Aug. 26, 1941. K. D. HOKE 2,253,707

CRUCIBLE FURNACE

Filed Dec. 9, 1939 4 Sheets-Sheet 1

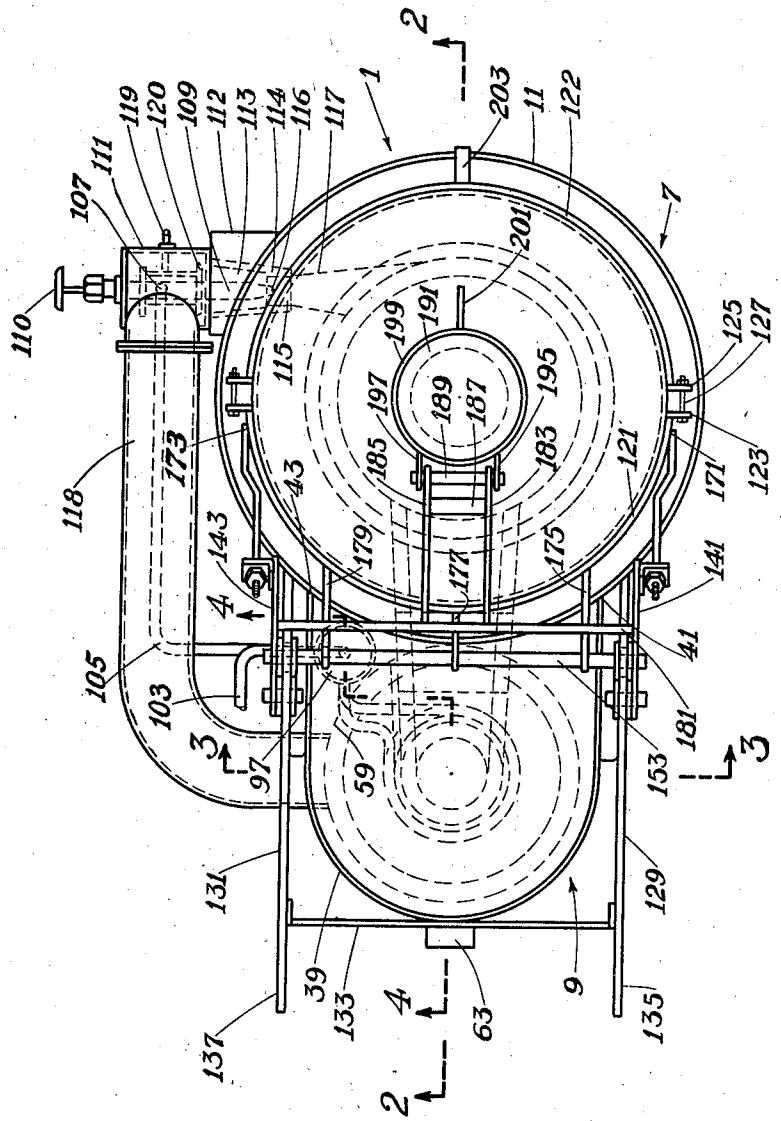


Fig. 1

INVENTOR.
Kenneth David Hoke
BY
Edward H. Lang
ATTORNEY.

