Aug. 1, 1933. A. E. GREENE 1,920,380

ELECTRIC INDUCTION FURNACE

Filed March 24, 1932

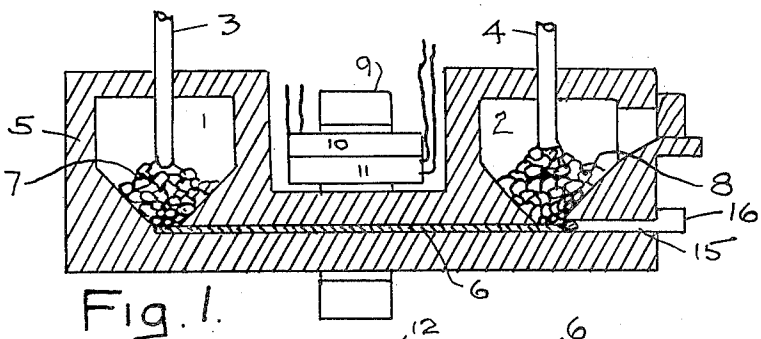


Fig. 1.

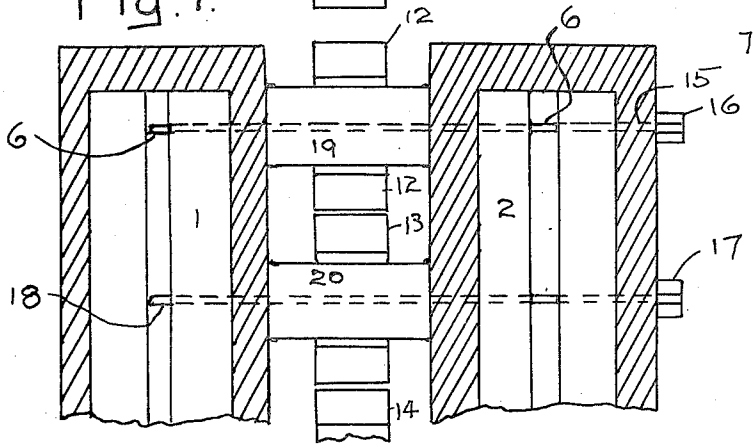


Fig. 2.

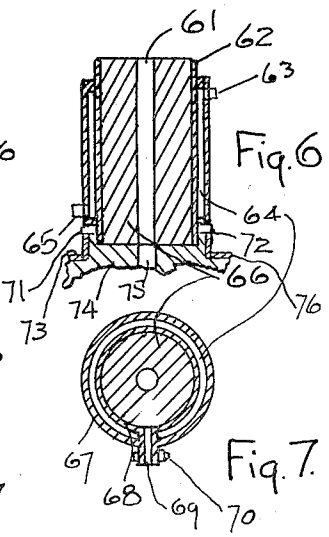


Fig. 6

Fig. 7.

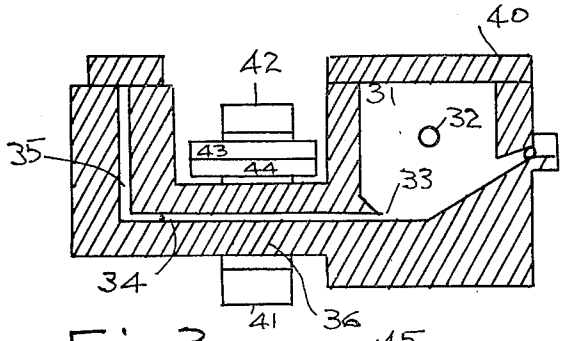


Fig. 3.

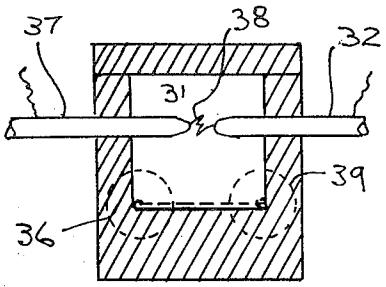


Fig. 4.

