July 12, 1960 J. D. NESBITT ET AL 2,944,805

HEATING METHOD AND APPARATUS

Filed Jan. 23, 1956 5 Sheets-Sheet 1

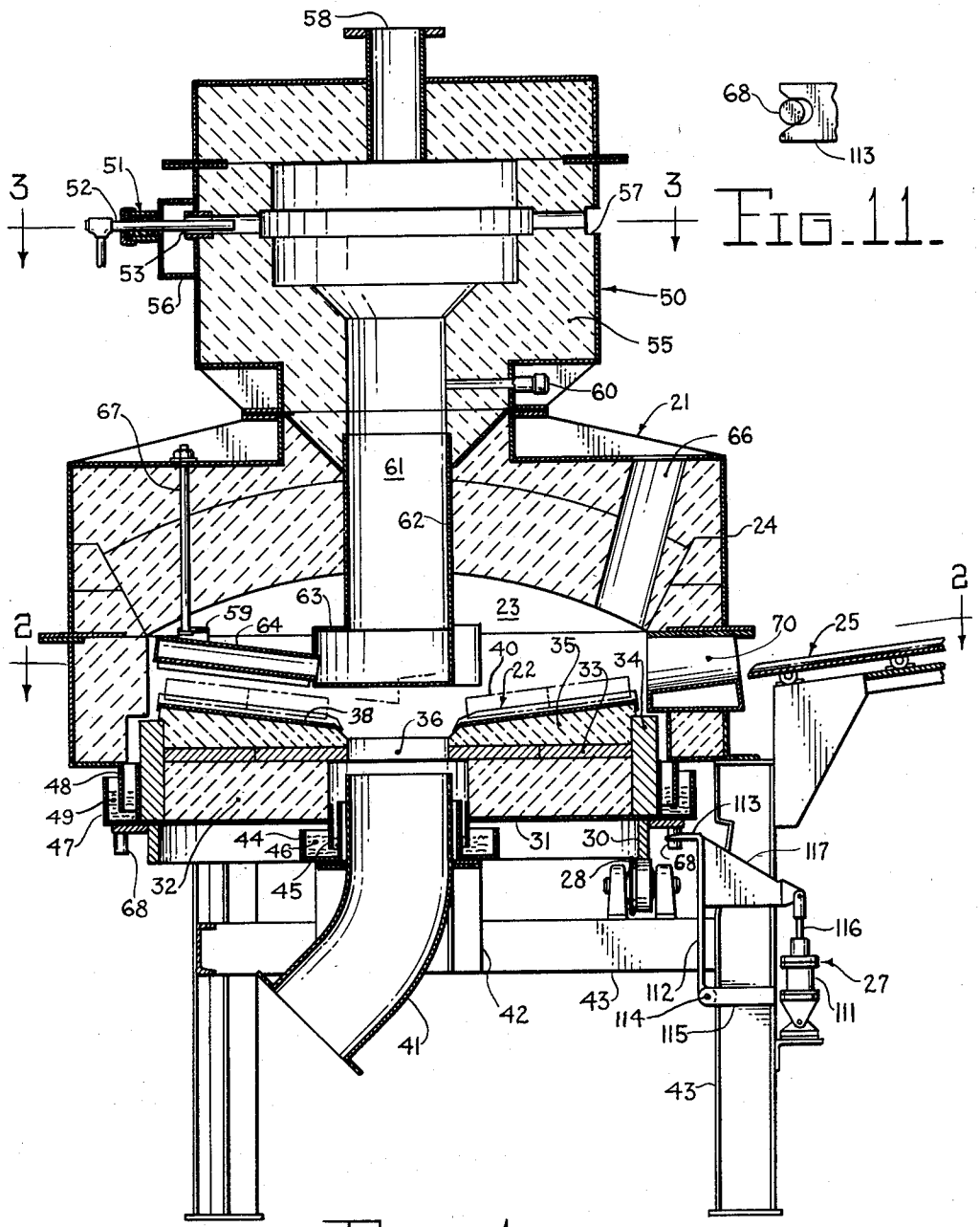


Fig. 11.

Fig. 1.

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HEATING METHOD AND APPARATUS

Filed Jan. 23, 1956 5 Sheets-Sheet 2

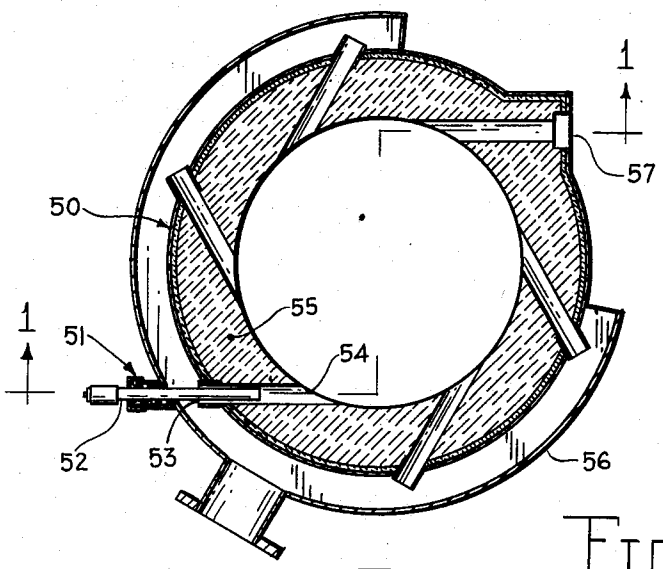


FIG. 3.

