April 5, 1932. E. F. NORTHRUP 1,852,214

INDUCTOR TYPE FURNACE

Filed Nov. 17, 1928

Fig.1.

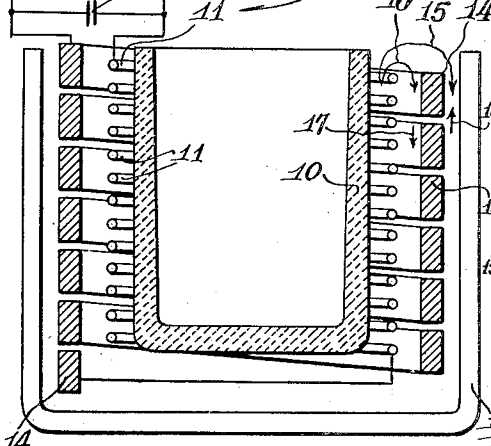


Fig.3.

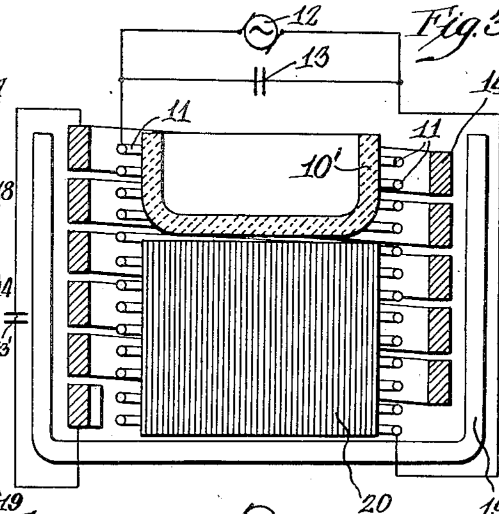


Fig.2.

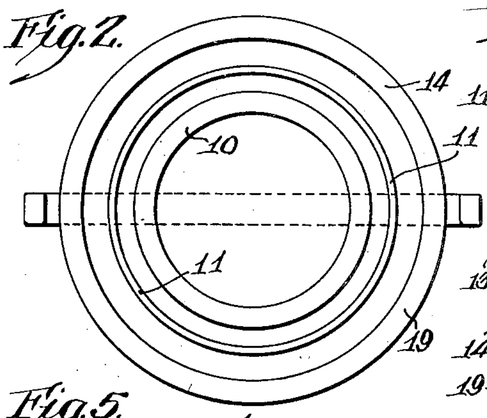


Fig.4.

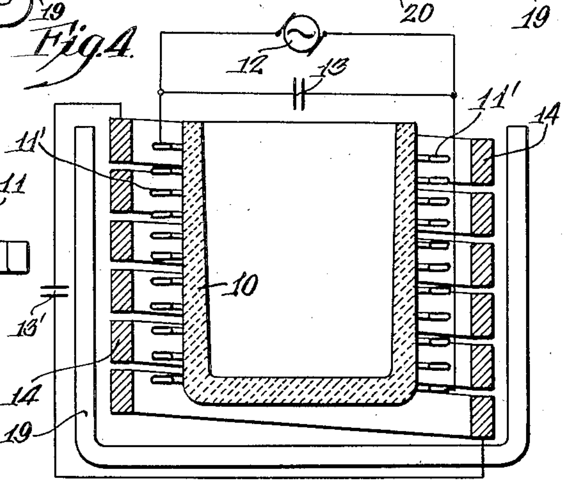


Fig.5.

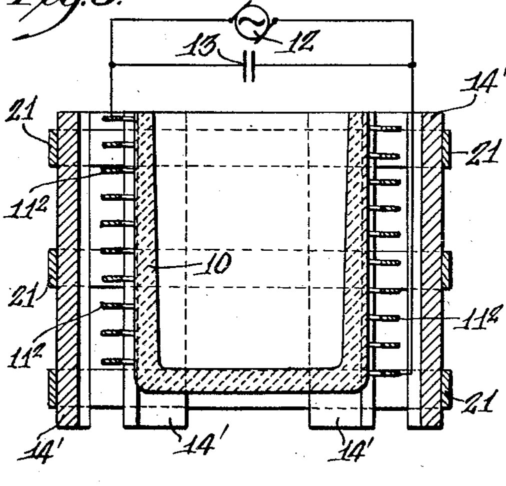
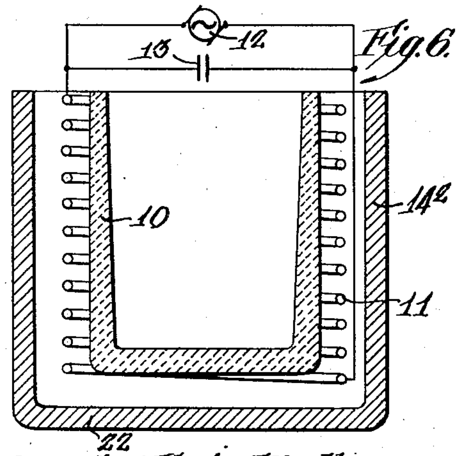


Fig.6.