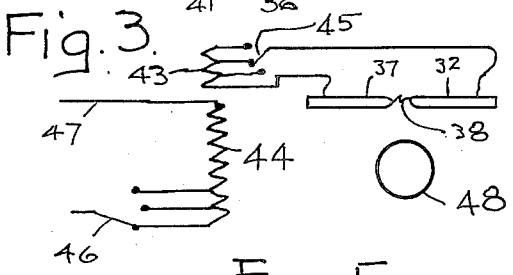


Fig. 5.

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ELECTRIC INDUCTION FURNACE

Albert E. Greene, Seattle, Wash.

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5 Claims. (Cl. 13—4)

My present invention relates to improvements in induction furnaces and particularly to improvements in construction and in operation whereby induction furnaces may be started easily on cold metal without the use of molten metal or without delay in melting cold starting rings, or circuits. My present invention also relates to improvements in the construction of parts of induction furnaces for containing molten metal.

My present application is a continuation in part of my U. S. application for patent Serial No. 323,515 filed Dec. 3, 1928, which issued as U. S. Patent No. 1,851,575, which application was in turn a continuation in part of my U. S. application for patent Serial No. 406,894 which issued as U. S. Patent No. 1,751,912 on March 25, 1930; and my Serial No. 455,601 filed March 25, 1921 which issued as U. S. Patent No. 1,751,856 on March 25, 1930, and of my U. S. application for patent Serial No. 575,630 filed July 17, 1922 (application abandoned).

Induction furnaces prior to the time of my invention described in this application were not well suited to the melting of cold scrap metal. They did not provide sufficient voltage in the secondary circuit to satisfactorily overcome the resistance between the cold scraps of metal and they did not provide for control of the voltage and of the current so that a high voltage could be used to melt the cold scrap and then a low voltage induced in the molten metal circuit. Nor did they provide for a positive mechanical circulation of the molten metal where small area conduits are part of the secondary single turn molten metal circuit around a magnetic core.

These earlier furnaces operated at relatively low voltages of 5 to 10 volts and in fact many of the V type induction furnaces for brass still use such a relatively low voltage. A disadvantage of such furnaces is that they must be started either very carefully with a cold insert or else heated and filled with molten metal, and they have a further disadvantage of very limited usefulness when the metal composition varies as between red brass and yellow brass and lead containing metal. Another disadvantage of such furnaces as the V type is that their refractory linings have to be made with great care and are liable to crack, and when they do crack they are no longer usable.

In the open ring type induction furnace, there is the disadvantage of low single turn voltage, poor power factor and inconvenient shape of charge chamber. It has not been possible to throw loose scrap into such a furnace and start it without molten metal or without a special single circuit ring.

My present invention is intended to obviate these and other disadvantages and to provide improved means for starting induction furnaces with cold scrap and to avoid the objections of low operating voltages and inability to melt metal with a varying conductivity.

My present invention contemplates the use of small area conduits connecting with one or more larger chambers whereby relatively high voltages may be utilized in the single turn circuit to advantage.

One object of my present invention is an improved construction of the small area duct containers so that replacement is simplified and so that very thin walls around the duct can be used without danger, and I accomplish this improvement by the use of a water cooled channel shell for this part of the secondary circuit. A further object of my invention is the provision of improved insulation of the shell parts of the furnace. Another object of my invention is an improved construction whereby a plurality of conduits can be used between enlarged chambers so that polyphase alternating current can be used advantageously. A still different object of my invention is an improved construction of chambers and ducts whereby straight metal bars may be inserted and utilized for starting the circuit thru the channels to avoid the necessity of starting with molten metal or with a solid closed ring circuit. These and other objects of my invention will be better understood by reference to the annexed drawing.

In the annexed drawing I have shown in Fig. 1 a sectional elevation view of an embodiment of my invention in which starting bars of metal are used between two chambers having electrodes and also means for inducing current thru the bars and charge in the chambers.

Fig. 2 is a plan view of the furnace shown in Fig. 1 in part showing two of the tubes and a part of the third core.

Fig. 3 is a sectional elevation view of another modification of my invention in which a main chamber is provided with a horizontal arc between two horizontal adjustable electrodes, and induction heating means combined therewith.

Fig. 4 is a sectional elevation view thru the electrodes of the arc chamber of Fig. 3.

