A. L. J. QUENEAU.

ELECTRIC FURNACE AND METHOD OF OPERATING THE SAME.

APPLICATION FILED NOV. 29, 1909.

948,343. Patented Feb. 8, 1910.

4 SHEETS—SHEET 1.

Fig. 1,

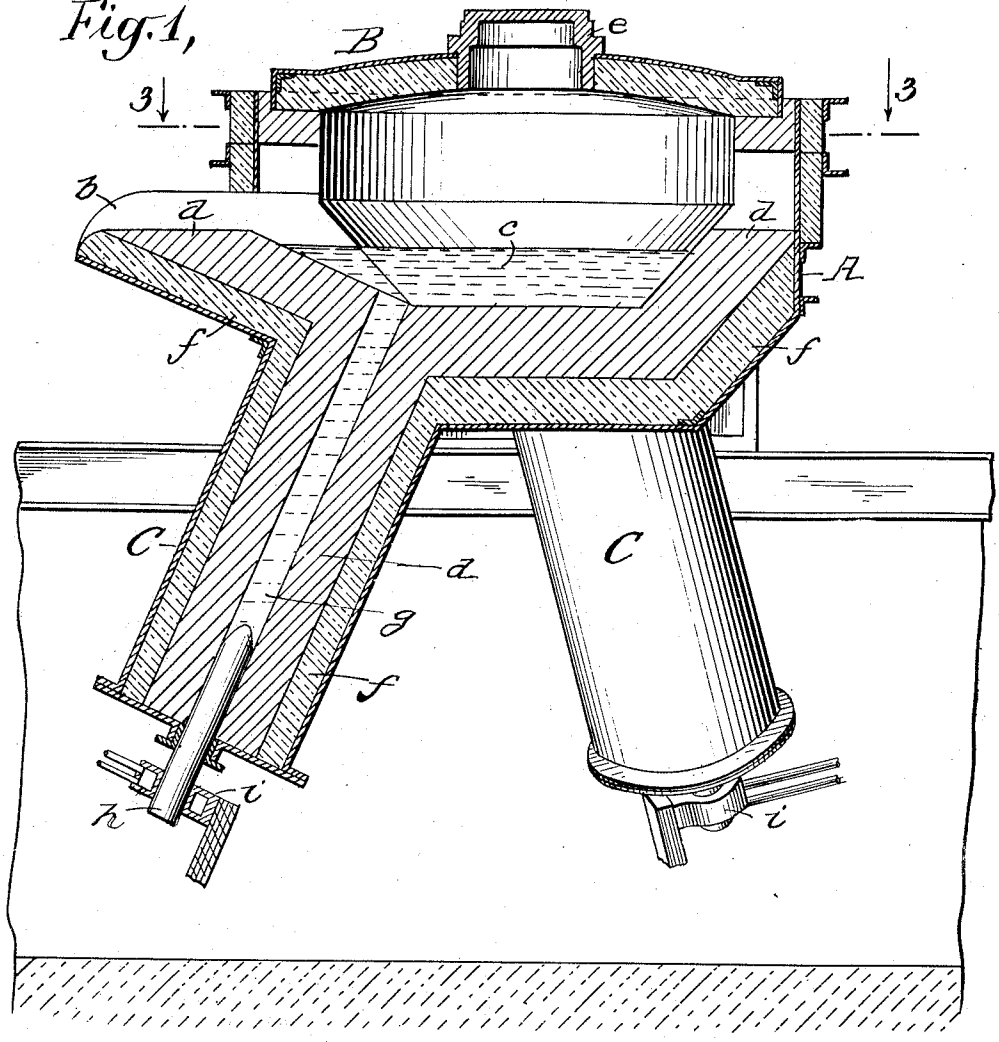
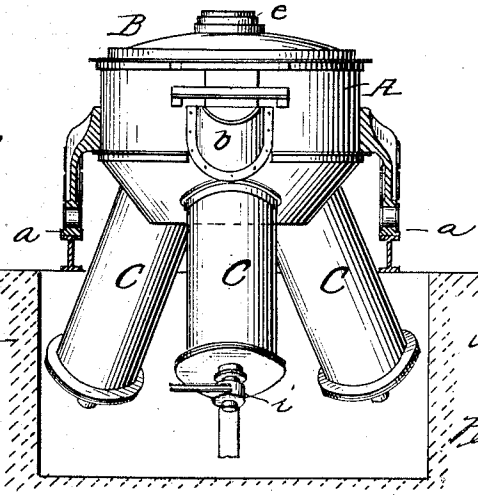


Fig. 2,



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4 SHEETS—SHEET 2.

