July 1, 1930. F. ORTH 1,769,853

OPEN HEARTH FURNACE AND METHOD OF HEAT GENERATION

Filed Feb. 7, 1921 6 Sheets-Sheet 1

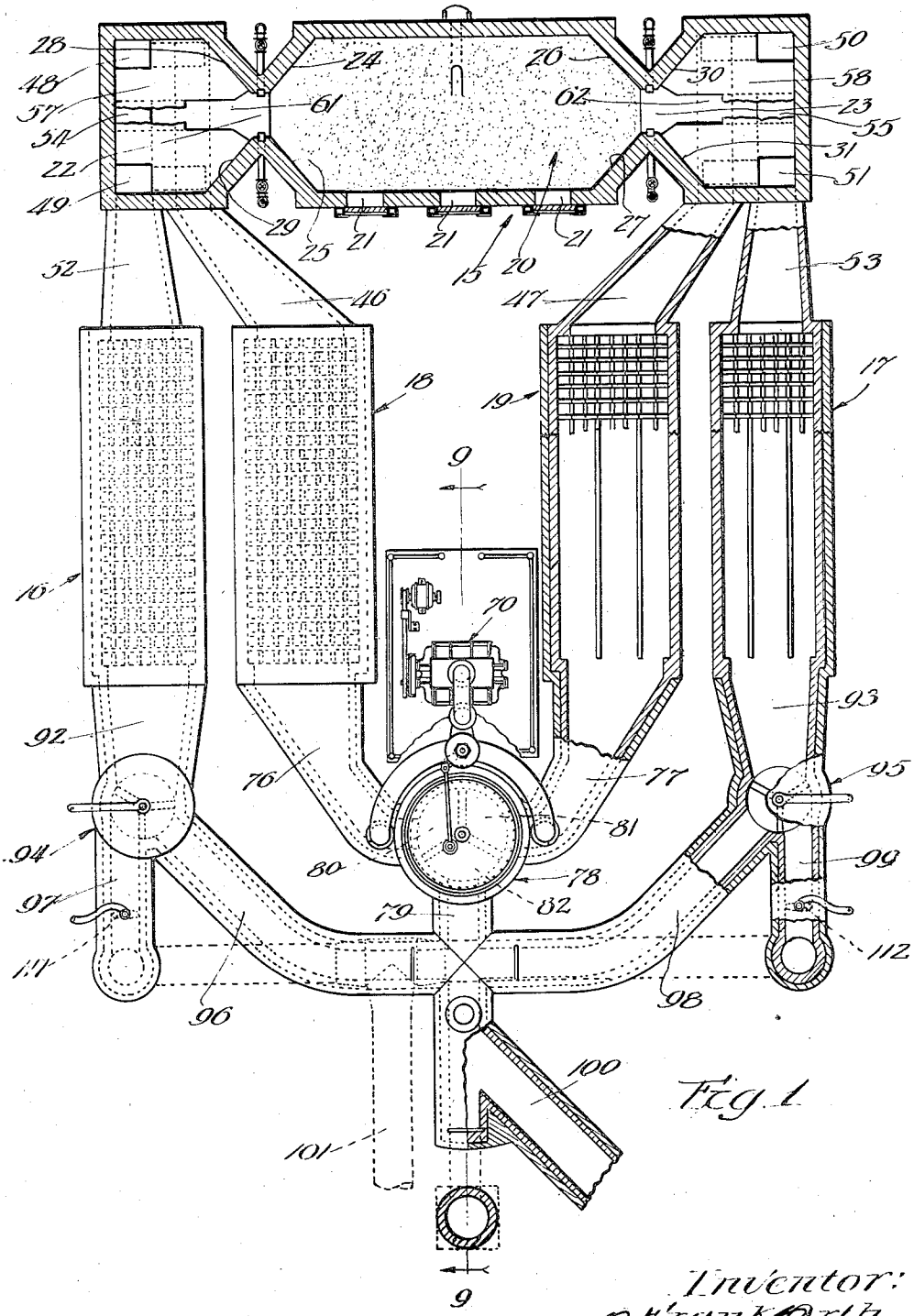


Fig. 1

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July 1, 1930. F. ORTH 1,769,853

