

April 23, 1940.

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2,198,304

METHOD AND APPARATUS FOR CIRCULATING GLASS

Filed Sept. 26, 1936

2 Sheets-Sheet 1

FIG. 1.

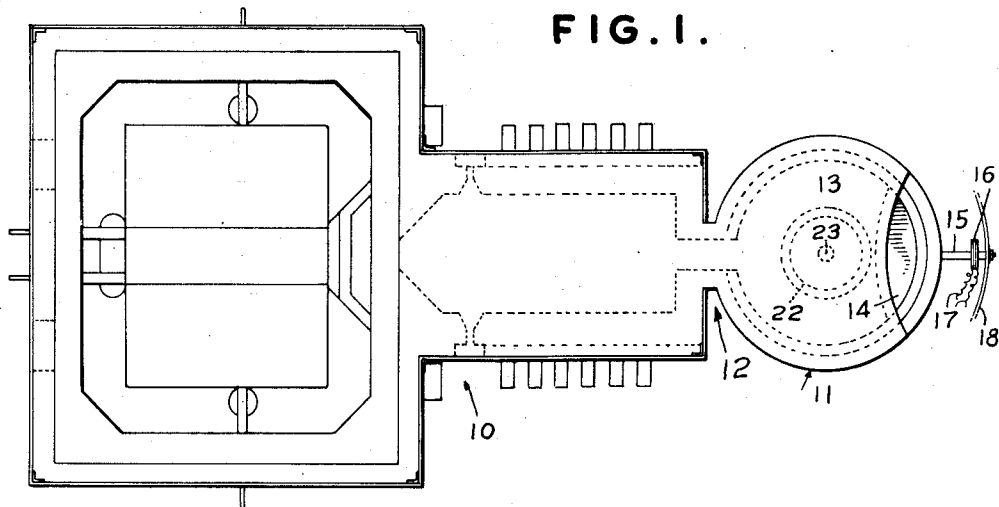


FIG. 2.

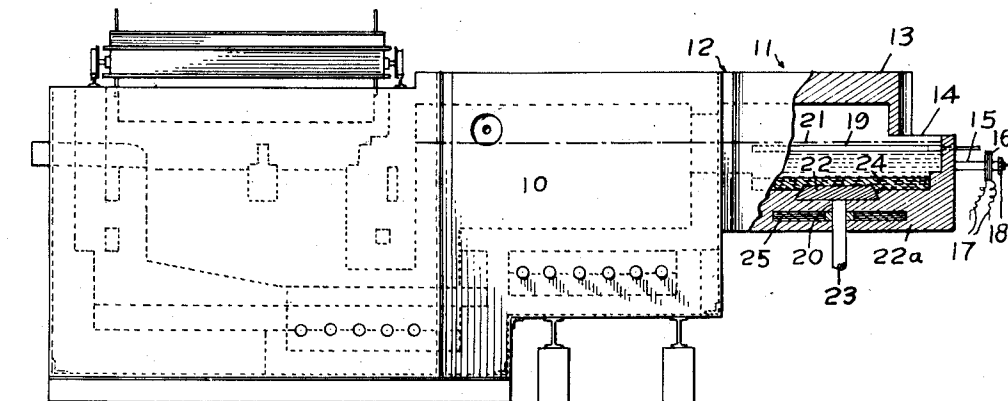
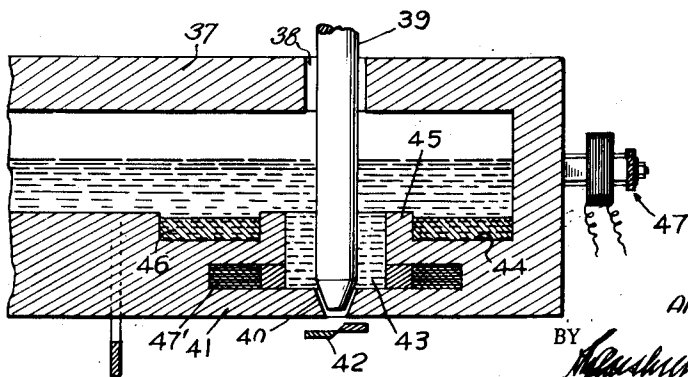


FIG. 3.



