E. A. A. GRÖNWALL, A. R. LINDBLAD & O. STÅLHANE.

TRANSFORMER FURNACE.

APPLICATION FILED MAY 2, 1907.

942,961.

Patented Dec. 14, 1909.

2 SHEETS—SHEET 1.

Fig. 1.

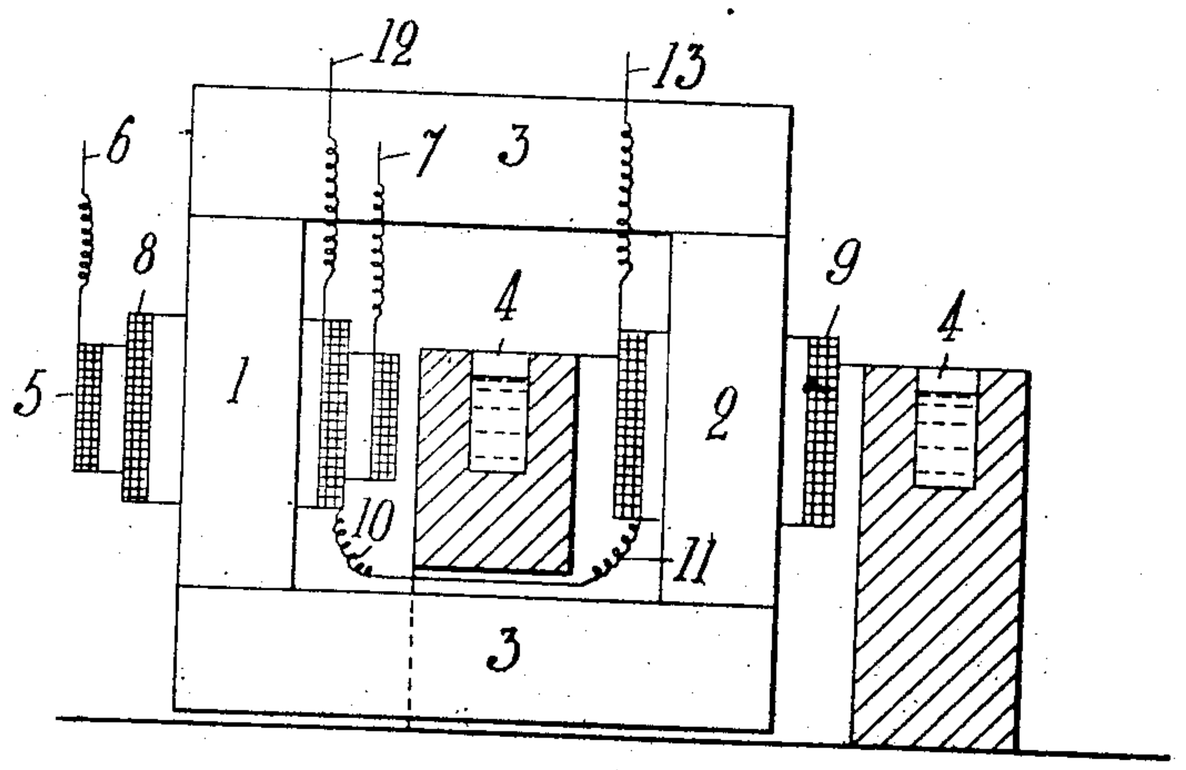
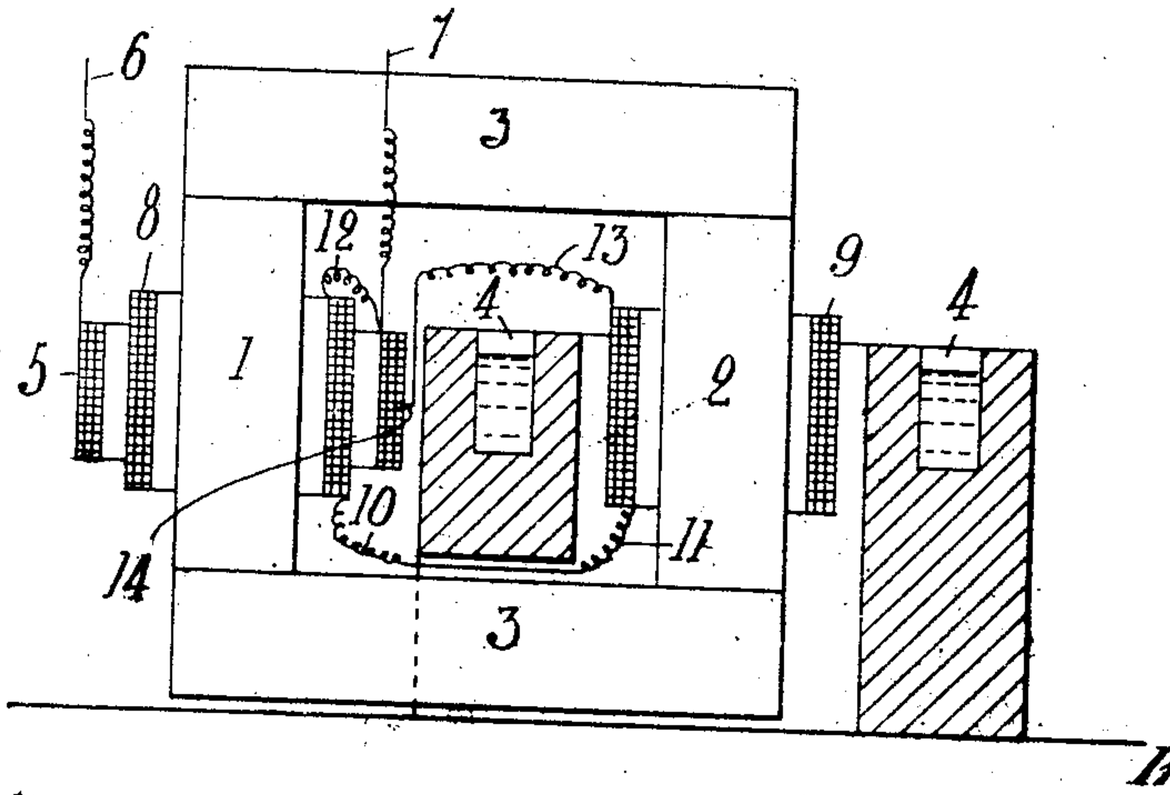


