Feb. 6, 1962 W. D. REDFERN 3,020,323

METHOD FOR STIRRING ELECTRIC-CURRENT-CONDUCTING MELTS IN FURNACES, MIXERS AND HOLDERS

Filed Nov. 18, 1958

FIG 1

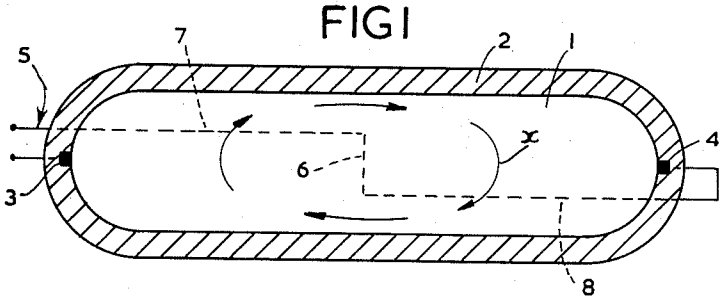


FIG. 2.

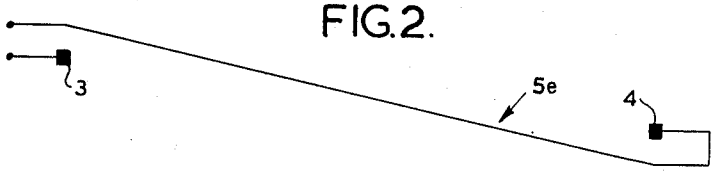


FIG. 3.

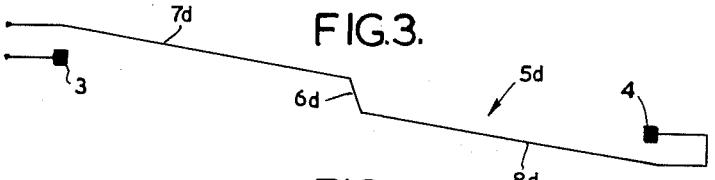


FIG. 4.

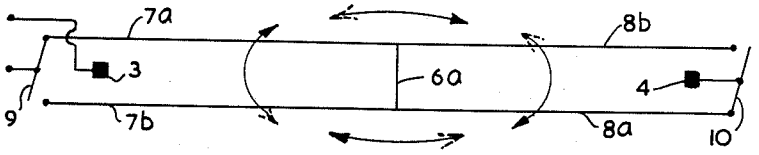
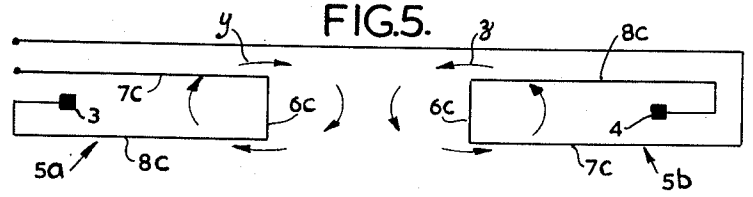


FIG. 5.



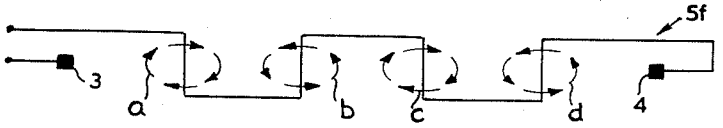


FIG. 6.

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METHOD FOR STIRRING ELECTRIC-CURRENT-CONDUCTING MELTS IN FURNACES, MIXERS AND HOLDERS

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6 Claims. (Cl. 13—5)

This invention has reference to a method of and means for stirring electric-current-conducting melts, in a furnace, mixer or holder (hereinafter, and where the context so admits, the word "holder" is to be regarded as meaning any furnace, mixer or holder suitable for melting purposes and/or for holding melts) which holder, if heated, is not primarily heated electrically. More particularly, the invention is concerned with a method of and means for stirring melts of ferrous and non-ferrous metals or alloys in an open hearth furnace.

In some cases, when a quantity of material such as a batch of metal or alloy is being melted and/or the melt is being treated in a holder, it is desirable that the melting or treatment process should be accompanied by oxidation, deoxidation or refining of the material and/or by the mixing, alloying or homogenizing of its constituents. In the past, various methods have been proposed to obtain such desired results: for example, it has been proposed to add chemicals or other agents to the melt or to cause the melt to come into intimate contact with slag on its surface.

