W. RODENHAUSER.

ELECTRIC INDUCTION FURNACE.

APPLICATION FILED NOV. 3, 1908.

987,404.

Patented Mar. 21, 1911

2 SHEETS—SHEET 1.

Fig. 1.

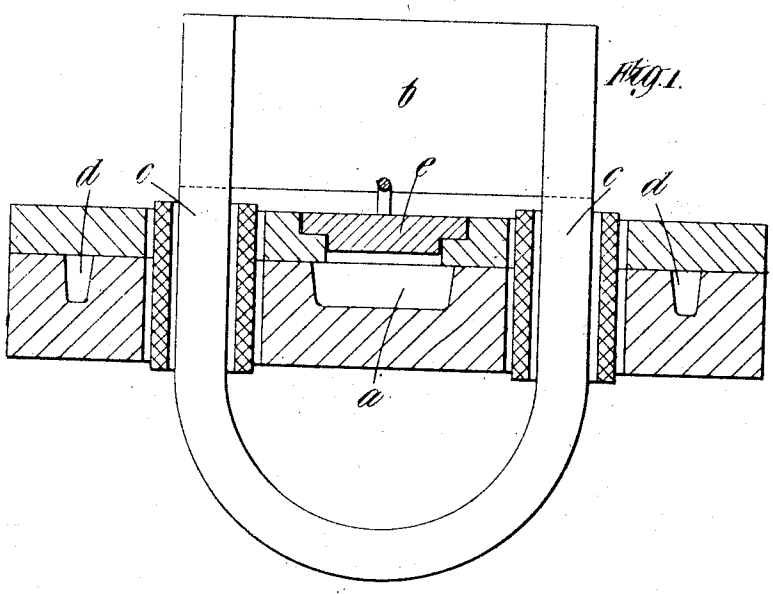
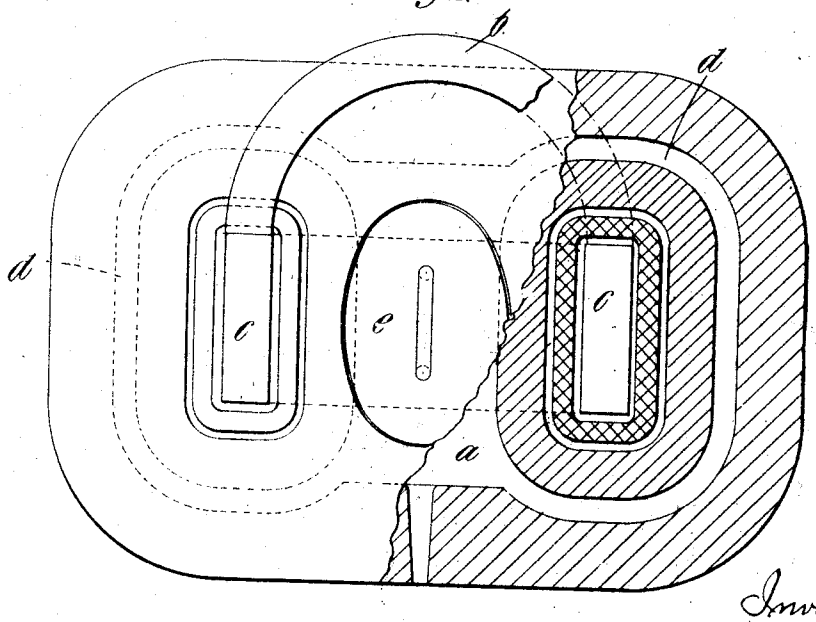


Fig. 2.



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2 SHEETS—SHEET 2.