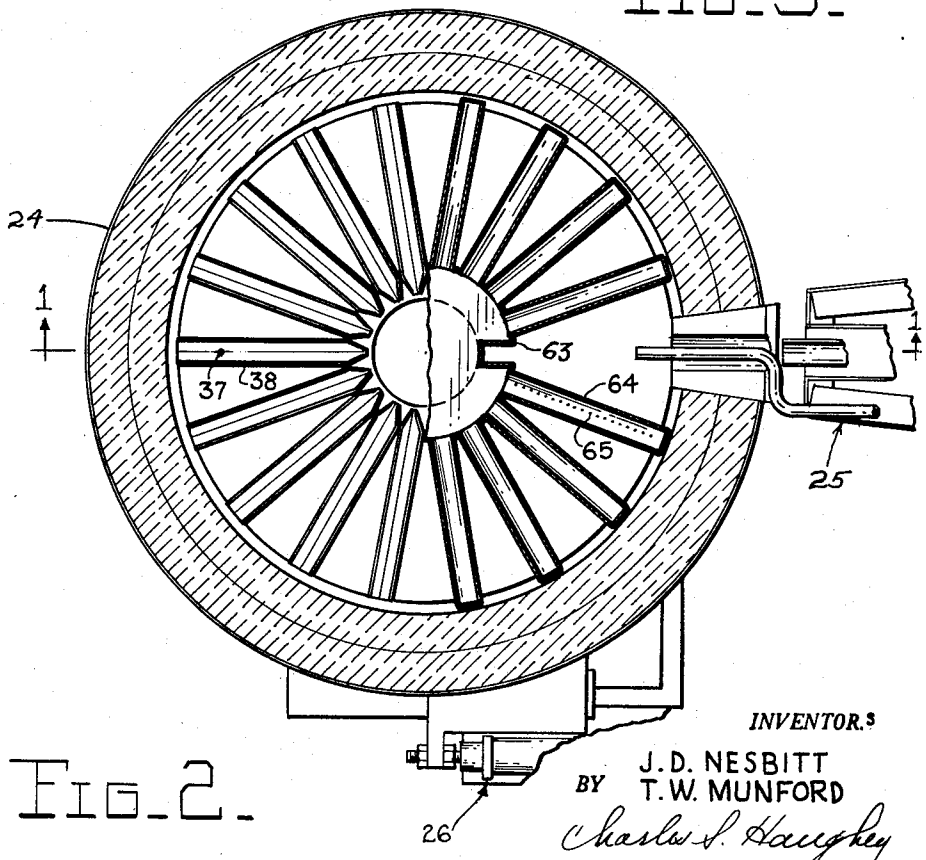


FIG. 2.

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HEATING METHOD AND APPARATUS

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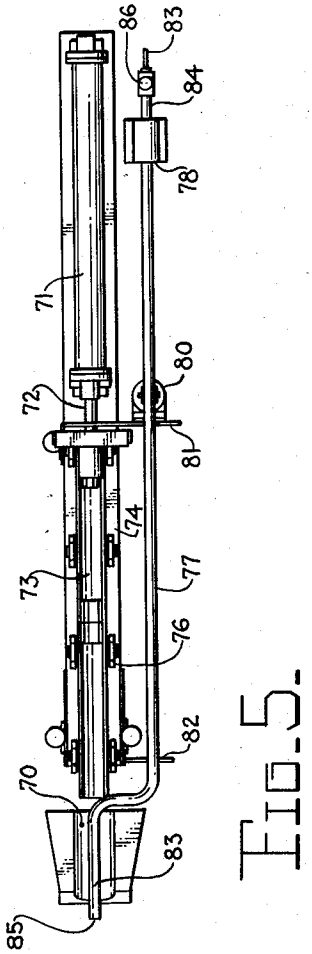


FIG. 5.

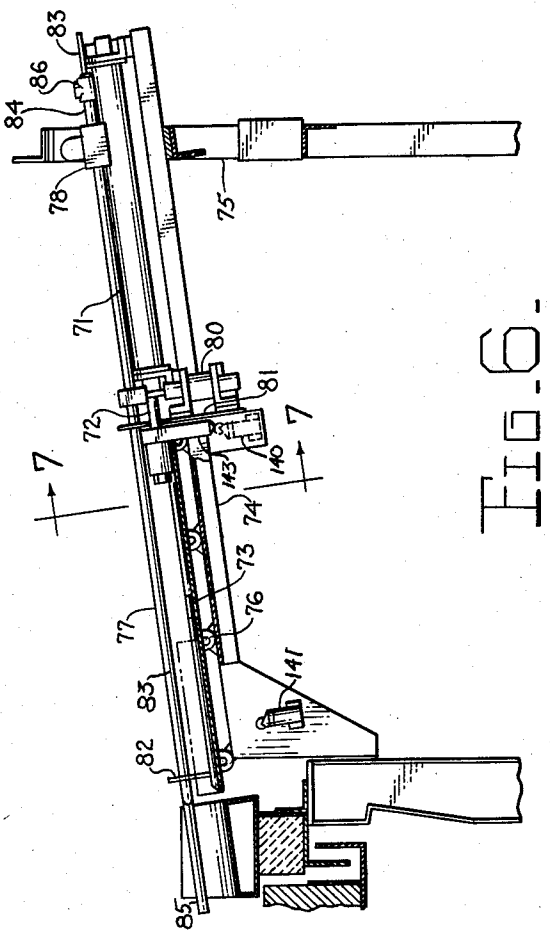


FIG. 6.

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HEATING METHOD AND APPARATUS

Filed Jan. 23, 1956 5 Sheets-Sheet 4

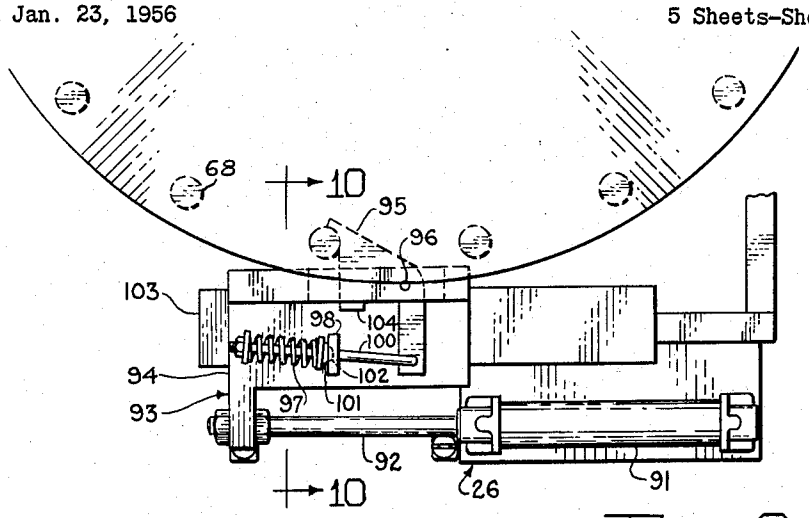


FIG. 8.

