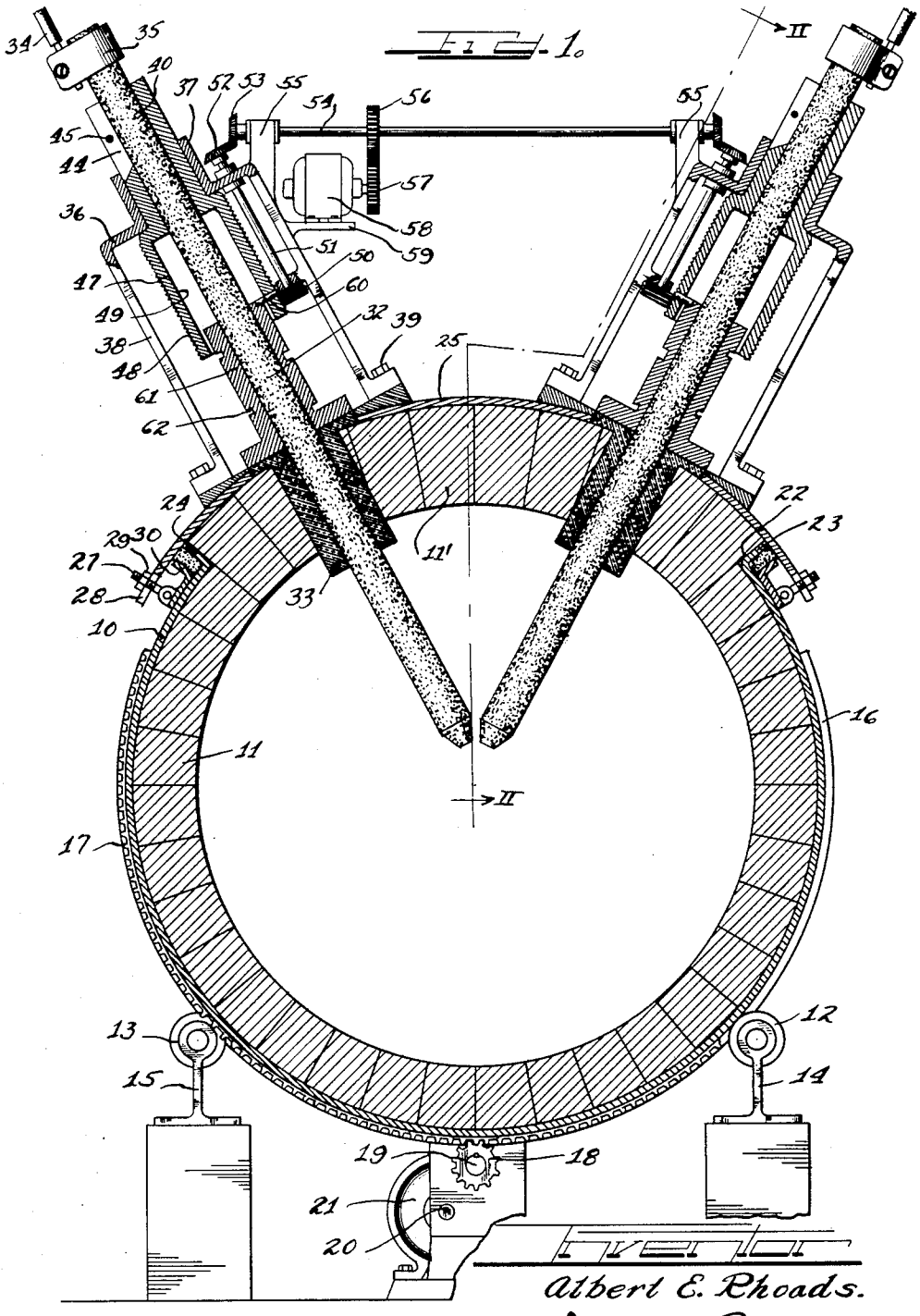
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Nov. 17, 1936. A. E. RHOADS 2,061,090

ELECTRIC FURNACE

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Fig. 1.