OPEN HEARTH FURNACE AND METHOD OF HEAT GENERATION

Filed Feb. 7, 1921 6 Sheets-Sheet 2

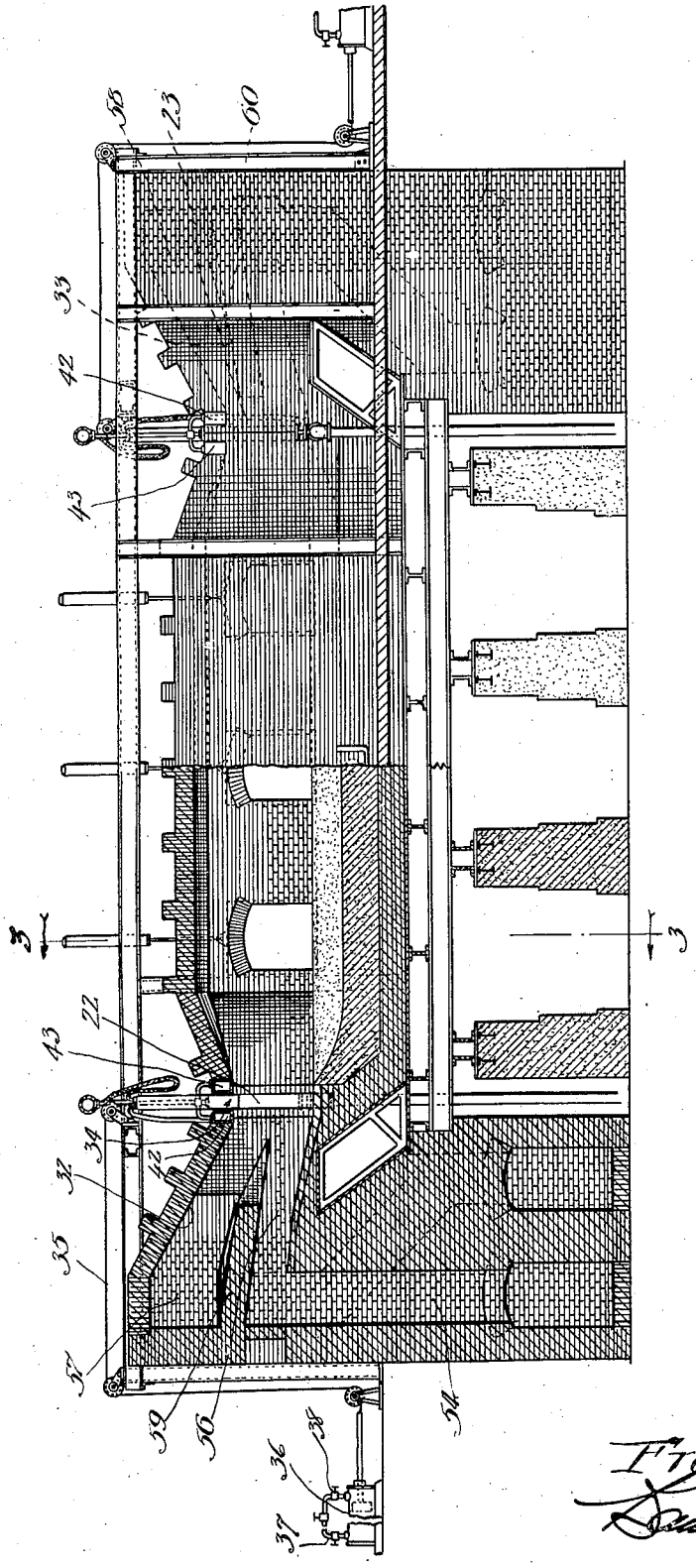


Fig. 2.

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July 1, 1930. F. ORTH 1,769,853

