Jan. 18, 1938. G. E. SEIL 2,106,022

ELECTRIC FURNACE

Filed May 23, 1935 6 Sheets-Sheet 1

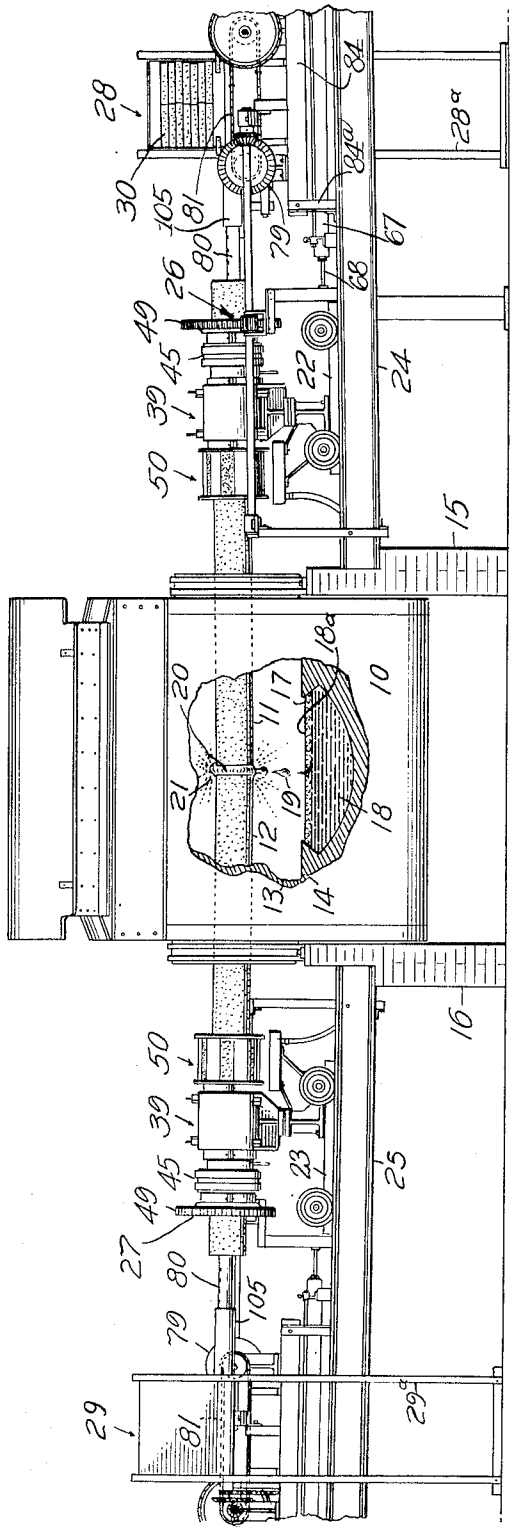


FIG. 1.

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ELECTRIC FURNACE

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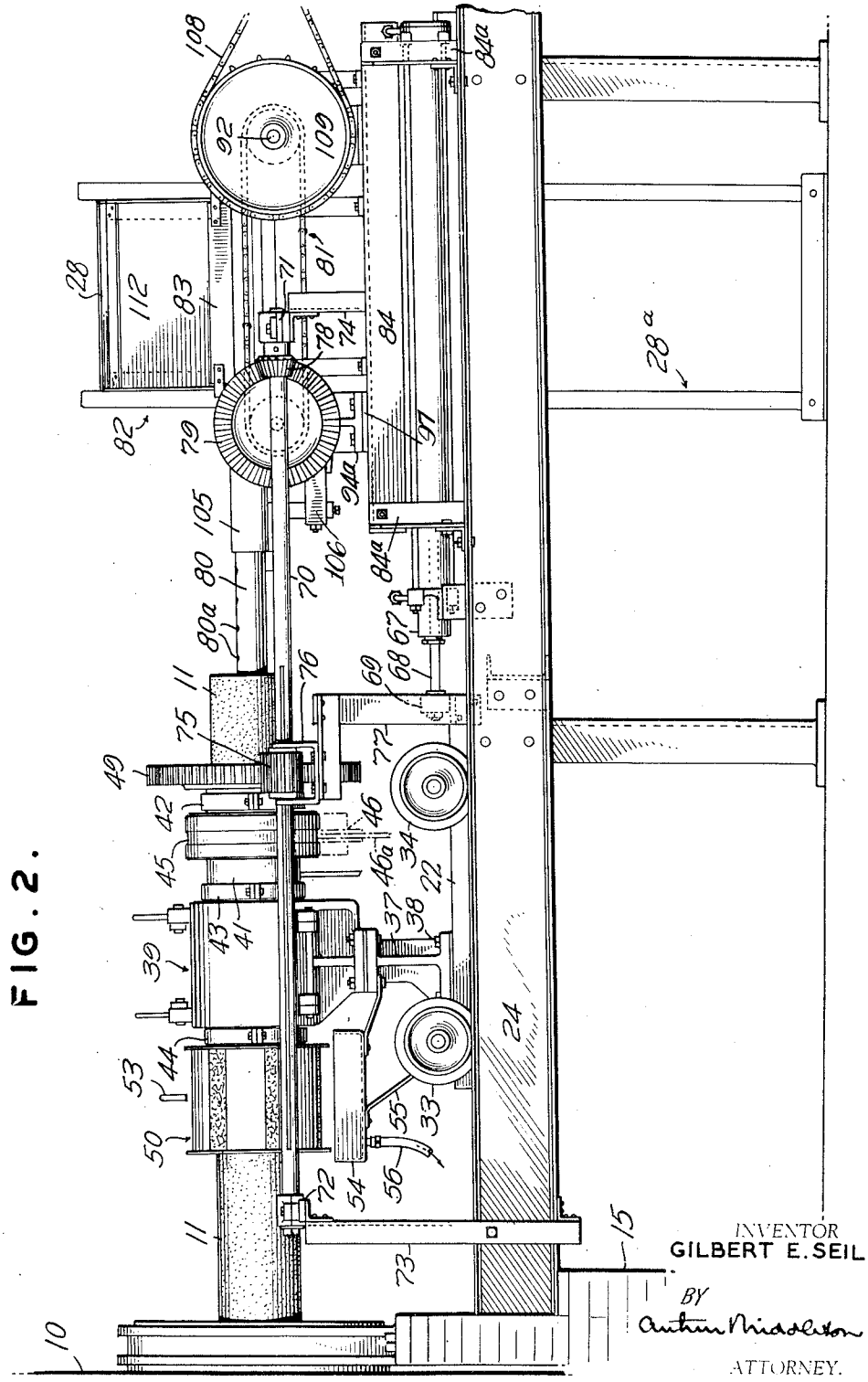


FIG. 2.

