March 24, 1942. S. F. KEENER ET AL 2,277,592

METHOD AND APPARATUS FOR HEATING METAL OBJECTS

Filed April 18, 1940 5 Sheets-Sheet 1

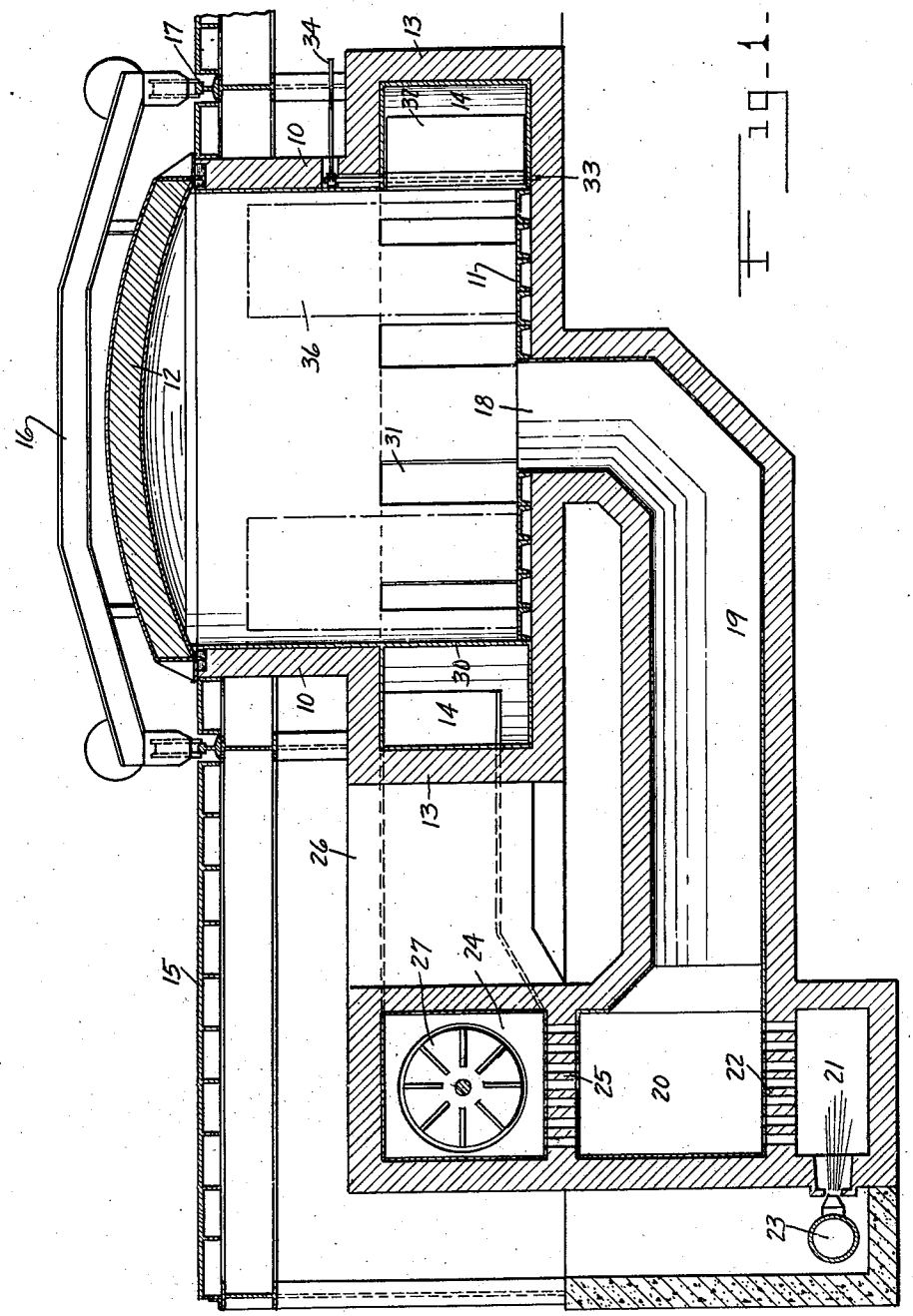


Fig. 1

Inventors
JAMES H. HOPKINS &
SAM F. KEENER

By
Francis J. Klempay
Attorney

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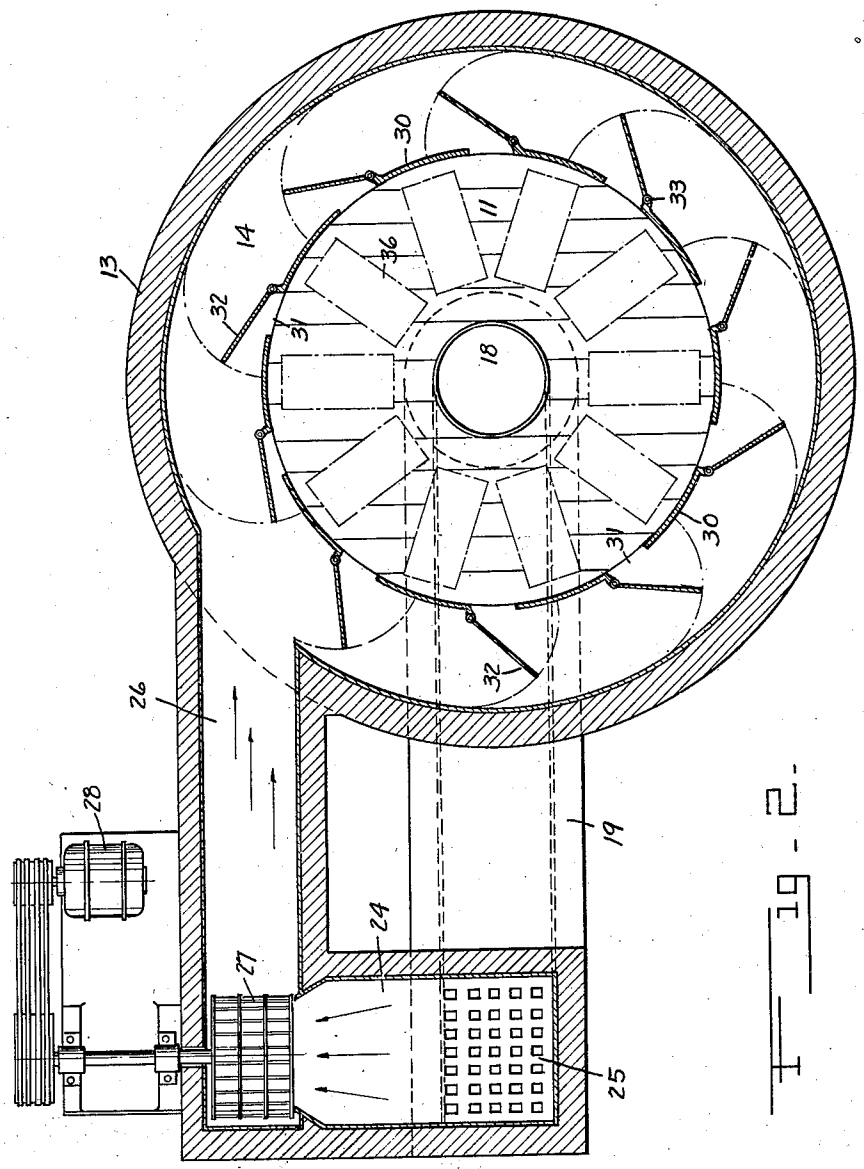


Fig. 2.

Inventors