Fig. 5 is a wiring diagram of the circuits and diagrammatic view of the secondary circuits of the furnace of Fig. 3 and Fig. 4.

Fig. 6 is a sectional plan view of a water-cooled

tube for the secondary circuit, embodying my invention, and Fig 7 is a sectional view of this tube.

Referring to this drawing and particularly to Figs. 1 and 2, I have illustrated here an induction furnace which embodies my improvement for starting the induction heating by means of metal bars which can be inserted into the tubes so as to make a circuit between the scrap in the two enlarged chambers. The two chambers are shown at 1 and 2 with top adjustable electrodes, 3 and 4, for arcing to or contacting with the charge. I have shown cold scrap charge at 7 and 8 resting on each end of the bar 6 which extends from one chamber to the other. The refractory of the main chambers is indicated at 5. The bar 6 extends thru the tube marked 19 in Fig. 2 where the tube is shown in dotted lines. The ends of the bar 6 are shown in Fig. 2 in each chamber. The cold scrap is not shown in the Fig. 2 illustration. A magnetic core 9 in Fig. 1 with vertical legs marked 12 in Fig. 2 encircles the bar 6. Two windings, 10 and 11 on this core are indicated in Fig. 1. One of these may be connected to the supply and the other to the electrode circuit in the furnace. In this way heating may be applied thru the electrodes and thru the bar 6 whereby the bar and the two electrodes form a single circuit of any suitable number of turns of winding around the magnetic core and switching means may be provided for adjustment of the electrode circuit voltage independently of the single turn circuit voltage. I have shown separate cores encircling each tube, the core 13 encircling tube 20 thru which a bar 18 is indicated, and another core 14 is shown in part for a third tube, for example where three phase power is used.

It will be noted that I have provided separate cores and windings thereon above the tubes. This is one particular feature of my invention Another feature is the provision for the use of the metal bars. The bar 6 is inserted thru the opening 15 and then the opening or tap hole 15 is subseqently closed by a plug of refractory material. The ends of the bar 6 extend into both chambers. Scrap may then be placed on the ends of the bar 6 and other bars such as 18, thus forming a circuit from one chamber to the other. With sufficiently high single turn voltage and sufficient weight of scrap on the ends of the bars, current can be induced thru the bars and loose scrap until the charge melts. If the circuit is broken, the electrode may be used and an arcing voltage applied thru the electrodes to the charge and thence to the bars and thru the coil on the core. The weight of the scrap is sometimes not sufficient for quick starting and then the electrode circuit is used. The electrode circuit may be used in any event. The voltage available from the coils on the core is ample for both the high single turn circuits and for the arcing circuits and adjustment of both voltages may be provided by taps on the coils on the core.

As mentioned in my earlier applications, in melting nonferrous metal such as brass, I may use a bar of copper in the tubes or of metal of different melting point from that to be melted in the main chambers, and may use a metal of either lower or higher melting point for the bars than the scrap to be melted. The starting bars melt up in the operation and new bars are provided for starting from the cold.

In Figs. 3, 4 and 5 I have illustrated a modification of my invention in which a horizontal arc is combined with an induction circuit. In this furnace a main chamber 31 is provided connecting with an induction tube circuit in which the tube 34 is one part and the reservoir 35 connects therewith at the part opposite the main chamber so that the furnace may be rocked. The rocking means is not shown, but it is understood that this as well as the furnace of Fig. 1 may be mounted for tilting or rocking movement and for circulation of metal from the one chamber, like 31 into the reservoir 35 and back. The magnetic core is shown at 41 and 42. Coils 43 and 44 are mounted on the core, and coil 44 is arranged with taps for connection to a supply circuit of single phase power, and coil 43 is arranged, also with taps, to supply current to the arc circuit between the electrodes 37 and 32. In Fig. 5 I have shown a circuit diagram of this furnace. Primary coil 44 has taps for the adjustment of the induced voltage. Coil 43 serves to supply different voltages to the electrodes. The arc is indicated at 38 and the induction secondary single turn circuit at 48. The voltage of this circuit is adjustable by the taps on coil 44.

