

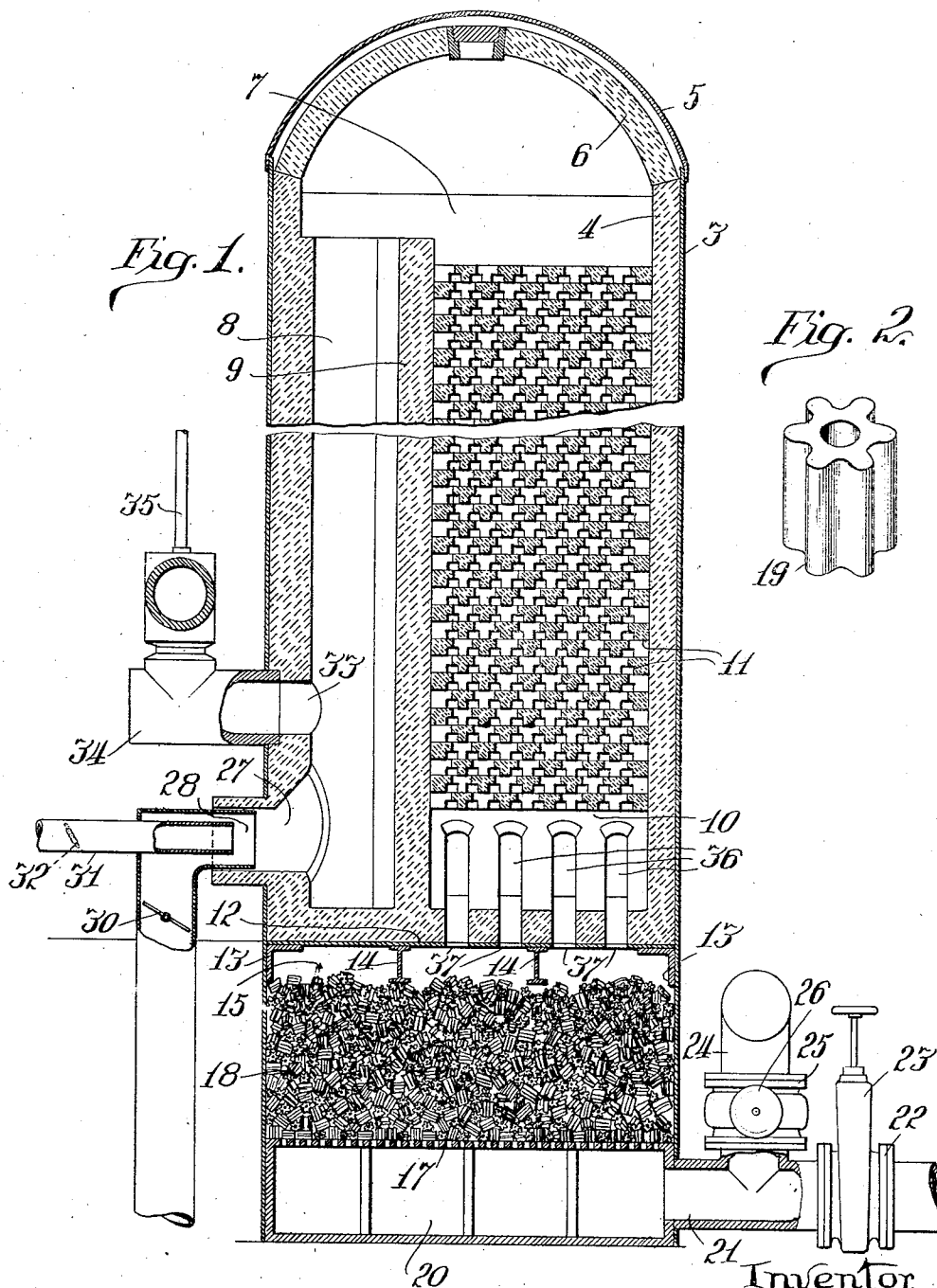
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APPARATUS FOR HEATING AIR AND OTHER GASES FOR INDUSTRIAL USES

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APPARATUS FOR HEATING AIR AND OTHER GASES FOR INDUSTRIAL USES

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My invention has to do with heating air or other gases by regeneration, and is more immediately concerned with the heating of the air used for blowing blast furnaces, although it is also applicable for heating gases for other industrial uses, such as in heating and smelting furnaces in the iron and steel, non-ferrous metal, glass, and other industries.