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ELECTRIC FURNACE

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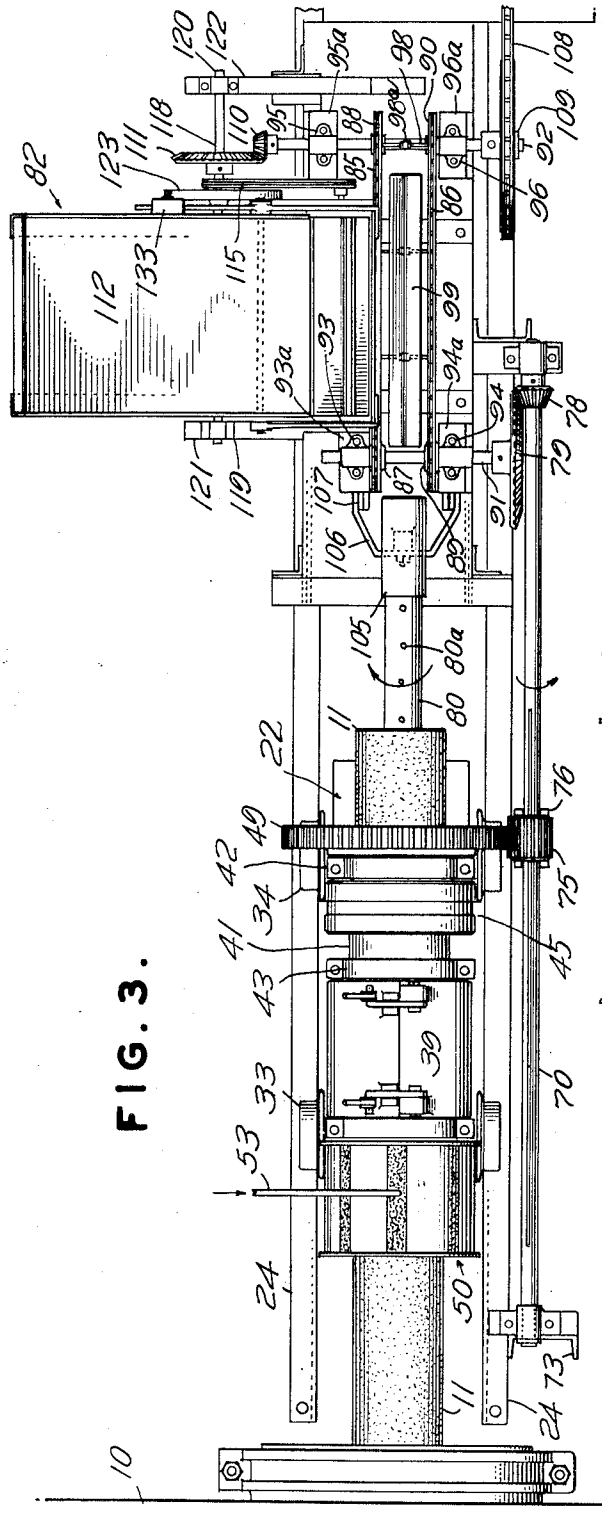


FIG. 3.

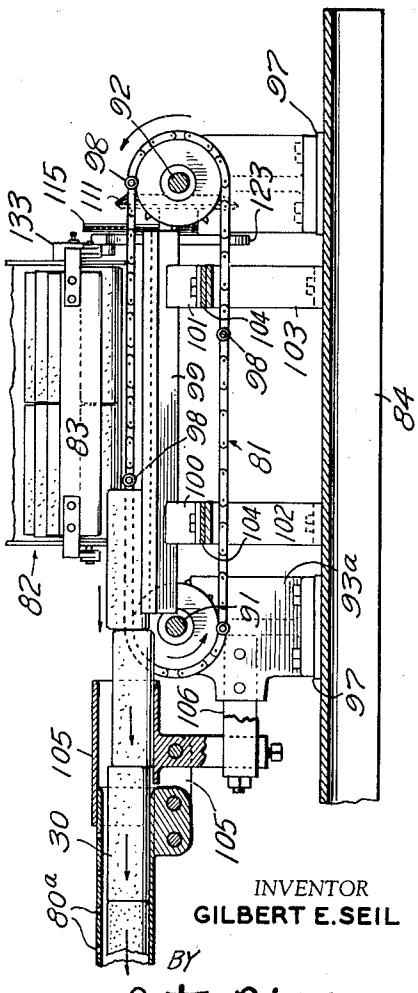


FIG. 4.

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ELECTRIC FURNACE

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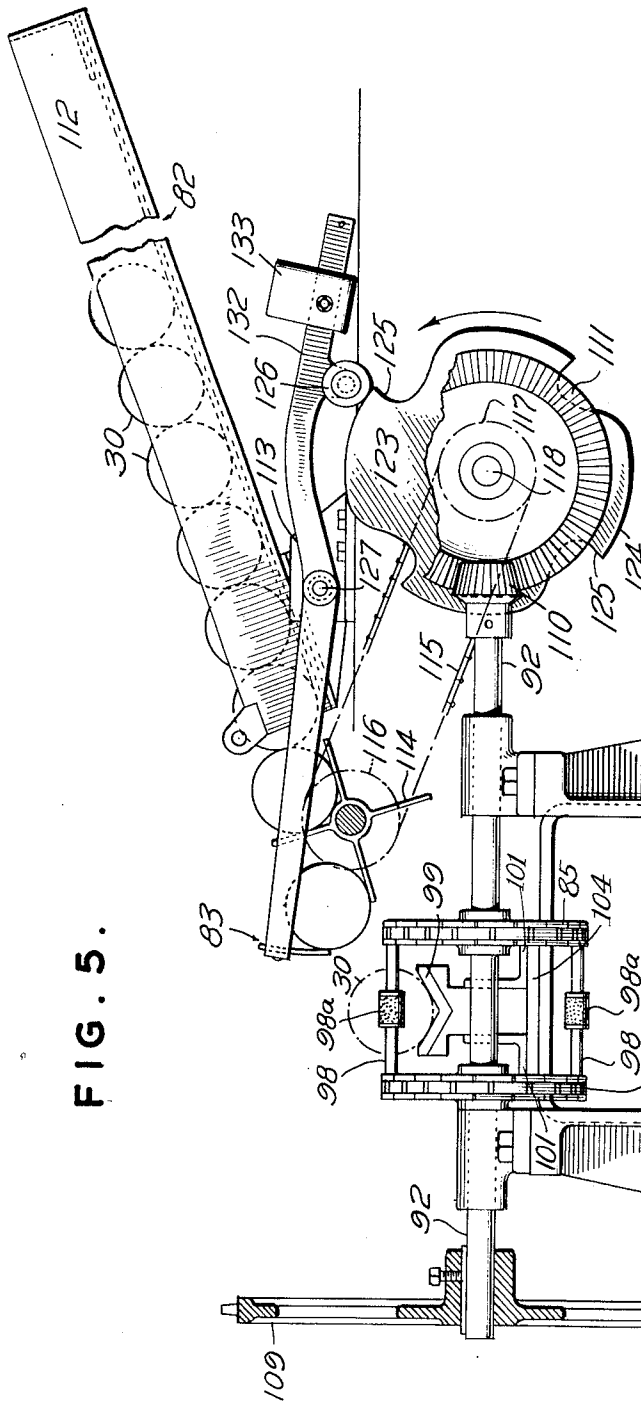


FIG. 5.

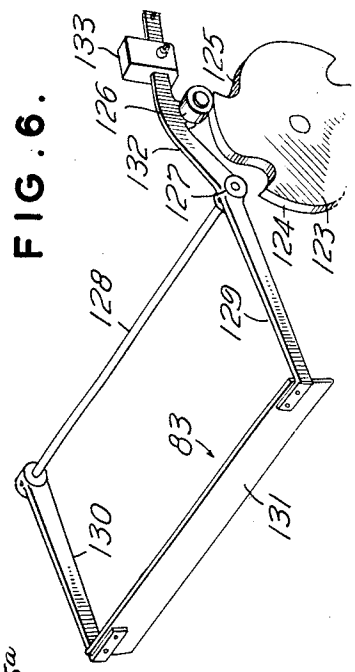


FIG. 6.

