March 17, 1936. A. A. WICKLAND 2,034,071

METALLURGICAL FURNACE

Filed Aug. 15, 1932 5 Sheets-Sheet 1

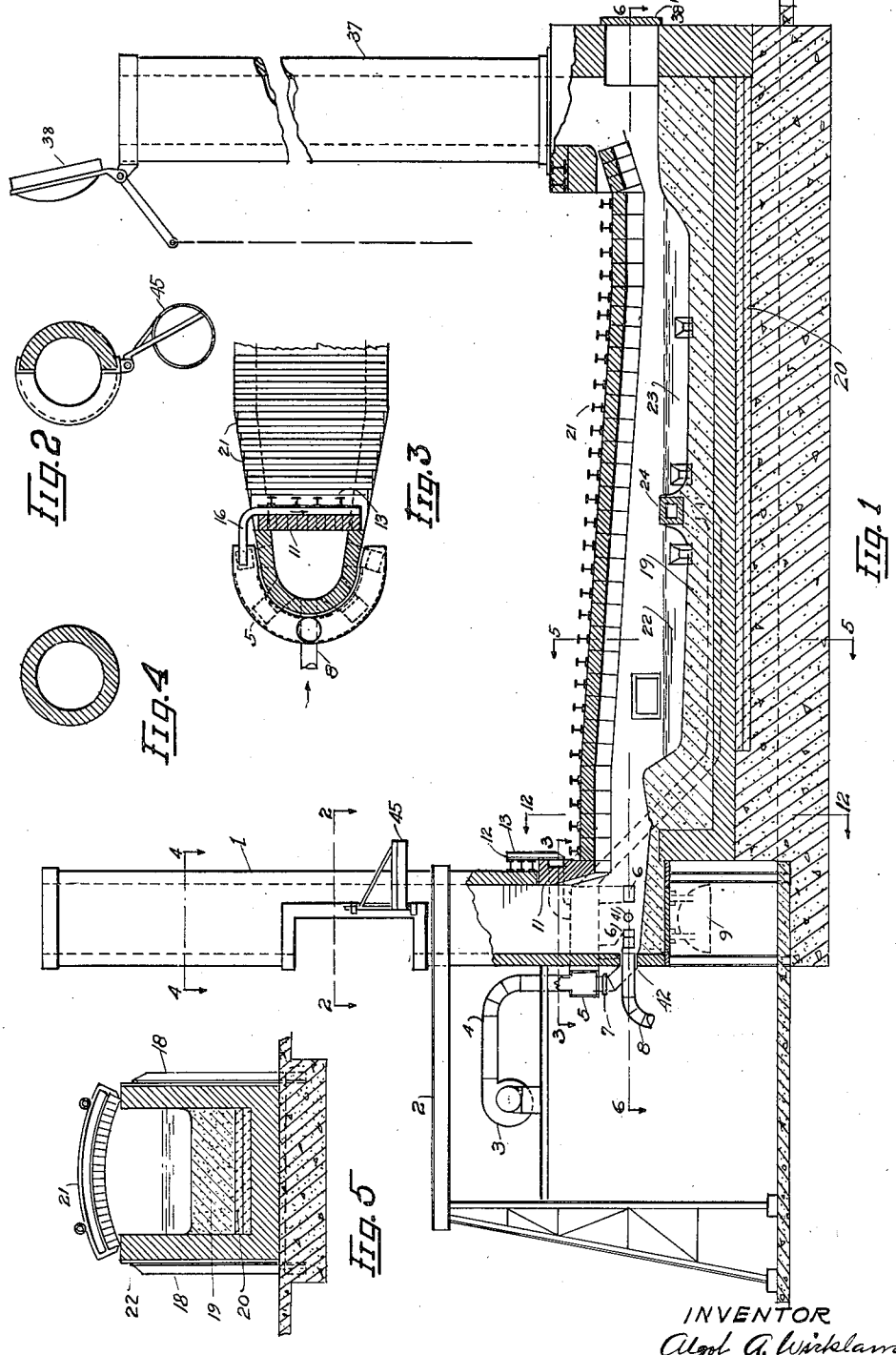


Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

INVENTOR
Algot A. Wickland
BY Jno. E. Blomstran.
HIS ATTORNEY.

