

Nov. 8, 1966

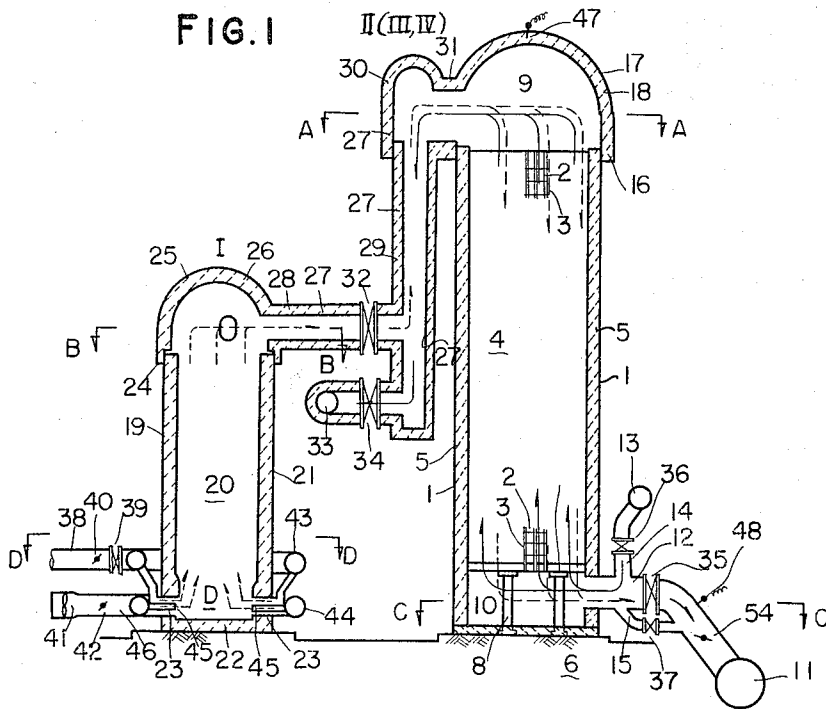
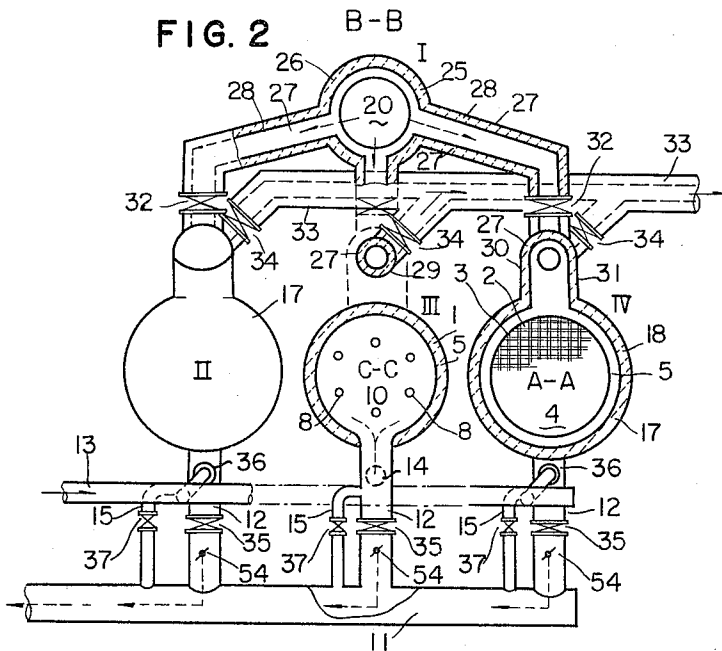
SAICHI NISHIDA ETAL