Heretofore regenerative hot blast stoves filled with fire brick have been quite generally employed for heating air for blowing blast furnaces, their usual construction being a cylindrical steel shell with a flat bottom and a spherical dome lined on its inner surfaces with fire brick and filled with checker brick of the same material; a section of the stove being reserved as a combustion chamber, located either to one side or centrally, and extending from the bottom of the stove to the top. In the usual mode of operation of such stoves the blast furnace gas is burned with air at the bottom of the combustion chamber, the flame and gases of combustion rising to the top and then turning downward, and descending through the checker work, giving up their heat to the same. During this heating period, which usually lasts about three hours, the highest temperature prevails in the combustion chamber and at the top of the checker work, and it rapidly decreases toward the bottom of such checker work, the temperature of the chimney gases passing out of the stove at the bottom being generally not over 500° F. After the three hour heating period the blast furnace gas is shut off and the air to be heated, which may be termed the cold blast, is admitted at the opposite or chimney end of the stove and travels in the opposite direction, or upward through the checker brick, absorbing the heat stored therein by the gases of combustion, and reversing its flow at the top of the stove to flow down through the combustion chamber and out through the hot blast main to the blast furnace.

Many modifications of this commonly used stove construction have been proposed. For instance, instead of the two-pass stove above described, three-pass and four-pass stoves, as well as single-pass stoves, have been de-

veloped, but in all such stoves the material used for heat interchange has always been fire brick. The chief advantage of using fire brick is because of its high melting point and general heat resisting qualities, but the use of fire brick is objectionable because it has a low coefficient of conductivity, so that when brick of the usual thickness are used, the inner portions of the brick are not heated to the full temperature of their surfaces during the heat period, nor are they able to release sufficient of their heat during the cooling period. This has resulted in the adoption of very much thinner fire brick but the latter are objectionable because they have the disadvantage of structural weakness, and are subject to crushing and abrasion, due to expansion and contraction, when weighted down by too high a column.

The objects of my invention are to avoid, or at least to minimize, the above-mentioned disadvantages of the use of fire brick, while still retaining the advantages incident to the use of that material as a medium of heat exchange, and also to realize the advantages of cheaper construction and operation. These objects I accomplish as hereinafter described. What I regard as new is set forth in the claims.

My improved process makes use of the principle of regeneration, and generally stated consists in causing the heating gases, which may be derived from a blast furnace or any other suitable source, to flow through a medium of heat exchange having a high refractory coefficient, such as fire brick checker work, so that it is capable of withstanding very high temperatures, and conducting such gases after they have given up a part of their heat to such checker work, over a heat exchange medium having a higher coefficient of conductivity, but a lower refractory coefficient, such as a mass of metal shapes, which may be of any convenient contour. After heating the metal pieces the blast furnace gases are discharged to the chimney and the air or other gas to be heated is introduced under pressure to flow in a reverse direction over the media of heat exchange in succession, and then down through the combus-

tion chamber to the blast furnace main, through which the air heated by its passage through the stove is conducted to the point at which it is to be used. The different heat exchange media are best located in separate chambers communicating with each other successively, and it should be understood that while for most purposes two of such chambers will suffice, my invention contemplates the use of more than two stages where conditions are such as to make that desirable.