March 17, 1936. A. A. WICKLAND 2,034,071

METALLURGICAL FURNACE

Filed Aug. 15, 1932 5 Sheets-Sheet 2

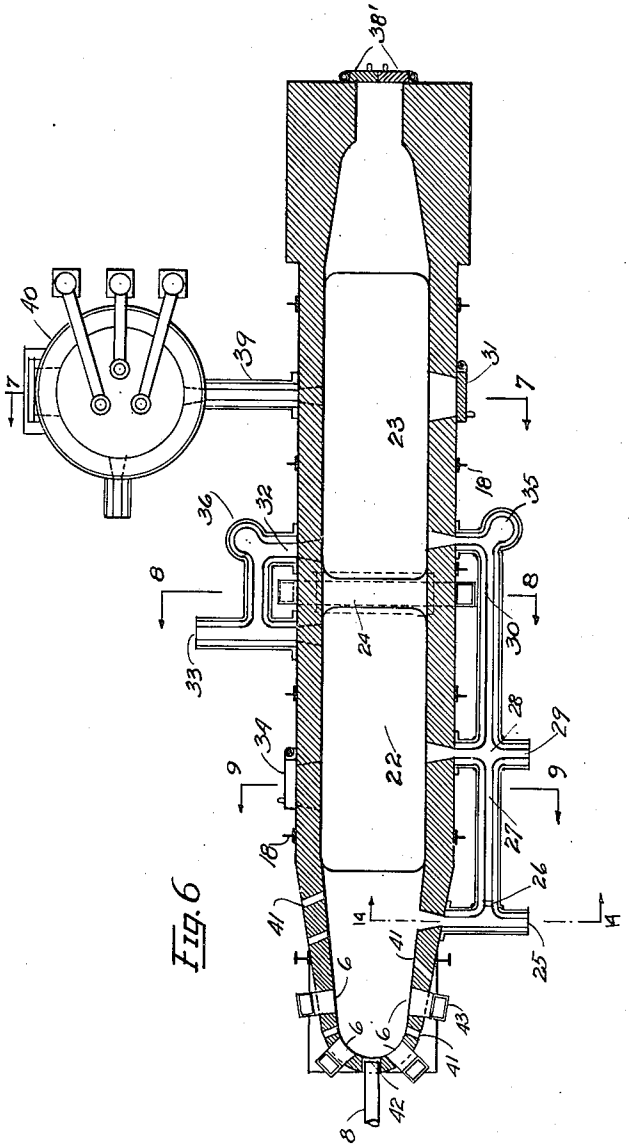


Fig. 6

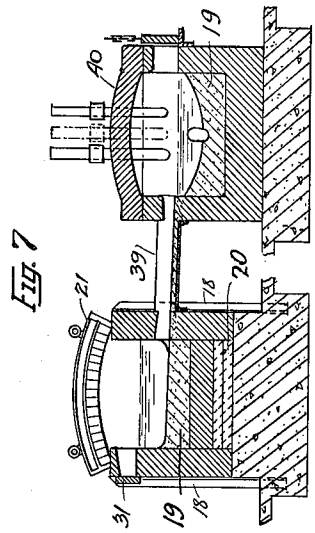


Fig. 7

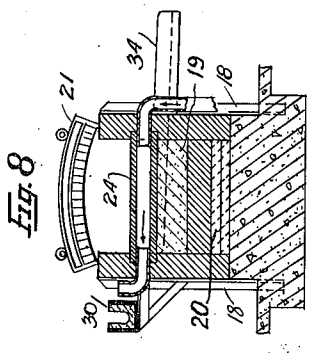


Fig. 8

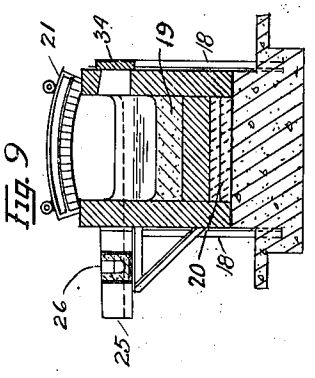


Fig. 9

INVENTOR
Algot A. Wickland
BY
Wm. G. Blomstrom.
HIS ATTORNEY.

March 17, 1936. A. A. WICKLAND 2,034,071

METALLURGICAL FURNACE

Filed Aug. 15, 1932 5 Sheets-Sheet 3

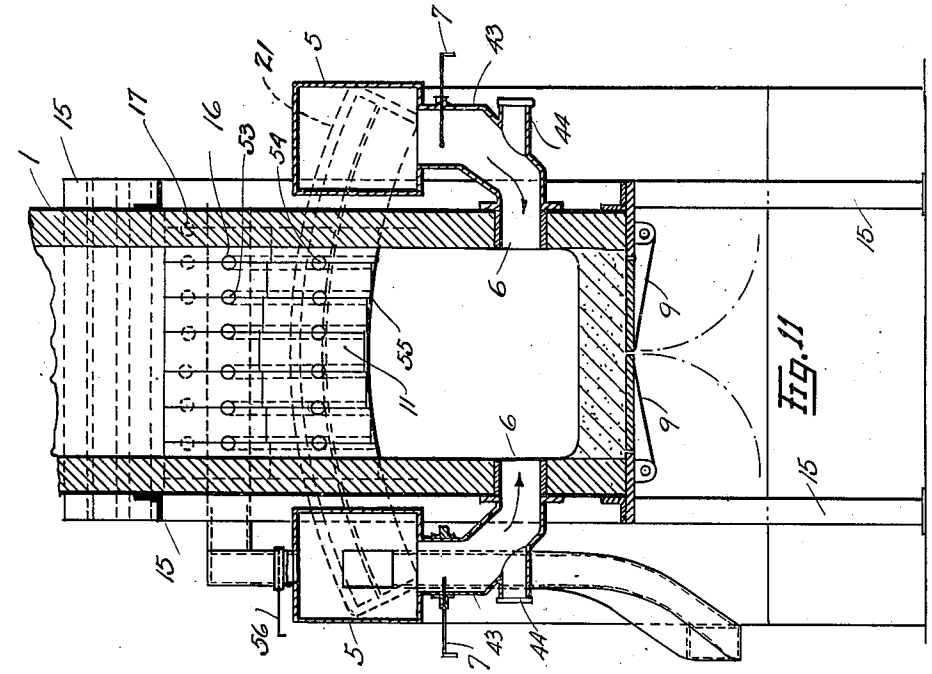


Fig. 11

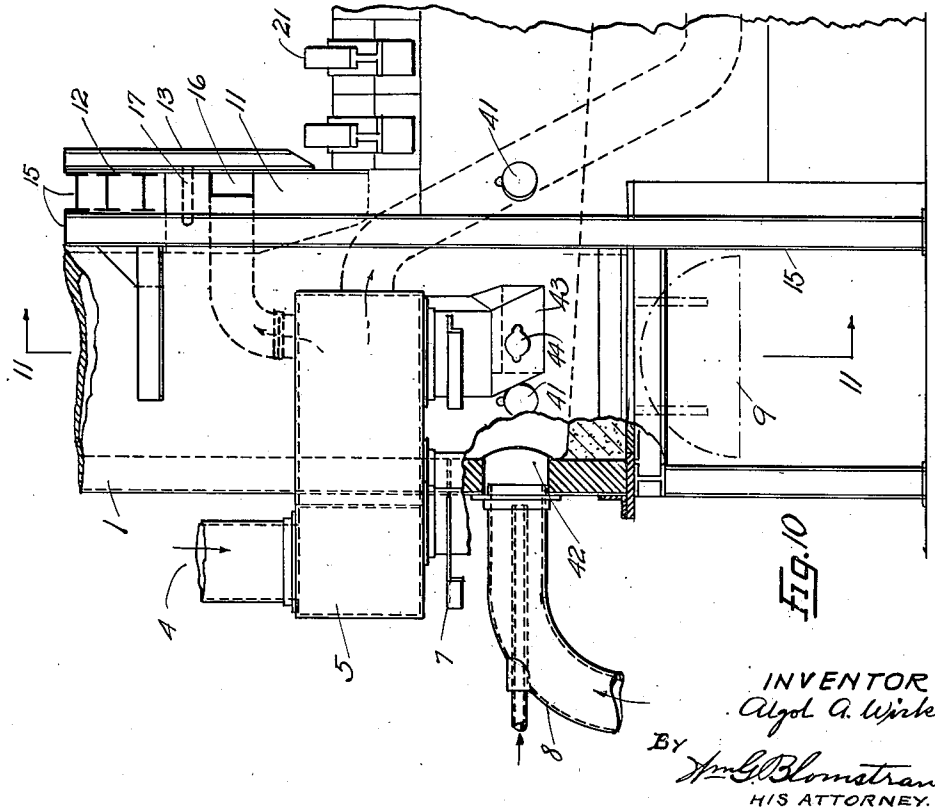


Fig. 10

INVENTOR
Algot A. Wickland
By Wm. G. Blomstrom.
HIS ATTORNEY.

