Jan. 14, 1969 A. J. BAKER ET AL 3,422,206

METHOD AND APPARATUS FOR MELTING METAL IN AN ELECTRIC FURNACE

Filed April 7, 1965 Sheet 1 of 4

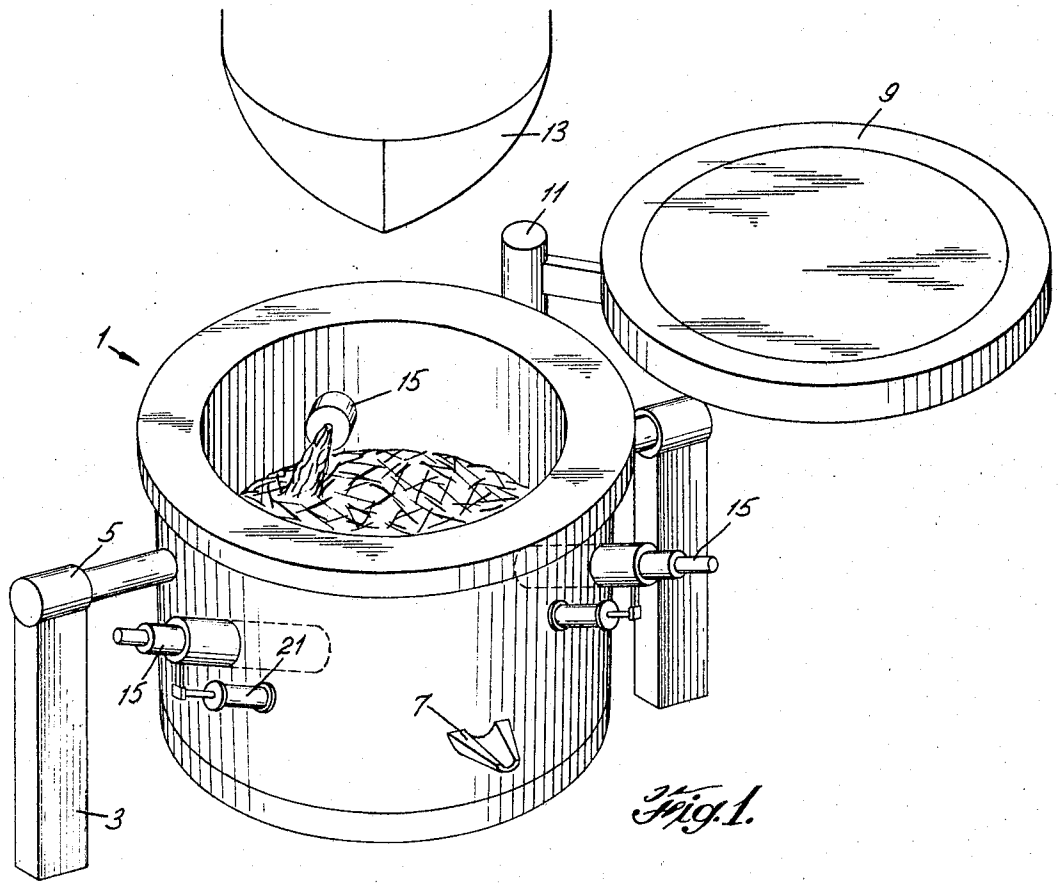

Fig. 1.

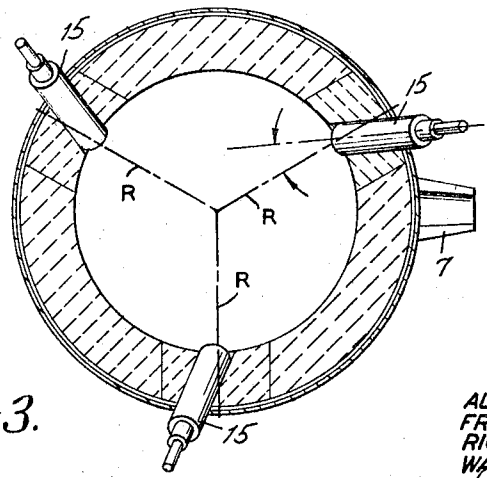

Fig. 3.

