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E. F. NORTHRUP

1,997,741

MUFFLE INDUCTOR ELECTRIC FURNACE

Filed May 2, 1933

2 Sheets-Sheet 1

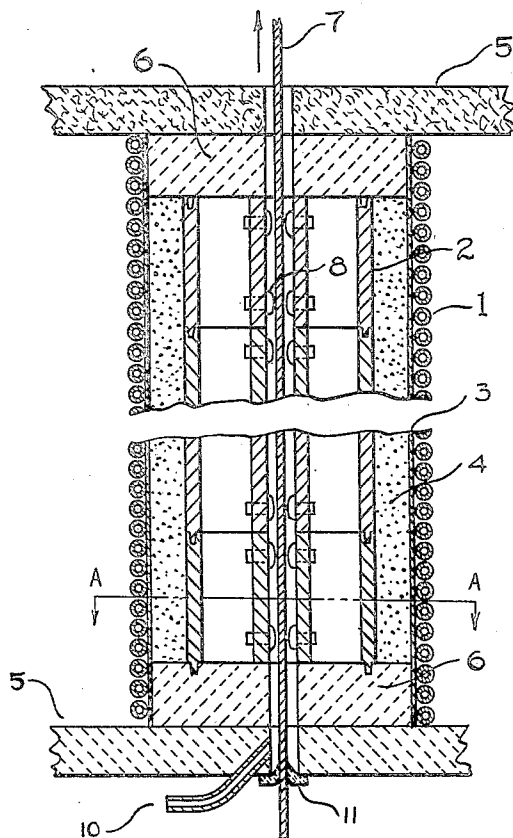


FIG. 1

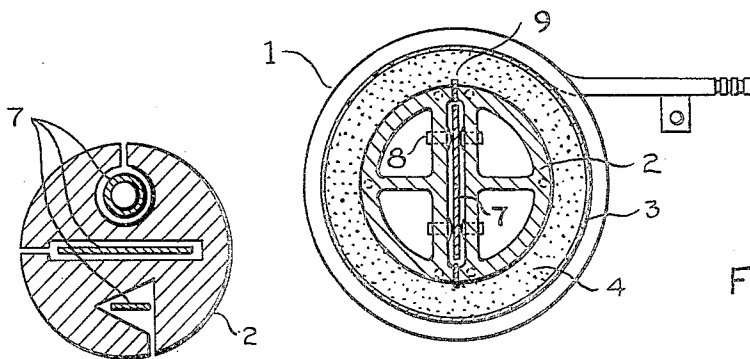


FIG. 2

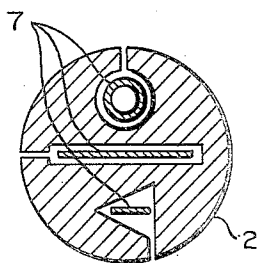


FIG. 8

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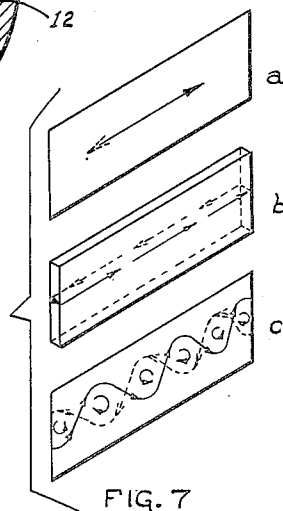
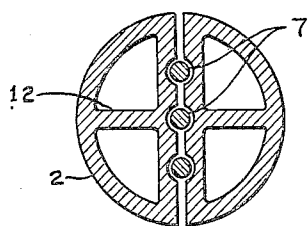
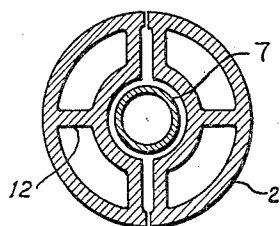
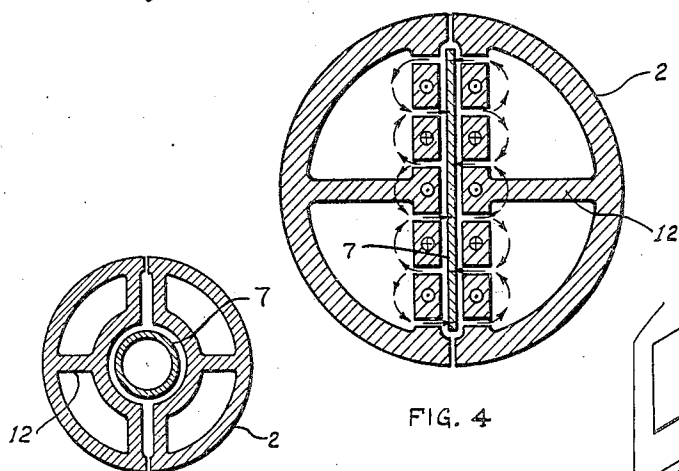
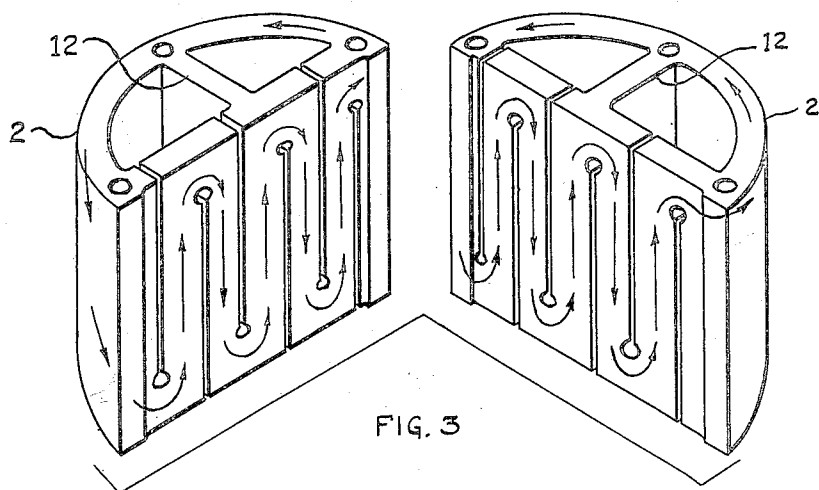
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MUFFLE INDUCTOR ELECTRIC FURNACE

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10 Claims. (Cl. 219—13)

This invention deals with an electric furnace for the heating of metal sheets and flat stock, but useful also for heating small rods, tubes and sections. It depends for its utility and novelty upon the combination of inductor, focus inductor and muffle furnace principles.

A purpose of the invention is to provide a new and improved furnace for the efficient heating of strip, sheet and flat stock as well as metal articles of tubular or other section.

A further purpose is to provide a combined induction and muffle furnace for heating articles of a small lateral dimension.

A further purpose is to provide a furnace of the focus inductor type wherein the focus inductor elements are themselves parts of a muffle and are heat insulated accordingly.

A further purpose is to provide a furnace of the muffle type so arranged that articles heated therein will have the advantage of inductive as well as radiation heating.

A further purpose is to construct a muffle of a plurality of generally similar parts so that the muffle may be lengthened or shortened depending upon the nature of the work required or so that damaged parts may be replaced easily and economically.

