No. 861,031. PATENTED JULY 23, 1907.

J. HÄRDEN.

ELECTRIC INDUCTION FURNACE.

APPLICATION FILED JAN. 24, 1907.

Fig. 1.

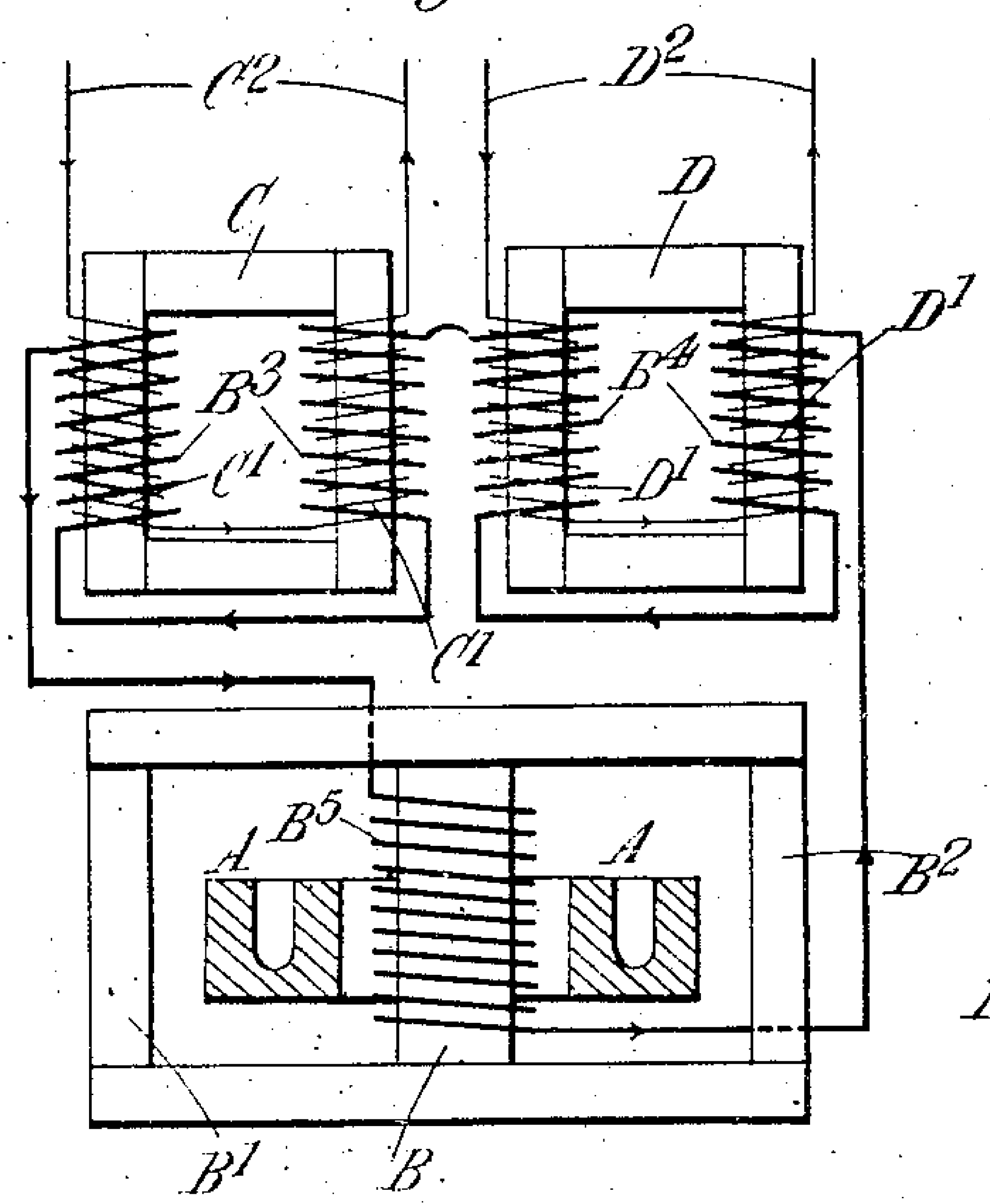
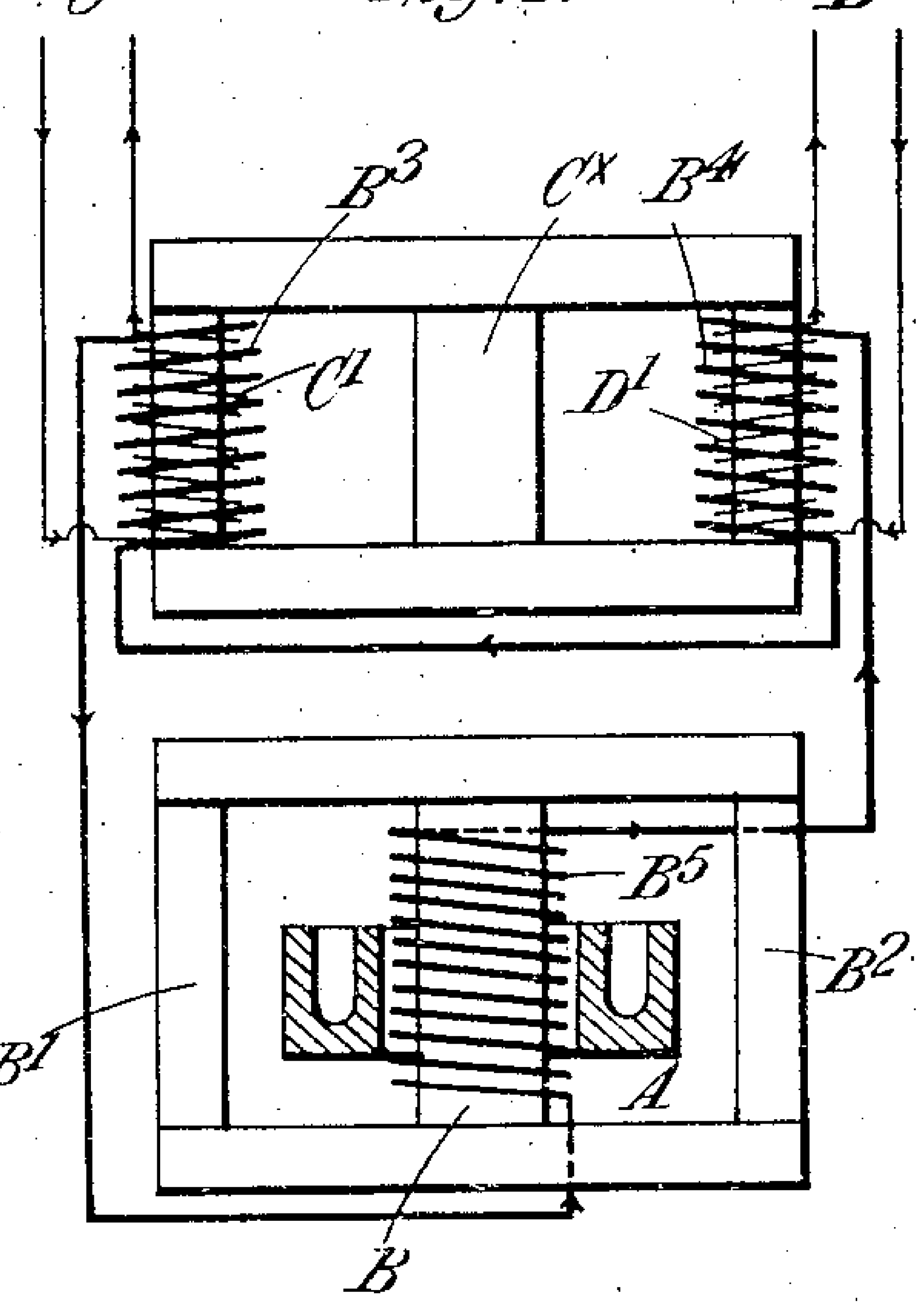


Fig. 2.



