RECUPERATOR FOR OPEN HEARTH FURNACES

Filed July 28, 1933 3 Sheets-Sheet 1

Fig. 1.

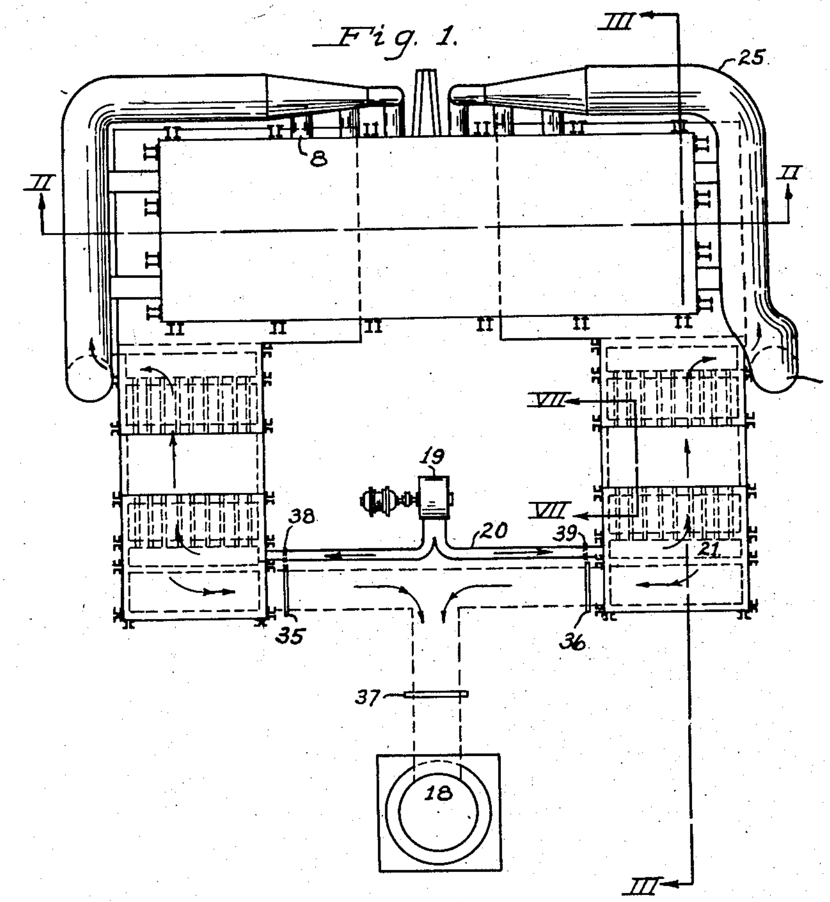
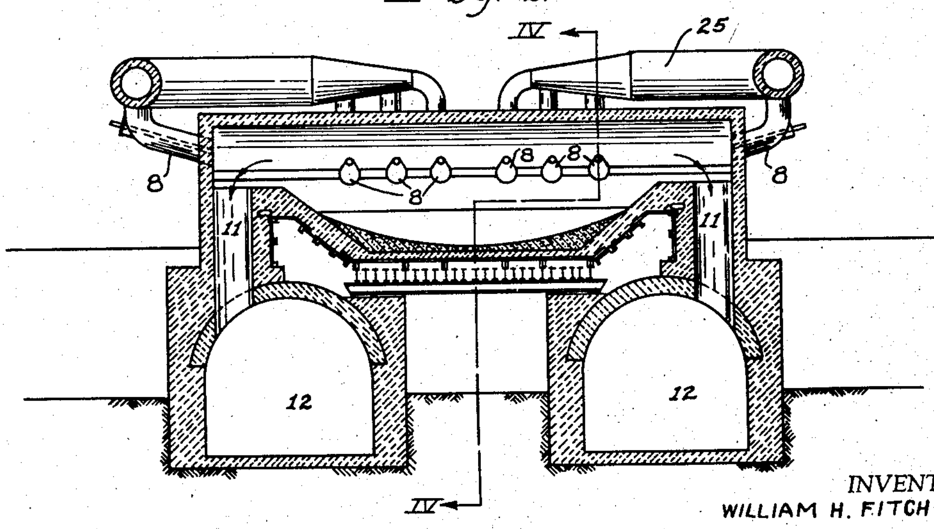


Fig. 2.