3,284,070

HOT BLAST STOVE HAVING ONE COMMON COMBUSTION CHAMBER

Filed Jan. 28, 1964

3 Sheets-Sheet 1



INVENTORS

Saichi Nishida

Takayuki Imaida

Haruki Uchiyama

BY

Wendroth, Lind and Ponack,
Attorneys

Nov. 8, 1966

SAICHI NISHIDA ETAL

3,284,070

HOT BLAST STOVE HAVING ONE COMMON COMBUSTION CHAMBER

Filed Jan. 28, 1964

3 Sheets-Sheet 2

FIG. 3

D-D-D

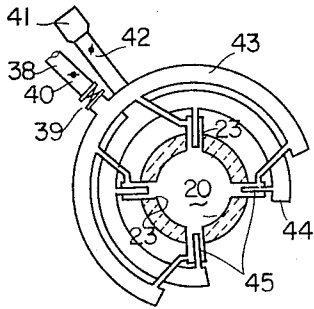


FIG. 4

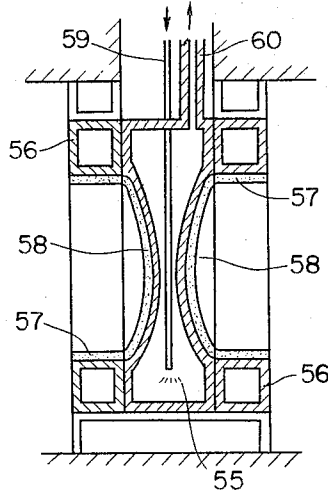
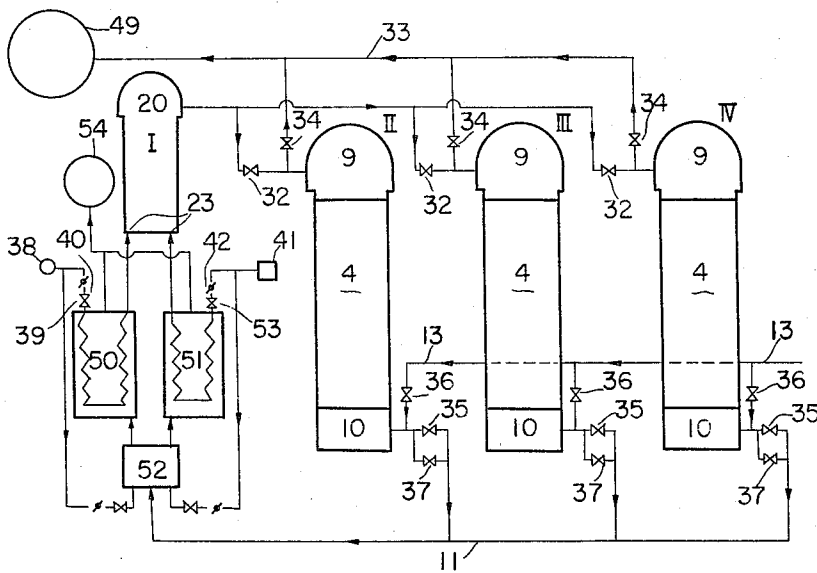


FIG. 5



INVENTORS

Saichi Nishida
Takayuki Imaida
Haruki Uchiyama

BY

Wunderoth, Lund and Ponsch
attorneys

Nov. 8, 1966

SAICHI NISHIDA ETAL

3,284,070

HOT BLAST STOVE HAVING ONE COMMON COMBUSTION CHAMBER

Filed Jan. 28, 1964

3 Sheets-Sheet 3

FIG. 6

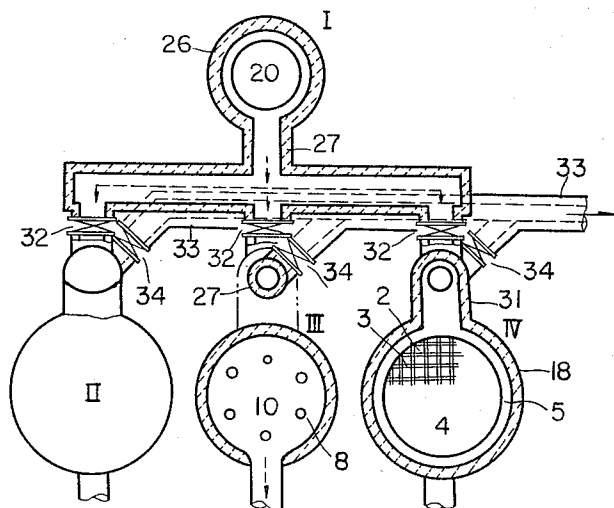
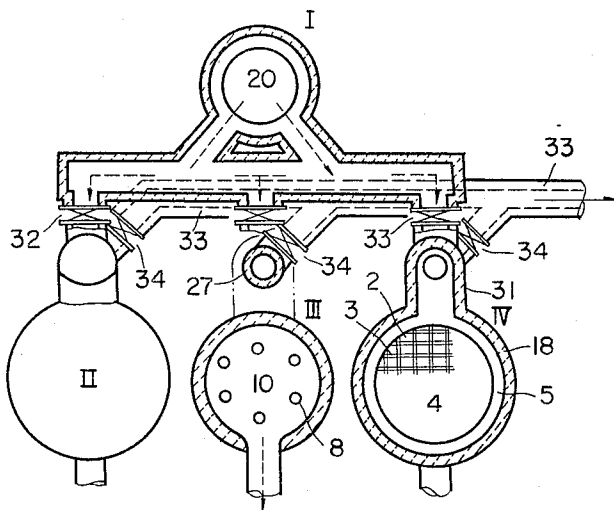