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FIG. 4.

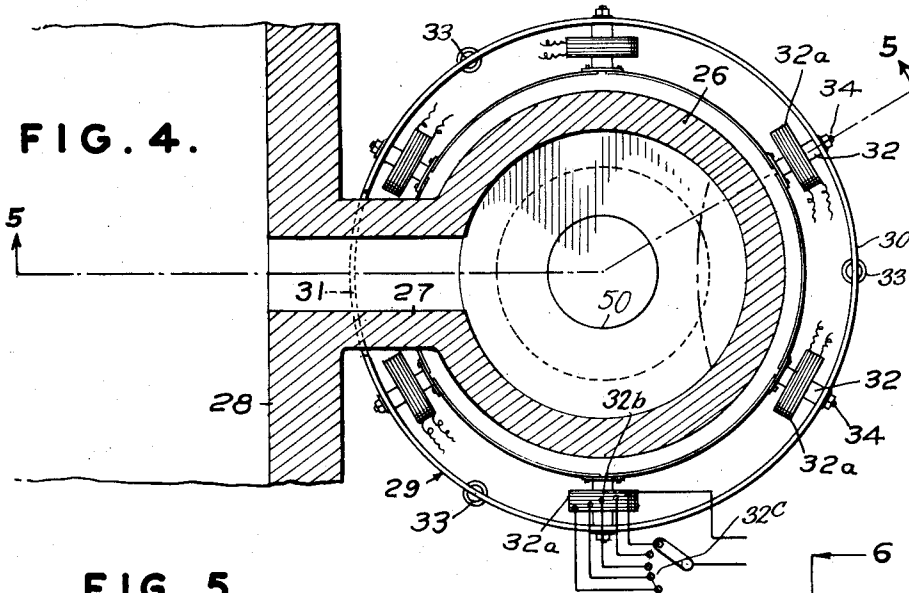


FIG. 5.

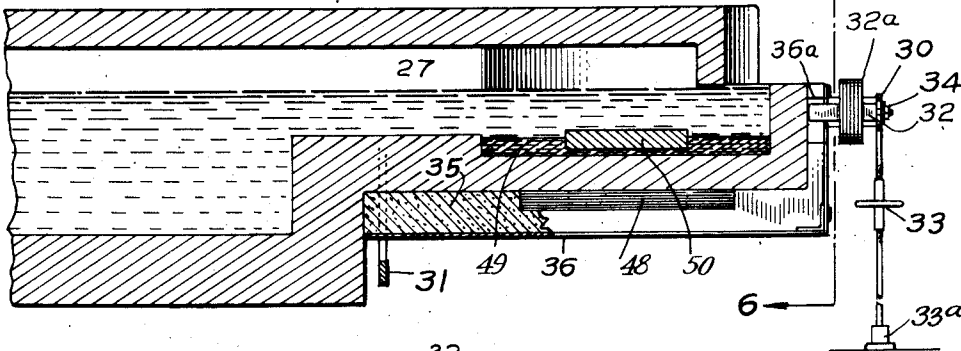


FIG. 6.

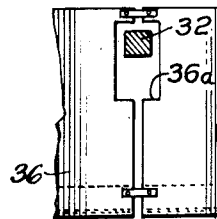
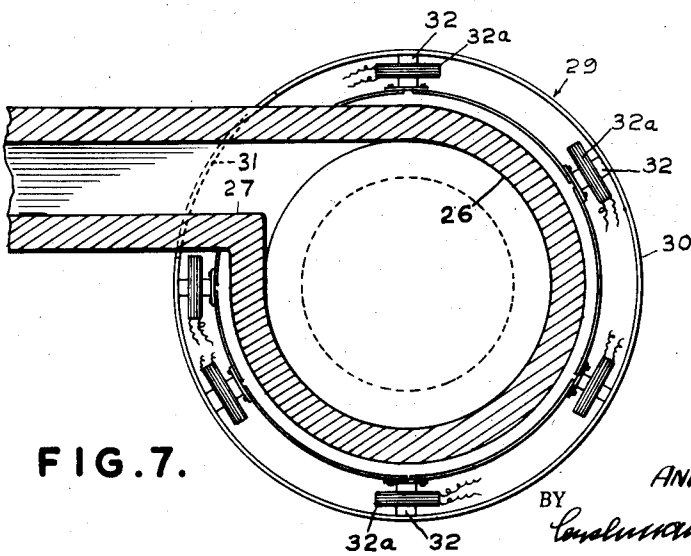


FIG. 7.