A further purpose is to provide a focus inductor muffle part with openings in the charge adjacent portion to increase the length of the current path in the muffle and to set up circulating heating currents in the charge.

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

In describing this invention I have chosen to make use of eight figures.

Figure 1 is a sectional elevation view of a furnace designed according to these specifications for the heating of flat strip or sheet stock.

Figure 2 is a sectional plan view of the furnace of Figure 1, taken at a point about A—A and in the direction of the arrows.

Figure 3 shows two opposing muffle sections with slots cut in the charge adjacent portions in a direction longitudinal to the furnace for which they are intended, so that the induced current path is broken and made to flow in such a way as to produce induced heating currents in swirls in a flat charge. In this figure the arrows show the instantaneous paths of current flow.

Figure 4 shows the sections of Figure 3 in spaced relation to a flat charge, in a section through the centers of the pieces, perpendicular to the furnace axis for which they are intended. The arrows in this figure show the direction of the

magnetic field set up around the muffle parts in relation to the charge sheet. The dots and crosses represent the relative directions of the current flow; the crosses representing a downward flow and the dots representing an upward flow.

Figures 5 and 6 are diagrammatic representations of inductor muffles adapted for small rod, pipe stock and the like.

Figure 7 is another diagrammatic figure showing the part the induced current plays in heating in a furnace of the combined focus inductor and muffle type. In this figure, (a) represents a thin sheet with un-slotted muffle; (b) represents a thick sheet with un-slotted muffle, and (c) represents either a thin or thick sheet with a slotted muffle.

Figure 8 is a sectional view showing additional ways in which an inductor muffle can be formed to accommodate various shaped or a plurality of charges.