FIG. 7



INVENTORS

Saichi Nishida

Takayuki Imaida

BY Haruki Uchiyama

Wunderlich, Lind and Ponack
attorneys

1

3,284,070

HOT BLAST STOVE HAVING ONE COMMON COMBUSTION CHAMBER

Saichi Nishida, Takayuki Imaida, and Haruki Uchiyama, all of Kitakyushu, Japan, assignors to Yawata Iron & Steel Co., Ltd., Tokyo, Japan, a corporation of Japan
Filed Jan. 28, 1964, Ser. No. 340,644

Claims priority, application Japan, Feb. 1, 1963, 38/5,076

1 Claim. (Cl. 263—19)

This invention relates to a hot blast stove, more particularly, to a hot blast stove consisting of several regenerators and one common combustion chamber.

As well known, in any conventional arrangement of hot blast stoves for use in a blast furnace, at least two hot blast stoves are required for one blast furnace, but in practice it is usual that three or four stoves are adopted for one blast furnace. And in almost all cases, the interior of each stove surrounded by a shell is divided into two sections—a combustion chamber, in which a fuel is burnt, and a regenerator filled with a checker-work, in which heat produced by the combustion in the combustion chamber is stored. That is, a combustion chamber and a regenerator are installed within the same shell. There is, of course, an exceptional case, in which a combustion chamber and a regenerator are installed in each separate shell respectively and are connected at one end of each shell. However, all conventional arrangements of hot blast stoves are common in the following points, that the combustion chamber and the regenerator make a pair and each hot stove is provided with a combustion device including a supply mechanism of fuel and air for combustion.

It is also well known that in the operation of a conventional hot blast stove (1) heating the checker-work by hot gas produced by the combustion in the combustion chamber and (2) heating blast by the checker-work, which stored heat, are carried out alternately. That is, in the first stage, for instance, a cleaned waste gas of a blast furnace is blown into the combustion chamber of the hot blast stove together with an air through an inlet provided at the one end of the gas passage of the stove and is burnt in the combustion chamber. The hot gas produced by the combustion in the combustion chamber goes up and then passes through the checker-work downwards from the top of the stove, imparting the heat to the checker-work. The waste gas is discharged from an outlet provided at the other end of the stove. In the second state, when the checker-work is sufficiently heated, the blowing in of the blast furnace waste gas and air into the combustion chamber is stopped and in lieu thereof a cold blast is blown into the checker-work through said outlet of the waste gas. A hot blast obtained by passing through the checker-work is taken out through another outlet provided at the middle of the gas passage of the stove. When the checker-work is cooled again by imparting the heat to the cold blast blown in, the blowing in of the cold blast is stopped and the first stage operation is resumed. Thus, the operation of the hot blast stove is carried out in alternation of the heating cycle (on gas) and the blasting cycle (on blast) with one total period lasting for 2 hours in the case of conventional arrangement of two stoves, 3 hours in the case of three stoves and 4 or 2 hours in the case of four stoves.

