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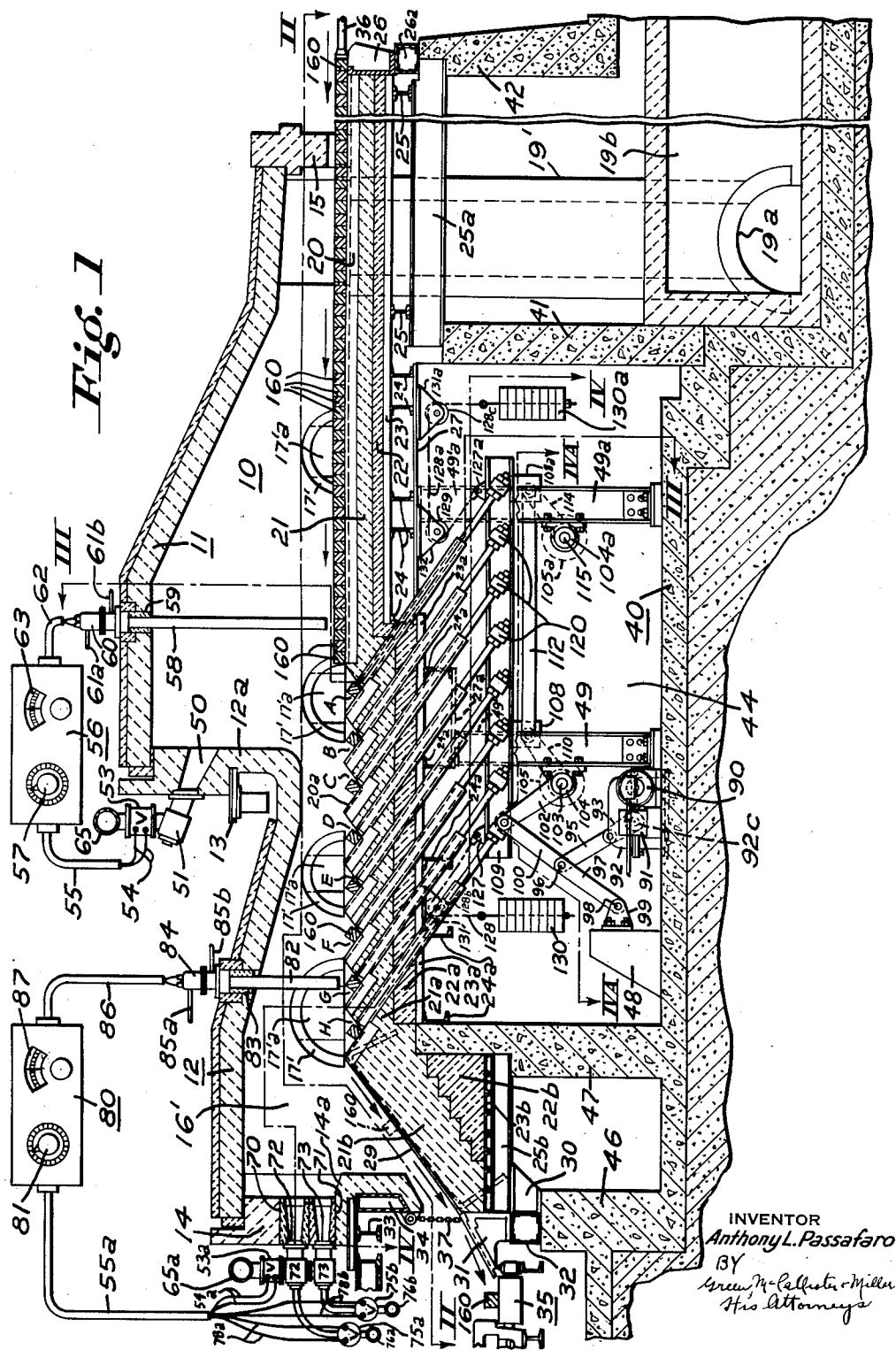
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BILLET HEATING FURNACE

Filed April 30, 1948

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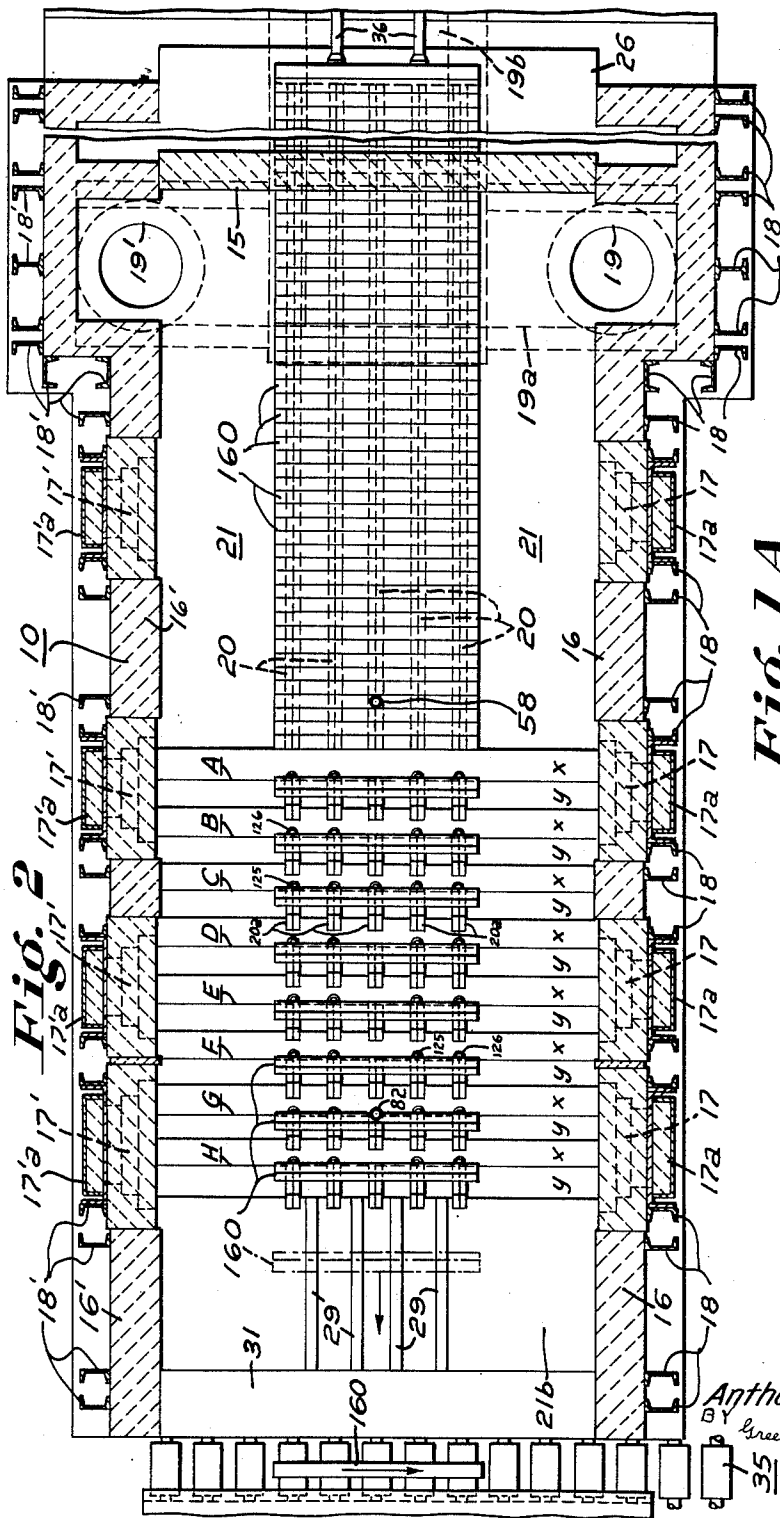
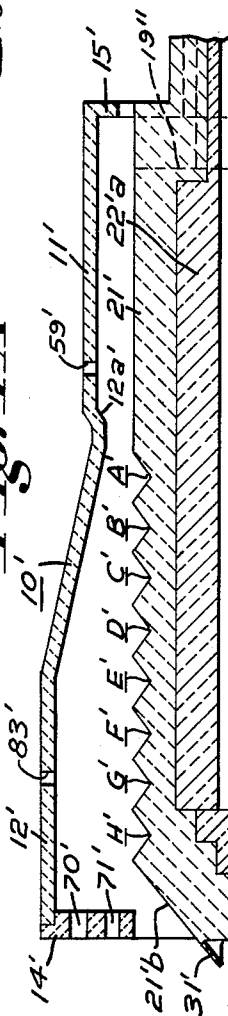