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2,198,304

METHOD AND APPARATUS FOR
CIRCULATING GLASS

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Application September 26, 1936, Serial No. 102,810

14 Claims. (Cl. 13—6)

This invention relates to devices for imparting agitative motion to substances of substantially liquid or viscous consistency for instance to the molten material of furnace charges.

5 More specifically it relates to devices for agitating such materials by way of electro-magnetic or electro-dynamic effects, that is to say, without the use of agitating elements such as paddles or the like, avoiding the direct contact of such elements or of undesirable materials with the material to be agitated.

10 While not to be understood in a restricted sense, this invention will be described in connection with and in a special adaptation to furnaces for melting glass or glass-like substances and, aside from its broader aspects, this invention is therefore also to be considered as an improvement in the construction and operation of such furnaces.

15 Therefore, as viewed with respect to one important embodiment and field of application this invention relates to furnaces for melting glass or glass-like substances as used in the feed for the making of commercial wares, for instance glass-ware, bottles, etc., and more particularly to the operation of that section of the furnace which constitutes the fore hearth from which a sequence of small quantities or gobs of glass can be with-
20 drawn as needed for instance in feeding subsequent glass machinery.

In a conventional furnace layout the glass bath in the fore hearth constitutes an outlying and substantially exposed portion or bay of the main furnace charge, which portion must be adequately insulated and otherwise protected against heat losses and so arranged as to permit the dispensing therefrom of gobs of a desired size. Dispensing means for this purpose may be in the nature of the conventional gob-plunger-feeder discharging
25 the gob through the bottom of the fore hearth, or in the way of a dipper operating from the top, or else it may be what is known as a suction gathering device, the purpose of these devices being the dispensing of substantially even quantities of the molten charge in even doses as required for the article to be formed and made therefrom.

30 In order to maintain homogeneity in the molten glass material to be dispensed from the fore hearth, and in order to insure a continually even degree of glass flux of fluidity or viscosity, smoothness of operation, and an evenly high quality of the glass product, it is desirable that the body of
35 molten material in the relatively exposed fore

hearth be kept in even gentle motion in such a manner that local chills or changes of flux of the melt or other undesirable phenomena are immediately compensated or dissipated, if not precluded; while a continuity of different portions
40 of the molten material in the fore hearth are brought to the point of discharge.

Also, the agitation effects induced for this purpose should be such as to avoid causing air bubbles to be entrained. Also, where a suction gathering device is used this agitation should prevent the glass sheared and cut in gathering of glass to one of a series of moulds from being sucked and gathered for the following mould. A similar reason for agitation applies where a gob plunger
45 feeder is employed.

Conventional ways and devices for realizing such agitation have not been satisfactory from an operating as well as from a constructional standpoint.

Heretofore, difficulties have been experienced with a paddle agitating mechanism whose paddles had to be made from a heterogeneous material such as refractory material because of the heat resistance required and the trouble that is likely to arise through chemical reaction and contamination of the glass from contact with other extraneous materials.

The ever present risk of mechanical failure of the agitating mechanism or agitating elements, the need of and the difficulty involved in observing their operation in the viscous medium; maintenance required; the problem involved in the design of a mechanism which must be coordinated with associated parts of the furnace and associated machinery, and which must extend into the chamber containing the hot molten material, and must extend through or past wall thickness including furnace wall, lining, and insulation, and where the molten material should be protected
50 against undue cooling or chilling; all these have been among the difficulties and problems to be faced where such a mechanism is or must needs be used.

