Aug. 1, 1967 B. FREDRIKSON ET AL 3,334,171

VACUUM FURNACE

Filed Nov. 16, 1964 3 Sheets-Sheet 1

Fig. 1

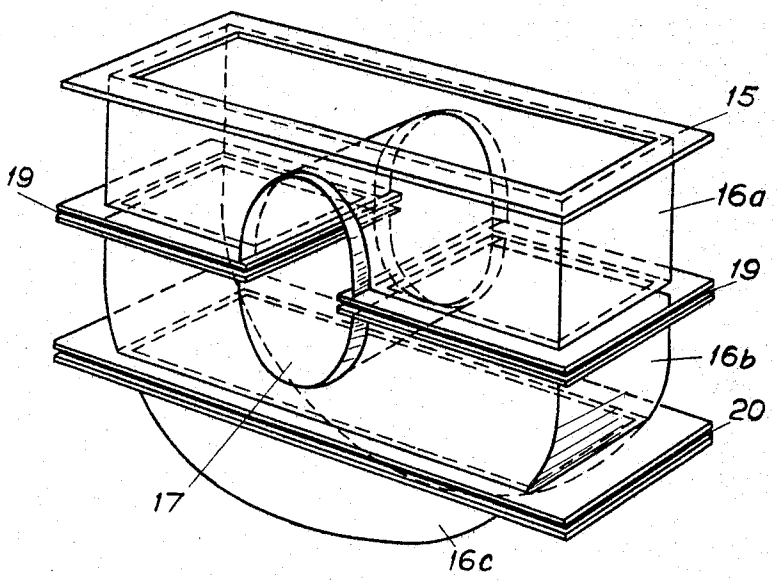
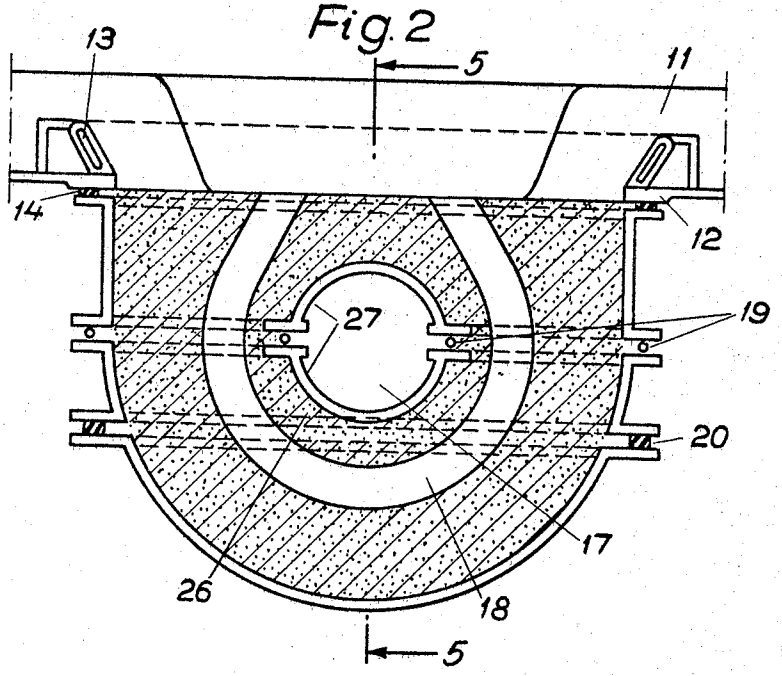


Fig. 2



INVENTORS
Bengt Fredrikson, Gustav Haas,
Gösta Karlsson, Mats Rydinger
BY
Bailey, Stephens & Huettig
Attorneys

