April 27, 1943. F. H. LOFTUS 2,317,927

COMBUSTION CONTROL

Filed Nov. 19, 1941

Fig. 1

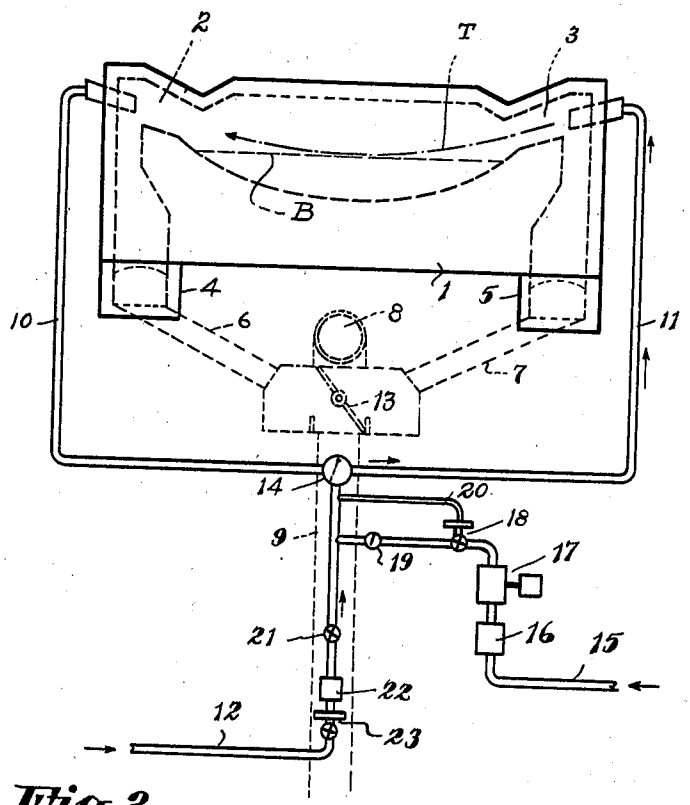
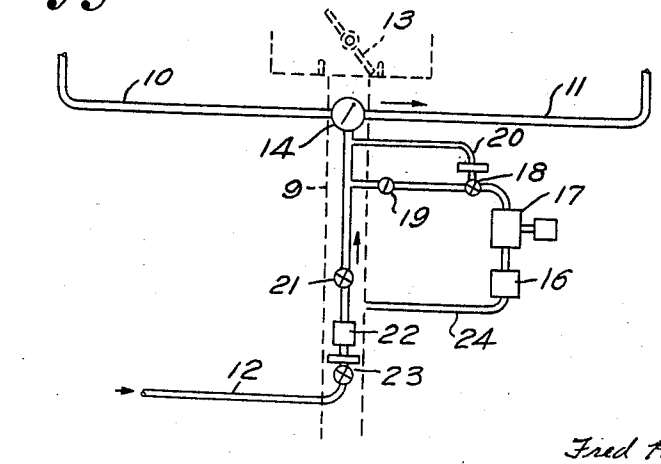


Fig. 2



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COMBUSTION CONTROL

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3 Claims. (Cl. 158—117.5)

The invention relates to industrial furnaces, such as the metallurgical furnaces used in the smelting and refining of metals, glass, and the like, and furnaces used in the heating and annealing of articles formed of metal, glass, or other material.

More particularly, the invention relates to the combustion of fuel that is required in the operation of such furnaces. The invention consists in improvements in method.

In the operation of an industrial furnace, the rate at which the flame-sustaining fuel and air are projected into the furnace chamber is essentially subject to control, in order that the rate of heat generation within the furnace may be regulated, and in many cases it is desirable that the flames within the furnace shall be held to definite paths or trajectories, this being particularly true in the case of the open-hearth furnaces of the steel industry.

I shall describe the invention as it is practised in the operation of a gas-fired open-hearth furnace, with the understanding that the description is exemplary of the many other fields in which the invention will find utility.

The usual open-hearth furnace is fired through a port at one end of the furnace, and the products of combustion escape through a port at the opposite end. From time to time the operation is reversed, and the port which had been serving as the firing port becomes the outgo port, and the port which had been serving as the outgo port becomes the firing port. As already mentioned, it is desirable that (in the intervals between such reversals) the flame projected from the firing port shall be held to a predetermined trajectory, the object being to "hold" the flame, hot gases, and heat in the region of the furnace chamber in which they will operate with greatest effect upon the furnace charge, and with minimum deleterious effect upon the refractory roof and walls of the furnace structure. While it is possible so to design a furnace that, for a given fuel and a given temperature of furnace operation, the flame will have the desired trajectory, the conditions of service have hitherto prevented the full realization of such desideratum. Specifically, the temperature within the furnace must be modified as the steel-refining operation progresses, and for this reason the quantity of fuel delivered into the furnace must be varied, with the consequence that the volume and velocity of the combustible mixture projected into the furnace are altered, whereby the flame follows a different path than that desired.

