

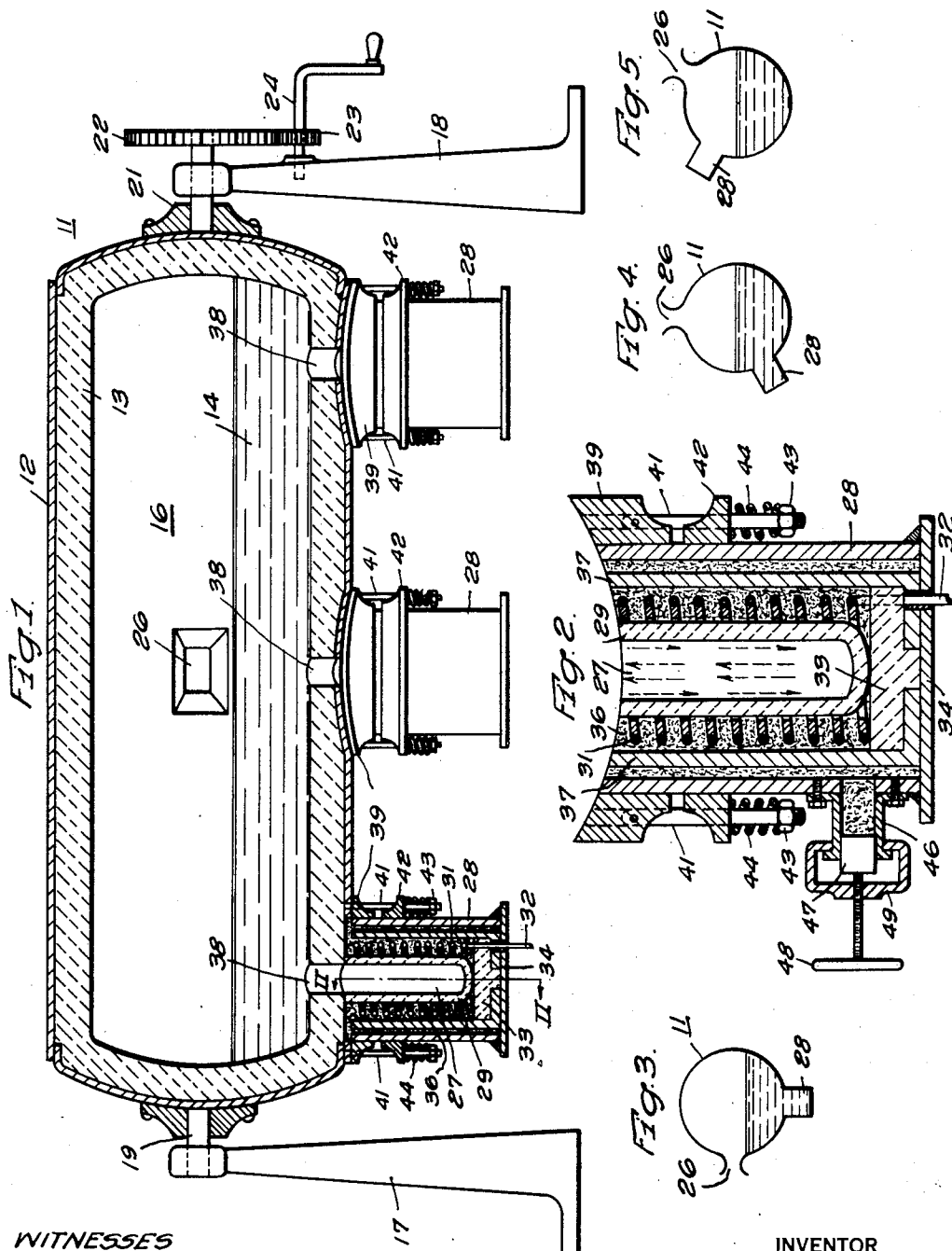
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INDUCTION FURNACE

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WITNESSES

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INDUCTION FURNACE

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My invention relates to electric furnaces, and particularly to induction furnaces of relatively large size.

5 An object of my invention is to provide an electric induction furnace of the surrounded-pool type and of relatively large size and simple construction.

10 Another object of my invention is to provide an electric induction furnace having provision for utilizing polyphase electric energy.

Another object of my invention is to provide an electric-induction-furnace assembly embodying a metal-holding chamber of relatively large capacity and one or more metal-melting chambers of relatively small capacity.

20 Another object of my invention is to provide a furnace structure having a metal-holding chamber provided with a heat-insulating lining of relatively large thickness and one or more metal-melting chambers having a heat-insulating lining of relatively small thickness.

25 Another object of my invention is to provide an induction furnace embodying means for varying the amount of stirring at the surface of the molten metal.