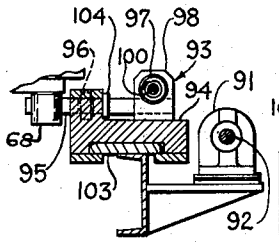


FIG. 10.

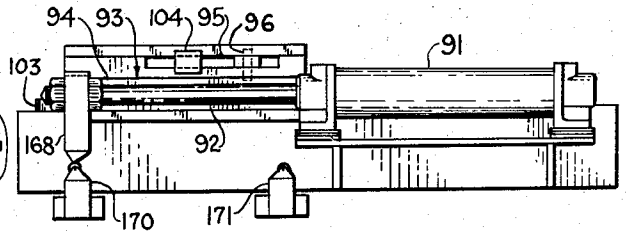


FIG. 9.

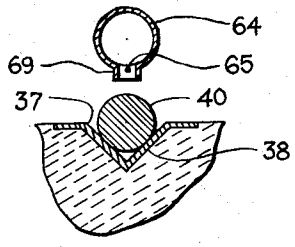


FIG. 4.

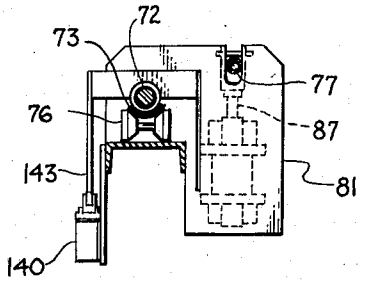


FIG. 7.

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HEATING METHOD AND APPARATUS

Filed Jan. 23, 1956 5 Sheets-Sheet 5

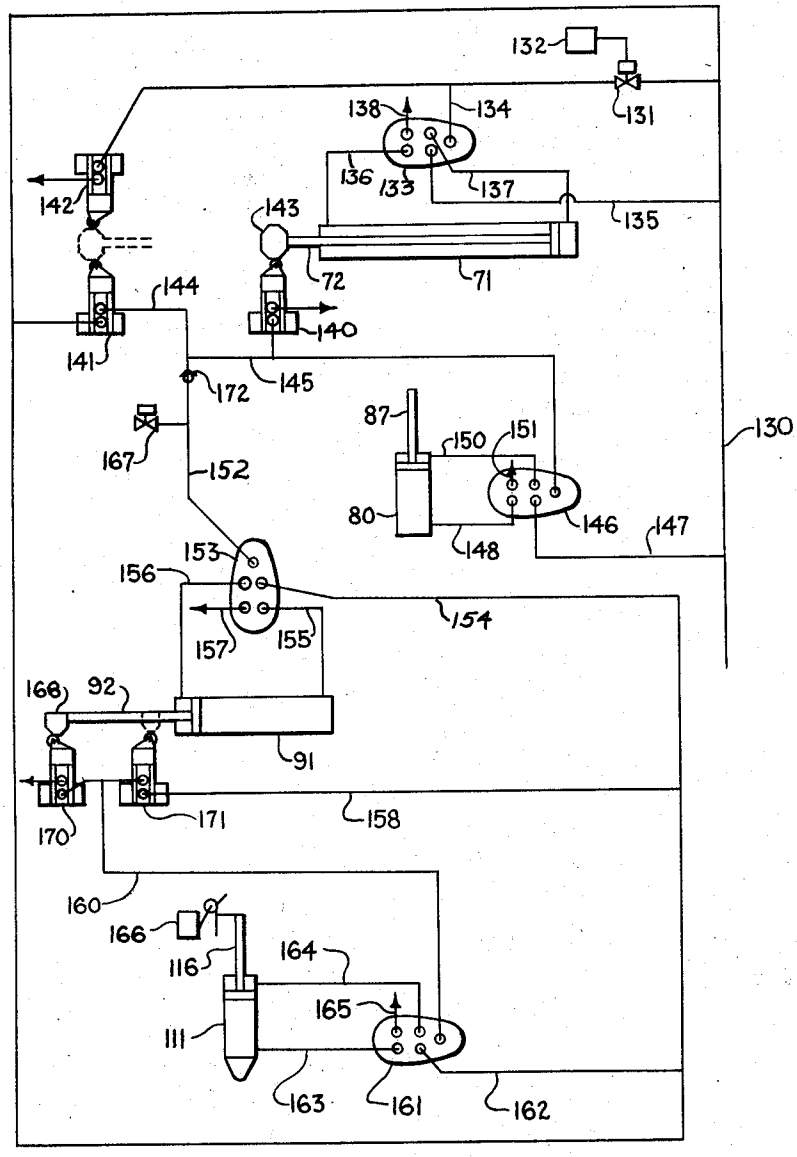


FIG. 12.

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United States Patent Office 2,944,805 Patented July 12, 1960

2,944,805

HEATING METHOD AND APPARATUS

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Filed Jan. 23, 1956, Ser. No. 560,479

12 Claims. (Cl. 263—7)

This invention relates to an improved method of heating work and to apparatus therefor.

The invention has particular application in the non-ferrous metal industry, especially for the heating of billets for extrusion and forging, but is applicable to heating any metals which are subject to variation in emissivity, as will be subsequently explained.

