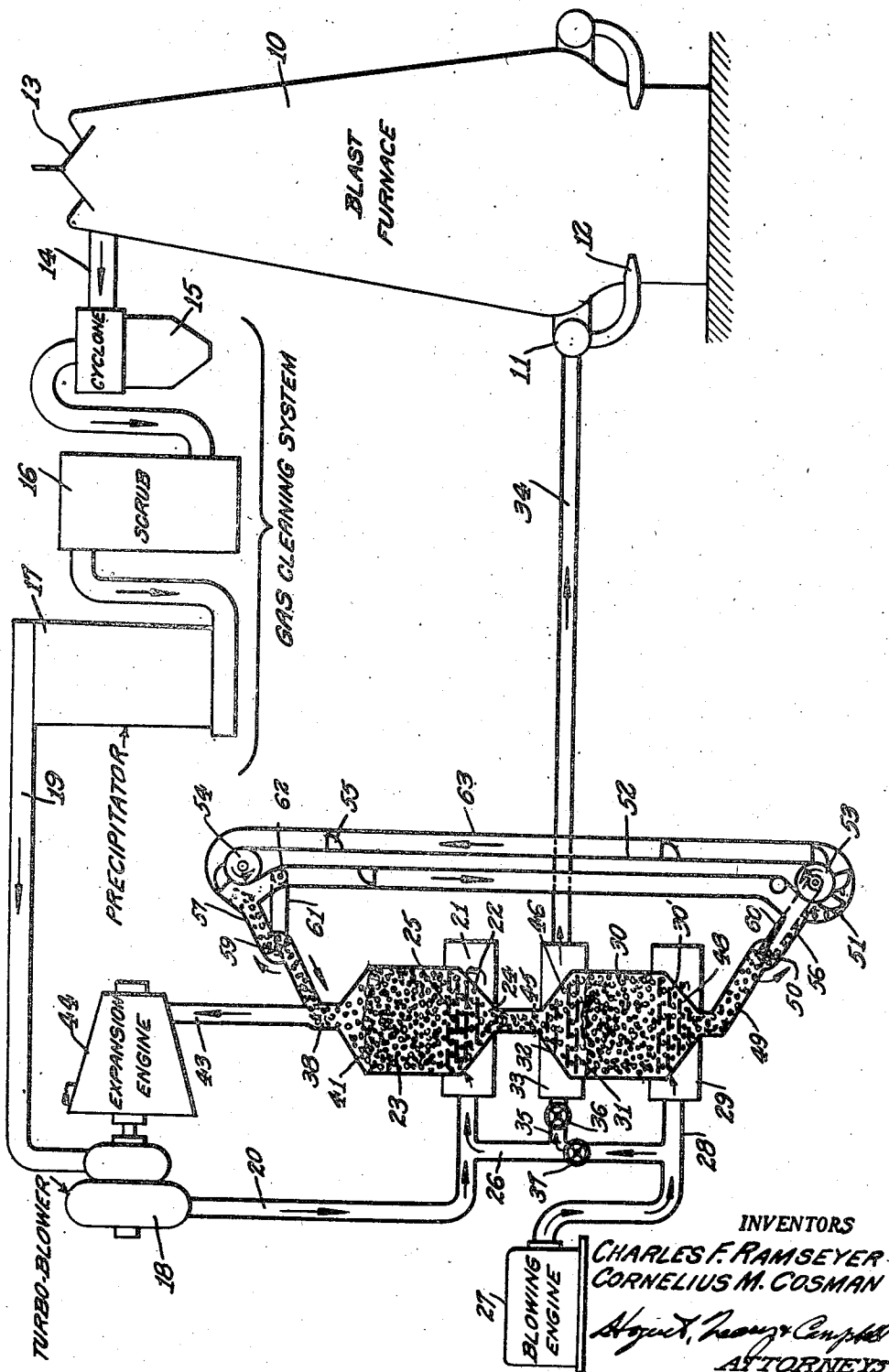


Aug. 3, 1948.