Fig. 1A



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Fig. 3

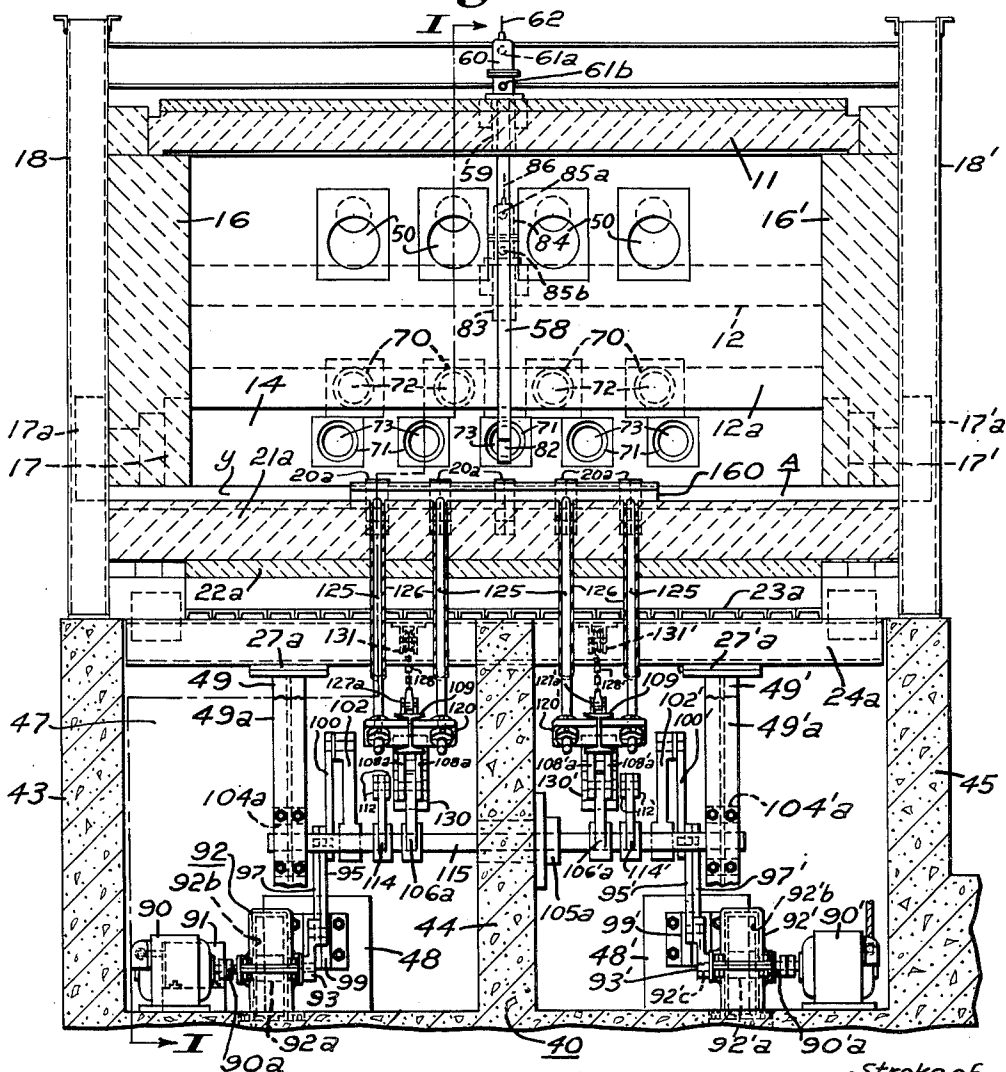
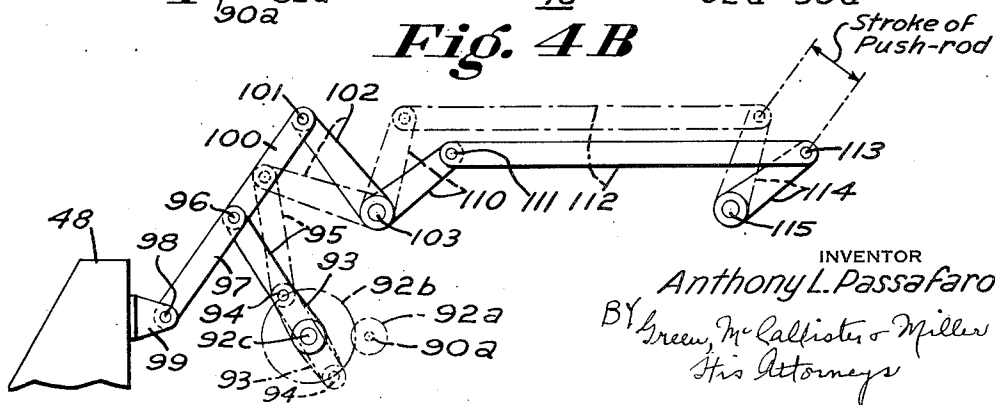


Fig. 4B



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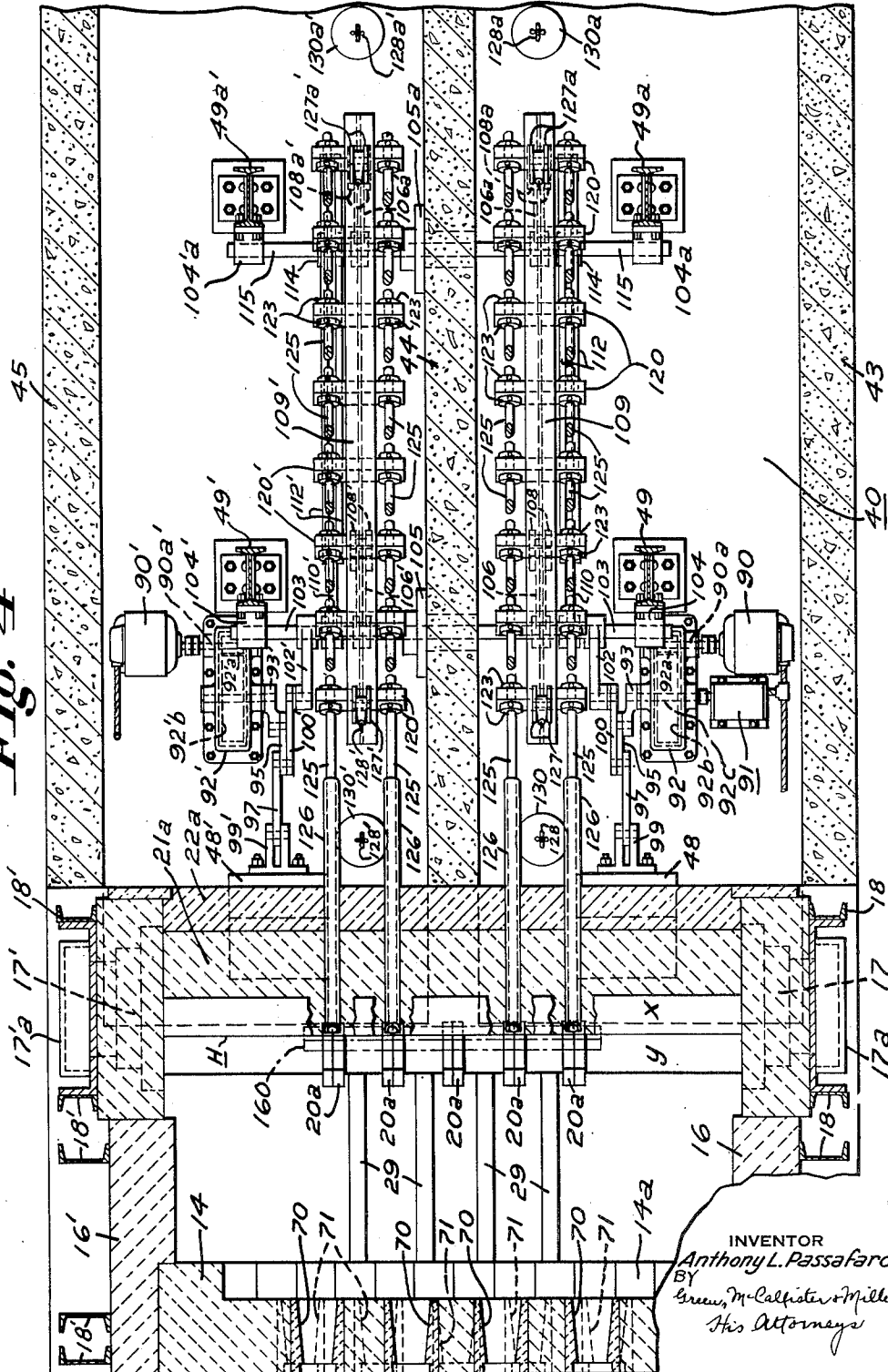
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Fig. 4



