

Sept. 22, 1931.

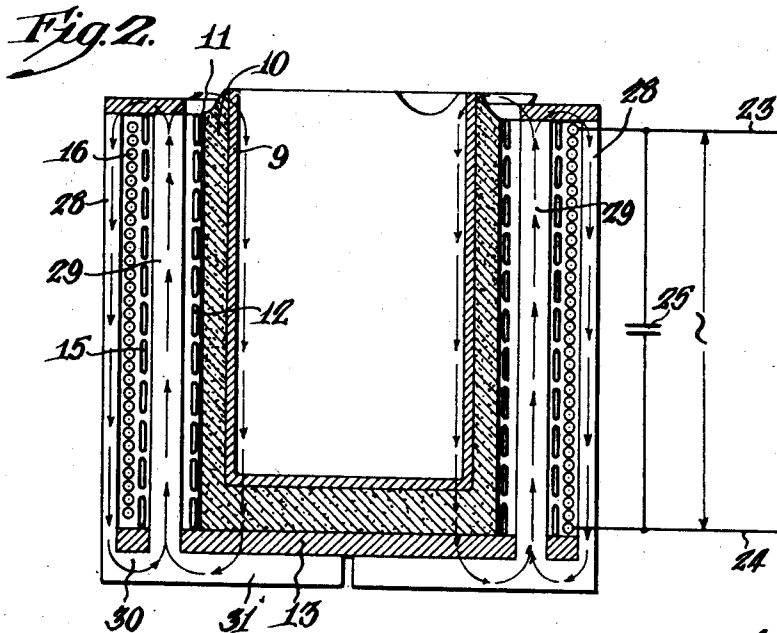
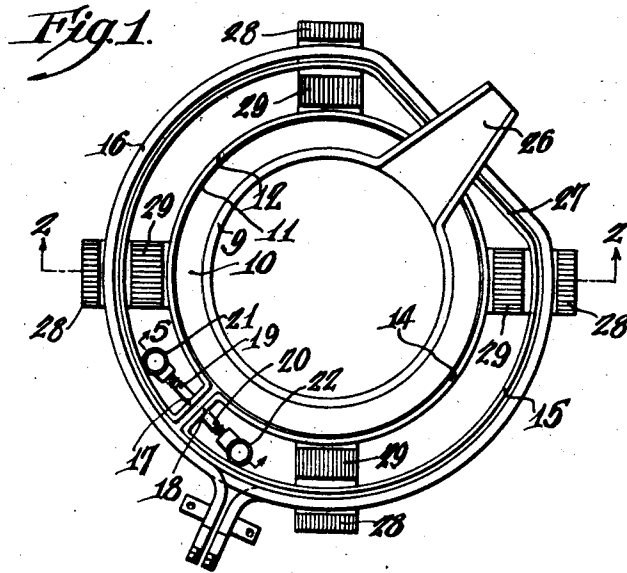
E. F. NORTHRUP