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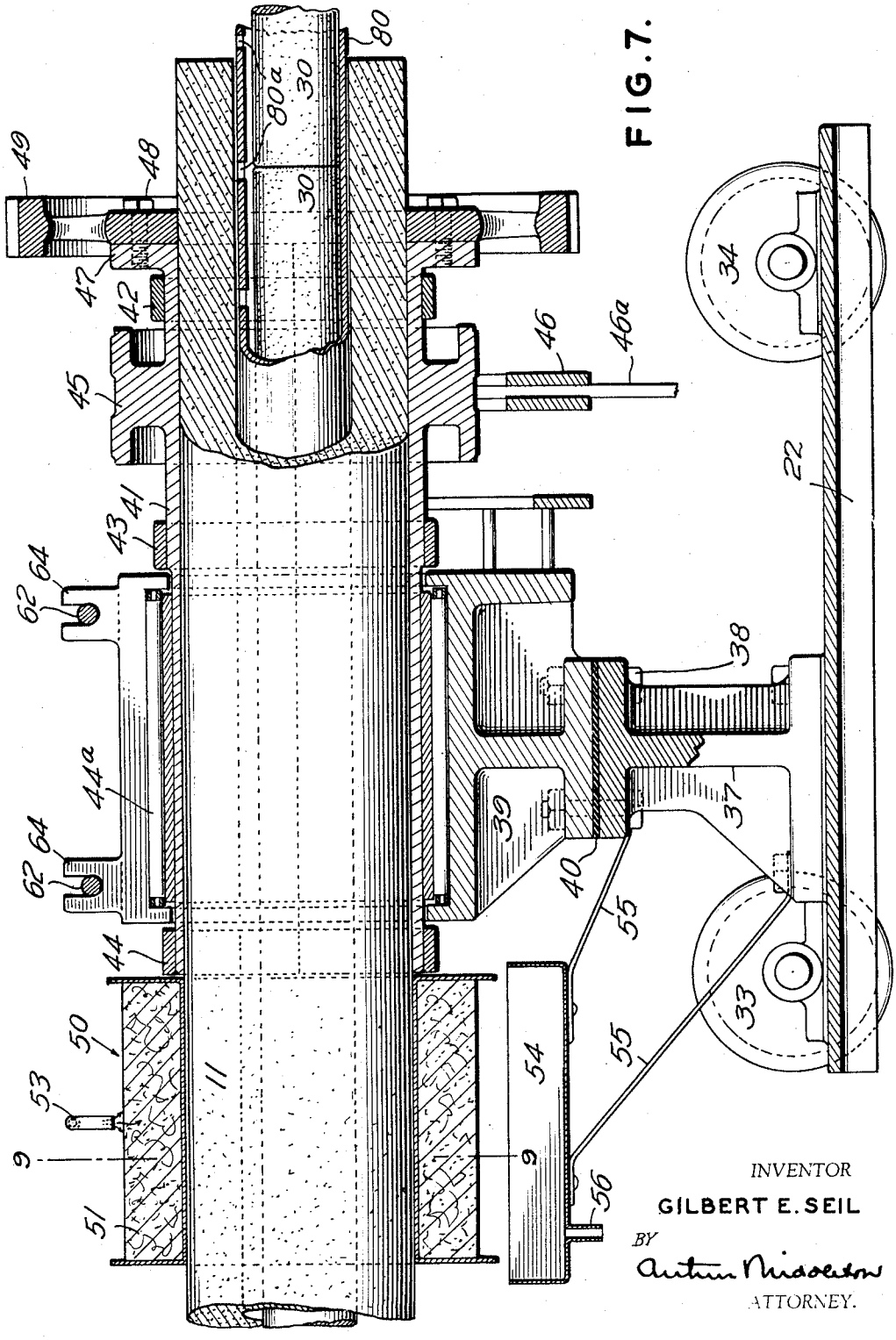
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FIG. 7.



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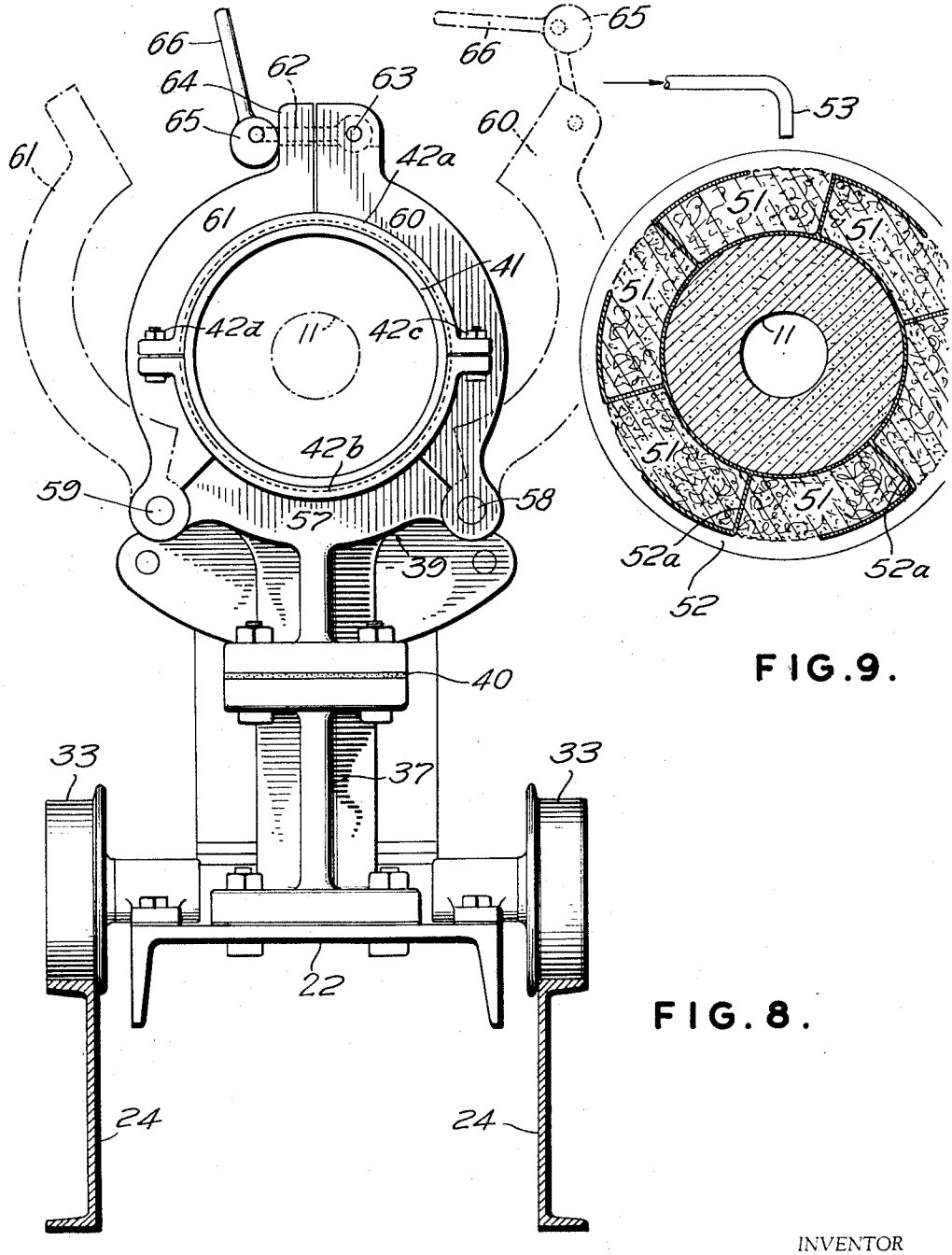


FIG. 9.

