To all whom it may concern:

Be it known that I, John M. Horwood, residing at Pittsburgh, in the county of Allegheny and State of Pennsylvania, a citizen of the United States, have invented or discovered certain new and useful Improvements in Regulating Combustion-Furnaces, of which improvement the following is a specification.

10 It has heretofore been the practice to regulate the rate of combustion in furnaces for boilers, etc., by and in accordance with the pressure of the steam in the boilers or gases in the combustion chamber, or both. These methods are lacking in efficiency for the reason that the pressure in the boiler does, to a considerable extent, depend upon the rate of use of the steam in engines and other motors, and hence in any system depending upon pressure, the operation of the regulating devices is due to what might be termed a secondary effect and not to a primary, i. e., the supply of steam or fluid which in itself produces this secondary effect. The pressure method of regulation is also inefficient as it is possible in the operation of a plurality of steam generators as a unit, that a number of the members of the unit will operate at full capacity and supply sufficient steam at high pressure to maintain the desired pressure of steam in a boiler operating inefficiently, and the feed of fuel, etc., to such generator will not be sufficient to bring its effectiveness up to the desired point.

The invention described herein relates to the regulation of the supply of fuel and air for the combustion of the fuel by and in accordance with the rate of use of the steam, by and in accordance with the flow of steam from the boiler and the pressure of steam in the boiler. The invention is hereinafter more fully described and claimed.

In the accompanying drawings forming a part of this specification, Figure 1 is a diagrammatic view illustrating a boiler and its settings and having applied thereto apparatus and mechanical devices for the practice of the invention; Figure 2 is a similar view illustrating a modified arrangement of the mechanism; Figure 3 is a sectional view on a large scale of a form of differential mechanism operated by differences between the static pressure and the total pressure of steam flowing along the steam supply pipe and adapted to operate other devices or apparatus for controlling the feed of fuel and the forced draft; Figure 4 is a sectional view on an enlarged scale of the valve mechanism shown in Figure 3; Figure 5 is a detail view showing a portion of the compensating mechanism shown in Figure 3; Figure 6 is a sectional view of a balanced valve usable for controlling operations of stoking mechanism; Figure 7 is a sectional view on an enlarged scale of a form of Pitot tube employed in the practice of the invention; Figure 8 is a sectional view of a device which can be used in lieu of the Pitot tube; Figures 9 and 10 are diagrammatic views showing the adaptability of the invention for controlling combustion when liquid or gaseous fuel is employed; and Figure 11 is a detail view of a modified form of mechanism for controlling the feed of fuel to the furnace.

In practice the improvements are applied to any form or type or construction of furnace for boilers and other purposes. Any suitable type of stoking mechanism indicated at 1 may be employed for feeding fuel into the fire chamber 2, and the ash-pit 3 has connected thereto one end of an air conduit 4 extending from a blower 5 operative by any suitable form of motor such as the steam motor 6 as shown in Figure 1. In the form of apparatus shown in Figure 1, the fuel is forced in upon the grate by a plunger 7, operated through suitable mechanism by the steam cylinder 8 which is connected through a balanced regulating valve mechanism 9 of any suitable construction, to the boiler. A suitable construction of regulating valve is shown in Figure 6. In the pipe 10 extending from the boiler to the engine 11 or other user of steam, is arranged what is known as the Pitot tube 12, the respective passages in such tube being connected by pipes 13 and 14 to opposite sides of a shell 16 across which is arranged a diaphragm 16 as clearly shown in Figure 3. This diaphragm motor may be of any suitable construction. The diaphragm 16 of this motor will be shifted in one or the other direction in accordance with variations of pressure due to changes in the rate of flow through the pipe 10, i. e., the amount of steam used in the engine or otherwise. This diaphragm 16 is adjustably connected by an arm 17 to a pivotally mounted frame 18 as shown in Figure 3. On the frame 18 is 110
... pivotally mounted a bell crank lever 19 having one end connected to the rod of the piston valve 20 arranged in the valve casing 21. The opposite end of this bell crank lever is connected by a rod 22 to a pin 23 on the pivotally mounted standard 24, as clearly shown in Fig. 3. A shoe 25 is pivotally mounted in the upper end of the rod 24 and is adapted to be engaged by and permit of the movement of an angle rod 26, which is so mounted on the frame 27 as to permit of its angular adjustment. The frame 27 is secured to a rod 28 having its upper end connected by an arm 29 to the piston rod 30 of a fluid pressure cylinder 31. In the operative mechanism just described, the movement of the diagram will shift the piston valve 20 in the shell 21 so as to admit fluid pressure to one or the other of the pipes 32 or 33, connected respectively to the upper and lower ends of the cylinder 31, and thereby causing a movement of the piston 34 in said cylinder. As the piston moves up or down, the angle rod 26 will also be shifted and by reason of its inclination as indicated in Fig. 3 will rock the standard 24, and by reason of the engagement of this standard through the rod 22 with the bell crank lever 19, will shift the valve 20 in the opposite direction to that imparted to it by the movement of the frame 18, thereby cutting off any further flow of fluid under pressure to the cylinder 31.