With these circumstances in mind, it is to be understood that my invention consists in an improved method of holding the flame to the desired trajectory, while varying the heat-producing effect of the flame. In accordance with the invention, an adulterant is mixed with the stream of fuel gas which flows under pressure into the firing port of the furnace, and such adulterant consists in fluid fuel of different B. t. u. value than said fuel gas, or in some cases it may consist partly or entirely of a non-combustible fluid. The quantity of the fuel, which comprises one of the ingredients of the mixture, is adjusted according as the temperature requirements of the furnace vary, while the quantity of the adulterant (the adulterant comprising the other ingredient of the mixture) is regulated under the effect or influence of the pressure of the mixture in such manner that the velocity of the mixture is held to substantially constant value. Thus, the B. t. u. content of the mixture is modified as need be, and the flame held to the predetermined optimum trajectory.

In the accompanying drawing, Fig. I illustrates an open-hearth furnace diagrammatically in side elevation, and in association with the furnace apparatus for the practice of the invention is shown schematically. Fig. II is a fragmentary view of the apparatus, illustrating a modification.

Referring to the drawing the open-hearth furnace 1 is provided at its ends with conventional ports 2 and 3. The ports communicate through regenerator chambers 4 and 5 and flues 6 and 7, respectively, with an air inlet 8 and a stack duct 9. Fuel pipes 10 and 11 extend from a fuel supply pipe 12 to the furnace ports severally, and the usual reversing valves 13 and 14 are arranged in the flue and fuel-delivering systems, as shown.

In the customary operation of the furnace, the port at one end of the furnace (the port 3, as here shown) serves as the firing port, while the port at the opposite end of the furnace (the port 2) serves as the outgo port. The valves 13 and 14 are so adjusted that fuel (in this case natural gas or coke-oven gas) flows from supply pipe 12 and through pipe 11 to the port 3, while air enters flue 7 from inlet 8, and streams upward through the hot checkerwork of regenerator 5 into the port. The fuel and air intermingle in the port and provide a combustion-sustaining mixture that in known way streams into the furnace chamber that bears on its hearth a bath B of molten steel undergoing refinement. And with the valves 13 and 14 so adjusted, communication between the

pipe 10 of port 2 and the fuel supply pipe 12 is blanked, and there is open communication between the flue 6 and the duct 9. The duct 9 opens into a stack (not shown). The hot products of combustion, escaping through port 2 from the metal-refining chamber of the furnace, are under the effect of the stack drawn downward through the regenerator 4, and are caused to yield large stores of heat to the checkerwork thereof, and from the bottom of such regenerator the waste products flow through flue 6 and duct 9 to the stack. Thus a burning column of fuel and air sweeps into the furnace from one end, and the products of combustion escape from the opposite end. From time to time the valves 13 and 14 are swung into alternate positions, and operation of the furnace is reversed; the port 3 becomes the outgo port and the port 2 the firing port. The heat yielded to the checkerwork of regenerator 4, while port 2 was serving as outgo port, is now yielded to the air streaming upward through the regenerator into port 2. Such in general is the usual operation of an open-hearth furnace.

As mentioned in the introduction to this specification, it is desirable that in the intervals between the successive reversals of the furnace the flame delivered by the firing port upon and across the charge or bath on the furnace hearth shall be held to a predetermined path or trajectory, while the temperature within the furnace is regulated as need be. In the drawing the broken-line arrow T indicates the desired flame trajectory when the port 3 serves as the firing port, and it will be understood that when the port 2 becomes the firing port the desired flame trajectory will be opposite in direction but in other respects the same as the trajectory indicated.