FIG. 8.

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Patented Jan. 18, 1938 2,106,022

UNITED STATES PATENT OFFICE

2,106,022

ELECTRIC FURNACE

Gilbert E. Seil, Cynwyd, Pa.

Application May 23, 1935, Serial No. 22,963

23 Claims. (Cl. 13—9)

This invention relates to electric furnaces more especially to that type thereof which has hollow electrodes through which is fed a quantity of material to be treated in the furnace. In particular, this invention pertains to an electric furnace devised with the aim to carry out economically the processes covered by the following patents:—Wiles 1,837,696; Wiles 1,912,560; Wiles 1,934,634; Wiles 1,946,252; Scott 1,896,789; Scott 1,904,761 and the following patent applications:—Wiles Serial No. 703,320 and Seil Serial No. 724,024, as well as Seil co-pending patent applications Serial Nos. 59,690, 59,691 and 59,692.

The processes to which this type of furnace are particularly adapted are those wherein many reactions favored by high temperatures can be more effectively produced because of the fact that the passing of small masses of reacting materials through the extremely high temperature zones within the hollow electrode permits practical use of these desirable high temperatures. A variety of uses for this furnace have been found in which useful advantage is taken not only of the abnormally high temperatures but of the confinement characteristic of the hollow electrode and of its combination duplexing functions of smelting within the electrode with subsequent refinement on the hearth.

As the essential uses to which this type of furnace has been put require the movement of solid and liquid materials through the approximately horizontal hollow electrode there must obviously be produced a certain amount of internal erosion on the lower part of the electrodes orifice. There is a further loss from the internal bore due to chemical reaction between dissolved oxides in metal and the graphite of the electrode. It was found that while this erosion was often very slight under certain conditions it was nevertheless accumulative and would ultimately result in an uneven arcing end on the electrode which in turn interfered with the uniformity of the furnace operation.

The correction of this uneven wear can be accomplished by intermittent rotating of the electrode by manual force but preferably by continuous rotation by mechanical force. The relative value of these two methods depends upon the rate at which erosion develops and upon the first cost factors involved.

The use of substantially horizontal electrodes requires a device which holds and supports the electrode and moves it back and forth to regulate the arc gap and the resulting current input of the furnace. Where rotation of the electrode is desired this support bearing must be of such a design as to permit either intermittent or continuous rotation of the electrode and in this characteristic the rotating horizontal hollow electrode support differs from the supports heretofore used for solid horizontal electrodes where service conditions developed no need for rotation.

As it is necessary to make occasional adjustments between the bearing support and the electrode to compensate for wear of the electrode and as it is also necessary occasionally to remove an electrode the bearing support must allow for both of these operations.

The process of the above mentioned Seil patent applications may be briefly described as comprising forming a molten bath of metal on the furnace hearth, the metal of which is to be refined by having removed therefrom undesirable elements. This refining is effected by causing to pass through the slag on the molten metal, a molten oxidizing reagent which reacts with the undesirable element in the molten bath to oxidize it and thereby remove it from the bath as a gas if the oxidized impurity is gaseous, or via the slag if the oxidized impurity is not gaseous. One feature of that process is that the molten reagent is formed in one or more hollow electrodes extending into the furnace from the comminuted and mixed materials being fed to and through the bore of the hollow electrode in the form of cores or cartridges.

So a prime object of this invention is the envisaging of a hollow electrode furnace with auxiliary and accessory instrumentalities, all co-acting to contribute to the effective realization of the formation in the electrode of the oxidizing reagent comprising a metal carrying a metal oxide and of the supplying of the reagent to the furnace burden by virtue of which the desired product is obtainable. Another prime object of the invention contemplates the devising of such a furnace having arrangements for lessening, if not avoiding, localized external erosion on the furnace-end of the electrodes and internal erosion in the bore of the electrodes by the rotation thereof; for cooling the electrodes; for dependably feeding the cores of the reactable materials to and through the hollow electrodes; and for providing a bridging connection through which the cores can be fed from a reservoir thereof to the hollow electrode of the furnace.

Generally, the invention may be exemplified in an electric furnace having a pair of co-acting hollow electrodes with electrical connections for effecting an arc between the adjacent and substantially abutting ends of electrodes. Each elec-

trode is mounted on a carriage with means (preferably automatic) for reciprocating the carriage toward and away from the furnace whereby the spacing apart of the arcing ends of the electrodes and consequently the power input to the furnace may be controlled. By controlling the power input, the temperature attained by the electrode burden in the region of the arc is assured to be high enough to realize the formation therein of the oxidizing reagent. The carriage for each electrode is provided with mechanism for rotating its electrode while energized, and with means for removably and rotatably mounting the electrode on its carriage. Also cooling means are associated with the electrode. Then there is provided adjacent to the free end of the electrode a reservoir or magazine of or for cores or cartridges to be fed to the electrode. But since the electrode is mounted for simultaneous rotation and reciprocation while the core-reservoir is preferably fixed, a telescoping bridging connection is provided for getting the cores from the reservoir to the bore of the movable electrode irrespective of the position of the electrode relative to the fixed reservoir. For impelling cores over or along this bridge connection a conveyor mechanism is provided which is timed to feed cores from the core-reservoir at just the speed required by the furnace.

Broadly the features of this invention are directed to mechanical arrangements to cover the rotatable as well as reciprocable mounting of the electrodes; an arrangement for supplying, for feeding, and for timing the feed, of the cartridges to and into the electrode; an arrangement for coordinating all driving, actuating and moving parts; and a specific manner of cooling the rotating electrodes.

Accordingly, one specific feature is exemplified in an attachment for removably supporting the rotatable or rotating electrode, which consists substantially in a split sleeve rigidly clampable around a portion of the electrode. This attachment is to provide an exterior bearing face to fit the electrode for rotary movement, to provide a face for movable electric contact to supply current to the electrode, and also to provide a means for mechanical driving engagement for the rotation of the electrode.

Another feature is illustrated in a reciprocable support or wheeled carriage adapted to move the electrode to and from the furnace, and having preferred bearing means for quickly mounting and dismounting the electrode. More specifically, a bearing shell upon the carriage is sectionalized to comprise a rigid lower central portion or sector which lends itself for positioning and sustaining the electrode body in substantially horizontal operating position when mounting or dismounting the same. The rigid sector carries hinged to each side a movable sector or wing, both together complementary to the first and rigid sector, arrangeable around a bearing surface of the electrode body. Suitable quick acting closure means permit rapid closing, or opening of the movable sectors of the bearing shell while leaving the electrode body proper in self-sustained aligned position.

Still another feature involves the core or charge feeding device which provides an endless flexible conveyor arrangement cooperating with a charging tube which telescopes into the associated electrode.

A further feature lies in an automatic supply or magazine device for the cartridges, and which is timed with the movement of the feed conveyor, altogether effecting a desired rate of speed.

Another feature is to be noted in the simple coordination of driving and driven parts, in that the feed conveyor of the present embodiment has a front and a rear driven shaft which serves in turn as a power transmitting element in supplying other coordinated movements of the mechanism such as the rotation of the electrode and the automatic control of cartridges fed from the magazine device. More specifically each axle of the conveyor has a second task of supplying by its very rotation the movement for one or the other coordinated movement of the mechanism.