March 17, 1936. A. A. WICKLAND 2,034,071

METALLURGICAL FURNACE

Filed Aug. 15, 1932 5 Sheets-Sheet 4

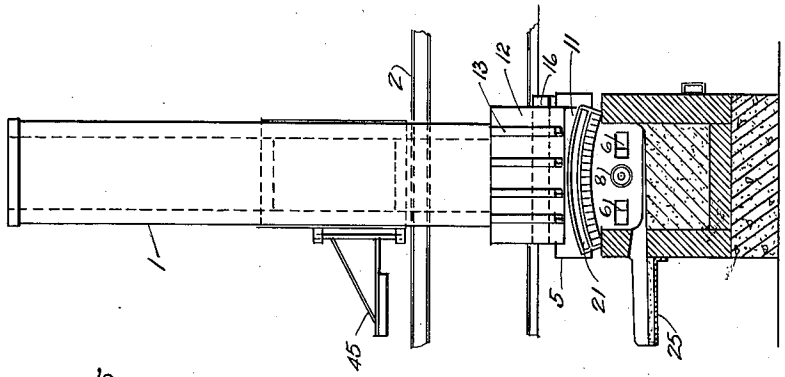


Fig. 12

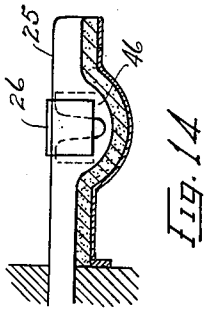


Fig. 14

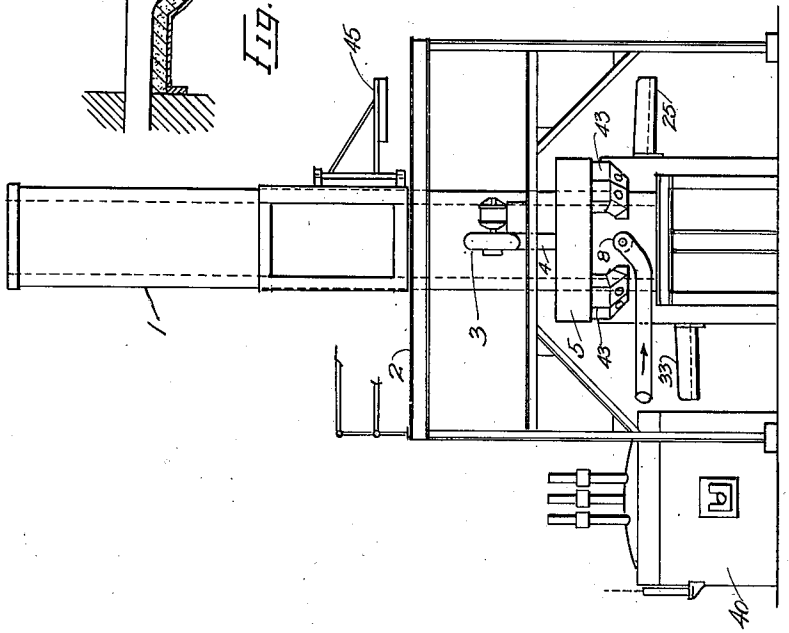


Fig. 13

INVENTOR
Algot A. Wickland
BY Emil J. Blomstrom.
HIS ATTORNEY.