INVENTOR.
WILLIAM H. FITCH

BY R. C. Benner

ATTORNEY.

June 11, 1935. W. H. FITCH 2,004,916

RECUPERATOR FOR OPEN HEARTH FURNACES

Filed July 28, 1933 3 Sheets-Sheet 2

Fig. 3

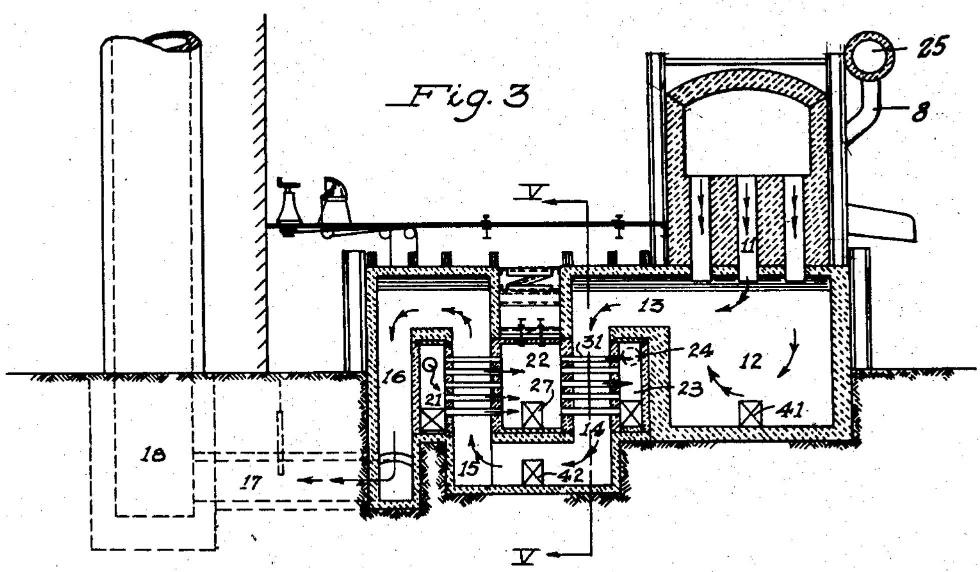


Fig. 4.

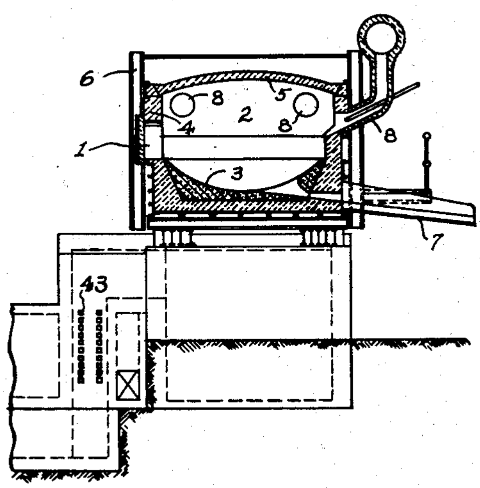
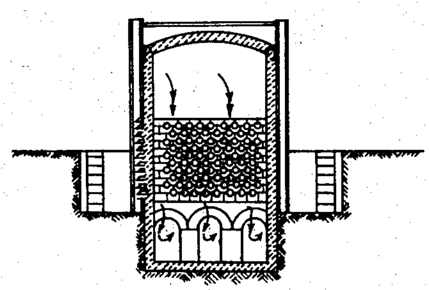


Fig. 5.



INVENTOR.
WILLIAM H. FITCH

BY RCBenner

ATTORNEY.

RECUPERATOR FOR OPEN HEARTH FURNACES

Filed July 28, 1933 3 Sheets-Sheet 3

Fig. 6.

