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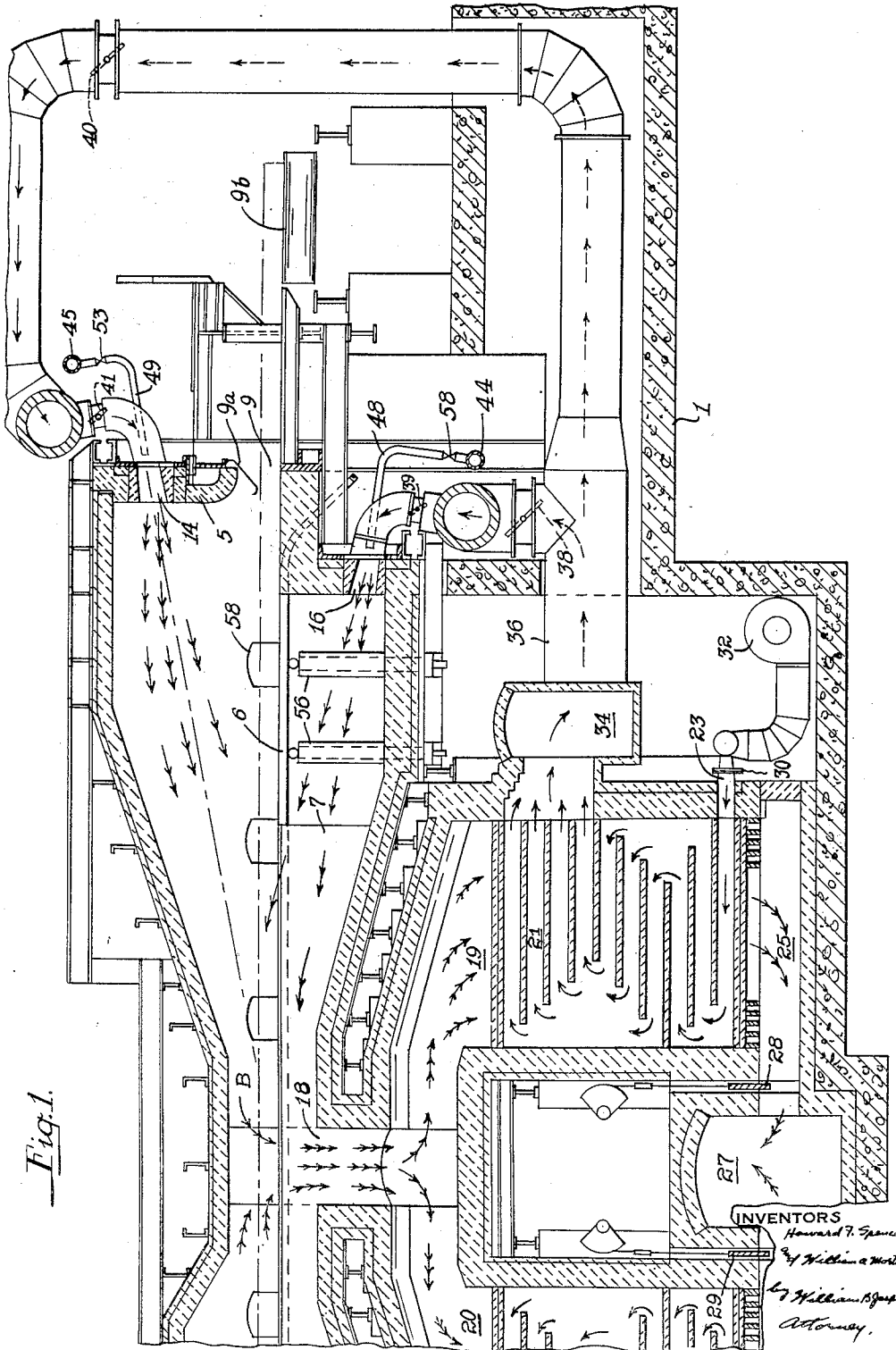
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CONTINUOUS HEATING FURNACE

