July 15, 1952 F. O. HESS 2,603,470

METHOD AND APPARATUS FOR HEATING

Filed April 26, 1949 3 Sheets-Sheet 1

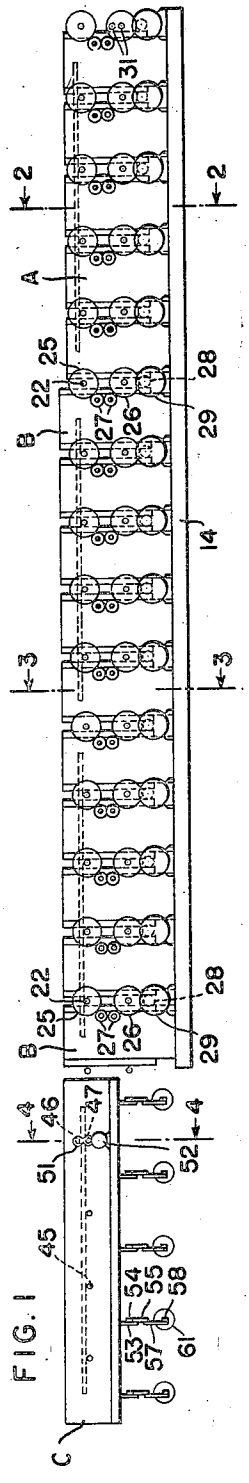

FIG. 1

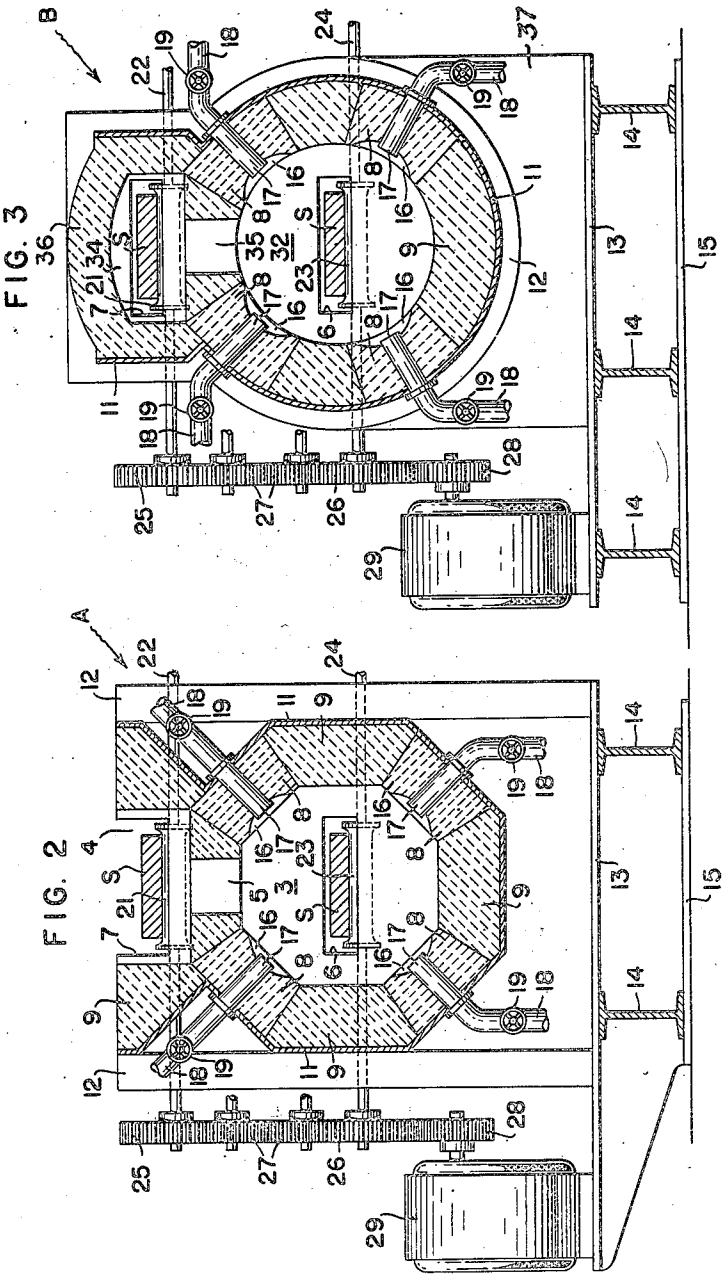

FIG. 3

FIG. 2

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METHOD AND APPARATUS FOR HEATING