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13. ELECTRIC FURNACE

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ELECTRIC FURNACE

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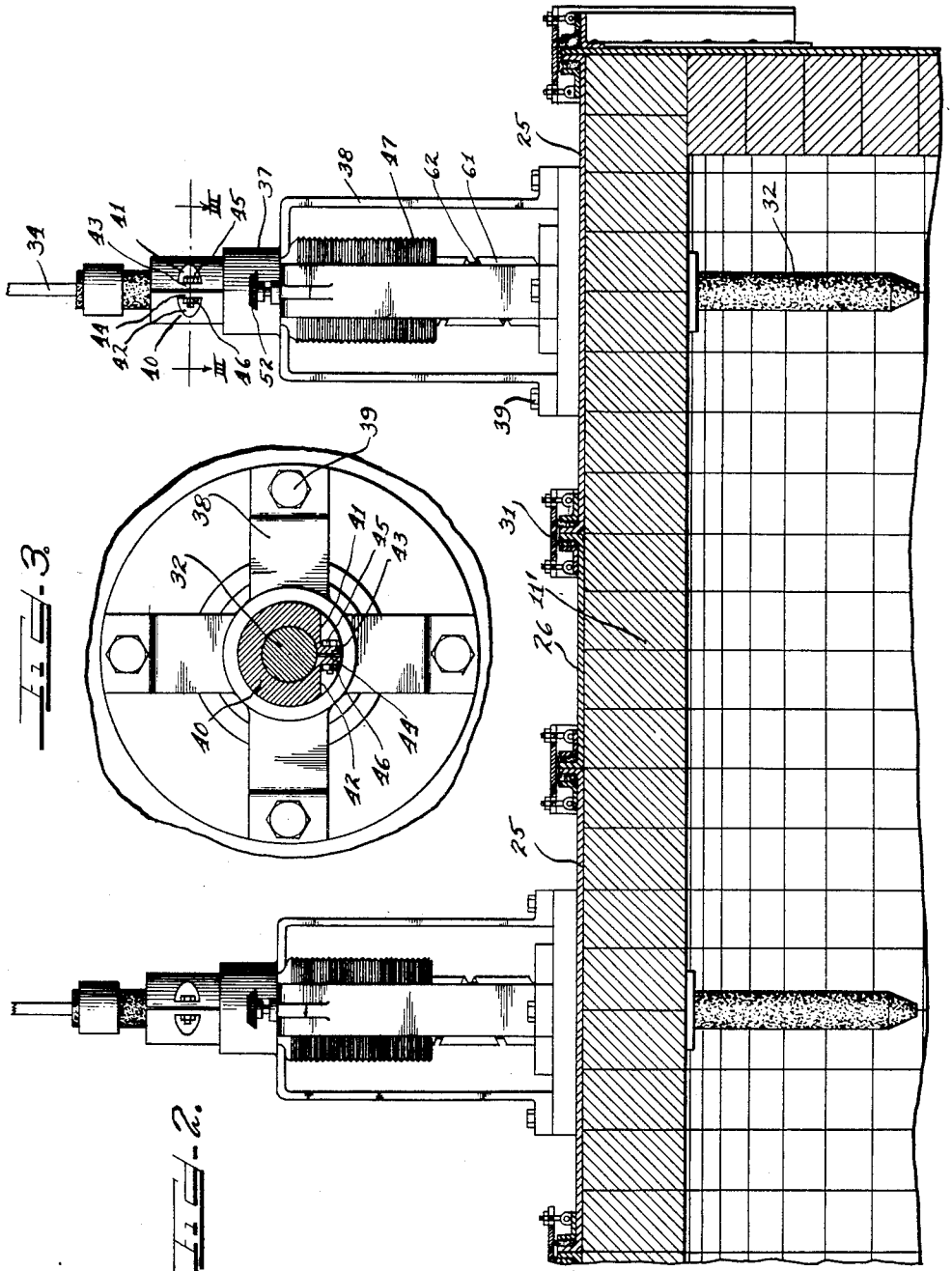


Fig. 2.

Fig. 3.

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Fig. 4.

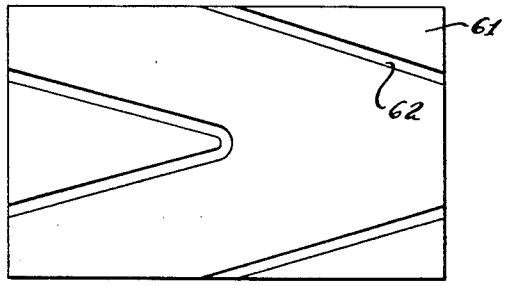


Fig. 5.