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Fig. 4A

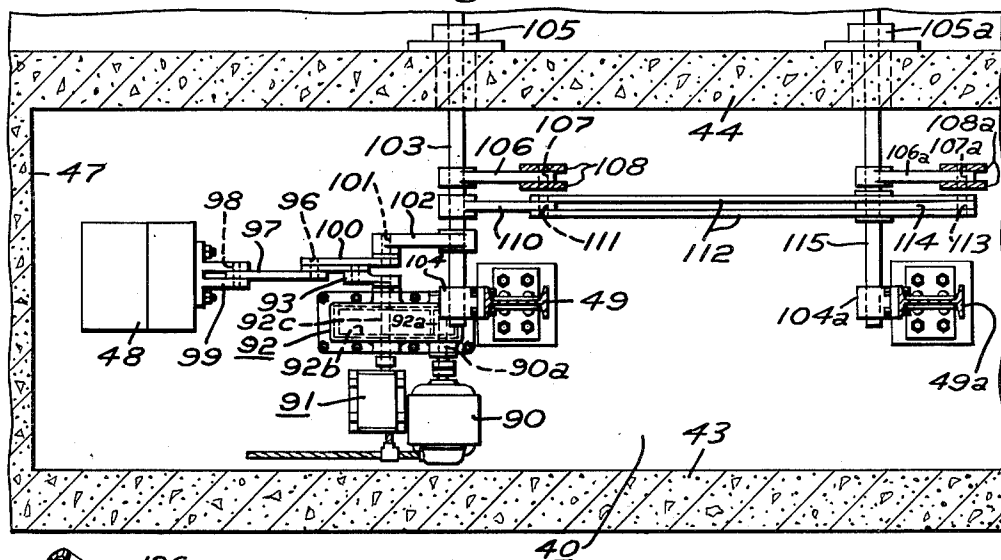


Fig. 5

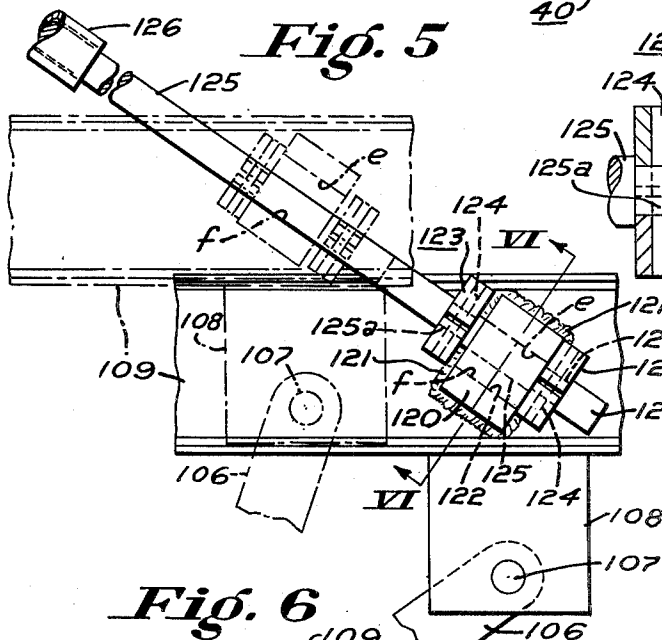
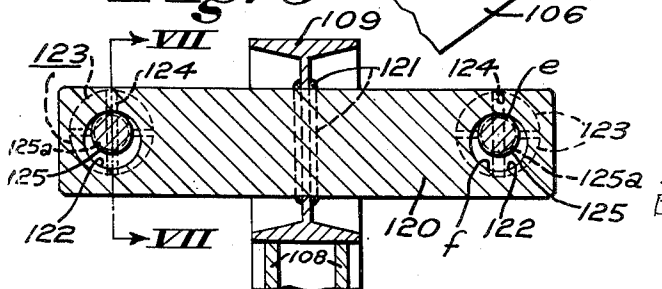


Fig. 6



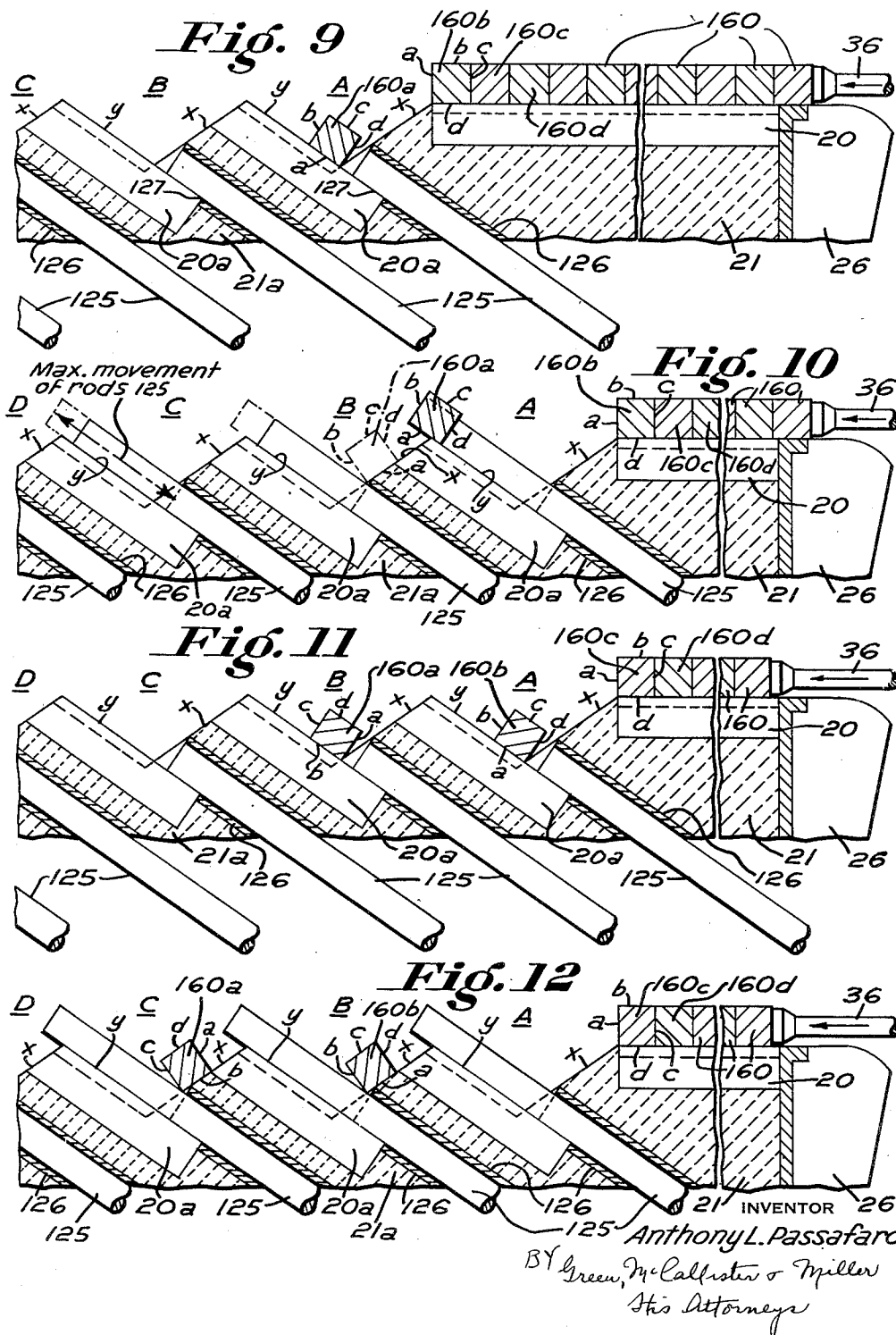
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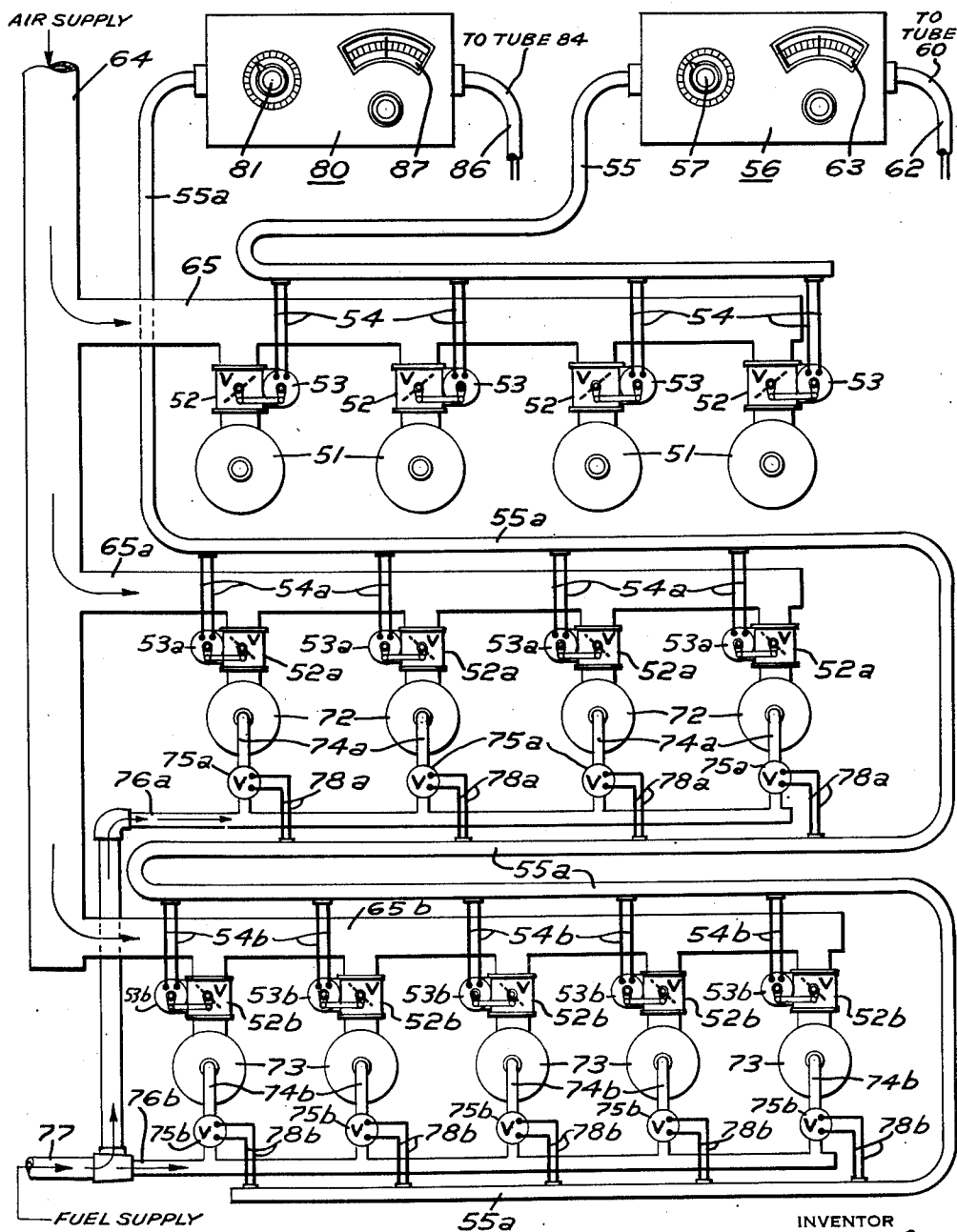
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Fig. 13