Fig. 2.



Witnesses;
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By their Attorney,
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2 SHEETS—SHEET 2.

Fig. 3.

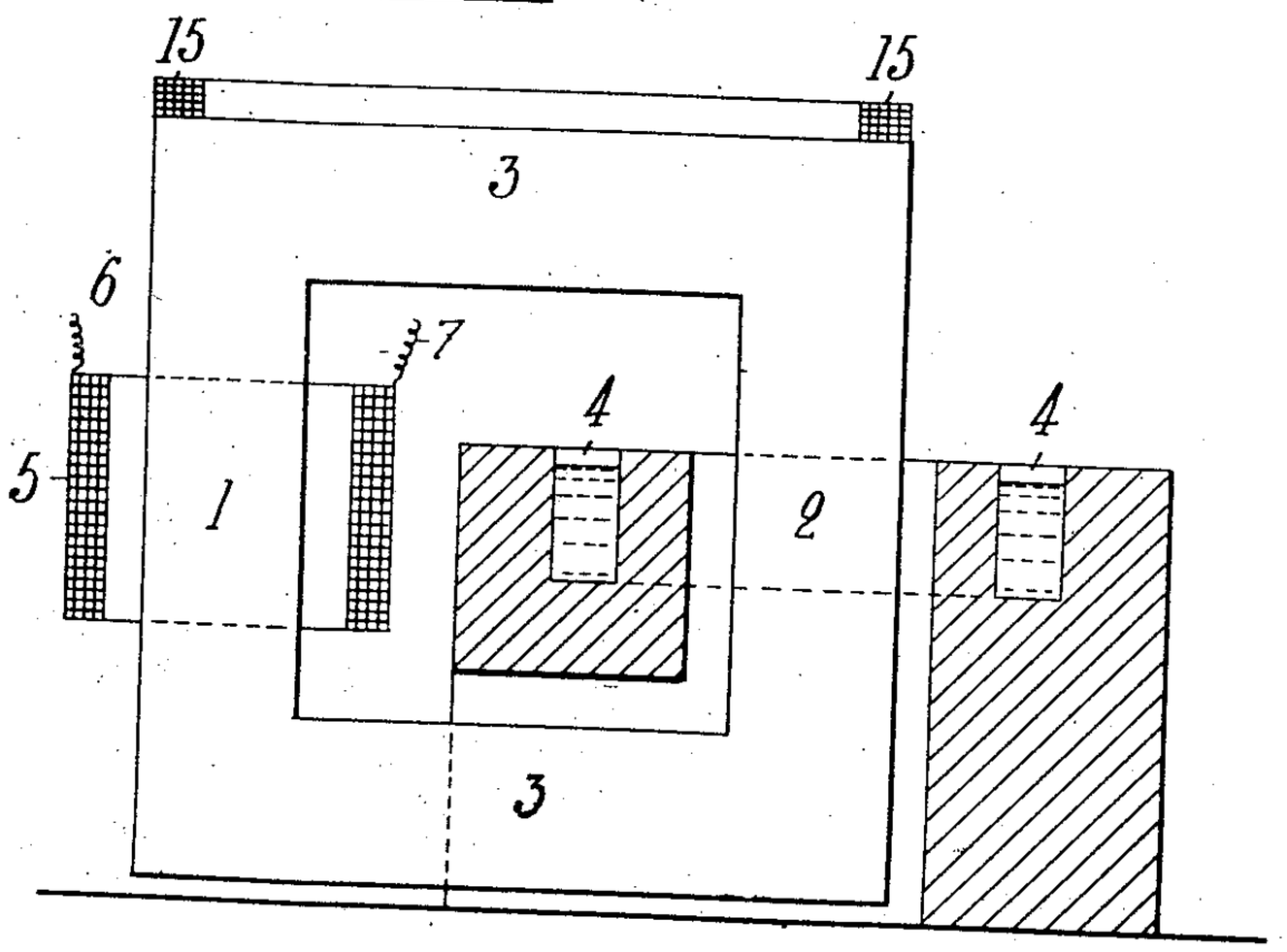
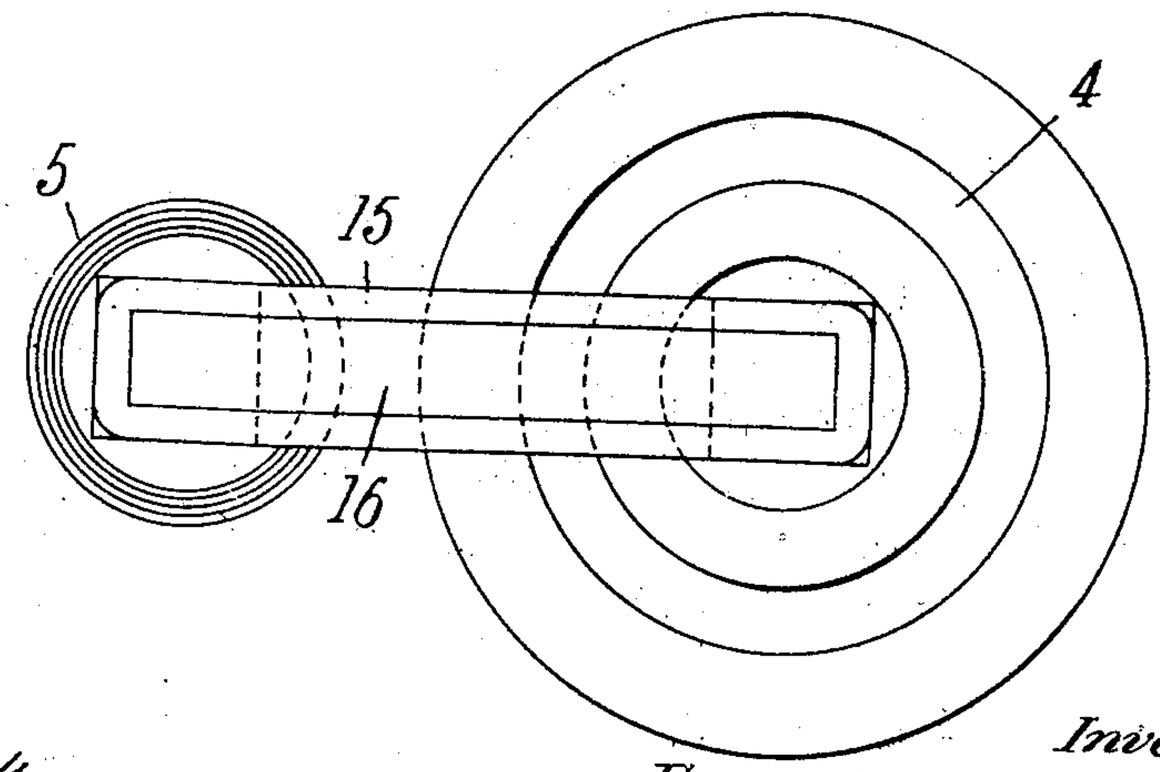


Fig. 4.



