H. L. DOHERTY.

PROCESS FOR INCREASING THE TEMPERATURE OF COMBUSTION IN GAS FIRED FURNACES.

APPLICATION FILED MAR. 31, 1909.

1,024,678.

Patented Apr. 30, 1912.

2 SHEETS—SHEET 1.

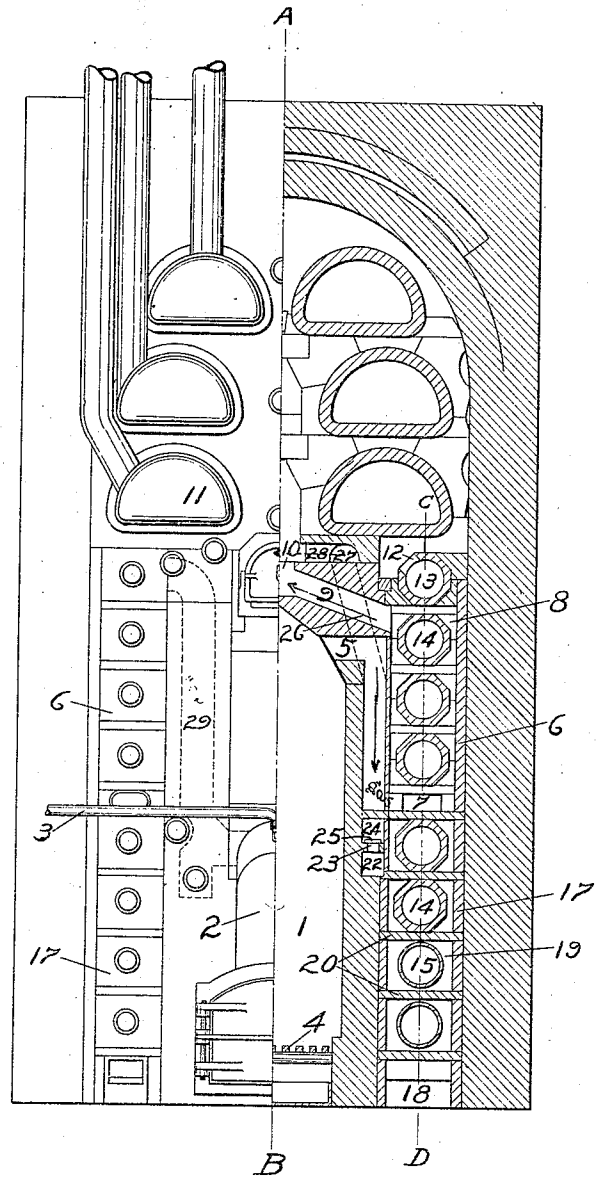

Fig 1

WITNESSES

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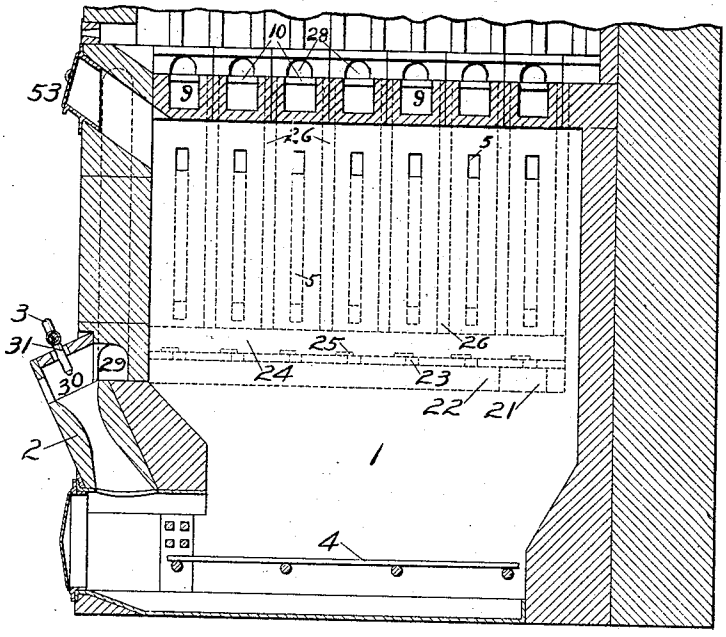