Aug. 26, 1941. K. D. HOKE 2,253,707

CRUCIBLE FURNACE

Filed Dec. 9, 1939 4 Sheets-Sheet 2

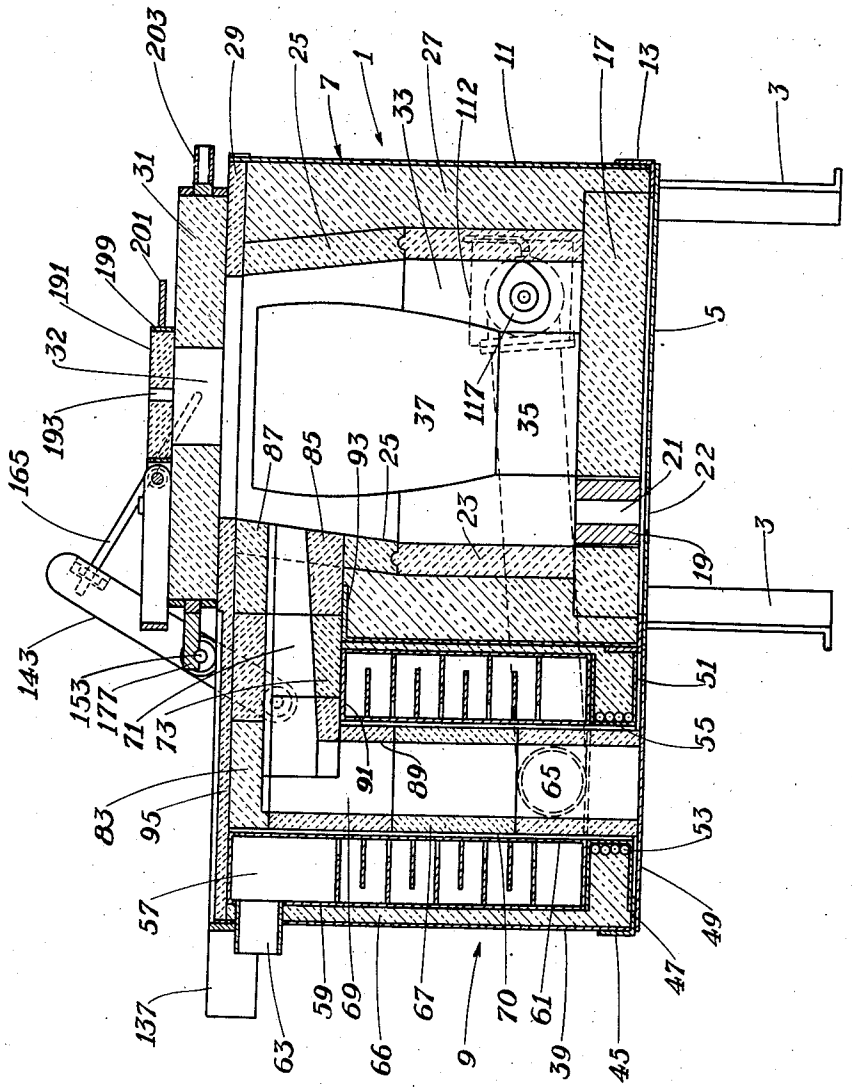


Fig. 2

INVENTOR.
Kenneth David Hoke

BY Edward W. Lang

ATTORNEY.