Fig. 3.

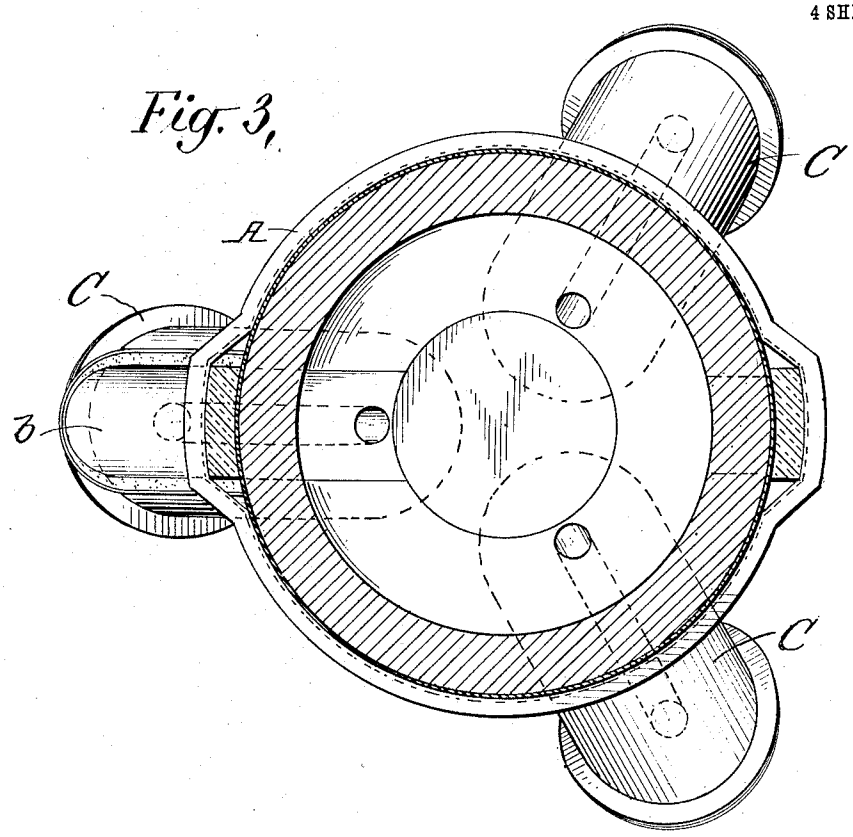
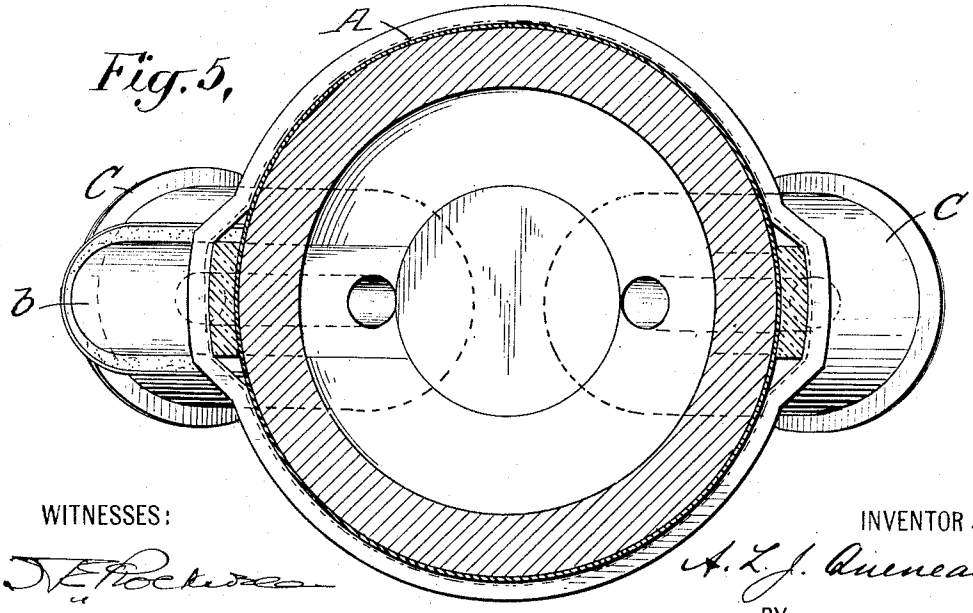


Fig. 5.