OPEN HEARTH FURNACE AND METHOD OF HEAT GENERATION

Filed Feb. 7, 1921 6 Sheets-Sheet 3

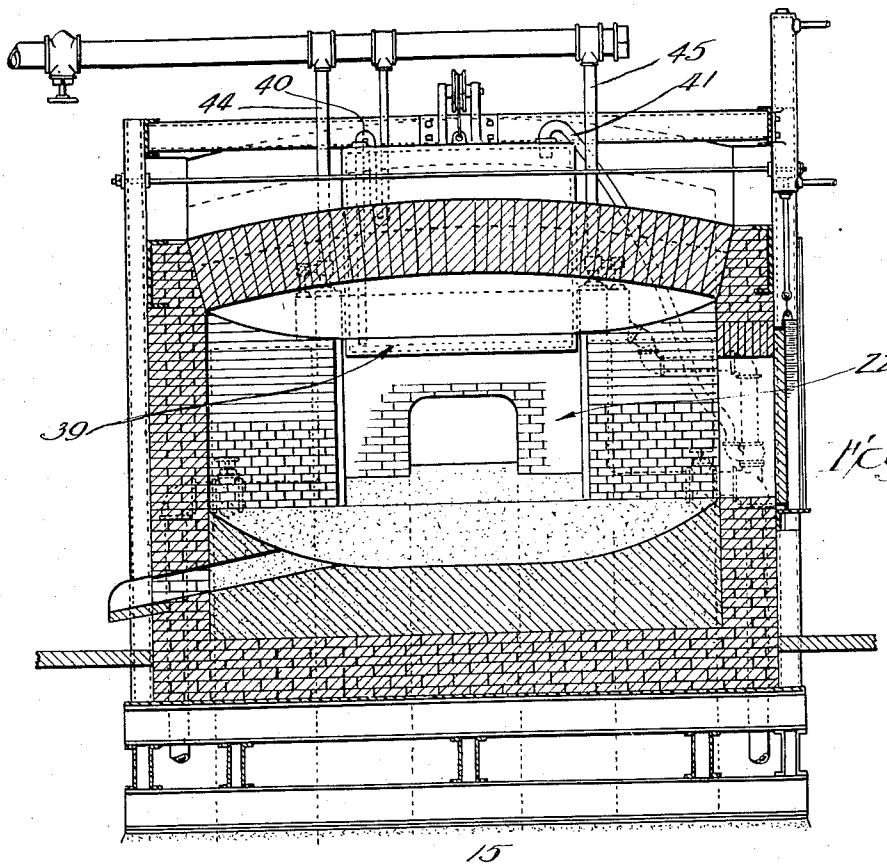


Fig. 3

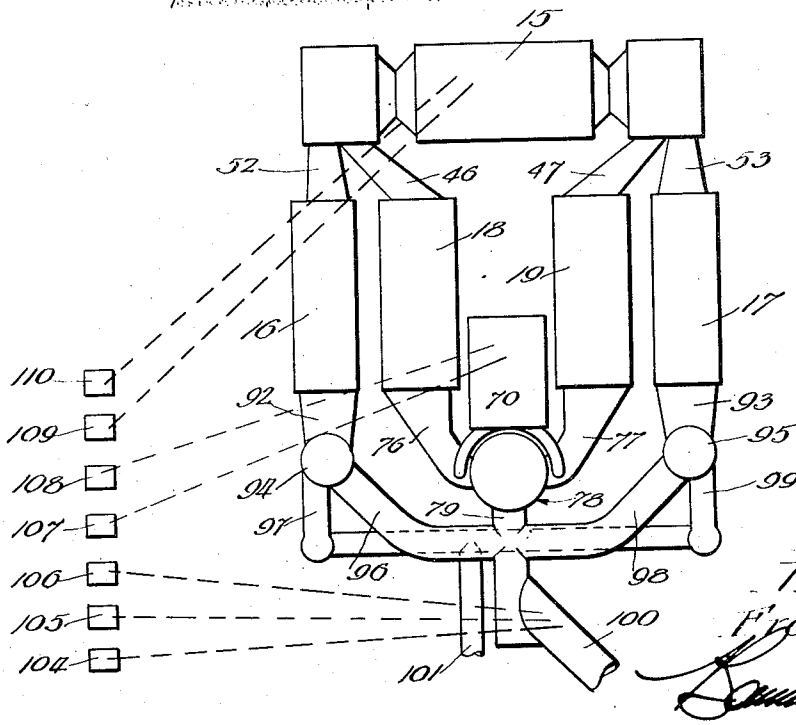


Fig. 12

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July 1, 1930. F. ORTH 1,769,853

OPEN HEARTH FURNACE AND METHOD OF HEAT GENERATION

Filed Feb. 7, 1921 6 Sheets-Sheet 4

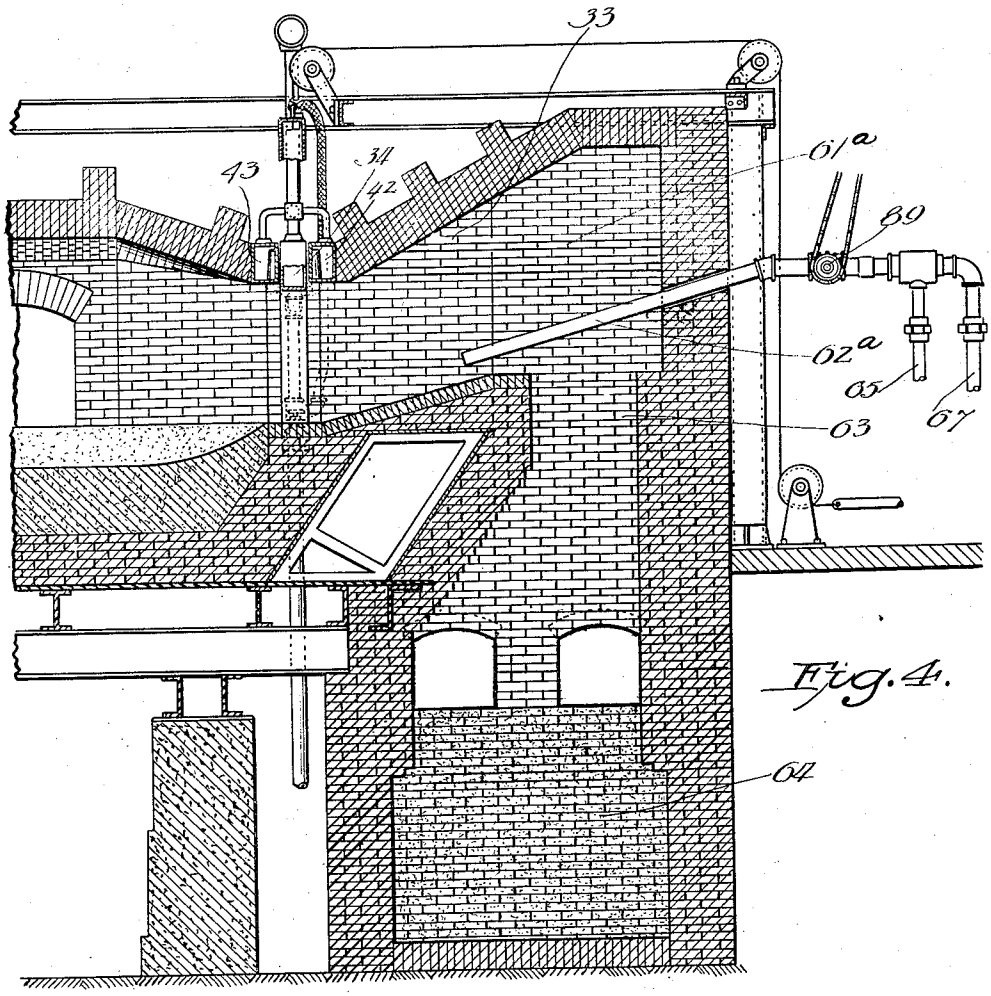
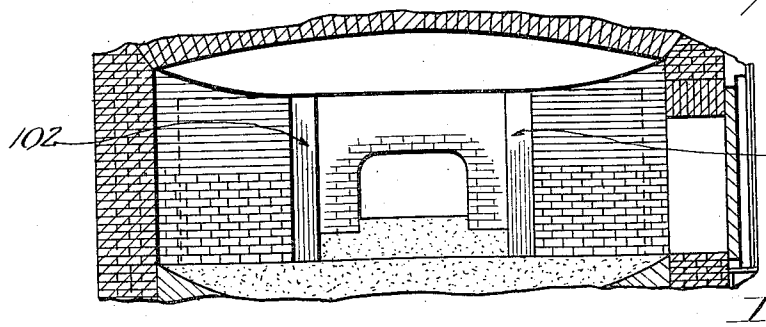


Fig. 4.

