

June 21, 1932.

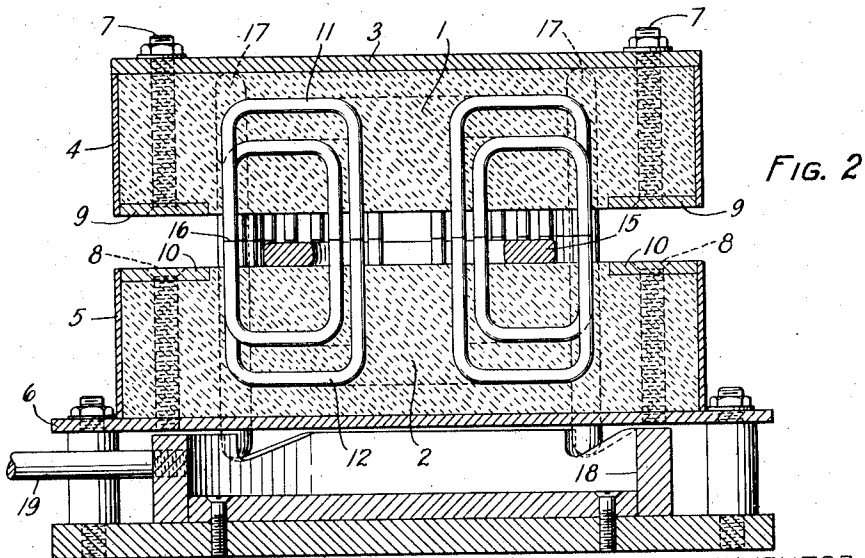
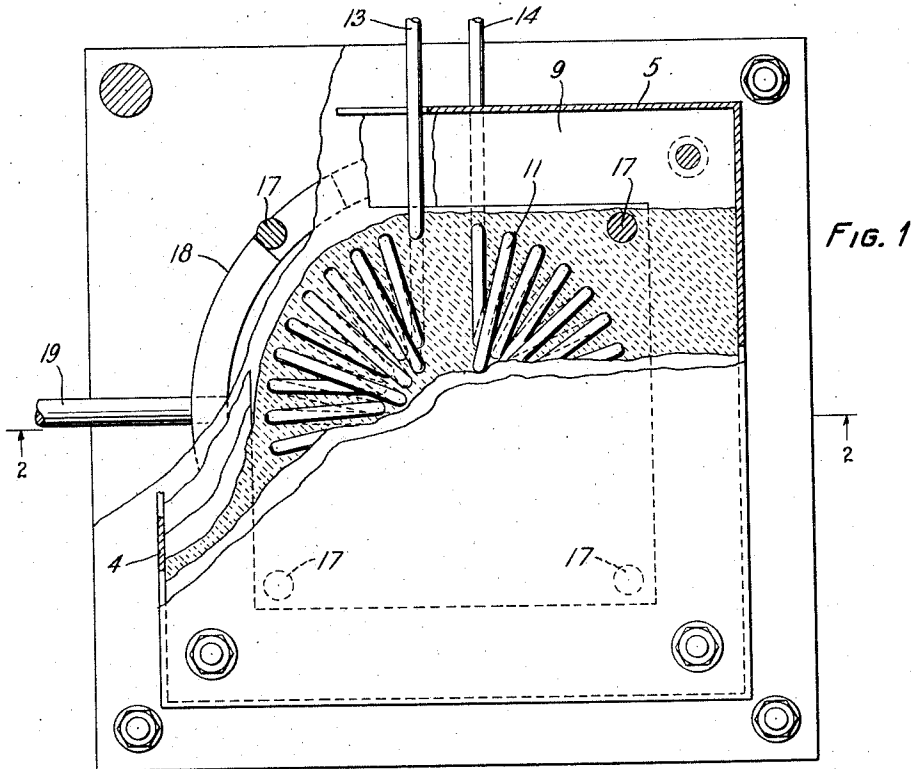
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HIGH FREQUENCY FURNACE