March 17, 1936. A. A. WICKLAND 2,034,071

METALLURGICAL FURNACE

Filed Aug. 15, 1932 5 Sheets-Sheet 5

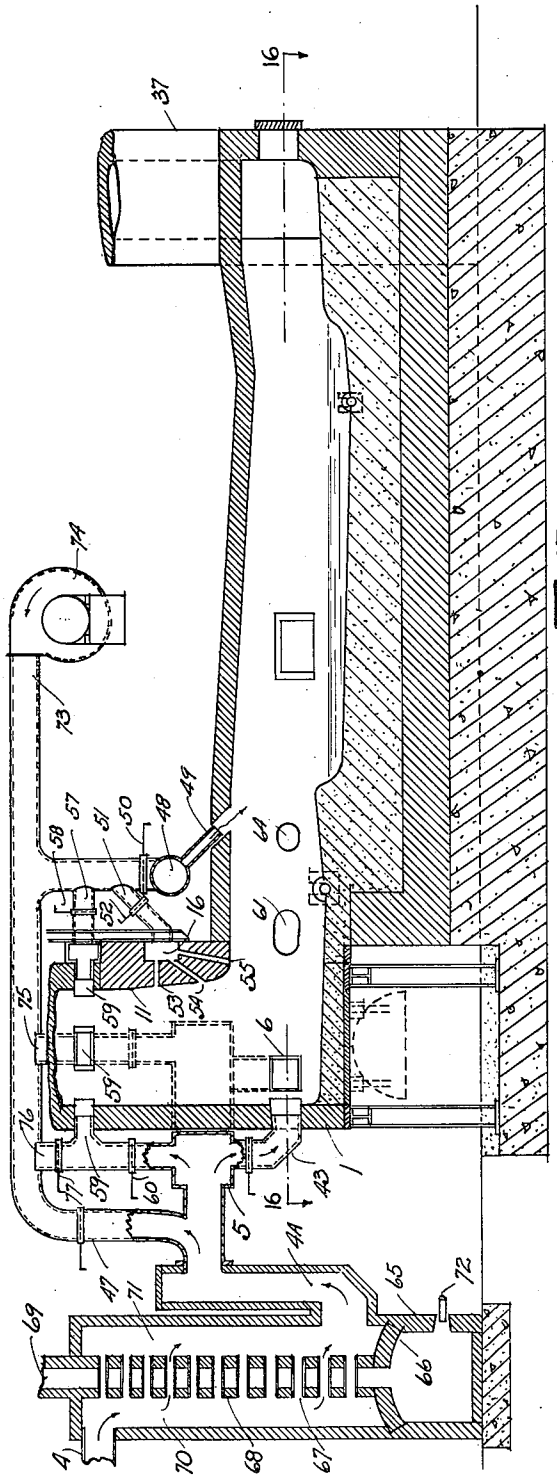


Fig. 15

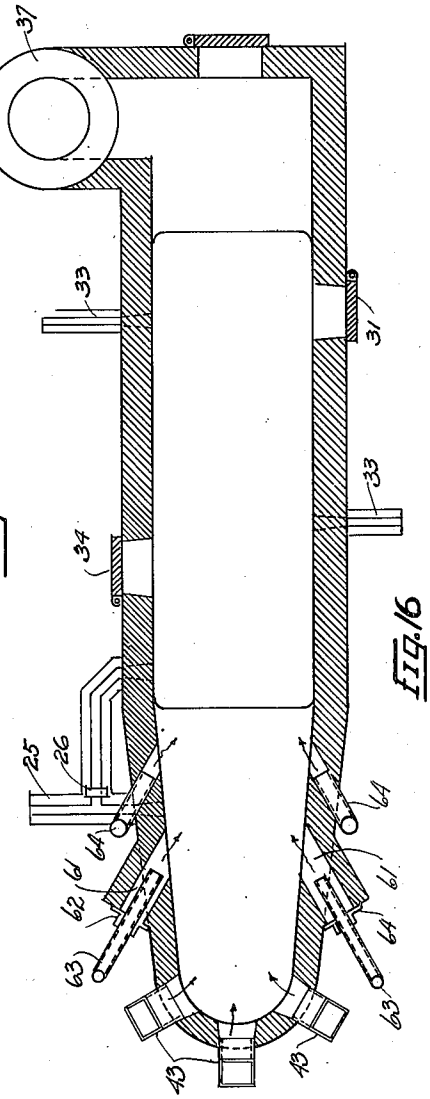


Fig. 16

INVENTOR
Alfred A. Wickland
By Wm. G. Bonnstrau.
HIS ATTORNEY

Patented Mar. 17, 1936

2,034,071

UNITED STATES PATENT OFFICE

2,034,071

METALLURGICAL FURNACE

Algot A. Wickland, Chicago, Ill.

Application August 15, 1932, Serial No. 628,857

8 Claims. (Cl. 266—24)

My invention relates to improvements in reverberatory metallurgical furnaces wherein are embodied the useful features of continuous charging, melting, and refining of metal.

One object of my invention is to provide a reverberatory furnace which facilitates continuous or intermittent operation wherein the metal is preheated, melted and refined to any degree desired preparatory to final treatment in an electric furnace.

A further object of my invention is to provide a reverberatory furnace which will eliminate the objectionable features and uncertainties of cupola melting and incorporate the desirable features found in air furnace operation. By combining the advantages of continuous charging and melting as practised in cupola operation together with means for continuous slagging, co-ordinated with an integral furnace combustion chamber, material economies in fuel consumption are attained and perfect control of the atmospheric condition within the furnace is at all times obtainable, and by embodying means to supply auxiliary fuel and air it follows that this construction offers a most ideal furnace for economical melting and refining of ferrous and non-ferrous metals.

Another object of my invention is to combine the outstanding features of cupola melting with that of standard box type reverberatory furnaces for the purpose of obtaining higher thermal efficiency and provide means for proper control of treatment of metals during the melting and refining processes.

A further object of my invention is to provide a reverberatory furnace adapted for continuous or intermittent melting and refining of metals, in small or large quantities as desired.

Another object of my improvement is to provide a reverberatory melting furnace which may be charged continuously or intermittently either mechanically or manually, as desired.

A further object of my invention is to provide a reverberatory furnace wherein the metal is pre-heated, melted and refined in successive stages before final treatment in an electric furnace.

Another purpose of my invention is to provide a rapid and efficient reverberatory furnace for melting and refining of ordinary gray iron, high test gray iron, cupola malleable, refined malleable, low carbon and alloy steel, electric steel, also non-ferrous metals.

A further object of my invention is to provide a melting furnace adapted for continuous or intermittent charging of melting stock wherein various fuels, such as coke, bituminous coal, powdered coal, fuel oil or gas, may be utilized singly or in combination, including electricity, should the molten metal require further alloy additions, refining and super-heating.

A further object of my improvements is to provide means whereby air furnaces now in use may be equipped for continuous charging of melting stock and fuel, thereby permitting continuous or intermittent melting and refining of metals.

Another object of my invention is to provide melting furnaces wherein the absorption of sulphur and carbon by the metal from the fuel will be reduced to a minimum.

One of the objects of my invention is to provide controllable means to obtain complete combustion of solid, liquid and gaseous fuels within the melting zone and combustion chamber. In a standard cupola, the products of combustion ascend vertically through superimposed layers of melting stock and solid fuel generating CO gas which escapes unburned to the atmosphere. In my invention this gas is directed to flow horizontally and burn within the combustion chamber thereby materially increasing the thermal efficiency of the furnace.

Another object of my invention is to reduce the maintenance cost of refractory materials. In operating a standard air furnace it is necessary to remove a part of the roof each time the furnace is charged. This entails a large waste of residual heat and the refractory lining in the roof and side walls is subjected to excessive temperature changes which quickly deteriorates the fire brick.

A further object of my improvement is to secure the greatest possible thermal efficiency of the furnace by increasing the effectiveness of the radiate heat. In an air furnace the melting chamber volume must be sufficiently large to receive the cold metal charge, consequently when this material is melted the distance from the surface of the molten metal in the hearth to the roof is much greater than required for the passage of combustible gases and it follows that the radiant heat acting upon the molten metal is less intense resulting in a corresponding reduction in heat transfer and lowering of thermal efficiency.