Fig. 5



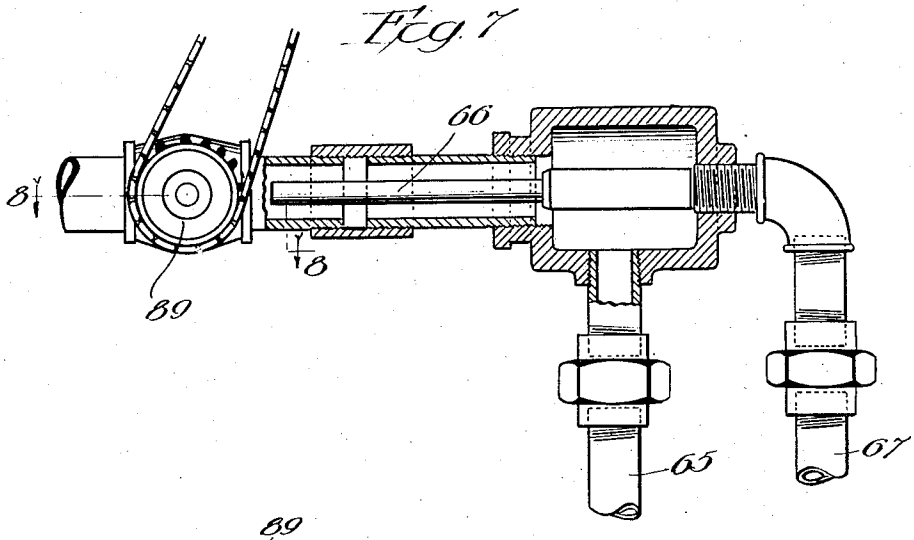
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July 1, 1930. F. ORTH 1,769,853

OPEN HEARTH FURNACE AND METHOD OF HEAT GENERATION

Filed Feb. 7, 1921 6 Sheets-Sheet 5

Fig. 7



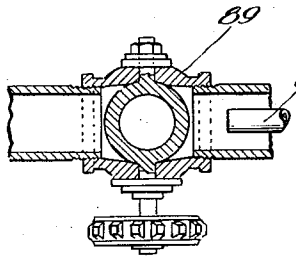
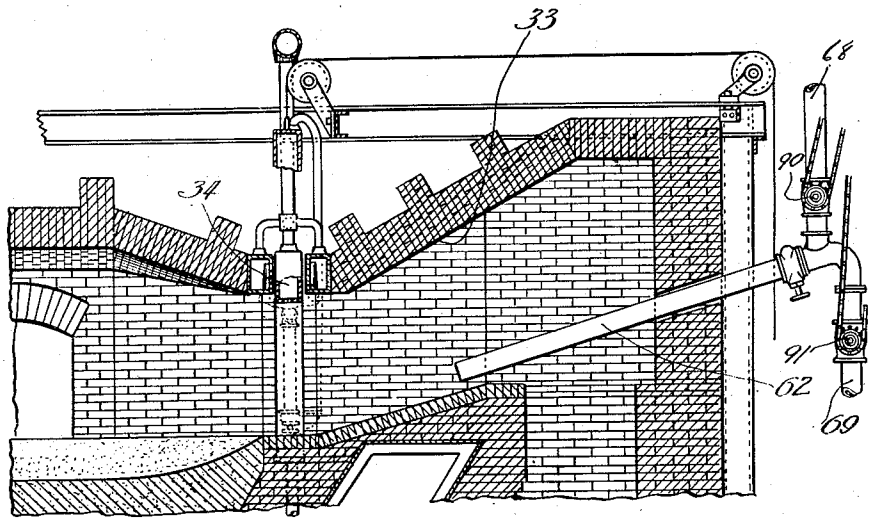


Fig. 8

Fig 6



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July 1, 1930. F. ORTH 1,769,853

OPEN HEARTH FURNACE AND METHOD OF HEAT GENERATION

Filed Feb. 7, 1921 6 Sheets-Sheet 6

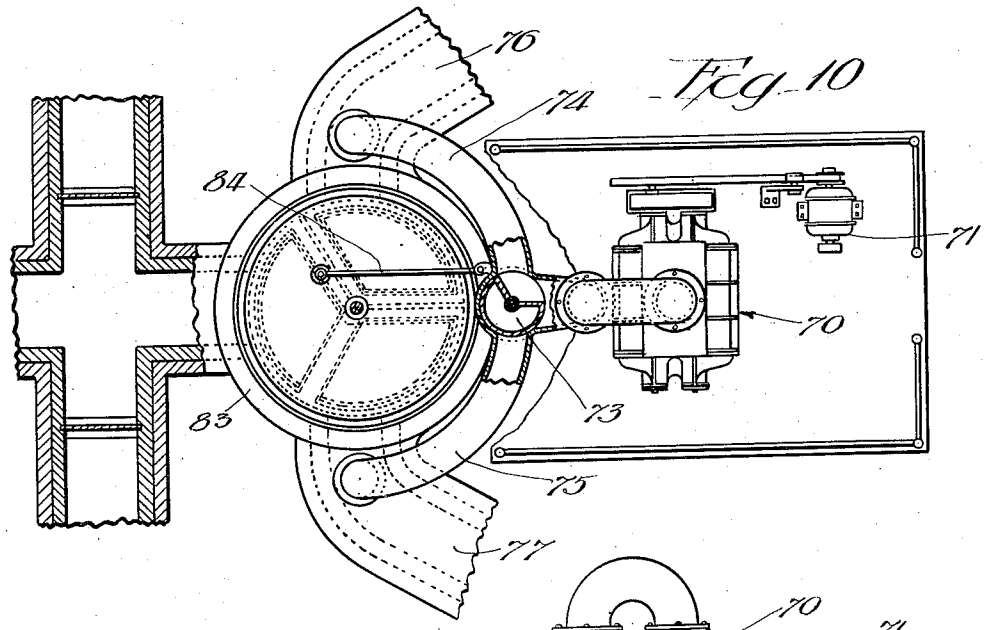


Fig. 10

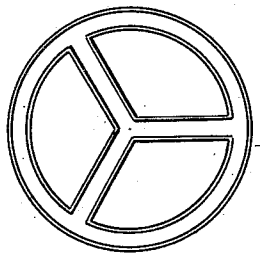


Fig. 11

Fig. 9

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UNITED STATES PATENT OFFICE

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OPEN-HEARTH FURNACE AND METHOD OF HEAT GENERATION

Application filed February 7, 1921. Serial No. 443,065.