Aug. 1, 1967 B. FREDRIKSON ET AL 3,334,171

VACUUM FURNACE

Filed Nov. 16, 1964 3 Sheets-Sheet 2

Fig. 3

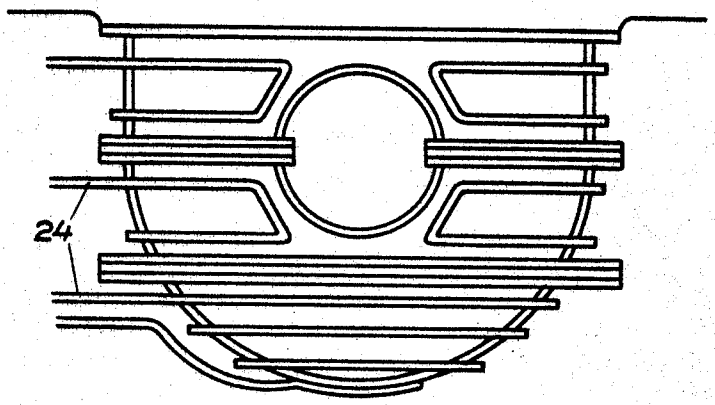
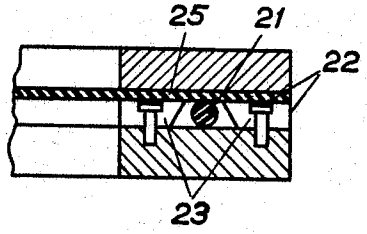


Fig. 4



INVENTOR
BENGT FREDRIKSON, GUSTAV HAAS
GÖSTA KARLSON, BY MATS RYDINGER

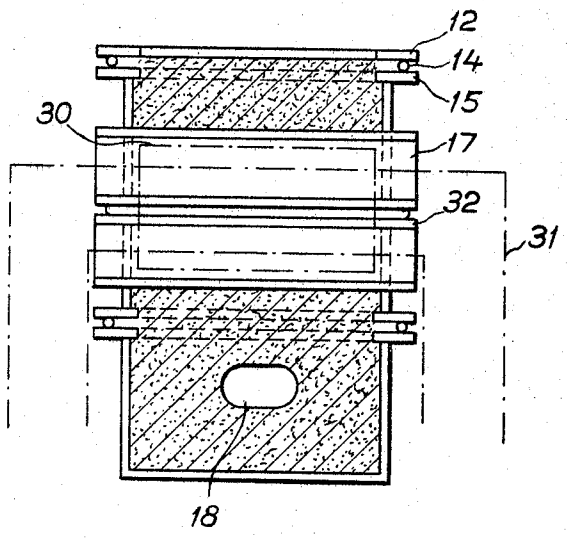
Bailey, Stephens & Huettig
ATTORNEYS

Aug. 1, 1967 B. FREDRIKSON ET AL 3,334,171

VACUUM FURNACE

Filed Nov. 16, 1964 3 Sheets-Sheet 3

Fig. 5



BENGT FREDRIKSON, GUSTAV HAAS INVENTOR.
GOSTA KARLSON, MATS RYDINGER
BY
Bailey, Stephens & Huettig
ATTORNEYS

United States Patent Office

3,334,171

Patented Aug. 1, 1967

3,334,171

VACUUM FURNACE

Bengt Fredrikson, Gustav Haas, Gosta Karlsson, and Mats Rydinger, Vasteras, Sweden, assignors to Allmänna Svenska Elektriska Aktiebolaget, Vasteras, Sweden, a corporation of Sweden

Filed Nov. 16, 1964, Ser. No. 411,197
Claims priority, application Sweden, May 20, 1964, 6,095/64
5 Claims. (Cl. 13—29)

ABSTRACT OF THE DISCLOSURE

Inductor unit for interchangeable application at an opening in the wall of a furnace of submerged resistor type; the attachment is accomplished by means of a packing for interchangeable application and the casing of the unit is divided into at least two portions, the first extending between said packing and a second, electrically insulating packing from which the second portion extends; the casing of the unit and the packings are made vacuum tight for application to a vacuum furnace and between the first and second portion a passage is defined for a coil and an iron yoke.

The present invention refers to a vacuum furnace for degassing metal melts, preferably steel. The furnace comprises a hearth of arbitrary shape. The invention also refers to an interchangeable inductor unit for such a furnace.

In vacuum melt furnaces the furnace has often been provided with stirring devices, often of electromagnetic, low frequency multiphase type. This has the advantage firstly of facilitating the retention of heat imparted to the melt by means of a heat source, and secondly of bringing the whole melt into such a circulation that all or principally all the melt is subjected to degassing. In induction vacuum furnaces of the crucible type, the whole furnace must be enclosed in a vacuum tank where the electrical arrangements will be found within the vacuum tank, which inter alia is accompanied with risks of glowing at these parts and demands special insulating devices. The possibilities of varying the geometrical shape and size of the furnace are also limited.

Our invention eliminates these inconveniences and is intended to be applied to furnaces of arbitrary shape. The invention is characterised in that at least one interchangeable inductor unit of the submerged resistor type for heat retention and stirring of the melt is connected vacuum tightly to the furnace, without emptying and cooling down. Such a furnace does not need to be enclosed in a special vacuum tank, but, like the parts of the induction unit itself, can be made vacuum tight, and at the same time the inductance coil within the unit can operate in atomspheric pressure. The units may be connected to furnaces of practically all feasible geometrical shapes and sizes.