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4 SHEETS—SHEET 3.

Fig. 4,

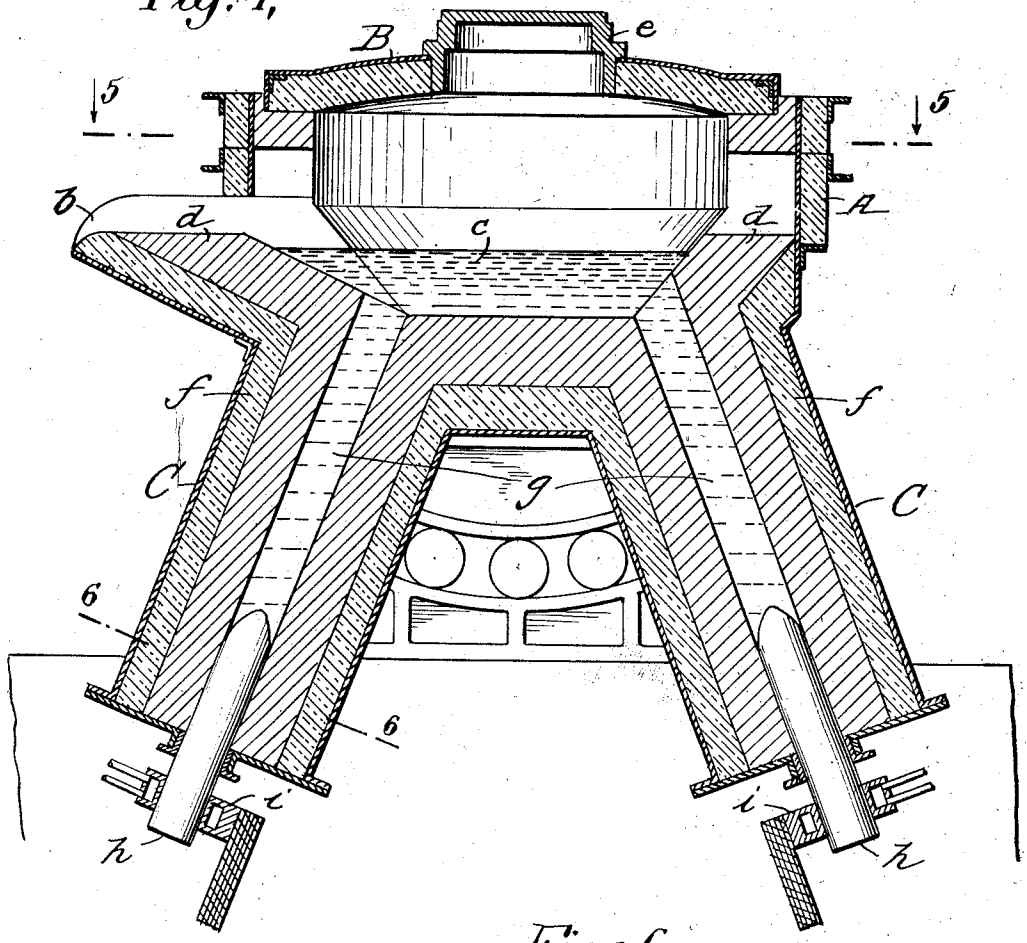
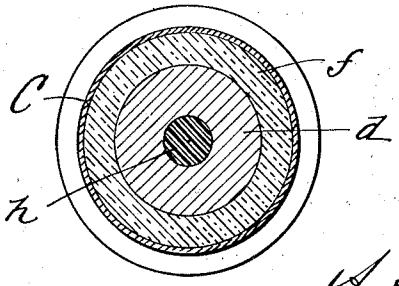


