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METHOD OF CONTROLLING COMBUSTION CONDITIONS IN GAS FIRED FURNACES

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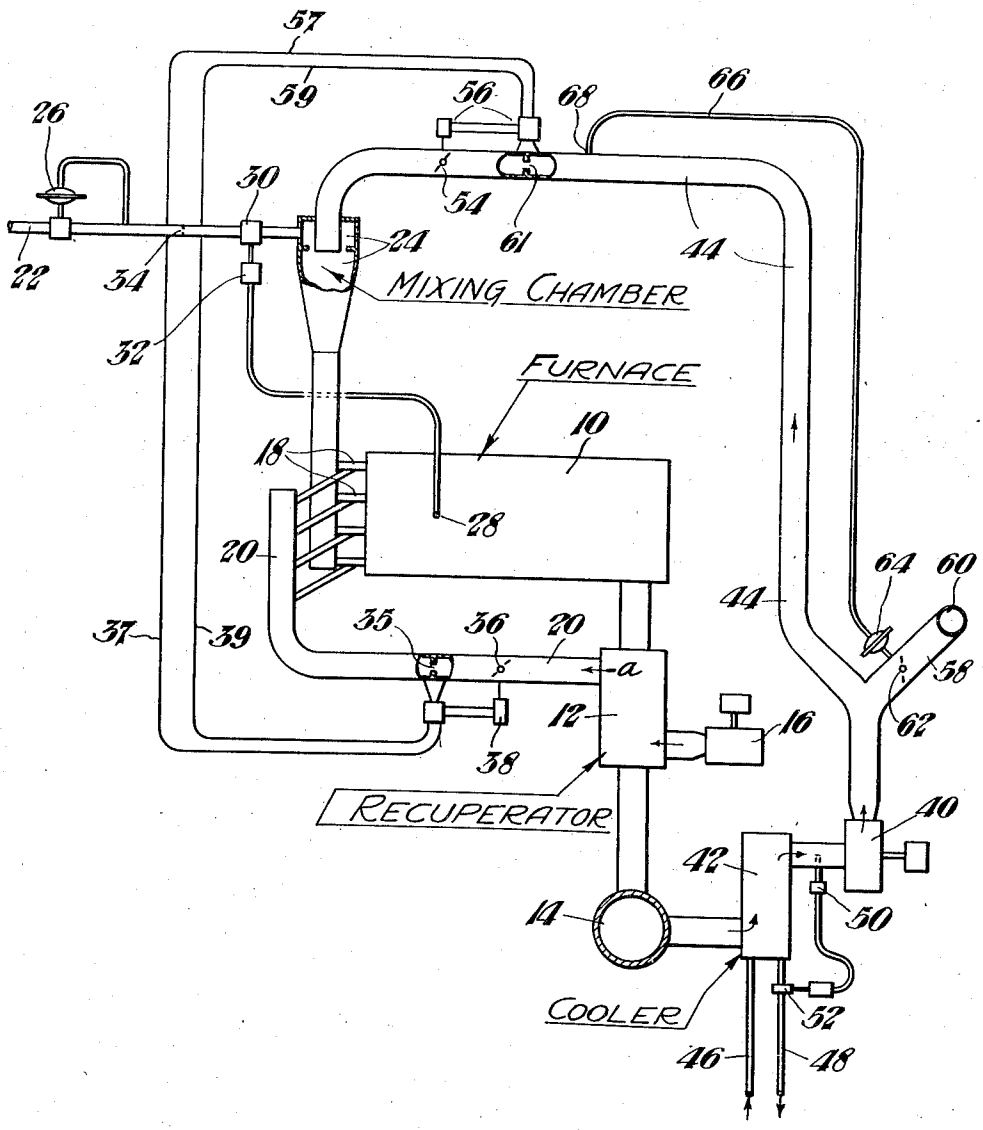

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METHOD OF CONTROLLING COMBUSTION CONDITIONS IN GAS FIRED FURNACES

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4 Claims. (Cl. 158—117.5)

The present invention relates to improvements in the method of firing soaking pits, heating furnaces, and the like, with a view of attaining high efficiency heating with a resultant maximum yield of salable product at a minimum cost of production.

Where a high B. t. u. or rich gas is used for fuel, the resultant flame temperature, when the air and gas are properly proportioned to minimize oxidation of the metal, will be extremely high, sometimes reaching a theoretical maximum of at least 4000° F. with the possibility of producing local zones of high temperature. Since the average furnace temperature determines the rate of heat input, the burning gases will not fill the combustion chamber of the furnace. This results in an undesirable or uneven distribution of hot gases with attendant uneven heating and burning or partial melting of the metal within the furnace if contacted by the flame.