Heating to forging temperatures of non-ferrous metals such as brass, aluminum, or copper prior to forging is generally accomplished in batch-type, slot furnaces. These furnaces, which are well known in the art, consist of rectangular, direct fired combustion chamber having open slots through which the billets to be heated are charged. An operator grasps a tray containing the work with a pair of tongs and passes it through the slot, onto the hearth. Here it is allowed to remain until a visual inspection indicates the work is at proper forging temperature, whereupon the tray and work are removed, and the work is then forged. Temperature uniformity is rare in these cases, the average temperature of the work being left to the judgment of the operator, and this method of heating also tends to scale the work.

To avoid overheating the hotter pieces or portions of pieces, lower average forging temperatures must be used and many dies cannot be properly filled by the relatively cold work. Scale often becomes imbedded in the work causing rejects. Flow patterns due to non-uniformity of heating become variable and undependable. With production of uniformly heated, clean work, the production is increased, uniformity and quality are improved, smaller, less powerful forging equipment may be used and designs not previously forged may be easily produced.

High speed heating primarily by radiation heat transfer has been proposed for this class of work, and has been applied to the heating of large billets, generally 6 inches diameter or more, as illustrated in our co-pending application S.N. 353,592, now United States Patent 2,802,657, issued August 13, 1957. The work is rapidly heated and brought to temperature by this method and produces a product relatively free from scale and zinc blush because of the short period of time it is in the furnace. Temperature differences from piece to piece are sometimes avoided by actually measuring discharge work temperatures with a contact thermocouple, a device not useable in the case of smaller pieces.

To obtain high production rates in treating small billets with reasonably sized equipment and without excessive scaling or zinc blush, high thermal head, radiation furnaces were tested in the non-ferrous industry for heating brass billets. Heat was transmitted primarily by radiation to work which was passed through the chamber. The work was rapidly heated and brought to temperature by this method, and was produced relatively free from scale and zinc blush because of the short period of time it was in the furnace.

Although this method of "high speed heating," as it is called, is adequate for many purposes, a substantial temperature differential between adjacent pieces in the furnace occurred in the above case. Steel has been satisfactorily heated by this method with uniformity in temperature between adjacent pieces; but non-ferrous metals, on the other hand, exhibited large variations in temperature from piece to piece, and for this reason unsatisfactory results were obtained.

Heat transferred to the work by radiation is dependent upon the emissivity of the work. Emissivity is a factor of both the quality or characteristics of the surface and also of the color of the material, and a difference in emissivity of adjacent work pieces will thereby produce a substantial temperature differential in these pieces. For instance, theoretically a difference in emissivity of .005 between two pieces will make a variation in final work temperature of 70° F. or more in rapid heating to about 1450° F. In a test, two brass billets were heated to 1450° F. by a slot burner of the type shown in patent to Nesbitt and Schramm 2,591,283. The billets were previously pickled to obtain as nearly equal emissivity as possible. Various pairs of such billets were tested and the temperature differential found ranged from 40° F. to 200° F. This occurred in spite of the fact that pieces were alternated in their positions to obtain as similar conditions as possible. Another experiment was conducted with different pairs of brass billets, one being bright and the other black, which were heated principally by radiation in a muffle furnace. The temperature differential occurring here was 400° F. as a maximum which was an indication of approximately the maximum temperature differential obtainable with pieces having maximum emissivity differences when heated by radiation.

It is apparent from the above that when small temperature variations in work subject to emissivity variations are to be maintained, radiation heating is unsatisfactory.

Accordingly, a method of heating and apparatus therefor have been developed capable of rapidly and uniformly heating such work and utilizing a rotary hearth furnace with a central discharge port, charge mechanism with control means, and a high velocity convection heating system. The hearth contains grooves for securely holding billets received from the charge mechanism and is then periodically indexed to maintain the work containing grooves below radial ducts that supply a stream of products of combustion and steam to the work.

For further consideration of what is novel and our invention refer to the following specifications and accompanying drawings.

In the drawings:

Figure 1 is a cross sectional, elevation view on lines 1—1 of Figures 2 and 3 of a furnace embodying the invention,

Figure 2 is a cross sectional, plan view on line 2—2 of Figure 1,

Figure 3 is a cross sectional, plan view on line 3—3 of Figure 1,

Figure 4 is a detailed view of a portion of Figure 1,

Figure 5 is a plan view of charge mechanism used with the furnace of Figure 1,

Figure 6 is an elevation view of the charge mechanism of Figure 5,

Figure 7 is a cross sectional view on line 7—7 of Figure 6,

Figure 8 is a plan view of an index mechanism for the furnace of Figure 1,

Figure 9 is an elevation view of the index mechanism of Figure 8,

Figure 10 is an end view of the mechanism of Figure 9,

Figure 11 is a detailed view of the locking mechanism shown on the furnace of Figure 1, and

Figure 12 is a schematic diagram of a control system utilized with the furnace.

Referring now to Figure 1, the upper portion of which is viewed from line 1—1 of Figure 3 and the lower portion from line 1—1 of Figure 2, convection furnace 21 may comprise a rotating hearth 22 on which work is car-

ried, a chamber 23 formed by walls 24, and a charge mechanism 25 which is shown in detail in Figures 5 and 6.

The hearth 22 is rotated by an index mechanism 26 and locked by a lock mechanism 27. This hearth is supported by rollers 28 which contact an annular ring 30 attached to supporting plate 31. Upon plate 31 is a layer of insulating refractory 32, hard brick 33 and 34, and castable refractory 35 which forms the surface of the hearth and is sloped toward the central discharge hole 36 to facilitate discharging and to allow any slag residue to flow out through this hole. Castable refractory 35 contains radial grooves 37 which extend radially outward from discharge hole 36 and are reinforced by alloy members 38. These grooves allow the work, which may be in the form of billets 40, to be maintained in proper alignment when being pushed from the hearth into the discharge hole. The grooves also maintain the billets in proper position for being heated by high velocity and high temperature convection gases as will be subsequently explained.