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Fig. 14

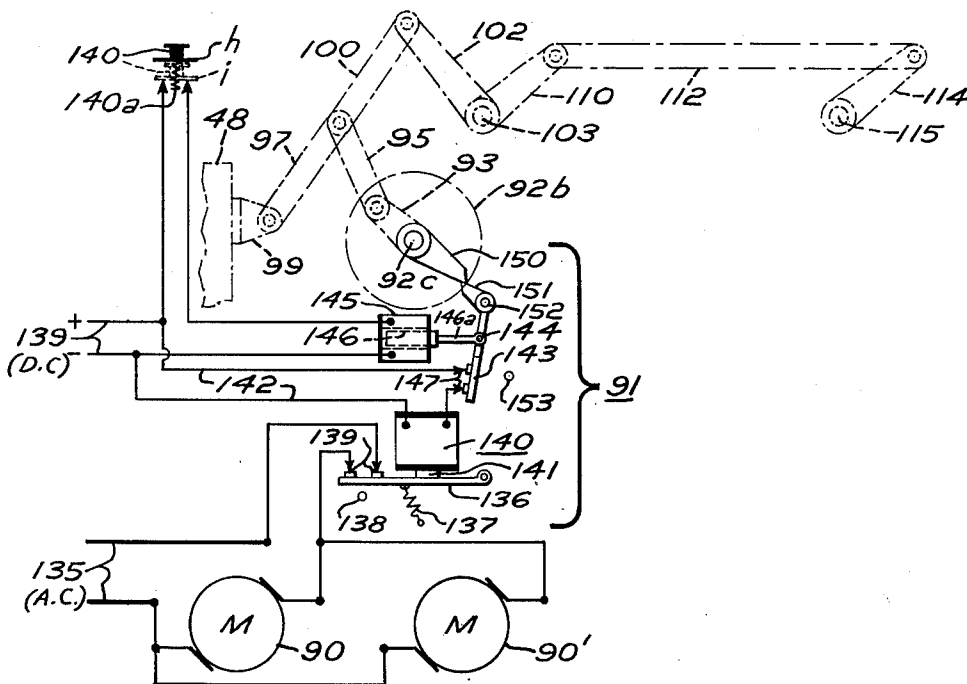
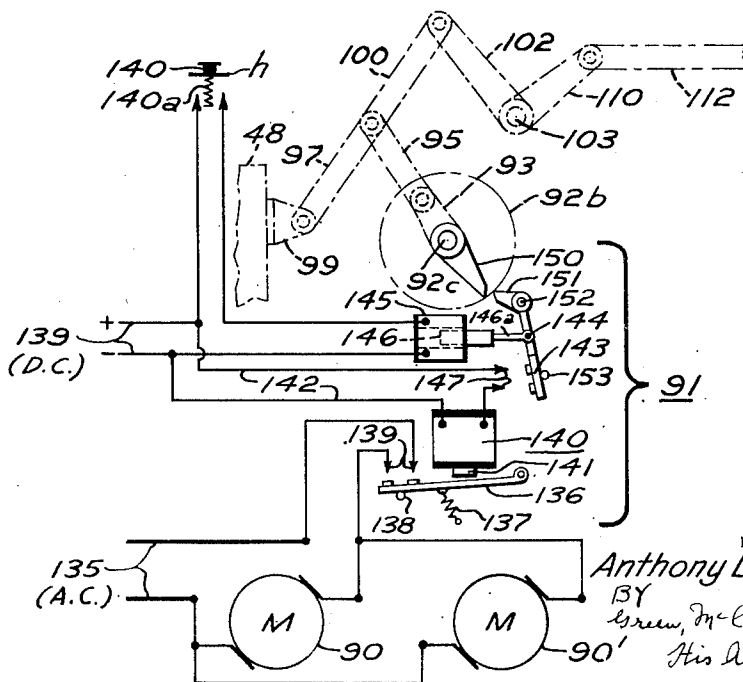


Fig. 15



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UNITED STATES PATENT OFFICE

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BILLET HEATING FURNACE

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Application April 30, 1948, Serial No. 24,187

7 Claims. (Cl. 263—6)

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This invention pertains to the heat treatment of metal shapes and to new and improved apparatus and procedure for effecting heat treatment of basic shapes of metal, and particularly, of steel and its alloys.

Heretofore, procedure employed for effecting heat treatment of metal shapes such as billets, e. g., prior to hot working, has involved many disadvantageous and limiting features. It is customary to move or advance billets of a suitable metal, such as stainless steel, for example, through a heat treatment furnace by pushing them transversely in a side-by-side, substantially abutting relationship into and along the furnace as a continuous layer in such a manner that successive billets are brought up to temperature and then treated.

In present furnace arrangements, the billets are permitted to reach a critical temperature in a preliminary heating-up zone. This is believed to be necessary due to the time required to provide them with a suitable treatment in a subsequent high temperature zone under conditions such that they are heated principally by heat transfer through their upper faces during their movement through such zone. A furnace used for this purpose ordinarily has a length of approximately 35 feet, and thus, houses a large number of billets that are being advanced therealong.

The billets are moved through by the application of a pusher arm to the last billet at the front or charging end of the furnace, and as a result, they tend to buckle-up, particularly in the annealing zone and adjacent the discharge or back end of the furnace. There is also a tendency for the adjacent billets to stick together when at a higher temperature, due to their highly heated condition. In addition, the billets have a tendency to stack-up like straws, and frequently fall endwise down the delivery chute at the back or discharge end of the furnace. When the billets buckle, stack-up, or get out of alignment, it is necessary to shut down the entire furnace and then take all of them out and recharge. Then difficulty is encountered in segregating them, where billet groups of different content are involved, in that their sequential order is lost.

In employing such procedure, it is apparent that the top portions or faces of the billets have the highest temperature, that their sides will have an intermediate temperature, and that their bottom faces will have a relatively lower temperature. This is one of the reasons why it is necessary to provide a furnace with a high temperature zone of great length or extent and why excessive

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scale is formed. Due to the uneven application of heat to the billets, it is apparent that the furnace must be maintained at a much higher temperature than the desired treatment temperature and that such billets, due to the uneven temperature gradient thereacross will have somewhat non-uniform properties. For example, if the inner section of the billet is given the proper heat treatment, the upper face of the billet may be burnt, while the under face of the billet may be under-treated.

The time element is also great in such a procedure and skilled man power is wasted. In the operation of such a furnace, it is customary to shut down at noon and then to advance dummy billets or frames through the furnace until all the billets have been removed therefrom. One of the reasons for this is that the billets in the preliminary heating zone reach an above-critical temperature and must be removed before the furnace is shut down to prevent damage to them.

As before intimated, it is frequently advisable to treat groups of billets having a particular alloying content. Under the customary procedure, when stacking up occurs, the furnace is shut down. Difficulty is then encountered in determining which billets belong to a particular alloy group. Then it becomes necessary to bore-test each billet to determine its content.

Another important limiting feature or disadvantageous feature rests upon the inability to properly control the temperature of the billets if it is desired, for example, to give a particular alloy group of billets a final, above normal treatment. It thus becomes necessary to cycle that particular group of billets through another furnace, greatly increasing time, labor, and other costs, and immobilizing such furnace for other work.

To determine the temperature of such a furnace, it is desirable to employ some suitable temperature indicating means. A Ray-O-Tube and other optical devices have to be placed within a few inches of the billet to work effectively. It is thus apparent that such devices may be damaged when the billets tend to pile up during their progression through the furnace.

It has thus been an object of my invention to provide new and improved procedure for heat treating metal shapes and particularly basic metal shapes, such as billets, bars, all of which will be hereinafter termed "billets."

Another object has been to provide new and improved procedure for handling billets during their heat treatment.

Another object has been to provide means and procedure for handling billets in a heat treatment furnace such that they may be more quickly and uniformly heated and their temperature may be more accurately and flexibly controlled.

A further object has been to provide new and improved apparatus for advancing the metal shapes through a heating furnace, and especially, a high temperature zone thereof.

A further object has been to provide a furnace arrangement having more definitely segregated heating-up (low) and heat-treatment (high) temperature zones, such that the temperature of the heating-up zone may be maintained at a value below the critical temperature of the billets, and that it will not be necessary to remove the billets from the heating-up zone when the furnace is shut down.