These and other objects and features of my improvements will be clearly presented in the several illustrations shown on the accompanying drawings and described more fully in the following specification and more particularly pointed out in the appended claims.

In the accompanying drawings, Fig. 1 represents a side elevation and partial longitudinal sectional view of the entire furnace embodying my improvements, showing an upright compartment or cupola furnace for receiving solid fuel and metal charges, and an arrangement of tuyères for admission of air required for combustion, liquid or gaseous fuels, a section of the melting zone and combustion chamber including a transverse bridge for separating the molten metal within the furnace, and also a stack or chimney through which the waste gases may escape to the atmosphere.

Fig. 2 is a cross section on line 2—2 of Fig. 1 through the charging door. This view also shows a hinged damper.

Fig. 3 is a cross section and plan view on line 3—3, Fig. 1 showing the wind box, air cooled breast forming a sectional wall and a roof over the duct leading to the combustion chamber. This view also shows a partial plan of the roof bungs above the combustion chamber.

Fig. 4 is a cross section of the upright compartment on line 4—4, Fig. 1.

Fig. 5 is a cross section through the furnace showing the removable arched roof, also side walls and furnace bottom taken on line 5—5, Fig. 1.

Fig. 6 is a cross sectional plan view of the entire furnace taken on line 6—6, Fig. 1. This view shows that relative-arrangement of tuyères, sight holes, openings for liquid and gaseous fuels, arrangement of tap spouts and troughs for slagging and transferring the metal from one hearth to another, tap spouts, pour backs and spout leading to electric furnace. Hinged inspection doors are shown on each side of the furnace also at the base of the stack.

Fig. 7 is a cross section on line 7—7, Fig. 6, through the combustion chamber of the reverberatory furnace and an electric furnace with a spout connection for the transferring of metal.

Fig. 8 is a cross section of the reverberatory furnace on line 8—8, Fig. 6, indicating the method of ventilating the center bridge also the relative positions of transfer trough and tapping spout.

Fig. 9 is a cross section taken on line 9—9, Fig. 6, showing the relative position of the hinged inspection door, slag spout and the longitudinal trough for transferring the metal.

Fig. 10 is a side elevation showing the lower portion of the upright or vertical compartment and the adjoining combustion chamber. This view also indicates the wind box and tuyère connections including the piping arrangement for powdered coal, gas or liquid fuel. It indicates, by dotted lines, air blast connections for ventilating the breast and the dividing bridge inside the furnace. Structural steel supports for carrying the breast and method of holding the refractory tile in place are also indicated.

Fig. 11 is a cross section on line 11—11, Fig. 10, looking towards the combustion chamber. This view illustrates a method of supporting and suspending the tile which constitutes the breast. It also shows cross sections of the wind box and tuyère connections including the hinged doors at the bottom of the vertical compartment.

Fig. 12 is a cross section taken on line 12—12, Fig. 1, also an elevation showing the rear view of the vertical charging shaft.

Fig. 13 is a front elevation showing the vertical or charging compartment with door openings, hinged damper, and charging platform. It also indicates the piping for powdered coal, liquid or gaseous fuel, arrangement of tuyères and wind box including a pressure blower mounted on a platform directly below the charging platform proper.

Fig. 14 is a cross section through the slag spout on line 14—14, Fig. 6.

Fig. 15 is a vertical longitudinal sectional view of a modified type of furnace having a single hearth, top and bottom tuyères, and auxiliary fuel and air ducts beyond the base of the upright charging compartment or cupola, auxiliary blower and cool air piping for the upper tuyères and other openings for air blast connections. A recuperator or heater for the primary air required for combustion is also shown.

Fig. 16 is a cross sectional plan of the furnace on line 16—16, Fig. 15. This view shows the relative position of the lower tuyères and auxiliary air and fuel inlet ducts, including slag spout, furnace doors, waste gas stack and tapping spouts. The stack is not shown in section.

Similar characters refer to similar parts throughout the several views.

Referring to Fig. 1, this illustration shows the adaptation of a vertical charging compartment or cupola providing a pre-melting furnace with a longitudinal box type combustion chamber. The vertical furnace, 1, consists of a steel shell, lined with fire brick from top to bottom. This furnace may be rectangular or circular in cross section, the latter form being shown in Fig. 4. To carry away burnt gases this furnace is extended up through the roof of the building in which it may be installed, and, to facilitate charging, an opening is provided slightly above the charging platform, 2, as shown. During certain intervals, as will be explained later, the hinged damper, 45, is placed in position within the cupola to check the flow of gases which may ascend to the atmosphere.

The charging platform, 2, may be of any convenient height and size and means for manual or mechanical charging, not shown on the drawings, of fuel and melting stock may be located on this platform.

For the purpose of clearness, a motor driven pressure blower, 3, with pipe connection 4, to the wind box, 5, is shown mounted on a balcony below the charging platform; however, this blower may be located elsewhere at any convenient distance. The wind box, 5, surrounds the cupola in a semicircle with tuyère boxes for conducting air under pressure to the respective openings, 6, within the fire brick lining. These tuyère boxes are equipped with dampers or sliding gates 7, for the purpose of controlling the quantity of air passing through each tuyère. Interposed between the tuyères a fuel pipe connection 8, is provided which terminates within an opening through the fire brick lining and it serves the purpose of directing the passage of powdered coal, gas or liquid fuel, singly, or in combination, into the melting zone and combustion chamber.

The cupola, 1, is supported on a structural steel framing of suitable design to carry the weight, and the bottom of the cupola is closed by two hinged doors, 9. When the furnace is in operation these doors are held in a closed position by steel props extending to the floor as shown on the drawings, Fig. 13. Above these doors, 9, a sand bottom or floor is prepared to support the solid fuel, metallic charges and receive the molten metal.

