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COMBUSTION APPARATUS AND TEMPERATURE LIMITING MEANS THEREFOR

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FIG. 1.

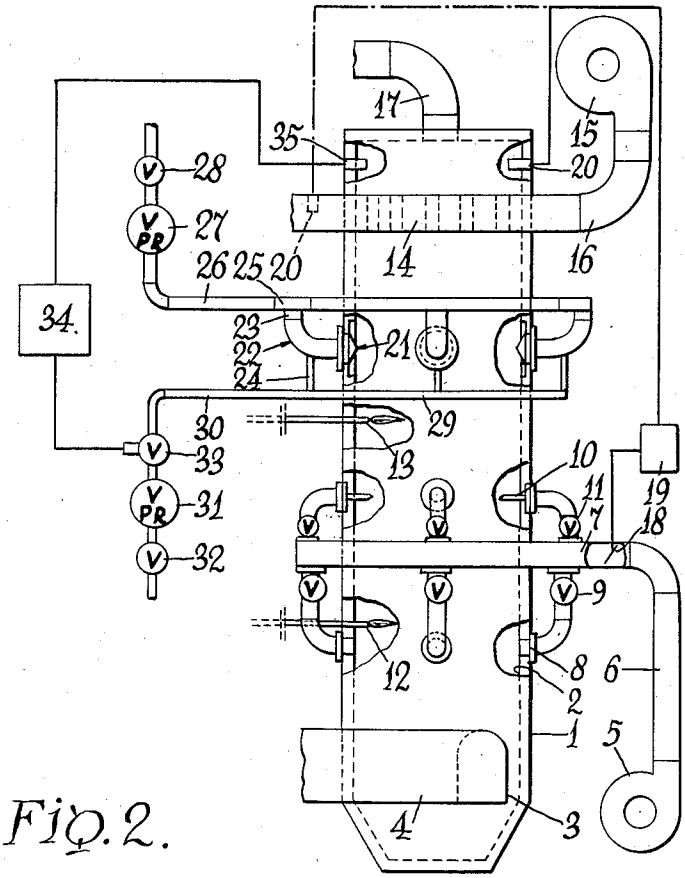
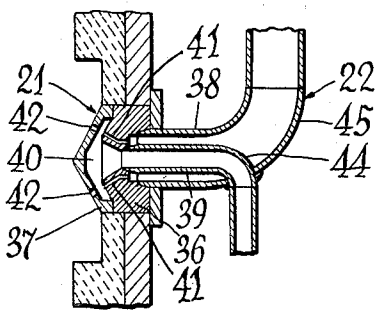


FIG. 2.



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COMBUSTION APPARATUS AND TEMPERATURE LIMITING MEANS THEREFOR

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Continuation of application Serial No. 287,888, May 15, 1952. This application May 11, 1956, Serial No. 584,377

9 Claims. (Cl. 263—20)

This invention relates to new and useful improvements in apparatus for combustion of low grade fuels and more particularly to such apparatus in combination with a heat exchanger and means for limiting combustion temperature in accordance with the requirements and desired operating temperature of the heat exchanger. This application is a continuation of my copending application, Serial No. 287,888 filed May 15, 1952, now abandoned.

The general objects of this invention are to provide a novel combustion apparatus which is particularly adapted for burning and reclaiming waste heat from waste exhaust gases such as from an iron melting cupola and also to provide a means to utilize the heat therefrom to preheat combustion air for the cupola in combination with means to limit the combustion temperature in such apparatus in accordance with the heat requirements and desired operating temperature of a heat exchanger for this purpose.

This invention comprises a new and improved construction and combination of parts and the operative relation of one part to another which will be described more fully hereinafter and the novelty of which will be particularly pointed out and distinctly claimed.

In the accompanying drawings, to be taken as a part of this specification, there is clearly and fully illustrated a preferred embodiment of this invention, in which drawings:

Figure 1 shows in more or less diagrammatic form a combustion apparatus which is novel in construction and which includes a temperature limiting means which forms a part of this invention, and

Figure 2 is a detail sectional view of the temperature limiting spray nozzle which is shown at the upper portion of the combustion chamber in Figure 1.