The central discharge hole 36 has a suitable metal chute 41 located therebelow for directing the discharged work to a receptacle or conveyor by means of which the billets may be conveniently transported to an area containing the forges. In place of the receptacle or conveyor, a quench tank may be installed or a holding chamber. The latter consists of a refractory lined heated chamber for holding the billets at the desired temperature until ready for forging or whatever next operation may be involved. Chute 41 is supported by appropriate members 42 which are, in turn, upheld by a fabricated supporting base 43. An annular seal 44 is also supported by members 42 and is located at the inner periphery of hearth 22. A cylindrical flange 45 extends from the hearth into liquid 46 forming a gas tight connection with the discharge chute. A second seal 47 is located at the outer periphery of the hearth which rotates therewith, and a second cylindrical flange 48 depends from wall 24 into liquid 49 to form a gas tight connection between the rotating hearth and stationary wall.

A cylindrical combustion chamber 50 is centrally located above the chamber 23. Five burners 51 are located on the periphery of this chamber and fire tangentially thereinto. They comprise a gas pipe 52, an annular air passage 53, and a discharge port 54 formed in refractory 55. An air manifold 56 supplies air for combustion to the air passage 53. Opening 57 is included for the insertion of a suitable pilot for igniting the combustible mixtures from the burners. It may be noted here that the heating and combustion chambers are made in easily detachable sections as shown to facilitate accessibility and repair.

A steam inlet 58 is provided for emitting steam to the mixture in the central portion of chamber 50, the mixture being substantially burned by the time it reaches the center. The steam is an important factor in the operation of the furnace since it cools the temperature of the flue gases to a desired point for heating the work, the temperature being measured by means of a thermocouple located in passage 60 provided therefor. The steam has a second function in producing an inert atmosphere for the work to prevent scaling thereof. The effectiveness of this has been proved in actual operation where excess air has been added to chamber 50 to the point where the gases exiting from the furnace had more than 7% free oxygen. Little scale was formed on the work even with this extreme degree of excess oxygen.

The flue gases, resulting from substantially complete combustion of the air-fuel mixture in chamber 50, and steam travel down duct 61 formed by refractory 55 and an alloy metal tube 62 into a cylindrical manifold 63. A portion of this manifold is cut-out over the charge-discharge groove to allow ample clearance for work entering the discharge hole. From the manifold, the gases travel radially outward through pipes 64 and emit vertically downward through nozzles 65 at high velocities where they contact and heat the work, such as billets 40. The size of the nozzles will vary with the volume of mixture and steam used and also with the number of nozzles employed. Furthermore, the nozzles may be drilled through a bar 69 (Figure 4) attached to radial pipe 64 or directly through the pipes themselves. The number of nozzles will depend principally on the size of the work, a sufficient number to afford uniformity in heating being requisite. The gases then exit through flues 66 of which six are equally spaced around the furnace chamber. The number and size of the flues actually depend on the pressure and volume of combustion products and steam emitted to the furnace chamber. The total amount of flue area must be proper to allow the mixture to be discharged at a temperature substantially equal to the final temperature desired for the work so that the walls of the furnace chamber will be heated to substantially the same temperature by these gases. Substantially no heat will then be transmitted from the walls by radiation to the work, especially in the latter portion of the furnace.

Pipes 64 extend radially outward from manifold 63 and are parallel to the hearth 22 being preferably from one to two inches from the work. Their outer ends, which are closed, are supported by means of rods 67 and hangers 59. A pipe 64 is located over each groove 37 except the charge-discharge groove which is in line with the charge mechanism.

The pipes 64 are close to the work and contain the high temperature convection gases. Under these conditions the radiation heating from the pipes to the work may be expected to be substantial. This heat transfer is actually small however since the projected area of the pipe is less than 30% of the total area the work "sees," in most case. Furthermore, the pipes are exposed to the large areas of the walls and hearth of the chamber which are colder than the pipes and which constantly absorb heat therefrom. This maintains the outer surfaces of the pipes at least two hundred degrees cooler than the gases they contain and further decreases the radiation effect of the pipes on the work.

Referring to Figures 5, 6, and 7, pusher 25 essentially consists of a pneumatic pusher cylinder 71, a rod 72, a tray 73 connected thereto, and suitable supporting members 74 and 75. Rollers 76 support the tray 73 and align it with a water cooled charge opening 70 and the hearth groove work thereon. The front of the tray will then butt against the heat treated work and discharge it down the central opening as the tray advances. This eliminates the problem of the work being charged having to butt against, and discharge, the treated work as would be necessary if no tray were used. With no tray, the number of pieces pushed by the charging mechanism would be doubled with the possibility of jamming or buckling likewise increased and, depending on the length, as many as four or five billets may be contained in a groove.

When tray 73 is at the extremity of its travel and begins to retract, the stripper bar 77 is lowered to strip the billets from the tray, being prevented from retracting with it by the bar. This stripper bar is pivotally supported by a member 78 attached to an extension of member 75, and end 85 of the bar is vertically moved by a stripper cylinder 80 and push rod 87. The bar is shaped as shown to permit easier access to the loading tray and is guided in its vertical travel by guide plates 81 and 82. An inner pipe 83 is placed within the bar and water passed therethrough, entering at end 84. This water exits pipe 83 at end 85 and flows back through the annular space formed between the inner wall of bar 77 and pipe 83 and is disposed of by means of a drain pipe connected to outlet 86.