It should be noted that the lower section of furnace or cupola 1, is cut away to provide a large side opening forming a gas passageway into the combustion chamber. This opening or throat is subjected to extremely high temperatures and it

follows that the construction of this part of the furnace is of great importance. For this purpose a roof bridge or breast, 11, consisting of a plurality of ventilated refractory tile, as is shown in section in Figs. 1 and 3, and in elevation Fig. 10, and in sectional views 11 and 12, is provided. These tiles are resting against a steel plate 12, securely supported by brackets, 13, and these in turn are carried by a structural steel frame, 15, extending to the floor as shown in Fig. 10. The bridge tile, 11, has a notch, 16, forming a continuous channel for the passage of air from the blower through the blast pipe connection to the wind box, 5, see Figs. 11 and 10.

As described, the breast tile are subjected to considerable abrasion due to the action of the metallic charges and solid fuel. They are also subjected to high furnace temperatures, and it follows that they must be replaced at intervals. To facilitate this work each tile is provided with grooves on their sides for suspension on steel rods or brackets, 17, carried by the supporting members, 13. It is intended that the breast tile be laid up without cement or mortar to permit the ventilating air to escape between the joints, thereby carrying away excessive heat, prolonging the life and usefulness of the breast.

As may be seen in Figs. 11 and 15, the refractory tiles, 11, are also provided with grooves on the sides extending from recess 16. When the tiles are placed in position these grooves form ducts or openings 53, 54, 55 for the passage of air into the melting zone within the vertical shaft.

It should be noted that the blast pipe connection leading to the wind box is provided with a damper 56 to control the volume of air entering the furnace through channel 16, and ports 53, 54, and 55 in the breast tile.

The combustion chamber as shown in Fig. 1, consists of refractory side walls resting on a concrete foundation, these walls being covered on the outside with sheet steel or cast iron plates held in position by heavy buck stays, 18, securely tied together and anchored in the concrete foundation. The furnace bottom consists of packed silica sand, 19, or similar material, resting upon insulating brick, 20. The roof of the furnace consists of a plurality of removable bung castings, 21, adapted to hold "circular" refractory brick in the shape of an arch; these roof bungs may be removed when it is necessary to make repairs to the furnace bottom or replace the side wall lining.

Referring to Fig. 6, it will be seen that the furnace bottom is divided into two hearths or sections, 22 and 23, having a ventilated refractory bridge or dam 24, which separates the metal-holding chamber into two compartments. Figs. 1, 6, and 8, indicate the means employed for ventilation by passing cold air through this bridge.

During the melting operation it is essential to remove the slag which forms in the melting zone and collects on the bottom of the pre-melting furnace 1; and for this purpose, slag spout, 25, is provided, see Figs. 6 and 9. The furnace slag being lighter than the metal will float on top and separation takes place when the metal passes under dam 26, causing the slag to be discharged through spout 25, while the molten metal is conducted through trough 27, and intersection, 28. At this point the metal may be directed into hearth, 22, or it may be removed at tap spout 29. For certain metallurgical treatment it will be necessary to pass the metal through trough, 39, into hearth, 23, for final treatment.

Inspection door, 31, is provided to permit the introduction of ores and ferro alloys, cold metal charges, soda ash and various other materials necessary to obtain the desired chemical composition of the metal. A spout, 32, is provided for conveying the metal either to the tap spout, 33, or into hearth, 22, as may be desired. A door, 34, is provided in the side wall of the furnace for treatment of the metal within this compartment. 35, and 36, are extensions or pour-backs on troughs to facilitate the work of pouring molten metal from ladles back into furnace.

At the far end of the combustion chamber as shown in Fig. 1, a stack, 37, is provided for the escape of waste gases. This stack may be of steel or brick construction lined with refractory materials. At the top of the stack is an adjustable damper, 38, which serves the purpose of controlling the flow of gases within the stack, thereby assisting in obtaining efficient control of the furnace. The furnace bottom proper terminates near the base of the stack 37. Inspection doors, 38', are provided to observe the action of the gases within the furnace and stack. These doors, may also be used for admitting cold air to the stack as a means to cool the lining and control the draft within the furnace.

Referring to Figs. 6 and 7, it can be seen that any metal which may have been accumulated and treated in hearths, 22 and 23, may readily be transferred through trough 39, to an electric furnace. The electric furnace, 40, may be of any standard type and located adjacent the reverberatory furnace, as shown on the drawings, or any distance therefrom, and the molten metal being contained in the reverberatory furnace may be transferred in a ladle to the electric furnace for further refining and superheating.

Again referring to Fig. 6, it will be seen that the combustion chamber is provided with a plurality of inspection openings, 41, extending through the side walls thereof. The tuyère openings, 6, may be arranged radially or at an angle with the axis of the furnace. An aperture 42, is provided for the injection of auxiliary fuel consisting of powered coal, liquid fuel or gases, either singly, or in combination, into the melting zone. Other openings for similar purpose may be provided in the side walls of the combustion chamber as shown.

Referring to Figs. 10 and 11, it will be seen that the wind box, 5 is provided with tuyère elbows, 43, having sliding gates or dampers, 7. These elbows have lateral openings 44, covered with mica or similar transparent material to enable the operator to observe the condition of the tuyère openings during melting operations.

It is obvious that for certain metallurgical operations the dividing bridge 24, may be entirely eliminated and this in turn will dispense with trough 30 and 32, as shown in Figs. 15 and 16.

As previously described, this furnace will provide economical means for continuous and intermittent melting, alloying, and refining of metals, and the following procedure should be followed in its operation:

It is presumed that the furnace bottom, 19, has been properly prepared and that the roof bungs, 21, are in place. The bottom doors, 9, being closed, and supported in the manner described, a layer of fire sand is placed thereon and so arranged as to have its top surface slope toward slag spout, 25; the sand supporting a quantity of kindling wood and a charge of coke or coal being delivered through the cupola from the charging floor. The kindling wood is then lighted

through the tuyères or side wall openings and the burning wood will in turn ignite the solid fuel. The blower, 3, now being started, with the gates, 7, slightly open; will cause a flow of air through the tuyères and support combustion of the fuel. Additional charges coal or coke may be made and be continued until the melting zone, combustion chamber, furnace walls and roof attain a suitable high temperature. Upon the incandescent fuel bed is now placed the first charge of melting stock and this is followed with a second charge of solid fuel. This procedure is repeated until a required amount of alternate charges of melting stock and fuel is attained.