JAMES H. HOPKINS &
SAM F. KEENER

By
Francis J. Klumpp
Attorney

March 24, 1942. S. F. KEENER ET AL 2,277,592

METHOD AND APPARATUS FOR HEATING METAL OBJECTS.

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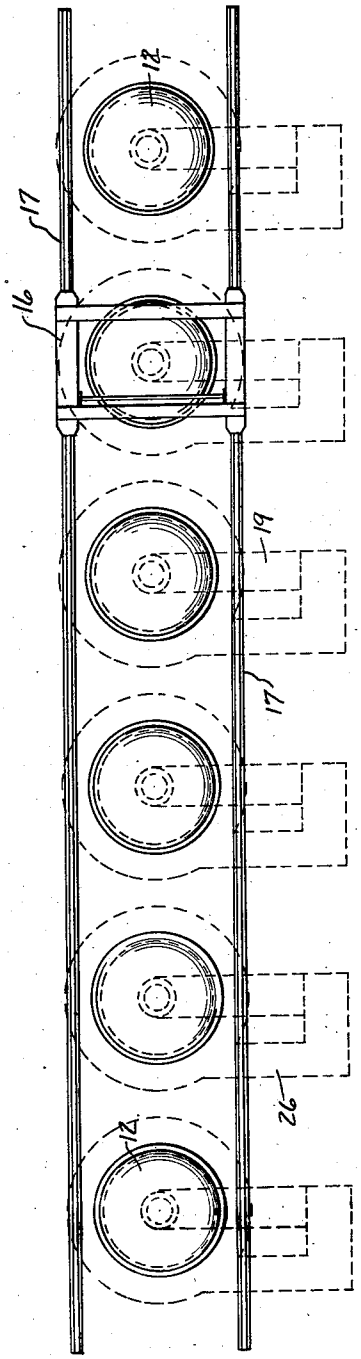


Fig. 3.

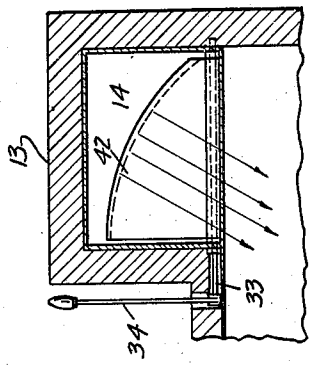


Fig. 5.

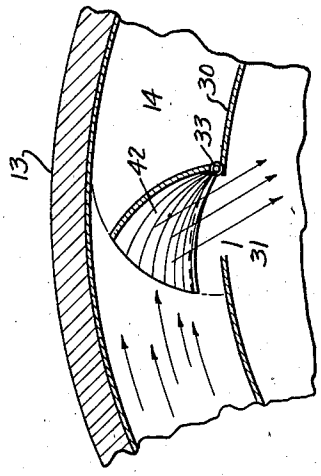


Fig. 4.