A further object has been to provide means for effecting a better and more efficient and effective heat treatment of billets, and more particularly, for turning them during their treatment to more quickly and to substantially uniformly bring them to and maintain them at a desired temperature or temperatures.

Although a basic object of my invention has been to eliminate the difficulties inherent in the present type of furnace treatments, various other objects will be apparent to those skilled in the art.

In the drawings:

Figure 1 is a longitudinal section through a furnace constructed in accordance with my invention, showing control apparatus somewhat diagrammatically; this view is taken along the line I—I of Figure 3;

Figure 1A is a view somewhat similar to Figure 1, but showing in outline a modified form of furnace that may be used in connection with my invention;

Figure 2 is a horizontal section taken along the line II—II of Figure 1;

Figure 3 is a vertical cross-section taken from the front of the furnace and along line III—III of Figure 1;

Figure 4 is a fragmental horizontal section taken along the line IV—IV of Figure 1 and illustrating apparatus employed in handling the billets;

Figure 4A is a horizontal sectional detail taken along the line IVA—IVA of Figure 1 and illustrating linkage employed in connection with the apparatus for handling the billets;

Figure 4B is a somewhat diagrammatic side detail of the linkage of Figure 4A;

Figure 5 is an enlarged side fragmental detail of a pusher rod and yoke assembly of billet handling apparatus;

Figure 6 is a cross-section taken along the line VI—VI of Figure 5;

Figure 7 is a still further enlarged fragmental sectional detail of a collar and pusher rod assembly, taken along the lines VII—VII of Figure 6;

Figure 8 is an enlarged fragmental detail taken along the line VIII—VIII of Figure 7;

Figures 9 to 12, inclusive, are enlarged, somewhat diagrammatic side sectional details showing progressive pusher-effected movements of billets through a furnace constructed in accordance with my invention;

Figure 13 is a somewhat diagrammatic view in elevation of a suitable fuel and air supply control system that may be used in connection with embodiments of my invention shown in Figure 1,

and by eliminating the separate air supply and control, may be used in connection with the embodiment of Figure 1A;

Figures 14 and 15 are somewhat diagrammatic views in elevation illustrating a limit switch arrangement that may be employed to control motor actuation of the exemplary billet handling apparatus of my invention; Figure 14 illustrates relative operative relationships when the motors are being energized; and, Figure 15 shows the relative relationships after the motors have completed a cycle of movement and while the billets are being heated at their respective positions.

Briefly summarized, I have provided a construction such that the billets may be brought up to a temperature below their critical temperature in a preliminary or heating-up zone within which they may rest at all times even when the furnace is being shut down. The billets are moved or advanced through a final or high temperature zone by means that may be actuated independently of the pusher means for advancing them through the first zone. That is, it is no longer necessary to advance dummy frames through the furnace to remove all the billets when it is being shut down. When the furnace is again heated-up or used, the billets in such preliminary zone can then be advanced into the second or critical temperature zone without, as heretofore, first removing dummies. The overall length of the furnace can now be decreased and the number of billets in the hotter portions of the furnace can be limited. The time required for bringing the billets up to their final treatment temperature and for treating them is minimized, and the billet heat treatment is effected uniformly and at a lower furnace temperature than heretofore possible. Scale has been reduced from 8% or more to less than 1%.

Any suitable type of radiation pyrometer, such as one that is sensitive to full scale heat radiation, can be now employed without danger of breakage. That is, pyrometers can now be mounted closely adjacent to the billets in such a manner as to obtain accurate readings of temperature without danger of damage to them. Thus, more accurate and sensitive heat-indicating equipment can now be employed with safety.

In the furnace embodiment of Figure 1, I have employed air for segregating the temperature zones, and in the embodiment of Figure 1A, I have effected segregation by furnace roof or ceiling design.

In accordance with my invention, the billets are individually handled in the high temperature zone, both from the standpoint of periodically subjecting their surface faces to maximum heat, and from the standpoint of their advance through such zone. One group of billets of a particular content may be fully treated and discharged before a second group is advanced into the high temperature zone. Thus, the time and the temperature of treatment for a second and consecutive group of different composition may be controlled or changed to give them a different treatment, as desired.

The billets in the high temperature zone may be turned over in about 70° steps by individual pusher means, as they advance step-by-step through such zone. Their movement through such zone is effected and coordinated in such a manner that there is no possibility of their piling or stacking up, sticking or getting out of alignment. The billets are always discharged trans-

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versely from the furnace with no possibility of difficulty arising from an endwise discharge.

More specifically speaking, in accordance with my invention, I have provided a preliminary zone within which the billets may be maintained at a temperature below their critical temperature and through which they are advanced in the usual manner by moving them on a substantially horizontal plane in transverse contact with each other by means of a pusher mechanism at the feed-in end of the furnace. That is, the billets may be advanced through this zone by sliding movement imparted through their adjacent faces. Although I also contemplate the same method of advancing as illustrated for the higher temperature zone, I find that it is not necessary, particularly because of the lower temperature of the billets, and due to the fact that they need not be heated above their critical temperature. They now have little if any tendency to stack or pile up in the preliminary zone, as the pusher means now only needs to provide sufficient force to move the billets through it. The efficiency of the heat treatment in the high temperature zone decreases the needed overall length of the furnace, and thus, it is possible to further reduce the number of billets which are pushed in the ordinary manner by contact with each other through the low temperature zone.

In the high temperature zone, I provide a number of offset or serrated portions or steps therealong and each of these offset portions is provided with pusher means for advancing the billets therefrom and for simultaneously turning them. Each pusher means for each step is preferably operatively connected with the means for the other steps in such a manner that the movement of each billet is coordinated with the movement of the other billets in the zone.

It will be apparent to those skilled in the art that any number of high temperature zones may be employed, although for the purpose of simplified illustration, I have shown a single high temperature zone. The linkage employed in actuating the pusher means for each billet, as shown, is preferably constructed in such a manner that there is a speed-up or acceleration during intermediate portions of its stroke cycle. Figures 9 to 12 of the drawings somewhat diagrammatically indicate how the individual billets are advanced and their exposed faces progressively turned over during such movement. It will also be noted that a minimum of two faces are exposed to the direct atmosphere of the furnace by reason of the construction of the steps. This may be contrasted with the billets in the soaking or preliminary treatment zone which have only one major face exposed. The latter type of exposure is typical of the presently known type of high temperature treatment.

As shown in Figure 9, a billet 160a, after it has been pushed upon a leading inclined surface or face *x* of a step A, falls and slides down that surface, so that it turns over at least 30°. Then, as it is pushed upwardly along a second or backwardly inclined surface *y* of the serration or step A, see Figure 10, pivots about its edge, slides down the surface *x* of the next step B, and turns to the position shown in Figure 11 with a turn-over of at least 30°. The total turn-over from step A to step B is about 90°. It will be seen that approximately 30° of this turn-over is effected in each instance when the billet rights itself within the bottom of two serrations or steps. That is, the momentum of the slide of the

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billet may cause it to move an additional 15°, in each instance, but in any event, such additional movement is definitely effected when pusher means contacts its lower surface to advance it up the surface *y*.

Referring again to Figure 9, and to surface faces *a*, *b*, *c*, and *d*, it will be seen that the previously exposed surface *b* is still exposed when the billet 160a has slid down into the bottom of the first step A, while the previously hidden surface *c* is now exposed, and a portion of either of the surfaces *a* or *d* will be exposed (ordinarily the surface *d*).

As the billet 160a, see Figure 11, completes its movement into the bottom of the second step B, the face *c* takes the former position of the face *b* of the first step A, while the surface *d* now becomes fully exposed, and either of the surfaces *a* or *b* becomes partially exposed. When this same billet 160a reaches the third step C, see Figure 12, the face *d* takes the former position of the face *c* of the second step B, while the face *a* takes the former position of the surface *d*, etc. In this manner the billet is progressively turned or rotated and makes a substantially complete rotation in four steps A to D. Ordinarily, about eight steps or two revolutions are sufficient, see Figure 1 of the drawings. Subsequent billets, such as 160b, 160c, and 160d are advanced consecutively in the same manner.

Referring particularly to Figures 1, 3, and 4, I have shown a furnace 10 employing my invention which is provided with a backwardly and upwardly extending furnace front roof portion 11. The roof portion 11 is connected with a vertically extending front wall part 12a of a backwardly sloped roof portion 12 to provide a complete top enclosure for the furnace. The roof construction may be supported and insulated in any suitable or conventional manner. In Figure 1, I have shown a transversely extending structural support 13 for the part 12a of the roof portion 12.

A refractory back wall portion 14 is provided with a pair of vertically-offset series of openings 70 and 71 for receiving fuel jets or nozzles 72 and 73 which will hereinafter be described. It will also be noted that vertical wall part 12a is provided with a series of openings 50 for receiving air jets or nozzles 51 which will also be later described. The front end of the roof portion 11 is closed off by a front wall portion 15 that has a transverse opening of sufficient size to permit the admission of billets 160 into the furnace.

As shown particularly in Figures 2 and 3, I also provide suitable refractory, opposite side wall portions 16 and 16' having, as shown in Figure 2, inspection windows 17 and 17' provided with inspection doors 17a and 17'a, respectively, on opposite sides thereof. Vertically-extending channels 18 position and support the side wall portions of the furnace construction.

