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RECIRCULATING SYSTEM FOR A HEAT TREATING FURNACE

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2 Sheets-Sheet 2

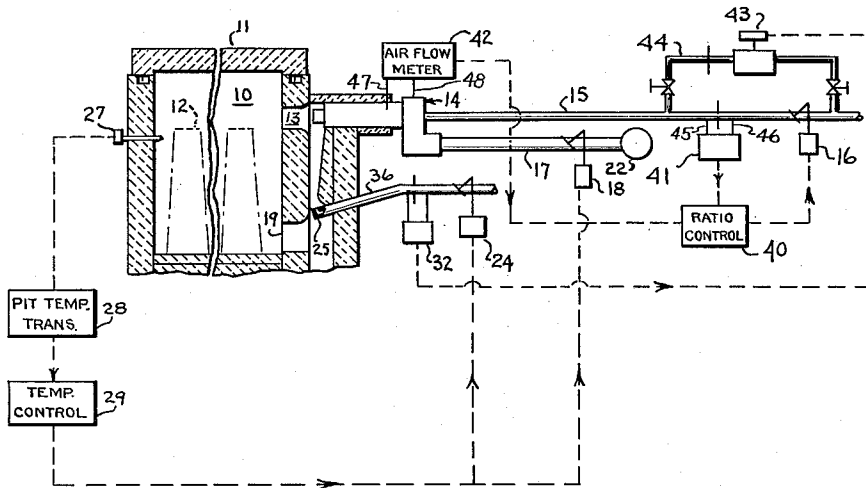


FIG. 3.

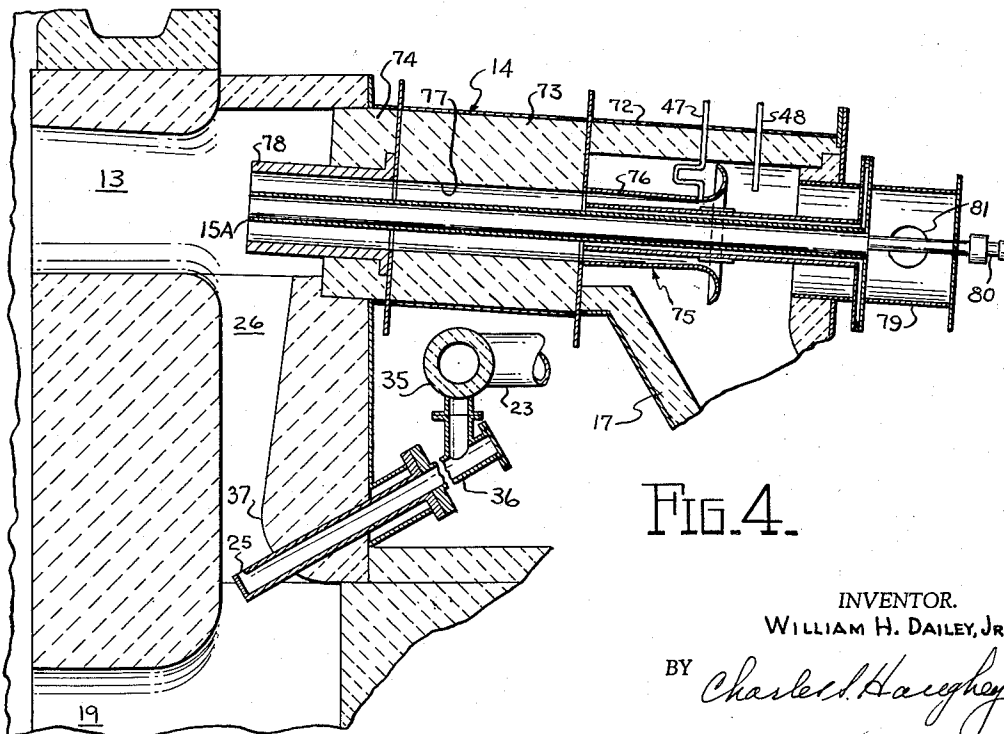


FIG. 4.

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RECIRCULATING SYSTEM FOR A HEAT
TREATING FURNACE

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3 Claims. (Cl. 158—1)

This invention relates to improvements in the art of circulating gases and particularly to recirculating flue gases in a one-way fired soaking pit furnace.

Soaking pit furnaces are used to reheat partially chilled or cold steel ingots to a uniform temperature preparatory to rolling. In operation, a number of ingots ordinarily are charged into the furnace heating chamber and are removed singularly for rolling after they have attained proper temperature.

The burner in a one-way fired pit is generally located in the upper portion of an end wall and directs its flame toward the opposite end of the pit with its maximum heat concentration located near the opposite end when the burner is firing at its full rate. The combustion gases then travel back through the lower portion of the pit and out through exhaust ports located in the lower portion of the end wall containing the burner.

