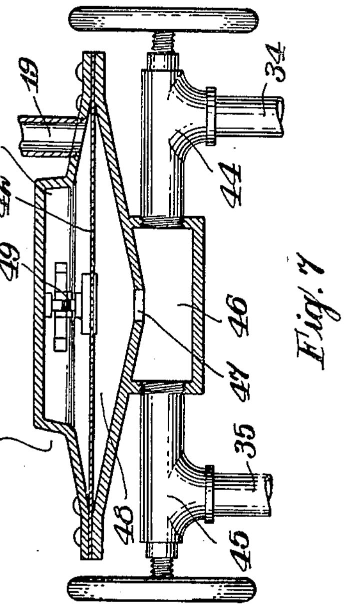

Fig. 7

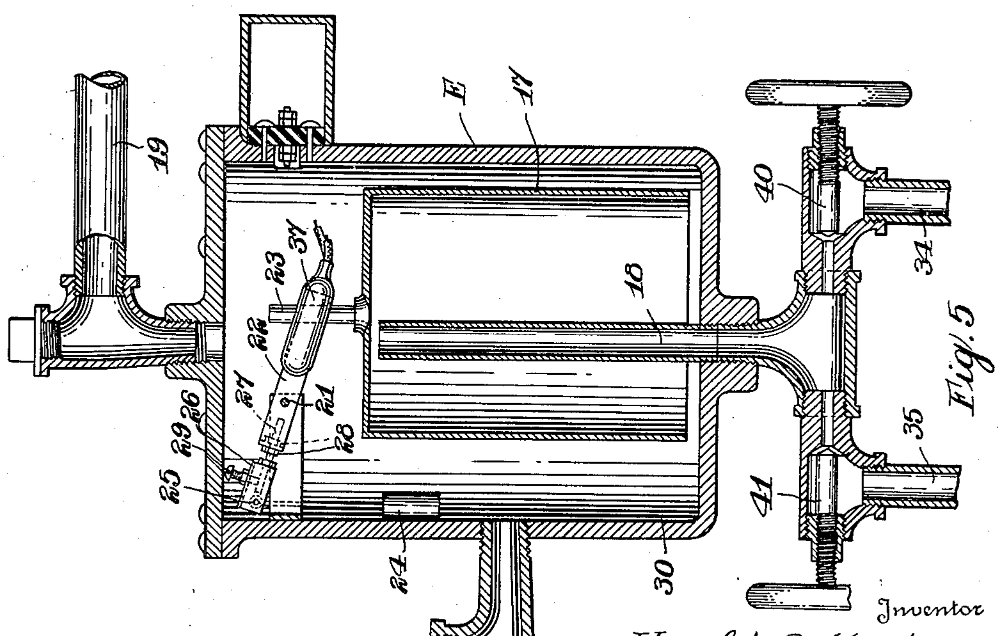

Fig. 5

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Patented Jan. 11, 1938 2,104,883

UNITED STATES PATENT OFFICE

2,104,883

METHOD AND APPARATUS FOR CONTROLLING FUEL BEDS

Harold S. Morton, St. Paul, Minn.

Application April 7, 1934, Serial No. 719,582

2 Claims. (Cl. 236—15)

My invention relates to a fuel bed control by means of which the resistance of the fuel bed may be maintained automatically to keep the bed at a desired thickness or depth.

It is the object of my invention to utilize the relationship between the rate at which air passes through the fire and the pressure differential which acts on the fire to cause this air flow. The quantity of air passing through the fire cannot be conveniently measured in the fire itself, but may be determined by any suitable means for determining its velocity of flow before it reaches the fire. I have found that if a Venturi tube is placed in an air duct through which air flows from a forced draft fan to the wind box of a stoker, that as long as the fuel bed remains approximately constant, the reduction in pressure at the throat of the venturi is in direct proportion to the pressure differential causing flow of air through the fuel bed, since both are directly proportional to the square of the rate of air flow. When the thickness of the fuel bed decreases slightly the velocity in the air duct increases, thus providing a further reduction of pressure in the Venturi throat and throwing this pressure reduction out of the desired proportion. As the fuel bed approaches proper depth, the velocity decreases, raising the reduced pressure at the Venturi throat and restoring the normal ratio between it and the pressure causing flow.