Fig. 3

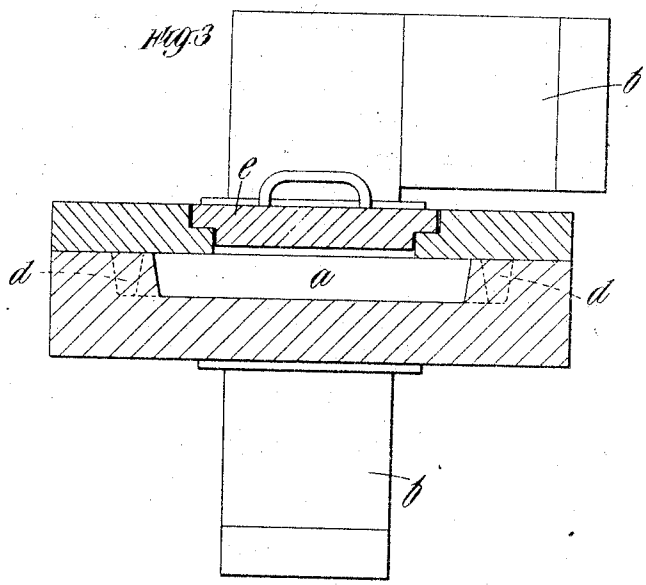
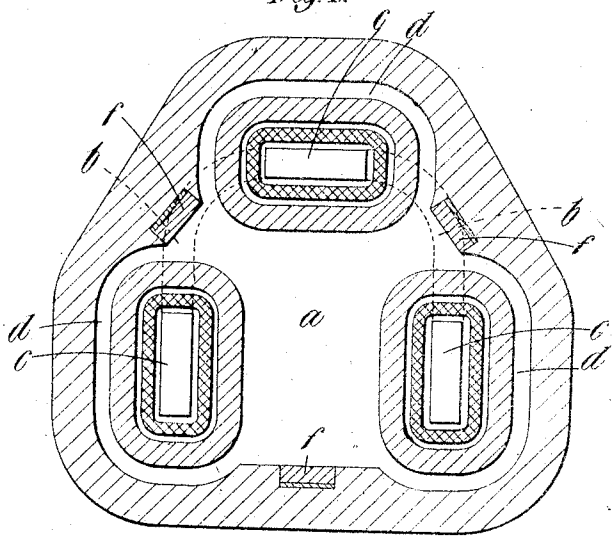


Fig. 4.



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UNITED STATES PATENT OFFICE.

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ELECTRIC INDUCTION-FURNACE.

987,404. Specification of Letters Patent. Patented Mar. 21, 1911.

Application filed November 3, 1908. Serial No. 460,955.

To all whom it may concern:

Be it known that I, WILHELM RODENHAUSER, a subject of the Emperor of Germany, residing at 58 Poststrasse, Völklingen-on-Saar, in the Empire of Germany, have invented certain new and useful Improvements Relating to Electric Induction-Furnaces, of which the following is a specification.

This invention relates to electric induction furnaces of the kind in which one or more of the limbs of the closed iron core, on which the primary winding is wound, are surrounded by continuous melting channels containing the material to be melted in such a manner that the current for melting the material in the melting channel or channels is produced directly by the induced currents set up in the material to be melted, which serves as a single secondary winding. Owing to the relatively great distance of the secondary winding (the material to be melted) from the iron core, great magnetic dispersion is produced; this dispersion entails, as is known, great phase displacement thus rendering necessary the use of currents of low periodicity and hence involving the use of costly current-generating plant; likewise making it impossible to connect the furnace to a current-generating system which has to supply other appliances fed by high periodicity current.

It has already been proposed to reduce the dispersion by arranging a secondary wire or bar winding upon the core limb itself, the current induced in this winding being conducted to the material to be melted by the aid of electrodes inserted in the wall of the furnace. It has not, however, been found possible to obtain thoroughly satisfactory results in this way because a secondary winding so arranged does not remove the defect to an extent commensurate with the complication of the arrangement, and because on the other hand, if an arrangement for utilizing the current of the secondary winding is not provided, so that this winding is short circuited on itself, much electrical energy is lost by the generation of ohmic heat in the winding.

The chief object of the present invention is to reduce the dispersion in a very simple but effective manner by means of a special formation of the cross section of the limbs or members of the closed iron core, and a novel arrangement of the members composing the said core. This arrangement is based upon a knowledge of the fact that a far greater number of lines of magnetic dispersion issue from the limbs at the two faces that are formed by the edges of the compressed sheet metal laminæ composing the limbs, than from the faces formed by the two outer sides of the two outermost sheet metal laminæ. As is known, the reason for this is that the eddy currents circulating in the laminæ act in opposition to the dispersion of the lines of force from the iron core in a direction transverse to the laminæ.