As clearly shown in Fig. 4, the valve mechanism controlled, as above described, consists in an outer shell 21 within which is arranged a sleeve 35 having rings forming a steam tight fit with inner wall of the shell 21, forming annular spaces for the flow of steam as hereinbefore described. The steam enters by the port through the pipe 36 to an annular space 37 and thence through port 38 into the interior of the shell and escapes in the shown position of the valve through the port 39 into the annular space to which the pipe 32 is connected. At the same time, the steam will flow from the lower end of the cylinder 31 into the annular space 40 of the valve, thence by the port 41 to the interior of the sleeve whence it will escape from the valve casing. The position of the valve shown in Fig. 4 is effected by the movement of the valve imparted thereto by the diaphragm, but as soon as the piston 34 is shifted downwardly a distance predetermined by the angle rod 26, the lever 19 will be so shifted as to move the valve 20 down, closing the port 39 and thereby preventing the further movement of the piston 34. To the piston 34 is connected, as before stated, a rod 30 and an oppositely arranged rod 39. A rope 50 or other flexible means which is connected to one of the rods as 30, passes around guide pulleys 51 to a rod 52 of the regulating valve mechanism 9. A rod 53 projecting from the opposite end of the valve mechanism 9 is connected to a rope 54 which passes around guide pulleys 70, one or more times around a drum 55, around a guide pulley 57, one or more times around a drum 58, around a guide pulley 59 to the rod 30. The drum 56 is connected to the shaft of a damper 60 arranged in the 75 air conduit 4 leading to the ash pit, while the drum 58 is secured to the shaft of a damper 61 arranged in the stack of the boiler.

It will be readily understood that upon a variation of the pressures exerted on opposite sides of the diaphragm 16, due to changes in the rate of flow of steam through the pipe 10, the piston in the cylinder 31 will be shifted and in accordance with such movement, will shift the piston of the valve in the mechanism 9 so as to vary the rate of feed of fuel on to the grate bars and will also change the position of the damper 60 in the air blast conduit 4, so as to shift more or less air into the under side of the grate. When a damper is employed in a stack as described, it will also be shifted at the same time with the changes of the mechanism for feeding fuel and controlling the air blast so as to permit a greater or less flow of products of combustion through the stack.

In the practice of the invention, the various mechanisms will be set so as to operate in accordance with the changes in the rate of flow or use of the steam, the quantity of steam required under normal conditions being known, as also the quantity of coal necessary to be burned to produce such quantity of steam and the volume of air required for effecting such combustion of the fuel. Supposing for example it requires one thousand—(1000)—pounds of steam in a predetermined time to normally operate the engine 11 the amount of coal which must be fed on to the grate bars and consumed in order to effect the generation of such quantity of steam in a given time can be readily determined as also the quantity of air required for such combustion. Having determined these factors, the setting of the apparatus to operate under normal conditions can be readily effected and any change from these normal conditions either up or down will produce an adjustment through the mechanisms described, of the feed of the coal and the quantity of air forced into the ash pit.

In Fig. 2 is shown an embodiment of the improvement in which a natural draft is employed, as is necessary when employing chain grate stokers. In such an installation only the rate of feed of the fuel and the flow of products of combustion from the furnace are regulated by and in accordance with the rate of flow of the products of combustion from the furnace.
with the quantity of steam passing through the outlet pipe 10.

As will be readily understood by those skilled in the art, the fluid pressure motor employed for feeding fuel as shown in Fig. 1, may be replaced by an electric motor 67, as shown in Fig. 2. In such a case a rheostat 68 will be substituted for the regulating valve mechanism 9, shown in Fig. 1 and the controller arm 69 of the rheostat will be connected to the motor 31.

If desired, this chain grate of the stoking mechanism may be operated step by step, as shown in Fig. 11, by securing a ratchet wheel 70 to one of the shafts of the stoking mechanism. This ratchet wheel is shifted by the oscillations of the lever 71, carrying with it the attached disk 72, and the lever is reciprocated by means of a constantly rotating shaft 43 through suitable mechanism, such as an eccentric mounted on the shaft and having its strip connected by a pitman 44 to a sleeve 45 slidably along the lever. The position of the sleeve on the lever and consequently the movement of the grate, is controlled by the motor 31.