Consequently, this agitating mechanism has been a weak point in the furnace layout and a sore spot to operators. According to another practice the substitution for the ordinary stationary fore hearth of a revolving fore hearth brought
55 new difficulty for old. While doing away with the need for providing an agitating mechanism and the direct contact of an agitating member with the molten glass, this presented the difficulty of insulation, the problem of maintaining constant

the glass level in the fore hearth, and others.

It is the object of this invention to eliminate at once all the aforementioned problems and difficulties by doing away with mechanical agitating devices of the aforementioned or other types, and avoiding the use in this connection of moving elements altogether, as well as avoiding the contact of the melt with any undesirable extraneous material.

The invention therefore contemplates effecting the desired type of agitation of the molten glass or substance in the fore hearth by way of electro-dynamic influences of electro-magnetic forces, and more specifically those produced from a stationary or stator device by virtue of a changing or shifting power field generated therein.

Therefore, it can be said that this contemplates imparting to the molten substance or charge in the fore hearth a gentle rotary motion or slow-motion swirl by virtue of the rotation or cycling or shifting of field intensity that is observed in an alternating current operated magnetic field similar to the one that drives the closed circuited rotor armature in an A. C. motor of the asynchronous type.

To this end the invention proposes to surround the fore hearth with a horizontally arranged stationary or stator frame in principle similar to the stator of an A. C. motor having a suitable number of peripherally spaced poles or electro-magnets with their suitable energizer or exciter windings for generating or setting up what may be termed a cycling power field, while the molten glass substance in the fore hearth, for the sake of comparison let it be said, takes the place of the closed-circuited rotor or armature. With the arrangement herein contemplated, despite the thickness of furnace walls intervening between the stator poles and the molten glass, the rapid rotation of the A. C. field will impose marginal rotary impulse upon the body of molten glass resulting in the relatively slow rotation thereof but of an intensity sufficient to obtain the gentle agitating effects desired.

According to one feature the rotation or agitation motion to be induced by the operation of the rotating or A. C. field is substantiated, intensified, or rendered sufficiently effective through the use of a movable or rotatable auxiliary conductor body or core for instance, a body or base or bath of liquid or molten non-contaminating metal in conjunction with, that is subjacent to the melt of glass material in the fore hearth in a manner to have frictional or movement transmitting relationship therewith.

Expressing the idea of this feature in different terms it can be said that there is established a stratification of coating materials or bodies which include a movable body of relatively low electric conductivity and a subjacent movable body of relatively high electric conductivity, which is particularly susceptible to the electro-dynamic influence from the stator device, and which therefore acts as an intermediary or relay for boosting the motion to be imparted to the first body.

Another feature proposes to substantiate and to intensify the rotary reaction by a conductor base of composite nature, that is one including a rigid, as well as a molten element, and thereby, of course, also intensifying the overlying strata of molten glass material. For this reason a loosely rotatable but in itself rigid conductor body may be embedded or contained or floatingly supported in the body of molten metal.

Other features have to do with the adaptation

and coordination of suitable magnetic field conditions to the requirements and conditions prevailing with respect to the structure of the fore hearth and its contents; more specifically they have to do with inducing magnetic flux of suitable intensity, character, and direction in view of the marginal impulse rotary motion to be desired of the molten material.

Still other features have to do with the adaptation of suitable glass- or gob-feeding devices such as the conventional plunger feeder, to the novel motion inducing stator device.

Still another feature has to do with superimposing one type of electrically produced agitation upon another, in that it proposes to impart to the molten material in the fore hearth electrically produced vibrating and agitating influences in superposition to the rotary motion which is due per se to the electro-dynamic effect of the stator device.

The invention possesses other objects and features of advantage, some of which with the foregoing will be set forth in the following description. In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit. In the accompanying drawings there has been illustrated the best embodiment of the invention known to me, but such embodiment is to be regarded as typical only of many possible embodiments, and the invention is not to be limited thereto.

The novel features considered characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawings in which:

Fig. 1 is a plan view diagrammatically of a glass melting furnace including a fore hearth of circular shape having communication with the main charge in the furnace, and a withdrawal opening at the top.