Inventor Edwin F. Northrup.

by W. Steele Jackson Attorney.

Patented Apr. 5, 1932 **1,852,214**

UNITED STATES PATENT OFFICE

EDWIN FITCH NORTHRUP, OF PRINCETON, NEW JERSEY, ASSIGNOR TO AJAX ELECTRO-THERMIC CORPORATION, OF AJAX PARK, NEW JERSEY, A CORPORATION OF NEW JERSEY

INDUCTOR TYPE FURNACE

Application filed November 17, 1928. Serial No. 320,173.

My invention relates to electric furnaces and particularly to means by which stray field is eliminated from about a furnace.

One of the main purposes of my invention comprises utilizing a stray field eliminator as a stiffening or protecting frame or casing for the furnace.

A further purpose consists in utilizing non-magnetic steel for the frame or for stiffening and supporting members in the construction of a coreless electric induction furnace.

A further purpose lies in surrounding a coreless-type inductor furnace by a coil capable of supporting and stiffening the furnace.

A further purpose is to pass an electric current through a heavy coil adapted to form a framework for the furnace, thus preventing stray induction beyond the frame coil.

Further purposes will appear in the specification and in the claims.

My invention relates both to the methods or processes involved and to mechanism by which these methods may be carried out.

I have preferred to illustrate my invention by a few forms only, selecting forms which are practical, efficient and reliable, and which at the same time well illustrate the principles of my invention.

Figures 1, 3, 4, 5 and 6 are central vertical sections showing several different forms in which my invention may appear.

Figure 2 is a top plan view of Figure 1.

In the drawings similar numerals indicate like parts.

I illustrate in Figure 1 an electric furnace having a conventional holder for molten metal in crucible 10 and an inductor 11 surrounding the crucible and of conventional form. A conventional source of alternating current electrical energy is shown at 12 with conventional power factor correction at 13. The source of energy may be high or low frequency or intermediate frequency, as there are different advantages for all of these frequencies, making the employment of one desirable in one case and of quite a different frequency in another case.

In Figure 1, the inductor coil is surrounded by a compensating current-carrying coil 14 whose purpose is two-fold in that it is intended to prevent straying of lines of magnetic force beyond the limits of this coil and is intended at the same time to serve as a casing for the furnace. It is designed to be strong and stiff for the purpose of supplying strengthening and stiffening functions so that the furnace will require no other frame structure or considerably less such structure than would be the case where no such coil be used.

The current through the coil 14 must be and is opposite in direction to that carried by the inductor coil, for reasons hereinafter given.

In order that the theory of stray field elimination by the combined casing and coil 14 may be understood, I have shown return lines of magnetic force 15 and 16 set up by the inductor 11 and tending, normally, to pass respectively outside and inside the position of the coil 14, and likewise have shown lines 17 and 18 of magnetic flux set up inside and outside the coil 14 by the electric current passing through the coil 14.

If the coil 14 be short-circuited, the current set up in it as a secondary would be opposite in direction to that of its primary. This determines the direction of current to be passed through it either directly or by induction.

The magnetic flux set up by the coil 14 inside of the coil, typified by line 17 will assist the return 16 of flux from the inductor coil, and the magnetic return flux 18 outside of coil 14 caused by the current through coil 14, will be opposed in direction to the return magnetic flux from the inductor represented by magnetic flux line 15. As will be seen, the two coils are connected in series, the connection from the lower right-hand end of the inductor being made to the lower left-hand end of the stray field eliminator coil 14 so as to provide for this reverse direction of current passing through the eliminator coil as compared with that passing through the inductor.

Because there would otherwise be interference with the pouring function of the furnace, the inductor coil and the compensator coil are not extended upwardly beyond the top of the crucible. As there is no such objection to downward extension of the field eliminator coil and some little downward extension is desirable to negative the magnetic flux at the lower end of the inductor, the eliminator coil has been extended slightly below the crucible and slightly below the end of the inductor coil 11.