According to the usual practice, more than one-half of the checker work in a stove is never heated above 1500° F., and I have found that the metal filler, or medium of heat exchange, is advantageous at temperatures below 1500° F., although metals of suitable composition can be used at even higher temperatures. My improved method, therefore, makes it possible to dispense with half of the present refractory checker work, which greatly reduces the cost of the regenerator, or hot blast stove, since on account of its very much greater conductivity only a very small amount of metal is required to provide the same heat interchange. It also has the further advantage that the refractory column of checker work becomes much lower, obviating the crushing effect of the high columns of checker work that are usually employed. Also, loose fire brick fillers can be employed to much greater advantage, so that the refractory material may be in the form of loose fire brick units, spherical, cylindrical, spiral, tubular, or of any other shape. Such loose fire brick fillers have the advantage of offering a larger heating surface than the usual checker brick construction, but heretofore their use has not been practicable because they have been subject to crushing and abrasion due to expansion and contraction, when weighted down by too high a column. By the use of the metal filler I derive a further advantage that thin sections may be used, and since the conductivity varies inversely with the thickness of the material, the efficiency of the metal filler will be proportionately greater than that of the refractory filler which it replaces. The metal filler may be made of cast iron, steel, wrought iron, or other metals having a high conductivity.

In practicing my improved process I prefer to use an apparatus having substantially the construction shown in the accompanying drawings, in which

Fig. 1 is a vertical section of a hot blast stove or regenerator; and

Fig. 2 is a perspective view of a metal shape exemplary of what may be used in the low temperature stage of the treatment.

Referring to the drawings,—3 indicates the steel shell of the stove, the upper portion of which is provided with a refractory lining 4, the upper end of the stove being prefer-

ably in the form of a dome 5 protected by a refractory lining 6. The upper portion of the shell constitutes a main heating chamber 7 at one side of which is a vertically disposed combustion chamber 8 separated from the chamber 7 by a partition 9 of refractory material. Near the bottom of the combustion chamber is an arch 10 on which rests checker work 11 of fire brick or other suitable refractory material. As has been explained, this checker work may be made either of brick work or of refractory material of other shapes. Below the arch 10 is a horizontal partition 12, preferably of metal that in the construction shown is supported by angle irons 13 and I-beams 14, but any other construction suitable for the purpose may be used. Below the partition 14 is a secondary heating chamber 15, the bottom of which is formed by a grate 17. On this grate rests a mass 18 of metal shapes of cast iron, steel, or other suitable material having a high coefficient of conductivity. The metal shapes 18 lie in the chamber 15 in a promiscuous mass without any special order or relation. In Fig. 2 I have illustrated a gear-like shape 19 which is one of many forms that can be used advantageously. A loose mass of these pieces is placed in the chamber 15 on the grate 17, so that the flow of air or other gas through said chamber is not obstructed to an objectionable extent. Below the grate 17 is a duct 20 leading to a pipe 21 that discharges to a chimney, not shown, through a coupling 22 provided with a valve 23. Between the stove and the valve 23 is a cold air supply pipe 24 connected to the pipe 21 by a coupling 25 provided with a valve 26.

The lower portion of the combustion chamber 8 is provided with an opening 27, into which extends a nozzle 28 leading from a gas pipe 29 provided with a valve 30, through which pipe blast furnace or other combustible gas may be supplied to the lower portion of the combustion chamber. An air pipe 31 having a valve 32 discharges through the nozzle 28 into the lower portion of the combustion chamber.

The latter chamber is also provided with an opening 33, preferably located above the opening 27, with which communicates a main 34 having a valve 35. In the illustrated construction this main leads to the blast furnace for supplying hot air thereto.

