F. H. BROWN AND J. M. HOPWOOD.

COMBUSTION REGULATING METHOD AND MECHANISM.

APPLICATION FILED FEB. 12, 1920.

1,338,899. **Patented May 4, 1920.**

2 SHEETS—SHEET 1.

Fig. 1.

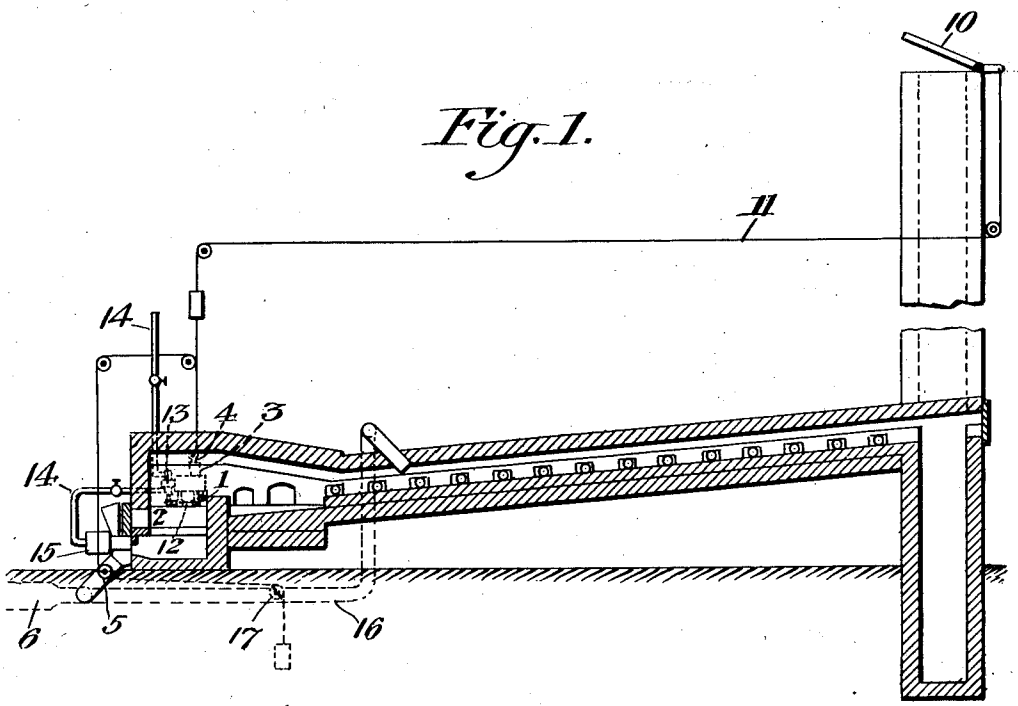
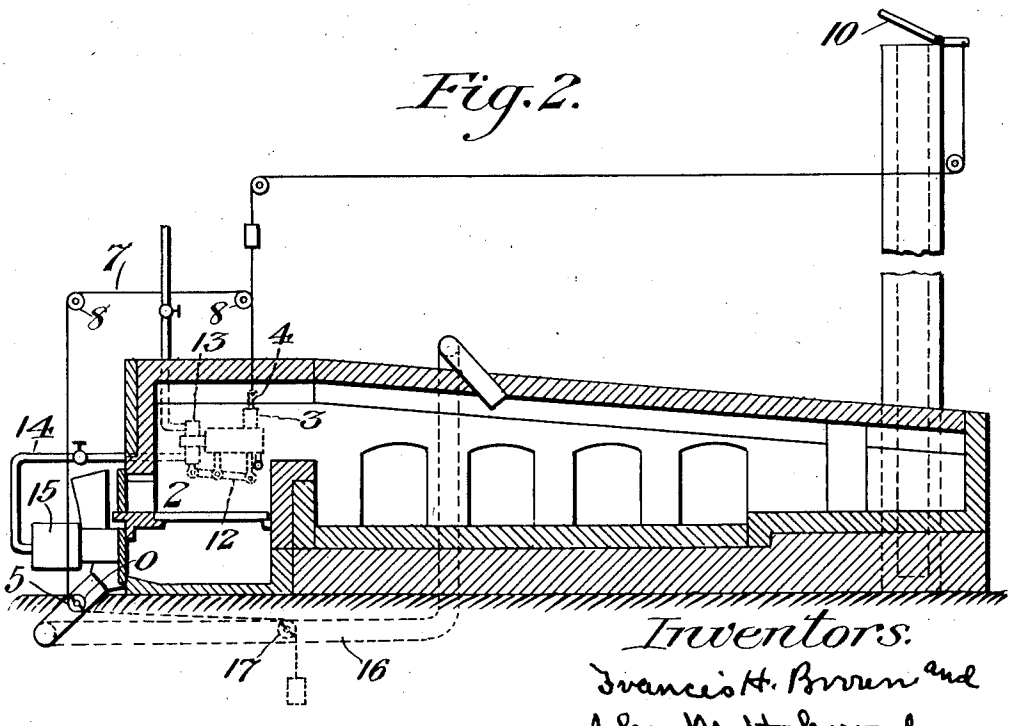