Inventors
JAMES H. HOPKINS &
SAM. F. KEENER

By Francis J. Klumpp
Attorney

March 24, 1942. S. F. KEENER ET AL 2,277,592

METHOD AND APPARATUS FOR HEATING METAL OBJECTS

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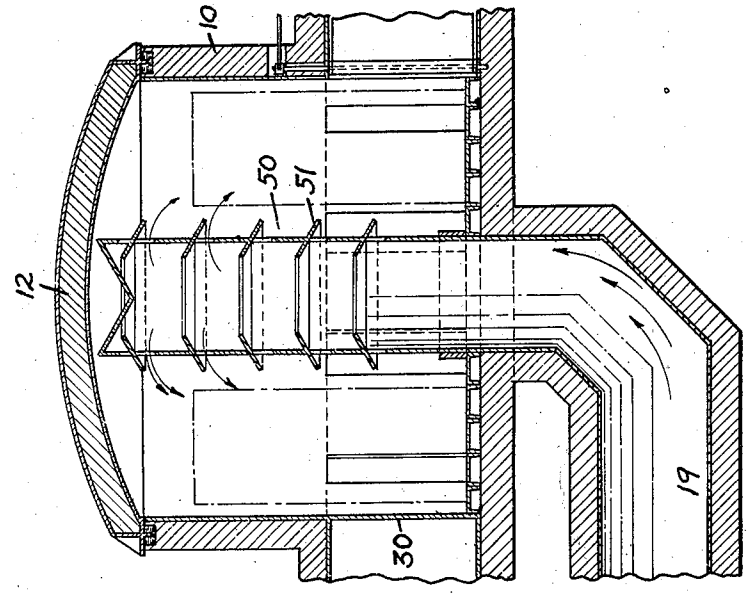


Fig. 6.

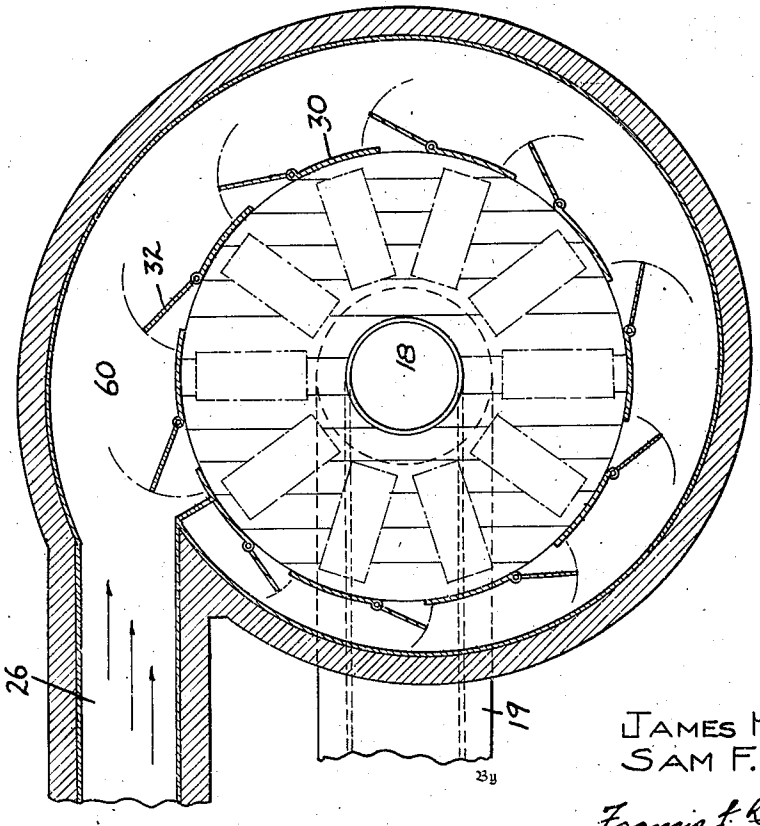


Fig. 7.