This invention has to do with improvements in open hearth furnaces. The improvements particularly disclosed herein are especially well adapted for use with open hearth furnaces for the treatment of iron and steel, but it will presently appear that many of the features of usefulness are not limited to furnaces used for this purpose. Since, however, certain of said features are especially well adapted for furnaces for the treatment of iron and steel, I have illustrated the features as applied to such furnaces and will particularly describe this application of the invention.

In open hearth furnace practice, the materials to be melted and subjected to the heat are carried in a "hearth" or "bath", and the flame is directed over said materials from one end of the bath or the other. In order to equalize the action, and to better adapt the furnace to the reversing principle, it is customary also to reverse the flame, first introducing it at one end of the bath for a certain length of time, and then reversing the operation and introducing it at the other end of the bath for a similar length of time.

The flame generated by the burning of suitable fuel usually commences close to the end of the bath where the flame is introduced, and for this purpose it is customary to bring the fuel and air together at or adjacent to such point. Owing to the very large amount of heat to be generated, it becomes necessary to use great quantities of fuel and air. The introduction of these quantities at a single point has, in the past, made it difficult to ensure a thorough mixing of the constituents of combustion, with the result that the combustion has been very inefficient. This has resulted in a great wastage of fuel as well as making it impossible to regulate the temperature conditions in the furnace as accurately as would be desirable. These conditions have been true largely on account of the necessity which has heretofore existed of introducing a surplus amount of air along with the fuel so as to ensure as complete combustion as possible; and this excess amount of air has to be heated and carries away from the furnace an enormous number of heat units which are thus wasted as far as any useful operation in the furnace is concerned.

One of the objects of the present invention is to provide an improved form and arrangement of ports for introducing the burning mixture to the bath, the arrangement being such that a very greatly improved mixture of fuel and air is brought about with an improved economy of operation, a higher possible temperature, and much better control of the operating conditions within the furnace.

In this connection another feature of the invention has to do with the provision of suitable indicating devices such as instruments for showing the CO_2 content of the gas delivered from the furnace so as to indicate to the operator the degree of combustion which is being secured; instruments for showing the rate of introduction of air and fuel to the furnace; instruments showing the temperature of the gases delivered to the stack; draft gauges for showing the draft both in advance of and behind the furnace itself; as well as other instruments for the purpose of making it possible to completely control the operation of the furnace, all of which will be presently explained in detail.

Another feature of the invention has to do with an improved method of operation of the furnace, and with an apparatus whereby said method may be practiced, for the purpose of still further improving the degree of combustion. In those cases in which the fuel and air are delivered in a steady stream, there is a tendency for them to assume more or less distinct channels of flow, so that the combustion is greatly retarded since the fuel does not, in such case, mix intimately with the air at all points. According to my improved method of operation, which constitutes one feature of the present invention, I introduce the fuel and air into the furnace by a series of puffs or pulsations, so that the flow through the ports into the bath is accordingly irregular, and the admixture of the fuel and air is greatly promoted. These puffs or pulsations may be brought about in any convenient manner, as, for example, by introducing the air in a pulsating manner,

while the fuel is introduced as a steady stream; or by introducing the fuel in a pulsating manner while the air is introduced as a steady stream; or by causing the introduction of both the air and fuel to be pulsated or in any other convenient manner. When practicing this feature of the invention, it is also convenient to provide an indicator for readily showing the rate of pulsations, so that the operator of the furnace may have a more perfect indication as to the conditions existing therein.

When the introduction of the air is pulsated, this may be readily accomplished by the use of a rotary positive displacement blower of proper design, and the speed of rotation thereof will determine the rate of pulsations. It is also possible in this connection to provide means for regulating the rate of delivery of air in volume per minute, and I, therefore, also sometimes provide means for indicating the rate at which the air is being supplied, so that the operator can have a perfect indication of the combustion conditions existing in the furnace.

Owing to the large size of the ports which have to be used for delivering the flame to the bath, there is sometimes a tendency for said flame to rise up into the upper portion of the furnace and travel along close to the roof thereof. In such cases the heating efficiency is largely destroyed, and the burning of the roof is accentuated with corresponding damage.

Another feature of my present invention, therefore, has reference to the provision of suitable adjustable closures for the purpose which may be so adjusted as to throw the flame in very direct contact with the bath. Such adjustable closure, when used, may be at all times under the control of the operator, and the parts may also be so arranged that he can readily observe the operation of the interior of the furnace while adjusting said closure into the proper position.

In connection with the features hereinbefore referred to, I desire to call attention to the fact that the excess amount of air which it is necessary to introduce under present methods of operation, brings about an increased amount of oxidation of the metal in the hearth, with corresponding wastage of metal as well as reduced economy of operation. Therefore, the use of the features of the present invention will promote a considerable saving of the metal. Besides this a much better metallurgical effect is produced in those cases in which the air introduced corresponds more nearly to the amount which is theoretically necessary for correct combustion.