Fig. 2.



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2 SHEETS—SHEET 2.

Fig. 3.

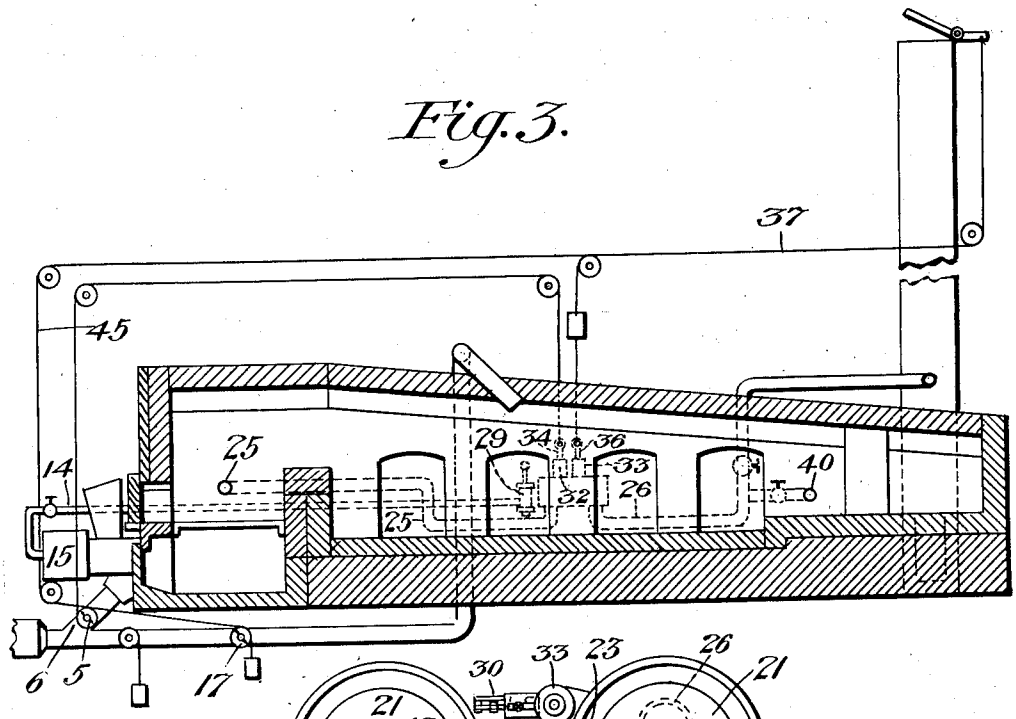


Fig. 4.

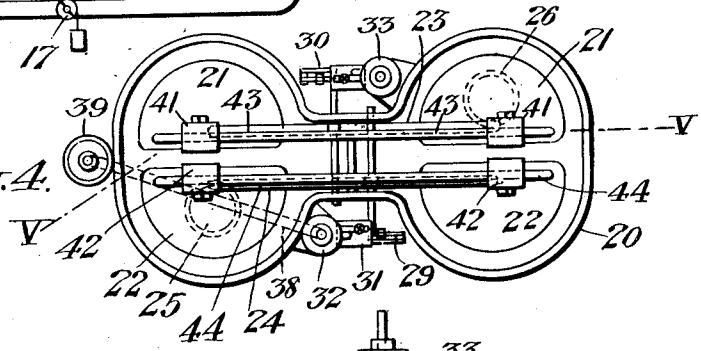
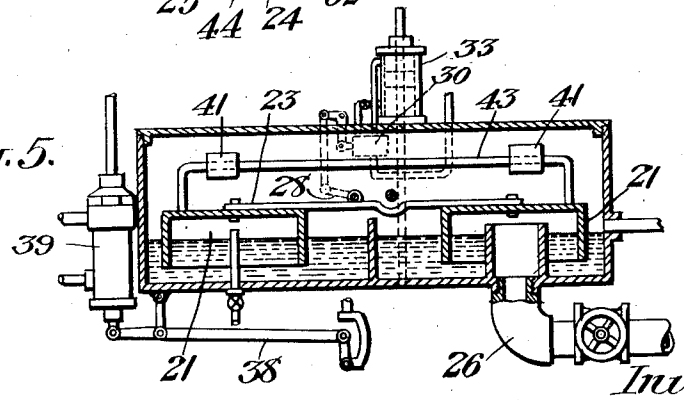