The transmitting of heavy currents (amperes) through moving contacts is unusual in the electrical industry but it has been found that the usual difficulties experienced with arcing of these heavy currents was practically eliminated by cooling the contact surfaces. This cooling has the twofold purpose of preventing the heat from the furnace being conducted through the electrode to the contacting surfaces or areas and the simultaneous carrying away of any heat generated because of resistance at the moving contact areas. This latter cooling is also accomplished by having a large mass of heat conducting metal in contact with these areas or zones of any hollow electrode. As the heat conducted by the electrode from the furnace is of greater magnitude than that generated at the contact areas, a feature of this invention is to place a cooling device between the contact areas and the furnace.

More specifically, however, the cooling collar of my present design has circumferentially arranged scoops which are consecutively charged with, and discharge, a cooling liquid. Also the collar may comprise a mass of subdivided but coherent, or porous material which offers a large wetting surface for the cooling medium or liquid.

As it is desired to have the electrode rotate while remaining energized it is necessary to have a moving current, transmitting contact between the rotating electrode and some fixed part of the electric circuit. This may be accomplished in many ways.

But in my preferred arrangement of the elements of this invention a pair of longitudinal members or rails serve as the basic support for the entire electrode actuating and feeding mechanism, the rail gauge being adapted to accommodate the electrode carriage in view of its reciprocating movement thereon. The rotation of the electrodes during operation is effective in discouraging uneven wear or erosion at the arcing end of the hollow electrode. Certain parts of the arrangement are current conducting, others arranged to be dead to the current which must be supplied to the electrode for arcing. Preferably the supporting base members are left free from current, and so are the feed conveyors and the supply magazine, the current being prevented from reaching the magazine through the charge of cartridges, all in a manner hereinafter more clearly described.

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.

Fig. 1 is a side view of the general arrangement of a furnace chamber equipped with a symmetrical arrangement of diametrically opposed mechanically operated electrodes.

Fig. 2 is a detail sideview of the electrode operating mechanism and the core feeding device associated therewith.

Fig. 3 is a top view upon Fig. 1.

Fig. 4 is an enlarged side view of the automatic core feeding mechanism.

Fig. 5 is an enlarged rear end view of the automatic core feeding mechanism.

Fig. 6 is a perspective detail view of an automatically timed gate for feeding the cores.

Fig. 7 is an enlarged detail view of the electrode carriage and parts movable therewith.

Fig. 8 is an end view upon the electrode carriage of Fig. 7.

Fig. 9 is a cross-sectional view upon the cooling jacket for the electrode.

The furnace designed to carry out a metallurgical process such as outlined above, is shown in Fig. 1 to comprise a furnace chamber **10**, a pair of tubular open ended electrodes or electrode bodies **11** and **12** shown to be symmetrically arranged and to extend through opposite sides of the furnace chamber into the interior thereof. The furnace chamber may consist of a suitable refractory material **13** inside of a metal casing **14** which may be supported on suitable base members **15** and **16**.

Inside the furnace chamber there can be discerned a hearth **17** arranged to receive a metallic bath **18** covered by a layer of slag **18***a*, and also molten or liquefied reagent material **19** flowing or dripping down upon the bath, from the inner ends of the bore of the electrodes **11** and **12** and through the gap **20** spanned by the electric arc **21**.

A supporting, actuating, and charging mechanism for each of the electrodes **11** and **12** is here shown to be identical for each electrode or side of the symmetrical furnace arrangement.

Each electrode is shown to be longitudinally as well as rotatably movable while energized and correspondingly supported by a carriage **22** and **23** respectively, pairs of operating tracks or channel irons **24** and **25** respectively, operable to advance the electrodes into or withdraw them from the furnace chamber **10**. Mechanism for rotating the electrodes is indicated at **26** and **27** respectively. The numerals **28** and **29** indicate in a collective way respective charge feeding devices which are stationary and have supports **28***a* and **29***a* respectively, for the purpose of feeding into the hollow interior or bore of the movable electrodes the charge or reagents which are furnished to the furnace in the preferred form of cylindrical cores or cartridges **30**. It is noted that each electrode and accordingly its associated apparatus arrangement is preferably slightly inclined towards the furnace as indicated by the drawings, wherein they slope a few degrees from the horizontal, namely, three degrees in the preferred form, with the inclination being downward toward the arc ends of the electrodes.

In the following it will suffice to describe one side or unit of the symmetrical arrangement, for instance, the electrode **11** and its associated mechanism such as substantially shown in Fig. 2. The supporting carriage for the electrode **11** more clearly shown in the enlarged detail of Fig. 7 comprises a frame **22** carried by pairs of front and rear wheels **33** and **34** to operate upon the top flange of the channel irons or tracks **24**. The carriage frame has mounted thereon a standard or bracket **37** upon which is fastened by means of screw bolts **38** a longitudinal bearing **39** for supporting therein the electrode **11**. A plate of insulating material **40** is shown to be interposed between the standard **37** and the bearing **39**. The electrode is rotatably mounted in the reciprocatable bearing through the intermediary of a longitudinally split or composite two piece sleeve **41** fitted around the electrode and clamped thereto by means of clamping straps **42**, **43** and **44** respectively, spaced along the sleeve **41**. A cage including antifriction rollers **44***a* may surround the sleeve **41**. The sleeve **41** is also provided with a current collector or moving contact ring **45** located between the straps **42** and **43**, to receive a supply of electric current for energizing the electrode through contact brushes generally indicated at **46** movable with the carriage and having a suitable movable connection with a live rail or other source of electric energy which may be located below the floor level as indicated by a depending contact arm **46***a* travelling with the carriage. The outer end of the sleeve **41** has a flanged portion **47** to which is fastened by means of screw bolts **48** a gear **49** coaxial with the electrode.

A cooling device or collar **50** is placed around the electrode to substantially overcome heat generated by the supplying of electrical current thereto and is located in an effective zone of the electrode, such as next to the supporting bearing **39**, preferably at the furnace side thereof, which may comprise a sectionalized arrangement (see Fig. 9), of subdivided, porous, or spongy material such as steel wool **51** assembled in an annular metal frame **52**, there being provided circumferential scoop like chambers **52***a* to receive the material **51**. A supply of cooling liquid **53** disperses into the steel wool and by way of evaporation withdraws heat from the enclosed portion of the electrode, and thereby also acts as a protective barrier against the heat which tends to spread from the electric arc inside the furnace through the electrode towards the outer end and the supporting members thereof. Surplus water dripping from the cooling collar **50** and from the steel wool is caught in a pan **54** beneath, which pan is shown to have supporting straps **55** fastened upon the standard **37**, and an outlet spout **56**.

The rotatable portion of this assembly, such as the electrode **11**, together with the sleeve **41**, the gear **49**, clamping straps **42**, **43**, and **44** may be removed as a unit from the supporting bearing or bearing shell **39** in a manner more clearly understood from the cross-sectional detail view of Fig. 8. The outer shell of the bearing is sectionalized into a lower central rigid portion or section **57** which carries hinged to each side as at **58** and **59** respectively a complementary shell sector **60** and **61** respectively. When swung into closed position as shown in full lines in Fig. 8 the sectors **60** and **61** will close around the bearing sleeve of the electrode and they may be locked in place by a pair of swivel bolts **62** pivoted at **63** to the shell sector **60**. The swivel bolts fitting into bifurcated lugs **64** of the shell sector **61**, have at their free ends a tensioning member such as an eccentric **65** provided with a handle **66**. The open position of the bearing sectors **60** and **61** is shown in dot and dash lines.

From Fig. 8 it can also be more clearly seen that each of the straps 42, 43, or 44 consists of two halves such as 42a and 42b bolted together as at 42c and 42d.