The effective depth of penetration of alternating current induced into a charge for heating purposes has been the main controlling factor in deciding whether certain charges should be heated by straight induction or whether they should be heated in an inductively heated muffle. While the direct induction method is the most desirable it becomes more or less ineffective and inefficient as the diameter of the charge grows small with regard to the depth of penetration of the inducing current.

In the past when small dimensioned articles have been offered for heating consideration the following points have been considered. First, whether the nature of the work is such as to justify the expense of an extra high frequency generator; second, whether the losses due to inefficient heating by a lower frequency are justified; and third, whether the problem could not best be solved by an inductively heated muffle or some other type of heater, such as the fuel fired or resistor types.

In the present invention the inductive method can be employed more or less regardless of the frequency used and at a high efficiency. Heating is accomplished by both induced currents and by radiation from a muffle. If the frequency is high the heat generated by the currents in the charge will be great and if the frequency is low, less heat will be generated by the induced currents. On the other hand all energy supplied is transmitted to the secondary muffle inductor and that portion which is not induced in the charge goes into the heating of the muffle. The muffle being well insulated loses no heat to the outside but supplies fur-

ther heating to the charge by radiation. The muffle inductor in fact becomes a focus inductor but is an improvement over known forms in that it not only concentrates power but utilizes that power which in previous focus inductor furnaces has been considered detrimental and which has been carried away by artificial cooling means in the form of losses.

The heating of thin sheets inductively has been a problem because of the difficulty of getting induced heating currents into the sheets, and then in insulating the sheets so that any energy induced therein will not be lost by radiation. As a result, the most effective means of heating sheets by induced currents has been the full muffle method. As will be shown, the present invention provides a means for the induced method of heating sheets in conjunction with muffle heating to gain such advantages as are possible with straight inductive heating.

It is thought for instance, by several experimenters that when chromium plated steel is heated to cause some of the chromium which is in contact with the steel to migrate into the steel, it is necessary to develop the heat in the steel inductively and not by radiation from without.

The process of making a coherent non-porous chromium plate on steel by high frequency induction alone is much in favor and is commercially applied. The application, however, has been confined to rods, tubes, large diameter hollow cylinders, and the like. No attempts made by experimenters to apply this direct induction process to sheets have been successful, chiefly on account of the seeming impossibility of heating sheets by direct induction uniformly to avoid warping. The present invention should allow these processes to be extended to sheets and flat strip.

In Figure 1 is shown a hollow water cooled copper inductor coil 1, of usual design. It is shown surrounding the muffle inductor 2 and is separated therefrom by electrical insulation 3 and heat insulation 4. The electrical insulation may be mica, fused silica, molded or sintered refractory material or the like, and the heat insulation may be carbon or silica powder, asbestos or other suitable material. Asbestos or refractory brick insulator blocks 5 and 6 are used at the muffle ends and are provided with openings through which the charge 7 may be fed into and out of the heater. Molded refractory guide pieces 8, are fitted into holes in the muffle wall to prevent the charge from rubbing on the metallic surfaces of the muffle proper. The muffle sections can abut in the longitudinal direction of the furnace without harm but are preferably separated at one or more points between horizontal sections by asbestos or other suitable spacers 9.

Both muffle and charge are preferably operated in an inert or reducing atmosphere and an inlet tube for supplying such a gas is shown at 10. Baffles 11 insure the travel of the gas through the furnace to the opposite end where it is discharged or burned as the charge leaves the heater.

It is sometimes desirable to prolong the chamber so that the gas atmosphere used in the heating section will remain around the sheet until it has cooled sufficiently not to react as it emerges into a different medium. Cooling chambers can be provided to expedite the cooling and to shorten the ultimate length of the apparatus required.

With particular regard to the muffle it may be said that in general it has been found advantageous to construct it of inter-fitted segments.

These segments are usually cast integrally in a shape which will permit them to be stacked to produce muffles of various lengths. In this way the muffle length can be adapted for the most economical temperature to deal with the speed and ultimate temperature of the charge, and in event of trouble certain damaged segments can be replaced more economically than if the whole muffle were of one piece.

The segments may be braced as at 12 or they may be made in almost any shape for strength without affecting their utility to a great degree. As an extreme the segments shown can be solid metal and still function because of the tendency of alternating currents to travel at the surface only.

The metal of which the muffles are cast is preferably an alloy of the non-corrosive and heat resisting type. The nickel-chromium alloys commonly used for resistance wires and those known in practice as "chromel" or "nichrome" have been found very satisfactory for this purpose.