Original Filed June 19, 1936

3 Sheets-Sheet 1



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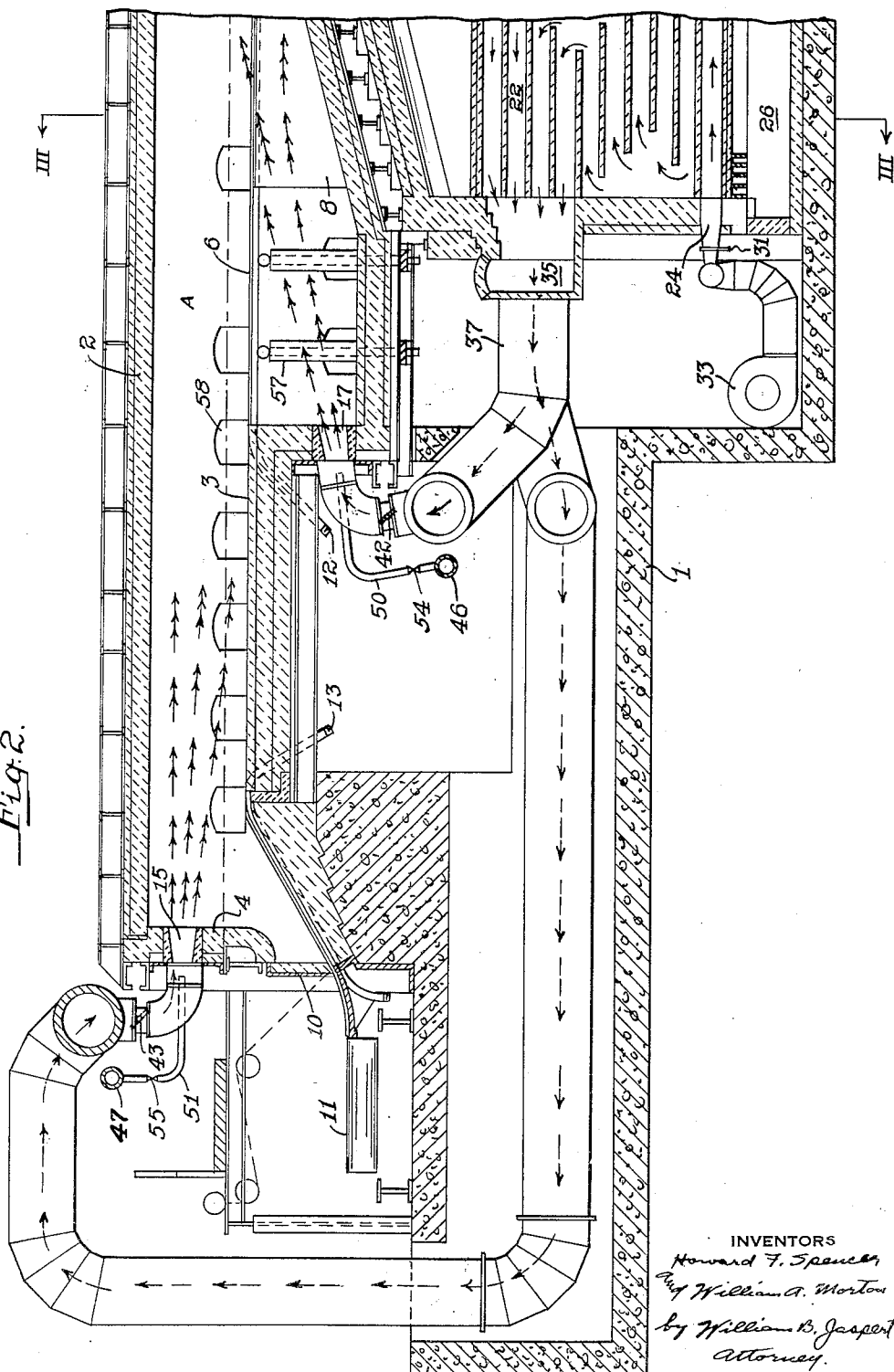
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Fig. 2.