Fig 2

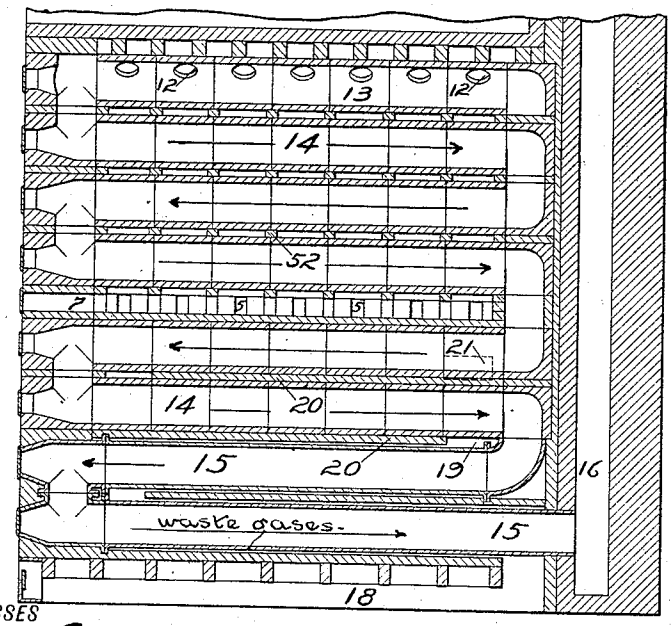

Fig 3

WITNESSES

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PROCESS FOR INCREASING THE TEMPERATURE OF COMBUSTION IN GAS-FIRED FURNACES.

1,024,678. Specification of Letters Patent. Patented Apr. 30, 1912.

Application filed March 31, 1909. Serial No. 486,888.

To all whom it may concern:

Be it known that I, HENRY L. DOHERTY, a citizen of the United States, residing at New York city, in the county of New York and State of New York, have invented new and useful Improvements in Processes for Increasing the Temperature of Combustion in Gas-Fired Furnaces, of which the following is a specification.

My invention relates to a process for increasing the temperature of combustion in gas-fired furnaces, and it relates particularly, to that type of such processes in which the control and regulation of the temperature in the producer is secured by the introduction of some endothermic agent.

The objects of the invention are, the increase in efficiency of heat utilization due to the increased temperature secured in the furnace, and the increased economy in fuel due to a more perfect recuperation of the heat of the flue gases, than is secured by the various processes in present use.

My invention can be applied to any gas-producing-and-consuming apparatus, in which the waste gases of combustion are at a higher temperature than the producer gas leaving the gas producer.

My invention can be used equally well in connection with, either the type of producer wherein the temperature control thereof is effected by the introduction of water vapor, or wherein, the temperature control is effected by the introduction of a regulated proportion of combustion gases into the air current supplied to the producer.

The particular application of my invention which I have selected for purposes of illustration, is that to a furnace for manufacturing illuminating gas by the destructive distillation of coal. In the usual type of these furnaces, the coal is distilled or carbonized in retorts, which are heated by the combustion of producer gas, generated in a producer placed below the retort oven. The name commonly applied to this apparatus is "gas bench". These are usually built back to back, forming twin settings, a number of these being erected side by side, forming what is known as a battery, or "stack of benches".

My invention may be applied to any combined gas-producing and gas-consuming apparatus in which the products of combustion leave the gas-consuming apparatus, or furnace, at a higher temperature than that at which the producer gas enters it, the relation of the two parts of the apparatus being such, that the products of combustion may be passed into recuperators for heating the producer gas at, substantially, the temperature at which they leave the furnace. For instance, my invention may be applied to zinc furnaces or open-hearth steel furnaces, and to many other similar types of furnaces. In the accompanying drawings, I show a single gas bench to illustrate the application of my invention to such apparatus. The bench shown in Figures 1, 2 and 3, is of the general type that is, at present, used and which is well adapted for use in the practical working of my process of gas-producer control. My invention can be applied equally well to the ordinary type of gas bench, wherein the temperature control of the producer is effected by the introduction of water or water vapor into the fuel bed.

In the drawings Fig. 1 shows a single bench partly in section and partly in elevation. Fig. 2 is a longiutdinal section on the line A—B of Fig. 1. Fig. 3 is a section through a recuperator on the line C—D of Fig. 1.

In the application of my invention which I herein claim, the recuperator portion of the bench is in duplicate, the construction being similar on either side of a longitudinal plane through the middle of the producer, save, that the entrance and take-off flues are, in each case, on the side of the recuperators next to the producer.