After charging the ingots into the heating chamber, the burner is fired at its full rate until the desired maximum temperature is approached. The firing rate is gradually decreased or throttled as the maximum temperature is approached to avoid overshooting this temperature and to also enable more uniform heating to be attained by changing the area of heat concentration as the burner's firing rate decreases. When the desired temperature is reached, the burner will be shut off or adjusted to a minimum firing rate until the temperature controller again calls for further heating.

The most difficult objective to attain in modern pit furnace operation is uniform heating of all ingots in a pit with no localized overheating of any ingot. A cause of uneven heating in pit furnaces is the fact that the top of an ingot is exposed to heat from all sides while the bottom rests on a relatively cold unexposed surface. Thus, it is necessary to compensate for this by proper distribution in the flow of gases in the pit particularly during the soaking period when the fuel burner is off, or at reduced firing rate, when the combustion gases in the chamber become stagnant and the colder gases tend to settle towards the bottom of the chamber and establish gaseous layers of varying temperatures.

To overcome this problem, it is proposed to utilize a jet pump in a novel arrangement to maintain high circulation of hot gases in the soaking pit when the heating burner is off or at its minimum firing rate. The arrangement involves using a portion of the combustion air at sufficient pressure and volume to entrain products of combustion from the soaking pit and direct the mixture into confluence with the combustion gases from the burner by means of a jet pump built into the passage connecting the flue passage with the burner port.

It is well known in the art to recirculate a portion of the spent products of combustion utilizing a jet formed by the fuel burner to temper the combustion temperature of said burner. While such arrangements are satisfactory for tempering the fuel burner temperatures, they do not serve to maintain a high volume of circulating gases during turn-down or the soaking period.

In the subject invention, at maximum fuel flow or B.t.u. input, the circulation of hot gases in the pit are at a maximum and the recirculating jets are not used. As the steel attains an intermediate temperature, the burners are throttled back thus reducing the circulation in the pit.

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To compensate for the reduced circulation a portion of high pressure combustion air is used in the air jets to entrain additional flue products to maintain the circulating volume at a preferred minimum of approximately 70% of the total maximum volume.

In the preferred operation, as the burner approaches 60% flow approximately 15% of the combustion air is metered through the recirculating air jets to entrain sufficient flue products to produce approximately 78% of the maximum flow. As the total fuel input is further reduced a greater percentage of combustion air is introduced through the recirculating air jets. This in turn, due to the greater entrainment ratio with reduced burner flows, recirculates greater percentages of flue products. At 20% total flow, approximately 75% of the air is metered through the recirculating air jets and with the reduced burner flow, entrainment ratios exceeding three to one are developed. As the burner approaches 10% maximum flow all of the combustion air is supplied through the recirculating air jets and the total flow through the burner port is approximately 70% of maximum flow.

In the preferred embodiment, combustion air flowing to the main burner is metered separately from that flowing through the recirculating air jets. The differentials representing these flows are added by a summarizing relay and balanced against the gas demand for the pit. A suitable system to proportion the percentages of the main burner air to the recirculating jet air may be supplied. This system may be mechanical, pneumatic, or electronic in nature.

For further consideration of what I consider to be novel and my invention, attention is directed to the following specification and the concluding claims thereof.

In the accompanying drawings forming part of this specification:

FIG. 1 is a more or less diagrammatic view of a soaking pit system with the present invention applied thereto without the controls;

FIG. 2 is a fragmentary schematic view of a soaking pit with the accompanying controls;

FIG. 3 is a view similar to FIG. 2 showing an alternate system of controls; and

FIG. 4 is an enlarged view of the recirculating jet construction.

The soaking pit comprises combined combustion and heating chamber 10 which is normally closed by a cover 11, the chamber normally being of a size to contain a plurality of steel ingots 12 indicated in outline by discontinuous lines. Heating flame enters the chamber 10 from a firing port 13, preferably having a venturi construction, whose inlet is coincident with the outlet of the burner 14 to which fuel is delivered by supply pipe 15 having a control valve 16 and to which air for combustion is delivered by a duct 17 having a control valve 18. Flue gas (products of combustion) is vented from the chamber 10 through an exhaust port 19 and then through exhaust passage 20. The heating unit thus far described represents nothing new and usually is one of several units having a common flue gas exhaust manifold 21 and a common burner air distributing manifold 22.

The flue gas manifold 21 connects with a stack 50 through a connecting flue 51 and there is positioned in said flue adjacent to said exhaust manifold 21 a refractory tile recuperator 52. A refractory tile recuperator is preferred over a metal recuperator because a tile recuperator is better adapted than a metal recuperator to withstand a relatively high temperature of the flue gas coming from said exhaust manifold. The cold air inlet for said recuperator is indicated at 53 and the hot air outlet at 54.