Referring to the drawings by characters of reference and more particularly to Fig. 1, there is shown in more or less diagrammatic form a combustion apparatus which is in the form of a cylindrical casing 1 enclosing a combustion chamber 2. The casing 1 has an inlet 3 which is connected by a duct or other conduit 4 to the outlet from a cupola or other furnace (not shown) for receiving the combustion products therefrom. The combustion apparatus 1 is designed to burn very low-grade waste furnace gases. There is herein provided a combustion apparatus which is particularly useful in burning exhaust gases from an iron melting cupola. The exhaust gases from a cupola which are supplied to this apparatus comprise a mixture of inert gases such as N_2 and CO_2 and about 12 to 18% combustible CO.

The combustion apparatus 1 is supplied with combustion air by a fan or blower 5 which discharges through a

supply duct 6 to an air inlet bustle 7. The air inlet bustle 7 has a plurality of connections to a plurality of large air inlets 8 for introduction of a relatively large volume of air at low velocity into the stream of waste furnace gases. The quantity of air supplied through the inlets 8 may be controlled by control valves 9 which are positioned between the inlets 8 and the air inlet bustle 7. The air inlet bustle 7 is also connected to a plurality of high velocity air inlet jets 10 which are controlled by air flow controlling valves 11. The air inlet jets 10 are positioned to discharge high velocity jets of air in intersecting relation to the stream of waste gas and air flowing upward through the combustion chamber 2.

The combustion chamber 2 is provided with one or more constantly burning pilot burners 12 positioned immediately above the large primary air inlets 8. There may also be provided second pilot burner 13 above the air jets 10, if desired. The combustion products from the combustion chamber 2 flow upward through a heat exchanger 14 which is illustrated as supplying heat to an air stream supplied from a fan or blower 15. The air stream from the fan 15 passes through an inlet supply duct 16 and is particularly adapted for supplying a hot blast of air to the cupola or other furnace from which the waste gases are withdrawn.

After passing over the heat exchanger 14, the combustion products are discharged from the combustion chamber through an outlet stack or flue 17. The air supplied to the combustion inlet bustle 7 may be varied by a control valve or damper 18 which is controlled by an automatic control device 19 having a thermostatic element 20. The controller 19 and responsive element 20 might also, if desired, be a gas analyzer control which could vary the air supply in accord with the degree of oxidation of the combustion products at the outlet end of the combustion chamber 2.

In order to prevent damage to the heat exchanger 14 and to the combustion chamber 2 by excessively high temperatures, there is provided a temperature limiting means comprising a plurality of water injecting spray nozzles 21 which are operable to introduce water in a fine spray into the combustion chamber to prevent the occurrence of excessive temperatures therein. The spray nozzle 21 is of a type which uses a compressed air jet blowing through a film of water to atomize the same. The spray nozzle 21 is connected to an elbow 22 having a compressed air inlet portion 23 and a water inlet connector 24.

The compressed air connection 23 is connected to an air supply pipe 25 which encircles the combustion apparatus for connection to each of the several nozzles and which is connected by a conduit 26 to a source of compressed air. The compressed air conduit 26 is provided with a pressure regulating valve 27 and a shut-off valve 28. The water connection 24 is connected to a water pipe 29 which encircles the combustion apparatus and which is connected by a conduit 30 to a water supply. The water supply conduit is provided with a pressure regulating valve 31 and a shut-off valve 32. The water supply line 30 is also provided with a modulating valve 33 which is operated by a control mechanism 34 having a thermostatically responsive element 35 positioned for response to combustion temperature at the outlet end of the combustion chamber.

In Fig. 2, the spray nozzle and elbow connection are shown in more detail. In this figure it will be seen that the nozzle 21 comprises a body member 36 and a cap member 37 spaced therefrom. The body member 36 is recessed to receive concentric air and water supply conduits 38 and 39, respectively. The water supply conduit 39 opens into an end cavity 40 in the nozzle whereupon the water spreads into an annular sheet or film through which the compressed air discharges. The compressed air conduit 38 supplies compressed air through small nozzle-like openings 41 which are aligned with openings 42 in the cap member 37. The compressed air which discharges through the openings 41 and 42 carries with it water from the cavity 40 in a fine spray. The conduits 38 and 39 are connected to the double elbow member 22 comprising a smaller elbow 44 which is welded into place within a larger elbow 45. The conduit 38 is connected to the outer elbow 45 and the conduit 39 is connected to the inner elbow 44.