Fig. 6,



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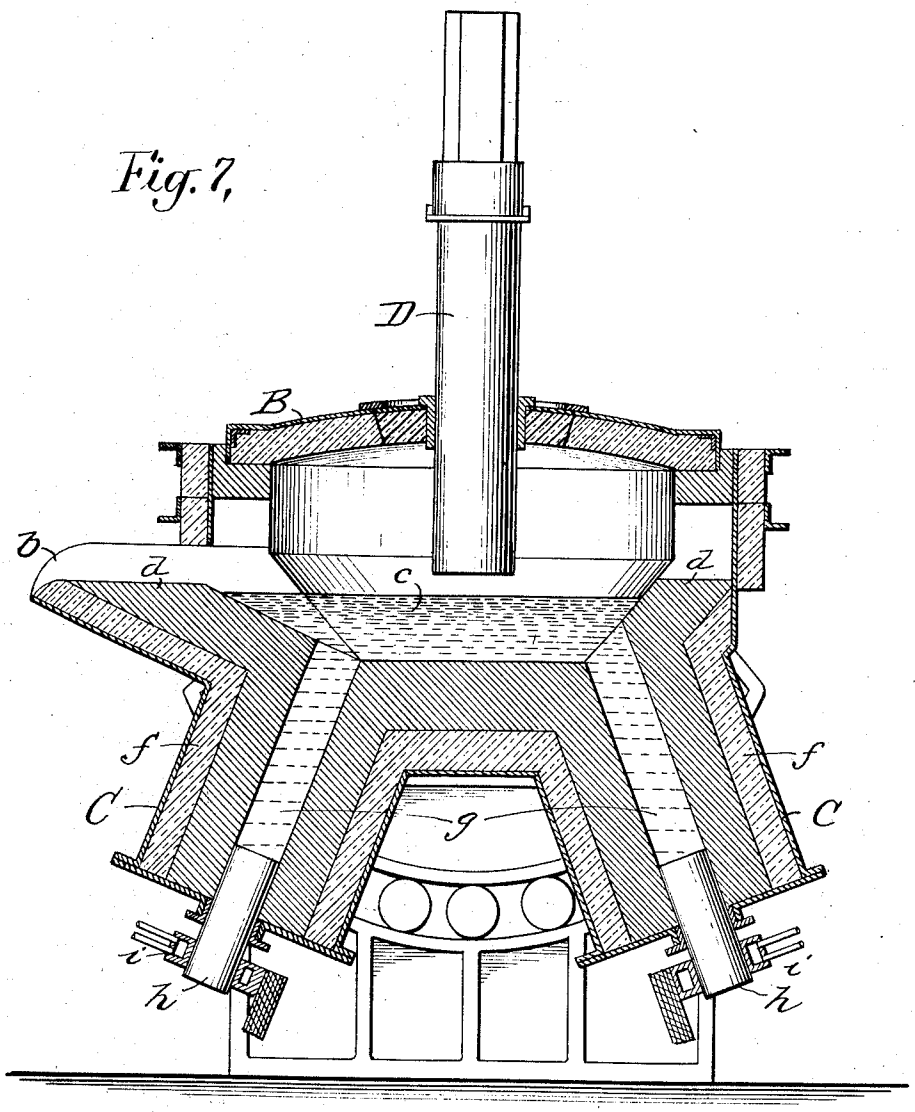
4 SHEETS—SHEET 4.

Fig. 7.



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ELECTRIC FURNACE AND METHOD OF OPERATING THE SAME.

948,343. Specification of Letters Patent. Patented Feb. 8, 1910.

Application filed November 29, 1909. Serial No. 530,396.

To all whom it may concern:

Be it known that I, AUGUSTIN LEON JEAN QUENEAU, a citizen of the Republic of France, residing at Overbrook, in the city and county of Philadelphia, State of Pennsylvania, have invented certain new and useful Improvements in Electric Furnaces and Methods of Operating the Same; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In the operation of electric furnaces, particularly those designed for the working and refining of iron and steel, serious difficulties have, in some instances, been noted, due to the so-called "pinch" effect, these difficulties sometimes resulting in the complete interruption of the operation of the furnace. This pinch phenomenon, heretofore regarded as disastrous, and altogether to be avoided, I turn to useful account in the practice of my present invention, employing it as an auxiliary to the electric furnace operation and, particularly, making it available as a means for more thoroughly mixing and refining the charge. Thus, I have discovered that by providing the bath of metal to be treated with a molten metal connection subject to the hydrostatic pressure of the bath, and by appropriately proportioning the electric current passing through said connection to the cross section thereof and to the hydrostatic head, I am enabled to produce in the metallic connection and in close proximity to the bath a series of impulses or pulsations within the molten metal, which impulses or pulsations are due to a series of disruptions of the molten metal in the connection and an alternate series of reëstablishments of said connection. These disruptions are exhibitions of the action of the pinch phenomenon and the reëstablishment of the connection after each disruption is, in my invention, produced by the hydrostatic head of the superjacent metal in the bath; and the arrangement is such that at the place where the resulting pulsations originate and where the disruptions occur, reducing conditions prevail so as to prevent the oxidation of the disrupted surfaces and the interruption of the working current thereat.