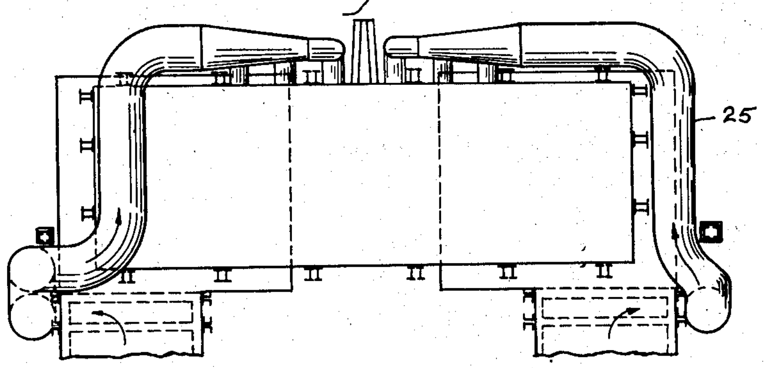
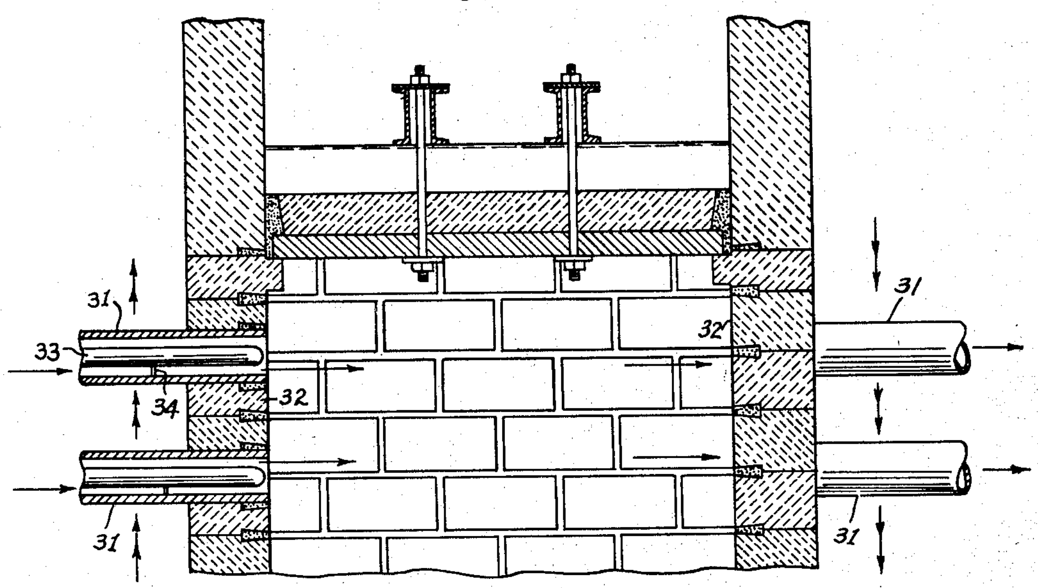


Fig. 7.



INVENTOR.
WILLIAM H. FITCH

BY R C Benner

ATTORNEY.

Patented June 11, 1935 2,004,916

UNITED STATES PATENT OFFICE

2,004,916

RECUPERATOR FOR OPEN HEARTH FURNACES

William H. Fitch, Plainfield, N. J.

Application July 28, 1933, Serial No. 682,654

3 Claims. (Cl. 263—15)

This invention relates to furnace installations and particularly relates to one-way firing of open hearth furnaces in which a plurality of recuperators are used to preheat the air needed for combustion of the fuel. My improved furnace represents an advance in the development of open hearth furnace design.

In the use of open hearth furnaces it is a common practice to fire the fuel from each end of the heating chamber alternately a regenerator being provided at either end of the heating chamber. For a given direction of firing one of the regenerators receives the burned gases which heat up the checker bricks or heat transfer elements while the other regenerator delivers heat, previously stored up in the manner described, to air which is being preheated for combustion purposes. Both regenerators are alike, each having the same amount of heat transfer surface, or double that required in a device operating on the recuperative principle if the rate of heat transfer were the same.

There are many disadvantages connected with the furnace arrangement just described. It is obvious in the first place that the volume of the very hot burned gases is much greater at a given pressure than the volume of the air which is needed for combustion. Hence difficulties arise in the regulation of the rate of flow of the fuel and air and gases produced by combustion through ports of one sized area in the furnace and the regenerator chambers.