It is characteristic of the methods and mechanisms heretofore employed for combustion, that regulation was effected by or in accordance with variations in what has been termed herein, secondary or resulting effects, i.e., pressure in the boiler, pressure in the combustion chamber and the flow of products of combustion or by or in accordance with combinations of such secondary effects; but the main characteristic of the invention described herein is the regulation of the fuel supply and the supply of air to effect combustion by and in accordance with the quantity of steam drawn from the boiler and entirely independent of any variations of pressure in the boiler resulting from the flow of steam to the point of use.

In the form of apparatus shown in Fig. 1, the fan is operated to give a constant volume of air in a given period of time, the operation of the engine being controlled by a Mason or other type of regulating mechanism 62. It may at times happen that the adjustment of the mechanism hereinafter described may not be such as to maintain the desired supply of steam and consequently the pressure in the boiler may drop when fuel and air feed when to the widest extent to which they have been adjusted. In such contingency, the Mason regulator as it is operative in accordance with changes of pressure in the boiler and controls the operation of the fan will permit of an increased operation of the fan. In order to effect the given period of time under such abnormal conditions, provision is made for increasing the rate of fuel feed. A convenient means to this end consists in so adjusting the fuel feed mechanism as to operate at a pressure below that desired to be maintained in the boiler and to insert in the steam supply pipe 63 a pressure reducing valve 65 of any suitable type, whereby a lower pressure may be employed to operate the fuel feed mechanism. A connection is made as indicated from the regulator controlling the fan engine by a rope 66 to the pressure reducing valve so that when the Mason regulator operates, to permit of the operation of the fan at a higher speed, the reducing valve 65 will be correspondingly adjusted so as to permit a higher pressure to flow to the stoking mechanism and thereby increase the feed of fuel. On the return of the Mason regulator to conditions to which it had been set for normal operation, the reducing valve may be returned to normal position by a weight or other suitable means.

In lieu of the Pitot tube, shown in Figs. 1 and 7, a disk 66 with an orifice less than the diameter of the pipe 10 may be arranged therein and the pipes 13 and 14 connected to the pipe 10 on opposite sides of this disk, as clearly shown in Fig. 8.

As shown in Figs. 9 and 10, the invention described herein may be applied for controlling the flow of liquid or gaseous fuel to a burner 67 and also the flow of air necessary for supporting the combustion of such gaseous or liquid fuel.

I claim herein as my invention:

1. The method herein described of controlling combustion in furnaces which consists in regulating the supply of fuel in accordance with the flow of steam from the boiler and varying the feed of said fuel in accordance with variations in the static pressure of the steam.

2. The method herein described of controlling combustion in furnaces, which consists in regulating the feed of fuel and the flow of air to support combustion in accordance with the flow of steam from the boiler and varying the supply of air in accordance with variations in the static pressure of the steam.

3. The method herein described of controlling combustion in the furnace of a boiler which consists in forcing air into the fuel and simultaneously regulating such feed of air and the discharge of gases from the furnace in accordance with the flow of steam from the boiler.

4. The method herein described of controlling combustion in furnaces which consists in normally regulating the supply of fuel and air to the combustion chamber in accordance with the rate of flow of steam from the boiler, and varying the supply of fuel and air in accordance with the variations of pressure of steam in the boiler.

5. The method herein described of controlling combustion in furnaces which con.
consists in regulating the feed of fuel and the flow of air to support combustion in accordance with the flow of steam from the boiler and varying the supply of fuel in accordance with variations in the static pressure of the steam.

6. The method herein described of controlling combustion in furnaces which consists in regulating the supply of air to the combustion chamber and escape of products of combustion from the furnace by and in accordance with the flow of steam from the boiler, and varying the supply of air by and in accordance with variations of the static pressure of the steam.

7. The method herein described of controlling combustion in a furnace which consists in regulating the escape of gases from the furnace and the supply of air and fuel to the furnace in accordance with the rate of flow of steam from the boiler and varying the supply of air and fuel in accordance with the variations of static pressure.

8. The method herein described of regulating the combustion in furnaces which consists in regulating the fuel and air supply by and in accordance with changes in the rate of flow of steam from the boiler and changes in the pressure of steam flowing from the boiler.

9. The method herein described which consists in utilizing the vapor in a boiler at a pressure somewhat below the normal boiler pressure to control the feed of fuel and air to the furnace of the boiler, varying the rate of such feed by and in accordance with the rate of flow of steam from the boiler, and speeding up such feed on a drop of pressure below a predetermined minimum.

In testimony whereof I have hereunto set my hand.

JOHN M. HOPWOOD.