In the accompanying drawings, I have illustrated my invention as applied to an electric steel furnace, for which it is well adapted, but it will be readily understood that the heating and mixing effect may be obtained in an electric furnace for the treatment of other metals (and also glass), or wherever a molten metal, slag, salt or other molten resister is to be used as the seat of the heating and mixing effects, and whether the molten resister so employed is itself to be refined or varied, or whether it is employed for the purpose of transmitting its heating effects to a charge of some other material superposed upon it, as, for instance, a zinc ore charge made up of the usual mixture of zinc ore and coke for the production of spelter.

In the drawings, Figure 1 represents the adaptation of my invention to a tiltable steel furnace, the molten metal connections being adapted for use with a three-phase alternating current; Fig. 2 represents, on a smaller scale, a front elevation thereof, partly in section; Fig. 3 represents a horizontal section and plan view taken on a plane indicated by the line 3—3 of Fig. 1; Fig. 4 represents a view similar to Fig. 1, but shows a furnace particularly adapted for either a monophase alternating current or a direct current; Fig. 5 represents a horizontal section and plan view taken on a plane indicated by the line 5—5 of Fig. 4; Fig. 6 represents a section taken on a plane indicated by the line 6—6 of Fig. 4; and Fig. 7 indicates a further modification wherein the current, either direct or alternating, is used not only to produce the pinch effect in the molten metal connections from the bath, but also to develop the heating effect of an arc produced between a top electrode and the bath or the slag floating upon the bath.

Similar letters of reference indicate similar parts throughout the several views.

Referring to the drawings, it will be noted that I have chosen as an illustration a steel furnace of the tiltable type. Thus, in Figs. 1 and 2, the main body portion A of the furnace is mounted to rock upon the supports *a* and is provided with the usual pouring nose *b* and with a hearth for containing the bath *c* of molten metal, together with the roof B, arched, as shown, and having an opening which is closable by the cap *e*.

Subjacent to the main body portion of the furnace are branches C. These branches C and also the hearth of the furnace are

lined with the usual fire brick lining *f* and an inner lining *d* of burned magnesia mixed with tar and rammed in place, the lining for the roof being usually of silica brick. It will be found suitable to place the subjacent branches or legs C at an angle of say twenty degrees from the vertical, and it will be understood that the metallic frame work, water-cooled at any desired place as is customary in steel metallurgy, is suitably bound together, by its metallic plates or frame work so as to constitute a structure of the necessary inherent strength and stability.

The several legs C are provided with channels *g*, which channels converge upwardly toward a common central point represented by the opening in the furnace roof closed by the removable cap *e*, so that, on removing the cap *e*, it will be feasible, at any time, to repair the rammed lining of the channels *g* by inserting a suitable former (as, for instance, a metal rod of corresponding cross section) through the roof and into the channel *g*, or from the opposite end of the said channel after removing the solid electrode *h;* whereupon, the tamping material may be tightly rammed about the former so as to effect a speedy and efficient repair. If the rod employed is simply to subserve the functions of a former, it may then be removed from the channel, thereby leaving the channel open for the reception of molten metal from the bath when the charge is poured in; but, in some instances, the former may consist of the electrode *h* itself if the electrode is of such material (preferably that of the bath) that on the passage of the current it will become liquefied as indicated in Figs. 1 and 4.