Aug. 26, 1941. K. D. HOKE 2,253,707

CRUCIBLE FURNACE

Filed Dec. 9, 1939 4 Sheets-Sheet 3

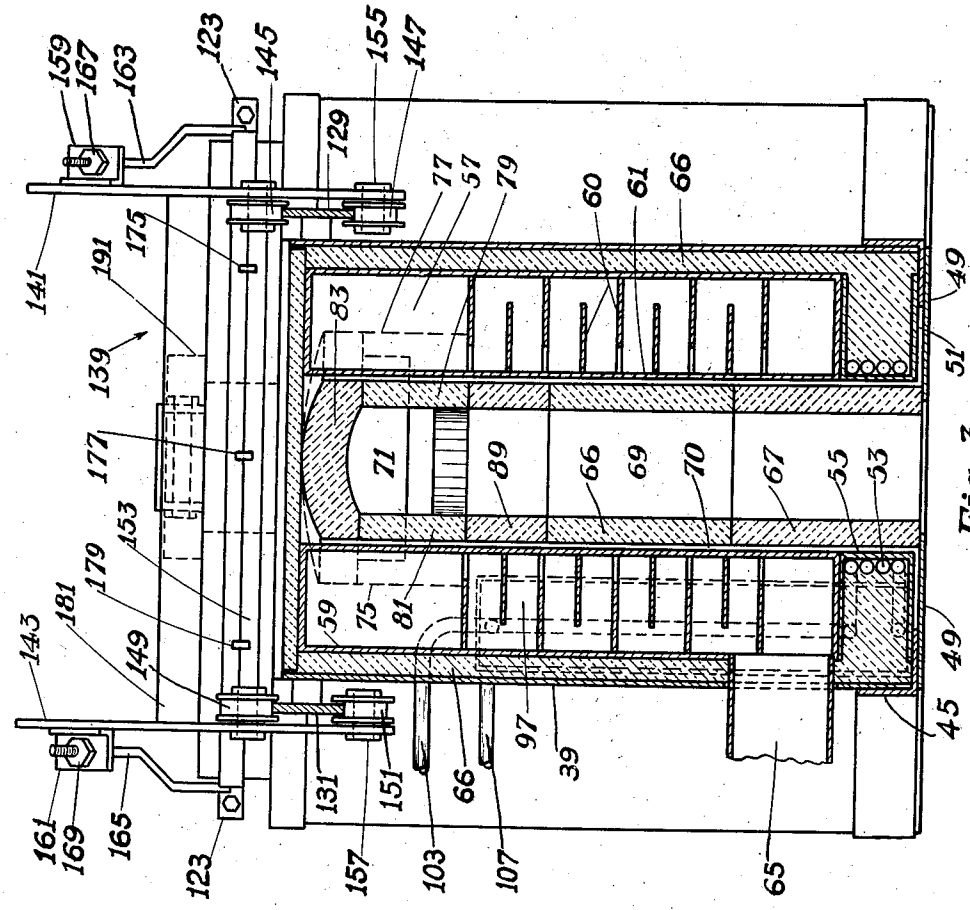


Fig. 3

INVENTOR.
Kenneth David Hoke
BY Edward H Lang
ATTORNEY.

Aug. 26, 1941. K. D. HOKE 2,253,707

CRUCIBLE FURNACE

Filed Dec. 9, 1939 4 Sheets-Sheet 4

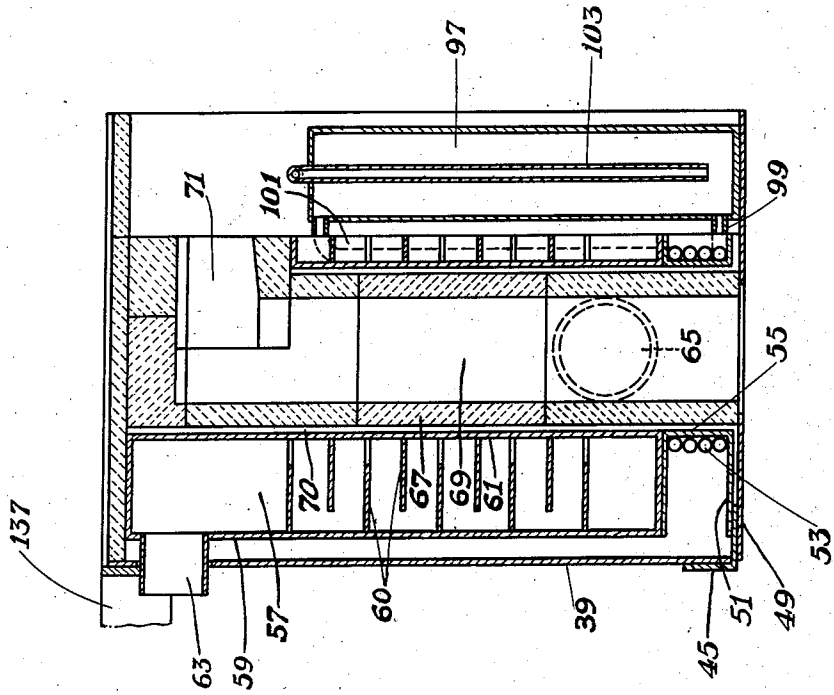


Fig. 4

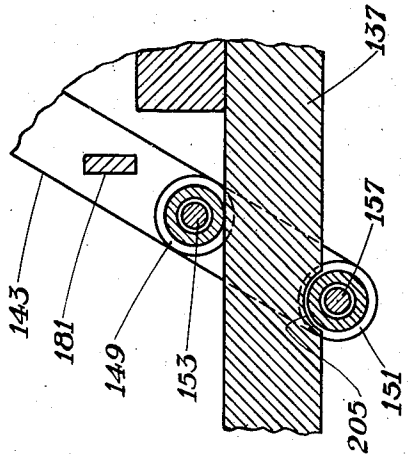


Fig. 5

INVENTOR.
Kenneth David Hoke
BY Edward H Long
ATTORNEY.

Patented Aug. 26, 1941 2,253,707

UNITED STATES PATENT OFFICE

2,253,707

CRUCIBLE FURNACE

Kenneth David Hoke, Chicago, Ill., assignor to Fisher Furnace Company, Chicago, Ill., a corporation of Illinois

Application December 9, 1939, Serial No. 308,419

14 Claims. (Cl. 263—14)

This invention relates to furnaces and the method of operating the same, and more particularly to oil fired or gas fired crucible furnaces.

It is common practice among foundrymen engaged in the manufacture of small castings from high melting point metals and alloys, to melt the charge in a crucible placed in a furnace. These furnaces are generally cheaply constructed, with the result that not only are the fuel costs high because of excessive consumption, but the furnace temperatures are relatively low, requiring long periods for melting, thereby reducing the capacity of the furnace and causing high metal losses by permitting the metal to become gassed.