1,824,618

INDUCTION ELECTRIC FURNACE

Filed July 9, 1929

2 Sheets-Sheet 1



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*Fig. 3.*

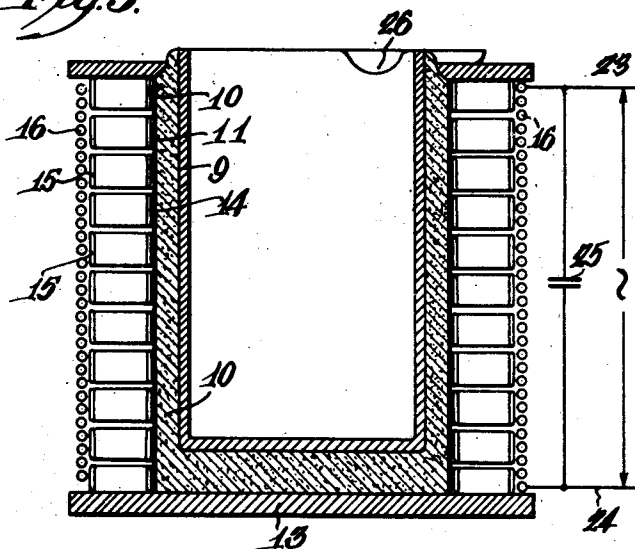


*Fig. 5.*

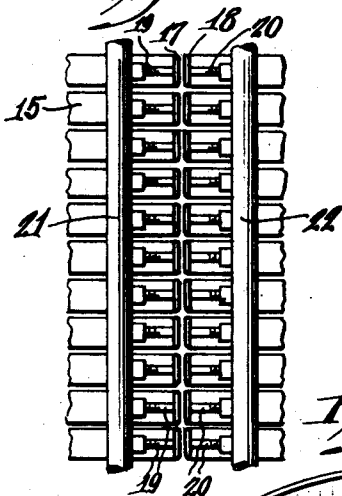


*Fig. 6.*

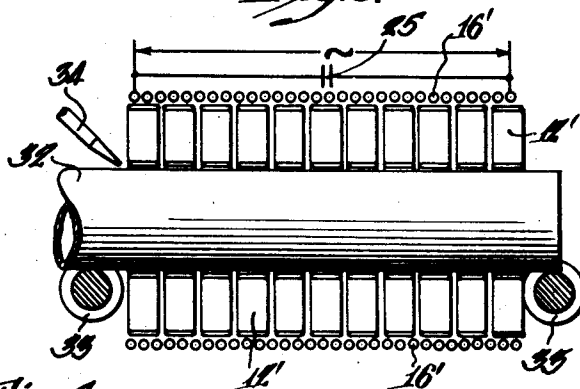
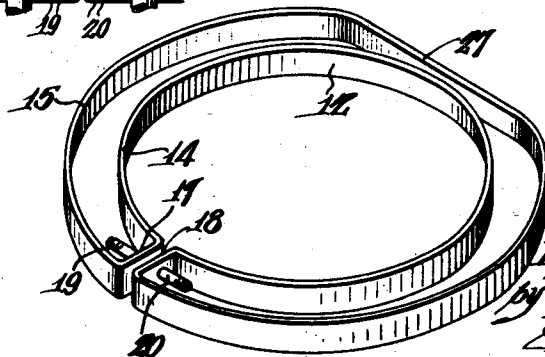


*Fig. 4.*



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# UNITED STATES PATENT OFFICE

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## INDUCTION ELECTRIC FURNACE

Application filed July 9, 1929. Serial No. 376,921.

My invention relates to induction electric furnaces of the coreless type.

A purpose of my invention is to provide for water cooling of a focus inductor type of furnace.

A further purpose is to make the fluid resistance of water flow in cooling low in focus inductor furnaces.

A further purpose is to improve the coupling between a focus inductor coil and its primary coil in a coreless furnace.

A further purpose is to reduce the injury in case of leakage flow of molten metal to the immediate parts with which contact of the metal takes place.

A further purpose is to increase the efficiency of an inductor furnace.

A further purpose is to simplify the mechanical construction of a furnace.

A further purpose is to water cool the individual inner and outer turn or turns of each section of a focus inductor in parallel and to water cool in parallel the several sections greatly reducing the resistance to water flow.

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

This invention is applied to the general type of inductor furnace shown in my Patent No. 1,378,187 of May 17, 1921. Though applicable to the forms of focus inductor connection shown in Figures 12-21 and 28, the principle is so well shown in furnaces of the type shown in Figures 24 and 25 that I have preferred to illustrate figures of this general type only, intending, however, to make my claims broad enough to cover application of the invention to the other type also.

The invention has, therefore, been shown in connection with the concentric form of focus inductor only, the illustrations, to essentially the same form, differing only in that both melting and heating furnaces are illustrated and the melting furnace is shown with and without magnetic core to improve the coupling of the primary and focus inductor.

Figure 1 is a top plan view of a focus inductor furnace embodying my invention with the water supply pipes in section.

Figure 2 is a vertical section of such a furnace taken upon lines 2-2 of Figure 1.

Figure 3 is a vertical section corresponding to Figure 2 but omitting the magnetic coupling between the primary and the focus inductor.

Figure 4 is a perspective view of one of the focusing coils of the focus inductor, seen in Figures 1, 2 and 3.