The tamping of the hot mixture of burned magnesia and tar employed for making the inner lining D of the hearth and the subjacent legs is preferably rammed by means of the well known pneumatic rammer, and it will be understood that in thus making the inner lining, the portion of said lining occupying the subjacent legs C is first inserted, and that, when this portion has been brought to the level of the bottom of the hearth, the remainder thereof is firmly rammed in place to form the hearth bottom and sides. Water-cooled bronze collars *i* are now firmly attached to the electrodes *h*, which electrodes may conveniently be made of iron. The molten metal which is to serve as the bath *c* in the furnace is then poured upon the hearth and to the working depth required, and this molten metal enters the channels in the subjacent legs C at a temperature sufficient to enable it to reach the bottom of the channels and make electric connection with the electrodes *h*. The three electrodes *h* being connected up with the leads of a three-phase alternating current, the current employed is to be so chosen as not only to bring the metal *g* in said channels to the desired molten condition, but also to produce the pinch phenomenon therein. This pinch phenomenon will exhibit itself at a short distance below the entrance to the hearth and will thereupon cause a disruption of the column of metal. Thereupon, owing to the hydrostatic pressure of the bath, the column is immediately reëstablished, a new contact being made, and without oxidation, inasmuch as the conditions prevailing at the locus of the pinch effect are reducing. A good electric contact is, therefore, made as often and as soon as a break takes place, and the alternate series of disruptions and contacts thus produced result in a series of pulsations or impulses. These impulses or pulsations effect a thorough mixing of the metallic bath, thereby increasing the efficency of the chemical reactions and shortening the time of the operation, and the same phenomenon is reproduced in each of the three legs or branches, to the corresponding advantage of the operation.

For the treatment of steel, such as, for instance, steel which has been decarbonized to the usual extent met with at the termination of the blow and the disappearance of the carbon flame in the Bessemer converter and which has then been poured into the electric furnace, the current employed will usually be of low voltage and of high amperage, so as to develop the required large number of amperes (say from 1000 to 3000) per square inch, necessary to develop the pinch phenomenon, at the hottest point of the molten metal column as against the countervailing hydrostatic head. By suitably regulating the amperage of the current with respect to the hydrostatic head, until the impulses or pulsations manifest themselves in the bath, the operator will be able to obtain the desired effect and to regulate its value and intensity. So also, if it is desired to give a rotary motion to the bath, the channels in which the metal *g* is contained may be so built as to have their axes in planes inclined to the vertical axis of the hearth, so as to set up a corresponding whirling motion. The usual metallurgical reactions having been effected and the quality of metal being satisfactory, the furnace is tapped if stationary, or tilted if tiltable, as desired, or at least until the tubular channels are exposed. In carrying out the metallurgical reactions, the metal may be deoxidized, desulfurized, dephosphorized, or otherwise purified, and then converted into steel by the usual additions, all as is well understood in the art.

If, after the furnace has been tapped, an examination reveals the necessity of repairs, the *modus operandi* is as follows: Through

the side doors of the furnace and through the opening in the roof, (closed during active operations by the cap *e*), a pneumatic chipping tool is introduced and the eroded portions of the magnesia lining *d* are removed. In the meantime, if the metal *g* in the channels of the legs C has been permitted to remain, it will have solidified therein to such an extent that, by means of hydraulic jacks or the like, pressure applied to the electrodes *h* will force the solidified metal *g* upwardly until its extremity is slightly above the bottom of the hearth, the electric connection and water-cooling block *i* having first been removed, if necessary. A fresh mixture of magnesia and tar is then thrown into the furnace around the ends of the solidified metal projecting from the channels, and is rammed tightly in place by a pneumatic rammer, the sides and bottom being likewise repaired by a similar mixture. In case the furnace has been tilted to such an extent as to drain the molten metal *g* from the channels, the necessary repairs to the lining of the channels may be effected by inserting the forming rod through the opening in the roof of the furnace and similarly ramming the mixture of magnesia and clay as described.

In the form of the invention shown in Figs. 4, 5 and 6, the same construction and mode of operation described with reference to the form of furnace shown in Figs. 1, 2 and 3 is preserved with the exception that in the furnace of Figs. 4, 5 and 6 the electrodes are adapted to be connected either to a source of direct current supply or to a source of monophase alternating current supply.

In the form of the invention shown in Fig. 7, one of the current leads may be connected to the carbon electrode D. The pinch effect, incident to the practice of my invention, is, as in the two former modifications shown in the remaining figures, realized as before, in the molten metal *g* contained in the channels of the depending legs; but the heating effect is reinforced by the arc established between the carbon D and the bath. It will be understood that, in starting the furnace of Fig. 7, the electrode C may be brought into actual contact with the bath or the slag floating upon the bath, but, in operation, it will preferably be withdrawn to the desired extent necessary for producing the arc heating effect desired. With the arrangement shown in Fig. 7, the furnace may utilize either a direct current or a monophase, two-phase or three-phase alternating current, as may be most appropriate to local conditions.