Operation

In operation, this invention functions generally as follows: The combustion apparatus 1 is designed to burn low-grade fuels such as waste gases from iron melting cupolas. The inlet 3 to the combustion chamber 2 receives waste cupola gas through a supply duct 4. The cupola gases comprise about 82 to 88% N_2 and CO_2 and about 12 to 18% CO and thus require special burning apparatus. The combustion apparatus and method of combustion which are used herein are described in more detail in my co-pending application, Serial No. 287,889, filed May 15, 1952, entitled Method of Combustion for Low-Grade Fuel and Apparatus Therefor.

As the cupola gases rise within the combustion chamber 2, they are supplied with a quantity of air at low velocity for combustion through the large primary air inlets 8. The air supplied through the inlets 8 is supplied by the fan or blower 5 and is controlled by the control valve or damper 18. When the large quantity of combustion air is supplied through the inlets 8, there is a relatively slow diffusion between the air and cupola exhaust gases so that only in the boundary region between the air and cupola gases is there a sufficiently rich mixture to support combustion. This boundary layer of gas and air is ignited by the constantly burning pilot 12.

After the gas and air streams have passed upward beyond the pilot burner 12 and the combustion has reached a point at which the rate of diffusion between gas and air has become fairly rapid, there is introduced into the moving gas and air stream a supplemental supply of air in the form of high velocity jets issuing from jet members 10 in intersecting relation to the gas and air streams. These high velocity jets create a high turbulence and facilitate the inter-diffusion of gas and air for more rapid combustion. An additional gas pilot burner 13 may be positioned above the air jets 10, if desired, to insure the ignition of all the resulting mixture of gas and air.

The combustion products pass over a heat exchanger 14 and out through a flue or stack 17 to the atmosphere. In a combustion apparatus of this type, the air supply may be adjusted for either a partial or complete combustion of the waste gases. If only a partial combustion is desired, the air flow past the damper 18 may be controlled by a controller 19 and thermostatic element 20 which is responsive to heat output of combustion products adjacent the heat exchanger 14. The element 20 may be positioned in the combustion outlet or in the heat exchange outlet, as shown. This thermostatic control element will vary the air supply in an attempt to maintain a constant heat exchanger outlet temperature.

In some situations it may be necessary that all of the waste gases passing through this combustion apparatus be burned and in such an installation the controller 19 and control element 20 therefor would comprise a gas analyzer control or other combustion controller which would vary the air supply in response to the state of oxidation of the combustion products in an attempt to maintain complete oxidation thereof. In either type of installation just described, there will frequently arise conditions during which the combustion outlet temperatures exceed a safe value. It should also be noted that the temperature control mechanism for the air control valve 18 will always lag somewhat behind the actual temperature to which the control element 20 responds and the combustion temperature may thus exceed the desired temperature for which the responsive element 20 is set to respond.

In order to protect the combustion apparatus and more particularly the heat exchanger 14 against such excessive temperature, there is provided a plurality of water supply nozzles 21 which are operable to spray water into the combustion chamber at a point below the heat exchanger 14. When water is sprayed into the combustion chamber, it is vaporized almost instantly and is mixed with the combustion products as superheated steam. It will be obvious then that the introduction of water sprays into the combustion chamber will result in the water absorbing heat from the combustion products both in the form of the latent heat of vaporization and the sensible heat required to superheat the steam which is formed upon vaporization.

The spray nozzle which is shown is described more fully and claimed in my co-pending application, Serial No. 280,759, filed April 5, 1952, now U.S. Patent No. 2,678,236, entitled Spray Nozzle. This spray nozzle is supplied with water and compressed air through separate concentric supply conduits. The compressed air is supplied through the larger conduit 26 and is maintained at a predetermined constant value by the pressure regulating valve 27. The compressed air supply is controlled for shut-off by a valve 28. The water supply to the nozzle 21 enters through the conduit 30 and is controlled by a pressure regulating valve 31 and a shut-off valve 32. There is also provided in the conduit 31 a modulating valve 33 which is controlled thermostatically in response to the temperature at the outlet end of the combustion apparatus by a control element 35.