The movement of one or of both electrode carriages 22, 23, is preferably automatically controlled in such a manner as to correct and make up for the shortening of the electrodes due to combustion from the arc, in order to maintain constant a predetermined gap or clearance 20 between the arcing points of the electrodes, determining the length of the arc. This is important for assuring the attainment of the temperatures in the electrode necessary for the formation of the reagent of my said patent application Serial No. 724,024, and of my co-pending patent application Serial No. 59,692, which comprises a metal having a metal oxide in solution therein. A corrective longitudinal movement of the electrode may be effected by some known electro-automatic arrangement which needs no specific disclosure but is indicated as by the showing of a hydraulic or oil cylinder 67 whose plunger rod 68 is operatively connected with the electrode carriage as at 69, and which responds to controlled hydraulic pressure in moving the carriage at a rate corresponding to the disintegration of the electrode arcing points. So there is provided means for varying the speed of the longitudinal movement of the electrode as well as its rotation.

It is necessary to provide flexible or movable driving means for imparting rotary motion to the electrode 11 while the carriage 22 travels. To this end a horizontally arranged splined shaft 70 extends substantially parallel to the axis of the electrode and is carried at each end in stationary journals 71 and 72 respectively suitably mounted upon standards 73 and 74 supported upon the tracks or channel irons 24. Slidable upon the splined shaft is a pinion 75 made of electric insulating or non-conducting material having meshing engagement with the large gear 49 of the electrode. Such meshing engagement is insured by having the pinion 75 confined in a cage 76 which is rigidly connected with the carriage frame 22 by way of a standard 77. The splined shaft is driven through a pair of bevel gears 78 and 79. While the splined shaft 70 could be optionally impelled in some other way adapted to impart a desired rate of rotation to the electrode, it is herein preferred to have the driving means for the splined shaft 70 coupled or operatively interconnected with the driving means for the charge feeding device 28 presently to be described and the details of which are more clearly shown in the Figs. 3, 4, 5 and 6.

This feeding device is designed to feed the charge material in the form of cores or cartridges 30 in sequence and at a certain predetermined rate into the interior or bore of the electrode. The device therefore consists essentially of a feed tube 80 which telescopes into the electrode and which along its upper side is provided with holes or perforations 80a; an endless conveyor 81 to feed the cores into the tube 80 at a desired rate; and a magazine 82 carrying a supply of the cores 30, combined with an automatic device which is controlled to deal out one by one or a number of cores to the conveyor at predetermined intervals in co-ordination with a chosen speed of the endless conveyor. That is to say a suitable driving system couples the movement of a core releasing gate 83 at a fixed ratio with the rate of progress of the conveyor, so that a continuous sequence of cores 30 is caused to enter through the feed tube 80 into the bore of the electrode and then into the zone of liquefaction or other metallurgical phases.

More specifically, (see Fig. 2) my preferred feeding device as a whole is mounted upon a frame or base structure 84 having mountings or legs 84a and comprises an endless conveyor to charge the cores 30 into the feeding tube 80 consists of a pair of endless chains 85 and 86 arranged side by side, each chain running over a pair of sprockets 87, 88 and 89 and 90 respectively. Corresponding parallel sprockets such as 87 and 89 are fixed upon a shaft 91, the other two sprockets 88 and 90 being mounted upon a shaft 92. The shaft 91 is operatively supported in a pair of journals 93 and 94, (see Fig. 3) carried upon supporting brackets 93a and 94a fastened upon the base frame 84. Correspondingly the other shaft 92 operates in journals 95, 96, carried upon similar supporting brackets 95a and 96a. The journals 93, 94 and 95, 96, respectively, or their respective supporting brackets are shown to be insulated against ground as by insulating plates 97. The chains 85, 86, which are thus arranged to move in unison carry pushing members 98 in the form of cross-rods extending from chain to chain at suitable intervals. Each pushing member or cross-rod 98 has a collar or sleeve 98a made of some suitable non-conductor or insulating material (see Fig. 5).

A channel or V-shaped bed 99 is to receive individual charges or cores 30 supplied at suitable intervals from the magazine 82, and it extends substantially between and adjacent the upper strand of the endless conveyor chains 85 and 86 and substantially in line with the electrode 11.

The V-shaped bed 99 has lugs 100 and 101 by which it is supported upon standards 102 and 103 fastened upon the supporting frame 84. The V-shaped bed 99 furthermore is electrically insulated against the standards 102 and 103 as indicated by the interposed insulating material 104. Cores 30 placed into charging position upon the V-shaped bed 99 will be advanced into a receiving collar or inlet member 105 of the feed tube 80, by the pushing action of the insulated pushing members 98 as the chains 85 and 86 rotate. The inlet member 105 is shown to be adjustably held by arms 106 upon the supporting brackets 93a and 94a and so as to be insulated against these supports, as indicated at 107. In this way no current from the electrode or from the charge therein will reach the elements of the feed conveyor or of the magazine 82.

Looking at Figs. 3 and 5, suitable means may be devised to provide driving power to the various operating sections of the machine. In a preferred simple embodiment such as herein disclosed, movement is imparted from a primary source as through a main driving chain 108 and a main driving sprocket 109 which latter is mounted upon the one free end of the conveyor sprocket shaft 92. The other conveyor sprocket shaft 91 in effect constitutes a countershaft to the shaft 92 and carries at its one free end the aforementioned large bevel gear 79 through which it drives the electrode rotating mechanism or a power transmitting sequence of geared elements 78, 70, 75, 49. In other words the conveyor chains 85 and 86 perform a dual function in the character of power transmitting as well as charge conveying feeding elements.

The rotary motion of the other sprocket shaft 92 is furthermore utilized to automatically oper-

ate the discharge of cartridges 30 from the magazine device 82 onto the endless conveyor 81. Therefore, the other free end of the sprocket shaft 92 extends far enough so that a small bevel gear 110 fixed thereto will be enabled to maintain operative or meshing engagement with a larger bevel gear 111 which is part of the magazine actuating and timing mechanism presently to be described.

The magazine or core dispensing mechanism of the present embodiment of this invention collectively indicated by the numeral 82 comprises a supply container in the way of an inclined chute 112 mounted in some suitable way as by brackets 113 upon a base structure or the like. The container or chute 112 is shown to be capable of accommodating an array of predetermined size cartridges 30 which if released may roll down in a direction transversely of the conveyor chain 86 and drop into charging position onto the V-shaped support 99. The discharge from the chute 112 occurs periodically and is timed by a star-wheel 114 (see Fig. 5) in conjunction with the swivel gate or frame 83. The star-wheel 114 is driven through an endless element or chain 115 running over sprockets 116, 117 the latter sprocket 117 being coaxial with the large bevel gear 111 and rotating therewith, both being fixed upon a shaft 118 which is operatively mounted in journals 119 and 120, the journals again being fastened upon bracket members 121 and 122 respectively forming part of the general supporting framework.

Also mounted upon the shaft 118 is a scalloped cam wheel 123 shown in this particular case to have four identical protruding cam faces 124 alternating with recesses 125. This cam wheel is adapted to cooperate with a cam roller 126 which is mounted upon the swivel frame or rocking gate 83. The rocking gate 83 is pivoted as at 127 upon the brackets 113 which holds the core magazine or chute 112 and it surrounds the lower or run off portion of the chute 112 as well as the star wheel 114.