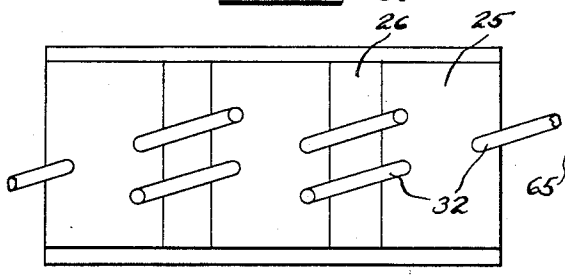


Fig. 7.

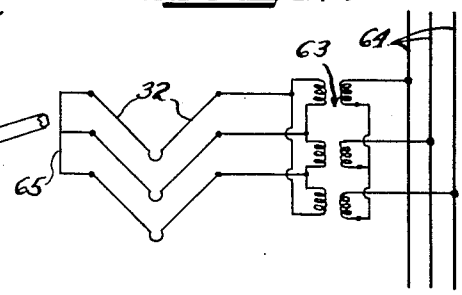


Fig. 8.

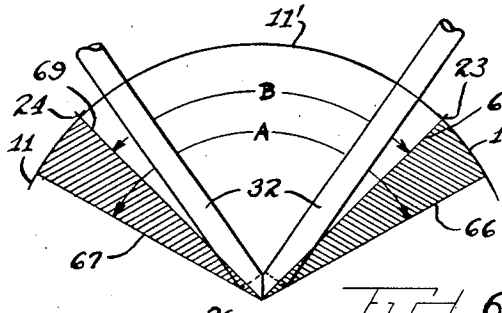


Fig. 9.

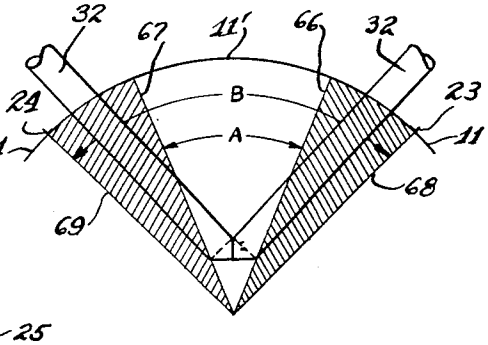
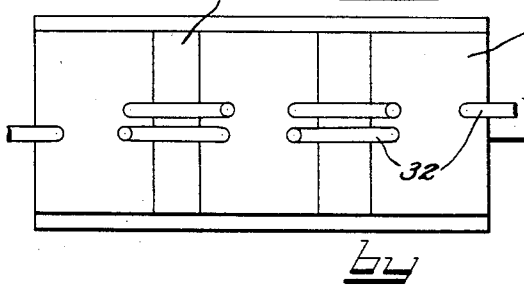


Fig. 6.



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Patented Nov. 17, 1936 2,061,090

UNITED STATES PATENT OFFICE

2,061,090

ELECTRIC FURNACE

Albert E. Rhoads, Detroit, Mich., assignor to Detroit Electric Furnace Company, Detroit, Mich., a corporation of Michigan

Application November 16, 1933, Serial No. 698,284

9 Claims. (Cl. 13—10)

This invention relates in general to electric furnaces and is more particularly concerned with an improved construction wherein the maximum thermal energy resulting from the transformation into heat, by the aid of the electric arc, of the electric energy may be most efficiently utilized in metallurgical operations, such as the melting of iron and other metals.

It is an object of the hereindescribed invention to provide an electric furnace of the type utilizing a plurality of pairs of electrodes, such as in a multi-phase furnace, wherein each pair of electrodes together with its feeding mechanism is assembled and mounted in such a manner as to constitute a unit which may be replaced by a spare unit or interchanged with the other units of the furnace.

A further object is to provide an electric furnace of the oscillating or rocking type which is constructed in such a manner as to enable the electrodes to be disposed at such an angle in relation to the angle between the limits of oscillation for a predetermined load, that the melting of the metal will be carried on most efficiently and the refractory wall of the furnace will be washed a maximum amount by the molten metal.