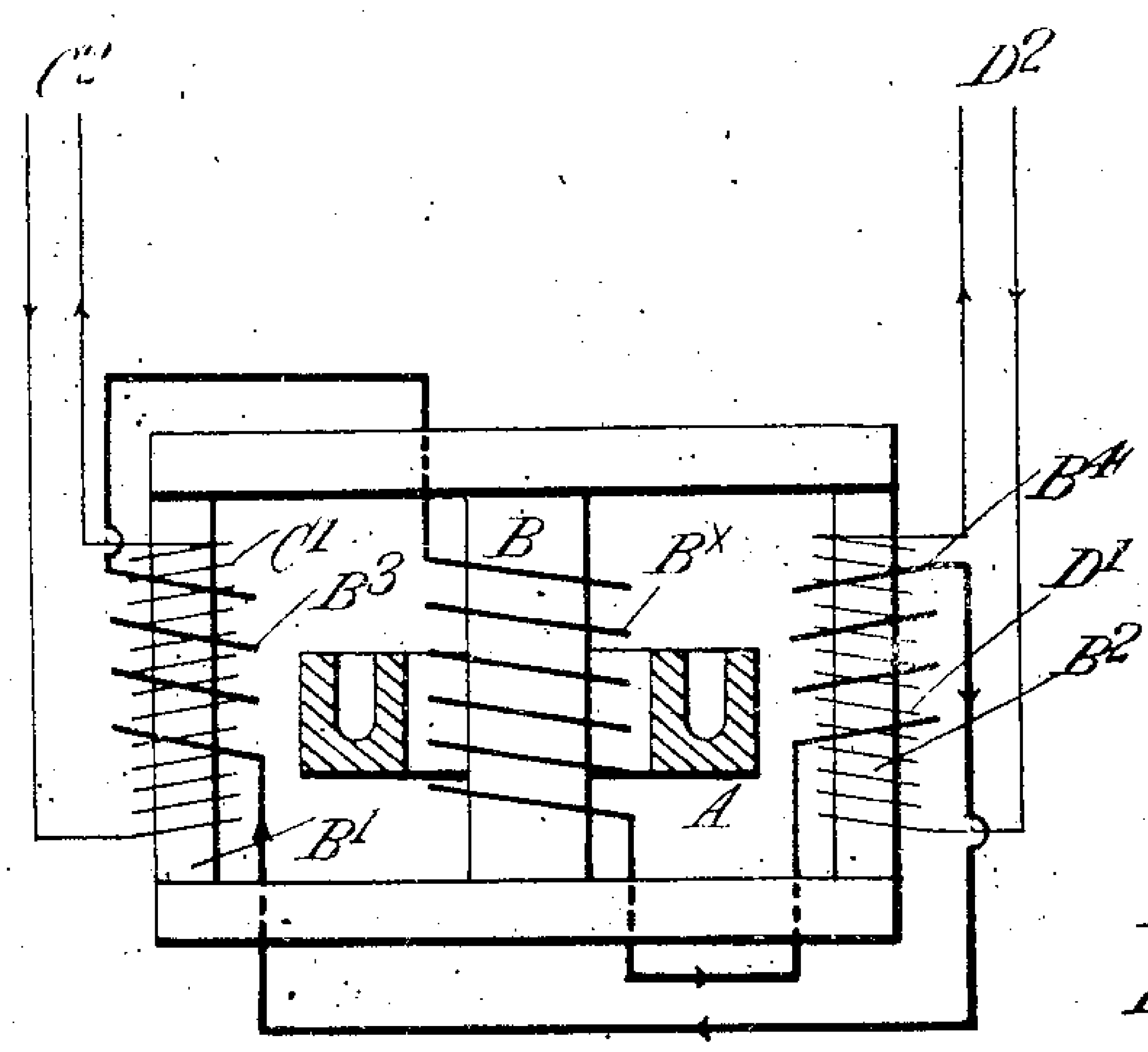


Fig. 3.