As shown more clearly in the perspective detail of Fig. 6 the swivel frame 83 more specifically comprises an axle 128, a pair of arms 129 and 130 extending fixedly from the axle, and the retaining blade or gate member 131 proper interconnecting the free ends of the arms 129, 130. The arm 129 has a rearward extension 132 which carries thereon the aforementioned cam roller 126, and also an adjustable counterweight 133.

The star wheel 114 acts in the way of a sluice-gate permitting only one set of cartridges 30 at a time to drop onto the conveyor below, each set of cartridges actually and individually being released only by a momentary upswing of the swivel frame 83 whenever the cam roller 126 drops and is weighted into one of the recesses 125 of the cam wheel 123 by the counterweight 133.

It is noted that since the elements of the feed conveyor are dead with regard to electric current due to its insulation at various points, no current will reach the magazine device and its driving elements. In the operation of the furnace and the electrodes respectively just described it is conceivable aside from the preferred arrangement shown to have one electrode only equipped as shown with regard to the mechanical rotatability and/or movability and the feeding of the charge therethrough, while the other electrode might be assumed as stationary and not necessarily serving as a feed canal. Consequently it will suffice in describing the operation to refer to the functioning of one side or one electrode of the furnace only.

In order to begin at the beginning it may be assumed that my novel electrode body is to be placed into operating position in the furnace. To this end it may be assumed that the bearing 39 has its pivoted wings or sectors 60 and 61 open and ready to receive the electrode, while the feed tube 80 as well as the feed inlet collar 105 may be assumed to be removed so as not to interfere with the placing of the electrode 11. Before the electrode 11 can be placed into operating position in the furnace assembly it is to be mounted with the bearing sleeve 41 by placing the two halves thereof around the electrode and fastening them by placing and bolting thereabout the straps 42, 43 and 44 at the places shown in Fig. 7. Thereafter the large gear 49 may be bolted to the flanged portion 47 of the bearing sleeve 41. Also the cooling collar 50 is to be slipped into place over and around the electrode at the furnace end thereof, whereupon the electrode thus equipped is ready to be placed or seated upon the central sector 57 of the bearing 39 after the furnace end of the electrode has been introduced through the opening in the wall of the furnace chamber 10. While positioning or seating the electrode the large gear 49 will come to mesh with the pinion 75, and the current collector ring 45 engage with the contact brushes 46. The feed tube 80 is then introduced into the bore of the electrode and positioned with the holes 80*a* pointing upwardly and connected with the stationary feed mechanism by means of the feed inlet collar 105. Thereafter the sectors 60 and 61 are closed and locked around the electrode by manipulating the locking bolts 62 and the locking handles 66.

The electrode current may now be turned on while it is assumed that a bath or burden of molten metal 18 has been prepared in the furnace chamber and which molten metal is to be refined in the course of operating and charge-feeding the electrode. After the electric current has been turned on and all parts brought to an operative temperature, the carriage 22 may be assumed to have adjusted itself with regard to arcing gap 20 of the electrodes due to the automatic response of the carriage controlling hydraulic cylinder 67 and the plunger rod 68 thereof. The main driving chain 108 and sprocket 109 through the conveyor chains 85 and 86 and the bevel gears 78 and 79, shaft 70 and pinion 75 start the electrode 11 rotating at a suitable rate, while the splined connection between the pinion 75 and the shaft 70 permits of longitudinal adjustment of the electrode by virtue of a corresponding movement of the carriage 22. Rotation of the electrode substantially overcomes erosion tendencies acting both internally and externally of the electrode. The arcing tends toward external erosion at the arcing end of the electrode while internal erosion would otherwise be produced by the passing through the bore of the electrode of molten charges, especially as these charges constitute metal saturated at its molten temperature with metallic oxides. These oxides in passing through the carbon electrode which is a reducing material naturally tend to effect a wearing away of the carbon, but rotation of the electrode appears to overcome this tendency.

Rotation of the electrodes offers further far-reaching advantages in that thereby the molten or fluid constituents effected within the hollow

electrodes are kept in well-dispersed condition, that is, stratification is discouraged. My novel oxidizing reagent, heretofore referred to, is effected by forcing into the bore of the electrodes formed charges such as cores made up of a metal oxide together with a reducing reagent such as carbon in a deficient quantity to insure a reduction of only a portion of the metal oxide to metal. The cores also contain a corrective suitable for controlling the mass, and particularly the reduced metal in the electrode long enough to attain a temperature above the melting point thereof, but below the melting point of the unreduced metal oxide, whereby when the molten metal is emitted from the arc end of the electrode, it carries with it and indeed is saturated with unreduced metal oxide (which oxide is believed to be in solution in the metal). The cores become porous and disintegrate slowly under the influence of the heat and as the metal oxide is reduced to metal (which first appears in the form of drops thereof), they hold the metal in place long enough to attain its desired superheat. As long as the cores are in core form, they exhibit a sponge-like function. Nevertheless, as the drops of metal form, the drops should be kept away from the carbon of the electrode and this is done to some extent by this sponge-like action of the cores, but rotation of the electrode facilitates this action by causing any drop of metal which comes into contact with the wall of the electrode bore to flow back into the core, rather than to stick to the electrode. The metal which is usually chromium is the heaviest constituent of the mass in the electrode and would settle out so rotation of the electrode prevents this where otherwise it might react with the carbon of the electrode, which is hotter than the chromium, and a detrimental pick-up of carbon would result.

The flow of the cooling liquid **53** is also started to supply the cooling collar **50**, so that operative temperature equilibrium may be established as to the energized electrode when the cores or cartridges **30** of the charge shall have begun to advance through the feed tube **80** into the electrode from the supply of the magazine **82**.

While it is feasible to withhold such feed until a desired time by merely arresting the weighted arm **132** of the swinging gate frame **83**, a controlled feed of the cores **30** to the feed conveyor **81** will be at once established when the arm **132** is released and the cam roller **126** thereof permitted to engage upon the cam faces **124** and recesses **125** respectively of the scalloped cam wheel **123**.

Through the conveyor shaft **92**, the bevel gears **110** and **111**, the chain **115** and starwheel or sluice gate **114**, the feed of the cores **30** is then at once timed at a fixed rate relative to the movements of the feed conveyor, and the absolute speed of the mechanism is controlled by suitable means from the main driving chain **108** and sprocket **109**.

Consequently, whenever the cam roller **126** drops from one of the cam faces **124** into a recess **125** a core or set of cores **30** which has been separated by a sector of the star wheel **114** is released as the swinging gate **83** tilts up permitting the cores to drop over the conveyor chain **85** into charging position upon the V-shaped bed **99**. As the mechanism continues the cam roller **126** will mount again onto one of the cam faces **124** causing the swinging gate **83** to drop into closing position while simultaneously the star wheel **114** sluices a new set of cores **30** into contact with the gate.

With proper timing of associated moving parts, the feed conveyor will advance the released cores **30** by way of the insulated core pushers **98** engaging behind each set of cores into the feed tube **80** and into the electrode at just the rate of speed required by the operation of the process involved.

It is to be noted that electrode current is blocked from reaching the feed devices and the supporting members through the conductivity of the sequence of feeding cores, by the insulating power of the sleeves **98a** of the core pushers and by the insulating effect of the plates **104** underneath the V-shaped bed **99**, and by reason of the insulators placed between the feed tube **80** or feed collar **105** and its supporting brackets **93a** and **94a**.

When the furnace and the electrodes are in proper operation carbon monoxide generated inside the furnace will seek its outlet from the interior of the furnace chamber **10** through the feed tube **80** and countercurrently to the direction of cartridge feed therein, through the holes **80a** which are provided for that purpose along the upper side of the feed tube **80**.