In the preferred practice of the invention an auxiliary supply of fuel is provided, and the auxiliary fuel comprises an adulterant having lower B. t. u. value than the principal fuel delivered by the pipe 12. When peak temperature is desired in the furnace all of the fuel delivered to the firing port may be the high B. t. u. fuel from the pipe 12, but when some lower temperature is desired in the furnace I introduce in regulated quantity the auxiliary fuel or adulterant into the combustible mixture of air and fuel supplied to the firing port, and in consequence I modify the heat-generating capacity of the flame that is sustained in the furnace chamber. The quantity of the principal fuel relatively to the quantity of the adulterant is nicely regulated, so that the heat generated by the flaming mixture projected into the furnace will be adequate to afford the temperature desired. While thus controlling the heat-producing capacity of the combustion-sustaining stream, I maintain the velocity and quantity of the mixture streaming from the firing port substantially constant, with the effect that the flame is held to the predetermined optimum trajectory. Thus, I maintain a constant flame trajectory, while varying the temperature conditions within the furnace.

Various apparatus may be used in the practice of the invention, and the showing in the drawing hereof is exemplary only.

I provide an auxiliary fuel inlet 15 that in this case opens into the main fuel pipe 12 on the upstream side of valve 14. Whereas the fuel (typically natural gas or coke-oven gas) supplied by pipe 12 is of high B. t. u. value, the adulterant supplied by the pipe 15 is of relatively low B. t. u. value, say blast-furnace gas. In the extent of pipe 15 provide a gas washer 16, a pressure-boosting fan or turbine 17, an automatic pressure regulator 18, and a check valve 19. The pressure of the mixed fuel and adulterant is the effective agency that controls the regulator 18, a branch pipe 20 providing the essential communication. In the main fuel pipe 12 I provide a control valve 21, a meter 22 and an automatic pressure regulator 23, arranged in the order named on the upstream side of the delivery end of auxiliary fuel pipe 15.

The valve 21 is manipulated to vary the quantity of fuel delivered by pipe 12 in accordance with the temperature requirements of the furnace, and such variation in the quantity of fuel delivered produces a variation in the pressure of the mixture of fuel and adulterant. The regulator 18 responds immediately to such variation in the pressure of the mixture, and makes a compensating adjustment in the flow of adulterant from pipe 15, whereby the pressure of the mixture is immediately restored to original value. Thus, when the opening of valve 21 is decreased the quantity of adulterant flowing from auxiliary pipe 15 is automatically increased, and the heat-affording capacity of the flame within the furnace is reduced. Alternately, when the opening of the valve 21 is increased, the quantity of adulterant admitted to pipe 12 drops, and in case such valve is turned into fully opened position, to obtain a peak temperature in the furnace, the flow of fuel from pipe 15 will be entirely arrested, and the check valve 19 will close. In any event the velocity of the mixture is maintained at substantially constant value, while the B. t. u. content of the mixture is modified in accordance with the temperature requirements of the furnace. It will be understood that, with the velocity of the combustion-sustaining air maintained in the usual way at substantially constant value, the above-described regulation of the mixture is effective to control the velocity of the flame-sustaining column sweeping from the firing port into the furnace.

While I have specified blast furnace gas as the auxiliary fuel I use, it is to be understood that other fuels or gases may provide the auxiliary fuel or adulterant. As an example I may draw flue gas from the stack flue of the open-hearth furnace being fired, and in Fig. II of the drawing such expedient is diagrammatically indicated. The pipe 24 is arranged to deliver flue gas from the stack duct 9, through the washer 16, pressure booster 17, and the regulator 18, to the main fuel pipe 12.

I claim as my invention:

1. In the operation of a furnace in which a flame-sustaining stream of fuel having an adulterant mixed therewith is projected into the furnace chamber, the method of regulating the heat of the flame while holding the flame to a substantially constant trajectory which comprises regulating the fuel in the stream to alter the heat-producing value thereof, and under the influence of the pressure of said stream automatically regulating the adulterant in the stream to hold the velocity of the stream substantially constant.

2. In the operation of a furnace in which a flame-sustaining stream including a mixture of two fuels of different B. t. u. contents is projected under pressure into the furnace chamber, the method of regulating the heat of the flame while holding the flame to a substantially constant trajectory which comprises regulating the quantity of one of the fuels in the stream to alter the

heat-producing value thereof, and under the influence of the pressure of said stream automatically regulating the quantity of the other of said fuels in the stream to make compensation for the regulation of the first fuel and hold the velocity of the stream substantially constant.

3. The method of regulating the heat of a flame projected into a furnace while holding the flame to a substantially constant trajectory by the introduction to a flame-sustaining stream of an adulterant which alters the heat-producing value of the stream while maintaining the stream velocity substantially constant, which comprises regulating the flame-sustaining stream, and under the control of the regulated stream automatically regulating the quantity of adulterant entering the stream.

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