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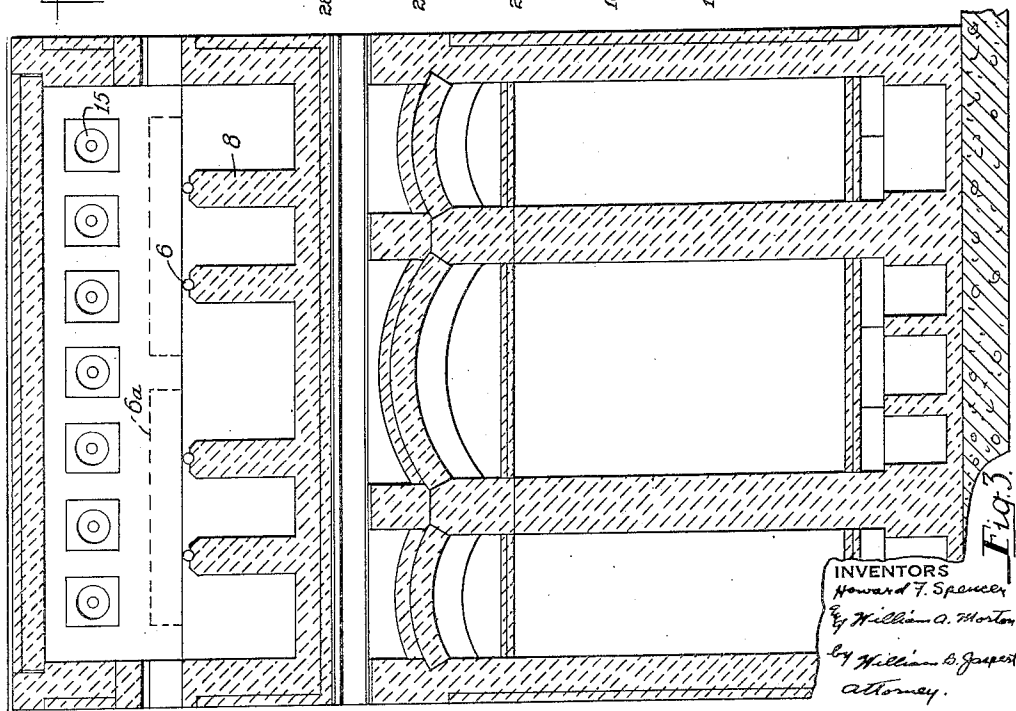
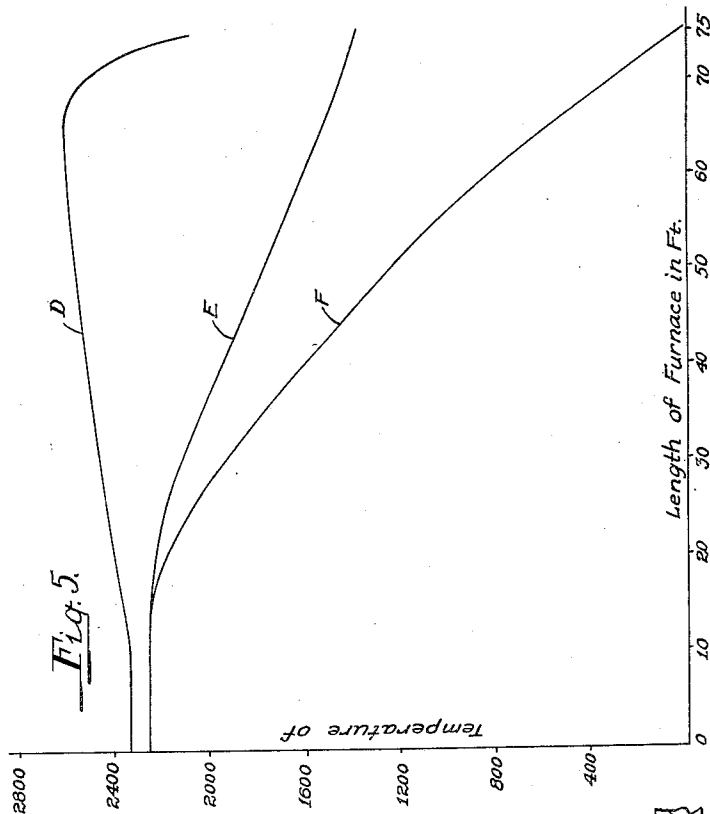
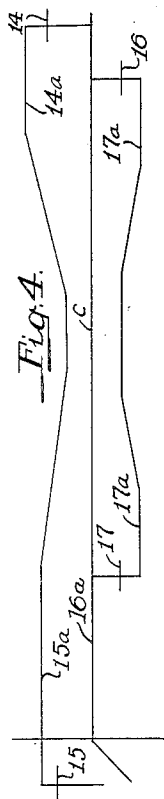
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CONTINUOUS HEATING FURNACE