According to the present invention the dispersion above referred to is reduced by making the faces constituted by the outermost sheet metal laminæ considerably broader than the faces formed by the edges of the compressed laminæ; in other words each lamina is considerably broader than the thickness of the assemblage of compressed laminæ. By this means limbs which present an elongated rectangular form in cross-section are obtained. The length of the melting channels which inclose the rectangular limbs formed in this manner is of course greater than if the cross section of the limbs were of square or circular shape in cross section other conditions being the same. The resistance opposed by the material in the melting channels to the passage of the current induced in it is therefore increased, and this increase in resistance of the secondary circuit causes a reduction of the phase displacement, and this, as is known, produces a favorable effect in the working of the furnace. As a further precaution against magnetic dispersion at the edges of the laminæ, the joints between the yoke pieces and vertical limbs comprising the iron core should be such as to cover as much as possible the faces constituted by the edges of the laminæ, and cause the laminæ of one member to be continuous with those of its adjacent members. This is the case if the plane in which the extremity of the central lamina of each yoke piece lies is identical with that in which the adjacent extremity of the central lamina of the corresponding vertical limb lies.

In applying the principle of this invention to electric induction furnaces in which the core comprises two straight horizontal yoke pieces lying at right angles to and con-

necting the ends of two vertical limbs surrounded by melting channels which unite between the said limbs to form a common working hearth, the longer cross sectional axes of the two rectangular limbs would be in a line with one another, the yoke pieces extending in the same line between the said limbs. It will readily be understood, however, that this would result in a defective form of furnace; the furnace would be disproportionately long and narrow in plan, and the melting chamber formed by the union of the two melting channels surrounding the limbs and serving as the working hearth would be small. Both these defects are avoided and the working conditions rendered favorable by arranging the vertical limbs in such a manner that their broad side faces are directed toward each other and their short cross sectional axes are in line; by this arrangement the furnace may be such that its form in plan does not differ largely from a square, and the melting chamber or working hearth may be given a very extended area. As however, with this arrangement of the vertical limbs, their central laminæ are not in the same plane but in parallel planes, separated by the distance between the limbs, it follows that, if the requirement referred to above, namely that the laminæ of the vertical limbs and yoke pieces shall be continuous at the joints, is to be fulfilled, the two yoke pieces connecting the ends of the vertical limbs cannot be formed as straight bars but each yoke must be curved in such a manner that its two ends, which are to abut against the ends of the vertical limbs, are similarly directed. Preferably the yoke pieces are bent semi-circularly, the inner diameter of this semicircle being equal to the horizontal distance between the oppositely placed faces of the two vertical limbs. The plane of the circle into which each yoke piece is bent must be perpendicular to the planes in which the laminæ composing the vertical limbs lie; it may lie either in the plane containing the longitudinal axes of the two vertical limbs or be perpendicular thereto, that is to say it may be horizontally directed. The last-named arrangement presents special advantages; in the first place the cover plates of the melting chamber, or a working door arranged, say, in the cover of the furnace, are rendered readily accessible and can readily be removed for effecting repairs to the furnace or the like; secondly, the upper yoke piece being, in accordance with this invention, very narrow compared with its depth, covers only a very small part of the furnace, and need not therefore be removed each time the furnace is prepared for smelting.

Polyphase current transformers have not hitherto been used for electrical induction furnaces, although the advantages presented by the use of polyphase currents for factory installations as compared with ordinary alternating currents are well known, for the reason that in using transformers of known construction the furnace has not been accessible and has been difficult to supervise. In accordance with the present invention, however, polyphase current transformers may readily be used without any constructional complications; their use secures the advantages enumerated above and in particular a favorable distribution of the melting chambers. Moreover by erecting the vertical limbs corresponding to the several phases in a triangular manner, the effect of the alternating current will of itself cause a vigorous circulation of the material on the melting hearth, while in order to produce such a circulation in furnaces of the kind in question, for which heretofore polyphase current transformer furnaces with vertical limbs arranged triangularly have not been used for the reasons given, it was necessary to provide special and complicated means.