The operation of the above-described apparatus is as follows: Gas and air are admitted to the lower portion of the combustion chamber through the burner comprising nozzle 28 and pipe 31, the mixture of gas and air being burned in the combustion chamber and rising therethrough to the upper portion of the heating chamber 7. The highly heated products of combustion then flow down through the checker work and through passages 36 in the arch 10 and openings 37 in the

plate 12 to the chamber 15 containing the metal shapes. The gases then pass down through the mass of shapes and through the grate 17 to the duct 20, whence they pass to the pipe 21 and through it to the stack. During this operation the valves 35 and 26 are closed and the valve 23 leading to the chimney is open. In the passage of the products of combustion through the checker work the latter is highly heated, and the gases are cooled to a considerable extent, so that when they reach the second stage in the operation, to-wit, the chamber 15, they are ordinarily at a temperature of about 1500° F. In their passage through the material in the latter chamber the gases are further cooled so that when they reach the conduit 20 they are at a temperature of 500° F. or less, the metal being correspondingly heated. This operation is continued until the refractory filling in the main heating chamber 7 and the metal filling in the secondary chamber 15 have absorbed all the heat possible with a stack temperature of approximately 500° F., whereupon the valves 23, 30 and 32 are closed and the valves 26 and 35 are opened. Opening of the air valve 26 admits air under pressure from any suitable source to the duct 20, whence it flows upward through the metal filler in the secondary chamber 15, and then through the refractory material in the main heating chamber 7, after which it flows down through the combustion chamber 8 and out to the blast furnace through main 34. This reverse flow is continued until the heat stored in the refractory and metal fillers has been absorbed by the air to the greatest practicable extent, when the above described cycle of operations is repeated. Ordinarily the hot blast and cold blast periods are approximately equal where the pressure burner system is used, and the volume of gas and air for combustion admitted during the heating period is equal to the air admitted during the blast period, but where a lesser volume of gas and combustion air are admitted than the volume of blast which is to be heated, the hot blast period is generally longer than the cold blast period.

Although the construction shown in the drawings provides for heating in only two stages, it will be obvious that a greater number may be provided if desired, and also that instead of arranging the heating chambers one above the other they may be disposed so that the air or other gases will pass horizontally from one to the other, or along an inclined course. Also it is not essential that the heat exchange media be placed in distinctly separate chambers, as any equivalent arrangement by which the gases are caused to pass successively over a plurality of media of heat exchange of such character that the coefficient of conductivity of each succeeding medium differs from that of the preceding

medium in the manner above described, comes within the scope of my invention.

It will be seen that the heat is extracted from the products of combustion in successive stages, in which successively the rate of heat absorption per unit of time for a given temperature difference is successively greater. Also in the successive stages the permissible maximum temperature which the material will stand is successively less.

Both the refractory checkerwork 11 and the mass 18 of loose metallic bodies 19 may be classed as granular masses.

The advantage of my invention lies not only in the cheaper construction, but the stove can be operated on a shorter cycle in accordance with the method of Letters Patent No. 1,535,146, granted April 28, 1925, to Charles W. Andrews and myself. With my improved process and apparatus the normal time required to heat the stove can be decreased to a fraction of what it is at present.

What I claim as my invention and desire to secure by Letters Patent, is—

1. A regenerative furnace comprising a shell, a horizontal wall dividing the shell into an upper main heating section and a lower secondary heating section, said wall having openings therein for permitting the passage of gases between said sections, a vertical combustion chamber alongside said upper main heating section, the lower section extending beneath said vertical combustion chamber and beneath said upper main heating section, a mass of refractory material supported in the upper section by said partition, a mass of loosely and promiscuously mixed irregularly shaped metal objects in the lower section, said objects having corrugated surfaces to increase the radiating area, means for passing hot gases through the refractory material and through the metal mass to heat the refractory mass and the metal mass, and means for passing air through the masses to extract the heat therefrom.

2. A regenerating furnace comprising a shell, partition means dividing the shell into a combustion chamber, a main heating chamber, and a secondary heating chamber, said combustion chamber being arranged vertically over said secondary heating chamber, a mass of refractory material in said main heating chamber, a mass of loosely and promiscuously mixed metal objects in said secondary heating chamber and having their surfaces formed to increase their radiating area and forming irregular tortuous channels for the passage of gas therethrough, means for passing hot gases through the refractory material and through the metal mass to heat the same, and means for thereafter passing air through the metal mass and the refractory mass to extract the heat therefrom.

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