The excess air also serves to carry over a considerably increased amount of dust and solid particles from the furnace and deposit the same in the regenerator; and therefore, the use of the feature of the present invention will be of considerable benefit to the regenerators themselves and will considerably increase the life of the regenerators by reducing the amount of dust and other solid matter which is carried over. Besides this, the regenerators may be made of smaller capacity, since they do not need to handle as large a quantity of air as formerly. Furthermore, where the combustion constituents are so adjusted as to secure substantially complete and perfect combustion without excess of air the flame is shortened. For this reason the operation without excess of air makes it possible to keep the flame entirely within the bath so that the flame is not drawn out into the downcomers and slag pockets. This is a great advantage since in the past much difficulty has been experienced owing to the burning of the walls of the downcomers, slag pockets and other parts. In the past it has often happened that a large amount of the structure has fused and run into the slag pockets with corresponding damage and obstruction to the proper operation of the unit.

Other objects and uses of the invention will appear from a detailed description of the same which consists in the features of construction and combinations of parts hereinafter described and claimed.

In the drawings:

Figure 1 shows a plan view of an open hearth furnace embodying certain of the features of the present invention and a set of regenerators and other equipment in association therewith embodying certain other features of the invention;

Fig. 2 shows a longitudinal view of an open hearth furnace embodying certain features of the present invention, said furnace being shown partly in longitudinal section and partly in elevation;

Fig. 3 shows a vertical cross section taken on line 3—3 of Fig. 2, looking in the direction of the arrows;

Fig. 4 shows a fragmentary vertical detail section of one end of the open hearth furnace on enlarged scale as compared to Fig. 2, and modified to the extent that it is intended particularly for handling liquid fuel such as oil or tar;

Fig. 5 shows a fragmentary detail view of a modified arrangement of port having horizontally sliding doors instead of a vertically adjustable door;

Fig. 6 shows another fragmentary view similar to that of Fig. 4, with the exception that the construction therein illustrated is intended particularly for handling powdered fuel such as powdered coal;

Fig. 7 shows an enlarged detail view in section of the oil burner shown in the combination of Fig. 4;

Fig. 8 shows a fragmentary cross section taken on the lines 8—8 of Fig. 7, looking in the direction of the arrows;

Fig. 9 shows a detail elevational view taken on the line 9—9 of Fig. 1, looking in the direction of the arrows, but on enlarged scale;

Fig. 10 shows a plan view corresponding to Fig. 9;

Fig. 11 shows a plan view of the stationary parts of the reversing valves of Figs. 9 and 10; and

Fig. 12 shows a diagrammatic view of certain of the apparatus of the present invention and suitable indicating or controlling instruments for use in conjunction therewith in order to advise the operator as to the conditions existing within the plant.

In the drawings I have designated the open hearth furnace in its entirety by the numeral 15. There are illustrated the gas regenerators 16 and 17 for the two ends of the furnace, and the air regenerators 18 and 19 corresponding thereto. In some cases the gas regenerators are not needed, as for example where liquid fuel is used, but for purposes of convenience I have illustrated the gas regenerators as being present in Fig. 1.

The bath 20 may be of usual form, being provided with suitable doors 21 for giving access to its interior.

At the two ends of the bath are the ports 22 and 23 respectively. On one half of the cycle the flame is directed from the port 22 across the bath to the port 23, the products of combustion then passing downwardly and through the regenerators 17 and 19 and heating them; and on the other half of the cycle the flame passes from the port 23 across the bath and out through the port 22 and through the regenerators 16 and 18. These methods of operation are well understood in the art.

Examination of Figs. 1 and 3 in particular discloses the fact that the ports 22 and 23 are relatively restricted in size. The end portions of the bath at the port 22 are formed by the walls 24 and 25 which slant towards each other; and the end portions of the bath adjacent to the port 23 are formed by the walls 26 and 27 which slant towards each other. These slanting walls provide tapering end portions for the bath so that as the flame enters the bath through either port it widens out and is thus drawn over the entire surface of the bath.

At the back side of the port 22 are the slanting walls 28 and 29 which draw towards each other at the port; and at the back side of the port 23 are the slanting walls 30 and 31 which draw towards each other at the port. Consequently, the fuel and air approaching either port preparatory to passing through it into the bath is drawn into a passage of constricted size so that its velocity is rapidly increased to a maximum as it flows through the port. The result of this is that the fuel and air are very intimately thrown together before they enter the bath and therefore, the combustion effect is greatly improved with corresponding increase of economy and temperature.

It is observed in this connection that these ports constitute in effect Venturi throats. According to the well understood laws of operation the static pressure is reduced in the throat while the dynamic pressure of velocity is increased at that point, and this reduction of the static pressure greatly promotes the intimate mixture of the fuel and air. It is therefore evident that according to one feature of the present invention, I provide ports or throats of relatively restricted size at the ends of the bath so as to promote the intimacy of the mixture as the air and fuel flow therethrough.

Reference particularly to Figs. 2, 4 and 6 discloses the fact that at the back side of each of the ports or throats 22 and 23 the roof of the chamber slants downwardly towards the port, as at 32 at the back side of the port 22 and as at 33 at the back side of the port 23. Consequently, the air and fuel are directed more or less in a downward direction as they enter the bath, which movement tends to throw the flame down onto the surface of the bath and thus cause the flame to more closely hug the materials in the bath during the entire passage through the chamber. In order to still further improve this operation and tendency, I provide in some cases a damper 34 for each port, which damper may be lowered from the top so as to close the upper portion of the port and still further compel the flame to travel down closer to the surface of the bath. When such a damper is used, it may be raised and lowered in any convenient manner, but preferably by some means which can be conveniently manipulated by the operator from a point where he can observe the conditions existing within the furnace. Such an arrangement is that illustrated in Fig. 2, for example, where each of the dampers is sustained by a cord or steel rope 35 passing over suitable pulleys and operated by a plunger within a hydraulic cylinder 36. Valves 37 and 38 may be provided for said cylinder so as to lock the plunger in the desired position in order to sustain the damper as to whatever position may be selected by the operator.