The sliding gates, 7, may now be adjusted to increase the volume of atmospheric air. At this juncture, liquid fuel, powdered coal or gas in small proportions may also be admitted through pipe 8. The combustion of oxygen and carbon will create an exceedingly high temperature and a small percentage of the combustible gases being generated may ascend through the cupola 1, but by far the greater volume will be directed into the combustion chamber imparting high temperature to the roof, side walls and bottom thereof.

Melting stock descending through the cupola will quickly reach a melting temperature and the molten metal and slag will trickle down and follow the said sloping sand bottom and leave the furnace through tap spout, 25, and 27, as previously described. Owing to the fact that the cupola is filled with charges of melting stock and solid fuel, the ascension of gases is obstructed to a great extent and it follows that the combustible gases must enter the combustion chamber and that the products of combustion will escape through stack 37. At the end of a heat, the material in the cupola will descend to the bottom offering no resistance to the flow of gases through the cupola 1, and to prevent this it is necessary to move damper, 45, into its closed position within the cupola to obstruct the free passage of gases.

For certain purposes, the molten metal which flows through trough 27, may be collected directly in a ladle at tap spout, 29, and poured into molds without further treatments. Should the requirements call for refinement of the metal in batches, the content of this ladle may be poured into the refining furnace through trough extension, 35, for further treatment in the furnace hearth, 23. Metal confined in this reservoir is subjected to the radiant heat from the roof and side walls thereof and it is also acted upon by the flow of the gases passing through the furnace. In the event it is desired to reduce the silicon and carbon content in the metal an oxidizing furnace atmosphere may be maintained. The addition of ore will also reduce the carbon content of the charge, and ferro-silicon, ferr-manganese, or other alloys, may be added to bring about the desired composition of the metal.

For further superheating and refining of the charge, the metal may be transferred to hearth 22, and kept there until ready for tapping. The transfer of the metal from part, 23 to 22, may be accomplished by placing a dab of clay at the outer end of tapping spout 33 thereby directing the flow of the metal.

It is understood that the several tapping spouts and troughs have suitable provisions in the side walls to hold the metal in the furnace. This detail, is not shown on the drawings for the sake of clearness.

In producing high test grey iron it is necessary to lower the carbon content and control the sulphur, silicon and manganese and phosporus within a close range. As previously described the charged stock attains a melting temperature in descending through cupola 1. As the process of melting progresses the liquid metal is collected on the said sloping sand bottom and does not come in contact with the fuel except for a short period of time, and it follows that the carbon and sulphur absorption is thereby lessened to a marked degree. Should it be found desirable to raise the carbon content in the metal this can be accomplished by carbon additions such as petroleum coke and an excess of CO gas which can be produced by controlling the supply of air and the admission of the auxiliary fuel supply consisting of liquid fuel, powdered coal, or gas. As described, the injection of air and auxiliary fuels constitute excellent means for controlling the temperature and furnace atmospheric condition when a reducing, oxidizing, or neutral condition is required. These same conditions may be obtained by the proper adjustment of the air supply and fuel.

During the required time molten metal is being confined in hearths, 22 and 23, a thorough mixing takes place which insures a homogeneous mixture so desirable in producing quality metal. Whenever it is necessary to utilize an electric furnace for further refining and super-heating, the process is exactly the same as previously described. When the reverberatory furnace is being operated in conjunction with an electric furnace the dividing bridge, 24, may be dispensed with and the metal conveyed directly from the melting zone to the furnace hearth through troughs, 25 and 27. The metal bath may then be treated in various ways until the desired analysis and temperature is obtained after which the metal is transferred through trough, 39, or by a ladle to the electric furnace for further metallurgical treatment.

By this method of operation, namely, pre-heating and melting the stock in a vertical furnace or cupola with further treatment of the metal in a large bath maintained at a high temperature, the electric input required to complete the process of refining or alloying is very small with a very material saving in the cost of refractory linings. The metal in the electric furnace may be tapped either continuously or intermittently as needed. Whenever a quantity of metal is drawn from the electric furnace a corresponding amount is transferred from the pre-heated bath in the reverberatory furnace as described.

At the end of the heat the bottom doors, 9, are opened permitting the sand bottom to drop carrying with it unburnt fuel which collects below the tuyères. These doors are left open to allow cold air to enter the furnace to permit inspection of the interior of particularly breast, 11. Should repairs be necessary these are made before the furnace is made ready for the next heat.

As previously mentioned, solid fuels are charged alternately with the melting stock, the object being to separate the charges and facilitate melting, but under certain conditions, the solid fuels may be entirely dispensed with. The auxiliary air and fuel supply being sufficient to support combustion and maintain high temperatures within the melting zone and combustion chamber. The importance of having an auxiliary fuel supply consisting of either powdered coal, liquid fuel or gas, is paramount in the successful operation of the furnace.

In making ordinary grey iron or malleable, especially when it is desired to tap the furnace intermittently, the transverse dividing bridge, 24, and tap spout, 30 and 32, may be entirely dispensed with, as shown in Figs. 15 and 16.

It should also be noted that for the sake of clearness I have omitted to show the alternate layers of solid fuels and melting stock as they would appear within the vertical shaft.

A further refinement of the furnace is shown in Figs. 15 and 16. This construction differs from the design shown in Fig. 1, principally with respect to the arrangement of the tuyères in the vertical furnace and the location of the ducts for admission of auxiliary fuel and air. These views illustrate a furnace having a single hearth.

For certain metallurgical operations exceptionally high temperatures are most desirable and can best be obtained by supplying heated air for combustion. For this purpose a conventional type of heater or recuperator is provided consisting of fire brick lined shaft 65, having an arch, 66, carrying interior dividing walls, 68, through which refractory tubes, 67, are placed. These tubes are subjected to the action of the hot gases generated by burner 72, and these gases ascend within the dividing walls escaping through chimney, 69. The air blast enters the heater through blast pipe, 4, into chamber, 70, thence through the tubes, 67, into chamber 71. The fire brick lined duct 4A carries the heated air to wind box, 5, thence to the lower or upper tuyères, as desired.

The air which passes through the heater is furnished by a blower, 3, same as shown in Fig. 1.