INVENTORS
ALLEN J. BAKER
FRANK S. DEATH
RICHARD C. MYERS
WALTER B. FARNSWORTH
BY Dominic J. Terminello
ATTORNEY

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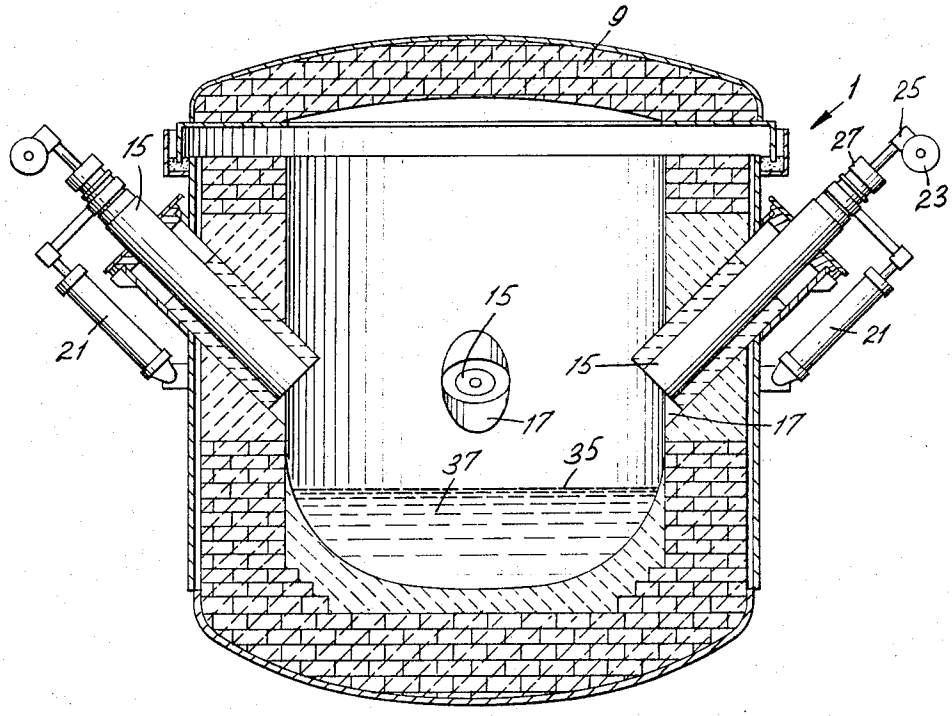

Fig. 2.

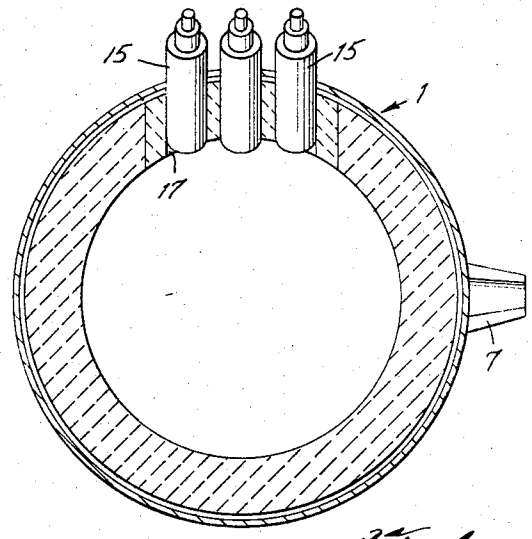

Fig. 4.

