

Oct. 20, 1959

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2,909,585

VACUUM MELTING FURNACE

Filed June 29, 1956

FIG. 1

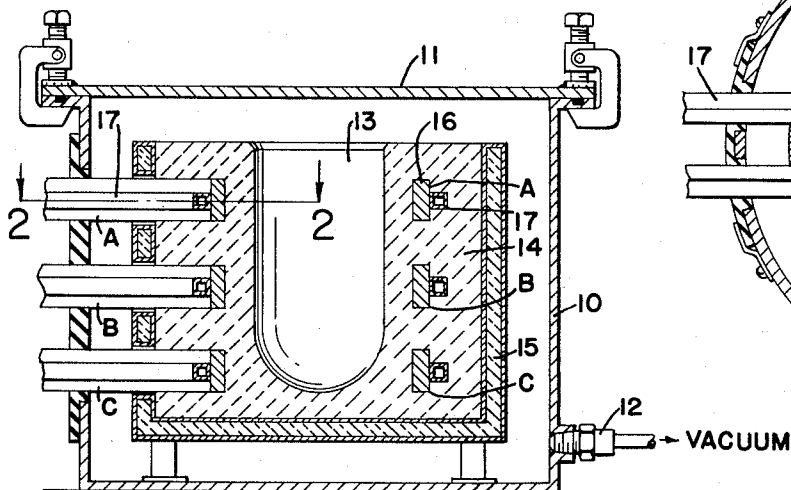
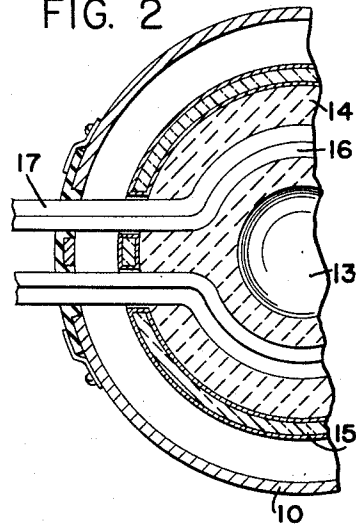
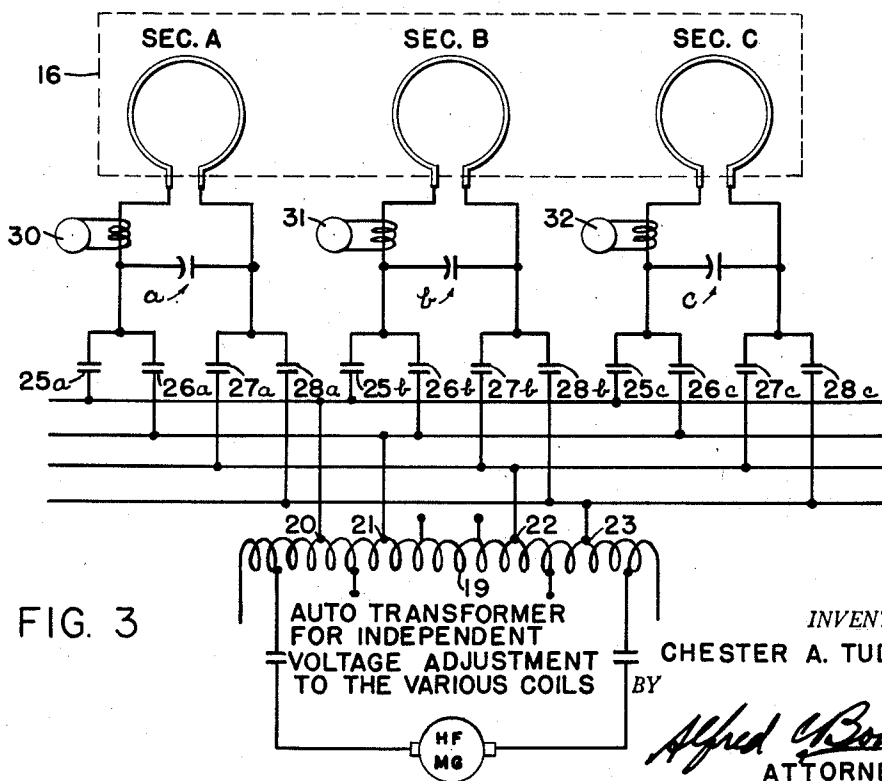


FIG. 2



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VACUUM MELTING FURNACE

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Application June 29, 1956, Serial No. 594,735

2 Claims. (Cl. 13—27)

The present invention pertains to the art of induction melting vacuum type furnaces and, more particularly, to an inductor arrangement for such furnaces.

In the art of induction melting furnaces, it is conventional to surround a container or crucible for a molten metallic charge, with a multiturn induction coil energized from a source of alternating current, usually of a frequency higher than normal line frequencies. Current flowing in this coil, induced by transformer action, causes currents to flow in the metal charge in the crucible, which currents generate heat and melt the charge.