Inventors
JAMES H. HOPKINS &
SAM F. KEENER

By Francis J. Klempay
Attorney

March 24, 1942. S. F. KEENER ET AL 2,277,592

METHOD AND APPARATUS FOR HEATING METAL OBJECTS

Filed April 18, 1940 5 Sheets-Sheet 5

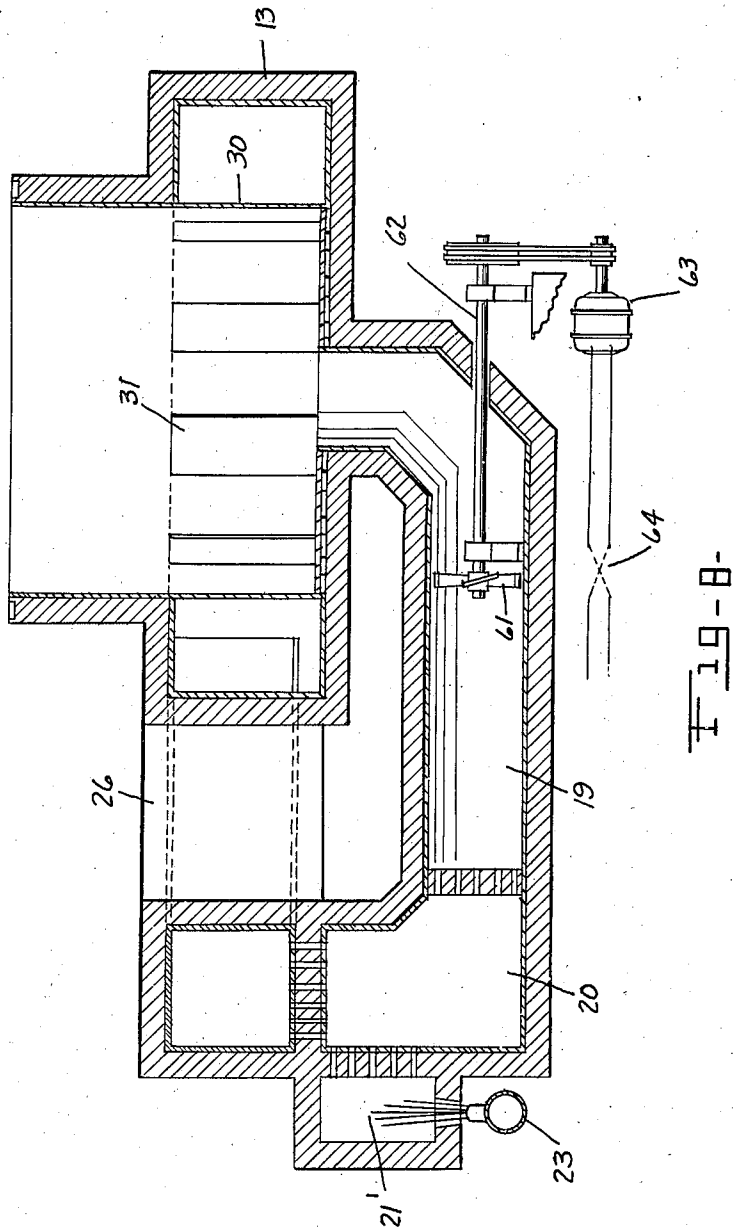


Fig. 8.

Inventor

JAMES H. HOPKINS &
SAM F. KEENER

By Francis J. Klempay

Attorney

Patented Mar. 24, 1942 2,277,592

UNITED STATES PATENT OFFICE

2,277,592

METHOD AND APPARATUS FOR HEATING METAL OBJECTS

Sam F. Keener, Salem, and James H. Hopkins, Alliance, Ohio, assignors to Salem Engineering Company, Salem, Ohio, a proprietorship

Application April 18, 1940, Serial No. 330,292

19 Claims. (Cl. 263—15)

This invention relates to an improved method and apparatus for heat treating ingots and other objects of aluminum and other non-ferrous metals preparatory to their utilization in rolling and other processes and the primary object of the invention is the provision of a novel heating method and an improved furnace for carrying out the method whereby the ingots and objects may be uniformly heated in less time and at less cost than is possible by the use of methods and furnaces heretofore employed for the purpose. The function of the apparatus with which the invention is concerned is the uniform heating of the metal throughout its entire mass and the heating of the inner portions of the ingots and objects must be accomplished by conduction from the outer surfaces thereof at a rate determined by the temperature differential existent between such surfaces and inner portions. An efficient heating method will therefore require that the outer surfaces of the pieces or ingots be maintained at a reasonably high temperature and this presupposes that the rate of heat absorption by the surfaces will be sufficient to enable this high temperature to be maintained.

There are three possible methods which may be employed to supply heat to the outer surfaces of the objects—radiation, conduction and convection—and the first of these has heretofore been principally relied on to accomplish the object involved. It has been found, however, that in the heating of certain metals, particularly aluminum, by this method it is difficult to maintain a sufficiently high rate of heat absorption due to the reflective power of the metal. The specular nature of the metal turns back the major part of the radiant energy impinging on its surface, thus mitigating from the efficiency of the process and rendering difficult the control of the furnace. Also, as it is impractical to expose all surfaces of the objects to the radiant energy sources, one surface or side of the objects is invariably subjected to more energy than the other surface or side resulting in uneven and slow heating. The control of the apparatus must be such that the heat absorbed by any surface must be less than the capacity of the adjacent metal to conduct it away as otherwise the metal at the surface will melt and flow. If an attempt is made to force the heating, one side of the objects may melt while the other side is comparatively cool. The present invention seeks to overcome the above mentioned deficiencies in present heating practice as related to aluminum and other non-ferrous metals by employing a heating furnace for objects of such metals in which convection solely is relied on to transfer the heat to the same. A number of definite advantages, to be hereinafter explained, result from the adoption of the stated principle for non-ferrous metal heating.

Heat transfer by convection is determined by the character of the flow of the fluid transferring the heat, the surface conductance of the object being heated, and the total amount of fluid flow or convection units impinged on the object. It is another object of the present invention to employ a convection type furnace for heating ingots, blooms, billets, castings and the like and to incorporate an arrangement within the furnace which will be operative to distribute the fluid flow in such manner that substantially equal large volumes of fluid at the same temperature will be impinged against each of the objects, whereby the objects will be more rapidly and uniformly heated. Another object of the invention is the provision in a convection type metal heating furnace of an arrangement whereby the flow of fluid relative to the metal objects will have substantial components normal to the outer surfaces of the same. It has been found that the efficiency of convection heating is determined in part by the type of fluid flow with a minimum of heat transfer occurring when the flow is purely laminar and parallel with the conducting surface and with a maximum of heat transfer when the flow is directly against the surface.