Referring particularly to Figures 1 and 2, the front or feed end of the furnace 10 is provided with a pair of vertically-extending flues 19 and 19' on opposite sides thereof that are, as shown particularly in Figure 2, open to the furnace at their upper ends and at their lower ends are connected to a common transverse flue 19a, see also Figure 1. The flue 19a is connected to a longitudinally-extending flue 19b which leads to a stack for exhausting spent furnace gases.

Referring particularly to Figure 1, the furnace 10 is provided with a longitudinal floor or hearth made up of transversely-spaced-apart and longi-

itudinally extending Carbofrax or other suitable, billet-bearing refractory inserts or rails 20 of requisite strength, see also Figure 2. The refractory rails 20 serve as support guides for the progression of transversely-positioned billets, generally designated as 160, during their abutting or side-by-side movement along a preliminary or heating-up zone of the furnace. The refractory guides or rails 20 are positioned in longitudinal slots cut in a refractory support bed portion 21, and preferably, extend vertically-upwardly, slightly beyond a horizontal plane representing the upper longitudinally-extending surface of the refractory support bed. The refractory bed portion 21, made up of fire brick or other suitable material, is supported on a longitudinally-extending refractory hearth portion 22. The hearth portion 22 is supported by a channel floor 23, whose channels extend longitudinally of the furnace. The channel floor 23 is positioned on suitable, transversely-extending channels 24 and I-beams 25. As shown in Figure 3, the beams 25, channels 24, 24a, etc., may be supported at their opposite ends on foundation walls 43 and 45, and extend through an intermediate wall 44. The front end of the furnace floor or hearth construction is shown held in position by a transversely-extending face member 26 which is mounted on a box-like structural member 26a, see Figure 1. The concrete foundation is indicated generally as 40. The I-beams 25 are also supported on longitudinally-extending, short-length beams 25a that are supported on upwardly-extending transverse wall portions 41 and 42 of the foundation 40. The bottom flanges of the transversely-extending support channels 24 are secured to a pulley-mounting support plate 27.

Somewhat corresponding portions of the bed construction in the high temperatures and delivery zones of the furnace 10 have been given the same numbers with alphabetical suffixes. That is, in connection with the high temperature zone, I have shown vertically-backwardly-inclined refractory inserts 20a for the steps or stations A, B, C, etc., a suitably serrated or stepped refractory bed portion 21a, and a refractory hearth portion 22a which are supported on a channel floor 23a, see Figures 1 and 3. The inserts 20a are mounted within grooves or slots in the surface *y* of each step, see Figure 9. The channel floor 23a is mounted on transversely-extending, longitudinally-spaced-apart support channels 24a and these are supported, as shown particularly in Figure 3, on the longitudinally-vertically-extending, transversely-spaced-apart wall portions 43, 44, and 45 of the concrete foundation 40. A front pair of the channels 24a carry bearing plates 27a and 27'a for upper ends of I-beam columns 49 and 49' which, as hereinafter explained, support a pusher rod actuating mechanism. In a like manner, columns 49a and 49' are attached at their upper ends to the bearing plates 27 and 27'; these columns provide a pair of front supports and the pair of columns 49 and 49' provide a pair of back supports for a pusher rod actuating frame. The lower ends of the columns are secured to the foundation 40.

In the delivery zone of the furnace, see particularly Figure 1, the refractory bed portion 21b supports U-shaped metal guides 29 that are positioned to guide the billets 160 down an outwardly-declining, sloped surface of the bed portion 21b at the delivery end of the furnace. The bed portion 21b is supported on a stepped hearth

portion 22b, both of which are supported at one end on a transversely and upwardly-vertically-extending wall portion 47 of the concrete foundation 40 and by a channel floor 23b. The channel floor 23b is supported on short-length, longitudinally-extending beams 25b, that are, at one of their ends, mounted on a bearing step of the upwardly-extending wall portion 47, and are, at their other ends, mounted on a transversely-extending abutment member 30.

An outwardly-declining metal delivery chute or skid member 31 supports the front end of the bed 21b and is mounted on a transversely-extending, box-like structural member 32. Both the box-like member 32 and the abutment member 30 are positioned on a transversely-extending back wall portion 46 of the concrete foundation 40. The billets 160 are delivered from the delivery member 31 to a conventional form of an endwise-delivery type of roll conveyor 35. The conveyor 35 may be employed to deliver the billets in endwise succession in the usual manner to a hot mill, for example.

As shown in Figure 1, the back wall portion 14 of the furnace is provided with a U-shaped portion 14a at its lower end which is supported on structural members 33 and which carries a transversely-extending cooling box 34. The structural members 33 may also carry a suitable catwalk. A chain screen or metal curtain 37 is shown extending downwardly from the cooling box 34 and in close adjacency to the skid member 31, in such a manner as to prevent an excessive loss of heat at the delivery end of the furnace.

I have somewhat diagrammatically indicated conventional horizontal pushers 36, see the right-hand end of Figures 1 and 2, that may be employed to advance the billets 160 progressively along the relatively flat or planar surface of the preliminary treatment zone of the furnace. The pushers 36 may be actuated hydraulically or mechanically in the usual manner. The billets, when advanced by the pushers 36, move or slide along rails 20 from the front towards the back or delivery end of the furnace, or more specifically, along substantially the full extent of the heating-up zone of the furnace 10. The first billet in the progression (the most advanced one) is pushed into the first station or step A of the heat treatment zone, see Figure 9. The billets are then advanced consecutively along the progression of stations A to H of the heat treatment zone and are then moved in succession upon the inclined rails 29 of the delivery zone. At the delivery zone, they slide down the rail track provided by the U-shaped members 29 and the chute member 31 and fall transversely upon the rollers of the conveyor 35.

Referring particularly to Figures 1, 3, 4, and 13, I will now describe suitable means for controlling the temperature with the furnace 10. I have shown, see particularly Figures 1 and 3, an aligned series of openings 50 within the vertical furnace wall part 12a which diverge and incline inwardly therethrough. A series of cooling fluid nozzles 51 are positioned to feed a suitable fluid, such as air, into the preliminary heating-up zone of the furnace and to direct such flow towards the billet-introducing end thereof. The cooling fluid flow serves to keep the preliminary or heating-up zone at a suitable temperature which is preferably below the critical temperature of the billets 160 that are in an adjacent side-by-side-abutting relationship. That is, the flow of cooling air is so controlled as to maintain the bil-

lets which are being moved along the refractory runners or guides 20 at a gradually increasing temperature as they approach the treatment zone or the steps thereof, such as A, B, etc. It will be noted in this embodiment that step or station A is positioned ahead of the converging front end of the furnace top wall or roof portion 12, in order that the billets as they are fed from the refractory runners 20, can then be gradually brought from a preliminary heat up through a critical temperature to a desired final treating temperature. Each of the stations A, B, C, etc., is provided with advancing and retracting pusher means for turning each of the billets in such a manner that they have a substantially uniform heat throughout their cross-sectional areas. A uniform heat is particularly important from the time the billets reach their critical temperature and while they are being treated at or above their critical temperature.

Each of the cooling nozzles 51 may, as shown in Figure 13, be provided with a butterfly valve 52 operated in any conventional manner through a lever mechanism by, for example, the amount of electric current energy imparted to a solenoid motor 53. An electrical cable 55 is connected at one end to a control device or box 56, and at its other end is connected in parallel with individual leads 54 of the motors 53. The control box 56 is shown provided with a rheostat control and switch knob 57 for controlling the amount of current supplied to the motors 53, and thus, for controlling the positions of the valves 52 and the amount of cooling fluid flow through the nozzles 51.

A suitable pyrometer tube, such as a Ray-O-Tube 58 is shown extending downwardly through a mounting 59 in the top furnace wall portion 11 into close adjacency with a billet in the preliminary or heating-up zone. The tube 58 may be cooled in a conventional manner by cooling water circulation through inlet 61a and outlet 61b of its housing 60. An electrical cable connection 62 extends from the housing 60 of the tube and connects to the panel 56, and particularly, to a visual temperature-reading dial 63 thereof. It will thus be seen that the operator can control the flow of cooling fluid into the preliminary portion of the furnace 10 by adjusting the control knob 57 in accordance with the temperature reading of the dial 63. In this manner, all of the billets within the heating-up zone may be maintained at a temperature below their critical temperature. Air is supplied to the cooling fluid nozzles 51 by a supply line 64 and a branch supply line 65, see particularly Figure 13.

I will next describe suitable means for heating the furnace 10 to its desired temperature, and in this connection, particular reference is made to Figures 1, 3, and 13.

The back wall portion 14 of the furnace is provided with an upper series of openings 70 and a lower series of openings 71 within which are mounted fuel nozzles 72 and 73, respectively. Each of the nozzles 72 is provided with an air intake having a suitable valve, such as a butterfly valve assembly 52a, which is connected between a branch air supply line 65a and the nozzle. The valves 52a may be operated through a suitable lever system by individual solenoid motors 53a that are connected in parallel by leads 54a to a common electrical cable 55a.

In like manner, the other set of nozzles 73 are provided with air control valves 52b, solenoid motors 53b, and are connected through individual leads 54b in parallel to the cable 55a.

The cable 55a at its other end leads to a control panel 80 provided with a rheostat control and switch knob 81. The intensity of the flame may thus be adjusted by adjusting electrical current flow to motors 53a and 53b to vary the positions of valves 52a and 52b.