Fig. 5.



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FRANCIS H. BROWN, OF PHILADELPHIA, AND JOHN M. HOPWOOD, OF PITTSBURGH, PENNSYLVANIA; SAID BROWN ASSIGNOR TO SAID HOPWOOD.

COMBUSTION-REGULATING METHOD AND MECHANISM.

1,338,899. Specification of Letters Patent. Patented May 4, 1920.

Substitute for application Serial No. 206,464, filed December 10, 1917. This application filed February 12, 1920. Serial No. 358,090.

To all whom it may concern:

Be it known that we, FRANCIS H. BROWN and JOHN M. HOPWOOD, residing, respectively, at Philadelphia and Pittsburgh, in the counties of Philadelphia and Allegheny, respectively, and State of Pennsylvania, citizens of the United States, have invented or discovered certain new and useful Improvements in Combustion - Regulating Methods and Mechanism, of which improvements the following is a specification.

The invention described herein relates to certain improvements in the control of the operations involved in the combustion of fuel for the heating of furnaces for metallurgical and other purposes such as continuous furnaces, sheet furnaces, etc. The invention has for its object the regulation of the flow of products of combustion from the fire box and furnace by and in accordance with the pressure of gases in the fire box or heating chamber or both, and the regulation of the feed of fuel to the combustion chamber. The invention is hereinafter more fully described and claimed.

In the accompanying drawings forming a part of this specification, Figure 1 is a sectional elevation of a continuous billet heating furnace, having our improvement applied thereto; Fig. 2 is a similar view of an ordinary plate or sheet heating furnace having the rate of feed of fuel and the flow of air for combustion controlled by and in accordance with the pressure of gases in the fire box or heating chamber; Fig. 3 is a view similar to Fig. 2 showing an embodiment of the improvement in which the regulation is effected by and in accordance with pressures in one or more parts of the furnace; Fig. 4 is a plan view of the pressure controlled regulating mechanism employed when dual control is desired, and Fig. 5 is a sectional elevation, the plane of section being indicated by the line V—V, Fig. 4.

It has been found in the operation of heating furnaces that under normal conditions the supply of air and fuel should bear a certain predetermined relation to each other, so as to maintain conditions necessary for the desired and uniform combustion effects. As for example, if through inattention or for other reasons, the bed of burning fuel becomes thin or holes are formed therethrough, permitting a too great flow of air through, the heating efficiency will be reduced and the flow of air through the fire box into the furnace must be reduced until the fuel is restored to normal conditions. On the other hand, if the feed of fuel is such that sufficient air cannot be forced through the bed to permit of a complete combustion of the gases generated, the rate of feed of fuel should be reduced and preferably the feed of air increased.

In the practice of the invention, provision is made for regulating the flow of air to the fire box by any suitable means known in the art and also for regulating the flow of gases and products of combustion from the furnace by the employment of any suitable means known in the art, such for example as the damper shown at the top of the stack. Under normal conditions, *i. e.*, with a fuel bed of proper thickness and without any holes or openings therethrough, the means controlling the flow of air to the fire box and the damper on the stack are adjusted so as to maintain such a pressure within the fire box as has been found to exist with a rate of combustion in the fire box necessary to produce the desired heat conditions. A convenient method of regulating the flow of air through the fire box by and in accordance with the pressure of gases in the latter, consists of a furnace-pressure-actuated device such as described and shown in Letters Patent No. 1,150,097, dated August 17th, 1915. A conduit 1 having one end connected to the fire box 2 of the furnace projects up within an inverted shell or bell of the device shown in said patent, and as the lower edge of this bell or shell is immersed in a liquid, any change of pressure in the furnace will cause a corresponding change in the position of the bell, the latter raising when the pressure increases and dropping when the pressure diminishes. This bell is connected by a suitable means to a valve mechanism controlling the flow of fluid under pressure to and from the fluid pressure cylinder 3. The piston of this cylinder is provided with a rod 4 extending through opposite ends thereof and one end connected in any suitable manner to suitable means whereby the flow of air through the conduit to the ashpit of the furnace may be varied. In the construction shown, air is forced by a blower (not shown) through the conduit 6 into the