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UNITED STATES PATENT OFFICE

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CONTINUOUS HEATING FURNACE

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7 Claims. (Cl. 263—52)

This invention relates to new and useful improvements in industrial heating furnaces of the type where the material, such as billets of steel, is continuously charged into one end of the furnace chamber and discharged at the other end, the material, while passing through the furnace, being subjected to the heat from combustion of gaseous or liquid fuels at such temperatures as will bring it to the proper heat for subsequent rolling or other operations, and the present application is a division of an application Serial No. 86,146 filed June 19, 1936.

Furnaces of this character are of the so-called top or bottom fired types, the modern continuous furnace being fired at both top and bottom to completely envelope the billets or slabs in the heating medium while they pass over skid rails on the furnace hearth. The temperatures of the prior art furnaces are such that the billets are charged into a heating environment of approximately 1400° F. and as the billets pass toward the discharge end of the furnace, they are subjected to gradually increasing temperatures and quantities of heat until a temperature of substantially 2400° F. is obtained, the average temperature being substantially 1900° F. These temperatures are obtained by firing the furnace at or near the critical heating range of the billets near the discharge end and withdrawing the products of combustion at or near the charging end.

In accordance with the present invention, furnaces of the continuous type may be operated to greatly increase their heating capacity per square foot of furnace hearth by maintaining an average furnace temperature greatly in excess of that heretofore employed, without subjecting the steel and refractories to excessive heating and possible welding or melting temperatures in the critical heat zones of the furnace.

The invention contemplates substantial increase of furnace temperatures at the charging end of the furnace where the relatively cold steel will absorb heat very rapidly. This method of heating provides maximum temperature difference between the steel being heated and the furnace throughout the heating cycle.

The initial heating chamber temperature can be reduced when heating thick steel or special steels of such a composition that would be injured by a high initial temperature. This can be controlled independent of the final heating and soaking hearth by regulating the fuel and air preheat temperature at this end of the furnace, or by varying the combustion characteristics from

luminous to non-luminous by regulation of the air.

The method of moving steel through a diminishing temperature gradient in a continuous heating furnace provides the correct cycle, that of applying the maximum heat where the most heat is to be absorbed and the minimum where the least heat is required.

The invention further contemplates the establishment of a higher average furnace temperature by the arrangement and distribution of a plurality of burners and by the location of the exhaust passage for the waste gases at a point intermediate the burners to maintain efficient combustion. The waste gases when leaving the furnace are of higher temperature than in the conventional type of continuous furnace and are utilized to preheat the air for supporting combustion in the furnace by passing them through a suitable recuperator structure.

The foregoing and other objects of the invention will become more apparent from a consideration of the accompanying drawings constituting a part hereof in which like reference characters designate like parts and in which:

Fig. 1 is a vertical section longitudinally of the charging end of a continuous fired furnace embodying the principles of this invention and Fig. 2 a similar view of the discharge end of the furnace, Figs. 1 and 2 constituting the complete furnace; Fig. 3 a transverse section taken along the lines 3—3, Fig. 2; Fig. 4 a diagrammatic structural outline of the furnace; and Fig. 5 temperature curves illustrating the temperature conditions of the furnace and the steel passing through the furnace.

With reference to Figs. 1 to 3 inclusive of the drawings, the numeral 1 designates the pit or foundation which is of reinforced concrete for supporting the superstructure of the furnace and on which the recuperators for preheating the air for supporting combustion are constructed. The heating chamber of the furnace is designated by the reference character A and is constituted by the roof 2, hearth 3 and end walls 4 and 5, a water-cooled skid rail 6 being mounted on the hearth 3 and on refractory pillows 7 and 8, Figs. 1 and 2, which are more clearly shown in Fig. 3 of the drawings. The charging end of the furnace is shown in Fig. 1, the charging opening being designated by the reference numeral 9 which is controlled by a gate 9a. The discharge opening is controlled by a gate 10, the skid rails 6 being inclined adjacent the discharge end of

the furnace to permit the discharge of the billets by gravity onto a conveyor 11.