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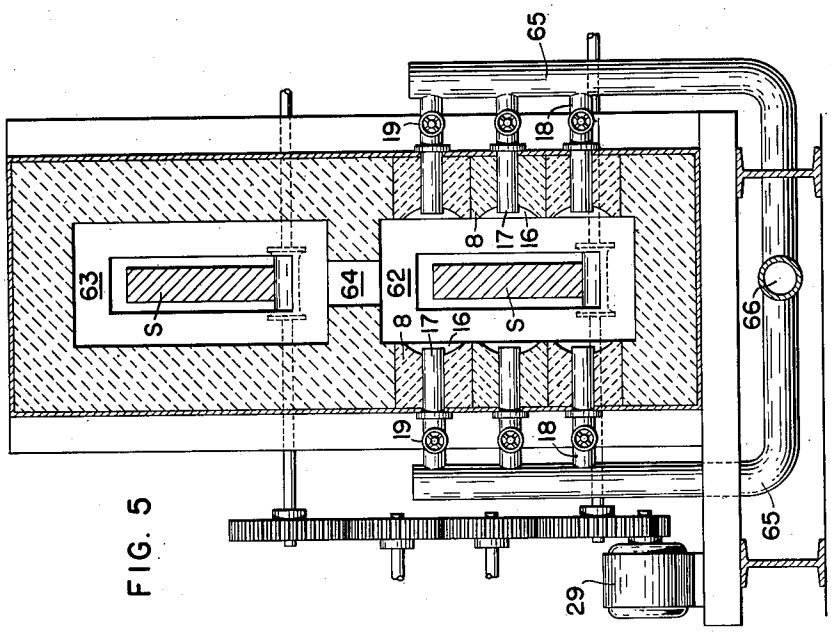

FIG. 5

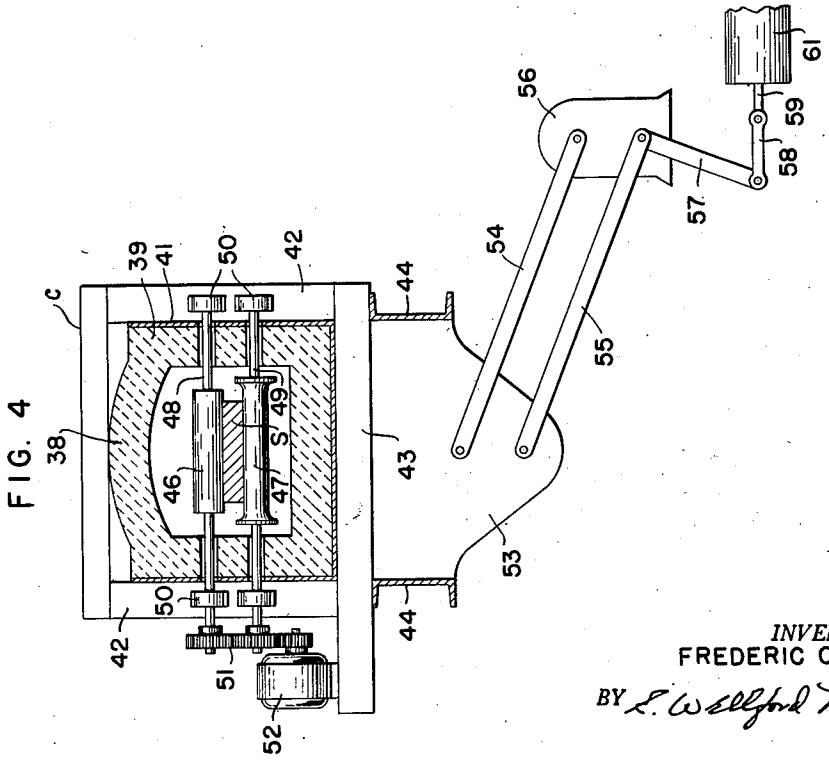

FIG. 4

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METHOD AND APPARATUS FOR HEATING