It is also an object to provide improved means for feeding the electrodes, which are so arranged as to not only move the electrodes in an axial direction, but also simultaneously cause the electrodes to be rotated, whereby the electrodes will be prevented from becoming cemented in their bearings by the condensed fumes of volatile metals. This rotation of the electrodes also prevents the possibility of the electrodes sagging should they become soft under the intense heat of the furnace, and, when considered in connection with the proper angular disposition of the electrodes, also causes the electrode points at the arc to be symmetrically maintained and thus assure a proper position of the arc.

Still another object is to provide an electric furnace of the electrode type wherein the electrodes are so mounted as to permit of a maximum charge of unmelted metal and in which the electrode tips are removed from the charging door, thereby lessening the possibility of the electrodes becoming damaged during the charging operation.

In accordance with the general features of this invention, it is proposed to provide a cylindrical melting chamber which is supported for oscillation or rotation about its longitudinal axis. The furnace is provided in a portion of its wall with aligned removable sections. The charging door and electrodes are supported on these sections. Each pair of electrodes is supported to form a V and is mounted on one of the removable sections to form a unit structure which may be interchanged with one of the other sections supporting a similar pair of electrodes or may be replaced by a spare service unit. Each unit is provided with a motor which is connected through a driving mechanism so as to simultaneously feed the electrodes of each unit in a longitudinal direction. Moreover, cam means are provided for rotating the electrodes in response to their longitudinal movement. The cam means are so arranged that rather than cause the electrodes to rotate continuously in one direction, which would necessitate a sliding or slip type of electrical connection to the electrodes, the electrodes are rotated first 360 degrees in one direction and then reversed and rotated 360 degrees in the opposite direction. This arrangement obviates the necessity of a slip connection and enables the cables to be securely clamped to the electrodes.

Other objects and features of this invention will more fully appear from the following detail description taken in connection with the accompanying drawings which illustrate several embodiments thereof, and in which:

Figure 1 is a fragmentary cross-sectional view taken through a furnace of the character described and embodying the features of this invention;

Figure 2 is a fragmentary longitudinal section of the same, taken substantially on the line II—II of Figure 1;

Figure 3 is an enlarged fragmentary sectional view through one of the electrode supports, taken substantially on the line III—III of Figure 2;

Figure 4 is a detail view showing the development of the cam surface for rotating one of the electrodes;

Figure 5 is a view diagrammatically showing a modified arrangement of electrodes in the furnace;

Figure 6 is a view diagrammatically showing an alternative arrangement of the modification shown in Figure 5.

Figure 7 is a schematic view showing the electrical connections to the electrodes; and

Figures 8 and 9 are views diagrammatically showing the relationship between the angle between a pair of electrodes and the angle lying between the points of maximum oscillation of the furnace.

As shown on the drawings:

In order that an electrical furnace of the herein described type shall operate most efficiently, it has been found desirable to keep the mass of the furnace, per unit of charge, as low as possible. In so doing, the amount of electrical energy required to bring the furnace proper up to temperature is maintained at a low value. For such purpose, the furnace should be of a cylindrical shape.

The furnace, as illustrated in Figure 1, comprises an outer metallic shell **10** of cylindrical shape which is provided with a refractory lining **11**. This shell is supported upon a pair of spaced grooved rollers **12** and **13** which are rotatably supported in brackets **14** and **15**, a pair of these rollers being placed at each end of the furnace so as to support the furnace with its longitudinal axis in a horizontal position, although where maximum mixing is required, the axis may be eccentrically mounted, as shown in the patent to Crosby, No. 1,336,820, issued April 13, 1920. Movement of the furnace is guided by means of a rail **16** which is secured to the cylindrical shell so as to engage the grooved pulleys. Adjacent the rail **16** is a curved rack **17** having teeth which are in engagement with a pinion **18**. This pinion is rotatable with a shaft **19** which is connected through an automatic reversing mechanism with a shaft **20** of a driving motor **21**.

The reversing mechanism may be of any suitable type, but should preferably be of the type which will automatically drive the pinion **18** to rock or oscillate the furnace in one direction a predetermined amount and then reverse to cause the furnace to move in the other direction a predetermined amount. Such mechanisms are usually adjustable so that the movement of the furnace may be regulated as desired, and are also usually so arranged that they may be manually operated to move the furnace, as, for example, during the pouring operation.

As clearly shown in Figure 1, the shell **10** does not form a closed metallic shell, but the ends are in spaced relation to leave a longitudinally extending opening **22** in the furnace for mounting the electrode units. The ends of the shell **10** are deflected to form outwardly extending flanges **23** and **24**.