It will be noted that the skid rail 6 extends from the charging end of the furnace to the refractory hearth 3, Fig. 2, at which portion it extends downward as shown by the end 12, and the inclined portion of the skid rail also bends downward as shown by the end 13, the ends 12 and 13 being connected in a circulating system whereby water or other cooling medium is continuously circulated through the supporting skid rails 6.

The furnace is fired by a series of spaced burners located as follows: The front wall 5 and the rear wall 4 are each provided with firing ports 14 and 15, there being a plurality of firing ports transversely of the furnace, as shown in Fig. 3. Additional firing ports 16 and 17, Figs. 1 and 2, are provided beneath the skid rails of the furnace and are disposed to project a heating flame underneath the material to be heated.

A center downtake waste gas passage 18, Fig. 1, withdraws the products of combustion from both ends of the furnace downwardly into the collecting chambers 19 and 20 of a pair of recuperators, and the products of combustion pass downwardly in a vertical direction in heat exchange relation with a series of air passages 21 and 22 constituted by refractory tile which is in heat exchange relation with the waste gas passages to thereby heat air drawn into the passages 21 and 22 at inlets 23 and 24 respectively, the waste gases collecting in bottom chambers 25 and 26 from which they are drawn through a passage 27 to a stack not shown. The passage from the bottom chambers 25 and 26 are controlled by dampers 28 and 29 and the air inlets are similarly controlled by dampers 30 and 31. Blowers 32 and 33 are provided to furnish a constant but variable supply of air to the preheating recuperator passages 21 and 22 from which air is drawn into side chambers 34 and 35, thence through conduits 36 and 37 which are divided as shown to conduct air to the firing ports 14, 15, 16 and 17, the quantity of air to each port being regulable by dampers 38, 39, 40 and 41, Fig. 1, and dampers 42 and 43, Fig. 2, dampers 39, 41, 42 and 43 controlling the air supplied to each individual burner port. Fuel is supplied by manifolds 44 and 45, Fig. 1, 46 and 47, Fig. 2; individual burner pipes 48 and 49, Fig. 1; and 50 and 51, Fig. 2, project into the multiple burner ports. Valves 52 and 53, Fig. 1, and 54, 55, Fig. 2, being provided for individual regulation of the fuel supply to the respective burner ports.

The billets 56a, Fig. 3, to be heated are conveyed to the charging opening 9 of the furnace on a roll table conveyor 9a from which they are transferred to the skid rail 6 of the furnace by pusher mechanism which advances the billets one by one into the furnace, and with each charge entering the furnace, a billet is moved step by step through the furnace, over the refractory soaking hearth and then to the inclined portion of the skid rail and discharged onto the conveyor 11. The roof 2 of the heating chamber dips downwardly to provide a constricted area B in the region of the waste gas passage 18 to concentrate the products of combustion at their point of discharge and prevent their re-circulation in adjacent firing zones as well as to concentrate the heat upon the billets superposed on the skid rail. Conventional refractory supports 56, Fig. 1, and 57, Fig. 2, are provided for the skid rails 6 and a series of gate controlled openings 58 are provided longitudinally

of the furnace at the level of the hearth and skid rail.

Primary air is designated by the single arrows, the heating flame by double arrows, and the products of combustion by triple arrows. The operation of the above described furnace will be more readily understood with reference to the graphic illustrations of Figs. 4 and 5 of the drawings and is briefly as follows:

Fig. 4 shows a diagrammatic structural outline of the furnace walls and burners. The furnace is fired through a series of ports 14, 15, 16 and 17 to produce the desirable heating characteristics. Lines 14a, 15a, 16a and 17a together with the end walls, represent the furnace walls. The line C represents the hearth. In Fig. 6 the curve D illustrates the working temperature of the furnace; curve E the temperature rise of the steel when charged into the furnaces in a preheated state; and, curve F the temperature rise of the steel passing through the furnace when charged into the furnace in an unheated condition. The low point of the curves represent temperatures at the charging end of the furnace. The ordinate represents temperatures in ° F. and the abscissa the length of furnace in feet.