It is difficult to distribute the flow of the burned gases and of air respectively through the checkers in a regenerative system in such a manner that a large percentage of the regenerator surface will be utilized. The burned or waste gases which are admitted at one end of the regenerator chamber tend to flow through the upper part of the chamber until they reach the opposite end whence they move down to the outlet. The checkerwork is therefore not uniformly heated on account of the difficulty of obtaining a well distributed flow of burned gases through the checkerwork. After the direction of firing is reversed, air is admitted in a stream through a duct which previously formed the outlet for the burned gases. The cold air tends to flow along the floor of the regenerator chamber until it is forced up by the opposite end wall. After rising to the top of the chamber the air passes on to mix with the fuel. The path traversed by the inflowing air is therefore different from that previously traversed by the outflowing burned gases. The efficiency of regenerators used in the manner described is consequently quite low.

Again the change of the flow of waste gases from one regenerator to the other, and the similar change of the flow of air, require the installation of valves which are expensive to install and which add to the cost of upkeep of the furnace.

Owing to the large variations in temperature in the regenerative chamber and in portions of the combustion chamber, there is successive expansion and contraction of refractories with a corresponding shortening of the life of these materials.

It is impossible to fire at one end of a long furnace and distribute the heat of combustion at a high uniform temperature over the entire length of the furnace. If a short flame is maintained there is an appreciable drop in temperaature at the outlet end of the furnace and if a long flame is maintained the whole temperature is lowered, excessive fuel burned and combustion takes place beyond the melting chamber, an uneconomical result in either case.

The present invention is directed to the provision of a furnace installation in which these difficulties are overcome and in which the recovery of the waste heat from the burned gases is efficiently and economically carried on, so that the cost of furnace operation is materially reduced. In order to accomplish this object according to the present invention I make use, for example, of a one-way fired furnace which includes in addition to the combustion chamber one recuperator divided in two sections which are sufficient in themselves to preheat the air (used for combustion) to the maximum extent. These recuperators are so constructed that the total heat recovery per unit volume of structure is much greater than that obtained by the use of two regenerators with standard checkerwork. The recuperator arrangement uses smaller floor space than the regenerators, and the cost of building and maintaining the equipment is less with the recuperator arrangement than is the case with the regenerators.

I employ therefore a furnace of the non-reversing type with a recuperator unit connected to each end of the combustion chamber. A plurality of burners is provided along the ends and along the back wall. By the use of a number of burners it is possible to mix the fuel and air for combustion in proper proportions for obtaining and maintaining the kind of flame desired throughout the length of the furnace. By this method of firing continuously from a plurality of burners (distributed along the whole length of the furnace) it is possible to regulate the areas of ports in all parts of the furnace for economical and efficient operation. For example, larger ports are provided for the outlet of burned gases than are provided for admitting fuel and air for combustion. By maintaining uniform distribution of temperature over the back of the furnace, minimum time of making a heat is obtained and production is increased. By maintaining uniform flame temperatures the refractories are maintained in good condition for long periods.

My invention is illustrated by the accompanying drawings in which:

Figure 1 is a somewhat diagrammatic plan view of a furnace installation constructed in accordance with the principles of my invention;

Figure 2 is a sectional elevation on the line II—II of Fig. 1;

Figure 3 is a sectional elevation on the line III—III of Fig. 1;

Figure 4 is a sectional elevation on the line IV—IV of Fig. 2;

Figure 5 is a sectional elevation on the line V—V of Fig. 3;

Figure 6 is a plan view similar to a portion of Fig. 1, but showing a modified arrangement of the burners; and

Figure 7 is a fragmentary sectional elevation on the line VII—VII of Fig. 1 showing the manner in which the heat transfer elements are mounted in place.

Referring to the drawings in detail a furnace chamber **2** is indicated in transverse section in Fig. 4. This chamber may be of a standard construction (such as is used for melting furnaces) and it contains a hearth **3** with side walls **4** and an arch **5**, the structure being supported by means of buck stays **6**.