One of the objects of this invention is to provide a crucible furnace in which high furnace temperatures can be quickly attained and in which the desired temperature can be readily retained.

Another object of the invention is to provide a crucible furnace for burning oil efficiently.

A third object of the invention is to provide a crucible furnace in which the waste heat in the combustion gases can be utilized for preheating the oil and air prior to entering the burner nozzle.

Still another object of the invention is to provide a crucible furnace of unitary and compact construction.

A further object of the invention is to provide an improved carriage and supporting device for the furnace cover.

Other objects of the invention will become apparent from the following detailed description and accompanying drawings of which

Figure 1 is a plan view of a furnace in accordance with the invention;

Figure 2 is a vertical cross-sectional view taken on the line 2—2 of Figure 1;

Figure 3 is a vertical view partly in cross-section, taken on the line 3—3 of Figure 1;

Figure 4 is another vertical cross-sectional view taken on line 4—4 of Figure 1; and

Figure 5 is an enlarged fragmentary, vertical cross-sectional view of one side of the carriage for supporting the cover.

Referring to the drawings, the numeral 1 indicates generally a furnace adapted to be supported above the ground by legs 3. The legs 3 are preferably cast iron angle bars, four in number bolted to a circular steel plate 5 on the bottom of the furnace.

The furnace is built in two main sections, the crucible heating section indicated generally by the numeral 7 and the air preheating section indicated generally by the numeral 9. As shown in the drawing (Figure 1), the crucible heating section 7 is cylindrical in shape. The outermost wall 11 is a cylindrical steel shell approximately 32 inches in diameter and 28 inches high.

Welded to the lower edge of the shell 11 is a circular angle 13 with one side thereof extending horizontally inwardly to provide a surface to which the bottom plate 5 can be welded.

Supported by the angle 13 is the fire brick 17. This brick may be made of cheaper material than the remaining brick with which the furnace is lined and is somewhat smaller in diameter than the shell 11. The brick 19, which is approximately four inches thick and made of silicon carbide, is adapted to fit into a space in brick 17 and form a portion of the bottom lining of the furnace. Brick 19 is provided with a passageway or port 21 through which slag or metal can be withdrawn from the furnace in the event the crucible breaks. The plate 5 is provided with a hole 22 immediately below the port 21 in order to permit the slag to run out the bottom of the furnace.

The interior side walls 23 of the crucible heating chamber are also made of silicon carbide brick. The side wall is circular and formed from circular, semi-circular or arcuate sections of brick about two inches thick. The inside diameter of the crucible heating chamber is 19 inches at the bottom and 17¼ inches at the top. The depth of the chamber is about 22.5 inches. The brick in the lower half of the side wall is tongued on the upper edge and the brick in the upper half is grooved on the lower edge in order to make a tight fit. The bricks 25 on the upper half of the side wall are inclined slightly inwardly toward the top in order to constrict the space between the upper part of the wall and the crucible. This construction tends to keep the hot furnace gases near the bottom of the crucible where the most intense heat is desired.

In building up the interior side wall, the silicon carbide brick is spaced from the steel shell which forms the outer wall. The space between the steel shell and the side wall brick is filled with fire-clay 27, rock wool or other refractory insulation in order to prevent escape of heat from the furnace. The insulation is approximately four inches thick at the lower portion and slightly thicker toward the top.

The top surface of the side wall and fire clay is overlaid with flat silicon carbide brick 29 which provides a surface on which the lid 31, about 24 inches in diameter and 3½ inches thick, can rest. The lid 31 has an opening 32 centrally thereof.

Centrally located in the heating chamber 33

and resting on the floor brick 17 is the crucible block 35 upon which the crucible 37 is adapted to sit when it is being heated. The block 35 is also constructed of silicon carbide or other heat refractory material and is approximately five inches high and somewhat smaller in diameter than the chamber.

The air preheating section 9 has an outer U-shaped steel shell 38 which is welded to shell 11 at 41 and 43. The shell 39 is approximately 19 inches wide. A U-shaped angle 45 is welded to the bottom edge of the shell 39 with one side 47 extending horizontally inwardly. The angle 45 forms a surface to which is welded bottom plate 49.

Supported within the shell 39, immediately above the angle 45 and welded thereto, is the annular steel setting 51 open at its outer edge. A heating coil 53 is nested in the annular space of the setting 51 adjacent the vertical wall 55 thereof.