For rotating and indexing hearth 22, another pneumatic cylinder 91 of Figures 8, 9 and 10 provides the power. Cylinder rod 92 horizontally moves a latch as-

sembly **93** which consists of a plate **94** to which a latch **95** is pivotally attached at **96** and depressably held in its outer position by a spring **97**, support **98**, and rod **100**. A ball joint is provided by ball **101** located between spring **97** and a hole **102** in support **98** to allow rod **100** to freely pivot as latch **95** moves. These foregoing items are omitted from Figure 9 for clarity of illustration. Plate **94** is slideably mounted on a rail **103** to properly guide the assembly **93** in its movement. Latch **95** engages a lug **68** on the under side of the hearth when rod **92** is moved outward, thus rotating the hearth. There is one lug for each groove in the hearth and so positioned to move a new groove in front of the charge opening **70** and under each radial pipe **64** upon each forward motion of rod **92**. When the rod retracts, latch **95** is pushed downward by the next lug and springs out again after passing this lug to thus be in position for gripping on the next forward motion. A stop **104** limits this outward motion of latch **95** and maintains it in the proper position.

To securely position the hearth after indexing, a locking mechanism **27** is included (Figures 1 and 11). This consists of an L-shaped member **112** having a grooved head **113** for engaging a lug **68**. Member **112** is pivoted at **114** to a support **115** and is moved by a pneumatic lock cylinder **111** and rod **116** which is pivoted to a lever **117** that is affixed to member **112**. After the hearth is indexed to a new position, rod **116** is raised forcing member **112** forward so that the groove in head **113** engages a lug **68** and thereby maintains the hearth in a fixed position until ready to be indexed again.

In the operation of this mechanism, the work to be charged, which may consist of one longer billet or several shorter ones, is placed on the charging tray which is then extended into the furnace. The stripper bar is lowered and the tray retracted, leaving the billets positioned on the hearth which is then indexed, locked, and the process repeated. Each groove, when indexed, is positioned under a new row of nozzles enabling the billets to be constantly subjected to a high velocity stream of hot gases except during the period of time in which the hearth is actually being indexed.

The invention comprises a cylindrical heating chamber whose axis is substantially vertical and a horiztontally disposed frusto-conical shaped hearth in the chamber and with its smaller end below the larger end. An axially located discharge hole communicates with the lower end of the hearth. A plurality of equally spaced, radial grooves extend outwardly from the discharge hole to the outer periphery of the hearth. There is a cylindrical combustion chamber axially aligned with the heating chamber and located above it. Associated with the combustion chamber are burner means for tangentially emitting a combustible mixture to it and an ignition means for igniting the mixture. A manifold is centrally located in the heating chamber and is connected to the lower end of the combustion chamber by means of a vertical duct. A plurality of radial pipes extend from the manifold that are each parallel with the hearth and vertically aligned with a groove. Each pipe also contains a plurality of nozzles for directing the mixture toward work in the grooves.

The invention also comprises a novel heating method including placing the work on the hearth of a refractory lined chamber, supplying a mixture of fuel and air to a combustion chamber located externally from the refractory lined chamber, burning the mixture in the combustion chamber, and directing a high velocity stream of the mixture toward the work. The stream impinges at high velocity on the work only and subsequently contacts the surrounding hearth and walls of the chamber at low velocity. Thereby, the stream transfers the majority of its heat load to the work and then heats the walls and hearth of the chamber to a temperature substantially equal to the final temperature desired for the work. Finally, the work is withdrawn from the chamber when the temperature of it attains that desired.

The subject heating system is particularly advantageous for heating operations involving work temperatures between 800° F. and 2000° F. Below the former temperature, heat transfer by radiation is of little importance, and conventional heating systems may be employed with good results. The latter temperature is at present an upper limitation due to the melting points of alloys available for forming the duct work for the convection gases. The gases, after flowing through the pipes and contacting the work, are discharged through the flues at an average temperature substantially equal to or slightly higher than that of the work. After impinging upon the work at a velocity measured in thousands of feet per minute, the kinetic energy of the gases is expended, and they immediately slow down to very low velocities and are discharged through the flues. The heat transfer by convection is dependent on the velocity of the hot gas, being greater at higher velocities. Thus, a greater portion of the thermal load is transferred by the high velocity gases when they impinge on the work than when the cooler, low velocity gases later contact the walls of the chamber. The walls of the furnace are thereby heated to an average temperature less than that of these gases and to an average temperature approximately equal to that of the billets. The temperatures of the work and walls being substantially equal, little heat is transmitted to the work by radiation, at least 70% of the heat being transferred to the billets by convection. Of course the percent of radiation heating will be greater for the cooler billets in the charge section of the furnace and less for the hotter ones, with the aforementioned figure of at least 70% being an average one. Depending on the factors in each case, this figure may be as high as 85%. Heating by convection does not depend on emissivity of the billets and, in spite of differences in surface characteristics and color, they are heated to uniform temperatures varying less than plus or minus 9° F. This is the first time known that high speed heating has been accomplished for other material than steel with such a high degree of uniformity.

In a specific heat treating operation, brass billets measuring 1.625" in diameter and 5.625" in length and weighing 3.6# were heated to a forging temperature of 1450° F., two billets per groove. The burners for this were supplied 2,200 c.f.h. of natural gas and approximately ten times this amount of air for combustion. Approximately 1000 lbs. per hour of 50 p.s.i. steam were added to the combusted air-gas mixture which resulted in a 1840° F. temperature for the combination. The nozzles for directing the mixture toward the work were sized in this case to afford an equivalent cold velocity of 8000 f.p.m. The furnace, containing 18 radial grooves, was loaded and indexed on a 20 second cycle which brought the work to temperature at a rate of 3.7 minutes per inch of thickness and produced approximately 1300 lbs. per hour within plus or minus 9° F.

For this operation in the latter portion of the furnace, a heat coefficient of convection, h_c, of approximately 30 was attained with a heat coefficient of radiation, h_r, of approximately 6. Of the total heat transfer there, about 83% was accomplished by convection. The h_c for any case can be increased by increasing the velocity of gases impinging the work or increasing the temperature or heat head thereof. The larger velocity of gases or higher temperature of them will raise the temperature of the ducts and walls also, which will increase the h_r, but not to the extent that the h_c is increased. The resulting proportional increase in the heat transferred by convection will create an even greater temperature uniformity in the work, theoretical heat transfer by convection of 100% creating a theoretical temperature differential between adjacent work of 0° F. Thus, the temperature and velocity of the gases depend in part on the temperature uniformity desired as well as on the final temperature of the

work desired. In actual practice, a heat head of the gases of at least 100° F. and a ratio of h_c to h_r of at least 2 to 1 are necessary to maintain reasonable tolerances under any conditions.