30 Another object of my invention is to provide a furnace in which the inductor elements, including an energizing coil and a metal melting chamber, shall be so assembled as to be easily and quickly detachable from the rest of the furnace structure without emptying the metal from the metal-holding chamber.

35 In practicing my invention, I provide a metal-holding chamber, having suitable refractory heat-insulating walls therearound and a housing for the refractory walls, of relatively large holding capacity and provided with means for tilting or turning the same.

40 When a plurality of metal-melting chambers of relatively small size and capacity are secured to the housing of the metal-holding portion, resilient securing means are provided to connect the two portions. Energizing coils

45 surround the respective metal-melting chambers, the housings of which are filled with granular electric and heat-insulating material, means being provided on each of the housings for the metal-melting chambers to

permit of compressing the granular material therein to assist the lining of the chamber in withstanding the relatively high pressure to which it may be subjected.

In the single sheet of drawing:

55 Figure 1 is a view, partially in horizontal section and partially in side elevation, of an electric induction furnace embodying my invention,

Fig. 2 is an enlarged view, in lateral, vertical section therethrough, taken on the line II—II of Fig. 1, and

60 Figs. 3, 4 and 5 are schematic views showing the furnace structure in different operating positions.

65 Some of the elements which enter into the design and operation of relatively large induction furnaces are the choice of frequency and the question of single-phase or poly-phase supply of energy. In the case of relatively small induction furnaces, particularly those of the so-called surrounded-pool type, that is, the type in which an energizing coil of substantially helical shape is located around a bath of metal, it is possible to use frequencies which may be considered high or, at least, to use a frequency which can be generated by an alternating-current generator of substantially standard type.

70 As the size or capacity of a furnace of this kind increases, the optimum frequency decreases until, in very large furnaces, the optimum frequency may be but a few cycles per second, this requiring special and expensive generating equipment.

75 The problem of the refractory lining in large furnaces becomes extremely important, particularly so if it is to be located between the energizing coil and the material being melted. It is obvious that the thicker the lining, the less is the so-called coupling between the energizing coil and the secondary thereof, constituted by the metal to be melted. Both the power factor and the efficiency of a furnace of this kind having a relatively thick lining are decreased and the decrease may be such as to make a design of this kind non-commercial.

80 When using very low-frequency alternating-current energy and when conducting

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relatively large power input into the metal being melted, particularly when using high-power input per unit volume, the stirring action on the metal may become excessive and require special means for its control.

Referring to the drawing, I have illustrated an electric induction furnace 11 including a metal housing 12 which may be built up of suitable metal body and end members, here shown as connected to provide a substantially cylindrically tubular housing having a lining 13 of high-temperature-resisting and heat-insulating refractory material. The thickness of the refractory lining 13 is made relatively large in order to reduce the amount of heat which may be conducted therethrough when metal 14 located therein and in the chamber 16 has been raised to a relatively high temperature. The chamber 16 constitutes a metal-holding or a metal-containing chamber.

Means for tilting the furnace may be constituted by bearing brackets 17 and 18 engaging stub shafts 19 and 21. A gear wheel 22 may be located on shaft 21 and be rigidly secured thereto to engage a pinion 23 which is mounted on a crank shaft 24 to permit of effecting a turning movement of the housing 11. It is, of course, obvious that, when housing 11 is made of very large metal-holding capacity, some other design than that shown in the drawing for tilting the furnace can be provided, but I have shown the pinion, its operating crank shaft and the cooperating gear wheel as illustrative of such tilting mechanism.

An opening 26 is provided in the housing 11 which may be utilized not only as the charging door but also as a pouring spout.

A plurality of relatively small metal-melting chambers 27 are provided in close operative engagement and connected with the metal-holding chamber 16, the metal-melting chambers being located entirely outside of the contour of the metal-holding chamber.

Each metal-melting chamber 27 is located within a housing 28 which may be made of a suitable high-resistance metal, that is, a metal which will have a tendency to cut down or reduce the temperature rise thereof when it is subjected to an alternating-current flux. Each chamber 27 is defined by a lining 29 which may be in the form of a crucible of a suitable refractory material, usually employed in metal melting, or it may be a rammed-in lining.

An energizing coil 31 is located around the crucible 29 and may be of any suitable or desired construction but is here shown as including an inner solid current-conducting portion and an outer tubular current and cooling-fluid conducting portion. I have shown only one terminal 32 but it is to be understood that a second terminal will be provided, in a manner well known in the art.

