Dec. 7, 1965 G. F. KOLLE 3,222,446

BUSHING INSULATOR FOR CORE TYPE INDUCTION FURNACE

Filed July 24, 1962

FIG. 1

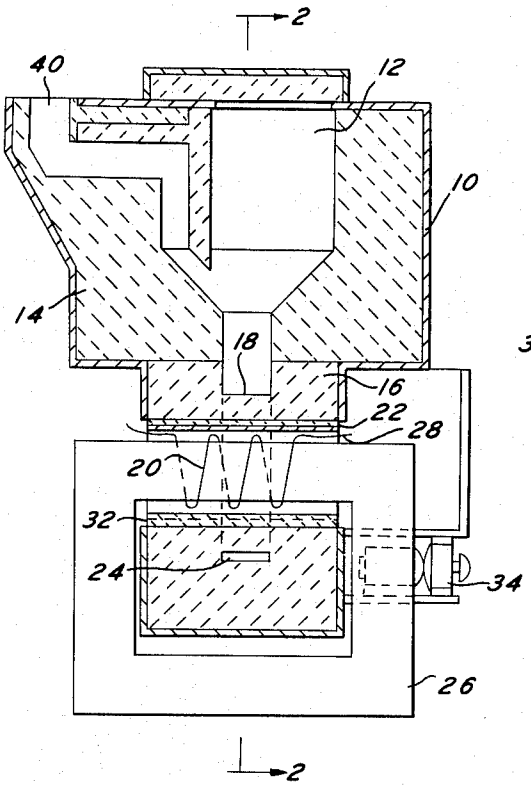


FIG. 2

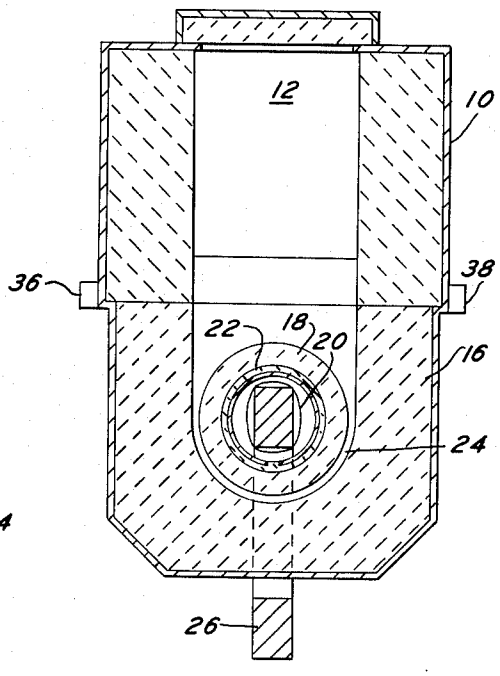
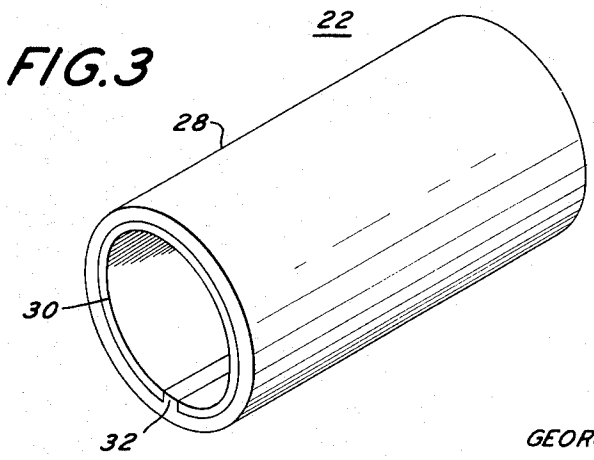


FIG. 3



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BUSHING INSULATOR FOR CORE TYPE INDUCTION FURNACE

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In general, this invention relates to a new and improved insulated bushing for a core type induction furnace and, more particularly, to an insulated bushing for the air duct of a core type induction furnace which is manufactured from two materials.

Induction furnaces of the core type have been in successful operation for more than forty years for the melting of many metals and their alloys. One of the problems inherent in this type of furnace has been the inability to melt lead-rich copper alloys containing more than 5% of lead. When high-lead alloys are melted, the lead rapidly penetrates the lining short-circuiting the primary and causing an overload. Previous studies have involved the problems inherent in melting lead-rich and particularly lead-rich copper and lead-rich copper tin alloys in core type induction furnaces.

These alloys, and particularly the tin containing alloys, form in the furnace and particularly within the refractory lining adjacent to the molten metal, low melting segregations of easy fluidity and of a composition which is entirely different from that of the molten charge. The lead and tin contents of the segregations are very high and much higher than that of the metal charged in the furnace. The melting point is sometimes as low as about 600° F. and less. The thinly fluid lead and tin-rich segregations accumulate in the secondary slot and penetrate from and through the smallest cavities or pores of the secondary block towards the cooled duct in which the primary is located. As soon as even a slight penetration has occurred, a quick deterioration and breakthrough of the refractory block follows very shortly with the result that the coils of the primary circuit are often attacked and destroyed. The exudations of low melting temperature penetrating through the refractory walls of the secondary block tend in many cases also to form a second ring of metal around the primary. As soon as a new secondary is formed in this manner, more electrical current is absorbed and the process of deterioration is accelerated. In the past, this problem has been solved by the combination of an increase in the wall thickness or that portion of the refractory block which extends between the secondary slot and the cooling duct, and an increase of the surface coefficient of heat transmission at the cold face of the secondary block.