A further object of the invention is the provision of a furnace for heating metal objects which is operative to uniformly heat a number of such objects in a rapid and economical manner but which nevertheless may be operated at full capacity without danger of injury to the surfaces of the objects or to any parts of the apparatus and without requiring any substantial skill on the part of the furnace operator. This is accomplished, in accordance with the present invention, by lining the heating furnace and the convection fluid flues with either hard glazed brick or metal sheets having high heat resisting properties, such as chrome alloy sheets. With this construction it is possible to employ very high velocities of fluid flow in the furnace without any errosive effect on the inner walls of the furnace and flues or on the outer surfaces of the objects positioned therein as would occur if conventional construction was used, since then bits of abrasive particles would enter the fluid stream and, due to the high velocities, would rapidly accumulate in quantity and have a very destructive effect on the furnace and objects po-

sitioned therein. Also, it should be apparent that by maintaining the fluid streams substantially free of abrasive particles the objects will be maintained in a clean and bright condition, thereby preventing particles from being subsequently rolled into or otherwise embedded in the metal. By employing high velocities large quantities of uniformly heated fluid may be supplied to the furnace per unit of time and by maintaining the temperature of the fluid just slightly below the melting point of the metal the heating may be accomplished at the maximum rate with safety.

These and other objects and advantages of the invention will become apparent from a consideration of the following detailed specification and the accompanying drawings wherein there is specifically disclosed a preferred embodiment of the invention.

In the drawings:

Figure 1 is a vertical section of a metal heating furnace constructed in accordance with the present invention;

Figure 2 is a horizontal section of the furnace of Figure 1;

Figure 3 is a plan view of a representative installation of a group of the furnaces;

Figures 4 and 5 are horizontal and vertical views of a modification of one of the elements of the furnace of Figures 1 and 2;

Figure 6 is a fragmentary vertical section of a modified form of furnace constructed in accordance with the teachings of the invention;

Figure 7 is a horizontal sectional view of a modified form of fluid distributing or collecting duct which may be incorporated in the furnace of the invention; and

Figure 8 is a vertical section of a further modified metal heating furnace constructed in accordance with the invention, the modification illustrating the representative manner in which the direction of flow of convection heating fluid through the furnace may be reversed.

The illustrated preferred embodiment of the apparatus capable of carrying out the method of the invention includes a circular heating chamber or furnace having an annular side wall 10, a hearth 11 and a removable cover 12. A portion of the annular wall 10 and preferably the lower part thereof is of increased diameter as indicated at 13 to privide an annular fluid distributing duct 14 about the furnace. The furnace proper is below the operating floor 15 and a cover crane 16 running on rails 17 built into the floor is employed to lift and remove the cover 12 for charging the ingots or removing the ingots from the surface. As indicated in Figure 3 of the drawings, one crane may service a battery of furnaces.

An outlet 18 is provided in the hearth 11 substantially centrally thereof and is connected with a flue 19 which leads to a mixing chamber 20. Adjacent one wall of the mixing chamber 20 is a combustion chamber 21, the two chambers being separated by checkerwork 22. One or more fuel burners 23 discharge into the chamber 21 and upon complete combustion the gaseous products pass into the chamber 20, the checkerwork 22 assisting in the completion of the combustion.

Adjacent the chamber 20 opposite the combustion chamber 21 is a blower chamber 24 which is separated from the chamber 20 by the checkerwork 25 and leading from the chamber 24 is a flue 26 which connects with the annular distributing duct 14. A blower 27, driven by a motor 28, is located in the chamber 24 and is operative to withdraw the air and gases from the furnace through the outlet 18, flue 19, chamber 20, and to force the same through the flue 26 into the distributing chamber 14.

Separating the annular distributing duct 14 from the principal space within the furnace is a circular wall 30, which may be of metal plate or sheathed brick construction and in which is provided a plurality of circumferentially spaced ports 31. Each of the ports is provided with a door or vane 32 pivotally mounted on a vertical pivot adjacent the clockwise edge of the ports 31, as viewed in Figure 2 of the drawings. Each of the vanes 32 is arranged to be adjustably rotated about its pivot and to be held in its adjusted position by a hinge rod 33 which extends upwardly through the upper wall of the annular chamber 14 where it may be engaged by a suitable operating tool 34. By referring to Figure 2 of the drawings it will be observed that the flue 26 enters the chamber 14 substantially tangentially thereof and therefore the air and gaseous products of combustion coming into the chamber from the flue at high velocity will swirl through the duct 14 in a clockwise direction as viewed in the figure. Since the outer free ends of the vanes 32 are presented to the fluid stream, the amount of the fluid diverted into the respective ports 31 will be determined by the angular position of the adjacent vanes. It is possible to so adjust the various vanes that the amount of fluid passing through each of the ports 31 will be equal. This is accomplished by substantially closing off the port closest to the point of entry of the fluid stream and progressively adjusting the vanes 32 outwardly clockwise about the furnace.

The invention contemplates that the interior surfaces of the furnace proper, flues 19 and 26 and chambers 20 and 24, be lined with a metallic sheathing having high heat resisting properties, as chrome alloy sheets, with a hard surfaced glazed brick having sufficient abrasion resisting properties to prevent spawling and breaking off, or with other material which is suitably heat resisting and substantially free from abrasive particles which may be removed therefrom during operation of the furnace. Blower 27 and motor 28 are of sufficient capacity and the flues 19 and 26 are of sufficient size to enable very large volumes of the convection heating fluid, in this case air and gaseous products of combustion, to be circulated through the furnace per unit of time. In certain instances of actual practice it is contemplated that the furnace and its ancillary equipment will be so designed that the fluid within the furnace may be charged up to twenty or thirty times per minute. The velocities required are of cyclonic proportions and result in very rapid charge of the fluid impinging on the metal objects and consequently heating thereof at the maximum rate.