The opening **22** is closed by a plurality of removably secured plates or sections **25** and **26** which are respectively adapted to support a pair of electrodes and a charging door. In the illustrated furnace, the plates or sections **25** and **26** are alternately arranged with the outermost sections **25—25** separated from a central section **25** by means of sections **26—26** disposed on either side of the central section **25**. The sections **25** are interchangeable and the sections **26** are also interchangeable with each other.

The ends of the plates or sections **25** and **26** respectively project past the flanges **23** and **24** and are secured to the shell in the same manner. The end to be secured cooperates with a series of clamping bolts **27** which extend through appropriate slots **28** and are provided with clamping nuts **29**. Each clamping screw or lug is pivoted at its inner end so that when the clamping nut is released, the lug may be swung out of clamping position, thereby releasing the ends of the plate. The joints between the shell **10** and the plates **25** and **26** are sand sealed. For this purpose, a flange **30** extends along each of the flanges **23** and **24** in spaced relation thereto to form a cavity for receiving the sand which is to form the seal. It will be observed that when one of these plates is clamped into position, the sand in this cavity engages the inner surface of the plate and forms a seal. The interior of each of the removably mounted plates is provided with refractory material **11'**, the inner ends of which cooperate with the inner ends of the refractory material **11** to form the interior of the melting chamber. In removing one of these plates, the refractory material supported thereby would also be removed.

Referring to Figure 2, it will be observed that the same type of seal is provided for connecting the lateral edges of the plates **25** and **26** to each other and to the furnace. The only difference is that, where the sections are to be secured together or to the furnace, the flanged edges of the plates are in abutment rather than overlapping, and the clamping bolts cooperate with a circumferentially extending band **31** which is clamped against the sand within the respective containers along the edges of the plates.

Each section **25** not only forms a portion of the furnace shell but also serves the purpose of providing a support for each pair of electrodes together with the electrode feeding mechanism. In other words, each pair of electrodes mounted on a section **25** forms a complete unit which may be interchanged with any other electrode unit of the furnace or may be replaced by a spare unit when necessary. The electrodes of each pair are mounted to form a V with the converging ends of the electrodes disposed within the melting chamber. Each electrode in its passage through the refractory material and the outer shell of the furnace, formed by the plate **25**, is slidably supported in a bushing **33** of insulating material. In order to support the outer end of the carbon electrode and the weight of the electric cable **34**, which is clampingly secured to the outer end of the carbon by a clamp **35**, a bracket **36** is provided. This bracket has a central hub portion **37** which surrounds the electrode and a plurality of radial and downwardly deflected legs or supports **38** which are secured at their lower ends to the plate **25**, as by bolts **39**.

Rotatably and slidably supported for axial movement in the hub **37** is a split sleeve **40** which is provided with cut-out portions **41** and **42** in its periphery to define opposed flanges **43** and **44** disposed respectively on each side of the split of the sleeve. A clamping bolt **45** with cooperating nut **46** extends thru apertures in these flanges. With this arrangement, the sleeve may be clamped to the electrode **32**, and, since the head of this bolt and the nut **46** are countersunk or disposed in the cut-out portions adjacent the flanges **43** and **44**, it is possible for the sleeve to rotate within the hub **37** without interference. The lower end of this sleeve is extended to define a cylindrical shell **47** which surrounds the electrode. The outer surface of this shell is provided with circumferentially extending threads **48** and the inner surface is radially spaced from the surface of the electrode to define a cylindrical socket **49** which is open at the lower end of the shell portion.

Longitudinal or axial feed of the electrode is attained by means of a worm wheel **50** which is secured to and rotatable with a shaft **51**, this shaft being rotatably supported on one of the legs **38** of the bracket **36**. The upper end of this shaft is connected by means of a pair of bevel gears **52** and **53** to a main shaft **54** which is rotatably supported upon bearing brackets **55—55** of the two

supporting brackets 36—36 of the electrodes which constitute a pair. The bracket 55 may, if desired, be integrally formed with the bracket 36. The other end of the shaft 54 is connected through a similar pair of bevel gears to the longitudinal feeding mechanism of the other electrode of the pair. The common shaft 54 is driven through a pair of suitable gears 56 and 57, the former being carried by the shaft 54 and the latter by the driving shaft of a motor 58, this motor being supported in any desired manner, as for example, on a bracket 59 which may be integrally formed with one of the brackets 36. This arrangement enables each pair of electrodes to be simultaneously fed in an axial direction as the points are consumed, whereby the arc is maintained at a fixed distance from the metal which is being melted.