The set of burners 72 are also provided with fluid supply inlets 74a which are connected through electromagnetic, solenoid-operated valves 75a to a branch fuel supply line 76a, and thence, to a main fuel supply line 77. Each of the magnetically-controlled valves 75a has individual electric connections 78a which are connected in parallel with the main cable 55a. In like manner, the second or lower series of burners 73 are provided with fuel inlets 74b, magnetically-controlled valves 75b, and are connected through such valves to a branch line 76b, and thus, to the main fuel supply line 77. In this arrangement, the control motors 53a and 53b for the air supply of the valves 72 and 73 are set in a suitable relationship with the fuel supply, magnetic control valves 75a and 75b, in such a manner that an adjustment of the rheostat 81 will simultaneously adjust the flow of air and fuel to each of the fuel nozzles 72 and 73, in accordance with the desired intensity of flame.

Means is provided, as shown, for indicating the temperature of the billets in the heat treatment zone which may consist of a Ray-O-Tube 82 positioned in the back roof portion 12 of the furnace by a mounting 83. The housing 84 of the tube is provided with cooling fluid inlets and outlets 85a and 85b, and an electric cable 86 extends therefrom. The cable 86 is connected to a temperature indicating dial 87 of the control panel 80. It will thus be seen that the rheostat knob 81 may be adjusted in accordance with the temperature reading of the dial 87 to provide any desired intensity of heat within the furnace by simultaneously adjusting the control of flow of fuel and air to the nozzles 72 and 73. The specific mechanism used in connection with the temperature control of the furnace is merely illustrative and it will be apparent that any suitable conventional arrangement may be employed, and if desired, that one set of fuel supply nozzles 72, for example, may be independently controlled from the other set 73, in order that one set may be completely extinguished when a much lower temperature is required.

In the modified furnace construction shown in Figure 1A, I have employed prime suffixes to indicate parts that are similar to those of the previously described embodiment. In this arrangement, I eliminate the cooling air nozzles 50 of the embodiment of Figure 1 by suitably shaping the roof portion 11'-12' of the furnace. That is, the part 11' of this roof extends in a substantially parallel plane, relatively close to the billets. The openings 70' and 71' for the fuel nozzles are mounted on the back wall portion 14' and can be operated at a lower flame intensity, such that a saving of fuel is effected. The nozzle-like flow of the spent gases between the bed portion 21' and the roof portion 11' provides the requisite cooling action to insure a lower temperature within the preliminary or heating-up zone.

I will next describe the apparatus or mechanism for moving and turning the billets 160 within the heat treatment zone. In this connection particular reference is made to Figures 1, 2, 3, 4, 4A, 5 to 12, and 14 to 15. It will be noted that the actuating mechanism is duplicated on

opposite sides of the furnace 10, and for this reason, I have employed prime suffixes to indicate one side and avoid unnecessary repetition of description. It will also be noted that although each side of the mechanism is actuated by individual motors 90 and 90' that such sides have common linkage or connecting crank shafts which also insure their operation in synchronism. The motors 90 and 90' are provided as shown in Figures 14 and 15 with a limit switch mechanism 91 operably coupled to crank shaft 92c, such that they are manually started simultaneously, and are stopped automatically and simultaneously after a complete cycle of pusher movement (advancement and retraction) has been accomplished.

The motor 90 is shown mounted on the concrete foundation 40 and is provided with a limit switch generally indicated as 91. The shaft 90a of the motor 90 is provided with a pinion gear 92a which meshes with and drives a speed reducing gear wheel 92b of a speed reducing unit 92. The unit 92 is also mounted on the foundation 40. The speed reducing gear 92b is secured to a crank shaft 92c to which is attached a crank 93 that is pivotally connected at 94 to an actuating link 95. The actuating link 95 is at its other end pivotally connected at 96 to a fulcrum lever 97. The lever 97 is at one end fulcrumed on a mount 99 that is secured to an abutment portion 48 of the foundation 40.

At its other end, the fulcrum lever 97, in addition to being pivotally connected to the link 95, is also pivotally connected to a connecting link 100 by the pivot pin 96. A second crank arm 102 is at one end pivotally connected by pivot pin 101 to the other end of the link 100, and at its other end, is operably secured on a cross or crank shaft 103. The cross or crank shaft 103 extends through a mounting 105 in the central wall portion 44 of the foundation and is at its other end secured to a corresponding crank 102' of the part of the mechanism on the opposite side of the furnace. As shown particularly in Figure 4, the shaft 103 is journaled at its opposite ends within mounting brackets 104 and 104'. The brackets 104 and 104', as shown particularly in Figures 1 and 4, are secured to flanges of vertical upright I-beam column members 49 and 49' on opposite sides of the furnace.

The shaft 103, as shown particularly in Figure 4A, is also provided with a crank arm 110 secured at one end thereon and extending therefrom to actuate a pair of cross arms 112 which are operably connected to the extending end of the crank arm 110 by pivot pin 111. The other ends of the cross arms 112 are pivotally connected by pins 113 to one end of a front crank arm 114. The crank arm 114 is secured on a front, cross or crank shaft 115. The front cross-shaft 115, in a manner similar to the back cross-shaft 103, extends through a mounting 105a in the central vertical wall portion 44 of the foundation, and is journaled at its opposite ends within bearing mounts 104a and 104'a that are secured to flanges of the front set of vertical upright members 49a and 49'a, respectively.

The back cross-shaft 103, see Figures 1, 4, and 4A, also carries a pusher-frame-actuating crank 106 that is secured thereon at one end and at its other end is operably connected by a pivot pin 107 to a bifurcated mounting lug 108 that projects downwardly from a beam 109 of the frame. The pusher frame is made up of a pair of longitudinally extending I-beams 109 and 109' that are

located on opposite sides of the central wall 44 of the foundation, see particularly Figures 1, 4, 4A, 5 and 6. As will be noted, the beam 109 that is located on one side of the furnace 10 is provided with a downwardly-projecting lug mounting 108 adjacent a back end thereof and a similar bifurcated lug 108a adjacent the front end thereof. In the same manner, the other beam 109' is provided with spaced lugs 108' and 108'a.

The front cross or crank shaft 115 is provided with a pusher frame actuating crank 106a which is operably connected at its extending end by a pivot pin 107a to the front lug 108a of the beam 109. It will thus be apparent that both ends of the beams 109 and 109', forming the pusher frame structure for actuating the pusher arms, are simultaneously actuated through the agency of connecting linkage 110, 111, 112, 113, and 114 and on one side of the furnace and by similar linkage 110' to 114' on the other side of the furnace.

Referring particularly to Figures 3 and 5 to 8, inclusive, it will be noted that the beam 109 is provided with a series of cross-head members 120 that extend horizontally through its web portion and are secured thereto by suitable weld material 121. As shown particularly in Figure 4, the cross-heads 120 are located at longitudinally spaced-apart positions along the extent of the beam 109 and correspond in number to the number of stations A, B, etc., at which pusher actuation is to be effected upon the billet.

The cross-head members 120 are provided at their opposite sides with enlarged bore portions 122 each of which is constructed and arranged to receive a lower end portion of a pusher rod shaft 125. The shaft 125 is provided at its other end with a mounting sleeve 126 that extends upwardly with a backward slope through the support channels 24a, the flooring 23a, the hearth 22a, and the refractory bed 21a into the bottom of an advanced surface portion x of each station or step within the heat treatment zone of the furnace. The tubes or sleeves 126 may be suitably cemented within the refractory portions of the furnace and are preferably welded to the furnace hearth metal support structure, such as the channels 24a and the channel floor 23a. It will be noted that the upper end of each tube or sleeve 126 is notched on one side at 127, see Figure 9, to permit the insertion of the refractory or Carbofrax inserts 20a.

As shown particularly in Figures 5 to 8, inclusive, the pusher rod shaft 125 is, at its lower end, provided with spaced-apart, reduced portions 125a, each of which is adapted to receive a mounting collar 123 thereon. As shown particularly in Figure 8, the collar 123 is of two-part or slit construction and its bore is locked in position on the reduced portion 125a by pins 124. As shown particularly in Figure 7, the collars 123 are so mounted with respect to each other that a spacing g is left between the front and rear ends of the cross head 120 to provide sufficient play along with the play between the opposite bore walls e and f of the collar 123 to permit a slight pivot movement of the I-beam frame members 109 and 109' when they are advanced from their initial position shown in the full lines of Figure 5 to their advanced position, shown by dot and dash lines of the same figure. In this connection, it will be noted that one side of the cross-head 120 abuts the lower collar 123 when the frame is pulling the rods 125 downwardly and that the opposite side of the cross-head 120 abuts the upper collar 123 when the frame is

moving the rods upwardly to the dot and dash line position of Figure 5.

The pusher rod actuating frame structure provided by the beams 109 and 109' is, as shown in Figures 1, 3 and 4, provided with a pair of counter-weights adjacent its front and rear ends. Each beam 109 and 109' has a counterweight adjacent its front and rear ends. Referring to the beam 109, it is provided with a pair of upwardly-extending bifurcated lugs 127 and 127a. A counterweight chain or cable 128 is secured at one end to the back lug 127 of the beam 109, is carried by a pulley wheel 128b, and is secured at its other end to a counterweight 130. A bifurcated pulley mount 131 is secured to and extends downwardly from the channel floor 23a and rotatably carries the pulley 128b. A similar counterweight system 127', 130', 128'b and 131' is provided for the back end of the other beam 109'.