The openings in the assembled muffles can be of a shape to fit the charge. In Figures 1 to 4 inclusive, the openings are shown which are best adapted for heating sheets, strips and flat stock, but in Figure 5 the adaptation is for a tube or rod. In furnaces for heating tubes and rods the inductive effect becomes greater and greater as the diameter of the piece is increased, much in the same manner and for the same reason as in usual inductive heating. It might be here said that the tube forms one of the most effective charges for the muffle inductor furnace. In Figure 6 several rods or small tubes are shown in a muffle especially adapted to receive them. It is evident therefore that the muffles may be designed to accommodate thin or thick sheets, rods, tubes, pipes or irregular sections without disadvantage.

The muffle segments may be plain faced with respect to the charge or they may be slotted as shown in Figures 3 and 4. The slots increase the path of travel of the currents across the face of the muffle; they change the direction of travel of the current and hence the direction of the magnetic field, and cause eddy currents of a circulatory nature which become effective in heating thin sheets where the normal muffle is ineffective.

In Figure 7 I have shown diagrammatically what the effect of the slotted muffle is. The piece shown in 7a is a thin sheet as it would be affected in a normal inductor muffle. The depth of penetration is so great and the thickness of the sheet so small that all current which would be induced by one muffle face is directly and exactly opposed by all current which would be induced by the opposite muffle face. No heating by induced currents can be effected and any rise in temperature must necessarily come by radiation from the muffle surfaces.

Where the thickness of the sheet begins to be appreciable as in Figure 7b the current induced in the sheet by a plain inductor muffle does not penetrate to the middle and flows in opposite directions on the two sides of the sheet. In this way heating takes place by straight induction and is augmented by radiation from the muffle surfaces.

The effect shown in 7c is that of a thin sheet which has been made to absorb a charge by induction by slotting the charge adjacent faces of the inductor muffle. Muffle segments horizontally adjacent are slotted in reverse order so that parts carrying current in the upward or downward directions are immediately opposite respectively.

This arrangement is shown in Figure 4 where the dots represent current in the upward direction and the crosses represent current in the downward direction. The result is that the direction of the magnetic field is changed from one which would induce completely opposing currents in the sheet to one which combines to produce a highly circulating series of eddy current swirls over the entire surface of the sheet. In this way the sheet receives energy by induction quite comparable to that of the thick sheet.

Having thus described my invention what it is desired to protect by United States Letters Patent is described in what is claimed.

1. An induction electric furnace comprising a primary inductor coil, a heat insulated and segmented muffle within said inductor coil having its coil adjacent periphery interrupted to provide an inwardly extending current path and adapted to surround and to heat a charge by effective secondary induction and by radiation.

2. An induction electric furnace comprising a primary inductor coil, a heat insulated muffle within said coil forming a plurality of independent inwardly extending paths for current induced from the primary coil said current paths spaced to embrace and to heat a charge by effective secondary induction and by radiation.

3. In a furnace for heating articles of small lateral dimension a main inducing coil embracing a heat insulated secondary inducing muffle said muffle having inwardly projecting current paths shaped to surround and to heat a charge by effective secondary induction and by radiation.

4. In a furnace for heating articles of small lateral dimension a main inducing coil, a muffle heat insulated from and adapted to receive current from said main coil having inwardly extending current paths and shaped to embrace and to heat a charge by effective secondary induction and by radiation.

5. A muffle inductor furnace comprising a main inductor coil, a heat insulated secondary inducing muffle within said main coil having inwardly projecting current paths shaped to surround and to heat a charge by effective secondary induction and by radiation.

6. A muffle inductor furnace comprising a main inductor coil, a heat insulated secondary inducing muffle within said main coil having inwardly projecting current paths shaped to surround and to heat a charge passed therethrough by effective secondary induction and by radiation.

7. A muffle inductor furnace comprising a heat insulated secondary muffle divided in a plurality of segments both longitudinally and laterally of the axis of the furnace said divisions affording inwardly projecting current paths shaped to surround a charge to be heated by effective secondary induction and by radiation.

8. An externally heat insulated muffle for an induction furnace having its exterior surface in current receiving relation to a primary inductor coil and a re-entrant current path shaped to surround a charge to be heated by effective secondary induction and by radiation.

9. An externally heat insulated muffle for an induction furnace having its exterior surface in current receiving relation to a primary inductor coil and a plurality of re-entrant current paths shaped to surround charges to be heated by effective secondary induction and by radiation.

10. In a combined muffle and inductor furnace a muffle in inductive relation to a main inducing coil having re-entrant current carrying portions in secondary inductive relation to a charge and means in the charge adjacent portions of said muffle to break the main current path and to cause the current in these parts to flow in a circuitous and indirect path.

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