The changing over of the cycles, that is, from the heating cycle to the blasting cycle or vice versa, is performed usually by various valves installed in the stove. However, this changing over operation is very troublesome and much time is required therefore. For instance, in the case of changing over from the heating cycle to

2

the blasting cycle nine operations of closing or opening various valves or operating devices must be carried out in continuation, for instance, for cutting off the feeding of fuel to the combustion chamber, cutting off the feeding of air under pressure, cutting off the connection between the combustion chamber and the combustion device, cutting off the connection between the stove and the flue, blowing a cold blast into the checker-work and supplying the hot blast into the blast furnace, and in the case of changing over from the blasting cycle to the heating cycle 10 operations are required for cutting the connection between the stove and the hot blast pipe, stopping blowing in of the cold blast, discharging the residual blast within the stove, putting the combustion device and the combustion chamber in connection, blowing the fuel and air for combustion into the combustion chamber and the like. Therefore, for changing over the cycles 19 operations will be required in total in one whole period, which take more than 20 minutes in total in the case of the manual operation of changing over and about 10 minutes in the case of the whole automatic operation. The time required for changing over the cycles results in the reduction of the heating time, because the hot blast should be supplied to the blast furnace without an interruption. Thus, in the case of an arrangement of two stoves, in which two hours are required for one whole period of operation and one hour for the heating cycle, the heating time will be 40 minutes, if the changing over operations are carried out manually.

From the view point of the efficiency of the hot blast stove operation and the heat economy it is unfavorable to require much time for changing over the cycles, because each stove does not participate in the heat exchange operation during the time of changing over the attached valves and the combustion device. In addition thereto, it is to note that the conventional arrangement of hot blast stoves has shortcomings in the equipment costs and land utilization, because the combustion device is at a standstill during the blasting cycle and each stove is provided with a combustion chamber which occupies a relatively large space. Further, the conventional arrangement of hot blast stove is accompanied by the serious problem with respect to fuel and air for combustion to be supplied to the stove. The main fuel used for the hot blast stove nowadays is a blast furnace waste gas, the calorific value of which is, however, the lowest (about 700 to 800 Kcal./Nm.³) among the all industrial fuels, and moreover has a tendency to decline in accordance with the improvement in the coke ratio, which indicates the development in the efficiency of the blast furnace operation. On the other hand, a more higher temperature of the hot blast to be fed from the stove to the blast furnace is required from the necessity of increasing the productivity of the blast furnace. This requirement will be intensified when such reducing materials as heavy oil, CO gas or pulverized coal and the like are blown into the blast furnace. This requirement of obtaining the hot blast, only resorting to the blast furnace waste gas of low calorific value without using any other fuel of high calorific value may be met by preheating fuel and air for combustion, thereby to elevate the temperature of the combustion flame. For this purpose, heretofore, a metallic heat exchange preheater has been additionally installed in order to preheat fuel and air for combustion and supplying the preheated fuel and air to each stove. However, the method of preheating fuel and air for combustion by providing with said preheater will bring unfavorable effects (deformation of valves or leakage of gas) on the use and maintenance of the gas valve, gas flow regulating valve, air cutting off valve and air flow regulating valve attached to the combustion device of

the stove, which are to regulate the fuel and air preheated by said preheater to a temperature of 200 to 400° C. so as to agree with the standard of combustion control (flow and temperature), when these valves are exposed to a high temperature of 200 to 400° C. for a long time. Even if the pre-regulation of fuel and air is carried out before entering into said preheater, the hot blast must be once more regulated immediately before it is blown into the blast furnace in order to supply the hot blast of the fixed temperature from each stove, because a uniform blast can not be obtained from each stove due to the blast resistance inherent to each stove and different temperature within each stove with each other. Further, the above conventional arrangement is undesirable from the point of the heat efficiency, because relatively large radiant heat losses must be expected on the way of the preheated gases flowing from said preheater to each stove through the regulating valves. Moreover, it is to be added that as the blast furnace waste gas used as the main fuel is an asphyxiating deadly poison gas the leakage thereof will detrimentally effect the hygienic conditions of the workers.

The present invention is to eliminate the defects of the conventional arrangement of the hot blast stoves as above mentioned.

The object of the present invention is to provide a hot blast furnace, in which the combustion is carried out in continuation irrespective of the blasting cycle.