In a previous application, I regulated the fuel bed by arbitrarily proportioning the size of the air duct in which the Venturi tube was placed so that with a normal fuel bed condition the reduction in pressure at the Venturi throat was equal to the static pressure in the air duct. This resulted in exactly atmospheric pressure at the Venturi throat under normal fuel bed conditions, because the reduction in pressure due to the velocity of flow is subtracted from the static pressure in the duct and the net result is zero pressure. This, however, often necessitated an extremely high velocity in the air duct to provide a negative pressure in the Venturi throat large enough to equal and balance the positive static pressure; and it resulted in loss of pressure and capacity in the air duct so that larger fans and more power were needed to deliver the required quantity of air to the fire at the required pressure.

It is therefore the object of this invention to avoid the necessity for such high velocities and such wasteful losses of air pressure and duct capacity, by effecting proper fuel bed control when the reduction in pressure at the Venturi throat is not equal to the static pressure, but is some lesser amount which can be realized with more liberal duct dimensions and lower air velocity. This reduction in pressure is proportional, under any desired fuel bed conditions, to the pressure causing flow of air through the fire, and I utilize this proportionality in this invention, rather than the equality of pressures which was necessary in my previous invention. It is, therefore, the purpose of this invention to provide a balance between the reduction in pressure at the Venturi throat caused by air velocity, and some proportional part or fraction of the total pressure differential acting on the fuel bed.

In providing a balance between pressure differentials, various types of apparatus could be used. Inverted bells of unequal areas might be balanced against one another. Bells or diaphragms of unequal area might similarly be balanced against one another. Bells or diaphragms could be balanced against one another by linkages having a proper mechanical advantage to compensate for the ratio of the two magnitudes of pressure differentials. The result may also be accomplished by reducing the differential of higher magnitude in some definite ratio until it is on a par with the one of lesser magnitude so that a direct balance between the two becomes possible.

I have provided means for establishing an adjustable pressure differential which will always be any desired fraction of the total pressure differential acting on the fuel bed, and means of balancing this against the pressure differential caused by the venturi, so that any inequality between the two acts to change the rate of fuel feed in a way which will bring the fuel bed back to normal and restore the balance between these pressure differentials.

In carrying out my invention, I preferably provide a conduit transmitting air duct pressure to a pressure reduction chamber. Orifices, adjustable in size, control the inlet to this chamber from the conduit, and the exhaust, which is connected to atmosphere or preferably to the combustion chamber above the fire. By adjusting the size of the inlet orifice with respect to the exhaust orifice, the pressure drop through the inlet orifice can be maintained at any desired proportion of the total pressure causing air flow through the fuel bed. The pressure in the chamber between the inlet and exhaust orifices is at a pressure equal to the static pressure in the air duct minus the drop through the inlet orifice. The pressure at the Venturi throat is at a pressure equal to the static pressure in the air duct minus the reduction due to velocity at the Venturi throat. Since the two pressure differentials which I wish to balance against each other are each subtracted from the same pressure (viz. the static pressure in the air duct) it is possible to balance the pressure at the Venturi throat directly against the pressure in the chamber between the inlet and exhaust orifices described above, knowing that whenever there is an inequality between the two pressure differentials, there will be a like inequality between the differences resulting from the subtraction of two unequal pressure drops from a common initial pressure. By changing the relative sizes of the orifices, any desired proportion of the total pressure drop acting on the fire may be made to take place through the inlet orifice, and thus it is possible to arbitrarily control the fuel bed thickness at which the Venturi reduction will balance the drop through the inlet orifice. The control tends to continually maintain whatever fuel bed condition is predetermined when the relative size of the orifices is adjusted to any desired value.