In order to overcome this undesirable condition, attempts have been made in various applications to dilute the rich fuel gas with products of its own combustion, thereby providing control of the flame temperature by proportioning the ratio of fuel gas to the waste gas diluent (combustion products). Such practice results in less severe heating with reduced destructive action on the refractory lining of the combustion chamber of the furnace and more uniform distribution of the hot gases with resultant better heating and less danger of overheating the steel. However, during the normal operation of heating furnaces, soaking pits, and the like, variations in the temperature of the waste gases leaving the furnace and entering the stack inherently occur as an incident to normal operation, thus making it difficult to properly control the quantity of waste gas used as the diluent.

The present invention aims to overcome the above difficulties which have been encountered by those skilled in the art and provides a method for stabilizing the factors involved in the operation of various types of furnaces when using a rich fuel gas diluted with products of combustion.

By the method hereinafter described and claimed in detail, I control the mixture of fuel gas and combustion products to produce a gaseous fuel having an adjustable B. t. u. content that can be maintained accurately at any desired B. t. u. value within the combustion range of the mixture. The improved method aims to attain higher furnace efficiency, better furnace temperature control and an improved furnace product when using rich gas, such as coke oven gas, natural gas, or petroleum gas diluted to any predetermined B. t. u. value.

The invention will be fully apparent from the following detailed disclosure when read in connection with the accompanying single figure of drawing. The drawing schematically illustrates a heating or reheating furnace but it is to be understood that the principles of the invention may be applied to various other types of furnaces, such as soaking pits, or other furnaces adapted to the use of the leaner types of gas.

Referring in detail to the drawing, 10 represents a heating furnace from which the waste gases are drawn through a recuperator 12 by the draft of a suitable stack 14. Air for combustion is forced through the recuperator by a fan 16 and such pre-heated air, as indicated by the arrow *a*, is forced to the burners 18 through a pipe 20. Gas of high thermal value, such as coke oven gas, natural gas or the like, is supplied from a suitable source by a pipe 22 to a mixing chamber 24. The pressure of such rich gas is maintained substantially constant by a regulator 26 and the quantity of the gas required to maintain a uniform furnace temperature, as indicated by a pyrometer 28 is regulated by a sensitive valve 30 operated by a temperature responsive controller 32 of known construction. Such known type of controller may constitute an electrically operated device responsive to the thermocouple constituting an element of the pyrometer.

The flow of rich gas is measured by a control orifice 34 formed in a diaphragm in the fuel pipe and the air required for combustion is measured by a control orifice 35 in a similar diaphragm in the air pipe 20, such air being proportioned to the requirements of combustion of the high temperature gas by a butterfly valve 36 actuated by a known type of control regulator 38.

The regulator 38 is operated in response to pressure conditions in the fuel gas pipe 22 on opposite sides of the gas measuring orifice 34 and is connected to such opposite sides by small pipes 37 and 39. The pressure differential within the regulator 38 thus provides the motive force for actuating the valve 36. The regulator 38 may be referred to as a "fuel to air" regulator as it measures the flow of fuel gas through the gas orifice 34 and the flow of air through the air orifice 35 and adjusts the flow of air through orifice 35 by movement of the valve 36 so that the flow of air through orifice 35 is correctly pro-

portioned to the demand of the fuel gas flowing through orifice 34.

Products of combustion for diluting the fuel gas to any desired B. t. u. value are drawn from the stack 14 by an exhauster 40 through a cooler 42 and delivered by way of pipe 44 to the mixing chamber 24. The exhauster 40 is driven at a substantially constant speed and has a capacity at constant volume and constant pressure slightly in excess of the maximum amount of combustion products required for dilution. The cooler includes a cold water inlet pipe 46 and an outlet pipe 48 for water which has absorbed heat from the products of combustion. A known type of thermostat control 50 is set to maintain the temperature of combustion products leaving the cooler at any desired point by regulating the flow of water through the cooler, by means of the valve 52 in the outlet water pipe 48.

Since this control is not sufficiently sensitive to maintain uniform combustion products temperature if the flow thereof is variable, it is necessary to maintain a uniform flow of combustion products through the cooler 42. This function is accomplished by keeping the combustion products flow at a constant rate by delivering the amount for required dilution to the mixing chamber 24 and bleeding the balance of the constant quantity of combustion products withdrawn from the exhauster. This is accomplished by butterfly valve 54 which is operated by a known type of regulator 56 which proportions the quantity of products of combustion entering the mixing chamber 24 in accordance with the flow of rich fuel gas through the orifice 34 to produce a mixture of any desired predetermined B. t. u. value. The regulator 56 is operated in response to pressure conditions in the fuel gas pipe on opposite sides of the orifice 34, and is connected to such opposite sides by small pipes 57 and 59. The pressure differential within the regulator 56 thus provides the motive force for actuating the valve 54. The regulator 56 may be referred to as a "fuel gas to inert gas regulator" for it measures the flow of fuel gas by means of the pressure connections 57 and 59 on each side of the orifice 34 and adjusts the flow of waste gas (which flows through a measuring orifice 61) by movement of the valve 54 in order to provide a mixture of fuel gas and waste gas in the mixing chamber 24 in the correct proportions to produce any desired B. t. u value less than that of the rich fuel gas.