Billets heated by this method are capable of being forged to more intricate shapes than by previous heating methods since, with the uniformity attained, the billets may be heated to a higher temperature, closer to the melting point, without danger of any particular billet overheating and melting within the furnace. The amount of scale formation has also been decreased from that produced with previous methods. Less scale decreases rejected work due to better surfaces and increases the life of the dies. Results have shown that brass billets heat treated by this method produce stronger forgings for the same cross section.

Since billets are heated rapidly by this method, the time being less than three minutes for smaller work, the charging, stripping, indexing, and locking operations must be accomplished in a minimum of time. Accordingly, a control circuit as schematically shown in Figure 12 has been developed for this mechanism which operates as follows:

Air is supplied from air manifold 130 indirectly to pneumatic pusher cylinder 71, stripper cylinder 80, index cylinder 91, and lock cylinder 111. The cylinder rods are shown in their initial positions as the cycle begins with no indexing air being supplied to their four-way valves. Solenoid operated valve 131 is opened temporarily by means of a timer 132 to supply air to a commercially available, four-way, air operated valve 133 through line 134. This air pressure on valve 133 diverts air supplied through line 135 from line 136 to line 137 and forces push rod 72 forward, extending work into the furnace chamber. As rod 72 moves forward, air from the inactive end of the cylinder bleeds through line 138. Valves 140, 141, and 142 are operated by tangs 143 located on rod 72. As this rod moves forward, valve 140 closes and when rod 72 reaches the end of its stroke, valve 141 opens. The latter emits air from manifold 130 through lines 144 and 145 to four-way valve 146, similar to valve 133, and diverts air flow through line 147 from line 148 to line 150. This air causes push rod 87 to retract and lower the stripper bar. Air from the inactive end of cylinder 80 escapes through line 151.

As push rod 72 reaches the end of its stroke, it also actuates valve 142 which is opened and allows air from line 134 to bleed off. Four-way valve 133 then again directs air from line 135 back to line 136 and rod 72 retracts. Push rod 87 acts quickly in bringing the stripper bar into position. The bar is thus positioned in time to strip the work off the loading tray in spite of the fact it is actuated at the same time push rod 72 begins to retract. When rod 72 again retracts to its initial position, tang 143 opens valve 140 bleeding air from line 145. Four-way valve 146 thus allows air from line 147 to flow again through line 148 and extends rod 87 to its original position.

At the same time air is emitted to the stripper cylinder 80, it is also emitted through line 144 and 152 to four-way valve 153. Air supplied through line 154 is then diverted from line 155 to line 156 which retracts index push rod 92. During movement of this rod, air in the opposite end of the cylinder is bled through line 157. The push rod 92 contains a tang 168 which, as the rod retracts, moves off of valve 170 and closes it. When push rod 92 is fully retracted, tang 168 opens the valve 171 which emits air from line 158 to line 160 and four-way valve 161. Air from line 162 is then changed from line 163 to line 164 and retracts locking push rod 116. During movement of rod 116, air in the inactive end of cylinder 111 is bled through line 165. As rod 116 retracts, it moves off of electric limit switch 166 which causes solenoid valve 167 to open. Air is thus released from line 152, and the rod 92 is again extended.

As rod 92 moves forward, it shuts off air from line 158 by means of valve 171, and when it reaches its forward position, having indexed the hearth, it opens valve 170. This releases air on four-way valve 161 and allows air from line 162 to again pass through line 163, thus projecting rod 116 which locks the furnace and actuates limit switch 166 again. Limit switch 166 then closes bleed valve 167 which prevents rod 92 from forward movement and thus the possibility of indexing the hearth as long as rod 116 is extended to its forward position. The cycle is thus completed and the various rods are again in their initial positions until valve 131 is opened once more and another cycle commenced. A check valve 172 is located in line 152 to prevent indexing air in this line from bleeding through valve 140 when rod 72 is retracted. This makes the operation of the indexing valve dependent on the locking cylinder only.

The entire cycle is capable of fast operation since various movements are accomplished simultaneously. In actual practice, cycles of less than ten seconds have been accomplished. To summarize the operation: The loading tray is moved into the furnace carrying with it a new charge of work, and at the same time the end of the tray pushes previous work into the central discharge opening. Upon reaching its extended position, the tray immediately begins to retract, and at the same time the stripper bar is lowered. Also, as the loading tray is retracted, the indexing rod is retracted to its inward position. When the loading tray has been retracted, the stripper bar is immediately raised; simultaneously, the indexing rod is extended to its forward position, the locking rod retracting at the beginning of this forward movement. Upon the complete extension of the indexing rod the locking rod is again extended to lock the furnace and complete the cycle.

The foregoing discloses the best mode known to the inventors of carrying out the invention, the scope of which is limited only by the appended claims.

We claim:

1. Apparatus for heating work comprising: a heating chamber having a work supporting area on which the work is to be heated; a combustion chamber located externally to said heat treating chamber; burner means for supplying a combustible mixture of air and fuel to said combustion chamber; ignition means for igniting said mixture; duct means for carrying said mixture from said combustion chamber to said heating chamber; a plurality of pipes extending from said duct means to said work supporting area in said heating chamber said pipes being of sufficiently small diameter whereby their projected area is less than 30% of the total area the work is exposed to, the remaining area comprising the walls and hearth of said heating chamber; and a plurality of nozzles in each of said pipes for directing said mixture toward said work supporting area, said nozzles being sufficiently close to the work supporting area to assure that all of the mixture emitting from said nozzles will directly impinge on said work.