Another object of the present invention is to provide a hot blast furnace, in which the operations of changing over the valves are much less in number and less time is required therefore than any conventional arrangement.

A further object of the present invention is to provide a hot blast furnace, which is capable of supplying a hot blast of sufficient temperature as required for a blast furnace, while resorting only to a blast furnace waste gas.

A further object of the present invention is to provide a hot blast furnace, in which regulating valves may be protected from damages and radiant heat loss may be prevented.

The details of the present invention will be made clear by the following description in reference to the attached drawings.

FIG. 1 shows a longitudinal section of a regenerative hot blast stove having one common combustion chamber and attached equipments according to the present invention.

FIG. 2 is a plan of an arrangement of three regenerators and one common combustion chamber and shows a section on the line A—A, a section on the line B—B and a section on the line C—C of FIG. 1.

FIG. 3 shows a section on the line D—D of FIG. 1.

FIG. 4 is a longitudinal section of a water-cooled valve.

FIG. 5 is a diagram of preheating fuel and air for combustion in the regenerative hot blast stove having one common combustion chamber according to the present invention.

FIG. 6 shows a plan of a partial section of a modified arrangement of combustion gas pipes for distributing combustion gases to a plurality of regenerators from the common combustion chamber according to the present invention.

FIG. 7 is another modification of FIG. 6.

As shown in each of the above mentioned drawings, a hot blast stove according to the present invention is characterized by comprising one common combustion chamber and a plurality of regenerators independently with each other, said combustion chamber and said regenerators being connected with connecting pipes, through which combustion gas produced in said combustion chamber is supplied to each of said regenerators, and further said combustion chamber being provided with a pre-heater of air for combustion having a valve for

controlling the flow rate of air before preheated and a preheater of fuel having also a valve for controlling the flow rate of fuel before preheated.

The hot blast stove according to the present invention is a typical example of the regenerative heat exchanger, which supplies a hot blast to a blast furnace of smelting iron ores and has the purpose of continuously supplying a hot blast to a blast furnace by heating the regenerators of the stove by burning mainly waste gas generated in the operation of the blast furnace or, though in a rare case, burning said blast furnace waste gas mixed with such fuel of high calorific as coke oven gas or the like, and then heating a blast (air of gauge pressure of 0.5 to 3 kg./cm.²) blown into the regenerators under pressure from a blower by passing said blast through said regenerators.

The present invention will be explained more in detail in reference to the drawings.

As shown in the drawings, the common combustion chamber (I) is installed separately from the regenerators (II), (III) and (IV), and each of regenerators contains within its bottomed cylindrical shell 1 of an air-tight structure respectively a regeneration chamber 4 of round form in the cross-section thereof, which is compactly filled with the known checker-work provided with small holes 2 representing the passage of combustion gas or blast, a wall 5 which is prepared by a combination of refractory materials and heat-insulating materials with a view of reducing the heat loss due to radiation heat, and a bottom 6 which is constructed with refractory materials or heat-proof ferro-concrete. The lower part of the chamber 4 is provided with steps 7 and their stanchions 8 for supporting the checker-work 3. Both above and below the chamber 4 there are sufficient large spaces 9 and 10 to allow the equal distribution of combustion gas or blast to the small holes 2 provided in the checker-work. At the lower part of the cylindrical shell 1 of each regenerator there are installed a waste gas outlet 12 connecting with a flue 11 for combustion gas, a blast inlet 14 for the introduction of cold blast from the blower into the regenerator through a blast pipe 13 and an exhaust port 15 for discharging residual blast in the regenerator into the flue 11 when changing over from the blasting cycle to the heating cycle. The top part of the cylindrical shell 1 of each regenerator is provided with a semi-spherical shell 17 of air-tight structure, which is connected air-tightly with said cylindrical shell 1 by means of a ring-formed plate 16 and is projecting in a mushroom-form in order to settle itself at a substantially fixed position, without being influenced by the elongation of the wall 5 due to heat expansion (an elongation of about 300 mm. has been measured in the case of a hot blast stove of 35 m. high), the inside of which shell being lined with a domed wall 18 made by a combination of refractory materials and heat-insulating materials.