INVENTORS
ALLEN J. BAKER
FRANK S. DEATH
RICHARD C. MYERS
WALTER B. FARNSWORTH
BY Dominic J. Terminello
ATTORNEY

METHOD AND APPARATUS FOR MELTING METAL IN AN ELECTRIC FURNACE

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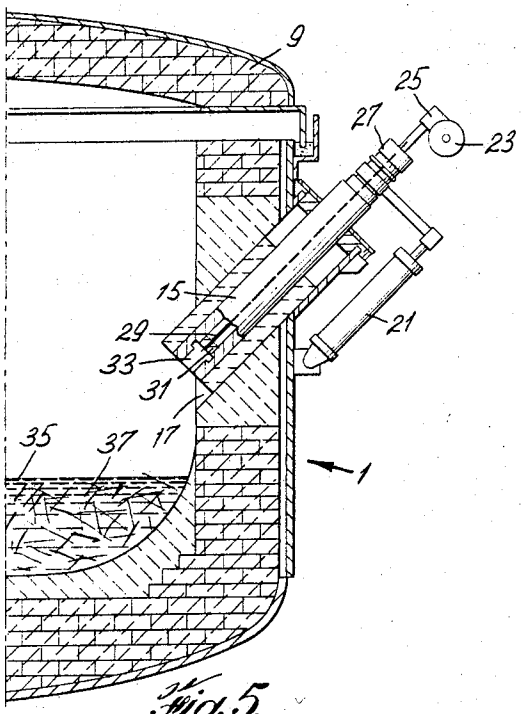

Fig. 5.

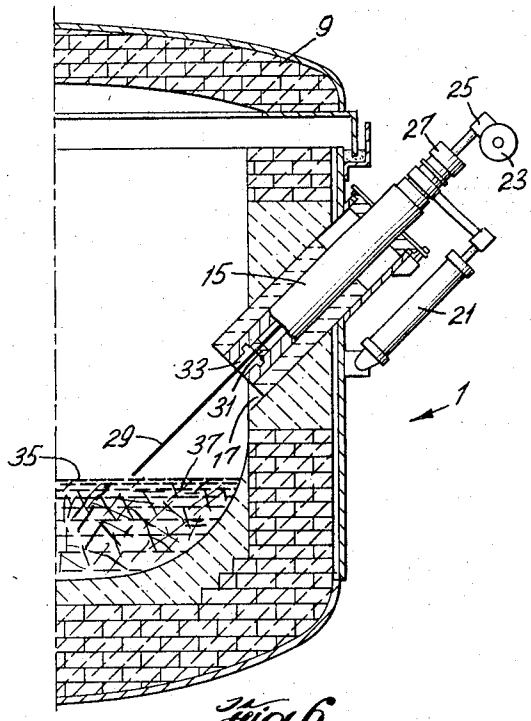

Fig. 6.

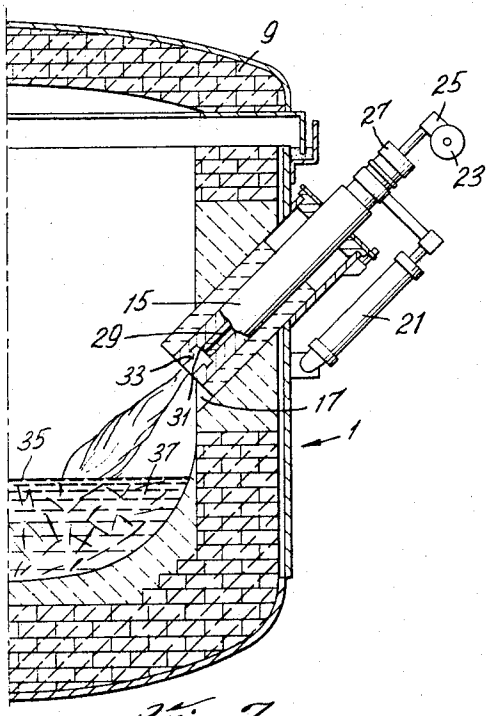

Fig. 7.