Figure 5 is a section taken upon line 5-5 of Figure 1.

Figure 6 is a central longitudinal section through an inductor which is applied to heating travelling stock.

In the drawings similar numerals indicate like parts.

In Figures 1-5 I show means for holding and heat insulating a molten pool which is intended to be diagrammatic as it may be greatly varied, but which as shown includes a crucible 9, refractory 10 and a casing 11 about the refractory holding it in place and acting as an insulator between it and the inner turns of the focus inductor 12.

The character of holding means for the melt will depend upon the needs of the furnace and the refractory will differ according to whether it be intended for low-melting point or high-melting point metals and whether or not it be intended to sinter with contact from the leakage molten metal. For low-melting point metals asbestos wool could be used but for higher temperatures or where sintering is desired it is desirable to use finely divided refractories having a sand or chrome ore base. Micanite is quite suitable for the retaining and insulating shell 11.

The parts as so far described are supported upon a base 13. It may form any convenient heat insulating support for which alberene stone is well suited.

The focus inductor 12 surrounds the furnace with its inner turns 14 as close to the material as is safe in order to get as close coupling with the charge as possible. The outer turns 15 are spaced from the inner turns far enough to get away from the heat of the furnace, thus spacing the primary inductor 16 to a point where the temperature is relatively cooler and where it can be insulated to the best advantage. It induces current in the outer and inner turns in series as in the

case of the focus inductor furnace described in my patent previously referred to.

The focus inductor turns are shown as comprising individual inductor turns (Figure 4) in parallel one with another, electrically and hydraulically. The inductor is of hollow flat tubing and is shown as flat-wound, as distinguished from edge-wound.

The inductor is water cooled along parallel paths. The most convenient place to make the division between the paths is at the connections between the paths. This is therefore the form illustrated. The water passes in one of the connections 17 between the inner and outer turns, traverses the inner and outer turns in parallel and comes out the other connection 18.

The water connections are made through nipples 19 and 20, the nipples for the several inductor sections being connected in parallel from supply pipes 21 and 22 which may be flexible or rigid as is found most convenient.

The primary inductor winding 16 is supplied with alternating current from mains 23 and 24, which current supply is shown as corrected for power factor by capacity 25 which is thrown across the mains. This primary coil can be water-cooled, if desired, in any of the usual ways.

In order to permit close approach of the pouring spout 26 to the mold the outer focus inductor turn 15 is shown as flattened at 27.

The current is supplied to the primary coil at a relatively high voltage. Because of its position at considerable distance from the furnace pool it can be insulated well without complication from the higher temperatures present nearer to the pool and can be coupled to the outer focus inductor turns as closely as the electrical insulation will permit.

The focus inductor coils carry current at so low a voltage that but little attention need be paid to their insulation. They are therefore well suited from an electrical standpoint to lie very close to the molten metal.

In operation the current in the main inductor induces opposite current in the adjoining (outer) turns of the focus inductor, with the result that the current in the inner focus inductor turns flows in the same direction as that of the primary inductor. There is substantially no external or stray field outside of the primary.

The water flow takes place through the different focus inductor coils in parallel and within the individual coils also flows in parallel through the inner and outer turns, greatly reducing the resistance of the fluid flow and making it possible to secure the requisite cooling with a minimum of water pressure.

The only difference between the form shown in Figures 1 and 2 and that in Figure 3 lies in the fact that the coupling between the primary inductor coil and the focus inductor coils within it in Figures 1 and 2 is im-

proved by the use of a return magnetic circuit comprising iron or steel legs 28 and 29 respectively inside and outside the primary inductor and outer turns of the focus inductor. The legs are magnetically connected at 30. This connection is desirably extended to nearly the center of the coil as shown at 31.

That the present invention is not restricted to melting furnaces but can be applied for heating or heat-treating solids will be evident from a single example shown in Figure 6 where the common axis of the primary inductor 16' and focus inductor 12' is horizontal and where both of the coils surround travelling stock 32 here shown as a section of pipe.