The combustion chamber 1 contains also within its bottomed cylindrical shell 19 of air-tight structure a combustion room 20 of round form in the cross-section thereof, a chamber wall 21 prepared by a combination of refractory materials and heat-insulating materials and a bottom 22 constructed with refractory materials. The lower part of the combustion chamber is provided with a plurality of burner ports 23, through which ports fuel and air for combustion are blown into the combustion chamber, and the top part thereof is provided also with a semi-spherical shell 25 of air-tight structure, which is connected air-tightly with said cylindrical shell 19 by means of a ring-formed plate 24 and is also projecting in a mushroom-form in order to settle itself at a substantially fixed position, without being influenced by the elongation of the chamber wall 21 due to heat expansion, like the regenerators (II), (III) and (IV), the inside of which shell being also lined with a domed wall 26 made by a combination of refractory materials and heat-insulating materials. A part of each top of the combustion

5

chamber 1 and the regenerators (II), (III) and (IV) is provided with an opening respectively. The opening of the combustion chamber and the respective opening of the regenerators are connected by the connecting pipes 28, 29, 30 and 31, which are connecting with each other to form a pipe and are all provided with a lining 27 made by a combination of refractory materials and heat-insulating materials. A water-cooled combustion gas valve 32 for cutting off the communication between the combustion chamber and the regenerator is installed on the connecting pipe 28 and also a water-cooled hot blast valve 34 for cutting off the communication between the regenerator and a blast pipe 33 leading to the blast furnace.

As high temperature gases pass through said connecting pipes and blast pipe it is very advisable to adopt a water-cooled valve of special construction as shown in FIG. 4 for use in cutting off the flow of high temperature gases. In FIG. 4 the valve consists of a valve plate 55 and valve seats 56, 56. The valve plate 55 is characterized by forming the concaved curves at its center part on both sides and the surface thereof touching with high temperature gases is covered by a refractory coating 58. The valve seats 56, 56 are also covered by a refractory coating 57, 57. The valve plate 55 and the valve seats 56, 56 are touched with each other immediately. The valve plate 55 is movable vertically, thereby opening or closing the pipe. FIG. 4 shows a closed situation. When the pipe is to be opened, the valve plate 55 is pulled up to the position, where the bottom of the valve plate reaches nearly the level of the bottom of the upper valve seats. A sea water or fresh water is poured within the valve plate 55 through a pipe 59 for cooling the valve plate, and is discharged from a pipe 60. A cooling water is also poured into the valve seats from the lower parts thereof and is discharged from the upper parts thereof (not illustrated). This construction of the valve has the following advantage that a greater cooling effect may be obtained due to an accelerated flowing speed of the poured water at the center part of the valve plate resulting from its concaved forms, thereby the valve material may be protected from high temperature of gases.

At the respective lower part of the regenerators (II), (III) and (IV) valves of various kinds, which have the same purposes as of the conventional Cowper-type furnace, are provided, that is, a flue valve 35 at the waste gas outlet 12, a blast valve 36 attached with a small valve at the blast inlet 14 and an exhaust valve 37 at the exhaust port 15. Also the combustion chamber 1 has a gas valve 39 and a fuel flow regulating valve 40 installed within the fuel feed pipe 38, and a fan 41 for feeding air for combustion under pressure and an air flow regulating valve 42 installed within the air feed pipe 46. The fuel feed pipe 38 and air feed pipe 46 are connected with a plurality of burners 45 by the ring pipes 43 and 44 respectively. These valves, pipes and burners constitute the combustion device of the combustion chamber.

The operation of the hot blast stove comprising one common combustion chamber and a plurality of regenerators according to the present invention will be explained in the following.

As shown in the attached figures an arrangement of three regenerators will be taken as an example, though the number of regenerators is not limited to three in this invention and may be more than three.