INVENTORS
ALLEN J. BAKER
FRANK S. DEATH
RICHARD C. MYERS
WALTER B. FARNSWORTH
BY Dominic J. Gemmell
ATTORNEY

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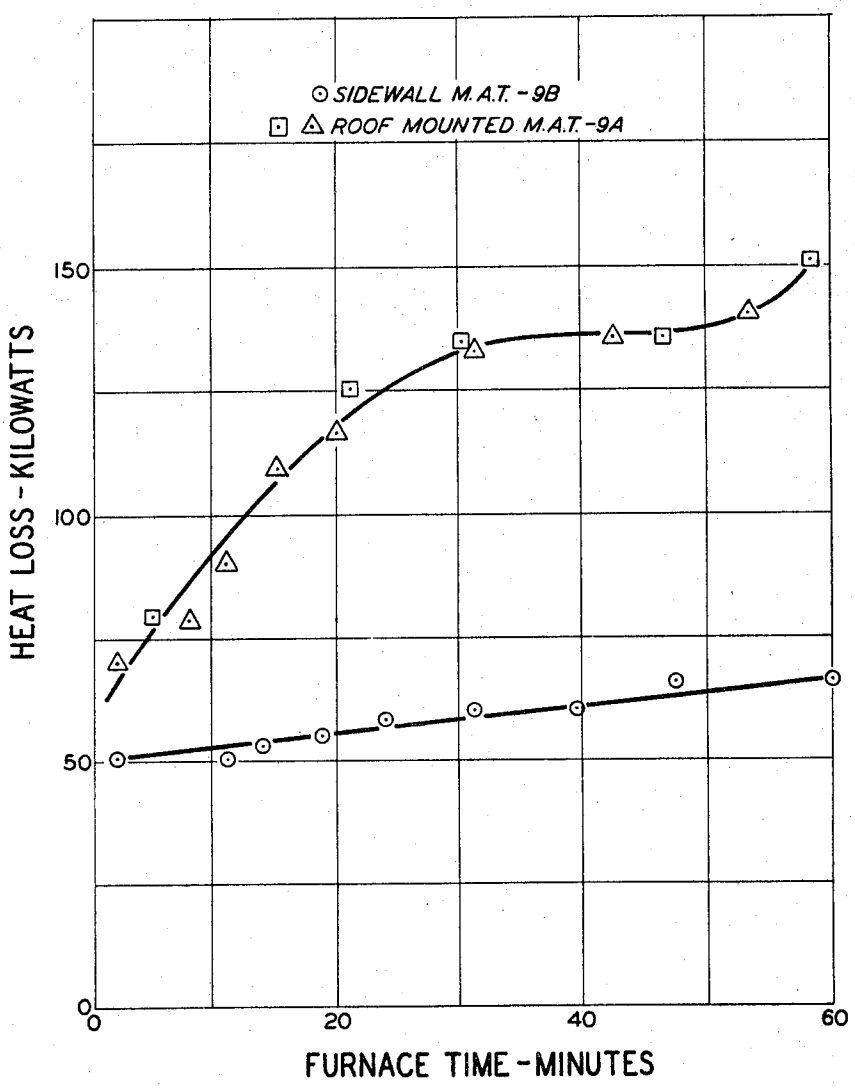

Fig. 8.

INVENTORS
ALLEN J. BAKER
FRANK S. DEATH
RICHARD C. MYERS
WALTER B. FARNSWORTH
BY Lawrence J. Fennelly
ATTORNEY

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3,422,206

METHOD AND APPARATUS FOR MELTING METAL IN AN ELECTRIC FURNACE

Allen J. Baker and Frank S. Death, Tonawanda, Richard C. Myers and Walter B. Farnsworth, Williamsville, N.Y., assignors to Union Carbide Corporation, a corporation of New York

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U.S. Cl. 13—34 8 Claims
Int. Cl. H05b 31/00

ABSTRACT OF THE DISCLOSURE

An improved method and apparatus for melting material in an electric furnace by establishing a directionally stable arc from an arc device mounted in the side walls of the furnace so as to minimize excessive heat losses to arc devices depending from the furnace roof.

The present invention relates to electric arc furnaces and more particularly it relates to such furnaces wherein arc torch devices capable of producing directionally stable arc plasmas are employed.

In any electric furnace wherein charge material is to be melted down to form a molten bath the object is to achieve as high a melting rate as possible. Recently improvements have been made over standard electric furnaces wherein an open arc was established from graphite electrodes. Open arc furnaces face technical limitations which will limit the power supplied to the furnace and hence the melting rate. One important factor in these limitations is the unsteady nature of the open arc itself. Directionally stable arc plasmas were discovered to be ideally suited for high power electric furnace uses. These arc plasmas are capable of producing constant high intensity heat because the heat generating capacity of such plasmas can be controlled by adjusting the arch length and/or controlling the atmosphere in which the arc plasma is produced.