Having thus described my invention, what I claim is:—

1. The method of treating a bath of molten metal in an electric furnace, which consists in providing the bath with a connection likewise of molten metal, and passing through said molten metal connection an electric current so proportioned to its cross section as to cause a series of disruptions of the connection, alternating with a series of reëstablishments of the connection by the hydrostatic pressure due to the bath; substantially as described.

2. The method of treating a bath of molten metal in an electric furnace, which consists in providing the bath with a connection likewise of molten metal, and passing through said molten metal connection an electric current so proportioned to its cross section as to cause a series of disruptions in said connection in close proximity to the main body portion of the bath, alternating with a series of reëstablishments of such connection by the hydrostatic pressure of the bath; substantially as described.

3. The method of treating a bath of molten metal in an electric furnace, which consists in providing the bath with a connection likewise of molten metal, passing through said molten metal connection an electric current so proportioned to its cross section as to develop a series of disruptions in said conductor, alternating with a series of reëstablishments of the connection by the hydrostatic pressure of the bath, and preventing oxidation of the molten connection at the place of disruption by providing reducing conditions thereat; substantially as described.

4. The method of treating a bath of molten metal in an electric furnace, which consists in providing the bath with a connection likewise of molten metal, passing through said molten metal connection an electric current so proportioned to its cross section as to cause a series of disruptions of the connection, alternating with a series of reëstablishments of the connection by the hydrostatic pressure due to the bath, and effecting a thorough mixture of the metal in the bath by the pulsations due to said alternate disruptions and reëstablishments; substantially as described.

5. The method of treating a bath of molten metal in an electric furnace, which consists in providing a bath with a multiple connection likewise of molten metal, and passing through the said multiple connection a multi-phase current so proportioned to its cross section as to cause a series of disruptions of the connection, alternating with a series of reëstablishments of the connection by the hydrostatic pressure due to the bath; substantially as described.

6. The method of treating a bath of molten metal in an electric furnace, which consists in providing the bath with a connection likewise of molten metal, establishing an electric arc above and out of contact with

the bath and passing across the arc and through said molten metal connection an electric current so proportioned to the cross section of the molten metal connection as to cause a series of disruptions of the connection, alternating with a series of reëstablishments of the connection by the hydrostatic pressure due to the bath; substantially as described.

7. The method of treating a bath of molten metal in an electric furnace, which consists in providing the bath with a multiple connection likewise of molten metal, establishing an electric arc above and out of contact with the bath and passing across the arc and through the molten metal multiple connection a multi-phase current so proportioned to the cross section of the multiple molten metal connection as to cause a series of disruptions thereof, alternating with a series of reëstablishments of the connection by the hydrostatic pressure due to the bath; substantially as described.

8. An electric furnace provided with a hearth for containing a bath of molten metal, subjacent branches depending from the hearth and having channels communicating therewith, said channels being so proportioned with respect to the working capacity of the hearth that, upon the passage of the predetermined current necessary for treating the bath of metal thereon, there will be produced a series of alternate disruptions and reëstablishments of connection in the molten metal contained in said channels; substantially as described.

9. An electric furnace provided with a hearth for containing a bath of molten metal, subjacent branches depending from the hearth and having channels communicating therewith, said channels being upwardly and inwardly inclined, and a furnace roof through which the hearth and channels are accessible for repair; substantially as described.

10. An electric furnace provided with a hearth for containing a bath of molten metal, subjacent branches depending from the hearth and having channels communicating therewith, said channels being upwardly and inwardly inclined, toward a common center, and a furnace roof having a closable opening through which all of said channels are accessible for repair; substantially as described.

11. An electric furnace, provided with a hearth for containing a bath of molten metal and having subjacent branches upwardly and inwardly inclined toward a common center, a permanent lining for said hearth and branches, a supplemental tamped lining, and a furnace roof through which, with the coöperation of a suitable former, repairs to the tamped lining may be made; substantially as described.

12. In an electric furnace, the combination with a hearth for containing a molten metal bath, of subjacent branches depending therefrom, said branches containing upwardly and inwardly extending channels communicating with the hearth, a furnace roof, and a closable opening in said roof through which a suitable former may be passed into any of the channels so as to permit their wall lining to be made and repaired by tamping; substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

AUGUSTIN LEON JEAN QUENEAU.

Witnesses:
JOHN C. PENNIE,
LAURA B. PENFIELD.