A hot air duct generally indicated at 55 connects the recuperator hot air outlet 54 with the hot air distributing

manifold 22 for the burners 14 and the means for causing the heated air to flow from said outlet 54 to said manifold 22 comprises a jet pump in said duct 55.

The pump comprises an entraining tube 56 and a nozzle 57 for discharging motive fluid into the mouth of said tube across an intervening air space whereby to draw heated air from said outlet and hence force it to said air distributing manifold 22. The resulting partial vacuum at said outlet 54 is sufficient to cause air at atmospheric pressure to enter and flow through the air passages of the recuperator from the air inlet 53.

The motive fluid for the jet pump is air under pressure that has been preheated by being passed through the air passages of a metal recuperator 60 positioned in the flue 51 at a point between the stack 50 and the tile recuperator 52 whereby the flue gas which heats the metal recuperator is flue gas which has already passed through the tile recuperator and which, therefore, is cool enough to make it practical to employ a metal recuperator at that point. The motive air delivered under pressure to the air intake side of the metal recuperator 60 by a motor driven blower 61, the delivery conduit in the blower being indicated at 62, with valve 70. The delivery conduit from the metal recuperator to the jet pump nozzle 57 comprises the conduit sections 63, 64, 65, and 66, and valve 71.

The stack 50 may be of the ejector type comprising a nozzle 67 for the discharge of the motive fluid for drawing flue gas from the flue 51. The motive fluid may be heated air coming from the metal recuperator 60, the delivery conduits in such case comprising the conduit sections 63 and 64, branch line 58, valve 68 and line 69.

The burner 14 comprises a refractory lined steel box 72 forming a plenum chamber for receiving air from the duct 17. The burner 14 further comprises annular refractory rings 73 and 74 and venturi tube 75 which is supported with its inlet in said plenum chamber. The venturi tube 75 is comprised of an alloy inlet section 76, core 77 of ring 73, and terminating alloy insert 78. The fuel delivery pipe 15A extends from the firing port 13 through the venturi tube 75 and the air plenum chamber to a gas receiving box 79. A sight tube 80 in the box 79 extends through the box in a manner that sight is had to the venturi tube 75 and pipe 15A. The burner 14 is adapted to receive fuel gas through a side inlet 81 to the box 79 where fuel is delivered by fuel supply pipe 15.

A portion of the combustion air to firing port 13 is delivered through duct 23 to manifold 35, thence to passage 36, having control valve 24, which leads to the nozzle portion 25 located in passage 26. The passage 26 communicates with the exhaust port 19. Part of the products of combustion exiting through port 19 are carried through the passage 26 to the firing port 13 by the inspirating effect of the high velocity air discharged through the nozzle 25. The passage 26 is preferably in the form of a venturi orifice 37 to enhance the inspirating effect of the high velocity air.

The ratio of air to fuel delivered to the burner 14 may be maintained during the varying rates of fuel supply (as necessitated by furnace operation) by any preferred ratio control means which, for purpose of illustration, has been shown as comprising fuel valve operating instrument or ratio control 40 which in order to maintain volumetric proportions with the air and fuel is made responsive first, to changes in differential pressure in the fuel stream at an ordinary meter 41 through pressure taps 45 and 46 and second, the changes in differential pressure in the air stream at a venturi type meter 42, shown as embodied in the burner 14 itself, through pressure taps 47 and 48; the instrument 40 actuating the gas control valve 16.

In order to proportion the rate of flow of the fuel in accordance with the extent of deviation of the temperature set point from the temperature in heating chamber 11 as indicated by thermocouple 27, the thermocouple is positioned within the chamber, and through transmitter 28 operatively connected to the temperature control 29; the actuation of air control valve 18 is controlled. In

operation, if the chamber 10 is cold or contains a cold charge, a large deviation from normal registered by the thermocouple 27 will result in more fuel and air reaching the burner 14. As the air passes through the metering orifice 42, the ratio control instrument 40 will automatically introduce the correct amount of gas into the burner 14. The proportioning system thus far described is not new and is usually employed where a constant predetermined ratio of fuel to air is desired to be maintained.

To maintain high circulation of hot gases in the soaking pit 10 when operating at high temperatures and low fuel input a portion of the combustion air is delivered through nozzle 25 to entrain products of combustion from the soaking pit. The control valve 24 in passage 36 is responsive to the temperature control 29 in the reverse order that control valve 18, in the main supply duct 17, is responsive to said temperature control 29. When the work 12 is at temperature and a minimum of fuel flows through the burner 14, the valve 24 is in its maximum open position, and the valve 18 is in its minimum open position.