2. Apparatus for heating work by convection comprising a cylindrical combustion chamber; a work heating chamber; burner means for emitting a combustible mixture tangentially to said combustion chamber; ignition means for igniting said mixture, an inlet axially located at one end of said combustion chamber, steam supply means for emitting steam to said inlet, and duct means for directing the combusted mixture and steam from said chamber to work in said work heating chamber.

3. The combination according to claim 2 wherein said duct means comprises an axially aligned passage connecting the end of said chamber, opposite the steam inlet end, to a series of radially extending pipes, said pipes containing a plurality of nozzles for emitting the combusted mixture and steam toward the work.

4. In a rotary hearth furnace having a central discharge port, a hearth, and a plurality of equally spaced

grooves in the hearth extending radially from said discharge port to the outer periphery of the hearth for containing work to be heat treated, a heating system comprising: a cylindrical combustion chamber externally and axially located with respect to the axis of the furnace; burner means for emitting a combustible mixture substantially tangentially into said combustion chamber; ignition means for igniting said mixture; an inlet axially aligned with said chamber and opening into one end thereof; steam supply means for supplying steam through said inlet to the substantially combusted mixture; a manifold centrally located in the furnace and above the hearth; a duct connecting the other end of said combustion chamber to said manifold; a plurality of radial pipes extending from said manifold, each pipe being aligned with a groove in the hearth; and a plurality of nozzles in each pipe for directing said steam and said mixture from said pipes to work contained in the grooves.

5. A rotary hearth furnace comprising: a cylindrical heating chamber whose axis is substantially vertical; a horizontally disposed frusto-conical shaped hearth located in said chamber and whose smaller end is below the larger end; an axially located discharge hole communicating with said lower end; a plurality of equally spaced, radial grooves in said hearth extending from said discharge hole to the outer periphery of said hearth; a cylindrical combustion chamber axially aligned with said heating chamber and located thereabove; burner means for tangentially emitting a combustible mixture to said combustion chamber; ignition means for igniting said mixture; a manifold centrally located in said heating chamber; a vertical duct axially aligned with said chambers and connecting the lower end of said combustion chamber to said manifold; a plurality of radial pipes extending from said manifold, parallel to said hearth, and each being vertically aligned with a groove; and a plurality of nozzles in each pipe for directing said mixture toward work in said grooves.

6. Charging mechanism, for loading work to be heat treated into a furnace chamber having a work receiving surface, comprising: a support; a roller supported by said support; a tray adapted to receive work, supported on said roller, initially located externally to said chamber, and parallel to said work receiving surface; a fluid operated cylinder axially aligned with said tray, said cylinder including a pushrod connected with an end of said tray to extend said tray into the furnace chamber; a stripper bar adapted to strip work from said tray after being carried into the furnace chamber; and power means for moving said bar into and out of interference with the travel of said work.

7. The apparatus according to claim 6 characterized by control means for controlling the operation of said cylinder and said power means whereby said stripper bar is moved into interference with the travel of said work after said push rod and tray are extended into said chamber to prevent retraction of the work when said rod and tray are retracted, and said bar is moved away to prevent interference with said rod and said tray when again extended.

8. The method of heating metal work to a desired temperature which comprises: placing said work in a refractory lined chamber; heating a gas to a temperature substantially higher than the desired final temperature for said work, said gas being substantially inert to the metal work; tempering the gas to a temperature at least 100° F. higher than the final temperature desired for said work; impinging a high velocity stream of the tempered gas upon said work; removing said gas from said chamber at a temperature substantially equal to said desired temperature whereby the walls of said chamber are heated only by the gases leaving the work to a temperature substantially equal to that desired for said work and a relatively small amount of heat is transferred from said wall to said work by radiation, the heating of said work being accomplished with the coefficient of convection being at least twice the coefficient of radiation; and discharging said chamber when its temperature attains that desired.

9. The method of heating non-ferrous metal work to a desired temperature substantially by convection at high rates of convective heat transfer comprising: placing the work on the hearth of a refractory lined chamber; heating a gas inert to said metal work in a chamber located externally to said refractory lined chamber; creating a high velocity stream of said heated gas; impinging said high velocity stream of gas upon said work at a temperature substantially higher than the final temperature desired for said work, said stream expending its velocity upon impinging said work and subsequently contacting the surrounding hearth and walls of said chamber at a low velocity whereby said stream transfers the majority of its excess heat to said work; and immediately withdrawing said work from said refractory lined chamber when the temperature of said work reaches that desired.

10. The method according to claim 9 characterized by admitting steam to said stream before said stream is impinged upon said work.

11. The method of heating non-ferrous metal work to a desired temperature substantially by convection at high rates of convective heat transfer comprising: placing the work on the hearth of a refractory lined chamber; heating a gas inert to said metal work in a chamber located externally to said refractory lined chamber; creating a high velocity stream of said heated gas; impinging said high velocity stream of gas upon said work at a temperature substantially higher than the final temperature desired for said work; transferring the majority of excess heat in the gas to said work; substantially decreasing the velocity of the gas immediately after it impinges said work; withdrawing said gases from said refractory lined chamber; and immediately removing said work from said refractory lined chamber when the temperature of said work reaches that desired.

12. A rotary hearth furnace for high velocity, convection heating of a plurality of work pieces comprising: a cylindrical heating chamber; a hearth for supporting said work pieces thereon whose surface is of frusto-conical configuration and whose smaller end is lower than the larger end; means forming a discharge hole communicating with said smaller end through which said work pieces and residual slag are discharged from said surface; a plurality of radial grooves in said surface extending from said discharge hole to the outer periphery of said hearth for holding the work pieces on the hearth; a manifold located in said surface above said hearth; a plurality of radial pipes extending from said manifold, each pipe adapted to be aligned above a groove in the hearth; a plurality of nozzles in each pipe; and means for supplying heated gas to said manifold; whereby the heated gas is directed through said nozzles at high velocity towards the work pieces which are maintained positioned on said hearth relative to said nozzles by said radial grooves.

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