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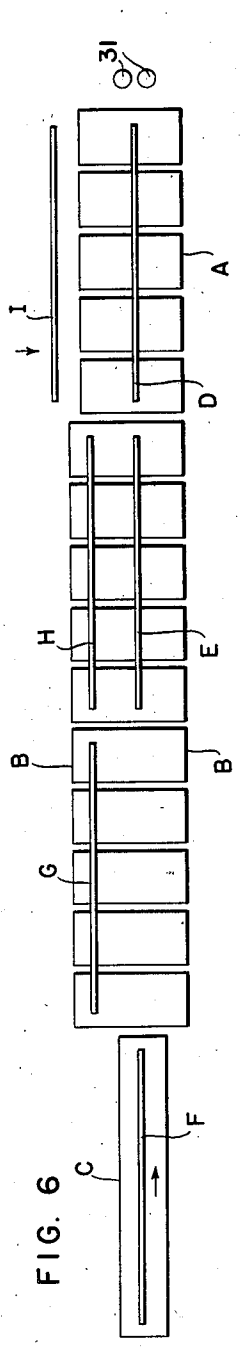

FIG. 6

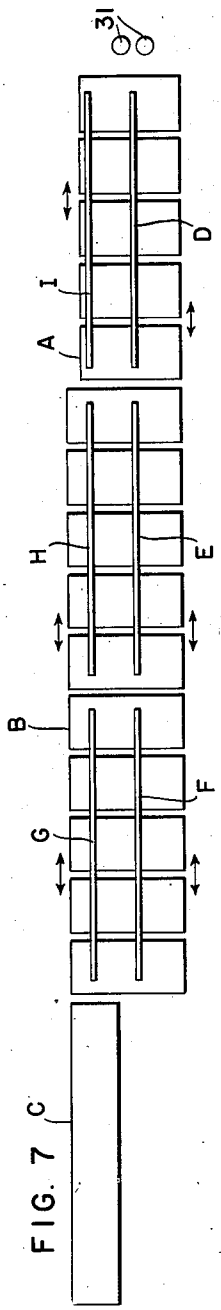

FIG. 7

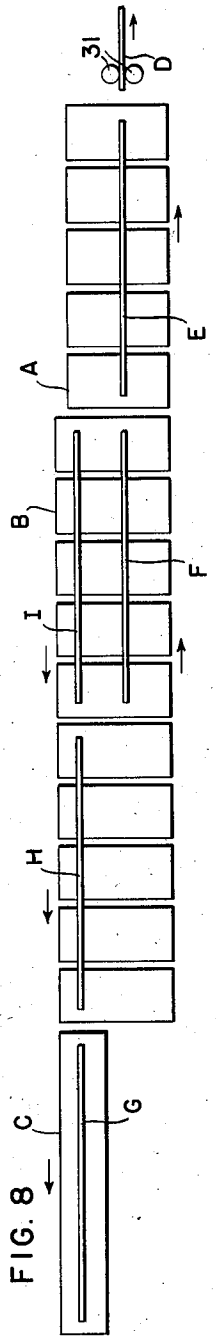

FIG. 8

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Patented July 15, 1952 2,603,470

UNITED STATES PATENT OFFICE

2,603,470

METHOD AND APPARATUS FOR HEATING

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Application April 26, 1949, Serial No. 89,606

3 Claims. (Cl. 263—2)

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The present invention relates to the heating of metal, and more particularly to the method of and apparatus for heating slabs or other large bodies of metal from ambient to hot working temperatures such as the elevated temperatures required for rolling.