Moreover, it is well known that, to obtain any one or more of the said desirable results with the greatest economy, it is advisable to stir the melt. Various methods of stirring have been proposed and some degree of agitation or stirring is inherent to furnaces which are heated inductively by high frequency currents. Similarly, some degree of agitation or stirring may be obtained if the melt is heated electrically by feeding alternating current to electrodes immersed in the melt, and by producing in the melt a second magnetic field which reacts with the field produced by the heating current; for example, it has been proposed to produce the second magnetic field by feeding alternating current to each of two flat, concentric windings disposed around a central core and housed within a pocket in the underside of the holder.

The principal object of the present invention is to provide an improved and simpler and more economical method of and means for stirring an electric-current-conducting melt in a holder by means of reacting magnetic fields produced in the melt.

The foregoing and other objects of the invention will be apparent from the following description when considered in conjunction with the accompanying drawings in which FIGURE 1 is a diagrammatic sectional plan of a holder, for example, an open hearth furnace, provided with one form of sub-conductor adapted to cause stirring of a current-conducting melt within the furnace, and each of FIGURES 2–6 shows a different alternative arrangement or form of sub-conductor.

The holder shown in FIGURE 1 may be of any known construction which is adapted to be heated other than electrically, for example, by the combustion of preheated gaseous or vapourised liquid fuel. The said holder is formed with a chamber having a refractory hearth which is bounded by refractory walls **2** so as to be capable of receiving and holding a charge of molten metal or other electric-current-conducting melt.

The holder is provided with two electrodes **3** and **4** which are located respectively at or in the vicinity of opposite ends of the chamber and of which at least the tips are immersed in the melt, and with an electric current

conductor **5** having portions **6**, **7** and **8** and which is disposed below or is embedded in the hearth **1**.

The said electrodes are disposed in the longitudinal centre line of the chamber, whereas the said conductor, which preferably is water or otherwise artificially cooled, extends from end to end of the holder and is cranked at **6** midway between the electrodes **3** and **4**; each of the conductor portions **7** and **8** on opposite sides of the cranked portion **6** is straight and parallel to the vertical plane passing through the said longitudinal centre line, the said portions being located respectively on opposite sides of and equidistantly from the said plane which, consequently, bisects the cranked portion of the conductor. Preferably, each conductor portion **7** and **8** is located midway between the said vertical plane and the side walls of the chamber.

The electrode **3** and the adjacent end of the conductor are connected, in any known and suitable manner and through controlling switchgear (not shown), across a source of alternating or direct current supply adapted to feed a heavy low voltage current (for example, a current of or in the region of 10,000 amps.) to the said electrode and conductor.

The electrode **4** is connected to the opposite end of the conductor **5** so that, upon closing the controlling switchgear, the current flows between the electrodes through the melt and also through the conductor, the flow through the melt being in the opposite direction to the flow through the conductor. Consequently, re-acting magnetic fields are produced in the melt and these fields initiate and maintain a circulatory or stirring movement of the melt as indicated by the arrow *x*.

If desired, instead of locating the electrodes **3** and **4** in the longitudinal centre line of the chamber as indicated in FIGURE 1, they may be disposed symmetrically on opposite sides of the said line as indicated in FIGURE 2 and/or the conductor **5***e*, instead of being cranked as indicated in FIGURE 1, may extend in a straight line which is symmetrical to the vertical plane passing through the said centre line, from one side of the said plane to the other, passing through the plane midway between the electrodes. Alternatively, and as indicated in FIGURE 3, the conductor **5***d* may be cranked at **6***d* and each of the straight portions **7***d* and **8***d* may be parallel to a vertical plane passing through an imaginary straight line extending between the electrodes. In a holder in which the conductor **5***e* or **5***d* is arranged as indicated in FIGURES 2 and 3, the closing of the controlling switchgear will initiate and maintain a circulatory or stirring movement in the melt which is similar to that initiated and maintained by the arrangement in FIGURE 1.