My stray field eliminator coil 14 may be made of aluminum or, for greater strength, of non-magnetic steel alloy.

As my combined stray field eliminator and supporting frame coil may be designed for an ampere-turn strength suited to eliminate stray field outside of any selected position (radius) at which the coil 14 is to be placed, magnetic material such as ordinary steel can be used outside the coil if desired. My furnace may be completely stiffened and supported without the need of any additional outside frame structure. However, where the support of the furnace from a bail, for example, makes it desirable to use any additional frame member such as the U-shaped bar 19, it can be constructed from steel. Where there is no magnetic material about the location of the furnace near enough for the stray field from the furnace to be objectionable, the stray field may be wholly or partially ignored and the effect of uncompensated stray field may be avoided within the furnace by the use of non-magnetic steel for the entire frame structure.

The form shown in Figure 3 corresponds with that shown in Figure 1 generally, but with several differences. The crucible 10′ is here of shallow form and the effective length of the crucible has been increased, for the purpose of making it possible to use to the best advantage a long inductor coil, by the interposition of laminated magnetic material 20 below the shallow crucible and within the inductor.

The coil 14 should be non-magnetic. Because of the additional strength to be secured it will usually be desirable to make it of non nagnetic steel. Any outside additional structure may be of magnetic or of non-magnetic steel.

The coil 14 is here short circuited to form an additional secondary for the inductor coil. Where this coil is short circuited it is desirable that it be given many turns in order that the current may be kept down. The ampere-turns must of course be designed to provide the required magnetic flux to eliminate the stray field or approach this elimination as closely as may be planned. The direction of current flow induced in the coil as a secondary will, of course, be reverse to that of the inductor as is required to produce the flux sought. In the form of Figure 1 this reverse induction will, of course, be present and will assist in the passage of current through the coil.

If the coil 14 be merely short-circuited its current will lag and will not be directly opposite to that through the inductor. This lag will be greater if coil 14 be but little larger in diameter than the inductor coil than if it be much larger than the inductor coil. Where this lag is objectionable it may be avoided by inserting a condenser 13′ in series with coil 14. The best results will be attained if the condenser tune or approximately tune this circuit.

In Figure 4 the structure is similar to that seen in Figure 1, with the difference, however, that the inductor is here shown as an edgewise-wound hollow inductor 11′, and the combined frame and stray field eliminator coil 14 forms a secondary and is short-circuited through condenser 13′ as in Figure 3. The yoke outside may be of magnetic steel if the field be sufficiently eliminated but can be of non-magnetic steel or other metal if the designer has chosen to but partly eliminate the field.

In Figure 5 I show an inductor of edgewise-wound solid strip 11^2 with a non-magnetic steel frame about it comprising a plurality of vertical strips 14′ which are connected circumferentially by bands 21 for mechanical strength or stray-field elimination, or for both. These bands are preferably also of non-magnetic steel and may be made continuous circumferentially to provide for induced current flow for stray-field elimination, or if it be the intention to disregard stray field elimination wholly, may be interrupted electrically at different parts of the circumference and in that event insulated from the vertical strips 14′.

Where any yoke, or other additional frame work such as 19 in Figures 3 and 4 is used, it may be made of non-magnetic steel.

The cross-section of the bands 21 may be cut down to reduce the induced current in these bands so that the ampere turns will not exceed those desired for compensation.

In the form shown in Figure 6 the frame work is shown in the form of a cylinder 14^2 completely surounding the inductor coil to form a cylindrical compensating coil of a single turn 14^2 which at the same time forms an effective frame member for the furnace.

For compensating purpose it is immaterial whether the cylinder 14^2 have a bottom 22 or not, but for frame purposes some bottom structure, even if not a complete closed bottom is desirable. This is true also in Figure 5. The structure in Figure 6 is more likely to be used without the bail 19 than some other desirable forms because in this figure the compensating frame work itself supports the furnace very thoroughly from the bottom reducing the advantage of any additional frame structure.

The cylindrical wall 14^2, and, where a bottom structure is used, the bottom 22 are preferably made of non-magnetic steel. There are various non-magnetic ferrous alloys available, referred to generally as non-magnetic steel. One example of this has a composition of chromium 18 parts, nickel 8 parts, iron 74 parts.