For the sake of simplicity, it is assumed that one hour is required for one heating cycle and one hour for one blasting cycle respectively in each regenerator. The supply of a hot gas from the combustion chamber to a regenerator is commenced, for instance, from the regenerator (II) among three regenerators (II), (III), and (IV). After one hour, the regenerator (II) is changed over from the heating cycle to the blasting cycle and at the same time the regenerator (III) is fed with a hot gas. After one hour the regenerator (III) is changed over

6

from the heating cycle to the blasting cycle and at the same time the regenerators (II) and (IV) are fed with hot gases. After further one hour the regenerator (IV) is changed over from the heating cycle to the blasting cycle. At the same time the regenerator (III) is changed over from the blasting cycle to the heating cycle and the regenerator (II) continues the heating cycle and so on. Then, it is obvious that in each cycle two regenerators are in the heating cycle and one of them is in the blasting cycle, and from the view point of each regenerator it passes two heating cycles and one blasting cycle. Thus, the combustion in the combustion chamber is continued uninterruptedly. For the purpose of obtaining the equal distribution of the combustion gases to any two regenerators, which are in the heating cycle, a waste gas flow control valve 54 is installed in the waste gas outlet 12, which valve changes the degree of its opening in compliance with the temperatures indicated by a thermometer 47 installed in the domed wall 18 of each regenerator and a thermometer 48 installed in the waste gas outlet 12.

As the combustion chamber 1 is common to all regenerators and is always uninterruptedly in operation, the changing over operations pertaining to the combustion device may be entirely eliminated. Therefore, the operations of changing over the cycles according to the present invention may be much simplified as compared with those of the conventional arrangements. For instance, in the changing over from the heating cycle to the blasting cycle, at first the water-cooled combustion gas valve 32 is fully closed to cut off the communication between the combustion chamber 1 and the regenerator (II) and thereupon the flue valve 35 is fully closed to cut off the communication between the regenerator (II) and the flue 11. Then, a small valve contained in the blast valve 36 is fully opened to introduce gradually a cold blast into the regenerator, and when the inner pressure within the regenerator becomes substantially equal to the blast pressure within the blast pipe 13, the blast valve 36 is fully opened. Thereafter, the water-cooled hot blast valve 34 is fully opened to supply the hot blast to the blast furnace. Thus, by carrying out 5 operations of closing or opening the valves successively, the changing over operation of the cycles can be completed. The solid line with an arrow shown in FIG. 1 indicates the course of the cold blasting being converted to the hot blast and the latter being introduced to the blast furnace. On the contrary, when changing over, for instance, the regenerator (III), which was in the blasting cycle, to the heating cycle, the operations are carried out in the following sequence: the water-cooled hot blast valve is fully closed, the blast valve 36 is fully closed and then the exhaust valve 37 is fully opened to discharge the residual blast in the regenerator into the flue 11. Thereupon, the flue valve 35 is fully opened and at the same time the exhaust valve 37 is fully closed and then the combustion gas valve 32 is fully opened, thereby the combustion flame may be introduced from the combustion chamber to the regenerator (III). Thus, 6 operations are carried out in order to change the blasting cycle over to the heating cycle. The dotted line with an arrow shown in FIG. 1 indicates the course, through which a gas heated in the combustion chamber passes through the regenerator, imparting the heat thereto, and is discharged to the flue 11 from the exhaust outlet 12. Therefore, in the present invention the changing over operation of the cycles can be completed only with 11 operations in total of closing and opening the valves, while in the conventional arrangement 19 operations in total are required as already mentioned, that is, in the arrangement according to the present invention the number of the operations of valves may be reduced to a half that in the conventional arrangement, and consequently, the time required therefore may be also reduced substantially to a half, resulting in a great advantage of lessening loss time which does not participate in the heat exchange, indicating a great improve-

ment as well in the efficiency of operating the hot blast stove as in the heat efficiency. The curtailment of the time required for the changing over operations indicates another possibility of improving the heat efficiency and operation efficiency, because the frequencies of changing over the cycles may be thereby increased. Moreover, the economic advantages may be achieved in the equipment costs and site utilization, because all the equipments may be fully utilized contrary to the conventional arrangement, in which the combustion chamber and combustion device, which occupy relatively large sites, must be at a standstill during the blasting cycle, and in addition thereto the regulating system concerning the combustion may be eliminated in the present invention. Finally, it is to note that the following advantages may be gained by the continuous operation of the combustion chamber.