In furnace practice, steel may be delivered hot at about 1200° F. or cold. When hot steel is delivered into the ordinary furnace, the heating rate is about 70% greater than with cold steel. The ordinary furnace has a waste gas temperature of about 1400°, therefore, when hot steel is charged there is a very low initial rate of heat exchange, but over 50% of the total ultimate heat is already in the steel; when cold steel is charged, more useful heat is added to the steel than when hot steel is heated, even though the tonnage per unit of time is less; this is due to the greater initial rate of heat transfer brought about by the temperature differential, between 1400° furnace and cold steel at the charging end. The heating effect of this improved furnace where greater temperature differentials are provided is obvious.

As shown in Fig. 5, curve D at X represents the temperature of the furnace at the charging end, which is maintained through burners 14 and 15, the curve showing a rapid rise to the maximum temperature of the furnace immediately beyond the charging opening. If steel is charged into the furnace in a preheated state as is sometimes the case, its absorption of heat may be less rapid than when charged into the furnace in a cold state, this being represented by curves E and F, respectively. Curve D may be termed a decelerating temperature curve as it gradually drops toward the discharge end of the furnace, and such characteristic of furnace temperatures is particularly desirable to prevent oxidation and to avoid excessive temperatures at or near the welding range, thereby avoiding mill delays.

In the conventional type continuous heating furnaces the high temperatures are developed at or near the soaking portion of the furnace, which is the portion designated by the hearth 3 after the steel passing through the furnace leaves the skid rail 6 and is supported by the hearth proper. Thus in the conventional furnaces maximum or high temperature of the furnace would be adjacent that portion of the furnace where the steel leaves the skid rail, which is in the zone of the furnace where the steel is apt to weld together as the billets or slabs about to be discharged are being conveyed out of the furnace. As shown in curve E, Fig. 5, the steel gradually comes up to the desirable temperature at which it will be

worked even though the temperature of the furnace is decelerating as the temperature of the steel increases. This is apparent by comparing the furnace temperature curve D, which is decelerating, with the steel temperature curves E and F which are accelerating. The flat portions of the curves represent the soaking period of the steel or the soaking zone of the furnace. The rapid absorption of the heat of the furnace by the metal being charged therein is represented by the curves E and F which show a sharp temperature rise during the passage of the steel through the furnace, particularly during its earliest travel along the furnace hearth. It is because of this that the maximum temperature may be applied at the charging end of the furnace chamber without subjecting the refractory parts to excessive and destructive heat.

Thus it is seen from the diagrammatic structural outline of Fig. 4 illustrating the hearth length and location of burners and by the furnace and steel temperature curves D, E, and F of Fig. 5, that the capacity of the furnace may be greatly increased because of the substantially higher average furnace temperature maintained throughout the heating cycle.

The heating characteristics of the furnace, as heretofore stated, are brought about by the location and distribution of the burners 14, 15, 16 and 17, respectively, and by the exhaust of the waste gases at a point intermediate the points 16 and 17 through the bottom of the furnace hearth.

The location of the center downtake exhaust passage, designated by the numeral 18 in Fig. 1 of the drawings, at a point intermediate the front and rear burners, permits complete combustion to take place in a constantly clearing atmosphere, which results in higher efficiency and economy in fuel consumption and is productive of desirable flame characteristics.

Again referring to Figs. 1 and 2 of the drawings, the waste gases designated by the triple arrows passing downwardly through the downtake passage 18 are at higher temperatures than in the conventional type furnace as they do not contact cold steel entering the furnace and are, therefore, productive of a higher preheat of the air supplied to the burner ports to support combustion.

By the employment of the temperature controls such as the gates 28 and 29 whereby the amounts of the volumes of waste gases passing through the respective recuperators may be regulated and by means of dampers 30 and 31 regulating the air supply to the recuperators, and further by the use of dampers 39, 41, 42 and 43, the volume and temperature of preheated air supplied to each individual bank of burners may be positively controlled, thereby making it possible to obtain any desired temperature condition at both the charge, discharge and intermediate portions of the furnace and above and below the material as it passes over the skid rails 6.