In order that the said invention may be clearly understood and readily carried into effect, I will describe the same more fully with reference to the accompanying drawings, in which:—

Figure 1 is a vertical section, Fig. 2 a sectional plan, and Fig. 3 a vertical section at right angles to the position in which Fig. 1 is taken, illustrating one form of furnace constructed in accordance with this invention. Fig. 4 is a sectional plan of a furnace constructed in accordance with this invention for use with three-phase current.

In each of the figures *a* represents the common melting chamber or hearth formed by the union of the melting channels *d* which surround the vertical limbs *c* of the closed iron core. The vertical limbs *c* are connected together by the yoke pieces *b*.

Referring first to Figs. 1 to 3 it will be seen that the furnace is about one and one half times as long as it is wide, and that the width of the laminæ of which each of the limbs *c* is composed is about three and one half times as great as the thickness of the assemblage of laminæ. The upper of the two yoke pieces *b*, which are bent semicircularly and connect the ends of the limbs *c* as shown, is arranged in such a manner that it lies in a horizontal plane with the result that free access can be had to a working door *e* arranged in the middle of the furnace cover and serving for the introduction of fluxes or the like into the melting hearth *a*. The lower of the two yoke-pieces is arranged in such a manner that it lies in a plane containing the longitudinal axes of the vertical limbs; by this arrangement the lower yoke piece *b* and the two limbs *c c* may consist of one piece as shown.

In Fig. 4, which represents a furnace for

use with polyphase current, two of the limbs *c* are arranged in the same relative positions as the two limbs in the furnace illustrated in Figs. 1 to 3. The third limb is arranged with its longer cross-sectional axis at right angles to those of the other two, and is so situated that the longitudinal axes of the three limbs are located in plan approximately at the corners of an equilateral triangle. The two ends of each of the two first named limbs are connected with the ends of the third limb by horizontal yoke pieces *b* which are curved approximately like a quadrant so that the direction of one end of each yoke piece is perpendicular to the direction of its other end; in this way, the laminæ of the yoke-pieces and the vertical limbs are similarly directed at the joints. The common melting chamber or hearth *a* located between the three vertical limbs and formed by the union of the three melting channels *d* inclosing the said limbs is of approximately rectangular shape in plan in the arrangement shown in Fig. 4, as is also the case with the furnace shown in Figs. 1 to 3. The cover plate or plates (not shown) serving for covering the working hearth *a*, are readily accessible. An electrode *f*, consisting of a plate of refractory material facing the material in the melting chamber and a metal plate between said refractory material and the furnace wall, may be let into each of those parts of the furnace wall which are situated between two limbs and serve to confine the working hearth *a*; a secondary wire or bar winding may be arranged upon one or more of the vertical limbs and the current induced in this winding may be conducted to the electrodes *f* in such a manner that the alternating currents conducted through the working hearth *a* in this manner flow through the material to be melted in the same direction as the currents produced in the melting channels by direct induction. This arrangement, which does not however form a novel part of the present invention, insures the material contained in the large working hearth being traversed, in addition to the direct induction currents, by alternating currents of such strength corresponding to its large cross sectional area and consequently to its small resistance that the heat produced in the working hearth is not much less than the heat produced in the melting channels. The use of a polyphase current furnace with its vertical limbs arranged triangularly in plan, whatever may be the form of the limbs in cross section or the method of arranging the yoke-pieces connecting their ends, insures that a circulatory movement of the material is obtained in the working hearth *a* arranged in the space between the three limbs, and, as is known, this circulation acts beneficially on the metallurgical process carried out in the furnace.

What I claim and desire to secure by Letters Patent of the United States is:—

1. In an electric induction furnace, the combination with the primary winding and the melting chamber, of a core on which the primary winding is wound, said core piercing the hearth and comprising sheet metal laminæ the width of each of which is considerably greater than the total thickness of the assembled laminæ, the broad face of said core facing the open working portion of the hearth, for the purposes specified.

2. In an electric induction furnace, the combination with the primary winding and the melting chamber, of a core on which the primary winding is wound, said core piercing the hearth and comprising sheet metal laminæ assembled together into elongated rectangular form in cross section, the planes containing the laminæ lying parallel with the longer axes and facing the open working portion of the hearth, for the purposes specified.