A second chain or cable 128a is secured at one end to the front lug 127a of beam 109, is carried by pulley wheels 128c and 129, and is secured at its other end to a counterweight 130a. A pair of longitudinally spaced-apart bifurcated pulley mounts 131a and 132 are secured to and extend downwardly from the plate 27 and rotatably carry the pulleys 128c and 129, respectively. The same counterweight arrangement is employed for the front end of the other side beam 109' and its corresponding parts are indicated by prime suffixes.

A suitable exemplary time limit switch arrangement 91 for the actuating motors 90 and 90' is shown in Figures 14 and 15. The motors 90 and 90' are connected to alternating current supply lines 135 in parallel with each other through a magnetic switch 140. The switch 140 is provided with a pivoted contact arm 136 that is normally urged against a stop 138 by a spring 137; contacts 139 are closed when current flows through the switch coil to energize its electro-magnet pole piece 141. The coil of the switch 140 is energized by a source of direct current 139 through lines 142 and a conductive portion of a switch arm 143 that is pivoted at 152. The switch arm 143 may be manually closed by a push button 140 and when closed, as indicated by the dotted position *i* of Figure 14, its coil 145 is energized to draw its electro-magnet core 146 inwardly. The connecting rod 146a that is pivotally connected to the switch arm 143 at 144 then pulls the arm 143 into contact with points 147. Thus, the coil of the switch 140 is close the contacts 139 and energize the motors 90 and 90'. The push button 140 is released after such contact is made, and is returned to position *h* by spring 140a. When the switch 140 is energized to close the A. C. current supply to the motors 90 and 90', speed reduction gear 92b makes one revolution.

After the speed reducing gear 92b of the speed reducing unit 92 has made its complete revolution, a trip arm 150 which is secured to crank shaft 92c, engages a dog 151. The dog 151 is an integral part of a switch-opening arm 143 that is pivoted at 152. Thus, the trip arm 150, after one complete revolution, will move the dog 151 and the arm 143 about the pivot point 152 and open the contacts 147 to the limit of the stop 153. This causes switch 140 to open and the motors 90 and 90' to stop, as shown in Figure 15.

From the above description of exemplary apparatus, it will appear that an actuation of the

motors in turn actuates and raises and then lowers the pusher rod frame 109 and 109' to reciprocate the pusher rods 125 within their sleeves 126. And, as shown particularly in Figures 9 to 12, the billets 160 are slid or pushed up the back surfaces *y* of each station A, B, C, etc. during the first half of the cycle of movement of the mechanism. In the second or final half cycle, the rods 125 are withdrawn to their original position shown in Figure 9, and the limit switch mechanism 91 is automatically operated to stop the motors. A study of the toggle joint or lever mechanism, see particularly Figure 4B, will disclose that there is a definite intermediate-position acceleration of movement of the pusher rods 125 with deceleration at each end of the reciprocating movement.

As shown in Figures 1, and 9 to 12, the pusher rods 125 slope or incline upwardly and backwardly of the furnace hearth and extend through surfaces *x* to slide substantially parallel to surfaces *y* of each station or step. That is, the pusher rods 125 are normally below a longitudinal plane of the hearth, see Figure 9, and project above such plane when they are fully advanced, see Figure 10.

Although I have for the purpose of illustrating my invention shown in some detail suitable apparatus for controlling the temperature of various zones of the furnace, it will be apparent that any conventional means may be employed and that optical pyrometers can be employed without danger of breakage due to the fact that buckling and piling up of the billets along the bed of the furnace is now eliminated.

What I claim is:

1. In a heat treatment furnace for metal billets of rectilinear shape, wherein the furnace has enclosing walls defining a longitudinally-extending and transversely-unobstructed heating chamber, means for heating the atmosphere of the chamber, and a bottom refractory hearth longitudinally along the chamber on which the billets are to be moved: the combination of a longitudinal series of billet-heating stations defined by the hearth transversely thereof, at least a pair of pushers operatively positioned in a transversely spaced-apart relationship along each station of said series within the hearth to engage a billet adjacent its opposite end portions and raise it out of each station and advance it to a succeeding station of said series, said pushers being slidably positioned for reciprocation in an inclined vertical plane within each said station, an operating frame structure positioned beneath the hearth to extend longitudinally therealong, said pushers being mechanically connected to said frame structure, and raising and lowering mechanism operatively connected to said frame structure to reciprocate said pushers in synchronism.

2. In a heat treatment furnace for metal billets of rectilinear shape, wherein the furnace has enclosing walls defining a longitudinally-extending and transversely-unobstructed heating chamber, means for heating the atmosphere of the chamber, and a bottom refractory hearth longitudinally along the chamber on which the billets are to be moved: the combination of a successive series of transversely-extending billet-receiving stations in longitudinal progression along the hearth and defined thereby, each of said stations having a rearwardly-positioned forwardly-descending surface and a forwardly-positioned and forwardly-ascending surface defining a valley with respect to each other, the forwardly-posi-

tioned and ascending-surface of one station defining an apex with the rearwardly-positioned forwardly-descending surface of a succeeding station, each of said rearwardly-positioned forwardly-descending surfaces having a sufficient inclination to cause a billet to slide by gravity therealong into the valley defined thereby with the forwardly-positioned and ascending surface of its station, at least a pair of pushers operatively positioned within the hearth for movement from the rearwardly-positioned and forwardly-descending surface of each station along a forwardly-ascending inclined plane substantially representing the forwardly-positioned and ascending surface of each station for movement along such surface to slidably push a billet upwardly along such surface and pivotally turn it about the apex defined with the rearwardly-positioned and forwardly-descending surface of the succeeding station, each pair of pushers being adapted to engage a bottom surface of a billet within the valley of each station and having a transversely spaced-apart relationship with respect to each other along each station to engage opposite end portions of the billet, an actuating frame structure operably positioned beneath the hearth to extend along opposite longitudinal sides thereof, each of said pair of pushers being operatively positioned on said frame structure, and means for raising and lowering said frame structure to reciprocate each pusher of each of said pairs in synchronism with each other and in synchronism with the other pairs along the hearth.

3. In a heat treatment furnace for metal billets of rectilinear shape, wherein the furnace has enclosing walls defining a longitudinally-extending and transversely-unobstructed heating chamber, means for heating the atmosphere of the chamber and a bottom refractory hearth longitudinally along the chamber on which the billets are to be moved; the combination of a series of billet-receiving stations in longitudinal succession along the hearth and extending transversely of the hearth, said stations being defined by saw tooth-like surfaces of the hearth to provide billet-receiving valleys at each station and billet-pivoting apexes between succeeding stations, at least a pair of pusher rods operatively positioned to extend upwardly through the hearth in a forwardly-inclined relationship with respect thereto for movement between the valley and the forward apex of each station, the pusher rods of each pair having a transversely spaced-apart relationship with respect to each other to engage a bottom face portion of a billet within the valley of each station and push it upwardly over and pivot it about the forward apex thereof into the valley of the next succeeding station, an actuating structure operatively positioned beneath the hearth and connected to lower end portions of each of said pusher rod pairs for reciprocating them within their respective stations in synchronism with respect to each other, and a mechanism operatively connected to said actuating structure to reciprocate it and said pusher rod pairs in synchronism to advance billets in each of said stations in a step-by-step relationship from one station to a succeeding station.

4. A furnace as defined in claim 3 wherein, said actuating structure comprises a longitudinally-extending frame positioned adjacent opposite sides of the furnace and connected to one

pusher rod of each of said pairs, and a second frame extending longitudinally along an opposite side of the furnace and connected to the other pusher rod of each of said pairs; and said mechanism comprises shaft means extending transversely across the furnace therebeneath and connected to each of said frames through oscillating levers.

5. In a heat-treatment furnace for metal billets of rectilinear shape, wherein the furnace has enclosing walls defining a longitudinally-extending and transversely-unobstructed heating chamber, means for heating the atmosphere of the chamber, and a bottom refractory hearth longitudinally along the chamber on which the billets are to be moved; the combination of a longitudinally progressive series of billet-heating stations defined by the hearth transversely thereof, each of said stations having a forwardly-downwardly declining back portion and a forwardly-upwardly inclining front portion that define an angular valley therebetween, the forwardly-upwardly inclining front portion of each of said stations defining an apex with the forwardly-downwardly declining back portion of the next succeeding station of said series, pushers operatively positioned on forwardly-upwardly inclining planes in the hearth to advance through openings in the forwardly-downwardly declining back portion of each of said stations along the plane of the forwardly-upwardly inclining front portion of each of said stations in engagement with a billet to raise the billet out of the angular valley of each of said stations along the front portion of one station and discharge the billet over the apex and along the back portion of the next succeeding station of said series, and an operating mechanism beneath the hearth and connected to said pushers to reciprocate and advance and retract them through the openings in the back portion of each of said stations.

6. In a furnace as defined in claim 5 wherein, motors are operatively connected to actuate said operating mechanism, and limit switch means is operatively connected to said motors to stop said motors after said pushers have completed a cycle of operation.

7. In a furnace as defined in claim 1 wherein, motors are operatively connected to actuate said raising and lowering mechanism, and limit switch means is operatively connected to said motors to stop said motors after said pushers have completed a cycle of operation.

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