In balancing the pressures as above outlined, it is possible for me to utilize a sealed bell or diaphragm which balances the pressure between the Venturi throat and a desired adjustable proportion of the pressure used in forcing air through the fire. When the velocity in the air duct becomes too great or too small in relation to the pressure causing flow of air to properly balance the adjusted diaphragm or bell, the bell or diaphragm moves, acting to close an electric switch connected therewith, for turning on or off the stoker motor.

It is also a purpose of my invention to provide a means for delaying or retarding the movement of the switch or operating means therefor. By this means it is possible to require a substantial difference in pressure between opposite sides of the diaphragm or bell before the switch will open, while the switch will close as soon as the pressure on one side of the bell or diaphragm drops below that of the other side, or vice versa. By this adjustment it is possible to maintain a perfect control of the fuel bed for every draft condition, without too frequent starting and stopping of the fuel bed.

I further provide a means of controlling the stoker motor or fuel feeding means which is sensitive enough so that even the natural draft, which draws air through the fan, duct, and fuel bed when the fan is not operating, will cause the control to operate and add fuel as needed to keep the fire from burning down too low.

The drawings disclose the apparatus which I employ to carry out the method herein by reducing the differential of higher magnitude by a definite ratio until it is on a par with one of lesser magnitude so that a direct balance between the two is obtained, to provide a sensitive, inexpensive controller for a stoker.

Figure 1 diagrammatically illustrates a portion of a fire box and stoker, showing the means and apparatus of carrying out my method.

Figure 2 is an enlarged plan view of a portion of the apparatus.

Figure 3 is an enlarged sectional side view of the apparatus illustrated in Figure 2.

Figure 4 is an outer side elevation of the apparatus illustrated in Figure 3.

Figure 5 illustrates another form of the apparatus in side sectional elevation, showing a different connection of the air pipes to the bell chamber and a different valve control.

Figure 6 is a plan view of a diaphragm control which may be used in place of the bell.

Figure 7 is a sectional view through the diaphragm control illustrated in Figure 6.

The furnace A illustrated in the drawings is adapted to be fed by a stoker feeding screw or plunger B to feed fuel 10 onto the grate or dead plate C to maintain the desired fire in the furnace A.

An air fan D provides the draft of air to the grate C through the chamber 11 through the air conduit 12 leading from the fan D to the chamber 11.

In carrying out my method I provide a controller E which is adapted to be regulated by the adjustable valve 13. The valve 13 is set into the desired position by the hand lever 14 and the indicating pointer carried by the handle 14 indicates the position of the setting of the valve. In conjunction with the pointer 15 I provide indicia 16 which may indicate a steady fire at the central setting of the valve and to one side of this central setting the indicia of "Heavy and run" is indicated, and to the other side "Light and stop". Thus when the handle 14 is set to set the valve 13 toward "Heavy" the fire and fuel bed 10 will be heavier than when the handle 14 is set with the pointer 15 toward "Light" which indicates a lighter or thinner fuel bed.

The controller E in its preferred form may be provided with an inverted bell 17, the inner portion of which is connected by the tube 18 to the pipe 19 which extends out through the bottom of the controller E and which is connected to the venturi 20 located within the air duct 12 leading from the fan D to the air chamber 11.