With the present method and apparatus for feeding the reagent in the form of suitably sized and prepared cores the reagent charge can be accurately dosed and timed, so that a reagent of a desired composition and in a desired solution phase of its constituents will fall in the form of drippings **19** from the arcing point of the electrodes onto the bath of molten metal **18**. This process is continued until the bath or burden of molten metal has reached the desired state of refinement.

I claim:

1. In an electric furnace, a substantially horizontally located hollow electrode, electric connections for energizing the electrode, mechanism for positively feeding a succession of shaped charges to the furnace through the electrode, and means for rotating the electrode while energized and while having charges fed therethrough by virtue of which rotation erosion of the electrode is discouraged.

2. In an electric-arc operated furnace an electrode operating arrangement which comprises a hollow electrode body substantially cylindrical in form, a combined clamping sleeve member and hollow supporting shaft comprised of a plurality of arcuate segments, a sectionalized bearing for said hollow supporting shaft, means for pivotally attaching the members of the sectionalized bearing together, means for clamping said members to form a rigid bearing for said hollow shaft, and a substantially horizontally reciprocable support on which said sectionalized bearing is mounted.

3. An electrode operating arrangement according to claim 2 in which the sleeve member comprises a circumferential contact member for supplying therethrough the working current for the electrode, and a flanged end portion, and in which a gear is provided concentric with and attachable to said flanged portion for imparting therethrough rotation to the electrode body.

4. An electrode operating arrangement according to claim 2 in which the sleeve member is formed with a flanged portion at its off furnace end, an annular contact member interposed between said flanged portion and said bearing arrangement for supplying therethrough the work-

ing current for the electrode, and in which a gear is concentric with and attachable to said flanged portion for imparting therethrough rotation to the electrode body, and in which clamping means are provided at each side of the bearing arrangement for holding the composite sleeve member fixed relative to said electrode body.

5. An electrode operating arrangement according to claim 2, in which the bearing for the rotatable electrode is longitudinally sectionalized and comprises a centrally located load supporting sector, and a pair of complementary swingably movable sectors, each such complementary sector being hinged to one respective side of said stationary sector, and locking means for closing or opening said movable sectors.

6. In an electric-arc operated furnace an electrode operating arrangement which comprises a hollow electrode body substantially horizontally extending and adapted to have fed therethrough material to be charged, a sleeve fixedly attachable to and normally surrounding a portion of said electrode body to provide thereon an exterior bearing surface, electrode supporting means including a longitudinally sectionalized bearing shell to have rotatably mounted therein the electrode by engagement upon said exterior bearing surface of the sleeved electrode, said bearing including a centrally located load supporting stationary sector, a pair of complementary swingably movable sectors, each of said sectors being hinged to one side respectively of said stationary sector, and locking means for closing or opening said movable sectors.

7. In an electric-arc operated furnace an electrode operating and charge feeding arrangement which comprises a bored electrode body substantially horizontally extending and adapted to have fed therethrough material to be charged, a movable support for the electrode body, means for rotating said electrode body upon said support, a feed guide associated with the bore of said electrode body, conveying means adapted to handle a sequence of bodies of charging material in the form of individual cores, said conveying means arranged with respect to said feed guide so as to introduce said cores there into, a magazine device associated with said conveying means for supplying thereto said cores at predetermined and desired intervals, and timing mechanism for actuating the supply of cores from said magazine at a desired rate relative to the rate of the conveyor movement.

8. In an electric arc furnace, in combination, a pair of substantially horizontal hollow rotatable electrodes located with abutting ends, means for energizing said electrodes, means for rotating said electrodes, and means for impelling through each electrode in sequence charges of material in the form of briquettes to be smelted by the furnace.

9. In an electric furnace according to claim 8, wherein the electrodes are mounted a few degrees from the horizontal with their inclination being downward toward their arc ends.

10. An electric furnace according to claim 8, with the addition of a reservoir device for holding a supply of formed charges of material to be acted upon by one of said electrodes, and means for conveying said charges from said reservoir to said electrode during rotation of the electrode.

11. In an electric arc furnace, in combination, a pair of abutting hollow rotatable energizable electrodes, means for feeding through each electrode in sequence formed charges of material to be smelted by the furnace, means for rotating each electrode, means for making a continuous electrical contact while rotating and reciprocable wheeled carriage means for supporting each electrode together with its rotating means.

12. An electric furnace according to claim 11, with the addition of a rail arrangement for supporting said carriage means and upon which said carriage reciprocates.

13. An electric furnace according to claim 11, with the addition of means for removing an electrode from its co-acting carriage.

14. An electric furnace according to claim 11 with the addition of a bearing supported from each said carriage means and reciprocable therewith for rotatably supporting the electrode carried by said carriage.

15. An electric furnace according to claim 11, with the addition of means for energizing said electrodes with said means for at least one of said electrodes comprising one contact element rotating with said electrode and a coacting contacting element reciprocating with said electrode but not rotating therewith.

16. An electric furnace according to claim 11, with the addition of a bearing carried by said carriage means for rotatably supporting the electrode of said carriage, means on one side of said bearing for energizing said electrode comprising one contact element rotating with said electrode and one contact element reciprocating with said electrode but not rotating therewith, and means on the other side of said bearing for cooling said electrode and said bearing.

17. In an electric arc furnace, in combination, a pair of abutting hollow rotatable energizable electrodes, means for feeding therethrough formed charges of material to be smelted by said furnace, means for rotating one of said electrodes, means for reciprocating said electrode, a metallic sleeve element on said electrode, and means for energizing said sleeve.

18. An electric furnace according to claim 17, with the addition of means for removably associating said electrode with said sleeve.

19. An electric furnace according to claim 17, with the addition of energizing means for said electrode and of cooling means with said energizing means and said cooling means carried by said sleeve.

20. In an electric furnace, a pair of abutting hollow electrodes, means for feeding therethrough charges of material to be smelted by the furnace, means for reciprocating one of said electrodes, a metallic sleeve element on said electrode, means for rotating said electrode including a drivable gear carried by said sleeve element, an energizable electrical contact element supported from said sleeve, a cooling device supported from said sleeve, and a bearing for rotatably supporting said sleeve deriving its support from said reciprocating means.

21. Apparatus according to claim 1, in which the means for permitting the electrode to be rotated while energized comprises a bearing mounted on a reciprocable carriage for moving the electrode longitudinally independently of the rotative movement of the electrode.

22. In an electric-arc operated furnace, an electrode operating arrangement which comprises a hollow body substantially cylindrical in form, a combined clamping sleeve member and hollow supporting shaft comprised of a plurality of arcuate segments, a sectionalized bearing for said hollow supporting shaft, means for pivotally at-

taching the members of the sectionalized bearing together, means for clamping said members to form a rigid bearing for said hollow shaft, a substantially horizontally reciprocable support on which said sectionalized bearing is mounted, and means for rotating said combined clamping sleeve and hollow supporting shaft independently of the reciprocation of the bearing.

23. In an electric-arc operated furnace the combination of a furnace, hollow electrodes extending into the furnace from opposite sides thereof and with their adjacent ends coacting, electrical connections for said electrodes for effecting an arc between the adjacent ends of the electrodes, a carriage for each of said electrodes, means for feeding formed charges to and into said electrodes and automatic means for reciprocating the carriages toward and away from the furnace whereby the spacing apart of the arcing ends of the electrodes and consequently the power input to the furnace is controlled.

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