Fig. 2 is a side view of the glass melting furnace shown in Fig. 1 with a partial section through the fore hearth disclosing the location of various electrodes, a stator device, and conductors, as elements of the novel electro-dynamic agitating device.

Fig. 3 is an enlarged detail view, partly in section, of a modified and substantially closed type of fore hearth equipped with gob plunger feed device, and a correspondingly modified arrangement of the electro-dynamic agitating device.

Fig. 4 is a plan view, partly in section, of another modification of the invention with a clearer disclosure of the stator device.

Fig. 5 is a longitudinal view partly in elevation and partly in section taken along the line 5-5 upon Fig. 4, and discloses certain adjusting means for the stator device and for the magnetic poles thereon.

Fig. 6 is a detail view partly in section of a pole of the stator device accommodated in recesses of the wall of the fore hearth.

Fig. 7 is an enlarged sectional plan view of a fore hearth with tangential influx from the main furnace charge.

Figures 1 and 2 show the general layout of a glass melting furnace, in which the numeral 10 designates the furnace structure which houses the

main hearth containing the main charge or bulk of the melt, and in which 11 designates a fore hearth here shown to be of substantially circular shape adapted to hold a portion of the furnace melt for withdrawal. The fore hearth is shown to have a relatively restricted communication connection 12 with the main furnace charge, and is shown to be partly covered over by a top wall structure 13 leaving an opening 14 for withdrawal from the top of molten substance. A portion of an alternating current operated stator device capable of inducing rotative agitation in the melt of the fore hearth, is indicated by the showing of one of a series of poles 15 having an energizer or exciter wire coil 16, wire connections 17, and the portion of a stator frame 18.

Each of the coils 16 is provided with a plurality of taps leading to a variable circuit controller or switch as shown in Figure 4, so that the effective number of turns of each coil may be changed, and the resulting ampere turns varied, to vary the intensity of the magnetic flux.

In Fig. 2 there is shown a pair of direct current operated electrodes 19 and 20 having current conducting relationship with the melt in the fore hearth, the purpose of these electrodes being to provide additional heat, thus insuring the maintenance of fluidity of the melt, and also to create additional electromagnetic forces which intensify and improve the agitation of the melt. The one and upper electrode 19 is shown to be in the form of an annulus submerged in the top strata of the melt and below a liquid level 21, shown in dot and dash, the other and lower electrode 20 includes a flat portion 22 set in dove-tailed fashion into the bottom wall 22a of the fore hearth and having its top face exposed to the contents thereof, and a connecting portion 23 leading from the flat electrode portion down through the bottom wall. A bath or layer or body 24 of molten metal is shown to cover the bottom of the fore hearth as well as the exposed surface of the electrode portion 22. Any metal which is non-contaminating and which has an appropriate melting point might be used, and it has been found that tin, antimony or lead are satisfactory for this purpose. A laminated annular metal or conductor body or core 25 for purposes herein-after to be explained is shown embedded in the bottom wall and somewhat spaced from and out of contact with the electrode 20 as well as spaced from and below the layer 24 of molten metal, and arranged to surround the electrode portion 23.

Figures 4 and 5 show further details in plan and side view of the stator frame and coils shown in Figs. 1 and 2 as well as a modified form of the invention. Fig. 4 shows the circular wall 26 in a horizontal section of the fore hearth having a constricted or bottle-neck portion 27 connecting the fore hearth with the wall 28 of the main furnace structure. An alternating current operated stator device is shown to include a stator frame 29 having a circular portion 30 and a downwardly looped portion 31 which latter portion is arranged and shaped to clear the bottle-neck portion 27 of the fore hearth. The stator frame 29 carries a series of power energized pole elements 32 shown to be substantially equi-distantly spaced from one another along the periphery of the fore hearth, the poles having shown thereon energizer or exciter wire windings in the form of a coil 32a. The coils 32a, also, will each be provided with a plurality of taps 32b and a variable circuit controller or switch 32c, to vary the effective number of turns. The stator frame as

a whole is adjustable in vertical direction because of adjustable supporting means such as a turnbuckle 33 resting on a stationary base 33a. Provision is also made to enable each individual pole element 32 to be adjusted upon and relative to the stator frame 29 as by a slot and bolt connection 34.