If the pressure and temperature of the products of combustion used for dilution of the fuel gas are maintained constant, proper position of the butterfly valve 54 will maintain an accurate proportioning of fuel gas and products of combustion with a resultant constant B. t. u. value of the mixture. The bleeding of the products of combustion above referred to is effected through a branch pipe 58 leading to a bleeder stack 60. Located in the pipe 58 there is a butterfly valve 62 operated by a diaphragm or other suitable type of pressure regulator 64 which is connected by a pipe 66 to a point 68 in the waste gas line 44 located in a zone adjacent the orifice 61. In operation, a change in rate of flow of products of combustion through valve 54 will result in an increase or decrease in pressure at the zone 68, causing pressure actuated regulator 64 to open or close the valve 62, thereby diverting more or less of the fixed quantity of combustion products to the bleeder stack 60. This not only maintains a uniform pressure of gas at the point of measurement for dilution purposes but also maintains a pressure balance between the combustion products used and bled that would be uniformly equal to the capacity of the fan, thus maintaining a constant flow through the cooler 42.

The operation of butterfly valve 62 by means of regulator 64, which maintains a constant pressure at the zone 68 in the pipe 44, divides the constant flow of products of combustion drawn through the cooler by the exhauster 40 so that the correct amount, as determined by the fuel gas-inert gas ratio control 56, goes to the mixing chamber 24 at a constant pressure, while the balance is vented to atmosphere through the bleeder stack 60.

A constant flow of gaseous products is maintained through the cooler in order to make it possible for the thermostatic controller 50 to maintain a constant temperature of the gas leaving the cooler 42 through regulation of the amount of water flowing through the cooler by means of the valve 52.

By the method described, it is possible to utilize the maximum temperature of the products of combustion that will not cause trouble by cracking hydrocarbons in the fuel gas. Thus, I secure resultant increased efficiency due to the utilization of the heat of the waste gases with an accompanying decrease in the fuel gas input to the furnace.

While I have described my improved method quite specifically with reference to the firing of a heating furnace, it is to be understood that the principles thereof are applicable to various types of furnaces and that the drawing and detailed description are to be interpreted in an illustrative rather than a limiting sense.

What I claim is:

1. The method of controlling combustion conditions in a gas fired furnace which comprises supplying to the furnace a mixture consisting of gaseous fuel and combustion products withdrawn from the furnace, supplying to said mixture air to support combustion in predetermined ratio to the gaseous fuel supply, and controlling the supply of products of combustion to said mixture in accordance with the rate of gaseous fuel supply, and maintaining at respective substantially constant values the temperature and pressure of the combustion products mixed with the gaseous fuel, whereby said mixture is maintained at a substantially predetermined B. t. u. value at all rates of flow of the gaseous fuel to the furnace.

2. The method of controlling combustion conditions in a gas fired furnace which comprises withdrawing combustion products from the furnace and cooling them to a substantially constant predetermined temperature, mixing a controlled fractional portion of the cooled combustion products with a rich gaseous fuel and discharging the balance of said combustion products, the respective amounts of said combustion products discharged and utilized being automatically varied by and in accordance with variations in the flow of gaseous fuel to the mixing zone whereby the B. t. u value of the thus diluted fuel mixture is automatically maintained substantially constant.

3. The method of controlling combustion conditions in a gas fired furnace including the steps of continuously withdrawing products of combustion from the furnace and passing the same through a confined zone to cool them to a substantially constant temperature and after cooling, bleeding off and discharging a fractional portion of said products of combustion and leading the remainder thereof to a zone where they are

mixed with rich gaseous fuel, the pressure and temperature respectively of the retained portion of the products of combustion supplied to the mixing zone being maintained at substantially constant values and being automatically controlled as to volume in accordance with variations in the flow of rich gaseous fuel to the mixing zone whereby the desired B. t. u value of the thus diluted fuel mixture is maintained substantially constant regardless of variations in the supply of rich gaseous fuel.

4. The method of controlling combustion conditions in a gas fired furnace which comprises mixing rich gaseous fuel supplied to the furnace with a diluent composed of products of combustion withdrawn from the furnace to produce a mixed gas having a predetermined B. t. u. value, including the steps of cooling the diluent and dividing the flow thereof after cooling, discharging one portion of the thus divided flow and leading the remaining portion to a mixing zone at a substantially constant temperature and pressure where it serves to dilute said rich gaseous fuel, the amount of diluent thus retained being governed by and in accordance with variations of the rich gaseous fuel supplied to the mixing zone.

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