C. F. RAMSEYER ET AL
PREHEATING FURNACE BLAST

2,446,388

Filed Oct. 20, 1943



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2,446,388

PREHEATING FURNACE BLAST

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Application October 20, 1943, Serial No. 506,942

6 Claims. (Cl. 263—19)

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This invention relates to heating furnace blast, and has particular reference to methods and apparatus for heating the blast air for blast furnaces, although the invention is not limited to that use.

The present practice of heating blast furnace blast air involves the use of a series of large regenerative stoves filled with checker brick heated by burning blast furnace gas, and, after the stove is hot, the blast air is circulated there-through to be heated, while the blast furnace gas is burned in another stove to which the blast air is diverted after the previously heated stove has become cool. Such regenerative stove arrangements not only occupy much space and involve considerable expense of construction and maintenance, but they are inherently inefficient and much of the sensible heat thereof is lost because of their intermittent operation.

In accordance with the present invention, a continuously operating, compact, simple and inexpensive system of heating the blast air for blast furnaces or other combustion or hot processing apparatus is provided, in which no regenerative stoves or other intermittent devices of the type presently employed are needed, and the heat of combustion of the blast furnace gas is substantially entirely utilized with a minimum of heat loss.

The invention comprises a series of zones through which a plurality of refractory elements, preferably in the form of ceramic balls, are continuously circulated, being heated in one zone by combustion of the blast furnace gas and exchanging their heat in another zone to the air blast to be supplied to the blast furnace in the usual way. More particularly, the apparatus comprises a chamber, constituting the heating zone, in which the refractory elements are heated by countercurrent flow with the hot products of combustion from burning blast furnace gases, this chamber communicating with an air preheating chamber to which the heated elements are transferred by gravity to flow countercurrently to the blast furnace air from the blowing engine. The air is accordingly preheated to the desired temperature in the heating chamber as the result of heat exchange with the heated elements, which are accordingly cooled and then returned to the first or combustion chamber.

The entire air preheating system is preferably operated under superatmospheric pressure and the pressure in the air preheating chamber is maintained at or slightly above that in the element heating chamber to prevent the blast air

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from being fouled with the combustion gases. If the pressure in the air preheating chamber is higher, a slight bleed of heated air from the preheating chamber into the element heating chamber takes place, but the sensible heat of this air is recovered, since it is added to the normally supplied combustion supporting air, which may be part of the preheated blast air from the preheating chamber. The entire system is sealed, including the transferring means for elevating the cool refractory elements from the lower chamber to the upper chamber, so that the desired superatmospheric pressure is readily maintained. Inasmuch as the flue gases issuing from the element heating chamber are also under pressure, they may be economically employed for operating a suitable expansion engine, such as a gas turbine, for driving a turbo-blower or multi-stage compressor for compressing the blast furnace gas supplied as fuel at the desired pressure to the combustion zone in the element heating chamber.

It will be seen that the method and apparatus of this invention provide a very simple, compact and effective means for preheating blast furnace air, and eliminate the commonly-used large, expensive and inefficient regenerative stoves, resulting in a simpler and more efficient system and a material reduction in the size and cost of the enormous blast furnace auxiliary equipment which has heretofore been employed as a supposed necessity.

For a more complete understanding of the invention, reference may be had to the accompanying drawing, which illustrates diagrammatically a preferred arrangement of the apparatus of this invention, utilizing the method of this invention.

In the drawing, numeral 10 designates a conventional blast furnace shaft having the usual bustle pipe 11, tuyères 12, charge feeding bell 13, and blast furnace gas down-take 14 leading from the top of the furnace. In accordance with standard practice, the blast furnace gas is first cleaned in the cyclone 15, and washed in the scrubber 16. A precipitator 17, preferably of the Cottrell type, is added to thoroughly clean the gas so that it may be safely compressed in the turbo-blower 18 or other compressor to which it is led by pipe 19. Turbo-blower 18 preferably supplies the blast furnace gas at a pressure of about 18 pounds per square inch gauge by pipe 20 to a bustle ring 21 surrounding the hopper 22 and lower wall portion of combustion chamber 23 in which the aforementioned refrac-

tory heating elements 24 are heated. These heating elements 24 are preferably one-half to one inch diameter balls and are composed of ceramic refractory material, although they may be of good heat conducting metal or other suitable material.