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UNITED STATES PATENT OFFICE.

EUGEN ASSAR ALEXIS GRÖNWALL, AXEL RUDOLF LINDBLAD, AND OTTO STÅLHANE,
OF LUDVIKA, SWEDEN.

TRANSFORMER-FURNACE.

942,961. Specification of Letters Patent. **Patented Dec. 14, 1909.**

Application filed May 2, 1907. Serial No. 371,370.

To all whom it may concern:

Be it known that we, EUGEN ASSAR ALEXIS GRÖNWALL, AXEL RUDOLF LINDBLAD, and OTTO STÅLHANE, engineers, subjects of the King of Sweden, residing at Ludvika, in the Kingdom of Sweden, have invented new and useful Improvements in Transformer-Furnaces.

In electric smelting furnaces heretofore known of the so-called transformer type, one of the greatest disadvantages consisted in the great shifting of phases arising from the magnetic leakage, which generally has been very considerable.

While in electric smelting furnaces of the transformer type, on account of the high temperature with regard to the magnetic leakage, the two electric circuits (*i. e.* the primary coil and the smelting bath), can not be placed so near each other as is desirable, it is necessary to resort to special measures in order to prevent the shifting of phases from being too great, and which makes the use of too expensive machinery necessary.

The present invention has for its object improvements in transformer furnaces whereby to reduce the said disadvantages.

The idea on which our invention is based is to place coils (of conducting materials), in the path of the leaking lines of force, to which coils suitable electric current is supplied, said coils being so arranged that the magnetic forces, which are generated in the said coils by the current supplied to the same, counteract the leaking lines of force.

In order that the present invention may be more clearly understood, it is described in the following manner with reference to the accompanying drawings on which, as example three different forms of the same are illustrated.

Figure 1 is a vertical section of a transformer furnace embodying the present invention. Fig. 2 is a vertical section of a transformer furnace embodying another form of the present invention. Fig. 3 is a vertical section, and Fig. 4 a top view of a transformer furnace embodying still another form of the present invention.

1 and 2 are the two legs of the iron core of the transformer furnace, said legs being arranged vertically and at their upper and lower ends united with each other by means of cross pieces 3.

4 is the groove, intended for the reception of the material to be treated,—*i. e.* the smelting bath,—5 is the primary coil, and 6, 7 its two terminals.

In Figs. 1 and 2, 8 and 9 are two coils, intended for counteracting the primary leakage in accordance with the present invention. According to the form of our invention illustrated by Fig. 1, the one terminal 10 of the coil 8 is connected with the terminal 11 of the coil 9. The two other terminals 12 and 13 of these coils are intended to be connected with an outer source of current. The two coils 8 and 9 are so wound that the electromotive forces that are induced in them by the lines of force passing through the iron core are directed against each other. If there is no primary leakage,—*i. e.* if all the lines of force generated in leg 1 also pass through leg 2,—the electromotive forces generated in coils 8 and 9 will be equal, (provided, of course, that the two coils have the same number of windings) and thus there will be no tension between the terminals 12 and 13. If, on the contrary, there exists a primary leakage a greater number of lines of force will pass through leg 1 than through leg 2, and thus, in this case, the tension induced in the coils 8 and 9 will not be equal. If it be assumed that a number, "*a*", lines of force pass through leg 1, and through leg 2 "*b*" lines of force, then the electromotive force induced in coil 8 will obviously be proportional to "*a*" and the electromotive force induced in coil 9 will be proportional to "*b*". As the two coils 8 and 9 are so connected with each other that they counteract each other, a difference of tension thus arises between the terminals 12 and 13 which is proportional to "*a*—*b*". But as "*a*—*b*" represents the number of lines of force leaking around the primary coil 5, it follows that the difference of tension between the terminals 12 and 13 caused by this primary leakage is equal to the tension induced in a coil of the same number of windings as the coils 8 or 9 have, if all the leaking lines of force were forced to pass through the same. The system of coils 8 and 9 thus acts in quite the same way as one single coil, through which all the primary leaking lines of force are compelled to pass. From this follows, finally, that if a suitable current

passes through the coils 8 and 9 and the strength of this current is so chosen that the magnetomotive force of the said coils will be equal to the magnetomotive force with which the primary leaking lines of force tend to issue from the iron core the primary leakage is also thereby overcome. It will be readily observed that when this takes place the difference in tension induced between the terminals 12 and 13 becomes 0, *i. e.* the system of coils 8 and 9 constitutes a non-inductive winding and therefore only so great a tension will be necessary for forcing the required amount of current through the said coils as is necessary for overcoming the ohmic resistance of the same. The circumstance that the system of coils 8 and 9 does not constitute an inductive winding is of great importance.