A charging door **1** is disposed in the front wall of the furnace and a spout **7** is disposed in the back wall of the furnace for tapping the metal. At the back wall of the furnace are provided burners which are conventionally illustrated at **8** in Fig. 4. The same reference character is used to denote the location of burners in other views such as Figure 2. These burners may use artificial or natural gas, oil, pulverized coal or any fuel suitable for the purpose. The flow of the burned gases from the combustion chamber, then through the recuperator, and finally to the stack is shown by means of double arrows particularly in Figures 2 and 3. Ducts **11** are provided through which the burned gases flow downwardly below the hearth level into dust settling chambers **12**. From the upper portion of each dust chamber a duct **13** (following the flow of burned gases on one side of the installation) permits the passage of the burned gases across a bank of recuperator tubes **31** which stretch across the chamber **14**, the general direction of the flow of the burned gases in this chamber being downward. The burned gases then pass to a chamber **15** where they flow in a generally upward direction past another bank of recuperator tubes. The burned gases then pass downward through a duct **16** (in large capacity furnaces tubes would be employed here) and horizontally through a duct **17** to the stack **18** which is sufficiently high to move the burned gases at the desired rate.

The flow of air through the recuperator takes place in a generally horizontal direction as illustrated, for example, in Fig. 3 by means of single arrows. There are a number of air chambers **21**, **22** and **23**. Air is forced by the motor driven pump **19** (Fig. 1) through a duct **20** (following the flow of air on one side of the installation) into the chamber **21** whence it flows through the recuperator tubes which cross the chamber **15**. The heated air then passes into the chamber **22** and from there through another set of recuperator tubes into the air chamber **23** from which it flows through an outlet **24** into an air duct **25** which supplies preheated air to the burners (placed at each end of the furnace and along a portion of the back wall of the furnace) as indicated in Fig. 2 and similarly in Fig. 1. Each of the air chambers (**21**, **22** and **23**) is provided with means of access, such as a door **27**. The chamber **23**, which is nearest the outlet, is comparatively narrow. It is used at intervals for inspection of the tubular heat transfer elements. The next chamber **22** is comparatively wide. This chamber provides space not only for inspection of the recuperator elements but is wide enough to permit replacement of defective recuperator elements.

The method of support of the recuperator tubes **31** is illustrated in Fig. 7. The tubes are shown as supported adjacent their ends in tube terminal walls, each of which constitutes a boundary wall between an air chamber and a duct which is used for the vertical flow of burned gases. These tube terminal walls are built from fireclay blocks **32** which are shaped to provide openings through which the recuperator tubes may be inserted in such a manner that the terminal portions of the tubes are supported by the tube terminal walls as indicated in Fig. 7. The supporting blocks can be undercut adjacent their edges to permit calking of the joints around the tubes and between the blocks by means of a plastic cement. As indicated in the drawings the recuperator tubes are provided with "corebusters" **33** which are made of refractory rods which are provided with legs **34** by means of which the rod is supported in a coaxial position within the corresponding recuperator tube. The air is thus forced to flow in a thin film between "corebuster" and the tube. Good thermal contact is obtained in this way between the air and the tube. The tubes themselves are made of a refractory material having a high thermal conductivity such as silicon carbide. This material also has a low coefficient of expansion which makes it resistant to spalling and it has great mechanical strength (when suitably bonded) at very high temperatures, even above 1400 degrees C.

In the modification shown in Fig. 6 the burners are mounted only in the rear wall of the combustion chamber and not on the end walls. With the burner arrangement as in Fig. 6 the burned gases take a more direct route to the dust settling chambers than is the case when end burners are also employed. On the other hand the use of end burners as well as back burners gives a wider distribution of high temperatures in the combustion chamber.

Dampers are shown in Fig. 1 at **35**, **36** and **37** for regulating the flow of burned gases from either recuperator or from both recuperators taken together. Valves **38** and **39** are also shown for regulating the flow of air through the air chambers and connecting tubes in each recuperator.

The provisions for keeping the space between recuperator tubes from being clogged by semisolid material carried over by the burned gases are indicated more particularly in Fig. 3. The burned gases which descend through the ducts 11 are carried by their momentum toward the bottom of the chamber 12 before leaving the chamber by way of the outlet duct 13. The chamber 12 is provided with a door 41 for cleaning purposes. The burned gases which pass through the chamber 12 pass down the duct 14 around the recuperator tubes 31. Dust and other semisolid materials which collect on the outer surfaces of the tubes are loosened with an iron bar (through cleaning holes 43 seen in Fig. 4) and fall to the bottom of duct 14. A door 42 is provided for cleaning solid material from the floor of the recuperator chamber. The provisions for keeping the recuperator chamber and its connections clean are therefore unusually good.