While the furnace described above is particularly suited for the heating of ingots of aluminum and other non-ferrous metals it should be apparent that it is equally adaptable to the heating of blooms, billets, castings and other non-ferrous metal objects and these various forms may be either supported directly on the hearth, being charged individually, or supported in racks which may be charged as such, depending on the size and character of the objects to be heated. Ingots are generally stood on end on the hearth and preferably arranged in ring formation, as

shown, and the same is true of other objects and racks containing objects but it should be understood that the material charged may be disposed in any manner due to the entire coverage of the chamber with high velocity convection currents. The racks or containers supporting the smaller objects are preferably perforated or of open construction to permit the convection currents to flow freely around the objects.

After the furnace is charged the cover 12 is applied, a liquid seal being employed for the cover to avoid the presence of the abrasive particles of a sand seal. The circulating blower and the burner or burners 23 are now operated and the air and gaseous products of combustion within the system are moved at high velocity successively through the ports 31, about the ingots 36 shown or other objects, through the flue 19, chambers 20 and 24, through the blower wheel 27 and back to the distributing chamber 14 through the flue 26. The burner or burners 23 are controlled in such manner that the temperature of the convection heating fluid in the system is maintained just below the melting point of the metal of the ingots. When the furnace is used to heat aluminum ingots this temperature is maintained at approximately 960° F. It is contemplated that a suitable control instrument, which is responsive to the temperature of the convection heating fluid, may be employed to automatically control the operation of the burner or burners 23. The temperature of the fluid stream is maintained by passing the high temperature products of combustion or "make up" from the combustion chamber 21 directly into the fluid stream through the checkerwork 22. In the event that the looseness of the cover 12 and other fittings of the furnace is not sufficient to permit a volume of fluid equal to the "make-up" volume to be displaced from the system, an exhaust port may be provided anywhere in the system remote from the chamber 21. For efficiency of operation the exposed walls and flues of the apparatus are preferably built up of insulating brick.

Referring now to Figure 2 of the drawings, it should be observed that, as the streams are diverted through the ports 31 by the vanes 32 onto the objects or racks standing on the hearth, the streams will impinge on the same substantially at right angles to the surfaces first encountered and will be reflected back and forth between the same. This, together with the high velocities used, will result in very turbulent flow of the fluid through the heating chamber which, as is well known, will result in maximum transfer of heat to the metal surfaces.

The above specifically described embodiment of the invention should be considered as illustrative only since many changes may be made therein without departing from the spirit or scope of the invention. For example, it is conceivable that equally efficient or better results may be obtained by positioning the annular distributing duct intermediate the top and bottom of the heating chamber instead of at the bottom of the chamber, as shown in the drawings. Also, the method and apparatus of the invention is independent of the type or kind of heat input means employed. The convection air stream may be maintained at its predetermined temperature by discharging the products of gaseous or liquid fuel combustion directly into the stream, as shown, by employing a conventional heat exchange apparatus in the flues, by electric resistance heating means positioned in the system or by any other equivalent means or combination. While specific reference has been made to aluminum ingot heating, it should be apparent that the method and apparatus of the invention is equally applicable to other heating problems where the final temperature required is not high.

The vanes 32 instead of being planar, as shown in Figures 1 and 2, may be spiraled upwardly, as indicated at 42 in Figures 4 and 5, to provide for a vertical as well as a lateral diversion of the fluid stream from the duct 14. This would aid the dispersion of the fluid over the length of the ingots placed on the hearth 11.

While in the furnace shown in Figures 1 and 2 the convection heating fluid is shown as being circulated from the annular distribution chamber through the heating compartment and out through the outlet 18, it should be obvious that the direction of flow of the convection heating fluid may be reversed. Thus the convection heating fluid may be caused to enter the furnace centrally thereof and move radially outward through the heating compartment, through the openings 31, into the duct 14. If desired, a distributing apparatus, such as shown generally at 50 in Figure 6, may be employed to deflect the heating fluid coming through the center opening of the furnace downwardly and outwardly against the objects supported on the hearth of the furnace. Apparatus 50 may consist simply of a perforated tube or of a series of vertically spaced frusto-conical deflectors 51, as shown. The function of the apparatus is to distribute the fluid coming into the furnace circumferentially and vertically throughout the furnace.

It is also contemplated, in accordance with the present invention, that the furnace of the invention may be operated in a reversing manner, i. e., the heating fluid may be circulated in the direction indicated in Figure 2 for a certain length of time and then reversed to flow in the direction indicated in Figure 6 for a subsequent period. These reversals may be effected as often as desired, thus further increasing the efficiency of the furnace and the uniformity of the heating thereof. This method is particularly advantageous if the furnace is densely charged with a multiplicity of small objects, such as forgings or castings, as a more uniform heat may be acquired in a short length of time. The reversing of the direction of the heating fluid flow may be accomplished either by employing a reversible propeller in the place of the squirrel cage type blower shown or by employing parallel ducts with blowers therein arranged for fluid propulsion in opposite directions and diverter valves at the ends of the parallel ducts to direct the fluid flow to one or the other of the ducts depending on the direction of flow of the fluid.

Referring to the modification illustrated in Figure 8, a fan or propeller 61 is arranged in the duct 19, being carried by a shaft 62 which extends longitudinally and centrally of the duct. Shaft 62 is driven by a reversing motor 63 whose operation is controlled by a reversing switch 64 arranged either for manual or automatic periodic operation. In this modification the combustion chamber 21 is arranged along side of the mixing chamber 20 so that the gases entering the fluid stream from the chamber 21' will move into the same in a lateral direction, irrespective of the direction of flow of the convection heating fluid. It should be obvious, of course, that the reversing feature is applicable in other specific

types of furnaces, as for example, the type utilizing the involute duct 60 (Figure 7).