In the modification shown in Figures 4 and 5, a solid laminated core 48 is embedded in the bottom wall below and spaced from the layer of liquid metal 49. A further modification shown in these figures consists in the provision of a loosely rotatable, but in itself rigid, conductor body 50 floatingly supported in the body of liquid metal 49.

There is moreover shown a layer 35 of insulating material to surround the fore hearth and a customary suitable casing or shell 36 covering the same. In the detail Fig. 6, the casing 36 is shown to be split and to have cut away or recessed portions 36a to clear a pole of the stator device, extending into the furnace wall and through and beyond the shell 36. There should be no side-tracking or short-circuiting of the magnetic flux or magnetic power lines generated in the poles, because of the conductivity of the body of the casing inasmuch as that would deaden the desired practical effect with regard to agitation. Therefore, contact between the poles and the casing should be avoided. Moreover, it is considered that the casing 36 be made of a material that will not intercept the desired flux of magnetic power lines, for instance of aluminum, or Monel metal, or a suitable alloy, Monel metal incidentally losing its ferro-magnetic properties at about 100 degrees C.

Fig. 3 is a modification of the fore hearth shown in Figs. 4 and 5, in that it constitutes an adaptation of the novel agitation inducing device with respect to the use of an otherwise known gob plunger feeder device for dispensing the melt from the fore hearth. Such a plunger device permits dispensing the melt in the form of gobs through the bottom wall of the fore hearth, and is desired for certain modes of operating subsequent glass machinery. The fore hearth according to this modification is substantially covered over as by a top section 37 having an opening 38 therein for the passage thereof of a plunger type valve element 39 shown to consist of a vertically movable cylindrical body having a conical or trunco-conical end portion adapted to be seated in a corresponding valve seat 40 defining an outlet opening in the bottom portion 41 of the fore hearth. A pair of conventional shearing members 42 are shown to be provided underneath the outlet opening for the purpose of severing a gob of desired size of discharging material.

In the bottom portion 41 of this fore hearth there is shown a centrally arranged cylindrical depression or space 43 through which the valve element 39 vertically extends and which depression 43 is normally filled with the molten substance to be dispensed. Surrounding this depression 43 there is a shallow annular groove or trough 44 separated from the depression 43 by a low cylindrical wall portion 45, which groove 44 is adapted to receive a bath or conductor body of molten metal 46. Again an alternating current operated stator device 47 is provided, which is adapted to make its operation manifest in the phenomenon of rotation induced in the molten metal by reason of the electro-dynamic influences from the stator device. An annular laminated iron core 47' is shown to be embedded in the bottom wall of this fore hearth and in a position to

surround the lower terminal portion of the plunger valve element 39 as well as the depression 43.

In the various modifications of the fore hearth herein shown, care is taken to establish a certain desired relationship between the stator device, the molten metal body, and the stationary laminated iron core below that liquid metal. It is noted that the iron core serves to concentrate in it and to deflect downwardly the magnetic flux from the respective poles, and furthermore that it is desirable to confine the rotary impulse or driving effect substantially to the outer marginal and peripheral portion of the body of molten metal. Therefore, the relative arrangement of the parts or elements involved is such that the magnetic flux is directed to intersect in a special way with the marginal portion of the metal bath. That is to say, the vertically adjustable stator device or the individually shiftable poles are brought into a position sufficiently high with respect to the level of the molten metal and perhaps to a point above the surface thereof so as to compensate for the downward deflection of the magnetic flux through the core with regard to intersection.

Regarding the operation of the fore hearth according to this invention it should be understood that the function of the agitation imparted to the melt in the fore hearth or to the molten metal conductor respectively, depends upon the motoric rotary impulse imparted thereto because of the changing field intensity or cycling power field generated in the stator frame by an alternating current. The principle as such of the electro-dynamic phenomenon involved is known from the operation of an alternating current operated motor of the asynchronous type, in which the cycling field generated in the stator imparts rotation to a rotor or armature which is closed-circuited and which may be said to correspond broadly to the movable conductor or molten metal body according to this invention. Without going into details of the known electrical theory involved, it will be understood that the rotation is effected by reason of a certain induction or transformer effect of the changing stator field relative to the rotor.