The illustration may represent one coil only of a series of coils or may constitute the entire heating equipment according to the needs met. The travelling stock is supported upon concave rollers 33, and may be driven by them.

In connection with or separate from water cooling, of which an example is seen in Figures 1-5, I may use air cooling by delivery of an air blast between the focus inductor and the travelling stock through any conventional nozzle 34. Where no melting takes place the inner coils of the focus inductor can be located quite close to the travelling stock, greatly improving the coupling. Neither heat insulation nor electrical insulation is necessary if slight spacing be effected by the rollers.

In all forms the coils as arranged are substantially without external field and can, therefore, be supported in a metallic case, if desired. Even with the highest primary voltages now customary, the voltage which can come upon the crucible or charge is not greater than 50 volts and the crucible or charge can be grounded at one point.

It will be obvious also that the construction is simple and offers no mechanical difficulties. In case of injury to any focus inductor part the injury is limited to the part affected and requires a minimum amount of repairs or replacement.

It will be obvious that the gain through improved coupling is greater than the loss through additional total coil resistance and that high efficiency can, therefore, be attained.

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. A focus inductor comprising a primary coil and inner and outer hollow focus inductor coils in series, one forming a secondary to the primary and the other about the charge, and fluid connections passing the fluid through the two focus inductor coils in parallel. 70
2. A primary inductor and a focus inductor within it comprising a plurality of sections electrically in parallel, each having outer turns secondary to the primary inductor and inner turns forming primaries to the charge and water-cooling in parallel through the outer and inner turns of each section. 75
3. A primary inductor and a focus inductor within it, comprising a plurality of sections in parallel, each having outer turns secondary to the primary inductor and inner turns forming primaries to the charge, the several focus inductors being electrically and hydraulically in parallel. 80
4. A hollow focus inductor section having inner and outer turns and water connections placing the turns in parallel. 85
5. A hollow focus inductor section having inner and outer turns, water connections passing the water through the coil in parallel paths and a magnetic return path between the inductor section turns. 90
6. A flattened and flat-wound hollow focus inductor section having inner and outer turns and water connections placing the turns in parallel. 95
7. A primary coil, a focus inductor coil within the primary having inner and outer coils connected in series and a magnetic return path between the focus inductor coils. 100
8. A primary coil, a focus inductor coil within the primary having inner and outer coils connected in series, and a magnetic return path between the focus inductor coils and also outside the primary inductor. 105
9. In an induction furnace, a focus inductor secondary winding having inner and outer concentric coils electrically in series, a primary inductor outside of the outer focus inductor coil and a magnetic return circuit located inside and also outside the primary inductor. 110
10. In an inductor furnace, a focus inductor secondary winding thereabout having concentric inner and outer coils in series, a primary inductor outside of the outer focus inductor coil, and a magnetic return circuit located inside and outside the primary inductor and within the outer coil of the focus inductor. 115
11. In a coil system, an outer primary coil, a source of alternating current therefor, a pair of secondary coils coaxial with the outer coil and with each other, within the outer coil, connected in series and a magnetic return circuit for the system. 120
12. In a coil system, an outer coil, a source of alternating current therefor, a pair of coils coaxial with the outer coil and with each other, within the outer coil, connected in series, and a magnetic return circuit threading between the pair of coils and extending outside of the outer coils. 125
13. In a coil system, an outer coil, a source of alternating current therefor, a pair of coils coaxial with the outer coil and with each other connected in series and a magnetic return circuit threading between the coils of the pair, extending outside of the outer coil and also across one end of the coils to a distance from the coil axis shorter than the radius of the innermost coil. 130
14. In a heating system, an outer coil, a horizontal axis focus inductor therein comprising inner and outer turns connected in series and a support for an article to be heated adapting it to move horizontally within the inner turn of the focus inductor. 135
15. In a heating system, an outer coil having a horizontal axis, a focus inductor therein comprising sections in parallel, each having inner and outer turns connected in series and a support for an article to be heated within the inner coil. 140
16. In a heating system, an outer coil having a horizontal axis, a focus inductor therein comprising inner and outer turns connected in series, water cooling means for cooling the focus inductor and a support for an article to be heated within the inner coil. 145

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