One of the methods of increasing the surface coefficient of heat transmission at the cold face of the secondary block has been the introduction of a split metallic liner on the cold face of the metallic block. This metallic liner has a high thermal conductivity. It is split and insulated in order for it not to become a secondary circuit about the primary core and coil. The liner functions are threefold: (1) it is used as a ramming mold in order to form the necessary path for threading the primary core and coil, (2) it is used to disperse the heat of the lining evenly throughout the air stream and thus avoid hot spots on the refractory and coil, and (3) minute leakage of metal to the air duct liner, or "bushing," is frozen against the essentially cold bushing and, thus, service life of the furnace can be enhanced.

Since these bushings must be electrically split, or insulated, it was traditional to use an insulator at the split in the bushing. These insulators, while being important to the electrical operation of the unit, subtract from the purpose of the bushing, i.e. the even distribution of heat in the lining. In some cases, where cracks through the lining allow metal to bridge the insulation, the bushing short circuits, conducts electricity, and leads to very prompt furnace failure. The fact that these electrical insulators have poor thermal conductivity promotes the leakage of metal towards them as they are effectively running hotter than the highly conductive bushing. This insulator in the prior art was usually made of an asbestos cement or any other suitable insulator.

The problem with the bushing discussed above has been recognized by persons working in this art. To overcome this problem, the bushings with their electrical insulators have been wrapped with mica and/or fiber glass and varnish in order to (1) equalize the heat conductivity of the bushing, and (2) give the bushing more mechanical strength and electrical insulation.

However, all of the insulating materials discussed above detract from the stated purpose of evenly distributing and effectively cooling the refractory into the air stream. It may also be stated, if a bushing is used uninsulated, it is rather difficult to obtain a good bond between the refractory and the bushing. This results in a poor thermal conductivity or sliding of the bushing into and out of position depending on the attitude of the furnace. In such cases, it is obvious that the bushing is serving little or no good purpose and, in fact, can be quite detrimental. Insulated bushings suffer not only from the fact that they hamper the essential functions of the bushing, but also insulating materials can easily be torn or at best make a very poor bond with refractory when the furnace is being lined.

To make the bushings of a non-metallic material offering high resistance to temperature and molten metal attack, having high thermal conductivity, and high electrical resistance is not practical. Such non-metallic structures can only be manufactured of materials which are highly fragile and do not offer mechanical strength necessary for their task.

It is therefore the primary object of this invention to construct a core type induction furnace where the penetration of the secondary block by low melting segregations and/or exudations formed from the molten charge is prevented.

Another object is to provide a new and better insulated bushing having a layer of an electrically nonconductive material bonded thereto which will have electrically insulating properties and high thermal conductivity.

Another object of this invention is to provide a new and improved liner for a core type induction furnace which is mechanically stronger, electrically insulating, and thermally better conductive, and provides a better surface to stop or freeze molten leakage through the refractory.

Another object of this invention is to provide a liner for a core type induction furnace which is stronger than the prior art liners as it has a metallurgically bonded coating which has a bond strength greater than any varnish or plastic type insulations at operating temperatures.

Another object of this invention is to provide a simple and better liner for a core type furnace which has a metallurgically bonded non-metallic insulator to which the refractory material can better adhere than the prior art liners.

Other objects will appear hereinafter.

For the purpose of illustrating the invention there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a vertical sectional elevation of a furnace incorporating the teachings of the present invention.

FIGURE 2 is a vertical sectional elevation of the furnace of FIGURE 1 taken along lines 2—2.

FIGURE 3 is a perspective view of the liner used between the secondary block and the air conduit incorporating the features of the present invention.

In the drawings, there is shown a housing **10** containing a hearth **12** adapted to hold the molten metal and provided in the usual manner with a refractory lining **14**. Suitable insulating material may be inserted between the lining **14** and the housing **10**. The metal forms a charge which is heated by means of currents produced in a secondary slot **24** formed as a loop in a secondary block **16**. The loop **24** is threaded by a primary circuit composed of iron core **26** and surrounded by primary coil **20**. The primary coil may be made of a flat wound copper wire, rectangular in cross section insulated and wound in layers. A flat wound multilayer coil develops less heat than an edge wound single layer coil occupying the same place and, therefore, helps in reducing the temperature prevailing at the cold face of the refractory block.

The hot face of the refractory block **16** is designated by the numeral **18**. The inner cylindrical face of the block **16** is the cold face and is rammed against a liner **22**. A cooling duct **28** is provided between the primary coil **20**, core **26**, and the liner **22**. Air is drawn through the cooling duct **28** by a motor driven blower **34**. By varying the rotational speed of the blower, the velocity of the cooling air can be increased and decreased.