When the temperature at the outlet end of the combustion apparatus exceeds the responsive setting of the element 35, the valve 33 is opened and water is supplied to the spray nozzles to be sprayed into the combustion chamber to reduce the combustion outlet temperature. The higher the combustion outlet temperature the greater is the quantity of water allowed to flow through the valve 33 to the nozzles 21. The quantity of water sprayed through the nozzles 21 is varied automatically to maintain a fixed limit temperature. The compressed air which is supplied to the nozzles 21 is supplied constantly so that when the water is shut off, there is a continuous flow of air through the nozzle openings 41 and 42 which tends to cool the nozzle and also to prevent the collection of foreign matter on the nozzles which might clog the spray openings.

Although there has been described herein only one modification of this invention, it should be obvious to the artisan that other means of accomplishing this invention are possible without departing from the scope and intent of the invention which is to be limited only by the appended claims.

I claim:

1. Combustion apparatus for burning waste gases from a furnace and supplying heated draft air to such furnace, means forming a combustion chamber, means including a conduit for supplying combustible waste gases to said chamber from said furnace, means including an inlet for supplying air to said chamber, said combustion chamber having an outlet, means responsive to a condition of the combustion products at said chamber outlet and operable to control the supply of air through said air supply means to produce complete combustion, a heat exchanger

at said outlet and adapted to be traversed by products of combustion from said chamber for supplying heat thereto, means causing air flow through said heat exchanger to supply heated draft air for said furnace, and means to limit the temperature at said heat exchanger comprising means for spraying water into the outlet end of the combustion chamber in advance of said heat exchanger.

2. Combustion apparatus for burning waste gases from a furnace and supplying heated draft air to such furnace, means forming a combustion chamber, means including a conduit for supplying combustible waste gases to said chamber from said furnace, means including an inlet for supplying air to said chamber, said combustion chamber having an outlet, means to control the supply of air through said air supply means to control the combustion temperature at said outlet, a heat exchanger at said outlet and adapted to be traversed by products of combustion from said chamber for supplying heat thereto, means causing air flow through said heat exchanger to supply heated draft air for said furnace, means to limit the temperature at said heat exchanger comprising means for spraying water into the outlet end of the combustion chamber in advance of said heat exchanger, and means including a thermostatically operated valve responsive to temperature at said heat exchanger to vary the quantity of water sprayed by said temperature limiting means to maintain a predetermined constant limit temperature at said heat exchanger.

3. Combustion apparatus for burning waste gases from a furnace and supplying heated draft air to such furnace, means forming a combustion chamber, means including a conduit for supplying combustible waste gases to said chamber from said furnace, means including an inlet for supplying air to said chamber, said combustion chamber having an outlet, means responsive to a condition of the combustion products at said chamber outlet and operable to control the supply of air through said air supply means to produce complete combustion, a heat exchanger at said outlet and adapted to be traversed by products of combustion from said chamber for supplying heat thereto, means causing air flow through said heat exchanger to supply heated draft air for said furnace, and means to limit the temperature at said heat exchanger comprising means for spraying water into the outlet end of the combustion chamber in advance of said heat exchanger, and means including a thermostatically operated valve responsive to temperature at said heat exchanger to vary the quantity of water sprayed by said temperature limiting means to maintain a predetermined constant limit temperature at said heat exchanger.

4. A combustion apparatus for utilizing waste furnace gases containing a small percentage of combustible CO, comprising means forming a combustion chamber having an inlet for said gases and an outlet for combustion products, a heat exchanger in said outlet to be traversed by said combustion products and adapted to supply heated draft air to a furnace, air supply means including a large air inlet for supply of combustion air, ignition means for igniting the fuel-air mixture, a second air supply means including high velocity air jets for creating high turbulence in the fuel-air stream to facilitate mixture of fuel and air, means including a thermostatically operated valve controlling air flow through said air supply means, and means including water spraying means at the outlet end of said combustion chamber in advance of said heat exchanger for introducing water therein to control combustion temperature at said heat exchanger.