The bustle ring 21 communicates with the interior of combustion chamber 23 through peripheral slots 25 in the intervening wall and combustion of the blast furnace gas takes place preferably in the ring 21, although the final traces of combustible gas may be burnt in the chamber 23, which preferably comprises steel shells lined with suitable refractory material. Slots 25 are of such dimension that escape of the refractory elements 24 therethrough is precluded.

Air for supporting combustion of the blast furnace gas in ring 21 and in chamber 23 is supplied by pipe 26 from the conventional blowing engine 27 used for compressing the blast air supplied to the blast furnace 10 through pipe 28, which leads to bustle ring 29 communicating through slots 30' with the interior of the lower or air preheating chamber 30. The preheating chamber 30 is similar to element heating chamber 23 in construction except that it need not be lined with such highly refractory material.

After being preheated by the heated refractory elements in a manner to be described, the blast air issues from chamber 30 through slots 31 in the dome 32 thereof into collecting ring 33, from which it is supplied to blast furnace 10 through pipe 34 at a pressure of about 18 pounds per square inch gauge, the air being supplied to the preheating chamber 30 by blowing engine 20 at a pressure of about 20 pounds per square inch gauge. In view of the leanness of blast furnace gas, it is preferred that preheated air be supplied to the element heating chamber 23, and to that end a by-pass 35 controlled by valve 36 leads from hot air collecting ring 33 to air supply pipe 26. When hot combustion supporting air is to be so supplied from ring 33, valve 36 is opened and a valve 37 in cold air supply pipe 26 below by-pass 35 is closed.

The refractory heating elements 24 are fed through a sealed tube 38 and fall by gravity through chamber 23, distributing and separating themselves substantially uniformly therein due to their special shape. As the elements move downwardly through chamber 23, they are first heated by the countercurrently flowing burned blast furnace gases, and as they collect in hopper 22, they are further heated by heat supplied from the burning gases in ring 21 which issue through slots 25 to circulate through the elements in the hopper 22.

The hot flue gases collect in dome 41 of chamber 23 and flow out through tube 38, having been cooled substantially by reason of the transfer of their heat to the descending refractory elements 24. The cooled flue gases are preferably conveyed from tube 38 by continuation pipe 43 to an expansion engine 44, such as a gas turbine, which may be employed to drive the turbo-blower 18 to compress the blast furnace gas in the manner described.

The refractory elements 24 are heated in the combustion chamber 23 to a temperature of about 2300° F. and to that end a temperature of about 2700° F. is maintained in combustion ring 21. The hot refractory elements descend by gravity through tube 45 connecting hopper 22 with the dome 46 of air preheating chamber 30 to move downward therethrough by gravity. In-

asmuch as the cold blast air rises through chamber 30 in the manner described, it flows countercurrently to the descending refractory elements, and heat is accordingly exchanged between them so that the blast air issues from preheating chamber 30 at a temperature of about 1425° F. to be supplied to the blast furnace tuyères 12 at about 1400° F. as aforementioned.

After heat exchange with the air in chamber 30 in the manner described, the refractory elements have a temperature of about 300° F. and collect in the hopper 48 of preheating chamber 30 to be discharged through conduit 49 to a star wheel type of feeder 50, which regulates the flow of the elements to the lower end of an elevator of the chain and bucket type. The chain 52 of the elevator 51 passes over sprockets 53 and 54, the lower sprocket 53 being driven from a suitable source of power, not shown. The cool refractory elements are discharged by the elevator buckets 55 into upper conduit 57 leading to a star wheel feeder 59 supplying the elements at a measured rate to the conduit 38 leading to the dome 41 of the combustion chamber 23 for repetition of the cycle. Lower feeder 50 may be driven from elevator sprocket 53 by a suitable chain and sprocket combination 60, and upper feeder 59 may be similarly driven by a chain and sprocket 61 combination from idler sprocket 62.