In the arrangement according to the present invention there is no trouble of confirming the ignition and extinguishment, which are to be repeated every three hours in the conventional arrangement of the hot blast stoves and further no danger of gas explosion due to defective ignition or wrong changing over operation pertaining to the combustion device, which are possible in the conventional arrangement. Another advantage resulting from the continuous combustion in the combustion chamber resides in the fact that an extreme stability may be secured in the mechanical properties of the refractory materials during the hot operation, because gases are always kept at a settled temperature and low pressure, thus the combustion equipments may semi-eternally maintain the capacity of producing hot gases of high temperature as of 1,200° C., while in the conventional arrangement the refractory materials constituting the combustion chamber, which belongs to the highest temperature atmosphere of the stove are apt to be deteriorated on account of mechanical stresses due to changes in temperature and pressure, because the heating and blasting cycles are changed in alternation. The same may also be applied to the combustion device attached to the combustion chamber, i.e. the burner valves and pipes for supporting the same are easily subjected to the deformation, thereby they are apt to break or cause the leakage of gases. The arrangement according to the present invention is free from these defects.

The present invention has a further advantage in preheating fuel and air for combustion. As shown in FIG. 5, besides the combustion chamber there are installed a known preheater of fuel 50, a preheater of air for combustion 51 and a combustion stove for heating the waste gas coming from the flue 11 like in the conventional arrangement. However, in the present invention the fuel flow regulating valve 40 and the gas valve 39 are installed for regulating the fuel coming through the fuel supply pipe 38, and the air flow regulating valve 42 and the cutting off valve 53 are installed for regulating the air supplied from the fan 41. That is to say, fuel and air for combustion of a normal temperature and normal pressure are regulated by means of these valves before entering into the preheaters. The thus regulated fuel and air are preheated in the preheaters up to a temperature of 200 to 400° C. and then burnt in the common combustion chamber, producing hot gases of 1,200° C., which are further distributed to the regenerators, imparting the heat to the latter. Thus, the hot blast to be supplied to the blast furnace may be obtained, only resorting to blast furnace waste gases of low calorific value. In the above mentioned process of producing the hot blast according to the present invention it is very advantageous that the regulation of gases will be sufficient only with the flow regulation thereof, because the temperatures thereof are substantially constant, and that the regulating operation of fuel and air for combustion is very simple, because those of normal temperature and pressure may be regulated before entering into the preheaters. Thus, the arrangement according to the present invention may be much more economically and effectively utilized in the view points of operation, equipment costs, site utilization, heat efficiency, maintenance, safety and hygienic conditions of the workers, as compared with the conventional arrangement of the hot blast stoves.

The scope of the present invention is not limited to the above description, which has disclosed only an example of the present invention. Modifications or changes in construction of details or combination thereof must be also included within the scope of the present invention, provided that they do not depart from the spirit of the present invention.

What we claim is:

A hot blast stove for supplying hot blast to a blast furnace, comprising a plurality of more than two regenerators, the inside of each of said regenerators being filled with checker-work, and one common combustion chamber, a connecting pipe between each of said regenerators and said combustion chamber, a water cooled combustion gas valve in each connecting pipe, a fuel preheater and a combustion air preheater connected to the intake end of said combustion chamber, a gas fuel supply pipe connected to the fuel preheater, a gas flow regulating valve and a gas shutoff valve in said gas fuel supply pipe for regulating fuel coming through the fuel supply pipe, a combustion air supply pipe connected to said combustion air preheater, an air flow regulating valve and air shutoff valve in said air supply pipe for regulating air flowing in said air supply pipe, and a fan at the upstream end of said air supply pipe, by means of which valves said fuel and air for combustion of normal temperature and normal pressure are regulated before entering said preheaters.

References Cited by the Examiner

UNITED STATES PATENTS

927,930	7/1909	Von Bechen	137—310
2,163,149	6/1939	Linder	263—19
2,175,611	10/1939	Linder	263—19
2,505,861	5/1950	Johnson	263—19
3,122,359	2/1964	MacDonald	263—19
3,150,865	9/1964	Goeke	263—19
3,153,532	10/1964	Touzalin	263—19

FREDERICK L. MATTESON, JR., *Primary Examiner*,
JOHN J. CAMBY, *Examiner*.