An annular enclosed steel structure 57 rests on the setting 51 and is preferably welded thereto. The outer wall 59 of the structure 57 is spaced from the shell 39 and extends to the top of the furnace. The annular space of the structure 57 is provided with alternate spaced baffles 60, one set of baffles being welded to the wall 59 and extending horizontally more than halfway to wall 61, and the alternate baffles being welded to wall 61 and extending horizontally more than halfway to wall 59. The annular structure 57 comprises the air preheater. An inlet 63 is provided at the upper end thereof for air induction. An outlet 65 is provided at the bottom of the preheater for withdrawal of air therefrom. The outside diameter of the annular structure 57 is approximately 17 inches and the diameter of the inside wall is approximately 8 inches.

The space between the shell 39 and the outer wall 59 of the air preheater is filled with fireclay, rock wool or other insulation 66 about one inch thick. The space between the wall 55 of the setting 51 and the shell 39 is likewise filled with insulation.

The central portion of the setting 51 and air preheater 57 is lined with silicon carbide brick 67 about one inch thick which may be circular, semi-circular or arcuate shapes adapted to form a circular wall when fitted together. As shown, three tiers of silicon carbide are placed upon each other in order to form a cylindrical flue 69 through which combustion gases from the crucible heating chamber pass before they are exhausted to the atmosphere. The space 70 between the preheater wall and silicon carbide brick lining is filled with silicon carbide granules. The upper end of the flue 69 is connected by a horizontal passageway 71 with the upper portion of the crucible heating chamber. The passageway 71 is built of silicon carbide brick in order to withstand the high temperature of the furnace gases passing therethrough. As shown in Figure 2, the bricks 73 forming the bottom of the passageway 71 are flat on the under side and taper gradually upwardly, in the direction of the crucible chamber. These bricks also taper gradually outwardly in the direction of the crucible chamber so that the passageway is wider at its junction with the crucible chamber than it is at its juncion with the flue 69. The width of the passageway at the former junction is indicated by the dotted walls 75 and 77 (Figure 3) and the width of the passageway at the latter junction is indicated by the walls 79 and 81. The side walls 79 and 81 of the passageway 71 are formed from rectangular shape bricks stood on end against the sides of the floor bricks. The roof of the passageway 71 is formed of arcuate shaped bricks 83 the sides of which are tapered to the same degree as the floor bricks. The roof bricks are adapted to rest on the top of the side wall bricks. The passageway is approximately twelve inches long, three and one-half inches high and five inches wide at its junction with the air preheater, and seven inches wide and two and one-half inches high at its junction with the crucible chamber.

The upper tier 25 of brick forming the interior wall of the crucible chamber has an opening cut out to receive the end bricks 85 and 87. Likewise, the air preheater structure 57 has a section cut out at the top to accommodate the opposite end of the passageway. The floor bricks 73 of the passageway are supported by the upper edge of the flue brick 89, the top plate 91 of the air preheater, the horizontal projection 93 of the shell 11 and the upper edge of brick 25.

Immediately overlying the roof of the passageway and supported at its edges by the fire clay 66 is the thin fire brick 95. This brick is preferably made in sections fitted together but may be in one piece. The brick 95 forms the top of the preheater section.

Referring more particularly to Figures 1 and 4, it will be seen that an oil tank 97 is placed in the space between the shell 11, shell 39 and the outer wall 59 of the air preheater. In Figure 4 the insulation has been purposely omitted in order to more clearly show the tank. The lower end of the tank is connected by means of pipe 99 to the bottom of the heating coil and the upper end of the tank is connected by means of pipe 101 to the top of the heating coil. Fresh oil is pumped to the lower portion of the tank through pipe 103 which enters the top of the tank and extends vertically downward to a level adjacent the bottom of the tank. Hot oil is withdrawn from the top of the tank through the line 105. The line 105 connects from below at the point 107 with the burner nozzle 109 equipped with a conventional control valve 110. The nozzle is set in an enclosed steel casing 111 which is in turn welded or otherwise fastened to the square steel neck 112 welded or otherwise fastened to shell 11 at approximately the level of the crucible block 35. The neck 112 is lined with fire brick and has a central passageway 113 frustro-conical in shape tapering from a larger outside diameter to a smaller inside diameter. A hollow casting 114 having a cylindrical port 115 at its innermost end is adapted to fit in the passageway 113. The tip 116 of the burner nozzle extends into the port 115. A frustro-conical passageway 117 forming the combustion chamber opens tangentially in the lower portion of the crucible chamber at the level of the crucible block 35. This passageway is coincidental with the passageway 113. It will be seen that the diameter of the passageway 117 at the line of meeting with the inside edge of casting 114 is substantially the same as the diameter of the part 115.