When the furnace coil is switched on, magnetic pressure action ("pinch"-effect) is obtained upon the melt in the loop. By means of this there is obtained an upwardly directed force from the loops of the inductor unit or units upon the melt and stirring is accomplished simultaneously with heat retention. Thus the bottom part of the melt will continually be brought to the surface by the action of the inductor unit. Such inductor units may be used also with very large furnaces regardless of the shape of the hearth.

Without the inductor unit a certain mechanical stirring would be produced in the surface layer because of rising and released gasses being produced, especially in connection with the production of CO, while the bottom part of the melt may not have been affected. Through the action of the inductor unit, this inconvenience has been eliminated and the simple construction of the inductor unit means that a vacuum tight construction can be made in a simple way.

The invention also refers to an inductor unit of submerged resistor type, which comprises a packing for vacuum tight, interchangeable connection to a furnace body and a metallic casing enclosing the inductor unit. The unit is characterized in that remote from this first mentioned packing is arranged a second vacuum packing, which electrically insulates the two parts of the cover at each side of this packing from each other, which second packing extends from a point at the periphery of the unit through at least one space for a coil to another point at the periphery of the unit and comprises two limiting layers and an intermediate, electrically insulating portion, each layer consisting of a lining around a part of the coil space and the intermediate portion having the form of two closed rings, each enclosing one branch of the melting loop or loops. By means of this the formation of a closed electrical secondary circuit around the insulation cover is avoided. By placing the electrical insulating packing remote from the furnace connection, sticking of the packing by sintering is avoided and thus the interchangeability of the inductor unit is not interfered with. The two layers of the packing will tighten the coil space walls at the intermediate parts, by means of which the coil can operate in atmospheric pressure and glowing can be avoided. In the coil space these layers would have the shape of half cylinders around the cylindrical coil space. The electrically insulating part forms closed rings round the branches of the loops which makes insulation and vacuum tight connection of the unit to the furnace possible.

In an embodiment of the invention previously discussed, the insulating part is situated along a plane passing through a coil space parallel with the connection plate to the furnace. In such an embodiment ramming of material around a loop form is facilitated, which form consists of hardened metal.

More remote from the connection than this second packing, a third packing is arranged (which does not need to be electrically insulating) which facilitates ramming of ceramic material also at the outer parts of the cover around the loop form. Such packing would otherwise be difficult.

These and other advantages are shown in more detail in connection with the description of the accompanying drawings.

FIG. 1 shows perspectively an inductor unit for interchangeable application to a vacuum furnace. FIG. 2 shows a section through the unit at right angles to the coil shaft; FIG. 3 shows the unit seen from the side; FIG. 4 shows a section through a vacuum tight, electrically insulated packing; and FIG. 5 is a cross-section through the center of FIG. 2.

To a vacuum furnace **11** (FIG. 2) of arbitrary type an inductor according to FIG. 1 is arranged to be interchangeably fastened. The furnace is made vacuum tight (for example with an enclosing metal cover of stainless, non-ferromagnetic material) and with the usual evacuation means. It is provided with one or more connection openings (FIG. 2) for interchangeable inductor units which must be connected so that the vacuum in the furnace does not disappear through the unit and that latter shall also be interchangeable. The furnace is provided with the usual lining and at the connection opening is provided with a connection plate **12**. Fluid cooled by means of an enclosing cooling channel **13**. The unit is connected to the furnace by means of a vacuum tight packing **14** (FIG. 2). This packing is not electrically insulating, as the use of such insulating material would create a risk of sticking by means of sintering despite

the fluid cooling from channel **13**, and then the unit would not be interchangeable.

The inductor unit is connected through a metallic connection flange (**15**, FIG. 1) and is provided with an enclosing casing formed of first, second and third parts **16***a*, **16***b* and **16***c*, respectively, part **16***a* extending from this flange itself. This casing also encloses a central tubular opening or space **17**, open at the ends, for receiving a coil **30** with iron yokes **31** (shown in broken lines in FIG. 5), intended to be connected to the network frequency, said coil as usual being the primary circuit and a melt loop **18** being the secondary circuit, said furnace operating as a transformer. The melting loop **18** is enclosed in rammed material of a ceramic nature (shown in FIGS. 2 and 5).