In accordance with the present invention there is provided a furnace system including a plurality of aligned furnace units through which the slab or other metal piece is moved. The furnace units are each provided with a high temperature heating chamber and a preheating chamber that are in direct communication with each other. The furnace units on the charge end of the system have their preheating chambers open at the top through which charging takes place, while those in the main heating portion of the system have their preheating chambers closed. Conveying means is provided between each of the furnace units to move the work through the system with the work in the preheating chambers moving in one direction and the work in the heating chambers moving in the opposite direction. At the end of the system opposite the charging and discharging end there is provided a transfer mechanism to shift the work from the upper preheating level to the lower heating level.

It is an object of the present invention to provide apparatus for heating rapidly and evenly slabs, billets, blooms and other shapes of metal. The apparatus is so designed that the work is heated evenly throughout its area from end to end. With the arrangement of the furnace units in the present invention a large portion of the heat normally lost is utilized to raise the temperature of the work to a relatively high value prior to the time the work passes into the actual heating chamber.

It is a further object of the invention to provide apparatus for preheating work in which the hot products of combustion from the heating chamber pass directly to the preheating chamber while still at substantially their highest temperature. So far as I am aware no apparatus has previously been used in which the natural draft of the products of combustion has been used to carry them directly and with a minimum of loss from a heating chamber to a preheating chamber which is directly above and in communication with the former.

It is a further object of the invention to heat slabs, billets, blooms and the like rapidly and to feed them directly from the heating apparatus to a mill at mill speed. With the present apparatus large pieces of work are passed directly and continuously from the place of the heating to a mill one after the other in a continuous line. The work moves in opposite directions through the heating apparatus for the dual purpose of reducing the space requirements for utilizing most efficiently the heat released by the fuel. The result is a compact and efficient heating system.

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It is a further object of the invention to provide a method of heating large metallic objects with a minimum of handling. By following the method of the present invention work is moved by mechanical means, which may be automatic in operation, directly from the point of loading through the furnace system to the mill, and is supplied to the mill at mill speed.

It is a further object of the invention to provide a method of heating metallic objects which comprises passing them in opposite directions and at different levels through preheating and heating chambers of a furnace system.

In the following description of the invention the work being heated will be referred to as slabs. It will be understood, however, that the work being heated could be billets or blooms or any large pieces or shapes as desired.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

In the drawings:

Figure 1 is a more or less diagrammatic view showing the furnace line and the apparatus used to transfer the billets from one level to another;

Figure 2 is a section of one of the furnace units on the loading end of the system;

Figure 3 is a section of one of the furnace units in the main heating portion of the system;

Figure 4 is a section of the transfer mechanism;

Figure 5 is a section of an alternative form in which the furnace units may be supplied; and

Figures 6 to 8 inclusive are diagrams showing the manner in which the system operates.

Referring to Figure 1 there is shown more or less diagrammatically the entire heating system to be used for heating slabs, billets, or other large bodies. In this system the furnace includes a plurality of furnace units forming the loading zone, which units are indicated at A. There are

also a plurality of furnace units B forming the main heating section of the system, and a transfer section C which is used to transfer the preheated billets to the high temperature heating chambers of the furnace units.

The furnace units of the loading section are identical as are the furnace units of the main heating section. The furnace units of these sections differ from each other only in that the units of the loading section are provided with means for loading the billets to be heated from above, while the units of the main heating section do not have this provision.

In Figure 2 there is shown a furnace unit A which is provided with a lower high temperature heating chamber 3 and an upper preheating chamber 4 that are directly connected by a passage 5 extending between the two chambers. Each end of the furnace unit is provided with openings 6 through which the slab to be heated may be passed into and out of chamber 3. Openings 7 are also provided in the preheating chamber 4 through which the slabs may be passed. It will be noted that each of these openings is considerably smaller than the size of the chamber and is only slightly larger than the dimensions of the maximum size slab that is to be heated.