fire box, its rate of flow being controlled by a damper 5, connected by suitable means to the rod 4 of the cylinder 3. A convenient form of connection consists of a cord or other flexible means 7 extending from the piston rod 4 around suitable guide pulleys 8 and connected to the drum 9 on the shaft of the damper 5. The damper 10 controlling the flow of gases from the furnace is similarly connected by a cord 11 to the piston rod 4.

As the pressure in the fire box 2 changes, *e. g.*, increases by reason of the thinness of the bed of fuel, or openings therethrough, thereby permitting an increased flow of air into the firebox, the piston rod 4 will, through the described mechanism, be so shifted as to effect a progressive closing of the dampers 5 and 10. At the same time, provision is made for a corresponding increase of feed of fuel so as to restore the bed of fuel in the fire box to normal thickness and close any holes or openings therethrough. To effect this increase of feed of fuel, the piston rod 4 is connected to one end of a lever 12 having its opposite end connected to the movable element of a valve mechanism 13 which controls the flow of steam or other fluid through pipe 14 to the motor 15 of the stoking mechanism. As fuel is fed to the furnace, the flow of air from the conduit will meet with resistance due to the increased quantity of fuel so that the pressure in the fire box will be reduced. This reduction in pressure will effect, through the described mechanism, a gradual opening of the dampers 5 and 10 so as to permit such an increase in the flow of air as is required for the combustion of the fuel so fed. As the pressure actuated controlling mechanism will respond to small changes of pressure in the fire box, the shifting of the means for controlling the flow of air to and the escape of products of combustion from the furnace will be gradual and the rate of operation of the fuel feeding mechanism will correspond to the incremental changes of pressure.

In some cases it may be desired to so adjust the combustion in the fire box that complete combustion of the gases generated therein will not be effected in the fire box, provision being made for what is termed a secondary combustion at a point beyond the fire box and in the heating chamber. In such cases, the conduit 6 is provided with a branch pipe 16 leading to the point at which it is desired to introduce air for the secondary combustion. In order that the air for secondary combustion may have suitable ratio as regards pressure and volume to that supplied for primary combustion, its flow is controlled by a damper 17. This damper is controlled by the movement of the piston rod 4 of the cylinder 3 so as to be opened and closed as the pressure rises and falls in the fire box or heating chamber.

Some furnaces have their stack connection located a considerable distance from the fire box and the charging or discharging doors so located that the opening of either or both of the doors will cause a change of pressure which would affect the controlling mechanism although conditions in the fire box were normal. In order to maintain a substantially uniform pressure in all parts of the furnace, provision is made for controlling the stack damper by and in accordance with pressures in the stack or portions of the furnace at a distance from the fire box.

While in such cases, two independent pressure actuated devices such as shown in Figs. 1 and 2 and hereinbefore described, may be employed, one of the mechanisms being connected to the fire box by a conduit is employed for adjusting the feed of air and fuel to the fire box, while the other mechanism is connected to the stack or other part of the furnace and is employed for shifting the stack damper. It is preferred, however, to employ the twin mechanism shown in Figs. 3, 4 and 5. This mechanism consists of a tank or shell 20, which is preferably constructed with enlargements at its ends in which are arranged one member of each pair of inverted cups 21 and 22, the members of each pair being connected to the respective ends of levers 23 and 24. These cups are made of substantially equal dimensions and are so supported by the levers as to be partially submerged in the liquid contained in the tank. Conduits 25 and 26 leading from the different portions of the furnace as hereinafter described, project up into the one cup of each pair, so that any change of pressure in the portions of the furnace to which the respective conduits are connected, will cause movement of the cups. One of the cups of each pair is actuated in accordance with changes of pressure and the other serves to control such movement, operating as a fluid pressure cushion limiting the extent of movement of the pair and serving to restore the pair to normal position after being moved by changes in furnace pressure. The cushioning effect is regulated by admitting more or less air into the adjusting cups through valves 27. The pivotal shafts of the levers 23 and 24 are provided with arms 28 and 29, having their outer ends connected by bell-cranks to valve mechanisms 30 and 31 adapted to control the flow of fluid under pressure to and from the respective ends of cylinders 32 and 33. The rod 34 connected to the piston of the cylinder 32 is connected by any suitable means such as the cord 35 to the damper 5 in the air conduit. The rod 36 connected to the piston

of cylinder 33 is connected by suitable means such as the cord 37 to a damper controlling the flow of products of combustion from the furnace.