For causing the electrodes to rotate simultaneously with their longitudinal feed, the shell 47 of each electrode assembly is provided with an inwardly extending pin 60 which is disposed near the open end of the socket 49 and projects thereinto. Cooperatively associated with this pin is a cylindrical sleeve 61 which surrounds the electrode and is secured at its lower end to the plate 25 in any appropriate manner. This sleeve is of such length that when the shell portion 47 is at its uppermost limit of travel, the upper end of the sleeve 61 extends into the open end of the socket 49. The outer surface of the sleeve 61 is provided with a spiral groove 62 for receiving the projecting end of the pin 60. Referring to Fig. 4 showing a development of the sleeve 61, it will be observed that the groove 62 is so arranged that when the electrode is longitudinally moved, the pin 60 will follow the groove 62 and, due to the pitch of the groove, will cause the sleeve 40 together with the electrode to which it is clamped to be rotated through 360°. At the end of this rotation, the groove is reversed and spiraled in the opposite direction, whereby the electrode will be rotated in the opposite direction 360°. Although in the present structure the groove is illustrated as being designed to rotate the electrode through two complete revolutions in opposite directions, it may be found desirable to increase the number of rotations in certain types of installations. This rotation of the electrode is advantageous in that, when volatile metals are being melted, there is little liability of the electrode becoming cemented in the bushing where it passes through the furnace wall, due to the vapor from the volatile metal. Moreover, the rotation also tends to prevent sagging of the electrodes due to their becoming soft from the intense heat within the furnace, and the points of the electrodes will also be symmetrically consumed, thus maintaining the arc in proper position for giving a high efficiency.

In Fig. 1, the electrodes constituting each pair are disposed so as to lie in a plane at right angles to the longitudinal center line of the melting chamber. As an alternative and modified arrangement, the electrodes of each pair may be supported on the associated plate 25 as shown in Fig. 5, where the plane of each pair of electrodes is disposed at an angle to the longitudinal center line of the melting chamber. This arrangement is advantageous in that it enables a shortening of the plates 25 and 26, whereby the rocking or oscillating angle of the furnace may be increased so as to wash a greater amount of the refractory wall thereof. Further, since the plane of the electrodes is brought more nearly into alignment with the center line of the furnace, the initial charge of metal to be melted may be more easily extended up on each side of the plane of the electrodes without interference. It is also contemplated, as an alternative electrode arrangement, that the planes of the pairs of electrodes may be brought into alignment or parallel relationship with the longitudinal axis of the furnace, in which case the respective pairs may be circumferentially offset relative to the furnace, as shown in Figure 6. Such an arrangement has the advantage that the electrodes will be further disposed from the charging door, thus decreasing the likelihood of the portions of the electrodes within the melting chamber becoming damaged during the charging operation.

The charging door may be of any suitable construction and is preferably mounted in one of the plates 26. Since it is preferable to provide two charging door plates, the second plate may contain a charging door or not, a desired. Since charging doors for furnaces of this type are so well known in the art, it has not been deemed necessary to illustrate the charging door. However, it is preferred that the inner opening to the pouring spout, which is usually constructed as a part of the charging door, be coincident with the joint between the refractory material 11 and the refractory material 11', since the pouring spout is usually left open to form a vent, and it is undesirable to have the melted metal wash the joint between the refractory portions 11 and 11'. In other words, the maximum angle of rotation of the furnace is determined by the joint just described.

While the features of this invention have been described in connection with a multi-phase, in this case three-phase, furnace, it is obvious that these features may be readily incorporated in a furnace for operating on two-phase or single-phase current. For three-phase operation, the electrodes may be connected as illustrated in Figure 7, or the three pairs of electrodes may be fed from individual transformers, thus in effect giving three single-phase furnaces in a single shell. Any desired connection of transformer windings may be used, depending upon the electrical source available. In Figure 7, a transformer 63 is shown with a Y connected primary connected to the respective conductors of a three-phase distribution circuit 64. The secondary windings of the transformer are connected in delta and to each of the corresponding electrodes of each pair. The other electrodes of each pair are interconnected by a common connection 65.