The current supplied to the system of coils 8 and 9 may, of course, be taken from the same source of current from which current is supplied to the primary coil, provided the tension of this latter current is suitable for the said purpose. If this is not the case the tension may be reduced to a suitable amount by means of a special, smaller transformer. Obviously the system of coils 8 and 9 may also be supplied with current from another source of current, provided the following condition is accomplished; viz., that this current is in phase with the current supplied to the primary coil or shifted in phase 180 degrees with regard to said current, and provided also the frequency of periods is the same.

In case the system of coils 8 and 9 is supplied with current from the same source as the primary coil and thereby a transformation of tension is necessary, the well known "Hick-transformer coupling" may with advantage be used instead of a separate transformer. The arrangement used in this case is illustrated in Fig. 2. The primary coil 5 is, as hereinbefore stated, supplied with current through the terminals 6 and 7, but the terminal 12 of the coil 8 is in this case connected with the terminal 7 of the primary coil, and the terminal 13 of the coil 9 with a point 14 on the primary coil, so chosen that the tension existing between the terminals 7 and 14 will be exactly the same as that necessary for the system of coils 8 and 9.

It is of course not necessary that the primary coil be placed in the manner shown on the drawings, but it may be located on the transformer core in any suitable manner, and it may also be subdivided into several sections or coils placed in any suitable way. The coils 8 and 9 also may be placed in another manner than that shown on the drawing and they may also be subdivided in some way or other.

In Figs. 3 and 4 there is shown still another form of our invention. In these figures 15 is a coil to which current is supplied, from an outer source of current, said coil being thus arranged and supplied with such current that a magnetic force arises which counteracts the leaking lines of force, which tend to issue through that surface 16 of the transformer core which is surrounded by the coil 15. Obviously the current which is supplied to the coil 15 must have the same frequency of periods as the current supplied to the primary coil 5 and must also be in phase with, or shifted in phase 180 degrees with regard to, the phase of the latter current.

The coils 5 and 15 may, of course, be supplied with current from one and the same source of current, or from separate sources of current, provided the conditions above stated are fulfilled. In Figs. 3 and 4 there is only one such coil shown arranged according to this form of the invention, but obviously any suitable number of such coils may be provided and placed on different parts of the transformer core, within or outside of the smelting bath, or, generally speaking, anywhere where leaking lines of force tend to issue. It will also be evident that the form of the coils, which form of course is determined by their position, may be chosen arbitrarily, and also that the number of windings of which the coils consist, and the tension of the current supplied to the same, may be chosen arbitrarily.

Obviously the use of the forms of our invention illustrated in Figs. 1 and 2 will in practice be preferred to the form illustrated in the Figs. 3 and 4, as the use of the first mentioned forms in an essential degree is facilitated on account of the number of coils necessary and thus also the amount of copper necessary is reduced.

Having thus described our invention, we declare that what we claim is:

1. A transformer furnace having a primary coil, and provided with coils placed in the path of the leaking lines of force, so arranged that the magnetomotive force generated by the coils will counteract the leaking lines of force from the primary coil.

2. In a transformer furnace, a primary coil, a core having coils arranged around different parts thereof and connected with each other in such a way that from an electromagnetic point of view they will counteract each other, said coils being supplied with current whereby the magnetomotive force generated by the system of coils fully or partly overcomes the magnetic force which tends to force the leaking lines of force out of the iron core of the transformer furnace.

3. In a transformer furnace, a primary coil, a transformer core having coils arranged on different parts thereof, such coils being from an electromagnetic point of view connected with each other so as to counteract

each other, and being supplied with current taken from a suitable number of windings of the primary coil.

4. In a transformer furnace, a core having a primary coil and a supplemental coil arranged around different parts thereof, one of said parts being surrounded by the smelting bath and the other said part by the primary coil, said coils being connected with each other in such a way that from an electromagnetic point of view they will counteract each other.

In witness whereof, we have hereunto set our hands in presence of two witnesses.

EUGEN ASSAR ALEXIS GRÖNWALL.
AXEL RUDOLF LINDBLAD.
OTTO STÅLHANE.

Witnesses:
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T. SWENSSON.