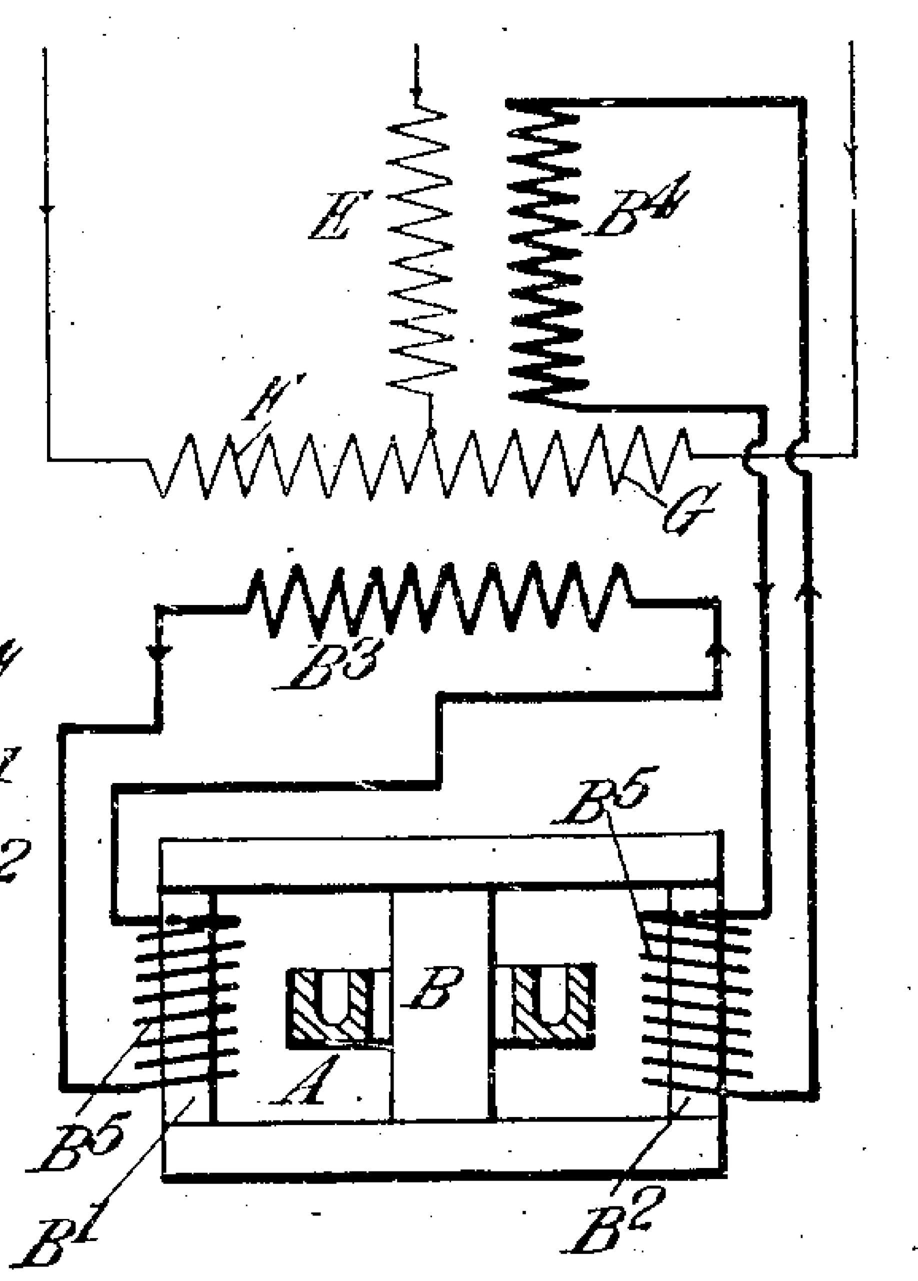


Fig. 4.

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UNITED STATES PATENT OFFICE.

JOHANNES HÄRDÉN, OF LONDON, ENGLAND, ASSIGNOR TO THE GRÖNDAL KJELLIN COMPANY, LIMITED, OF LONDON, ENGLAND.

ELECTRIC INDUCTION-FURNACE.