When a damper is used in conjunction with the port it should be of a construction to withstand the high temperature to which it is subjected. In the construction illustrated, each damper is in the form of a hollow cast iron box 39 provided with suitable water connections 40 and 41 so that a stream of water may be circulated through it at all times in accordance with the usual practice which is frequently used in connection with water cooled doors and the like. Furthermore, suitable hollow guides 42 and 43 may be provided at the two sides of the damper, and they may

also be made hollow and water cooled. When this is done they may be fed with water through suitable connections 44 and 45 in the manner which will be readily understood by those skilled in the art.

The particular construction illustrated in Figs. 1 and 2 is so laid out that it may operate on gaseous fuel. The air regenerators 18 and 19 connect by passages 46 and 47 with the risers 48, 49, 50 and 51 at the two ends of the furnace respectively. The gas regenerators 16 and 17 connect by means of the passages 52 and 53 with the risers 54 and 55 respectively. Each of the gas risers 54 and 55 connects with a passage 56 slanting down toward the lower portion of the corresponding port 22 or 23 as the case may be; and the air risers 48—49 and 50—51 connect with the air chambers 57 and 58 respectively, which are located above the passages 56. These air chambers extend downwardly towards the ports 22 and 23 respectively, and tend to throw the air down into the gas in a wide sheet in the manner which will be evident from a comparison of Figs. 1 and 2. The partitions 59 and 60 which separate the air chambers from the respective gas passages are slotted at their inner ends as at 61 and 62 in Fig. 1 so as to permit the air and gas to come together in a tongue or finger before reaching the port. Consequently, as the air and gas pass through the port they are subjected to a very thorough mixing action owing to the action of the throat as previously explained.

The arrangement shown in Fig. 4 is intended for operation with such fuels as oil and the like. For this purpose the partitions 59 and 60 have been eliminated thereby providing an enlarged chamber 61^a adjacent to each end of the furnace and communicating directly with the ports aforesaid. A fuel nozzle 62^a reaches part way through each of these chambers 61^a and delivers its fuel to the air which rises through the port 63. This air may come from either or both of the regenerators for that end of the furnace, and for purposes of convenience in illustration, I have shown the lower end of the port 63 communicating with a chamber 64 into which the air is delivered. When such fuel as oil or the like is used, it may be drawn from a pipe 65 by means of an air blast delivered through a nozzle 66 from the pipe 67 in the well known manner.

The arrangement shown in Fig. 6 is intended for operation on such fuels as powdered coal. For this purpose the nozzle 62 receives the powdered coal from a pipe 68, an air blast coming from the pipe 69 serving to draw the coal into the nozzle and throw it into the furnace.

It was previously explained that one of the features of the invention has to do with the provision of an improved method of heating and the means by which it is practiced. This method of operation consists in the introduction of the fuel or the air or both into the furnace as a series of puffs or pulsations as distinguished from a steady stream. This pulsation tends to so agitate the air and fuel as to ensure a very perfect mixture of them and bring each particle of fuel whether gaseous, liquid or solid into much more intimate contact with the surrounding air and thereby greatly improve the combustion.

In the arrangement shown in Fig. 1, I have provided suitable means for pulsating the air and have associated said means with the blowing mechanism by means of which the air is forced into the furnace. For this purpose, a positive displacement blower 70 is provided, the same being driven in any suitable manner as by means of a motor 71. The air coming from the blower passes through a pipe 72 and through a valve 73 by which the air is diverted either to the arm 74 or to the arm 75 of a Y connection. These arms 74 and 75 lead to the connections 76 and 77 which in turn lead into the air regenerators 18 and 19. The connections 76 and 77 also lead into a valve 78 such as a Dibblee or Blair valve, by means of which either regenerator connection 76 or 77 may be placed in communication with a connection 79 leading to the stack. This valve 78 is provided with three chambers 80, 81 and 82 as shown in Fig. 1, the chambers 80 and 81 communicating with the connections 76 and 77 and the chamber 82 communicating with the connection 79. A cap 83 is provided over the chambers, said cap being so constructed that by turning it to an angle of 120° either of the connections 76 or 77 may be placed in communication with the connection 79, sealing the other connection.

The cap 83 is connected to the valve 73 by means of a link 84 so that the two valves operate in proper synchronism to ensure the delivery of air to that regenerator which is sealed from the connection 79.

A positive displacement blower such as that shown in Figs. 9 and 10 will deliver its air by a series of pulsations. For this purpose there are provided the two cam shaped rollers 85 and 86 which turn in synchronism in the well understood manner. A valve 86^a may be placed in the pipe 72, which valve when periodically rocked may also be used to cause the pulsating delivery of air.

With the arrangement so far described the air will be driven into the regenerators by a series of pulsations, and the quantity of air delivered at each pulsation will be substantially fixed in amount. I have, however, provided a valved connection 87 leading from the pipe 72 and provided with a valve 88 so that a portion of the air may be released directly to the atmosphere, if desired, in order to reduce the amount of the air fed to the furnace without however having to change

the speed of the blower accordingly. It is thus possible to change the rate of the pulsations and the amount of air delivered to the furnace independently of each other.

In the arrangement shown in Fig. 4 and in detail in Figs. 7 and 8 there is provided a rotary valve 89 in the nozzle connection 62 which valve when rotated will cause the oil fuel to be delivered in a series of pulsations. Similarly in the arrangement shown in Fig. 6 the valves 90 and 91 when rotated in proper synchronism will produce a similar result.