The recuperators are separately controlled so that highly preheated air can be delivered to the burners at the charging end of the furnace where the highest flame temperature is permissible and to permit lower preheat temperatures for the burners at the discharge end to insure the lowest practical temperature differential between steel and the heating environment. According to this method, the high temperature recuperator might deliver air preheated to 1600° F. and the low temperature recuperators a minimum of 700° F. The advantages in first accelerating heating and in

then providing safety for final heating are at once apparent. By further regulation of the air supply to the respective ends of the furnace, the burners on the charging end are preferably operated with a luminous flame, and those on the discharge end with a clear or oxidizing flame, to control heating rates and surface of the billets, respectively.

It will be apparent from the foregoing description of the invention that continuous heating furnaces constructed in accordance therewith and embodying the principles thereof are productive of greater steel heating capacity per square foot of surface area per hour than furnaces operated at low average temperatures and fired at or near the discharge end of the furnace.

Although one embodiment of the invention has been herein illustrated and described, it will be apparent to those skilled in the art that various modifications may be made in the details of construction without departing from the principles herein set forth.

Thus, for example, it may be found unnecessary in some instances, depending upon furnace capacity and the kind of steel to be heated, to employ a burner both at the top and bottom portions of the furnace chamber at the charging end thereof, and the location of the burners may be altered without greatly disturbing the firing characteristics of that end of the furnace.

We claim:

1. The method of heating billets or the like in a continuous furnace which comprises, passing the billets through a heating environment of gradually diminishing thermal input to raise the billets safely to the desired temperature at which they are to be worked, and subjecting the billets to a soaking temperature when the billets have reached the maximum temperature to equalize the desired temperature of the billets before discharging them from the furnace.

2. The method of heating billets in a continuous furnace which comprises passing the billets through a furnace on an open work support for a major portion of the billet travel through the furnace, and applying heating flames to the billets at the top and bottom from both ends of the furnace to constantly envelope the billets at opposite ends of the furnace in initial heat flames.

3. The method of heating billets in a continuous furnace which comprises passing the billets through a furnace on an open work support for a major portion of the billet travel through the furnace, and applying heating flames to the billets at the top and bottom from both ends of the furnace simultaneously to substantially envelope the billets in the heating flame, and continuously maintain a combustion-supporting atmosphere by removing the products of combustion at the terminus of the heating flames.

4. The method of heating billets in a continuous furnace, which comprises charging the billets at one end of the furnace and passing them continuously through the heating chamber to the discharge end of the furnace, heating the billets at the maximum rate at the charging end of the furnace, then subjecting them to a diminishing rate of heating and then to a constant soaking temperature for a portion of their travel at the discharge end of the furnace.

5. The method of heating billets in a continuous furnace, which comprises charging the billets at one end of the furnace and passing them continuously through the heating chamber to the

discharge end of the furnace, directing a heat flame from burners at both ends of the furnace above and below the billets in paths substantially parallel to the paths of travel of the billets, and
5 regulating the preheat and fuel supply to the respective burners to obtain a decelerating temperature from the charging to the discharge end of the furnace and a substantially constant soaking temperature at the discharge end of the furnace.
10 6. The method of safely accelerating the rate of heating billets in a continuous furnace which comprises initially passing the billets through a zone heated to a temperature in excess of the final desired heated temperature of the billets, then
15 passing the billets through an extended zone having the temperature decelerating to a final temperature slightly higher than the final desired heated temperature of the billets and then passing the billets through a zone of uniform temperature to complete the desired heating cycle.
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7. The method of heating billets in a continuous furnace, which comprises charging the billets into a furnace at one end and passing them unidirectionally through the heating chamber to the discharge end of the furnace, heating the chamber adjacent the charging end to accelerate the rate of heat transfer to the billets by supplying flames at that end of the furnace with a deficiency of air to increase the radiation power of the flames at the inception of heating, continuing the application of heat as the billets move through the furnace, and finally raising the billets to the desired temperature in an atmosphere having an excess of air to decrease the radiation power of the flames to control the surface temperature of the billets prior to discharge from the furnace.

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