The bell 17 is adapted to be balanced on the pivot point 21 which supports the lever 22 which is pivotally connected to the member 23 extending from the top of the bell 17. The lever 22 is adjustably connected to the counter-balance weight 24 through the channel or U-shaped member 25 which is pivotally connected at 26 to the rod 27 extending from one end of the lever 22. The rod 27 is adjustably connected by the lock nuts 28 to the end of the lever 22 so as to set the member 25 in the desired position in relation to the end of the lever 22. The member 25 straddles the outer end of the rod 27 and is adjustable in relation to the same on its pivot 26 by means of the set screw 29 so as to raise or lower the center of gravity of the weight 24 in relation to the pivot point 21 of the lever 22. By this means the bell 17 may be adjustably counter-balanced in the bell chamber 30. The upper end 31 of the bell chamber is connected by the cam valve 13 to the ports 32 and 33. The port 32 is connected by the pipe 34 to the air duct 12 as diagrammatically illustrated in Figure 1, while the port 33 is connected by the pipe 35 to the fire chamber 36 of the furnace A.

The bell 17 is adapted to support a mercury electric switch 37 which is connected by the wires 38 to the terminals 39 which extend into the compartment 40 inclosed by the casing 41 on the side of the controller E. Suitable electric conductors, not shown, lead out from the casing 41 and from the terminals 39 to an electric motor which is adapted to operate the screw or plunger fuel feeding means B, the motor not being illustrated in the drawings, however, the feeding screw B being illustrated in Figure 1.

The mercury switch 37 is set to operate when the bell 17 is down in the position illustrated in Figure 3 or 5, so as to complete a circuit to operate the motor to feed fuel to the fuel bed 10 through the operation of the screw B. When enough fuel has been fed in to cause an increase in fuel bed resistance and a decrease in air flow, the excess of pressure below will raise the bell 17, causing the switch 37 to turn off the circuit to the motor which operates the screw B, and should the ratio become unbalanced from the predetermined requirement to maintain the fire or fuel bed 10 at the desired depth, the bell 17 will lower to operate the switch 37. In this manner the fuel bed 10 may be maintained as desired in the furnace A. The valve 13 is set by the handle 14 to adjust the ratio of air pressure between the air pressure from the venturi 20 to one side of the bell, and the connection 34 through the valve 13 to the other side of the bell, to give the desired balance through the controller E. By operating the lever 14 with the arrow 15 toward the indicia "Heavy", the duct 32 will be opened wider owing to the mounting of the valve 13 off-center, whereas, the duct 33 will be closed in proportion to the opening of the duct 32, thereby changing the ratio between that indicated through the venturi to one side of the bell, and that indicated by the connection 34 to the other side of the bell. It will be apparent that when the controller E is set that any change of the fuel bed 10 to permit more or less air to pass through the same from the duct 12 will change the air velocity and pressure in the duct 12, throwing the controller E out of balance and causing the switch 37 to be operated. In this manner I control the stoker B and maintain the fuel bed 10 as desired.

With the adjustment of the balancing means of the lever 22 of the bell 17 through the adjusting screw 29 to change the center of gravity of the weight 24 in relation to the pivot 21, I am able to retard the movement of the switch 37 in a manner so that the control will not operate at too short intervals or fluctuate back and forth rapidly between the on and off positions. While I have illustrated a means of adjusting the bell 17, any suitable means of balancing the same and adjusting the balancing means to retard the bell through a certain period may be employed. The valve 13 is adjustable to regulate a pressure reduction through the connection 34 from the duct 12 and the connection 35 from the valve to the fire chamber 36 to set the controller E for the desired ratio of operation. With this means I am able to secure a better method of controlling a stoker and the fuel bed thereof where I provide a balance by the proportional pressure differentials rather than by my former method where equal pressures were desired to be maintained to operate the controlling means. This method is more inexpensive to carry out and maintain.