A duct 118, three to four inches in diameter, connects the outlet 65 of the air preheater with the casing 111 so that hot air can be admitted to the space surrounding the burner nozzle. The only air which enters the burner opening comes through the duct 118 since the casing 111 is substantially air-tight. The handle 119 on the cas-

ing 111 is connected to a damper 120 adapted to regulate the amount of air admitted to the combustion chamber.

The crucible chamber lid 31, made of silicon carbide is bound by two semi-circular steel bands 121 and 122 having flanges 123 and 125 on each end provided with holes through which bolts 127 are adapted to be passed to hold the bands securely around the cover.

A pair of horizontal steel tracks 129 and 131 are welded to the shell 11 adjacent the top thereof and extend rearwardly along the U-shaped shell 39, spaced a short distance laterally thereof. A cross-bar 133 is welded to each of the tracks adjacent their rear ends 135 and 137 and also welded at its center to the shell 39, thereby forming support for the rear end of the tracks.

Slidably mounted on the tracks is a carriage generally indicated by the numeral 139 (Figure 3). The carriage is constructed of two arms 141 and 143 mounted on tracks 129 and 131 respectively, by means of flanged wheels 145, 147, 149 and 151. The wheels 145 and 149 are rotatably mounted on a shaft 153 which is in turn rigidly mounted between arms 141 and 143. Wheels 147 and 151 are rotatably mounted on pins 155 and 157 which are in turn rigidly fastened to the lower ends of the arms 141 and 143, respectively. The distance between wheels 145 and 147 and between 149 and 151 is such that the track will fit snugly between them when the arms 141 and 143 are in substantially vertical position.

Angles 159 and 161 are welded to the arms 141 and 143, respectively adjacent the upper ends thereof. The angles have holes bored therethrough through which are adapted to pass the upper ends of rods 163 and 165 respectively. The upper ends of the rods 163 and 165 are threaded in order to receive nuts 167 and 169. The lower ends of the rods 163 and 165 are welded at 171 and 173 respectively to the band 121 surrounding the lid 31. The lid 31 is additionally fastened to the carriage by means of the spaced rods 175, 177 and 179 welded at one end to the shaft 153 and at the other end inserted in a hole in and welded to the band 121.

A cross-bar 181 is welded between arms 141 and 143 above shaft 153. To cross-bar 131, adjacent the center thereof, are welded spaced, horizontally extending arms 183 and 185. These arms are supported on lid 31. Adjacent the other end of the arms 183 and 185 is welded a cross-bar 187 and the ends of the arms have holes bored therethrough to receive a pin or shaft 189.

A second circular lid or cover 191 made of silicon carbide about ten inches in diameter and one and one-half inch thick is mounted over the opening 32 in the lid 31. The cover 191 has a small opening 193 centrally thereof in order to permit observation of the crucible contents, furnace flame and temperature without opening the cover. The cover 191 is rotatably mounted by means of arms 195 and 197 on shaft 189. The arms are welded to a steel band 199 surrounding the cover 191. A steel rod 201 is welded to the band 199 at the front end in order to permit the cover 191 to be swung open.

A short hollow stem 203 is welded to the steel band 122 at the forward end of the cover 31 in order to permit a bar to be inserted therein when it is desired to roll the cover and carriage backward on the tracks.

Referring more particularly to Figure 5, the bottom edge of tracks 129 and 131 have an arcuate cut-out 205 conforming to the periphery of the wheels 147 and 151 and is adapted to receive these wheels. The notches or cut-outs 205 are so located that when the wheels 147 and 151 are seated therein the arms 141 and 143 tip forward and permit the lid 31 to close over the top of the crucible chamber as shown in Figure 2. When it is desired to open the crucible chamber a rod is inserted in stem 203 and the front end of the lid 31 is lifted until rods 141 and 143 are in substantially vertical position and the carriage is then pushed rearwardly. As soon as the wheels 147 and 151 engage the straight under-side of the track, the lid 31 will be held in a suspended, open position.