The gas regenerators 16 and 17 are provided with connections 92 and 93 which in turn lead to the three-way valves 94 and 95 respectively. The valve 94 has connections 96 and 97 and the valve 95 has the connections 98 and 99. The connections 96 and 98 as well as the connection 79 from the valve 78 lead to the stack by means of a connection 100; and the connections 97 and 99 lead to the gas supply pipe 101. The three-way valves 94 and 95 are intended to be operated in proper synchronism and harmony with the valve 78 so as to ensure the introduction of gas into the proper gas regenerator and the withdrawal of spent gas from the other gas regenerator in proper harmony with the operations of the air regenerators.

In Fig. 5 I have shown a modified construction of port and damper for the same. In this case there are provided two doors 102 and 103 which slide towards and from each other in a horizontal direction instead of being raised or lowered. This arrangement will tend to concentrate the flame towards the middle of the port and thus accentuate the Venturi action.

In order to enable the operator to see at all times the main operating conditions existing within the furnace, I have provided an arrangement of gages or instruments or indicators whereby he may at all times see what the main operating conditions are. This arrangement is shown diagrammatically in Fig. 12. In this figure the furnace, regenerators, blower, and certain other of the mechanisms of Fig. 1, have been reproduced diagrammatically. I have illustrated a CO_2 recorder 104 in connection with the stack for showing the completeness of combustion; a temperature indicator 105 for showing the temperature of the gases within the stack; a draft gage 106 for showing the amount of draft existing within the stack; a pressure gage 107 for showing the air pressure generated by the blower, a tachometer 108 for indicating the speed of the blower which is also an indication of the rate of the pulsations and the amount of air displaced when such a blower is used; a draft indicator 109 for indicating the draft within the furnace; and a temperature indicator 110 for indicating the temperature of the gases within the furnace. These instruments give such indications to the operator as to enable him to follow exactly the operating conditions at all times so that he may so manipulate the various dampers, fuel supply mechanism, and rate of pulsations when used as to give the most perfect combustion possible with the attendant benefits.

In Fig. 1, I have indicated butterfly valves 111 and 112 in the gas connections leading from the gas supply main 101 to the three-way valves 94 and 95. These valves 111 and 112 may be rocked in an intermittent manner so as to cause periodical or pulsating introduction of fuel gas to the gas regenerators 16 and 17 in order to assist the pulsating action if desired.

The waste gas delivered from the furnace and regenerators may be sent direct to the stack or to a fan if desired, but in many cases it will be found desirable to send it to a waste heat boiler in accordance with the well understood practice.

Examination of Fig. 1 in particular shows the fact that each of the end walls 24, 25, 26 and 27 lies at an angle of substantially 135° to the side walls of the hearth, so that the end walls if projected would come together at substantially 90°. Examination of Figs. 2 and 4 shows that the roof of each of the chambers behind the ports slopes down towards the port at an angle of substantially 30° to the horizontal. Examination of Fig. 1 also shows that the back walls 28, 29, 30 and 31 at the back sides of the ports lie at an angle of substantially 135° to the side walls and therefore lie substantially at right angles to the respective front walls 24, 25, 26 and 27. All of these angles have been purposely adopted since they materially improve the operation of the furnace and make it possible to secure more perfect combustion combined with a better ability to control the flame on the hearth, and the removal of the gases from the hearth.

While I have herein shown and described an arrangement of furnace and auxiliary mechanism and indicators of various kinds by means of which it is possible to secure the pulsating combustion in combination with the Venturi action at the port, and in combination with an adjustable damper at the port, still I do not limit myself to the use of all of these features in combination, since in many cases certain of the features may be used individually, or in other cases one or more of the various features may be combined without reference to certain other of the features.

I claim:

1. In an open hearth furnace a hearth, a port at each end thereof, means for delivering air and fuel for combustion through each port, and means for causing one of said combustion constituents to flow in an intermittent manner to produce a pulsating combus-

tion through the port, substantially as described.

2. In an open hearth furnace a hearth, a port at each end thereof, means for delivering air and fuel for combubstion through each port, means under the control of the operator for regulating the proportions of said combustion constituents, and means under the control of the operator for causing a selected one of said combustion constituents to flow in an intermittent manner, whereby the flame enters the hearth in a pulsating manner, substantially as described.

3. In an open hearth furnace a hearth, a port at each end thereof, means for delivering air and fuel for combustion through each port, means under the control of the operator for regulating the proportions of such combustion constituents, means under the control of the operator for causing a selected one of said constituents to flow in an intermittent manner, whereby the flame enters the hearth in a pulsating manner, a damper for each port, and means under the control of the operator for adjusting each damper, substantially as described.

4. In an open hearth furnace a hearth having at each end a port, a chamber behind each port, and means for introducing fuel and air for combustion through each chamber, the end walls of the hearth sloping towards the port at an angle of substantially 135° to the side wall of the furnace, and the walls of each chamber also sloping towards the adjacent port at an angle of substantially 135° to the side wall of the furnace, substantially as described.

5. In an open hearth furnace, a hearth having at each end a port, a chamber behind each port, and means for introducing fuel and air for combustion through each chamber, the end walls of the hearth sloping toward the port at an angle at substantially 135 degrees to the side walls, substantially as described.

6. In an open hearth furnace, a hearth, a port at each end thereof, a chamber behind each port, means for introducing fuel and air for combustion through each chamber, and a vertically adjustable damper working through each port and working downwardly, an end wall at each end of the hearth sloping towards the port at such end on an angle of substantially 135° to the side wall of the furnace, the side of each chamber sloping towards its port at an angle of substantially 135° to the side wall of the furnace, and the roof of each chamber sloping downwardly towards the adjacent port at an angle of substantially 30°, substantially as described.

7. The method of heating an open hearth furnace which consists in delivering air and fuel for combustion into each end thereof in a pulsating manner, substantially as described.

8. The method of heating an open hearth furnace which consists in alternately delivering air and fuel for combustion through opposite walls of the furnace and in a pulsating manner, substantially as described.

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