Normally and mainly such a stator consists of a series of circumferentially arranged poles connected by a surrounding stator frame, and provided with suitable energizer windings placed around each of the poles.

A similar stator, somewhat modified to suit the present special purpose, is adapted to and arranged around the fore hearth as herein described, and in view of the intensity and generation of an effective power field the free ends of the poles are in the present embodiment shown to be lodged in recesses of the furnace wall and thus placed as close as practical and feasible to the contents of the fore hearth upon which contents the electromagnetic field is to act. In view of the heat conditions prevailing in the fore hearth, a cooling device for the poles might be provided.

In applying the principle of this invention where the molten metal body is omitted from the setup, even the glass-like material alone can be said to respond to the electro-dynamic impulse, however the addition of the molten metal as a base appears to render the degree of rotation more substantial and substantial enough for the special purpose on hand. This is due in other words, to the stratification of materials of differ-

ent electrodynamic reaction; that is to say, due to the functioning of a layer of highly conductive material such as a suitable metal or metal alloy, fluid, viscous, or rigid, as a booster for the agitation of a superposed layer of material of relatively low conductivity. For the sake of obtaining certain desired agitating effects there is the possibility by alternately weakening and strengthening the magnetic field to induce a waving or undulating motion in the melt or molten glass.

Another consideration is that the electro-dynamic impulse should affect or make itself felt substantially in the marginal portion of the molten metal conductor so as to increase the total efficiency of impulse and of agitation. Therefore, in one of the embodiments there is shown a molten metal body of annular form, the central and functionally inefficient portion thereof having been omitted, thereby permitting the arrangement centrally of an otherwise known and often times preferred gob-plunger feed device for dispensing the charge.

Still another expedient in the way of substantiating the effectiveness of operation and increasing the total efficiency of the device is found in the provision of the stationary metal core shown in the respective embodiments and may be either an annular laminated conductor body, as shown in Figures 2 and 3, or it may be solid as shown in Figures 4 and 5. It may be made in any suitable way and consists preferably of conventional dynamo plate or the like. This core is shown to be disposed below and somewhat spaced from the molten metal and substantially embedded in the bottom portion of the fore hearth. Its function is to intensify the flux of power lines through and in it as well as through the body of molten metal to improve its responsiveness to the electro-dynamic impulse. More specifically it is noted that with the relative arrangements of the parts as shown the magnetic flux or field lines passing from pole to pole are deflected downwardly through the stationary core. Consequently, from the disclosure (see Fig. 5) it will be seen that the poles are raisable and preferably elevated to such an extent above the plane of the molten metal that the downward bend of the power lines or magnetic flux, whatever its intensity and direction may be, is made to intersect with the outer marginal edge-portion of the body of molten metal, whereby the rotary impulse or the electro-dynamic torque is substantially confined in its effect to that portion of the movable conductor or molten metal body where its action is most effective and most desired.

No specific comment is needed with respect to the modification shown in Fig. 7, the tangential introduction of the furnace melt into the fore hearth being substantially a matter of preference or choice.

I claim:

1. In a furnace for melting glass-like substances, having a fore hearth adapted to hold a portion of the melt for withdrawal, agitation inducing means comprising an alternating current operated stator device adapted to produce a rotating magnetic field, a body of liquid metal underlying the melt in the fore hearth, and adapted to transmit movement to the melt, when motivated from the stator device, a pair of direct current transmitting electrodes having current conducting relationship with said melt and including a horizontally arranged annular upper electrode of relatively large diameter in contact with

the top strata of the melt, and a second relatively compact lower electrode of smaller diameter concentric to said first electrode and located at the bottom of the melt.

2. An agitation inducing means according to claim 1, in which the liquid metal substantially covers and contacts said lower electrode.