This furnace provides means for heating the metal by induction and for heating the slag by means of a horizontal arc above the slag which may form on the metal. It is a special purpose of my invention to provide this combined means for heating both metal and slag, and for keeping the electrodes away from the metal, as for example in the melting of very low carbon metal.

Figs. 6 and 7 show a water cooled induction tube member such as might be used at 19 or 20 in Fig. 2 or at 36 in Fig. 3. In this water cooled tube, I have provided a metal shell 68 inside of which is a refractory material forming a tube or conduit 61. This conduit forms the container for the molten metal of the induction circuit. Around the metal 68 is an outer metal wall 67 so arranged that it holds water and that water may be circulated thru the cooling chamber 64. I have shown an inlet 63 and an outlet 65 for water. I have also provided for a joint of insulating material so that a complete circuit around the tube is avoided. I may use insulating material such as Transite for this purpose. This insulating member is shown at 69 in Fig. 6 and the two parts of the shell are held against the transits by bolts as shown at 70. I have also indicated the refractory joint between the tube shell and the furnace shell, the latter being indicated in section at 73 and 76. Insulation members are shown at 71 and 72 between the metal of the furnace shell and that the tube shell so as to prevent induced current from passing in this direction. The refractory material of the main furnace is indicated at 74 and the continuation of the conduit 61 is shown at 75 in the main chamber refractory. The refractory of the tube and that of the main shell are pressed together and held together by suitable structural bolting members not shown.

My invention is an improvement in many ways over past construction and methods of operation. By means of the bars it is easy to start the induction circuit without molten metal from an outside source and yet the furnace need not retain any molten metal from one heat to another. The electrode circuits provide for heating of the slag independently of the metal and in other modifications I provide for using induced current which may be passed from one electrode to another thru a bar or tube of metal in order to

start the melting of the loose scrap in the enlarged chambers.

My water cooled tube construction provides means for small refractory members so that the core of the induction furnace can be a comparatively short one and thus provide for high power factors. The location of windings above the tubes and on separate magnetic cores is likewise an advantage for electric operation since it places the coils in a convenient place and by means of the separate cores, one for each tube, I am able to remove and replace tubes independently of each other.

What I claim is:—

1. In an induction furnace comprising a straight channel section as part of the single turn induction circuit, said straight section connecting with two larger chambers having adjustable electrodes entering from above, means for inserting a bar thru the straight channel so as to extend into both the larger chambers, whereby a circuit can be completed from one electrode thru the bar to the other electrode.

2. In an induction furnace comprising one or more straight channel sections forming part of the secondary circuit and having a relatively small cross sectional area, means for inserting a bar of metal in the straight channels, means for closing the hole for inserting said bar into said channels so that the metal will not run out when molten, and means for inducing current thru said bar to cause it to melt.

3. An induction furnace comprising two enlarged chambers in refractory material and ducts in refractory material between said chambers, said ducts having a relatively small cross sectional area and joining the chambers at the lower parts of said chambers, means for inserting metal bars in said ducts so that the ends of said bars will extend into the chambers at both ends of the bars, and means for causing a current to pass thru the bars by the use of sufficiently high voltage to cause them to melt and to maintain a secondary circuit thru them and molten metal in the enlarged chambers.

4. In an induction furnace, two enlarged chambers in refractory material for holding loose metal charge, two or more small area conduits in refractory material joining said enlarged chambers at their lower parts, means for placing straight starting metal bars in said conduits so that their ends will make contact with the loose scrap in the enlarged chambers, and means for passing current from one enlarged chamber to the other thru said starting bars until the bars are melted and for continuing the flow of induced current thru the single turn circuit thus formed around a magnetic core thru the metal in the conduits and the enlarged chambers.

5. In an induction furnace comprising one or more enlarged chambers and one or more small area ducts in refractory material connecting with the larger chambers at different places near the bottom thereof, means for placing a straight metal bar thru said ducts to make contact with loose scrap in the enlarged chambers, and means for inducing a sufficiently high voltage thru the metal bar and scrap to melt the bar and to permit continuing the flow of current, means for rocking the furnace to move the metal thru said duct, and means for regulating the voltage around the induction circuit.

ALBERT E. GREENE.