The air cooling ducts of induction furnaces of the type shown in FIGURE 1 are not simple in shape like ordinary tubular ducts. The passage **28** of air is a small cavity located between the outside surface of the refractory liner **22** and the transformer. The transformer consists of two parts, namely the core **26** and the coil **20**, and the air will flow through the passages formed between them also.

In the case of liquid cooled furnaces, the liner **22** would also be necessary.

FIGURE 3 shows further details of the bushing or liner **22** in perspective. It consists of an inner split cylindrical former made of metal sheet rolled to size. The split cylinder **30** has a longitudinal slot running the total axial length thereof to split the cylinder **30** and prevent it from acting as a coil. The metallic split cylinder acts as a good heat conducting material having a very large surface exposed to the cooling air stream. Thus, it has good heat transfer characteristics.

A coating **28** of alumina is metallurgically bonded to the split metallic cylinder **30**. The alumina coating **28** also fills the longitudinal slot in the split cylinder **30** to form a bridge **32**.

The alumina coating **28** has a substantial thickness of $^{3}/_{1000}$ to $^{20}/_{1000}$ of an inch. It is to be understood that other refractory materials offering high resistance to temperature and molten metal attack and having high thermal conductivity, high electrical resistance, providing a surface with high resistance to mechanical abrasion, and an excellent bonding surface for the refractory may be utilized.

Metallurgical bonding of the refractory material to the metallic layer implies (1) bonding by direct physical or chemical fusion, (2) flame deposition, (3) electro- deposition and fusion, (4) flame deposition and fusion. An example would be flame deposited alumina on copper.

By utilizing a refractory material rather than asbestos or the like as an insulator, the thermal conductivity of the split cylinder **30** can more closely be approached. Thus, electrical insulator coating **28** having the same thermal conductivity as the metal will not promote the leakage of metal towards the insulator as it will operate at approximately the same temperature as the highly conductive split metal cylinder **30**. As the non-metallic material coating **28** offers a high resistance to temperature and molten metal attack, it will provide a better surface to stop or freeze molten leakage through the base refractory.

When the molten metal has been heated in the annular secondary slot **24**, the entire induction furnace is then rotated on trunions **36** and **38** and the metal poured from spout **40**.

The present invention may be embodied in other specific forms without departing from the spirt or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. An electric induction furnace for molten metal comprising a metal holding hearth, an induction heating unit including a secondary block of refractory material having a loop channel therein for receiving molten metal, said loop channel being in communication with said hearth, said secondary block having an opening therethrough centrally of said loop channel and defining a cold face on said secondary block, a primary core and coil for said induction heating unit located within said opening, a heat conductive, non-magnetic, metal, split, hollow, elongated former of uniform cross sections having high electrical conductivity, said former having an axial slot, said metallic former having a refractory electrical insulator material of high thermal-conductivity within said slot along the entire length of said slot to prevent the formation of a complete electrical circuit in said metallic former and permit heat transfer, said fromer and said insulator being held against said cold face, and cooling means for cooling said former and insulator located between said former and said primary core and coil.

2. An electric induction furnace for molten metal comprising a metal holding hearth, an induction heating unit including a secondary block of refractory material having a loop channel therein for receiving molten metal, said loop channel being in communication with said hearth, said secondary block having an opening therethrough centrally of said loop channel and defining a cold face on said secondary block, a primary core and coil for said induction heating unit located within said opening, an annular liner, said liner having its entire outer peripheral surface of a thermally conductive electrically insulating refractory material, said liner having an inner surface of a thermally conductive non-magnetic metallic split cylinder, means for electrically insulating the length of the split in said cylinder to prevent the formation of a complete electrical circuit in said metal cylinder, said liner being held in place against said cold face, and a cooling means for cooling said liner and insulator operative on the inner surface of said liner.

3. The electric induction furnace of claim **2** wherein said insulating means is a refractory insulator of high thermal and low electrical conductivity, said refractory material and said insulator being metallurgically bonded to said metal layer.

4. The electric induction furnace of claim **3** wherein said refractory material and insulator are alumina.

5. A liner for a core-type electric induction furnace comprising a split, thermally conductive, non-magnetic, hollow, elongated, metal former of uniform cross section, said former having a split along the axial length thereof, and a thermally conductive, electrically insulating refractory material on the entire outer peripheral surface of said former and in said split, said refractory material being metallurgically bonded to said metal former, said refractory material having a thermal conductivity approaching the thermal conductivity of the former.

6. A liner in accordance with claim **5** wherein said refractory material is alumina and said former is copper.

7. A liner for a core-type electric induction furnace comprising a thermally conductive non-magnetic hollow elongated former of uniform cross-section and good electrically conductive metal, said former having a gap along the entire axial length thereof, means for insulating said gap to pervent a complete electrical circuit in said former, and a thermally conductive electrically insulating ceramic material metallurgically bonded to the entire outer peripheral surface of the former, said ceramic material being alumina.

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