3. An agitation inducing means according to claim 1, in which the second electrode underlies the liquid metal, with the addition of an annular solid metal core underlying and spaced from said metal bath and surrounding and separated from said lower electrode.

4. The method of agitating the melt in the fore hearth of a furnace for melting glass-like substances, which comprises imparting to the melt electro-dynamic motivating impulses effective to produce slow motion swirl in a horizontal plane of the melt, and super-imposing upon such impulses direct-current produced vibrating impulses.

5. In a furnace, the combination of a hearth adapted to hold a charge of molten glass-like material and a device for agitating the material comprising electro-magnetic means arranged to produce a moving magnetic field, a liquid metal conductor underlying the material and adapted to transmit movement thereto when motivated by the electro-magnetic means, and a stationary metal core disposed below and spaced from the molten material.

6. In a furnace, the combination of a hearth adapted to hold a charge of molten glass-like material and a device for agitating the material comprising electro-magnetic means arranged to produce a moving magnetic field, a liquid metal conductor underlying the material and adapted to transmit movement thereto when motivated by the electro-magnetic means, a stationary metal core disposed below and spaced from the molten material, and means for providing up and down adjustment of the electro-magnetic means relative to the stationary metal core.

7. In a furnace, the combination of a hearth adapted to hold a charge of molten glass-like material, a device for agitating the material comprising a stator substantially surrounding the hearth and adapted to produce a rotating magnetic field, a liquid metal conductor underlying the material and adapted to transmit movement thereto when motivated by the stator and a stationary metal core disposed below and spaced from the molten material.

8. In a furnace, the combination of a hearth adapted to hold a charge of molten glass-like material and a device for agitating the material comprising electro-magnetic means arranged to produce a moving magnetic field, a liquid metal conductor underlying the material and adapted to transmit movement thereto when motivated by the electro-magnetic means, and a stationary metal core disposed below and spaced from the liquid metal.

9. In a furnace, the combination of a hearth adapted to hold a charge of molten glass-like material and a device for agitating the material

comprising a stator substantially surrounding the hearth and adapted to produce a moving magnetic field, a liquid metal conductor underlying the material and adapted to transmit movement thereto when motivated by the electro-magnetic means, a stationary metal core disposed below and spaced from the molten material and means for providing up and down adjustment of the stator relative to the stationary metal core.

10. In a furnace, the combination of a hearth adapted to hold a charge of molten electrically conductive material and a device for agitating the material comprising electro-magnetic means surrounding the hearth and adapted to produce a rotating magnetic field, and a stationary metal core disposed below and spaced from the molten material and adapted to concentrate the magnetic effect at the peripheral portions of the material.

11. In a furnace, the combination of a hearth adapted to hold a charge of molten electrically conductive material, a device for agitating the material comprising a stator substantially surrounding the hearth and adapted to produce a moving magnetic field, and a stationary metal core disposed below and spaced from the molten material and adapted to concentrate the magnetic effect at the peripheral portions of the material.

12. In a furnace, the combination of a hearth adapted to hold a charge of molten electrically conductive material, a device for agitating the material comprising a stator substantially surrounding the hearth and adapted to produce a rotating magnetic field, and a stationary metal core disposed below and spaced from the molten material and adapted to concentrate the magnetic effect at the peripheral portions of the material.

13. In a furnace, the combination of a hearth adapted to hold a charge of molten glass-like material and a device for agitating the material comprising electro-magnetic means arranged to produce a moving magnetic field, a liquid metal conductor in contact with the material and a solid metal conductor floatingly disposed in the liquid metal conductor, said liquid and solid metal conductors being so positioned and arranged with respect to the moving magnetic field as to be moved thereby and adapted to transmit movement to the molten material when motivated by the electro-magnetic means.

14. In a furnace, the combination of a hearth adapted to hold a charge of molten glass, and a device for circulating the molten glass therein comprising electro-magnetic means surrounding the hearth and adapted to produce a rotating magnetic field, and a liquid metal conductor underlying the glass and so positioned and arranged with respect to the rotating magnetic field as to be rotated thereby and adapted to transmit rotative movement to the molten glass when motivated by the electro-magnetic means.

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