Figure 7 illustrates a modified form of furnace in which the duct 60, corresponding generally to the fluid collecting or distributing duct 14 of the first described form of the furnace, is of involute form with the end of largest cross-sectional area adjacent the flue 26. The duct 60 is therefore of decreasing cross-sectional area in a direction away from the flue 26 and it is possible, by carefully calculating the fluid flow through the furnace, to make the furnace heat properly and uniformly without the necessity of incorporating the louvres 32. In this case the distribution would be effected by the decreasing cross-sectional area of the involute annular duct 60. Conversely, when the fluid is circulated through the furnace in the opposite direction, the duct 60, which then serves as a collecting duct, will operate to insure the proper distribution of the fluid coming into the furnace through the center opening.

It should now be apparent that we have provided a method and apparatus which accomplishes the objects initially set out. The ingots and other objects may be uniformly heated throughout their entire masses in the shortest possible length of time at low cost and without injury thereto, the latter resulting from the precision control which may be maintained over the heating process. The apparatus required is simple in construction and may be operated with a minimum of attention and maintenance. The invention places no limitation on the size of the apparatus involved. The furnaces may be either large or small.

Reference should be had to the appended claims in determining the scope of the invention.

What we claim is:

1. A metal heating furnace comprising in combination a substantially circular heating chamber having an encircling duct for the passage and distribution of convection heating fluid, a wall having a plurality of circumferentially spaced ports separating said chamber from said duct, a flue leading to said duct substantially tangential thereto, a second flue leading from said chamber at the center of the bottom wall thereof, means to connect said first and second mentioned flues, means to circulate convection heating fluid through said flues, duct and chamber at high velocity, means in one of said flues to heat said fluid, and a pivotally mounted vane associated with each of said ports to deflect a selected volume of said fluid through the respective ports, said vanes being each adjustable about an axis extending normal to the direction of fluid flow through said duct.

2. A metal heating furnace comprising in combination a substantially circular heating chamber, an annular duct encircling said chamber, a wall having a plurality of circumferentially spaced ports separating said chamber from said duct, a flue for the passage of convection heating fluid connected with said duct substantially tangential thereto, a second flue connected with said chamber at the center of the bottom wall thereof, means to connect said first and second mentioned flues, means to circulate the convection heating fluid through said flues, duct and chamber at high velocity, means to heat said fluid, and an adjustable closure associated with each of said ports to allow a selected volume of said fluid to pass through the respective ports.

3. A furnace for heating metal objects comprising in combination a substantially circular heating chamber having an annular hearth therein upon which the objects are adapted to be supported, an annular duct encircling said heating chamber and separated therefrom by a wall, a plurality of circumferentially spaced ports separating said chamber from said duct, and positioned substantially horizontally opposite the positions normally assumed by said objects on said hearth, a flue for the passage of convection heating fluid connected with said duct substantially tangential thereto, a second flue connected with the opening in said hearth, means to connect said first and second mentioned flues, means to circulate convection heating fluid through said flues, duct and chamber at high velocity, means to heat said fluid at a point remote from said chamber and means to control the amount of convection heating fluid passing through each of said ports.

4. A furnace for heating metal objects comprising in combination a substantially circular heating chamber, an annular hearth in said chamber adapted to support a plurality of said objects, a duct encircling said chamber, a wall having a plurality of circumferentially spaced ports separating said chamber from said duct, a flue extending downwardly and outwardly from the center of said hearth, a second flue leading to said duct, means to connect said first and second mentioned flues, means to circulate convection heating fluid through said flues, duct and chamber at high velocity, means to heat said circulated convection heating fluid, and means to control the volume of fluid passing through each of said ports.

5. Apparatus according to claim 4 further including means to reverse the direction of flow of the heating fluid through said chamber.

6. A furnace of the convection type for heating metal objects comprising in combination a substantially circular heating chamber, an annular hearth in said chamber and adapted to support a plurality of said objects, a plurality of circumferentially spaced ports in the side wall of said chamber, and positioned substantially horizontally opposite the positions normally assumed by said objects on said hearth, a flue extending downwardly and outwardly from the center of said hearth, means to conduct convection heating fluid to said chamber through said ports, means to control the amount of fluid passing through each of said ports, means to connect said flue and said first mentioned means, a power driven blower to recirculate convection heating fluid through said flue, first mentioned means, ports and chamber, and means to heat said fluid.

7. A furnace of the convection type for heating metal objects comprising in combination a substantially circular heating chamber, a hearth in said chamber for the support of a plurality of said objects, a flue for the passage of convection heating fluid from said heating chamber, a plurality of circumferentially spaced ports in the side wall of said chamber, and positioned substantially horizontally opposite the positions normally assumed by said objects on said hearth, means to conduct convection heating fluid to said ports, means to control the volume of fluid passing through each of said ports, means to connect said flue with said first mentioned means, a power driven blower to recirculate said convection heating fluid through said first mentioned means, ports, chamber and flue and means to

heat said fluid at a point removed from said chamber.