No. 861,031. Specification of Letters Patent. **Patented July 23, 1907.**

Application filed January 24, 1907. Serial No. 353,842.

To all whom it may concern:

Be it known that JOHANNES HÄRDÉN, a subject of the King of Sweden, residing at 20 Abchurch Lane, in the city and county of London, England, engineer, has invented certain new and useful Improvements in or Relating to Electric Induction-Furnaces, of which the following is a specification.

This invention relates to electric induction furnaces, such as those of the Kjellin type, which are constructed upon the principle of a transformer, of which the charge to be melted or otherwise treated forms the secondary. Hitherto these furnaces have been operated successfully with single phase alternating current only.

Various attempts have been made to utilize polyphase alternating currents such as two or three phase currents, one annular bath or fusion chamber being provided for each phase, either separate or in conjunction. But as the losses caused by heat radiation were found very high, in fact, about nine kilowatts per square foot of the bath surface, these attempts were not successful, and it was found necessary to convert the polyphase current into single-phase by means of special motor generators, thus greatly increasing the original cost of the installation. Moreover, as the fusion chambers or secondaries have to be placed at a considerable distance from the primary coil, an arrangement of two or three fusion chambers will greatly increase the magnetic leakage in the transformer, thus causing a low power factor and inefficient operation of the generating plant.

The chief object of the present invention is to overcome the above mentioned difficulties and defects in applying polyphase alternating currents for the operation of electric induction furnaces.

According to this invention polyphase alternating currents are employed in the working of electric induction furnaces by directly or indirectly combining therewith one or more transformers to convert the polyphase currents of the supply mains into single-phase currents in the induction furnace. For this purpose the primary windings of the transformer comprising the induction furnace are connected to the secondary windings of one or more transformers whose primary windings are connected to the different phase windings of a polyphase system, the connections being such that the currents induced in the aforesaid secondary windings are all in the same direction, but possess phase differences corresponding or proportionate to the phases of the polyphase system.

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

Figure 1 is a diagram of an induction furnace having two transformers independently connected to a two-phase system. Fig. 2 is a similar diagram in which the two transformers are combined. Fig. 3 is a diagram showing the transformers combined with the induction furnace. Fig. 4 is a diagram illustrating the application of this invention to a three-phase system.

A is the annular fusion chamber surrounding the middle member B of the induction furnace, the side members of which are indicated by the letters B^1, B^2.

Referring to Fig. 1, C, D represent the cores of two transformers whose primary windings C^1 D^1 are connected to the mains C^2 D^2 leading from the phase windings of a two-phase system. The secondary windings B^3 B^4 of these transformers are wound co-axially upon the primary windings C^1 D^1 and are so connected in series that the current in one is flowing in the same direction as the current in the other. Hence the total pressure obtained across the two secondary windings B^3 B^4 will be equal to one divided by the square root of two $\left(\frac{1}{\sqrt{2}}\right)$ times the sum of the pressures due to the windings B^3 and B^4 separately. These secondary windings are connected to the primary windings B^5 of the single-phase induction furnace which may be of usual construction. Tests have shown that the power factor obtained by this arrangement is quite normal.

In Fig. 2, the two transformers C D are shown combined, an advantage of this construction arising from the fact that the weight of iron required is less than when they are separate, since the sectional area of the middle member $C^{\times}$ need only be equal to one divided by the square root of two $\left(\frac{1}{\sqrt{2}}\right)$ times the sum of the component members to which it corresponds, to obtain the requisite magnetic saturation in the said member. The secondary windings B^3 B^4 are connected to the primary windings B^5 of the induction furnace, and the operation and results obtained are similar to those obtained from the arrangement shown in Fig. 1.

In Fig. 3, the transformers are combined with the induction furnace itself, the primary windings C^1 D^1, and also the secondary windings B^3 B^4 being wound upon the outer members B^1 B^2 of the induction furnace. In this case, the windings B^3 B^4, which are secondary windings with respect to the windings C^1 D^1, are the primary windings with respect to the charge contained in the annular chamber or bath A.