The walls of the chamber 3 have in them burner blocks 8 which are properly located for the heating pattern desired and which are separated by suitable high temperature refractory blocks 9. The entire furnace unit is built up of the refractory and the burner blocks and is supported by sheet metal backing 11 in accordance with ordinary furnace practice. The furnaces are provided with braces 12 and rest upon a platform 13. There are also provided supports 14 which extend throughout the length of the system and upon which each of the furnace units is mounted so that they may be positioned with the openings 6 and 7 in axial alignment. The beams 14 are mounted upon a suitable floor or foundation 15.

Each of the burners 8 that is used may be of any desired type that has suitable combustion characteristics for the size of furnace chamber 6 being used. The burner disclosed herein are similar to those described and claimed in Hess Patent No. 2,215,079, issued September 17, 1940. Each of these burners consists of the refractory block 8 that has a cup 16 formed in its face. Fuel, which consists of a combustible mixture of gas and air is supplied through a distributor 17 into the cup in a plurality of small jets where it is completely burned in the cup. The fuel in burners of this type is burned in the cup to heat the latter to incandescence thereby supplying radiant heat to the work. Heat is also supplied by the hot gases of combustion as will be explained more fully below. The distributors 16 are connected by pipes 18 with suitable manifolds and each pipe 18 has a valve 19 in it so that the amount of fuel supplied to each burner can be regulated individually.

Between each of the furnace units in both the loading section as well as the main heating section there is provided conveying mechanism to move the slabs that are to be heated through the system. As shown in the drawings there is an upper conveyor roller 21 located between each of the furnace units and on a level so that slabs can be moved through the preheating chambers. This roller is supported on a shaft 22 that is journalled in any suitable manner. There is also provided a lower conveyor roll 23 mounted on a shaft 24 between each of the furnace units at a level so that slabs can be moved through the high temperature furnace chambers. The lower conveyor rollers are so positioned that they will forward slabs to be heated through the high temperature chambers 3. It is noted that in actual practice these conveyor rolls and their supporting shafts will be water cooled in order to prevent overheating of the rolls. Since, however, provision for water cooling rolls of this type is well known, it is deemed unnecessary to describe such provisions in detail herein. The conveyor rolls are driven positively to move the slabs being heated in the two furnace chambers in opposite directions. To this end there is provided a gear 25 on shaft 22 and a gear 26 on shaft 24. These gears are connected for rotation together by a pair of idler gears 27 and are positively driven by a pinion 28 on the shaft of a motor 29. While it would be possible to drive the various conveyor rolls from a single motor and drive shaft it has been found preferable to drive each set of conveyor rolls individually by its own motor and hook these motors together electrically so that they will rotate in unison. It is noted that at the exit end of the high temperature heating chambers, as shown at the right of Figure 1 of the drawing, there is a pair of pinch rollers 31 which are used to feed positively the heated slabs into some mechanism for operating upon them such as, for example, a rolling mill.

As noted above the furnace units in the main heating section are similar to those in the loading section, with the exception that the upper preheating chamber 4 in these units is closed so that a higher degree of preheating may be obtained. Such a furnace is shown in section in Figure 3 of the drawings. The high temperature heating chamber of the furnace shown in Figure 3 is circular in shape rather than polygonal in shape as was the furnace disclosed in Figure 2. This is a matter of design however, since the shape the furnace chamber will take will be determined by the size and type of work being heated. In Figure 2 the lower high temperature chamber is shown at 32 and the upper or preheating chamber is shown at 34. These chambers are directly connected with each other by means of a passage 35. As shown in this drawing there is provided a top 36 for the preheating chamber, which top forms an integral part of the furnace unit and is built of refractory materials as is the rest of the furnace unit. In this case the furnace units B are mounted on a pair of supports 37, the upper part of which is semi-circular in shape to support the furnace and the lower part of which is flat to be received on platform 13. As noted above, the burners used in this chamber are exactly the same as those used in the heating chamber described in connection with Figure 2. The only difference in these burners is that their outer contour has to be changed to fit the cylindrical furnace chamber. The conveyors are placed between each of these furnace units as they were between each of the units in the loading zone and the conveyors are driven in the same manner.