8. A furnace for heating metal objects comprising in combination a substantially circular heating chamber, an annular hearth in said chamber adapted to support a plurality of said objects, a flue extending downwardly and outwardly from the center opening of said hearth, an annular duct encircling the lower portion of said chamber, a wall separating said chamber from said duct, a plurality of circumferentially spaced ports in said wall, a passageway connecting said flue with said duct, means in said passageway to circulate convection heating fluid through said passageway, duct, chamber and flue, means in said passageway to heat said fluid, and a curved deflector associated with each of said ports to deflect fluid from said duct inwardly and upwardly against the objects positioned on said hearth.

9. A furnace for heating metal objects comprising in combination a circular heating chamber, an annular hearth in said chamber, a plurality of circumferentially spaced ports in the side wall of said chamber, a passageway for convection heating fluid leading to said ports, a flue extending downwardly and outwardly from the center opening of said hearth and connected with said passageway, a combustion chamber adjacent said passageway, checkerwork separating said combustion chamber from said passageway, a fluid circulating means in said passageway and being operative to circulate the convection heating fluid through said passageway, ports and flue and means to control the flow of fluid through said ports.

10. A heating furnace for objects of aluminum and other non-ferrous metals comprising in combination a heating chamber, a hearth in said chamber for the support of a plurality of said objects, a removable cover for said chamber, a flue extending downwardly and outwardly from said chamber, openings in the side walls of said chamber horizontally opposite said objects and spaced substantially from said cover for the passage of convection heating fluids thereinto and against the sides of said objects, means to connect the outer end of said flue with said openings, means to recirculate said heating fluid at high velocity through said chamber, flue and openings, and means remote from said chamber to heat said fluid.

11. A furnace for heating metal objects comprising in combination a substantially circular heating chamber, an annular hearth in said chamber adapted to support a plurality of said objects, an involute duct encircling said chamber, a wall having a plurality of circumferentially spaced ports separating said chamber from said duct, a flue extending downwardly and outwardly from the center of said hearth, a second flue connected with said duct, means to connect said first and second mentioned flues, means to circulate convection heating fluid through said flues, duct and chamber at high velocity, and means to heat said circulated convection heating fluid.

12. Apparatus according to claim 11 further including means to reverse the direction of the flow of fluid through said chamber.

13. A furnace of the convection type for heatnig metal objects comprising in combination a heating chamber, a hearth in said chamber, a passage for convection heating fluid disposed centrally of said hearth, a duct substantially encircling said chamber and spaced substantially from the top of said chamber, a wall having a plurality of spaced ports therein separating said chamber from said duct, said ports being positioned substantially horizontally opposite the positions normally assumed by said objects on said hearth, a flue connected with said passage, a second flue connected with said duct, means to connect said first and second mentioned flues, means to circulate convection heating fluids through said flues, chamber and duct at high velocity, and means outside of said chamber to heat said circulated convection heating fluid.

14. The method of uniformly heating ingots and other objects of aluminum and other nonferrous metals which consists of subjecting said ingots and objects to large volumes of rapidly moving convection heating fluid issuing from a multiplicity of points surrounding the ingots and objects, withdrawing the fluid from a point below the ingots and objects, recirculating said fluid, and maintaining said fluid at a uniform temperature lower than the fusion temperature of the metal of the ingots.

15. The method of uniformly heating ingots and other objects of aluminum and other nonferrous metals which consists of arranging said ingots or objects about a central point and subjecting said ingots or objects to large volumes of rapidly moving convection heating fluid flowing laterally between said point and a multiplicity of points spaced radially outward with relation to said central point and circumferentially with respect to each other, recirculating said fluid, and maintaining said fluid at uniform temperature lower than the fusion temperature of the metal of the ingots.

16. A furnace of the convection type for heating metal objects comprising in combination a substantially circular heating chamber, an annular hearth in said chamber for the support of a plurality of said objects, a removable cover for said chamber, a plurality of circumferentially spaced ports in the side wall of said chamber positioned substantially horizontally opposite the positions normally assumed by said objects on said hearth and spaced substantially from said cover, a downwardly and outwardly extending flue connected to the center opening in said hearth, means to connect said ports and flue, a power driven blower to recirculate convection heating fluid through said means, ports, flue, and chamber, and means to heat said fluid at a point removed from said chamber.

17. A convection type heating furnace for objects of aluminum and other non-ferrous metals comprising in combination a heating chamber, a hearth in said chamber for the support of a plurality of said objects, a removable cover for said chamber, openings in the walls of said chamber horizontally opposite said objects and spaced substantially from said cover for the passage of convection heating fluid, a duct connected with the lower central portion of said chamber, means to connect said duct with said openings, a power driven blower to recirculate the fluid through said chamber, means, and duct at high velocity, and means remote from said chamber to heat said fluid.

18. Apparatus according to claim 17 further including a heat and erosion resistant lining for said chamber, means and duct.

19. A furnace of the convection type for heating metal objects comprising in combination a substantially circular heating chamber, an annular hearth in said chamber for the support of

a plurality of said objects, a removable cover for said chamber, a plurality of circumferentially spaced ports in the side wall of said chamber spaced substantially from said cover, a downwardly and outwardly extending flue connected to the center opening in said hearth, means to connect said ports and flue, a power driven blower to recirculate convection heating fluid through said means, ports, flue, and chamber, means to heat said fluid at a point removed from said chamber, and a lining of heat and abrasive resistant metal for said chamber flue and means.

SAM F. KEENER.
JAMES H. HOPKINS.