In order to preclude leakage of the combustion gases from chamber 23 into air preheating chamber 30 and thus fouling the blast air, the pressure in chamber 30 is maintained at a slightly higher pressure than the pressure in chamber 23, these pressures being regulated by valves 36 or 37. If the pressure in air preheating chamber 30 is maintained higher it may be on the order of 19 pounds per square inch gauge, and whereas that in chamber 23 may be at about 18 pounds per square inch gauge. As the result of this differential pressure there is a slight bleed of preheated air from chamber 30 into chamber 23, but this has a beneficial effect, since the sensible heat of the preheated air is recovered by the elements in chamber 23 and utilized in chamber 30. However, in normal operation a small leakage of the combustion gases in either direction is of little importance, and it may even be desirable to provide for leakage from element heating chamber 23 into air preheating chamber 30, such as for the purposes of controlling operation of the blast furnace 10. Thus, a certain amount of carbon dioxide may be conveniently added from chamber 23 to the air blast passing through chamber 30 in order to control the temperature in blast furnace 10 without disturbing either the volume or the temperature of the blast.

The chambers 23 and 30 and conduits 38, 45, 49, 56 and 57 are sealed and the elevator is enclosed in a housing 63, so that the entire system is sealed to permit the pressure operation described. Star wheel feeders 50 and 59 also serve as pressure seals and consequently the interior of elevator housing 63 is under a pressure which is the average of that in heating chamber 23 and that in preheating chamber 30.

Operation of the system of this invention will be readily understood from the foregoing description of the arrangement and function of the component elements, and although a preferred arrangement of parts is illustrated by the drawing, it is to be understood that the invention is not limited thereby but is susceptible of changes in form and detail within the scope of the appended claims.

We claim:

1. The continuous method of preheating air blast for furnaces by heat-exchange contact with recycled ball-like heated elements, which comprises heating the ball-like elements in a heating zone with hot gaseous products of combustion, feeding the heated elements from the heating zone through a heat-exchange zone by gravity, flowing the air to be preheated in heat exchanging relation countercurrently to said elements in the heat-exchange zone to heat the air and cool the elements, maintaining said zones under superatmospheric pressure, and maintaining the pressure in said heat-exchange zone at least substantially equal to the pressure in said heating zone to preclude flow of combustion gases into said heat-exchange zone, returning the cool elements from said heat-exchange zone to the heating zone to repeat the cycle, supplying the preheated blast air from said heat-exchange zone to the furnace, and supplying blast furnace gas from said furnace to said heating zone to provide said hot gaseous products of combustion therein.

2. The continuous method of preheating the air blast of a blast furnace by heat exchange contact with recycled heated ball-like elements, which comprises heating the ball-like elements in a heating zone with hot gaseous products from a combustion zone, supplying blast furnace gas as fuel to said combustion zone under pressure, feeding the heated elements from the heating zone through a heat-exchange zone by gravity, flowing the air to be preheated in heat exchange relation counter-currently to said elements in the heat-exchange zone under pressure to heat the air and cool the elements, returning the cool elements from said heat-exchange zone to the heating zone to repeat the cycle, supplying the preheated blast air from said heat-exchange zone to the furnace, maintaining said zones under the pressure provided by the entering blast furnace gas and air, operating an expansion engine by the resulting pressure of the flue gases from the combustion zone, and operating a compressor with said engine to supply the blast furnace gas to said combustion zone under said pressure.