Directionally stable arc plasmas are defined as an electric arc column in which the longitudinal axis or axes coincident with the flow of current remains invariant in direction regardless of the surrounding atmosphere and attitude of the torch itself. These types of arc plasmas are refefred to and described in Gage Patents No. 2,806,-124, issued Sept. 10, 1957, and No. 3,147,329 and No. 3,147,330, issued Sept. 1, 1964.

Until the present time, conventional electric furnaces usually were provided with a movable roof through which passed a plurality of graphite electrodes. In order to charge such furnace it was necessary to lift the electrodes out of the furnace and then move the roof. This, of course, was time consuming, inconvenient and required that the arcs be extinguished while additional charge material was added to the furnace.

Even with the advent of directionally stable arc plasma producing devices the custom of placing the torches in the furnace through the roof was maintained. One of the shortcomings of this procedure was that the torches themselves absorbed a substantial amount of heat which otherwise would be delivered as energy for melting charge material.

Accordingly, it is one of the main objects of this invention to provide an electric furnace system wherein thermal efficiency is improved.

Another object of the invention is to provide an electric furnace system wherein the charge material can be introduced into the furnace from the top while the power is still on.

Another object is to provide a novel means for starting directionally stable arc producing devices in an electric furnace.

Yet another object is to provide an electric furnace wherein directionally stable arc producing devices are positioned so as to provide stirring of the molten bath.

A further object is to provide an electric furnace wherein directionally stable electric arc producing devices are positioned in the side walls of such furnace.

These and other objects will become apparent or be pointed out in the following description or with reference to the drawings wherein:

FIGURE 1 is a perspective view of an electric furnace constructed according to the invention;

FIGURE 2 is a vertical cross-sectional of an electric furnace with side mounted arc devices;

FIGURE 3 is a cross-sectional top view of the furnace shown in FIGURE 1;

FIGURE 4 is an alternative arc torch arrangement in the side wall of the furnace;

FIGURES 5, 6 and 7 are partial front views in cross-section of the furnace showing an arc device with means for starting such device at various instances in the starting cycle; and

FIGURE 8 is a graph showing the heat losses with the arc devices mounted according to the invention as opposed to the prior art arrangement.

In one aspect of the invention the objects are achieved by a method wherein raw materials are charged into a hearth enclosed in a furnace. At least one directionally stable transferred electric arc column is established and maintained between the raw materials and a nonconsumable electrode positioned in the side walls of the furnace. The electric arc is continued until the raw materials are at least partially melted and then additional raw materials are charged to the hearth while the electric arc column is continued between the raw material and the nonconsumable electrode.

In another aspect of the invention the objects are achieved by apparatus including an electric arc furnace comprising a melting vessel, a hearth for containing raw material in said vessel, said vessel having side walls extending upward from and enclosing said hearth; a removable roof for said vessel; a plurality of directionally stable arc producing devices positioned in the walls of said vessel and being inclined toward the surface of said molten metal and at an angle with the radius of the vessel drawn in a horizontal plane through said vessel so as to impart angular movement to at least the molten bath surface.

Electric furnaces are traditionally graphite electrode furnaces. These electrodes have always been positioned in the furnace through the roof because the size, mass and strength of the electrodes do not permit positioning them in any other manner. With the advent of directionally stable electric arc producing devices, it was discovered that significant amounts of the heat energy generated by these devices was absorbed by the device itself because it extended so far from the roof into the furnace atmosphere. This invention is predicated on the discovery that a remarkable increase of the heat produced by arc devices is available to melt the raw materials in the electric furnace when such devices are mounted in the side wall. This advantage is obtained because of the further discovery of a practical way to reliably start arc devices mounted in the side wall of an electric furnace.

In describing the preferred embodiment of the invention, reference will be made to an arc device which broadly consists of a tubular electrode axially spaced and in substantial alignment with an outlet nozzle, the space between said electrode and nozzle is surrounded by a chamber for swirling gas about an arc established between such tubular electrode and the raw material in the furnace.

This type of device is described in copending application of Robert J. Baird, Ser. No. 223,484, filed Sept. 13, 1962. This device in the present invention is usually operated on A.C. power however D.C. power may be employed if it is found to be desirable or necessary.