The crucible or lining 29 may be located on a refractory base 33 resting upon the bottom 34 of the housing 28, and granular electric-insulating and heat-insulating material 36 is provided between the turns of the energizing coil and between the coil and a set of laminations 37 of substantially L-shape. I have illustrated the magnetic laminations 37 generally only and I prefer to employ these in order to increase the power factor and the efficiency of the energizing coil, although they are not absolutely necessary and may be dispensed with.

The open end portion of housing 28 is of such shape that it may cooperate with the external peripheral surface of housing or casing 12 to effect close interfitting engagement between the refractory wall 13 and the granular refractory material 36 in order to provide a fluid-tight joint. The lining 13 is provided with a plurality of symmetrically spaced openings 38 with which the upper ends of chambers 27 will register when the metal-melting chamber assemblies 27 are in proper operative positions. An annular member 39 is secured, in any suitable or desired manner, to the metal of the housing 12, and its inner peripheral surface may constitute a guide for the outer peripheral surface of an end portion of housing 28.

Resilient means, including a plurality of pivot bolts 41 mounted in recesses in annular member 39, extend through recesses in an annular member 42 secured to housing 28 intermediate its ends. Nuts 43 and springs 44 cooperate with the pivotally mounted bolts 41 and the ring 42 to resiliently clamp each metal-melting-chamber assembly in close operative engagement with the main housing.

Compression means is provided to follow up any possible shrinkage in the granular refractory material 26 and may include a member 46 of cylindrical shape, a piston 47 movable therein and adjustable, as by a hand wheel 48 having screw-threaded engagement with a clamping member 49 of substantially C-shape. Tubular member 46 is bolted against housing 28 which has an opening therein, as shown in Fig. 2 of the drawing.

As was hereinbefore stated, the device embodying my invention is particularly applicable to electric induction furnaces of relatively large capacity in which it is desirable that the heat lost by the molten metal shall be as small as possible and, for this purpose, the thickness of lining 13 is made relatively large, as no melting per se is done in the metal-holding chamber. The metal-melting-chamber assembly is relatively small in capacity, as compared with that of the metal-holding chamber, and the thickness of the crucible or lining 29 need not be made as large, and the provision of follow-up pressure or compression means ensures that the stress to which the lining is subjected by rea-

son of the hydrostatic head of the molten metal shall be counteracted to such an extent as to ensure that the refractory lining 29 shall not crack or break.

The electric energy transferred from energizing coil 31 to metal in chamber 27 has the result of producing a vigorous stirring action of the metal, the metal flowing downwardly adjacent to the outer periphery of the chamber 27 and flowing upwardly in the central portion thereof, as is indicated by the broken line arrows in Fig. 2. As the amount of energy transferred from the coil to the metal is increased, this movement of the metal increases and may become very violent, and one of the disadvantages or harmful results of excessive agitation of the surface of the metal is that oxidation of the metal may occur to too great an extent. This may particularly be the case where a single furnace is utilized at different times in the melting of entirely different metals or alloys.

Referring, for instance, to Fig. 2 of the drawing, I have there illustrated a position of the furnace assembly in which the greatest hydrostatic head or pressure on chamber 27 will be provided. If, now, it appears desirable to increase the agitation, the furnace may be tilted to a position substantially such as is shown in Fig. 4 of the drawing where the auxiliary or metal-melting chambers are no longer immediately below the metal-holding chamber but are intermediate a vertical downward and a lateral position relatively thereto.

It is, therefore, obvious that, if the furnace assembly is maintained in the position shown in Fig. 3 of the drawing, it will be possible to transfer a relatively large amount of energy per unit of volume of the molten metal without excessive agitation of the surface of the metal.

In case of damage to one of the metal-melting-chamber structures, it becomes necessary to remove the same and replace it by an undamaged unit in the shortest possible time, and, in order to effect this removal and replacement, the furnace structure may be tilted to the position shown in Fig. 5 of the drawing, that is, to such an extent that the level of the molten metal will be below the lower edge of the openings 38 so that a housing 28 and the other elements located therein may be removed by temporarily supporting the housing by a chain and a crane, removing the nuts 43 and loosening them to an extent sufficient to permit of swinging the bolts 41 out of the recesses in ring 42. The replacement of an undamaged unit may be effected in the reverse manner, and it is obvious that such removal and replacement may be effected in a minimum length of time.

Attention may also be called to the fact that the metal-melting-chamber assembly is relatively small and may, therefore, be han-

dled easily and that any damage to a part thereof will not be as serious to the continued operation of the furnace as would be the case if a single energizing coil extending around the furnace structure were employed. That is, in case of damage to one energizing coil, if no metal were leaking, it would be possible to continue energizing two out of three phases to complete the melting or the refining operation, if this became necessary.