More recently there has been a tendency to enclose the entire furnace in a container and exclude the atmosphere; that is to say, to melt the charge in a vacuum. Difficulties immediately arose, however. The voltages employed for conventional induction melting were much too high for vacuum melting and arcing between the power leads resulted when the air ionized between the power leads as a result of the reduction in the gas pressure in the furnace. To reduce the voltage between the leads to the furnace, it has heretofore been conventional to provide a single-turn coil surrounding the crucible, which coil was, in fact, a metallic sleeve having a length generally equal to the depth of the crucible.

However, the single-turn coil introduced additional problems particularly as the individual metallic pieces making up the charge began to melt. As the various pieces began to melt, the molten material flowed by gravity to the bottom of the crucible. This molten material, at the bottom of the crucible, is a better electrical secondary circuit for the inducing coil than the remainder of the unmelted pieces. As a result of this, the current in the single-turn coil tends to concentrate at the bottom of the coil or in that part of the coil which is closest to, or in closest proximity with, the molten material. The tendency is for the molten portions of the charge to absorb the principal or major part of the electrical energy and to become super-heated while the remainder of the pieces have a reduction of energy input and do not melt, or the melt down rate is considerably reduced.

The present invention contemplates a coil construction for induction melting vacuum type furnaces employing a single-turn coil wherein the current in the coil can be distributed lengthwise of the coil as desired to obtain desired ampere turn distribution axially along the charge or from the bottom to the top thereof.

In accordance with the present invention, the one-turn coil comprises a plurality of several one turn sections, each of which is narrower than the one-turn coil originally used. The width of the coil, or section of the

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coil, is measured along a line corresponding to the length of the charge or along a line between the bottom and the top of the charge to be melted.

Each section is independently energized so that the power in one section may be varied relative to another section to maintain desired ampere-turn distribution axially along the charge.

It is thus possible to slightly change the power in one one-turn section relative to another section of the one-turn coil from time to time and as the charge melts, or as various charges are inserted in the crucible, to more closely control the ampere-turn distribution axially along the length of the charge. Means are provided so that an operator of the furnace can adjust the power being fed into the sections of the coil when necessary to keep them in balance or in correct ampere-turn distribution. The proximity effect between the coil and the charge is thus controlled and the current in the coil is maintained in a distributed fashion and not allowed to concentrate in that section of the coil closest to the molten material in the bottom of the crucible.

The principal object of the invention is to provide an induction coil arrangement wherein axial, or lengthwise, distribution of induced current in a charge being melted can be maintained during melting of the charge.

Another object of the invention is to provide a one-turn induction coil with several sections and means for controlling the power energization of each of those sections.

A further object of the invention is to provide a one-turn inductor coil with several sections positioned longitudinally of the coil, each section being independently energized but all sections being energized from a single source of power.

Other objects, and a fuller understanding of the embodiment of the invention will become apparent from the following description of a particular embodiment of the invention when taken in conjunction with the accompanying drawings in which:

Figure 1 is a sectional view of a vacuum type induction furnace illustrating a one-turn inductor coil of several sections around a charge of material to be melted,

Figure 2 is a fragmentary sectional view approximately along the line 2—2 of Figure 1, and

Figure 3 is a schematic and wiring diagram illustrating the electrical circuits used for energizing the various sections of the one-turn coil.

The present invention may take physical form in the preferred embodiment of a single or one-turn coil for inducing melting currents in a charge to be melted in a vacuum furnace. This particular vacuum type induction heating furnace illustrated in Figure 1 has a housing 10 covered with a lid 11, and provided with a vacuum pump connection 12, which may be connected to a suitable vacuum pump for establishing a vacuum in the housing 10. Mounted in this housing in any suitable manner is a crucible 13 adapted to contain a charge of material to be melted. In this instance, the crucible 13 is supported by a refractory material 14 contained in an insulation material case 15. Imbedded in the refractory material 14 and around the crucible is a one-turn coil 16. It is noted that the axis of the coil 16 is parallel with, and may be coaxially extensive with, the axis or length of the crucible 13, and thus with a charge in the crucible. The width of the coil is measured along a line

corresponding with the length of the charge being melted or of the crucible which contains the charge to be melted.

In the embodiment of the invention illustrated, the single or one-turn coil 16 is in the form of three independent one-turn sections, A, B, and C. The exact number of sections may be increased, or decreased, depending on the specific application and the space limitations and physical characteristics needed in a one-turn coil, such as coil 16. However, in this instance, three sections are illustrated with section A positioned near one end of the crucible, section B near the middle of the crucible, and section C at the other end of the crucible. Each section of the coil may have the well-known coolant tube, such as the coolant tube 17 on section A, if desired.

In this particular embodiment, the ends of each section A, B, and C, extend outwardly through the refractory 14, case 15, and the housing 16, as illustrated at the left in Figure 1, so that they may be electrically connected to the source of high frequency current used to power the coils. Any standard vacuum seal arrangement commonly used in the industry may be placed between the housing and the individual coil sections and their respective coolant conduits at the place where they extend through the housing.