In the drawings, 1 is a gas producer, 2 is the injector by means of which a mixture of air and flue gas is introduced into the producer.

3 is a pipe through which air under pressure is supplied to the injector; 4 is the grate

of the producer; 5 are flues conveying producer gas to the producer gas recuperators 6; 7 are equalizing flues; 8 the producer gas flue through the recuperator.

9, and 10 are passages for conducting the producer gas from the producer gas recuperators to the retort oven.

11 are the retorts containing the coal to be carbonized.

12 is a series of ports or orifices in a flue 13, (one for each recuperator), through which the waste gases of combustion pass to the recuperator.

14 and 15 are flues affording passage for the waste gases through the recuperator to the flue 16 leading to the stack. 17 the air recuperators having air-inlet flues 18, and series of return-bend flues 19. 20, horizontal partitions dividing the air recuperators into a series of return-bend flues.

21 are ports, one for each recuperator, providing entrance for air into the equalizing flues 22.

23 are ports connecting flues 22 with parallel flues 24.

25 are movable tiles which can be used to regulate the area of the openings in the port 23, so as to secure a uniform flow of air from 22 to 24 along the entire length of the flues.

26 are two series of flues (one series for each side of the recuperator) connecting 24 with another parallel flue 27, from which the air discharges through the ports or nostrils 28 into the stream of producer gas entering the retort oven through the port 10.

29 are flues, one for each side of the bench, conducting part of the waste gases, after their passage through the retort oven, to the induction chamber 30 of the inductor 2.

31 is the nozzle of the inductor.

52 are vertical partitions in recuperators 6; 53 is a chute through which the fuel is charged into the producer 1.

The method of operating my invention is as follows: The bench being in operation, the main portion of the waste combustion gases is taken off from the retort oven through the ports 12 into the flues 13, from which the gases pass into the flues 14, back and forth through 14 and 15 in a serpentine course through the recuperators 6 and 17, and thence to the stack through the flues 16. The air, for the primary combustion in the producer, is brought under pressure to the injector 2, through the pipe 3. For compressing the air any satisfactory type of positive blower may be used. The air discharges into the inductor or injector 2 through the nozzle 31, creating a reduced pressure in the chamber 30. This, in turn, induces a flow of waste combustion gases through the flue 29, from the retort oven, the current of combustible gases mingling with the air discharged through the nozzle 31, the mixture forced under the grate of the producer, and thence passes up into the fuel bed. Here, in the manner described in my Letters Patent No. 829,105, the free oxygen of the air and one-half of the combined oxygen of the carbon-dioxid of the flue gases, combines with the carbon of the incandescent bed of fuel in the producer, to form the combustible gas, carbon monoxid, which constitutes the chief combustible ingredient of my producer-gas.

Although the product of the reaction in each case is the same, viz. carbon monoxid, I, by burning part of the fuel by the available O of the CO_2, secure certain very important results. By the reaction between the oxygen of the air and the carbon of the fuel, viz.:

$$C_2+O_2=2CO,$$

a very large amount of heat,—about 4450 B. T. U. per pound of carbon so consumed,—is liberated. This, if no provision is made for absorbing and removing it from the fuel bed, would raise the latter to a very high temperature, more or less completely fluxing the ash, with the result that the latter would form large aggregations in the fuel bed, known as clinkers. This action would, in time, almost completely prevent the passage of the gaseous current into the producer. By the second reaction, however, which I make use of in my producer, this excess heat is absorbed and made latent in the shape of carbon-monoxid. This second reaction is

$$2CO_2+C_2=4CO.$$

In this reaction, for every pound of the carbon of the fuel so consumed, about 10,000 B. T. U. are absorbed and rendered latent. It is apparent that by properly regulating the proportion of combustion gases to air, I may maintain any desired temperature in my producer.

The producer gas rising from the fuel bed of the producer is taken off from the producer through the flues 5 and passes therethrough to the equalizing flues 7 of the recuperators 6. These flues 7 are simply open passages running the length of the recuperators 6, and serving to distribute the producer gas uniformly throughout the length of the recuperators. These producer-gas recuperators have vertical partitions 52, which serve to support the flues 14, and, in effect, divide the main producer-gas flues into groups of sub-flues. The producer-gas rising through the flues 8, passes around the horizontal flues 14, receiving heat from the

same and having its temperature correspondingly increased.