In the operation of the system, as will be pointed out more in detail below, slabs are loaded into the preheating chamber and are moved to the left in Figure 1. After passing through all of the furnace units they are moved vertically

downward in alignment with the openings in the high temperature chambers and are then moved to the right to the exit of the system. A transfer mechanism C is used for lowering the slabs from the preheating to the high temperature chambers. This transfer mechanism includes a transfer duct **38** that is, in effect, a tunnel closed at its left end and open at its right end so that the slabs may be inserted and removed therefrom. The transfer duct **38** is made in accordance with ordinary furnace practice of a refractory **39** that is backed up by sheet metal work **41**, and suitable bracing **42**. The duct is mounted upon a platform **43** and beams **44** that hold it rigid throughout its length. Located at various points along the interior of the duct are a plurality of rollers **45** upon which the slab being heated is moved into and out of the duct. These rollers are normally not driven since the slab is moved into and out of the transfer duct by a pair of pinch rollers **46** and **47** that are mounted on shafts **48** and **49** respectively. These shafts are journalled for rotation in bearings **50** which are attached to the bracing **42** for the duct and may be driven in opposite directions by means of gearing **51** from a suitable electric motor **52** that is mounted on platform **43**.

In order to raise and lower the transfer duct a plurality of plates **53** are attached suitably to the beams **44** at various points along the length of the duct. These plates have pivoted to them a pair of levers **54** and **55**, the other ends of which are pivoted to a rigid support **56**. Thus by rotating the levers the entire duct can be moved vertically. The raising and lowering movement of the duct is accomplished by a lever **57** that is attached for movement with lever **55** to form a bell crank. The lower end of the lever **57** is connected by a link **58** to a piston rod **59** that has on its end a piston received in a cylinder **61**. Fluid under pressure can be admitted in any suitable manner to opposite ends of the cylinder in order to lower and raise the transfer duct to move slabs from the upper preheating chambers to a position in which they can be fed to the lower high temperature chambers.

Each of the furnace units that were described above shows the slabs to be heated mounted on their sides. The furnace units, however, could be constructed so that the slabs are mounted on edge rather than on their sides if it is so desired. The controlling factor in this case would be the type of working apparatus to which the slabs are supplied. There is shown in Figure 5 a furnace unit in which the slabs are mounted on edge as they are being moved through the system. It will be seen that high temperature chamber **62** and preheating chamber **63** in this case are rectangular in shape with their narrow sides at the top and bottom thereof. These chambers are connected by a passage **64**. The furnace unit is constructed, as were the previously described units, in accordance with ordinary furnace practice and similar parts are given similar reference numerals. The burners used in this type of furnace are also similar to those described above. It is noted, however, that the placement of the burners is slightly different in that the burners are located in the vertical sides of the high temperature chamber and are directed toward the slab which would be passing between them. In this case, each of the pipes that supply the burners is shown as being connected to a manifold **65**, and the manifolds in turn connected to a main **66**. In a system of the type described the main **66** would extend from one end of the furnace system to the other to supply fuel to all of the units of which it is comprised.

In order to fire the furnace a combustible mixture of gas and air is supplied through the main **66** and suitable manifolds to the various burners of the individual furnace units where it is discharged in a plurality of small jets to be completely burned in the cups **16** of the burners. The cups are heated to a high degree of incandescence and radiate their heat to all portions of the furnace chamber which is also heated to incandesence. In effect, the high temperature chambers **3**, **32** and **62** are radiant tunnels through which the slabs are moved so that they may be evenly heated around their entire surface. The hot products of combustion which are produced as a result of the combustion, and which would normally be wasted, rise through passages between the high temperature chambers and the preheater chambers where they circulate around a second slab to preheat the same. Some of these gases also flow through the openings **6** and **7** to protect the slabs from the atmosphere as they are moved from one furnace unit to the other. Thus the slabs are heated in a series of steps as they pass from one of the furnace units to the other and they are protected from oxidation as they move between the furnace units by means of a blanket of exhaust gases which blows through the entrance and exit openings of each unit.