When it is desired to reverse the direction of the circulatory movement of the melt periodically, the holder may be provided with a conductor arrangement as indicated in FIGURE 4. That is to say, the holder may be provided in or under the hearth, with an H-shaped conductor having a central bar or cranked portion **6***a* and parallel straight arm portions **7***a*, **7***b* on one side, and parallel straight arm portions **8***a*, **8***b* on the opposite side, of the said bar portion. In such circumstances, switches **9** and **10** are provided so that the electrode **3** and either the conductor portion **7***a* may be connected across the source of current supply and the electrode **4** may be connected to the conductor portion **8***a* to initiate the same circulatory movement of the melt as indicated in FIGURE 1 or by changing over the said switches, the electrode **3** and the conductor portion **7***b* may be connected across the supply and the electrode **4** may be connected to the conductor portion **8***b* to reverse the direction of the circulatory movement.

To initiate and maintain two separate zones of circulatory or stirring movement of the melt, the conductor ar-

rangement shown in FIGURE 5 may be provided. That is to say, two conductors 5*a* and 5*b* may be provided in or below the hearth 1 and on opposite sides and symmetrically of the vertical plane passing through the transverse centre line of the holder; one end of the conductor 5*a* is connected to the electrode 3, one end of the conductor 5*b* is connected to the electrode 4 and the opposite ends of the said conductors are connected across the source of current supply. Further, each conductor comprises two parallel straight portions 7*c* and 8*c* which extend from the end of the holder in which is located the electrode to which the conductor is connected, to a position half way between the said end and the said vertical plane where the said portions are spanned by a transverse portion 6*c*.

Hence, upon closing the controlling switchgear, current flows, for example, to and through the conductor 5*a* to the electrode 3, through the melt to the electrode 4, and then through the other conductor 5*b*. The portions 7*c* and 8*c* of the two conductors are located respectively on opposite sides of the vertical plane passing through the longitudinal center line of the holder, so that the current flows in opposite direction through the said conductors and therefore the circulatory or stirring movements initiated and maintained in the melt in the two halves of the chamber are in opposite directions, as indicated by the arrows *y* and *z*.

Alternatively, and as indicated in FIGURE 6, by cranking the conductor 5*f* at a plurality of equi-spaced intervals apart along the length of the chamber, a corresponding number of circulatory movements of the melt may be initiated and maintained, as indicated by the arrows *a*, *b*, *c* and *d*.

The electrodes may extend into the melt from the top or bottom, or through the walls, of the holder, and besides being water or otherwise artificially cooled, may be protected from slag action. Also, means may be provided for varying the value of the current in the electrode, melt and conductor circuit so as to control the stirring action on the melt.

What I claim is:

1. Apparatus for stirring an electric-current-conducting melt comprising a container for the melt, first and second electrodes carried by said container in spaced relation to each other and located in a vertical plane dividing the melt into substantially equal portions, a pair of conductors connected to said electrodes for establishing an electric current circuit between said electrodes, one of said conductors extending from the electrode to which it is connected back toward the other electrode and being carried by said container so as to be isolated from the melt held thereby, said one conductor having a first straight leg portion lying on one side of said plane and a second straight leg portion lying on the other side of said plane with there being a linear portion connecting such legs which passes through said plane.

2. An apparatus for stirring an electric-current-conducting melt according to claim 1, wherein said linear portion connecting the leg portions of said one conductor passes perpendicularly through said vertical plane.

3. An apparatus for stirring an electric-current-conducting melt according to claim 1, wherein said straight leg portions of said one conductor are of substantially equal length and said linear portion connecting said legs passes through said vertical plane approximately midway between said electrodes.

4. An apparatus for stirring an electric-current-conducting melt according to claim 1, wherein said one conductor extending from the electrode to which it is connected back toward the other electrode is provided with an additional pair of straight leg portions lying on opposite sides of said vertical plane, said additional pair of leg portions being connected by a second linear portion passing through said plane.

5. An apparatus for stirring an electric-current-conducting melt according to claim 1, wherein the other of said pair of conductors is also carried by said container so as to be isolated from the melt held thereby, said other conductor having a pair of straight leg portions lying on opposite sides of said plane and said pair of straight leg portions being connected by a linear portion which passes through said plane.

6. An apparatus for stirring an electric-current-conducting melt according to claim 1, wherein is additionally provided a third conductor isolated from the melt, said third conductor also having a first straight leg portion lying on one side of said plane opposite to the said first straight leg portion of the said one conductor and a second straight leg portion on the opposite side of said plane and opposite to the second straight leg portion of said one conductor, the straight leg portions of the third conductor being connected by the same linear portion of said one conductor, and switching means selectively connectable to said one and third conductor to substitute the third conductor for said one conductor in the electric circuit of said electrodes whereby to reverse the direction of stirring of said melt.

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