Figures 8 and 9 diagrammatically illustrate the feature of this invention, whereby it is possible to build a furnace of this type having an exceedingly high efficiency. As previously pointed out, the furnace has a cylindrical melting chamber which enables as large an area of the refractory lining as possible to be washed by the melted metal, thus not only cooling the lining but also raising the temperature of the charge by means of the heat abstracted from the lining. It will, therefore, be evident that the maximum rock of the furnace and thus the maximum wash of the lining will be determined by the joints between the refractory portions 11 and 11', or, in other words, at the flanges 23 and 24 as shown in Figure 1.

It is also desirable to direct the arc towards the metal, rather than toward the lining, and, to this end, it is desirable that, at the maximum

angle of rock, the arc end of the lowermost electrode shall be no further away from the surface of the metal than is the remainder of the electrode. Of course, it will be appreciated that the arc should be as close to the metal as possible, in order to reduce the amount of radiant heat falling upon the unwashed refractory between the electrodes.

In the consideration of the foregoing desiderata, which are the primary factors having a bearing on the furnace efficiency, it has been found that a definite relationship exists for a given load line or level between the angle defined by the electrodes of each pair and the angle between the refractory joints or the points defining the maximum rock of the furnace, both of these angles being about the same center, in this case the longitudinal axis of the furnace, this axis also being the axis about which it is rocked.

Referring to Figure 8, let it be assumed that the furnace is desired to be most efficient in its operation when the load level is at the longitudinal axis of the melting chamber. Then, in order to get the electrode points as close as possible to the metal they would have to be substantially in contact with it. Now, if lines **66** and **67** are drawn from the longitudinal axis of the furnace as a center, through the most widely spaced points of the electrode points to the interior wall of the refractory as represented by the arc **11—11'—11**, the angle A will be defined. Another angle, angle B, is now constructed by similar procedure, by drawing the lines **68** and **69** through the joints between the refractory portion **11'** and refractory portions **11—11**, designated as **23** and **24**. In this case, the angle A is found to be greater than the angle B and it will not be possible to secure a maximum wash of the refractory wall, the difference between the angles A and B being represented by the shaded portion. The greatest wash obtainable would, therefore, be when the level of the metal coincides with the lines **66** and **67**. Any further or increased rocking would cause the electrodes to dip into the metal, which, of course, is objectionable.

Referring now to Figure 9, it will be observed that if the electrodes are raised so as to have the arc too great a distance from the metal, the angle A then becomes smaller than the angle B, as shown by the shaded portions. Under these conditions the amount of furnace rocking is determined and limited by the joints **23** and **24**, but the furnace will not operate at its greatest efficiency because the arc is further from the metal than is necessary.

It is, therefore, apparent that in order to obtain the most efficient arrangement, the angles A and B should be equal or preferably angle A should be slightly less than the angle B. Thus it will be possible to get the arc as close as possible to the metal and at the same time be able to wash as much of the refractory lining as possible.

It will also be apparent from Figure 9 that, if the electrodes are placed with their axes substantially parallel to the lines **68** and **69**, and these axes are considered instead of the angle A, then the closest arc could be placed to the metal, without the electrodes limiting the maximum wash of the refractory, would be when the axes are spaced from the lines **68** and **69** a distance substantially equal to the radius of an electrode.

Although the foregoing description in regard to the relationship existing between angle A and angle B has been confined to the condition wherein the load level is coincident with the longitudinal center line of the melting chamber, this relationship also holds true for other load levels as well.

From the foregoing description, it will be apparent that the hereindescribed invention provides an improved electric furnace of the rocking type having novel means for feeding the electrodes in a longitudinal direction and simultaneously rotating the electrodes; a furnace in which each pair of electrodes is associated and mounted on the furnace in such a way as to form an interchangeable or replaceable unit; which is so designed and constructed as to enable electrodes to be disposed at such an angle in relation to the angle between the limits of rocking for a predetermined load that the melting of the metal will be carried on most efficiently and the refractory wall of the furnace will be washed a maximum amount; and wherein the electrodes are so mounted as to permit of a maximum charge of unmelted metal, the electrode tips being so disposed as to substantially avoid the possibility of damaging the same when the furnace is initially charged.