The advantage of the construction shown in Fig. 3 is a great economy of material occasioned by employing the furnace core B as the middle member of the transformer, while as well serving as means for positioning the magnetic flux.

In order to decrease the leakage field caused by the current induced in the annular chamber or bath A, additional windings $B^{\times}$ may, if desired, be placed around the middle member B of the induction furnace.

These additional windings, if used, as well as the sectional area of the member B, should bear approximately the same relation to the windings B^3 B^4 and the outer members B^1 B^2 respectively as that set forth with reference to the middle member of the construction shown in Fig. 2. An advantage of this construction is its compactness and saving of labor in manufacture.

Fig. 4 illustrates diagrammatically a method of converting a three-phase system into a single-phase system for use with an induction furnace. The upper part of the diagram represents the well known Scott's method of phase transformation for converting a three phase to a two-phase system. E, F and G are windings connected to a system of three phase supply mains and B^3 B^4 are two secondaries, the arrangement being such that the three-phase system is converted into a two phase system as will be readily understood. The secondary windings B^3 B^4 are then connected to or combined with the primary windings B^5 of the induction furnace with similar results to those described with reference to the Figs. 1, 2 and 3.

Although two and three-phase systems have been considered in the above description, it is not desired to limit this invention to these systems only, but to apply it to polyphase systems generally and in conjunction with any known method of phase transformation.

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

1. The combination with an electric induction furnace and a source of polyphase alternating current, of a plurality of primary windings electrically connected to and corresponding in number with the different phase windings of the aforesaid source, a plurality of secondary windings corresponding in number with the said primary windings, and magnetic cores carrying said primary and secondary windings and forming part of the core of the induction furnace, substantially as and for the purpose specified.

2. The combination with an electric induction furnace and a source of polyphase alternating current, of a plurality of primary windings electrically connected to and corresponding in number with the different phase windings of the aforesaid source, a plurality of secondary windings corresponding in number with the said primary windings and electrically connected so that the currents induced therein serve as the primary current of the induction furnace, and magnetic cores carrying said primary and secondary windings and forming part of the core of the induction furnace.

3. The combination with an electric induction furnace and a source of polyphase alternating current, of a plurality of primary windings electrically connected to and corresponding in number with the different phase windings of the aforesaid source, a plurality of secondary windings corresponding in number with the said primary windings, a primary winding on the central magnetic core of the induction furnace and electrically connected with the aforesaid secondary windings, and outer magnetic cores carrying said primary and secondary windings and forming with the central core carrying the primary winding, the transformer structure.

4. The combination with an electric induction furnace and a source of polyphase alternating current, of a plurality of primary windings electrically connected to and corresponding in number with the different phase windings of the aforesaid source, a plurality of secondary windings corresponding in number with the said primary windings and wound co-axially therewith, a primary winding on the central magnetic core of the induction furnace and electrically connected in series with the aforesaid secondary windings, and outer magnetic cores carrying said primary and secondary windings and forming with the central core carrying the primary winding, the transformer structure.

5. The combination with an electric induction furnace and a source of polyphase alternating current, of a plurality of primary windings electrically connected to and corresponding in number with the different phase windings of the aforesaid source, a plurality of secondary windings corresponding in number with the said primary windings, and electrically connected so that the currents induced therein serve as the primary current of the induction furnace, and outer magnetic cores carrying said primary and secondary windings and forming with the central magnetic core of the induction furnace, the transformer structure.

6. The combination with an electric induction furnace and a source of polyphase alternating current, of a plurality of primary windings electrically connected to and corresponding in number with the different phase windings of the aforesaid source, a plurality of secondary windings corresponding in number with the said primary windings, a primary winding on the central magnetic core of the induction furnace and electrically connected in series with the aforesaid secondary windings, and outer magnetic cores carrying said primary and secondary windings and forming with the central magnetic core of the induction furnace, the transformer structure.

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

JOHANNES HÄRDÉN.

Witnesses:
THOS. J. WALKER,
CHAS. J. H. YELVERTON.