As indicated in Fig. 4 the burner is directed downwardly toward the charge so that the charge receives the first impact of the flame instead of the roof or sides as is the case with many open hearth furnaces. The more complete combustion obtained by the applicant (as compared with furnaces using less highly preheated air or excess fuel) enables him to obtain better contact between the flame and the charge. By directing the flame on the metal charge, the roof and side walls of the combustion chamber are saved largely from the destructive action which is produced by very hot flames.

Preheating of the air to high temperatures suitable for the rapid combustion of the fuel is made possible in the applicant's furnace by the use of bonded silicon carbide in the manufacture of the recuperator tubes. The thermal conductivity of bonded silicon carbide is several times that of fireclay and may be as high as .036 calorie/cm^3/°C./sec. Suitably bonded silicon carbide stands much higher temperatures than metals which are commercially available. Its high mechanical strength at temperatures as high as 1500° C. also contributes to making it a suitable material for the construction of recuperator tubes subjected to high temperatures and to various active elements and gases found in this practice.

My furnace arrangement has a number of advantages arising from its continuity of operation and from the maintenance of substantial constancy of temperature in various parts of the furnace with consequent long life of the refractory parts. The recuperator material and design permit very high temperature of the air leaving the recuperator and a very low average overall recuperator structure temperature. This high preheating of the air causes very complete combustion of the fuel, thus diminishing the danger of contamination of the metal.

I claim:

1. An open hearth furnace unit adapted to continuous operation at very high temperatures for extended periods, said furnace unit comprising a combustion chamber disposed over an elongated hearth, burner inlets distributed along the back and end walls of said combustion chamber, a recuperator chamber disposed near each end of the combustion chamber and in front of the same, a slag chamber at each end of the combustion chamber, a plurality of burned gas outlets from each end of the combustion chamber and below the same, said outlets discharging downwardly into their corresponding slag chambers, an outlet from the upper end of each slag chamber to the adjacent recuperator chamber, horizontally disposed tubes of highly conducting refractory supported terminally by walls in each recuperator chamber and heated exteriorly by the flow of burned gases in a vertically upward or downward direction, and means for compelling a flow of air through the interior of said recuperator tubes and thence to the burner inlets.

2. An open hearth furnace unit adapted to continuous operation at very high temperatures for extended periods, said unit comprising a combustion chamber disposed over an elongated hearth, burner inlets distributed over the back and end walls of said combustion chamber, a charging door in the front wall of the furnace, a tap for molten metal in the rear wall of the furnace, a slag chamber at each end of the combustion chamber, a recuperator chamber disposed near each end of the combustion chamber and in front of the same, a plurality of burned gas outlets from each end of the combustion chamber and below the same, said outlets discharging downwardly into their corresponding slag chambers, an outlet from the upper end of each slag chamber to the adjacent recuperator chamber, horizontally disposed tubes of highly conducting refractory supported terminally by walls in each recuperator chamber and heated exteriorly by the flow of burned gases in a vertically upward or downward direction, and means for compelling a flow of air through the interior of said recuperator tubes and thence to the burner inlets.

3. An open hearth furnace unit adapted to continuous operation at very high temperatures for extended periods, said unit comprising a combustion chamber disposed over an elongated hearth, burner inlets distributed along the back wall of said combustion chamber, a charging door in the front wall of the furnace, a tap for molten metal in the rear wall of the furnace, a slag chamber at each end of the combustion chamber, a burned gas outlet from each end of the combustion chamber, said outlet discharging downwardly into its corresponding slag chamber, an outlet from the upper end of each slag chamber to the adjacent recuperator chamber, horizontally disposed tubes of highly conducting refractory supported terminally by walls in each recuperator chamber and heated exteriorly by the flow of burned gases in a vertically upward or downward direction, a door at the base of the slag chamber for the removal of ash, a door in the recuperator chamber for the inspection of the recuperator tubes, and means for compelling a flow of air through the interior of said recuperator tubes and thence to the burner inlets.

WILLIAM H. FITCH.