The casing parts are electrically insulated from each other with the object of preventing the formation of secondary electrical short circuits outside the melt. The insulation is accomplished by means of an insulating packing **20** (FIGS. 1 and 2) separating the casing into two parts insulated from each other, and by a packing **19** (FIGS. 1 and 2) positioned along each side of the coil space **17** (FIG. 5) and around the outer sides of the casing.

FIG. 4 shows a detailed view of the packing **19**. Packing rings **21** of electrically insulating material on each side of the coil space **17** each form a closed ring around each branch of the melt loop **18**. The ring is positioned in a loop between two aluminium strips **23**, fastened to one of the casing parts with screws. On the screw heads **22** and outside these, insulating layers **25** are arranged.

Strips **23** are of elongated form and are screwed to one of the flanges **32** of the casing at the packing **19**. Thus, by means of the packing **19** (and **20**), the casing is separated into parts electrically and magnetically insulated from each other. As seen from FIG. 2, at the packings **19** and **20** the casing is provided with flanges running in closed form around the unit parts and on both sides of the space **17** around the unit.

The position of the packing **19** (and **20**) makes it possible to separate the unit into two (more) parts in connection with the packing of material around the melting loops **18**, said loops being filled with a form. For example, first the lower part of the casing (below **19**) is filled with material and rammed around a loop form, after which the upper part of the casing is fastened to the packing **19** and the rest of the material is filled in and rammed around the loop form.

This model is made of hardened metal in the melting loop and in a loop through the furnace. The unit is provided with an extra vacuum tight packing **20**, which also makes possible the ramming of the material at the bottom of the unit, especially in the part **26** which lies below the lower half of the coil lining **27**. The coil **30** with iron yoke **31** is placed in the space **17** and as seen from FIG. 5 it operates at atmospheric pressure. The casing material enclosing said space is vacuum-tight. The coil **30** may thus operate without a tendency to glowing in the winding which would otherwise appear if the coil operated in vacuum. In order to produce uniform wear on the loop **18** and in order to prevent over heating and sintering of the packings **19** and **20**, cooling loops are arranged at the coil (not shown) as well as outside the unit (**24**, FIG. 3), said cooling loops **24** area, for the sake of clarity, eliminated in FIGS. 1 and 2).

As seen from FIG. 4, the cooling parts **24** are placed in the atmosphere. Upon leakage of condensed water in the vacuum no undesired pressure increases arise, which would otherwise involve risks. By placing the coil at atmospheric pressure and thereby operating in a conventional manner these risks are eliminated.

When the coil has been connected and the voltage is switched on, there is obtained both a heat generation in the loop and also on account of electromagnetic pressure action upon the melt in the loop **18** a stirring action from the bottom layer, making heat retaining possible and also an effective degassing of the furnace melt. The number of units can be one, two or more and with a suitable construction of the furnace these can be interchanged without cooling down and emptying the furnace.

The invention can be varied in many ways within the scope of the following claims.

We claim:

1. For attachment to a low frequency induction furnace having a wall section with an opening therein, an inductor unit attached at said opening comprising a metallic casing formed of a plurality of parts, a first of said parts being positionable adjacent said wall section with the interior of the casing communicating with said opening, an electrically non-insulating, packing carried by said first casing part engageable with said wall section around said opening, a second casing part positioned adjacent said first casing part, said first and second casing parts together forming a passage therethrough in a direction parallel to the plane of said wall section to receive a coil, thereby forming two branch portions, one on each side of said opening, electrically insulating packing means between said first and second casing parts extending around each of said branch portions, and means closing the end of the second casing part remote from the first casing part.

2. In an inductor unit as claimed in claim **1**, said closing means comprising a third casing part positioned adjacent the end of the second casing part remote from the second casing part, and second electrically insulating packing means engaged between said second and third casing parts.

3. In an inductor unit as claimed in claim **1**, ceramic means within said casing having a U-shaped passage therein communicating at each end with said opening to form a melting loop.

4. In an inductor unit as claimed in claim **1**, said packing means comprising inner and outer strips and an electrically insulating portion between said strips.

5. In an inductor unit as claimed in claim **1**, the plane of said packing means being substantially parallel to the plane of said opening.

References Cited

UNITED STATES PATENTS

3,098,887	7/1963	Calamari	13—29

FOREIGN PATENTS

170,046	10/1921	Great Britain.
532,441	12/1953	Italy.

RICHARD M. WOOD, *Primary Examiner.*

L. H. BENDER, *Assistant Examiner.*