Other devices which may be employed to produce the directionally stable arc column include devices having a non-consumable electrode usually made of tungsten or water-cooled copper, and a nozzle having a constricted outlet portion through which the arc passes together with an arc gas. The nozzle acts to stabilize the arc containing gas and produce a high heat content arc effluent. Such devices are described in Gage Patent No. 2,806,124, issued Sept. 10, 1957.

For the purposes of this disclosure, the term "raw materials" means any material capable of conducting electric current at least in the fused state. Raw materials may be metals, metal alloys, fused salts such as alkali and alkaline earth metal, halides and slags such as metallic oxides and silicates.

Referring to FIGURE 1, an electric arc furnace constructed according to known furnace construction techniques is noted generally at **1**. Such furnace is mounted on support means **3** which is provided with a tilting mechanism **5** for tapping the furnace through pouring spout **7**. The furnace shown is provided with a roof **9** pivoted on member **11** so as to be swung out of the way while the furnace is being top charged with raw material from charging bucket **13**. A plurality of directionally stable arc producing devices **15** are positioned through appropriate apertures **17**, see FIGURE 2, in the side wall of the furnace **1**. In this embodiment, the devices are positioned 120 degrees apart, see FIGURE 3, and are inclined downwardly preferably at about 45 degrees so that the arc plasma will strike the molten bath surface, see FIGS. 1 and 3. Additionally, the arc devices are at an angle with the radius R, see FIGURE 3, of the furnace. A typical angle is shown as being 10 degrees. The angle should not be so large that the arc will deteriorate the refractory walls of the furnace. On the other hand, the angle should be sufficient to impart angular momentum at least to the bath surface to produce surface stirring. Each arc producing device is connected to one phase of a three phase A.C. power source. While this is the preferred electrical arrangement, it is to be understood that the devices could be connected to D.C. or other A.C. arrangements, for example, a six phase system could be used with six arc producing devices. The invention is not limited in the number of arc devices used or to the electrical connections made to such devices.

Each device **15** is provided with withdrawal mechanism **21** which are used to move the torches into or out of the furnace **1** through ports **17**. This feature is utilized especially on starting the arc devices. In order to start the arc the devices are inserted through the ports **17** close to the raw charge material so that an arc could be drawn between the electrode in the arc device and the raw materials. Alternatively, it is possible to have the devices **15** fixed in ports **17** so that the problems of providing proper sealing are eliminated.

A new method of starting the arc devices has been discovered. Each device **15**, see FIGURES 5, 6 and 7, is provided with a motor **23** and drive mechanism **25** at its rear end **27**. A wire **29** is passed through the device to the back tubular electrode **31** in device **15**, see FIGURE 5. When ready to start, the motor is actuated and wire **29** is passed through electrode **31** making electrical contact therewith, through the nozzle **33** to the surface **35** of the charge material **37**, see FIGURE 6. In FIGURE 7, the power has been turned on between the electrode **31** and raw material **37** so that the wire burns and an arc is established therebetween. This starting method permits the arc device to be up to a foot away from the bath surface. When the arc device is of the type having a non-consumable tungsten or water-cooled copper electrode as described above, the wire is passed down along the electrode to insure electrical contact therewith. The wire then is passed through the nozzle to contact the raw materials while maintaining electrical contact with the non-consumable electrode. The power is turned on and the wire is vaporized as before. The success of this starting arrangement greatly contributed to the successful operation of arc devices in the side walls of electric furnaces. Up to this time, no reliable way of starting side mounted arc devices was known.

Mounting of arc devices in the side wall of the furnace has permitted heat losses to the arc devices to be minimized. Heretofore, the arc device was suspended from the roof and extended into the furnace atmosphere. These arc devices had to be water-cooled so that they would not "burn up" in the furnace. It was found that a large amount of furnace heat was being extracted from the furnace through the arc device cooling water. Side mounted arc devices do not have to be as long as roof mounted devices and in fact extend very little into the furnace. Accordingly as can be seen from FIGURE 8, the heat losses to side mounted arc devices is decreased by about 30%. Thus, thermal efficiency of the devices increased from about 45% to about 75%.