5. A combustion apparatus for utilizing waste furnace gases containing a small percentage of combustible CO, comprising means forming a combustion chamber having an inlet for said gases and an outlet for combustion products, a heat exchanger in said outlet to be traversed by said combustion products and adapted to supply heated draft air to a furnace, air supply means including a large air inlet for supply of combustion air, ignition means for igniting the fuel-air mixture, a second air supply means including high velocity air jets for creating high turbulence in the fuel-air stream to facilitate mixture of fuel and air, means including a thermostatically operated valve controlling air flow through said air supply means, means including water spraying means at the outlet end of said combustion chamber in advance of said heat exchanger for introducing water therein to control combustion temperature at said heat exchanger, and means including a thermostatically operated valve responsive to combustion temperature and controlling flow through said spraying means to maintain a predetermined temperature at said heat exchanger.

6. A combustion apparatus for utilizing waste furnace gases containing a small percentage of combustible CO, comprising means forming a combustion chamber having an inlet for said gases and an outlet for combustion products, a heat exchanger in said outlet to be traversed by said combustion products and adapted to supply heated draft air to a furnace, air supply means including a large air inlet for supply of combustion air, ignition means for igniting the fuel-air mixture, a second air supply means including high velocity air jets for creating high turbulence in the fuel-air stream to facilitate mixture of fuel and air, means responsive to the degree of oxidation of the combustion products flowing from said combustion chamber and controlling air flow through said air supply means, means including water spraying means at the outlet end of said combustion chamber in advance of said heat exchanger for introducing water therein to control combustion temperature at said heat exchanger, and means including a thermostatically operated valve responsive to combustion temperature and controlling flow through said spraying means to maintain a predetermined temperature at said heat exchanger.

7. A combustion apparatus for utilizing waste furnace gases containing a small percentage of combustible CO, comprising means forming a combustion chamber having an inlet for said gases and an outlet for combustion products, a heat exchanger in said outlet to be traversed by said combustion products and adapted to supply heated draft air to a furnace, air supply means including a large air inlet for supply of combustion air, ignition means for initiating combustion, a second air supply means including high velocity turbulence producing jets intersecting the gas stream and facilitating interdiffusion of the gas and air, a thermostatic valve controlling air flow through said air supply means and having a responsive element positioned for response to combustion outlet temperature, a spray nozzle positioned in advance of said heat exchanger for spraying water into the outlet end of the combustion chamber to control combustion temperature at said heat exchanger, means to supply water to said nozzle, a thermostatic valve controlling water flow to said nozzle and having a responsive element positioned to control water flow in accordance with temperature at said heat exchanger to maintain a constant temperature thereat, and means to supply air to said nozzle to atomize the water supplied thereto, said air supply means being constantly open to atomize water when present and to blow foreign matter away from the nozzle when the water supply valve is closed.

8. Combustion apparatus for burning gaseous fuel and utilizing the heat of combustion, means forming a combustion chamber, means including a conduit for supplying combustible gas to said chamber, said combustion chamber having an outlet, a heat exchanger at said outlet and adapted to be traversed by products of combustion from said chamber for supplying heat thereto, means causing flow of a gaseous medium through said heat exchanger, means to limit the temperature at said heat exchanger comprising means for spraying water into the outlet end of the combustion chamber in advance of said heat exchanger, and means including a thermostatically

operated valve responsive to temperature at said heat exchanger to vary the quantity of water sprayed by said temperature limiting means to maintain a predetermined constant limit temperature at said heat exchanger.

9. Combustion apparatus for burning gaseous fuel and utilizing the heat of combustion, means forming a combustion chamber, means including a conduit for supplying combustible gas to said chamber, said combustion chamber having an outlet, a heat exchanger at said outlet and adapted to be traversed by products of combustion from said chamber for supplying heat thereto, means causing flow of a fluid medium through said heat exchanger, means to limit the temperature at said heat exchanger comprising means for spraying water into the outlet end of the combustion chamber in advance of said heat exchanger, and means including a thermostatically operated valve responsive to temperature at said heat exchanger to vary the quantity of water sprayed by said temperature limiting means to maintain a predetermined constant limit temperature at said heat exchanger.

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