It will be evident that my use of non-magnetic steel in the frame of the furnace wholly overcomes the need of stray field elimination in so far as the effect upon the individual furnace is concerned; so that any stray field compensation may be considered with respect to conditions outside the furnace and not necessarily with respect to those inside the furnace, permitting great freedom of furnace construction and greatly altering the view regarding the elimination of stray-field. However, it will be further evident that I have provided effective frame stray field elimination which makes it possible to take care of the stray field or to disregard it in its effect upon the individual furnace in which the field is generated and to eliminate or reduce it to a point where it can be disregarded in so far as it affects other mechanism outside of the furnace.

The need of rigid and very strong supporting frame construction in coreless inductor type furnaces of large capacity may therefore be met, so far as the individual furnace is concerned, by either of two constructions, one eliminating the stray field and the other disregarding it.

Obviously the non-magnetic frame construction makes it possible for me to effect any compromise desired between complete stray field elimination on the one hand which will protect external apparatus as well as furnace structure and the absence of such stray field elimination on the other; using such field elimination as may be desired to suit the furnace for use in proximity to other apparatus and permissibly building the frame of the furnace free from stray magnetic field interference independently of the extent of field elimination.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the structure shown and I, therefore, claim all such in so far as they fall within the reasonable spirit and scope of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a stray field furnace eliminator construction, a furnace inductor adapted to surround the charge and a rigid combined coil and frame member of non-magnetic material, the coil surrounding the inductor and providing a path for electric current for stray field elimination purposes.

2. In a stray field furnace eliminator construction, a furnace inductor adapted to surround the charge and a rigid combined coil and frame member, the coil surrounding the inductor and providing a path for electric current for stray field elimination purposes.

3. In a stray field furnace eliminator construction, a furnace inductor adapted to surround the charge and a multi-turn rigid combined coil and frame member of non-magnetic steel, the coil surrounding the inductor and providing a path for electric current for stray field elimination purposes.

4. In a stray field eliminator for induction furnace, a furnace, an inductor coil surrounding the furnace, a secondary coil surrounding the inductor coil carrying current reverse in direction from the inductor coil current direction and comprising part of the stiffening frame structure of the furnace.

5. In a stray field furnace eliminator construction, a furnace inductor adapted to surround the charge and a multi-turn rigid combined eliminator coil and frame member in series with and surrounding the inductor and carrying current opposite in direction to the inductor current.

6. In a stray field furnace eliminator construction, a furnace inductor adapted to surround the charge and a multi-turn rigid combined eliminator coil and frame member in series with the inductor and carrying current opposite in direction to the inductor current.

7. In a stray-field furnace eliminator construction, a furnace inductor adapted to surround the charge and a rigid spiral combined frame member and coil surrounding the inductor, adapted to have a current induced in it opposite in direction to the inductor current and condenser power factor correction in series with the coil.

8. In a stray-field furnace eliminator construction, a furnace inductor adapted to surround the charge, a combined field eliminator coil and frame member carrying current reversed in direction from that of the inductor and a furnace supporting frame member outside of the field eliminator coil and shielded by it.

9. In a stray-field-reducing furnace construction, a furnace inductor adapted to surround the charge, a non-magnetic steel shield surrounding the inductor, adapted to carry current in a direction opposite to the inductor current to at least partially eliminate the stray field, and forming a frame member for the furnace and non-magnetic frame material additional to the shield.

10. In a stray-field furnace eliminator construction, a furnace inductor adapted to surround the charge, the inductor extending well below the lower part of the intended charge, magnetic material filling the space from the lower end of the charge to approximately the lower end of the inductor and a combined field

eliminator and frame member surrounding the inductor and carrying current in a direction opposite to that within the inductor.

11. In a stray field furnace eliminator construction, a furnace inductor adapted to surround the charge, the inductor extending well below the lower part of the intended charge, magnetic material filling the space from the lower end of the charge to approximately the lower end of the inductor, a combined field eliminator and frame member surrounding the inductor and carrying current in a direction opposite to that within the inductor and additional frame construction outside of the combined field eliminator and the frame member and protected by it.

12. In a stray-field furnace eliminator construction, a furnace inductor adapted to surround the charge, a crucible within the inductor and a cylindrical field eliminator member substantially enclosing the inductor and crucible and adapted to receive by induction current opposite in direction to that through the inductor and to eliminate the stray field about the inductor.

13. In a stray field furnace eliminator construction, a furnace inductor adapted to surround the charge, a crucible within the inductor and a single turn field eliminator member about and substantially as high as the inductor and adapted to receive by induction current opposite in direction to that through the inductor and to eliminate the stray field about the inductor.

EDWIN FITCH NORTHRUP.