It will be understood the dimensions have been given in order to furnish some idea of the relative sizes of the various parts of the furnace. Although the figures given are typical of commercial crucible furnaces, they may be larger or smaller as necessity dictates.

To operate the furnace, the covers 31 and 191 are opened and the crucible placed on the crucible block. The crucible is filled with the desired metal or alloy in solid form and the covers closed. The pump for pumping oil into tank 97 and the air blower which forces air into inlet 63 are started, the valves controlling the air and oil at the burner nozzle are opened and the oil issuing from the burner nozzle ignited. When the initial charge of metal or alloy is melted, the cover 191 is opened and additional metal is charged to the crucible until the crucible is full. The cover is closed and the crucible and contents heated until they reach a temperature suitable for pouring, whereupon the cover 31 is lifted upwardly and the carriage pushed backwardly until the cover clears the top of the crucible chamber. The crucible is withdrawn, the contents poured and the crucible recharged for the next melt.

In a typical operation in which red brass was melted, from 31 to 34 minutes were required to melt a charge weighing 210 pounds and bring it to pouring temperature, whereas with crucible furnaces now in general use, from 45 to 55 minutes are required. The gases in the crucible chamber attained a temperature of approximately 2900–3100° F. and the metal was poured at a temperature of 2300° F. The temperature of the gases entering the flue 69 was approximately 2900° F. and the temperature of the combustion gases leaving the flue was approximately 2400° F. The air was preheated to approximately 350° F. and the oil charged to the burner was preheated to a temperature between 300° and 350° F. Four gallons of fuel oil were consumed. The fuel consumption represented a saving of 25% to 30% over that used in crucible furnaces of conventional type.

The figures given above, of course, will vary with different charging material. If desired, the oil may be preheated to a temperature between 200–500° F. or more and the air may be preheated to temperatures between 350–500° F. if desired. By preheating the oil to higher temperature approaching or above the flash point, instantaneous and substantially complete complete combustion of the oil will take place in the combustion chamber.

The tank 97 has been found to be essential if clogging of the oil line is to be avoided. By providing a reservoir of relatively cool oil which can cyclicly circulate between the tank and the heating coil 53, overheating of oil remaining in

the coil when the burner is shut off between heats, with attendant carbonization and clogging of the coil is avoided. The air preheater structure, particularly the silicon carbide lining **89**, remains intensely hot for some time after the burner is shut off. If oil were permitted to remain stagnant in the coil **53**, the intense heat of the preheater would crack and carbonize it. The tank, which may have a capacity of approximately two and one-half gallons for a furnace of the dimensions above given, contains a sufficient quantity of oil so that it is not raised between heats or at any other time, to a temperature at which the oil or other fluid fuel will crack.

It will be seen that I have succeeded in providing a furnace of novel design and construction which is capable of melting metals much more rapidly than was heretofore possible with crucible furnaces now in use and which effects a considerable saving in fuel. The construction also facilitates the charging and discharging of the furnace and a more accurate control of conditions within the furnace is possible by virtue of preheating and control of the fuel and air. Not only can temperature conditions be controlled, but a neutral, reducing or oxidizing atmosphere can be maintained as desired.

I claim:

1. An integral crucible furnace comprising a crucible heating section and an air preheating section both of which are surrounded by insulation, said crucible heating section having a heating chamber and said preheater section having a vertical annular closed air preheating chamber, a combustion chamber in open communication with said heating chamber, a burner extending into said combustion chamber, a passageway for combustion gases connecting the upper part of said heating chamber to the upper part of the central passageway of said air preheating chamber, an inlet and outlet for air connected to said preheating chamber, a closed duct connecting said outlet to said combustion chamber, an oil tank located in said air preheating section, a heating coil connected to said tank in such manner as to permit cyclic circulation of oil through the coil, said coil being located beneath said preheater chamber and in heat exchange relation with flue gases leaving the furnace, and a conduit from said tank to said burner.

2. In connection with a crucible furnace having an open top heating chamber, a pair of tracks mounted on said furnace, a carriage slidably mounted on said tracks, said carriage comprising a pair of upstanding arms having wheels rotatably mounted thereon which engage both lower and upper edges of said tracks, recesses in said tracks adapted to cooperate with said wheels, a cover for said chamber rigidly mounted on said carriage and adapted to be held normally in open position and to be supported in closed position when said wheels engage said recesses.

3. The structure in accordance with claim 2 in which the cover has an opening centrally thereof, a second smaller cover adapted to close said opening, said second cover being pivotally connected to said carriage so that the cover can be swung open.