The piston rod 34 has its lower end connected by a lever 38 to the stem of a valve mechanism 39 controlling the flow of fluid under pressure through the pipe 14 to the motor 15 of the fuel feeding mechanism, as the stoker.

It will be observed that the feed of fuel and air to the fire box is controlled by the part of the mechanism connected by conduit 25 to the fire box, as changes of pressure of gases in the fire box are most generally due to changes in the fuel bed. Changes in the pressure of gases in portions of the furnace will be due in most cases to the opening of charging and discharging doors, and it is not desirable that changes from such causes should affect the conditions of combustion in the fire box, unless the abnormal conditions in the parts of the furnace remote from the fire box should be continued for a relatively long time.

In order to prevent fluctuations of pressure due to the opening of charging or discharging doors affecting combustion operations, the conduit 26 connected with the other member of the twin regulating mechanism, is connected either to the stack or by a valved branch 40 leading to any desired point of the heating chamber of the furnace. In case of a drop of pressure in or adjacent to the point or points to which conduit 26 is connected, the cup 22 will be shifted thereby shifting the valve mechanism 32 to admit fluid under pressure to the lower end of cylinder 33, causing an upward movement of the piston of this cylinder and thereby permitting of a closing movement of the valve controlling the flow of products of combustion from the furnace. As soon as pressure in the furnace has been restored to normal, the damper will be automatically shifted to maintain the normal predetermined pressure in the furnace.

In order to adjust the regulating mechanism to operate at any pressure or pressures, desired in the furnace, counterweights 41 and 42 are slidably mounted on rods 43 and 44 carried by the respective pairs of cups. By shifting these weights along the rods, the cups will be held stationary except on a change of pressure in the furnace from a normal or predetermined pressure.

The employment of means for controlling the stack damper by and in accordance with variations of pressure in the portions of the furnace remote from the fire box, as the rear portion of the furnace or in the stack, is useful when providing for secondary combustion of the gases after leaving the fire box. Such secondary combustion will result in an increase in the volume of gases and consequently an increase in pressure in the furnace, and when the stack damper is controlled by and in accordance with pressure in the fire box, the increase of pressure due to secondary combustion will extend back to the fire box and cause a change in the flow of air and the feed of fuel to the fire box at times when combustion conditions in the fire box are normal. But by controlling the damper regulating the flow of products of combustion from the furnace by variations of pressure intermediate the point of secondary combustion and such damper, any changes due to secondary combustion or other causes, which will affect combustion in the fire box are compensated for. It is also desirable to regulate the supply of air for secondary combustion by and in accordance with changes of conditions in portions of the furnace posterior to the point of secondary combustion, and to this end the damper 17 is connected by any suitable means as a cord 45 to rod 36 of the cylinder 33.

While the invention is shown and described in connection with solid fuel, it will be readliy understood by those skilled in the art that the flow of other forms of fuel such as liquid or gaseous fuel, can be regulated by and in accordance with the pressure of gases in the furnace, and under the term "furnace" is included both the fire box and stack, through the mechanism described, and other corresponding changes can be made in the flow of air necessary for the support of combustion by using such forms of fuel.

This application is filed in place of application Serial Number 206464 filed December 10, 1917, but became abandoned February 23, 1919.

We claim herein as our invention:

1. The method herein described of controlling combustion which consists in regulating the supply of air for combustion in a furnace by and in accordance with the pressure of gases in the furnace and varying the rate of feed of fuel inversely to the rate of supply of air.

2. The combination of a furnace, means for feeding fuel to the furnace, means for causing a flow of air to the furnace for combustion, means adapted to be operated by variations in the pressure of gases in the furnace from a predetermined standard for varying the rate of flow of air inversely and proportionally to changes of pressure in the furnace and means for varying the rate of feed of fuel inversely proportional to the flow of air.

3. The method herein described of controlling combustion in furnaces, which consists in varying the flow of air and the feed of fuel by and in accordance with variations in the pressure of gases in the furnace, one