Now, it is, of course, to be understood that although I have described in detail several embodiments of my invention, the invention is not to be thus limited but only insofar as defined by the scope and spirit of the appended claims.

I claim as my invention:

1. In a furnace having a closure structure defining a melting chamber, a removable section defining a portion of said structure, a pair of electrodes supported on said section and projecting into said chamber, means to feed said electrodes in an axial direction, and means to rotate said electrodes in response to their axial movement, said section, electrodes, feed means and rotating means being associated in such a manner as to form a unitary assembly.

2. In a furnace, a unitary assembly comprising a supporting member, a pair of electrodes projecting through said member, means to axially feed said electrodes, and cam means responsive to the axial movement for rotating the electrodes in one direction and then in the reverse direction.

3. A multi-phase electric furnace of the character described comprising an elongated melting chamber, and spaced pairs of electrodes aligned longitudinally of the melting chamber and extending thereinto, the planes of the respective pairs of electrodes being substantially in parallel relationship and at an oblique angle to the longitudinal axis of the melting chamber.

4. In an electric furnace having a closure structure defining a substantially cylindrical melting chamber with its longitudinal axis disposed substantially horizontally and arranged to be rocked substantially about said axis, a removably secured segmental section forming a part of said structure and having joints therewith circumferentially spaced of said chamber, a pair of electrodes supported on said section and arranged in a V with their converging ends adjacent the longitudinal axis of the furnace, the maximum angle at the widest portion of the electrode points measured at the longitudinal axis of the chamber being substantially equal to the angle lying between the joints of said section measured at the same axis.

5. In an electric furnace having a closure structure defining a substantially cylindrical melting chamber with its longitudinal axis disposed substantially horizontally and arranged to be rocked substantially about said axis, a removably secured segmental section forming a part of said structure

and having joints therewith circumferentially spaced of said chamber, a pair of electrodes supported on said section and arranged in a V with their converging ends adjacent the longitudinal axis of the furnace, the maximum angle at the widest portions of the electrode points taken at the longitudinal axis of the chamber being less than the angle lying between the joints of said section in said structure.

6. In an electric furnace having a closure structure defining a substantially cylindrical melting chamber with its longitudinal axis disposed substantially horizontally and arranged to be rocked substantially about said axis, a removable section in said structure forming a portion thereof, the joints of said section with the other portion of said structure being circumferentially spaced relative to said chamber and determining the maximum area of wash of the interior of the chamber during the rocking thereof, a pair of electrodes carried by said section disposed in a V with their converging ends contiguous the longitudinal axis of the melting chamber, the angle between the lowermost portions of the electrodes at the rocking limits of the chamber being less than the angle between the joints of said section taken with the longitudinal axis of the chamber as a center.

7. In an electric furnace having a closure structure defining a substantially cylindrical melting chamber with its longitudinal axis disposed substantially horizontally and arranged to be rocked substantially about said axis, a removable section forming a portion of said structure, the joints of said section with the other portion of said structure being circumferentially spaced relative to said chamber and determining the maximum area of wash of the interior of the chamber during the rocking thereof, a pair of electrodes carried by said section disposed in a V with their converging ends contiguous the longitudinal axis of the chamber, the respective axes of said electrodes being substantially parallel to lines drawn from the longitudinal axis of said chamber through the respective joints of said section and the other portion of said structure, and spaced from said lines an amount substantially equal to the radius of an electrode.

8. In an electric furnace having a closure structure defining a substantially cylindrical melting chamber with its longitudinal axis disposed substantially horizontally and arranged to be rocked substantially about said axis, a removably secured segmental section forming a part of said structure and having joints therewith circumferentially spaced of said chamber, a pair of electrodes supported on said section and arranged in a V with their converging ends adjacent the longitudinal axis of the furnace, the maximum angle at the widest portion of the electrode points measured at the longitudinal axis of the chamber being substantially no greater than the angle lying between the joints of said section measured at the same axis.

9. In a furnace having a casing with a refractory wall defining a melting chamber provided with an opening, a removable unitary structure adapted to provide a closure for the opening, said removable unitary structure comprising a refractory wall section, a pair of electrodes supported on said section and movable therethrough to project into the melting chamber, and power feed means for moving said electrodes mounted on said section and connected to said electrodes.

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