4. In a method of heating a furnace, the steps which comprise charging preheated fluid fuel to a burner in the furnace and there igniting the fuel, preheating the fuel by means of waste heat in the combustion gases resulting from burning the fuel, said combustion gases being of sufficiently high temperature to carbonize the fuel if it were allowed to remain static in the preheater and cyclicly circulating the preheated fuel to a body of relatively cool fuel and from said body back to said preheater when the burner is shut off in order to prevent carbonization of the fuel in the preheater by means of the hot surfaces contiguous thereto.

5. The steps in accordance with claim 4 in which the fuel is fed from said body to said burner.

6. A crucible furnace comprising a crucible heating chamber, a combustion chamber in open communication therewith, a burner located in said combustion chamber, an air preheater having an inlet and outlet, a closed duct connecting said outlet to said combustion zone, means for passing combustion gases from said crucible chamber into heat exchange contact with said air preheater, a heating coil arranged in heat exchange relation with said combustion gases leaving said crucible chamber, a tank connected at opposite ends to said heating coil and a conduit connecting said tank to said burner.

7. In a crucible furnace comprising a crucible heating section and an air preheating section, means for internally heating said crucible heating chamber and means for feeding preheated air to said heating means, a passageway connecting the upper portion of said crucible heating chamber to said air preheating chamber, the height of said passageway at its juncture with said crucible heating chamber being relatively small and gradually increasing in height toward its juncture with said air preheating section, but the cross-sectional area along the entire length thereof being substantially the same.

8. In connection with a crucible furnace having an open top heating chamber, the structure comprising a horizontal track, a carriage slidably supported on said track by means of a pair of spaced members one of which is adapted to engage the top surface of said track and the other of which is adapted to engage the bottom surface of said track, a cover for said chamber rigidly mounted on said carriage, said track being of such varying width and said members being spaced apart such a distance that when the cover is directly over the opening of said chamber, the carriage will be in such position that the cover rests on the top of said chamber, but when the carriage is pushed back along the track so as to expose the opening of the chamber, the carriage will hold the cover in suspended position.

9. The structure in accordance with claim 8 comprising a plurality of said tracks upon which the carriage is adapted to slide by means of a plurality of pairs of said spaced members.

10. In connection with a crucible furnace having an open top heating chamber, the structure comprising a horizontal track supported by said furnace, a carriage slidably mounted on said track by means of a pair of spaced wheels, one of said wheels being adapted to ride on the bottom surface and the other wheel being adapted to ride on the top surface of said track, a cover for said chamber rigidly mounted on said carriage, said track being of such varying width and said wheels being spaced apart such a distance that when the cover is directly over the opening of said chamber, the carriages will be in such position that the cover will rest on the top of said chamber, but when the carriage is pushed back along the track so as to expose the opening of the

chamber, the carriage will hold the cover in suspended position.

11. The structure in accordance with claim 10 including a plurality of said horizontal tracks, on which the carriage is adapted to slide by means of a plurality of pairs of said spaced wheels.

12. In connection with a crucible furnace having an open top heating chamber, the structure which comprises a horizontal track mounted on said furnace, a carriage slidably mounted on said track by means of a pair of spaced wheels one of which is adapted to ride along the bottom surface and the other along the top surface of said track, a cover for said chamber rigidly fastened to said carriage, said track being of such width and said wheels being spaced apart such a distance that when the carriage is in such position that the cover is not directly over the top of said chamber, the carriage holds the cover in suspended position, a recess in a surface of the track into which the wheel adapted to roll along said last mentioned surface is adapted to fit, said recess being in such a position and of such depth that when said wheel is recessed therein said cover is directly over said heating chamber and the carriage is in such position that said cover rests on the top of said chamber.

13. The structure in accordance with claim 12 comprising a plurality of said tracks on which the carriage is adapted to slide by means of a plurality of pairs of said spaced wheels.

14. A furnace comprising a heating chamber, a burner connected to said heating chamber, a source of liquid fuel supply connected to said burner, a preheating coil located in a portion of said furnace which is adapted to be heated to high temperatures by means of waste combustion gases from said chamber, an auxiliary reservoir for said fuel, means for continuously circulating fuel from said reservoir to and from said preheating means, when said burner is shut off and while said portion of the furnace in which the preheating means is located is hot, and means for feeding preheated fuel to said burner.

KENNETH DAVID HOKE.