The present apparatus and method is useful with almost any gas or gas combinations compatable with the metallurgical process being carried out. Gases such as air CO_2 and O_2 either alone or in combination may be used. In these cases, it is preferred that the electrode **31** be constructed from copper or of a copper-silver alloy such as about 80% silver and about 20% copper. Other gases may be CO or mixtures of CO and argon or nitrogen. The electrode in this case is also preferably copper. If pure inert gases such as argon or helium are used, the electrode **31** should preferably be graphite or copper with a carbon liner.

In FIGURE 4 is illustrated an alternative to the three arc device arrangement shown and described in the preferred embodiment. In this alternative, the devices are positioned side by side in the same manner described above.

While the invention has been described with reference to certain preferred embodiments, it is understood that various changes to the parts shown or their arrangement relative to each other may be made without departing from the spirit and scope of this invention.

What is claimed is:

1. A method for melting metal in an electric furnace which comprises charging raw materials into a hearth enclosed in said furnace; establishing and maintaining at lease one directionally stable transferred electric arc column between said raw materials and a nonconsumable electrode; directing the so established arc downwardly at an angle of about 45 degrees to less than 90 degrees from the perpendicular axis of the furnace; continuing said electric arc until said raw materials are at least partially melted, and then charging additional raw material to said hearth while continuing said electric arc column between the raw materials and said nonconsumable electrode.

2. A method for melting metal in an electric furnace which comprises charging raw materials into a hearth enclosed in said furnace; establishing and maintaining at least one directionally stable transferred electric arc column between said raw materials and a nonconsumable electrode; directing the so established arc downwardly at an angle of about 45 degrees to less than 90 degrees from the perpendicular axis of the furnace and continuing said electric arc until said raw materials are molten whereby a substantial decrease in heat losses from said directionally stable transferred arc column to the surrounding environment is achieved.

3. A method for starting an arc device in an electric furnace containing raw materials, said arc device including a tubular electrode axially spaced from an outlet nozzle the space between said electrode and nozzle being

surrounded by an arc chamber, which comprises passing a consumable wire through and in electrical contact with said tubular electrode and through the outlet nozzle of said arc device; contacting the raw materials with said wire and then impressing a voltage across said wire to vaporize said wire and thereby provide a path for an arc to be established between said tubular electrode and said raw material.

4. An electric arc furnace comprising a melting vessel, a hearth for containing raw material in said vessel, said vessel having side walls extending upward from and enclosing said hearth; a removable roof for said vessel; a plurality of directionally stable arc producing devices positioned in the side walls of said vessel and being inclined toward the surface of said raw material and at an angle with the radius of the vessel drawn in a horizontal plane through said vessel so as to impart angular movement to at least the surface of said raw material after it becomes molten.

5. An electric arc furnace comprising a melting vessel, a hearth for containing raw material in said vessel, said vessel having side walls extending upward from and enclosing said hearth; a removable roof for said vessel, a plurality of directionally stable arc producing devices positioned in the side walls of said vessel and being inclined toward the surface of said raw material whereby a substantial decrease in heat losses to said directionally stable transferred arc producing device is achieved.

6. Apparatus according to claim 5 wherein the directionally stable arc producing devices include a tubular electrode axially spaced from and in substantial alignment with an outlet nozzle, the space between said electrode and nozzle being surrounded by a chamber in which gas is introduced about an arc established from said tubular electrode.

7. Apparatus according to claim 6 including in addition a wire drive means mounted on said arc producing device for advancing a wire through and in electrical contact with said tubular electrode into contact with said raw material in said hearth in said furnace.

8. A method for starting an arc device in an electric furnace containing raw materials, said arc device including a nonconsumable electrode which comprises passing a consumable wire in electrical contact with said nonconsumable electrode; contacting the raw materials with said wire while maintaining the electrical contact with said nonconsumable electrode and impressing a voltage across said wire to vaporise said wire and thereby provide a path for an arc to be established between said nonconsumable electrode and said raw material.

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BERNARD A. GILHEANY, *Primary Examiner.*

ROY N. ENVALL, JR., *Assistant Examiner.*

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219—75, 121, 145