3. The continuous method of preheating the air blast of a blast furnace by heat-exchange contact with recycled heated ball-like elements, which comprises heating the ball-like elements in a heating zone with hot gaseous products from a combustion zone, supplying blast furnace gas as fuel to said combustion zone under pressure, feeding the heated elements from the heating zone through a heat-exchange zone by gravity, flowing the air to be preheated in heat exchange relation countercurrently to said elements in the heat exchange zone under pressure to heat the air and cool the elements, returning the cool elements from said heat-exchange zone to the heating zone to repeat the cycle, supplying the preheated blast air from said heat-exchange zone to the furnace, and maintaining the pressure in said heat-exchange zone in excess of the pressure in said heating zone by means of the pressure at which the air is supplied to said heat-exchange zone, whereby the fouling of the air blast by combustion gases from said heating zone is precluded.

4. The continuous method of preheating the air blast of a blast furnace by heat-exchange contact with recycled heated ball-like elements, which comprises heating the ball-like elements in a heating zone with hot gaseous products from a combustion zone, supplying blast furnace gas as fuel to said combustion zone under pressure, feed-

ing the heated elements from the heating zone through a heat-exchange zone by gravity, flowing the air to be preheated in heat-exchange relation counter-currently to said elements in the heat-exchange zone under pressure to heat the air and cool the elements, returning the cool elements from said heat-exchange zone to the heating zone to repeat the cycle, supplying preheated blast air from said heat-exchange zone to the furnace, and maintaining the pressure in said heating zone in excess of the pressure in said heat exchange zone to provide for a bleed of the combustion gases into said heat-exchange zone, whereby the blast furnace may be controlled by diluting the blast air with combustion gases.

5. In a continuous system for preheating the blowing engine air blast for blast furnaces by heat-exchange contact with recycled heated elements, the combination of a heating chamber for heating the elements, a combustion chamber for supplying combustion gases to said heating chamber, a heat-exchange chamber, conduit means between said heating chamber and said heat-exchange chamber for conducting the heated elements to said heat-exchange chamber for gravity flow therethrough, a connection between the blowing engine and said heat-exchange chamber for supplying air under pressure therethrough countercurrently to the descent of said elements to cool the same and preheat the air, means for collecting the preheated air from said heat-exchange chamber, a connection between said collecting means and said furnace, means for supplying blast furnace gas from said furnace to said combustion chamber under pressure, elevator means for returning the cool elements to said heating chamber, an enclosure for said elevator means, whereby said chambers, conduit means and elevator means constitute a closed system operating under superatmospheric pressure produced by said blast furnace gas and air blast supply means, means for collecting the flue gases under said pressure from said heating chamber, an expansion engine connected to said flue gas collecting means for operation by the pressure flue gases, and a compressor driven by said engine and interposed in said means for supplying blast furnace gas to said combustion chamber for providing said gas pressure.

6. In a continuous system for preheating the blowing engine air blast for blast furnaces by heat-exchange contact with recycled heated elements, the combination of a heating chamber for heating the elements, a combustion chamber for supplying hot combustion gases to said heating chamber, a heat-exchange chamber, conduit means between said heating chamber and said heat-exchange chamber for conducting the heated elements to said heat-exchange chamber for gravity flow therethrough, a connection between the blowing engine and said heat-exchange chamber for supplying air under pressure therethrough countercurrently to the descent of said elements to cool the same and preheat the air, means for collecting the preheated air from said heat-exchange chamber, a connection between said collecting means and said furnace, means for supplying blast furnace gas from said furnace to said combustion chamber under pressure, a by-pass between said heat-exchange chamber and said combustion chamber for supplying preheated air to the latter to support combustion of the blast furnace gas therein, elevator means for returning the cool elements to said heating chamber, an enclosure for said elevator means,

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whereby said chambers, conduit means and elevator means constitute a closed system operating under superatmospheric pressure produced by said blast furnace gas and air blast supply means, means for collecting the flue gases under said pressure from said heating chamber, an expansion engine connected to said flue gas collecting means for operation by the pressure flue gases, and a compressor driven by said engine and interposed in said means for supplying blast furnace gas to said combustion chamber for providing said gas pressure.

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