A description of the operation of the system will now be made with particular reference to Figures 6, 7 and 8. It is intended that the slabs will by supplied to the system at ambient temperature and discharged into a rolling mill for hot rolling, for example, at a temperature of about 2250° F. In order to attain this temperature the lower chambers of the furnace units are fired at a rate sufficient to maintain the burner cups **16** at substantially 2700° F., and the interior of the chambers at the slightly lower temperature of from 2400° to 2500° F. The time the slabs must be kept in the furnace units will vary with their analysis and their dimensions, with smaller slabs requiring less time to heat than those that are larger. The number of furnace units A and B that are used will vary with the length of the slabs being heated. As shown herein each slab is of such a length that five furnace units A are required to receive it, and there are provided ten furnace units B. A smaller or larger number of units B could be used, but there should be the same number as there are units A or a multiple thereof. Enough furnace units are disclosed herein to handle six slabs at once.

In Figure 6 slabs D and E are shown in the lower chambers and slab F is shown in the transfer section C, which is in its lower position, ready to be fed to the lower heating chambers. Slabs G and H are shown in the upper preheating chamber of furnace units B and a slab I is about to be placed in the preheating chambers of furnace units A. This may be accomplished by any suitable slab handling mechanism, such as an overhead crane. During this time the conveying mechanism is being operated to move slabs D, E, G and H back and forth for a distance at least equal to the distance between the various furnace units. The purpose of this movement is so that the slabs will be evenly heated throughout their length and will not have cold spots at points in between the furnace units. While some heating does take place between the furnace units

due to the exhaust gases encircling the slabs at these points, the gases are not as hot as the interior of the heating chambers of the furnace units. Pinch rolls 46 and 47 are operated to feed slab F into the heating chambers below slab G while slab I is being placed in position in the preheating chambers of furnace units A.

While all six slabs are in their respective chambers of the furnace units as shown in Figure 7, the transfer duct C will be raised to its upper position. When the various furnace units are full the motors 29 driving the conveyor rolls will be operated in unision to move the slabs back and forth in the furnace units until slab D has reached the desired temperature. This is a relatively short time of a few minutes. In many cases the slabs will reach the desired temperature and be ready to be discharged by the time the transfer duct reaches its upper position. During the time that the transfer duct is being moved from one level to the other, however, it is desirable to move the slabs back and forth to insure even heating throughout their length. When slab D is up to temperature it will be moved to the left far enough to be received by pinch rolls 31. The pinch rolls will feed the slab to a rolling mill or other mechanism to perform work upon them. The same operation of the conveying rolls which moves slab D to pinch rolls 31 will move slab G into pinch rolls 46, 47 in the transfer mechanism C. These latter rolls will then move the slab G into the transfer duct, as shown in Figure 8 by the time slab F leaves the heating chamber of the furnace unit A on the right end of the line.

The transfer mechanism C will then be moved to its lower position of Figure 6 carrying the slab F with it. The parts are then in position to start the heating cycle on a new slab that is to be placed in furnace units A.

With the arrangement shown the slabs will be heated to approximately 800° F. by the time they leave the preheating chambers to pass into the transfer duct. During their passage through the lower heating chambers the slabs are raised to a temperature of 2250° F. for hot working. In order to obtain these temperatures a combustible mixture of gas and air is burned in the cups 16 of the burners to heat them to a temperature of 2700° F. The radiation from the cups assisted by the hot products of combustion will heat the entire lower chamber of each furnace unit to a temperature in the neighborhood of 2400° F. to 2500° F. Therefore each chamber comprises a radiant wall entirely surrounding that portion of the slab received thereby to heat the entire area of the slab evenly. This heating is, of course, assisted by the high temperature products of combustion that are moving through the high temperature chamber to the preheating chamber. The products of combustion exhaust through the entrance and exit openings of each chamber and form a blanket of protective gases through which the slabs move from one of the furnace units to the next. The slabs are therefore protected from oxidation during the time they are being heated.