To maintain optimum proportioning of fuel to air, a ratio adjustment mechanism 30 is interposed in the control circuit to selectively alter or maintain the fuel to air ratio. The ratio adjustment mechanism 30 is actuated by an impulse received from a summarizing relay 31 which may integrate one or more of the following: the air flow through passage 36 as measured by orifice meter 32; the combustion air temperature as measured by thermocouple 33 and transmitted through transmitter 34; the pit temperature as transmitted by transmitter 28; and any change in the charge input which is manifested by the deviation from a set point of the temperature control 29.

A variation of the controls for maintaining a high rate of circulation and proper proportioning of the fuel to air may take the form as shown in FIG. 3, in which corresponding elements of FIG. 2 have been designated by similar numerals. The summarizing relay 31 and the ratio adjustment mechanism 30 may be omitted and a by-pass fuel supply independent of ratio control 40 is provided. The impulse from orifice meter 32 is transmitted to solenoid valve 43 in the fuel by-pass line 44. At high temperatures and low firing rate, when the valve 24 is in its maximum open position and the valve 18 is in its minimum open position, the valve 43 opens to a position to emit sufficient fuel to the burner 14 to efficiently burn with the volume of air emitted through nozzle 25. The operation of the remaining controls is the same as that described in connection with FIG. 2; hence, it will not be described here.

In the foregoing description the combination of separate means for delivering a supply of air to the burner port and for delivering a supply of fuel to the burner port has been referred to as a "burner." Since the "burner" illustrated and described is of a type where unburned fuel and air is delivered to the burner port by such separate delivery means the term "burner" in the description and claims should be interpreted to include any combination of fuel and air supply means which delivers an unburned mixture to the firing port wherein the burning occurs. This interpretation, however, does not preclude the introduction of recirculated products of combustion to the same said firing port.

As will be evident to those skilled in the art, various other modifications and alternatives can be made, in the light of the foregoing disclosure without departing from the spirit or scope of the disclosure or the claims.

What I claim is:

1. A furnace comprising, in combination: wall means forming a combustion and heating chamber and an outlet for products of combustion; a burner port located in said wall means; a burner arranged to fire into said chamber through said port; means for supplying fuel to said burner; means for supplying air to said burner; a passage connecting said outlet and said burner port; a nozzle in

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said passage arranged to discharge high pressure air in a manner to inspire hot products of combustion from said chamber directly through said outlet and passage and to direct the admixture formed in said passage into confluence with the fuel and air from said burner for circulation through said burner port, chamber, and outlet; and control means for maintaining a predetermined set point temperature in said chamber while maintaining a high gas circulation rate, said control means being responsive to the temperature in said chamber and acting to decrease the air and fuel supplied to the burner and increase the air flow through said nozzle in accordance with the deviation of the temperature in the chamber from the set point temperature.

2. A furnace comprising, in combination: wall means forming a combustion and heating chamber and an outlet for products of combustion; a burner port located in said wall means; a burner arranged to fire into said chamber through said port; means for supplying fuel to said burner; means for supplying air to said burner; a passage connecting said outlet and said burner port; a nozzle in said passage arranged to discharge high pressure air in a manner to inspire hot products of combustion from said chamber directly through said outlet and passage and to direct the admixture formed in said passage into confluence with the fuel and air from said burner for circulation through said burner port, chamber, and outlet; and control means responsive to the temperature in said chamber for decreasing the air and fuel supplied to the burner and increasing the air flow through said nozzle as the temperature increases to maintain a substantially constant temperature in said chamber while maintaining a high gas circulation rate.

3. In a heating furnace, the combination comprising: wall means forming a combustion and heating chamber and an outlet for products of combustion; a burner port located in said wall means and adapted to be supplied under pressure a gaseous mixture of fuel and air; first

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and second conduits through which fuel and air, respectively, are supplied to said burner port; a passage connecting said outlet to said burner port; a nozzle in said passage arranged to discharge high pressure air in a manner to inspire products of combustion from said outlet thereby forming an admixture and to direct said admixture to said burner port for recirculation in said chamber; a third conduit through which high pressure air is supplied to said nozzle; valve means in each of said conduits; furnace temperature measuring means; temperature responsive control means for controlling said second and said third conduit valve means; flow measuring means for each of said conduits; ratio control means responsive to the flow through said first and second conduits to adjust the flow through said first conduit valve means in a manner to maintain flow therethrough in fixed relation to the flow through said second conduit valve means; ratio adjustment means operatively associated with said ratio control means in a manner to adjust the fixed relationship between the flows through said first and second conduit valve means, said ratio adjustment means being responsive to a signal from said temperature responsive control means and to a signal from said flow measuring means in said third conduit, and said signals serving to actuate said ratio adjustment means to adjust said fixed relationship.

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