In Figure 5 I have illustrated the controller E connected in a different manner than that I have just described. In this figure of the drawings I have shown the controller E with the Venturi pipe 19 connected at the top into the bell chamber 31, whereas, the pipe 18 leading inside of the bell 17 is connected through the adjustable valve 40 to the pipe 34 which leads to the air duct 12 and through the adjustable valve 41 to the pipe 35 which leads to the fire chamber 36 of the furnace A. The valves 40 and 41 operate in a similar manner as the valve 13 to balance the pressure in the controller E, excepting that they are each separate valves, thus providing means to obtain the desired pressure reduction to balance the pressure from the venturi with that from the duct through the connection 34. It will be apparent that the same result may be obtained as heretofore set forth in the description of the structure illustrated in Figure 3 with the connections as illustrated in Figure 3, excepting that the connections are reversed in Figure 5 to show that the balance ratio may be carried on through the controller E in a reverse manner. The controller E is of the same structure, but the connections into the bell and above the same are reversed.

In Figures 6 and 7 I have illustrated a diaphragm controller F which is provided with a diaphragm 42 having a chamber 43 which is connected by the pipe 19 to the venturi 20, while the valves 44 and 45 are connected by the pipes 34 and 35 to the air duct 12 and the fire chamber 36, respectively. The valves 44 and 45 are connected through the chamber 46 and the passageway 47 to the chamber 48 on the opposite side of the diaphragm 42 to the chamber 43. Within the chamber 43 I provide a suitable electric switch 49 which is connected to the diaphragm and to the casing so that in the movement of the diaphragm the switch 49 is opened or closed. The central position of the diaphragm 42 illustrated in Figure 7, shows the switch 49 with its terminals open so that the circuit operated by the same would be open when the diaphragm 42 is in the position illustrated. Suitable electrical conductors, not shown, lead from the switch 49 to operate the motor of the stoker B. The valves 44 and 45 are of the same nature as the valves 40 and 41 and may be operated in the same manner to provide a pressure reduction means in the controller F.

With my method a stoker for a furnace may be regulated to maintain a thin fuel bed on the grate for a certain type of fire or may be proportionately increased to maintain a heavier fuel bed, the primary object being in the method of controlling the fuel bed.

The method of controlling a stoker has been defined as using a controller such as E or F which are only illustrative of a means of carrying out the method. It is apparent that the method comprises controlling the fuel bed by means of the resistance of the air through the same, whereby any variations in the air velocity or static pressure in the draft duct to the grate or in the relationship between the two may be utilized to operate an electric switch or other suitable means to control the feeding of fuel to the fuel bed. It is also apparent that the method may be employed for operating any component part of a stoker so as to completely control the same.

Thus I have provided a simple method wherein the balance between proportional pressure differentials between the velocity and static in the air duct connected with the combustion chamber of the furnace may be utilized to give a more desirable means of controlling a stoker to maintain a predetermined fuel bed and fire in the furnace.

I claim:

1. A static operated controller including, a housing, a pressure bell, adjustable means for balancing said bell within said housing, an air passage connecting the draft duct of the furnace with the combustion chamber thereof, a pressure reducing valve interposed in said air passage, a venturi positioned in the draft duct of the furnace connected under said bell, said valve in said controller operating to balance the re-

duced air pressure between the draft duct and the combustion chamber in relation to the velocity pressure from the venturi to provide a predetermined setting for said controller, and an electric switch carried by said bell and adapted to be operated by the unbalancing of the bell by a change in the static pressure or velocity in the draft duct or the combustion chamber of the furnace which unbalances said controller.

2. An air operated controller for stokers and the like including, a pressure chamber, a member operated from said pressure chamber, an electric switch carried by said member, an air balancing chamber on the opposite side of said member to said pressure chamber, a venturi, means for connecting said venturi to said first pressure chamber, means for connecting one side of said balancing chamber to the air duct in which said venturi is positioned, means connecting the other side of said balancing chamber with the fire chamber of a furnace, adjustable valve means in said balancing chamber for setting said air operated controller to a predetermined balancing position between the velocity and static pressure in the draft duct as relating to the pressure in the fire chamber, whereby when the ratio between the air duct and the fire chamber changes from the setting of the air controller, said electric switch will be operated to control the fuel bed regulated by the stoker.

HAROLD S. MORTON.