While I have illustrated and described a furnace embodying a tubular structure, I do not desire to be limited thereto, nor do I desire to be limited to the aligned spaced location of the metal-melting chambers. It is obvious that the inventive idea of a relatively large-capacity holding chamber and a plurality of melting chambers of relatively small capacity may be applied to other forms of furnaces, among which may be mentioned a furnace of substantially spherical shape.

Referring again to the matter of varying the degree of agitation of the metal in the metal-holding chamber, it may be noted that it is possible to continue supplying energy to the respective energizing coils during the tilting movement or during the time that the furnace is maintained in a tilted position, as shown in Fig. 4 of the drawing.

The device embodying my invention thus provides a relatively simple and highly efficient furnace structure in which the molten metal is protected against excessive heat loss therefrom by a relatively thick heat-insulating lining, and in which the transfer of energy from an energizing coil to metal located entirely therewithin is effected at relatively high efficiency by reason of a high coupling factor therebetween. It is possible, in a furnace embodying my invention, to operate it from a polyphase source of supply of electric energy with little or no electrical unbalance. The inductor element, including the lining surrounding the melting chamber, the energized coil and the housing surrounding these parts may be easily and quickly removed and replaced without the necessity of emptying the metal out of the furnace. As the amount of metal in the melting chamber is relatively small, the thermal losses through the walls surrounding the melting chambers are small, so that a relatively high electrical efficiency is obtained. The vigorous stirring action in the metal in the melting chambers effectively prevents localized high temperatures, such as are frequently found in large-capacity furnaces.

The use of relatively small-capacity melting or inductor elements permits of operating a relatively large-capacity furnace at frequencies which are well within the range of those which may be generated by ordinary generating equipment.

Since various modifications may be made in the device illustrated and described with-

out departing from the spirit and scope of my invention, I desire that only such limitations shall be placed thereon as are imposed by the prior art or are set forth in the appended claims.

I claim as my invention:

1. An electric induction furnace including a material-holding chamber of relatively large capacity, a pot-type material-melting chamber of relatively small capacity connected thereto and an inductive energizing coil surrounding said material-melting chamber.
2. An electric induction furnace having a metal-holding-chamber structure of relatively large capacity, a metal-melting-chamber assembly of relatively small capacity and means for resiliently clamping the melting-chamber assembly to the holding-chamber structure.
3. An electric induction-furnace assembly including a metal-holding chamber, a pot-type metal-melting chamber projecting from, and communicating with, the metal-holding chamber, said chambers having refractory walls, an energizing coil located around the wall of the metal-melting chamber, and means for varying the degree of surface disturbance of metal in the metal-holding chamber.
4. An electric induction-furnace assembly including a housing for a metal-holding chamber having an opening therein, an annular member on said housing around said opening, and a housing for a metal-melting chamber having a portion interfitting with the annular member to provide a fluid-tight joint.
5. An electric induction-furnace assembly including a housing for a metal-holding chamber having an opening therein, an annular member on said housing around said opening, a housing for a metal-melting chamber having a portion interfitting with the annular member to provide a fluid-tight joint, and resilient means for holding the housing of the metal-melting chamber in proper operative position against the housing of the metal-holding chamber.
6. An electric induction-furnace assembly including a chamber, a refractory lining therein, an energizing coil around the lining for heating metal located within the lining by inductive action, a housing enclosing the chamber, the refractory lining and the energizing coil, granular refractory material in said housing and around said lining and adjustable means for applying pressure to the granular refractory material to support the lining against relatively high internal pressures thereagainst.
7. An electric induction-furnace assembly including a main and an auxiliary housing enclosing a metal-holding chamber and a communicating metal-melting chamber, granular refractory material in the auxiliary housing and around said metal-melting chamber and adjustable means for effecting pressure on said granular refractory material to counteract the metal pressure in the metal-melting chamber.
8. A polyphase electric induction furnace including a casing for a metal-holding chamber of relatively large capacity, a plurality of relatively small casings for inductor chambers, and means for removably and resiliently securing said inductor-chamber casings against the casing of the metal-holding chamber.
9. A polyphase electric induction furnace including a casing for a metal-holding chamber, a plurality of casings for metal-melting chambers located in symmetrically-spaced relation to the vertical axis of the casing of the metal-holding chamber, and means for detachably and resiliently securing the casings of the metal-melting chambers against the casing of the metal-holding chamber.
10. A polyphase electric induction furnace including a casing for a metal-holding chamber, a plurality of casings for metal-melting chambers located in symmetrically-spaced relation to the vertical axis of the casing of the metal-holding chamber, and means for detachably and resiliently securing the casings of the metal-melting chambers in interfitting engagement with the casing of the metal-holding chamber.

In testimony whereof, I have hereunto subscribed my name this 27th day of December, 1930.

PORTER H. BRACE.