As has been noted above, the time required for heating the slabs will vary with their dimensions and physical characteristics as well as the final temperature that is desired. In any event, the time required will be a matter of minutes rather than the hours that are required for heating slabs in the conventional type of furnaces. Any suitable control system may be used to insure that the temperature of the work will be at the desired value. One suggested system is a so-called interlock system in which the fuel supply is controlled in response to the work temperature and the furnace temperature is used as a high limit control. The details of such a control system form no part of the present invention so for that reason have not been illustrated. One form that the control system may take is disclosed in Hess et al. application Serial Number 761,602, filed July 17, 1947.

In the operation of the system slabs are moved in what is, in effect, a continuous line through the furnace units. During their travel they are raised one after another from ambient temperature to the temperature required for hot working, and are delivered directly to the hot working mechanism before they have a chance to cool or become covered with an objectionable scale. The arrangement is such that a minimum of space is required for the equipment. After the slabs are placed in the preheating chambers no further manual handling of them is required.

From the above description it will be seen that I have provided apparatus by means of which slabs, billets or other large pieces of metal may be rapidly heated one after another to a desired elevated temperature. The invention also discloses a novel method of heating and handling large pieces of metal.

While in accordance with the provisions of the statutes I have illustrated and described the best form of embodiment of my invention now known to me it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit and scope of the invention, as set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

What is claimed is:

1. In apparatus for heating slabs and the like, the combination of a plurality of furnace units each having a pair of vertically displaced chambers in open communication with each other, each of said chambers having axially aligned entrance and exit openings, means to mount said furnace units in axial alignment with each other, means located between each unit and on a level with said openings for forwarding slabs through one set of chambers in one direction and through the other set of chambers in the opposite direction, means in the lower chamber of each unit to heat slabs in said chambers, a transfer device having an elongated chamber therein to receive a slab, means to mount said transfer device for movement from a position in which its chamber is aligned with the upper set of said openings to receive slabs therefrom to a position in which it is aligned with the lower set of said openings to deliver slabs thereto, and means to feed slabs into and out of the chamber of said transfer device.

2. In apparatus for heating slabs and the like the combination of a row of individual and axially aligned furnace units, each furnace unit having a pair of vertically displaced and communicating chambers in which slabs are heated, conveying means for slabs in each chamber located between the furnace units, drive means for said conveying means operative to move slabs in one direction through the upper chambers and in the opposite direction through the lower chambers of said units and a transfer device located at the end of said row of furnace units toward which slabs are moved in said upper

chamber, said transfer device including means forming an elongated chamber in which a slab may be received, mechanism operative to shift said transfer device from a position in which it is aligned with one of the rows of chambers of said furnace units to a position in which it is aligned with the other row of chambers of the furnace units, and means carried by said transfer device to move slabs into and out of the chamber thereof.

3. The method of heating slabs and the like in a row of separate heating units each comprising a heating chamber and a preheating chamber located vertically above the heating chamber and in direct communication therewith which comprises the steps of moving the slabs one after the other in one direction through the preheating chambers, receiving the slabs from the preheating chambers, moving them downward to a position aligned with said heating chambers, moving the slabs in the opposite direction through said heating chambers, protecting the slabs from substantial loss of heat from the time they leave

said preheating chambers until they enter said heating chambers, heating the slabs in said heating chambers by radiant heat and hot products of combustion, and in said preheating chambers by hot products of combustion, and moving said slabs in each direction from points between said heating units.

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Pages 8 and 9 of Trinks' Industrial Furnaces, vol. I, third edition, copyright 1944. Published by John Wiley and Sons, New York, N. Y.