Under certain operating conditions it may be found advisable to admit secondary air at room temperature through the upper tuyères, 59, air ports, 53, 54, 55, and blast pipe 49. These air ports are controlled by gates or dampers, 50, 52, 58 and 77, and it should be noted that an auxiliary blower, 74, with blast pipe connection, 73, supplies air under pressure to the upper and lower tuyères.

The upper tuyères, 59, are controlled by gates, 60 and 77. The lower tuyères, 43, and wind box, 5, is similar to the construction illustrated in Figs. 10 and 11.

These tuyères are arranged radially in a semicircle and the auxiliary fuel and air ports 61, 64 are situated in each side wall beyond the base of the vertical shaft, 1.

Above the roof of the furnace a transverse blast pipe, 48, with gate 50, is shown. This blast pipe is provided with a number of branch pipes, 49, for admitting secondary air through the roof into the furnace chamber. Branch pipe, 51, with gate, 52, conducts air to duct, 16, within the breast tile, 11, thence to ports, 53, 54, 55.

Slag spout, 25, with dam, 26, are similar to the construction shown in Figs. 6, and 14. Stack, 37, doors, 31, 34, also tap spouts, 33, are similar to the design previously described.

The object sought in arranging the lower tuyères, 43, and the auxiliary fuel and air ducts as shown in Fig. 16, is primarily to provide means whereby the temperature within the lower portion of the vertical furnace or cupola may be reduced below the melting point of the charged materials and at the same time maintain a higher temperature within the furnace as may be required for metallurgical treatment of the metal confined in the hearth.

The operation of the modified furnace is identical to that previously described with exception that heated air for combustion may be used, and further, that the operator has better means for controlling the operation of melting within the vertical furnace and for controlling the temperatures and atmospheric conditions within the confines of the furnace walls and roof.

It is apparent from the design shown in Figs. 1 and 15 that slag spout 25, may be dispensed with, and the molten iron and slag may flow directly into the hearth of the furnace.. In melting charges containing a high percentage of low carbon steel, the fluidity of the molten metal is very low and difficulties may be encountered in passing such metal through exterior spouts. By treating the metal in the hearth the fluidity may be increased as desired for pouring into molds.

Having thus described my invention it can be readily understood that minor details of the construction shown may be altered in several ways without departing from the spirit and scope of my improvement and without losing any of its attendant advantages. Therefore, what I claim and desire to secure by Letters Patent is—

1. A premelting cupola in conjunction with a reverberatory furnace, said reverberatory furnace comprising an horizontal combustion and heat radiating chamber provided with an outlet for waste gases, said chamber having an inlet for combustible gases formed integral with said premelting cupola, said cupola having an opening on one side thereof forming an outlet for combustible gases whereby the same may enter the said horizontal combustion chamber, said opening being lined with refractory material comprising a series of independently suspended ventilated tile having ports or channels for the passage of air under pressure from a common header or wind-box into the melting zone of the cupola, substantially as described.

2. A reverberatory furnace, of the character described, having a vertical premelting compartment, the said compartment being adapted to receive charges of melting stock and solid fuel, the wall of said compartment having a large opening formed on one side thereof at its lower end, the said opening being adapted to form a connection between the melting zone of said compartment and the combustion chamber of said reverberatory furnace, the said opening having a removable ventilated wall formed there-over whereby to form a breast-wall opposite the melting zone of said compartment, a plurality of removably supported refractory tile forming a roof over the combustion chamber of said furnace, and a stack providing an outlet for waste gases emanating from said chamber.

3. A premelting cupola in conjunction with a reverberatory furnace, said reverberatory furnace comprising an horizontal combustion and heat radiating chamber having an outlet for waste gases, said chamber having an inlet for combustible gases formed integral with said premelting cupola, the melting zone of said cupola being a continuation of the combustion chamber of the said reverberatory furnace, means through which to inject auxiliary fuel and air under pressure into the melting zone of the said cupola, and means for inducing a continuous flow of combustible gases into the said combustion chamber, substantially as described.

4. A reverberatory furnace, of the character described, having an horizontal combustion and heating chamber having an outlet for burnt gases, a premelting cupola formed integral with said

combustion chamber, means for admitting preheated air and auxiliary fuel into the melting zone of said cupola and the said combustion chamber, and means for introducing and regulating a continuous flow of secondary air, fuel, and combustible gases into the said chamber.

5. In a combined reverberatory furnace and premelting cupola, of the character described, an extended combustion and heat liberating chamber having a basin for receiving molten metal and an outlet for burnt gases, a premelting cupola furnace formed integral with said combustion chamber, said chamber having a floor arranged above its basin extending into the said cupola at its base, the said floor being adapted to support charges of melting stock and solid fuel, the melting zone of said cupola and the said chamber being a continuation of each other, and means to admit auxiliary fuel and preheated air into said zone and the said chamber.

6. A premelting cupola integral with a reverberatory furnace, said furnace comprising an horizontally extended combustion and heating chamber enclosing a basin, said chamber having an outlet for burnt gases and an inlet passage for combustible gases and fuel through an opening opposite the melting zone within the said premelting cupola, said inlet being a continuation of the said zone, and means for admitting auxiliary fuel and air under pressure into said melting zone and the said combustion chamber.

7. A premelting cupola integral with a reverberatory furnace, said furnace comprising an horizontally extended combustion and heating chamber enclosing a basin, said chamber having an outlet for burnt gases and an inlet passage for combustible gases and fuel through an opening opposite the melting zone within the said premelting cupola, said inlet being a continuation of the said zone, and means for admitting auxiliary fuel and air under pressure into the inlet forming a gas and fuel passage to the said combustion chamber.

8. A reverberatory furnace in combination with a vertical premelting furnace or cupola, the said reverberatory furnace comprising an extended refractory combustion chamber having an opening formed therein through which to receive fuel and combustible gases and having an outlet opening for burnt gases arranged opposite said opening, said fuel and gas opening being formed integral with an opening forming the melting zone at the base of said cupola, said cupola being open at its top, said cupola being adapted to receive alternate charges of melting stock and solid fuel, and an arrangement of tuyères suitably disposed in the wall surrounding said zone and chamber through which to admit air and auxiliary fuel necessary to support combustion within said zone and combustion chamber.

ALGOT A. WICKLAND.