The sections A, B, and C are independently and electrically connected to a suitable source of power or source of alternating current, such as the auto transformer 19 illustrated in Figure 3. The transformer 19 has a plurality of secondary taps such as the taps 20, 21, 22 and 23, the taps 20 and 23 being towards the ends of the secondary and the taps 21 and 22 being towards the center of the secondary. One side of each of the sections A, B, and C is connectable through suitable contactors 25a, 25b and 25c respectively, and suitable electrical wiring to transformer tap 20, or through suitable contactors 26a, 26b and 26c respectively and associated electrical wiring to tap 21 on the transformer. Similarly, the other side of each section A, B, and C is connectable through contactors 27a, 27b and 27c respectively and electrical wiring to tap 22 on the transformer, or through contactors 28a, 28b and 28c and suitable wiring to tap 23 on the secondary of the transformer.

The contactors 25a, 25b or 25c and 26a, 26b or 26c for each of the sections may be suitably inter-locked or otherwise mechanically joined by means well-known in the art so that only one of these contactors for each coil section may be closed at a time to insure and prevent possible short circuiting through the contactors of the taps 20 and 21. Similarly, the contactors 27a, 27b or 27c and 28a, 28b or 28c may be mechanically joined to prevent electrical short circuiting through the contactors between the taps 22 and 23.

Generally, it is desired to use a condenser with each coil section to correct the power factor of the system since the coil sections and the transformer are all basically inductive when they are energized with high frequency induction heating energy or power. In such instances, each section A, B and C of the coil 16 may be connected in parallel with its respective condenser a, b, c, with one end of each section electrically connected to one end of its condenser and the other end electrically connected to the other end of the condenser.

In the present circuit, closing of the contactors 25a, 25b and 25c, and the contactors 27a, 27b and 27c, directly and independently connect each section A, B and C, across the taps 20 and 22 of the transformer, so that the sections A, B, and C are operating independently of each other, and are inducing current into the charge. The actual current flowing in each section of the coil may be observed by an operator by means of meter devices 30, 31 and 32 mounted in electrical association respectively with sections A, B, and C. If, during the operation and heating of a charge in the crucible 13, the

operator notices on these meters 30, 31 and 32 that one of the sections A, B, or C is taking more current than another section, he can simply manipulate one or more of the contactors 25a, 25b, 25c; 26a, 26b, 26c; 27a, 27b, 27c and/or 28a, 28b, 28c to adjust the current flow so that the current flow in the sections A, B and C is again brought into the desired relationship. For example, to change the current flow in section A, an operator can open contactor 25a and close contactor 26a or open contactor 27a and close contactor 28a, or both, or vice versa. Similarly, the power or energy into the other coils may be changed by changing their respective contactors.

It is understood that the contactors may be operated from a remote point by suitable relay systems if desired; however, for the purposes of simplicity, hand operated contactors have been illustrated and described, with the operator visually watching the meters 30, 31 and 32, and manually adjusting the contactors. If desired, it is understood the contactors and their meters can be electrically inter-connected through well-known control systems so that the contactors will be opened and closed automatically upon definite changes appearing in the meters.

With the present one-turn coil comprised of several sections, each operating independently of the other sections, any proximity effect which may be established between the charge in the crucible 13 and one section will remain in or near the location of that section and any proximity effect between the charge and another section, will remain in the respective physical locations. Proximity effect which may be established cannot cause all of the current to move into the location of the section of the coil next adjacent the bottom of the crucible 13, or, in this instance, into that part of the coil where section C is located.

The primary current in the present single one-turn coil cannot concentrate at one end of that coil and result in super-heating that portion of the charge which is already melted without melting the remainder of the charge. For example, proximity effect cannot cause current flowing in section A to move into section C which is in closest proximity with molten material in the bottom of the crucible 13. Current directed to section A will remain in section A. Therefore, desired ampere turn distribution axially along the length of the charge is obtained with the present coil construction wherein the one-turn coil has several sections as illustrated and described herein.

Similarly, other modifications may be made in the present embodiment, and other similar embodiments of the invention can be had without departing from the spirit and scope of the invention as hereinafter claimed.

Having thus described my invention, I claim:

1. A coreless induction heating furnace adapted to melt a charge comprising a crucible containing the charge to be melted, a one-turn induction coil around said crucible, said crucible having a pre-determined length and said coil having a width extending longitudinally of said crucible, said coil consisting of a plurality of independent one-turn sections axially aligned and longitudinally spaced and electrically insulated relative to each other with the combined width of the sections being less than the width of the total coil, and means connecting said sections independently of each other to different voltage sources of alternating current.

2. A one-turn induction heating coil circuit for coreless induction melting furnaces comprising, an auto transformer having a plurality of secondary taps, a plurality of individual one-turn coil sections coaxially aligned and longitudinally spaced to effectively constitute a one-turn coil, and means connecting one side of all of said sections to a common tap and connecting the opposite side of all of said sections independently to other taps

whereby the coil sections are electrically connected independently of each other, said means including contactors.

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