The heated producer gas leaves the recuperator through the flues 9, the currents from the corresponding flues, 9, on either side of the bench joining and passing through a port 10, into the combustion chamber of the retort oven. Here the producer gas meets the secondary air and burns. The secondary air enters the recuperators, 17, through the air inlet flues 18, thence passes through the series of return-bend flues, 19, back and forth through the recuperators in a direction contrary to the flow of combustion gases through the smaller return-bend flues, 15, and 14. The lower flues, 15, are of metal of relatively high conductivity while the upper flues, 14, are of material such as fire clay, possessing a high degree of refractoriness. The use of material of relatively high conductivity for the lower flues of the recuperator enables me to secure practically as high a temperature in my secondary air as I could secure in my older type of recuperator such as shown in Letters Patent above referred to, although in my present invention I am entering the flue gases into the secondary air recuperator at a somewhat lower temperature.

The highly heated secondary air leaves the uppermost flue, 19, through the port, 21, and passes into the equalizing flue, 22. Along this flue, as shown, are small orifices or ports, 23, having movable tiles, 25, which may be adjusted by means of a metal rod or hoe worked through a suitable handhole at the end of the flue, so as to regulate the free area of the ports, 23. By this means I am able to secure a practically uniform flow of the secondary air into the flue, 24, along its whole length. From 24 the secondary air passes upward through the flues, 26, into a flue 27. From 27 the air is distributed to the nostrils, 28, from which it discharges into the combustion chamber of the retort oven burning the producer gas entering through 10. The products of this combustion pass up and around the retorts, imparting to the latter part of their sensible heat, thence to the upper flues, 13, of the recuperators and part to the injector. The part going to the injector is passed into the fuel bed in the manner already explained. The main current of combustion gases passes from the discharge flues of the recuperators through the flues, 16, to the stack, whence the gases discharge into the atmosphere.

In the particular application of my invention, which I have selected for purposes of illustration, viz., that to a furnace for heating retorts for the manufacture of illuminating gas by the destructive distillation of coal or other bituminous substances, the heat which does useful work is, only, that portion of the total heat developed in the furnace which is absorbed by the coal or other bituminous matter in the retorts. To effect this destructive distillation of coal in a manner which is commercially profitable, it is necessary to keep the retorts at a comparatively high temperature, say, at least 2000° F. Although in practice the temperature is more usually nearer 2300° F. It is easily seen that this temperature of the retorts fixes the temperature at which the waste gases must be allowed to leave the furnace, since, any further cooling of them, would involve a corresponding drop in the temperature of the retorts with which they were latest in contact. For this reason, it is not possible to increase the economy of heat utilization of the furnace by reducing the temperature at which the products of combustion are discharged. On the other hand, any increase in the maximum temperature of the combustion gases in the combustion chamber of the furnace, increases, correspondingly, the amount of heat that may be utilized in the retorts. This is due to the fact that the amount of heat transmitted by conduction from one fluid to another through a partition separating the two fluids is directly proportional to the temperature difference between the two. For example if, in the customary method of operating a bench, the retorts are kept at a temperature of 2000° F., while the highest temperature of the combustion gases is 2500° F., and the temperature at which they make their exit from the furnace is 2000° F., we would get a certain amount of heat transmitted from the combustion gases through the walls of the retort, to the gases or other material therein. Now if, through preheating the producer gas and the air supplied to the combustion chamber, we are enabled to raise the temperature of the combustion gases to, say, 2700° F., we would, theoretically, multiply the amount of heat transmitted by conduction by the ratio of the corresponding difference in temperature between the combustion chamber and the retorts. That is, assuming that the same weights of producer gas and air are supplied in the two cases, with the higher temperature in the retort oven, we would increase the quantity of heat passing into the retorts in the ratio 700/500, or an increase of forty per cent. over the quantity of heat passing into the retorts at the lower temperature. In addition to the heat transmitted by conduction we have to consider that transmitted by radiation. According to a well known law the radiation from a

body increases as the fourth power of the absolute temperature. By raising the flame temperature, therefore, from 2500° to 2700° F., (= from 2959° absolute to 3159° absolute), we would increase the radiation at 2500° in the ratio

$$\frac{3159^{(4)}}{2959^{(4)}} = 1.3 \text{ (about)}.$$

It should be noted, in this connection, that the average temperature of the mass of coal or other material in the retorts, is much lower than the temperature of the retorts themselves. Any increase in the heat passing into the retort goes to hasten the process of distillation, or carbonization as it is, usually, termed, and not, to any great extent, to raising the temperature of the coal. This is true as long as the coal is uncarbonized; and, since it is the aim to remove from the retorts the residual coke as soon as most of the volatile matter of the coal has been driven off, the above statement is, substantially, true in the practical operation of gas benches.