3. In an electric induction furnace, the combination with the primary winding and the melting chamber, of vertical limbs piercing the hearth and connecting yoke pieces constituting a closed iron core and composed of sheet metal laminæ the width of each of which is greater than the total thickness of the assembled laminæ, the broad face of said vertical limbs facing the open working portion of the hearth, the laminæ of abutting portions of the limbs and yoke pieces being in the same plane, so as to be practically continuous, for the purposes specified.

4. In an electric induction furnace, the combination with the primary winding and the melting chamber, of vertical limbs piercing the hearth and connecting yoke pieces constituting a closed iron core, and composed of sheet metal laminæ the width of each of which is greater than the total thickness of the assembled laminæ, the broad face of said vertical limbs facing the open working portion of the hearth, the said yoke pieces being bent so that their extremities are similarly directed, and the laminæ and abutting portions of the limbs and yoke pieces being in the same plane so as to be practically continuous, for the purposes specified.

5. In an electric induction furnace, the combination with the primary winding and the melting chamber, of two vertical limbs and yoke pieces constituting a closed iron core and composed of sheet metal laminæ, the width of each of which is greater than the total thickness of the rectangularly assembled laminæ, said vertical limbs piercing the hearth and having their broad sides facing the open working portion of the hearth, the shorter axes of the two vertical limbs being arranged in line with one another and the yoke pieces bent so that their extremities are

similarly directed, the laminæ of abutting portions of the limbs and yoke pieces being in the same plane so as to be practically continuous, for the purposes specified.

6. In an electric induction furnace, the combination with the primary winding, and the melting chamber, of two vertical limbs and yoke pieces constituting a closed iron core and composed of sheet metal laminæ the width of each of which is greater than the total thickness of the rectangularly assembled laminæ, said vertical limbs piercing the hearth and having their broad sides facing the open working portion of the hearth, the shorter axes of the two vertical limbs being arranged in line with one another, and the yoke pieces bent so that their extremities are similarly directed and the upper of the yoke pieces being arranged horizontally, the laminæ of abutting portions of the limbs and yoke pieces being in the same plane so as to be practically continuous, for the purposes specified.

7. In an electric induction furnace, the combination with the primary winding, and the melting chamber, of three vertical limbs located triangularly and piercing the hearth, and horizontal yoke pieces bent so as to join the extremities of the vertical limbs, the said limbs and yoke pieces comprising a closed iron core, being constructed of sheet metal laminæ the width of each of which is greater than the total thickness of the assembled laminæ, and arranged with the broad sides of the vertical limbs facing the open working portion of the hearth, and the laminæ of abutting portions of the limbs and yoke pieces being in the same plane so as to be practically continuous, for the purposes specified.

8. In an electric induction furnace, the combination with the primary winding, and the melting chamber, of two vertical limbs of elongated rectangular form having their shorter axes in line with one another, a third vertical limb of similar form located triangularly with respect to the other two and having its shorter axis at right angles to those of the other two, and horizontal yoke pieces bent so as to join the extremities of the vertical limbs, the said limbs and yoke pieces comprising a closed iron core and being constructed of sheet metal laminæ the width of each of which is greater than the total thickness of the assembled laminæ and the central laminæ of abutting portions of the limbs and yoke pieces being in the same plane so as to be practically continuous, for the purposes specified.

9. In an electric induction furnace, the combination with the primary winding and the melting hearth, of vertical limbs piercing the hearth, and connecting yoke pieces constituting a closed iron core and composed of sheet metal laminæ the width of each of which is greater than the total thickness of the assembled laminæ, the broad faces of said vertical limbs facing the open working portion of said melting hearth, as described.

10. In an electric induction furnace, the combination with the primary winding, and the melting chamber, of two vertical limbs of elongated rectangular form having their shorter axes in line with one another, a third vertical limb of similar form located triangularly with respect to the other two and having its shorter axis at right angles to those of the other two, and horizontal yoke pieces bent so as to join the extremities of the vertical limbs, the said limbs and yoke pieces comprising a closed iron core and being constructed of sheet metal laminæ the width of each of which is greater than the total thickness of the assembled laminæ and the central laminæ of abutting limbs and yoke pieces being in the same plane so as to be practically continuous for the purposes specified.

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

WILHELM RODENHAUSER

Witnesses:
LOUIS VANDORY,
H. STELZER.