It follows, from the above, that any increase one can make in the temperature of the combustion chamber, will, correspondingly, increase the capacity of the bench. Since, in my present invention, the heat that is used in the preheating of the air and producer gas is recuperated from the sensible heat of the waste flue gases, the increased utilization of heat that I get in my retort oven is clear gain. I am, simply, taking heat from the, otherwise, wasted heat of the flue gases and adding it to the heat utilized, using the producer gas and the air for combustion as the medium of transference. By my invention, I am, therefore, able to carbonize a considerably greater weight of coal for the same expenditure of fuel in the producer.

The method of operating the gas producer of the combined gas producer and gas-fired-furnace—in this case a gas bench—with my present invention applied thereto, in not, essentially, different from that described in my Letters Patent No. 829,105, when the application of the invention is to the type of combined gas producer and furnace therein described. The principal difference is that the flue gases leaving the retort oven are first passed through recuperators for heating the producer gas. They then pass into the recuperators, for heating the secondary air. During their passage through the producer gas recuperators the flue gases, of course, fall in temperature by an amount corresponding to the quantity of heat which they give up to the producer gas. They, therefore, do not enter the air recuperators at so high a temperature as in the type of bench described in my Letters Patent No. 829,105. In this present type of bench, therefore, in order to secure the same degree of preheating of the air, I cause the air current, instead of flowing in a direct vertical direction through the recuperators to flow back and forth in the recuperator in a direction contrary to the direction of flow of the flue gases passing through the smaller flues located within the air flues. Likewise, as described and claimed in the same application, I make the lower flues of the recuperator of metal of a relatively high heat conductivity. In thus causing the air to traverse a comparatively long path through a flue of relatively small cross-section, I gain an important increase in the efficiency of heat transference from the flue gases to the air. The transmission of heat from one fluid to another through a separating diaphragm depends, not only on the difference in the temperature between the two fluids, and the time during which they are in contact with the heat-transmitting diaphragm, but, also, upon what is, of equal importance, the velocities of the two fluids along the surfaces of the transmitting diaphragms. The quantity of heat taken up from or given out to a heat-transmitting surface by a fluid is proportional to the square root of the velocity of flow of the fluid along the surface. This factor is of even greater importance when the heat-transmitting diaphragm is—as in part of the recuperator we are now considering—of a rough porous surface. The combination of this type of recuperator with the recuperator for heating the producer gas is, therefore, a point of great importance, and it is this combination which gives my invention, as a whole, great practical utility.

This invention is, particularly applicable to producers in which bituminous coal, lignite, or any other fuel containing a large amount of volatile matter is used in the producer. In this case, the rapid evolution of volatile matter immediately after charging greatly reduces the temperature of the gas leaving the producer. This, in turn, results in a lower temperature in the retort oven, or furnace, and in consequence subjects the retorts with their contents to a decided chilling effect. By my invention this irregularity of operation is entirely avoided.

Having described my invention, what I claim is:

1. In the operation of a gas bench, the process which consists in passing a portion of the waste combustion gases from the retort-oven of said gas bench first through a recuperator for raising the temperature of the producer gas from the gas producer of said gas bench, then through a recuperator for

heating the air to be used for burning said gas, burning the so-heated gas and air in the retort oven of said gas bench, and introducing another portion of the waste combustion gases into the gas-producer of said gas bench for the purpose of regulating the temperature thereof, substantially as described.

2. In the operation of a gas-bench the process which consists in dividing the products of combustion leaving the retort-oven of said gas bench into two portions, introducing one portion, at substantially the temperature at which it leaves the retort-oven of said gas bench, into the gas producer of said gas bench for the purpose of regulating the temperature thereof, and passing the other portion of said products of combustion first through a recuperator for raising the temperature of the producer gas leaving the said gas producer, and then through a recuperator for heating the air for the combustion of said producer gas, and burning the so-heated producer gas and air in the retort-oven of said gas bench, substantially as described.

Signed at New York city, in the county of New York and State of New York this 30th day of March 1909.

HENRY L. DOHERTY.

Witnesses:
LOUIS F. MUSIL,
FRED I. SMITH.