Filed Oct. 17, 1928

2 Sheets-Sheet 1



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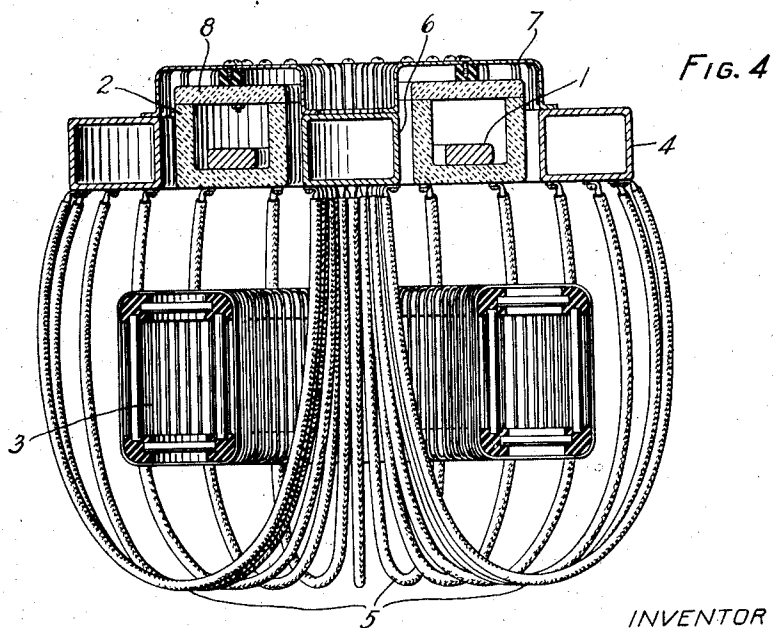
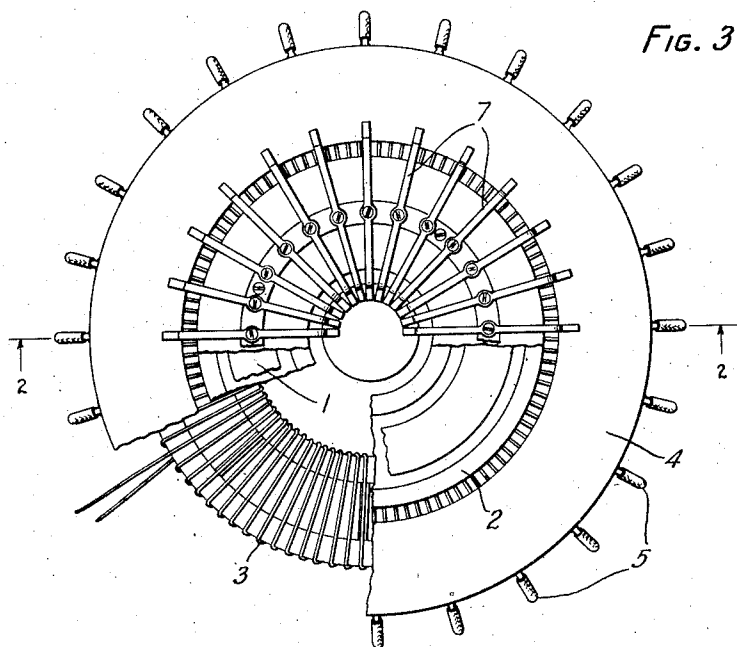
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HIGH FREQUENCY FURNACE

Application filed October 17, 1928. Serial No. 312,971.

This invention relates to the heating of materials for annealing purposes and particularly to the heating of a material by means of a high frequency magnetic field confined in a manner to heat the material most efficiently.

An object of the invention is to heat an electrically conducting body, especially a magnetic body, to a high temperature uniformly and rapidly.

A particular object of the invention is to heat a magnetic dust core to a comparatively high temperature without producing harmful effects on the insulating material in the core.

A further and related object of the invention is to heat a sample of magnetic dust or dust core to a comparatively high temperature without causing sintering of the dust particles.

Among the features of the invention are the production of a uniform high frequency field within the sample which is heated, the utilization to its full extent of the permeability of the material to be heated in generating the high frequency field in order that the greatest advantage may be taken of the magneto-motive force available for producing the field, and the use of a split coil to produce a toroidal field corresponding to the shape of the sample to be heated.

Although there is no limitation upon the kind of material which may be heated by means of this invention, provided of course the substance is an electrical conductor; the invention is particularly applicable to the heat treatment of magnetic dust, especially that made from the nickel-iron and nickel-iron-cobalt alloys and also to the heat treatment of magnetic dust cores made from the same materials. It is well known that the properties of the above alloys, known as permalloy and perminvar, depend to a large extent upon the process by which the alloy is annealed. Heretofore in annealing magnetic dust or dust rings it has been customary to subject them to the annealing temperature for a considerable length of time in order to insure a constant temperature throughout the sample. For this reason different parts of the sample are subjected to the annealing temperature for different periods of time

since considerable time elapses before the temperature is uniform throughout the sample. The temperature to which such magnetic materials may be heated is thus limited since long exposure of the dust rings to high temperatures results in a deleterious effect upon the insulation, and in the case of loose magnetic dust sintering may occur.

By means of this invention a high frequency field is generated which is substantially uniform throughout the material to be heated and preferably of the same shape. By confining the field to the shape of the core to be annealed a very large percentage of the flux will be generated within the core. Thus, most of the available magneto-motive force is usefully expended in establishing the flux which threads the core, resulting in high efficiency. This also enables the material to be heated to a high temperature uniformly and rapidly, and in the case of permalloy and perminvar dust cores the annealing process can be conducted at a considerably higher temperature and with greater rapidity than with the methods heretofore pursued.

A better understanding of the invention may be had by reading the following description in connection with the accompanying drawings of which Fig. 1 is a plan view of a furnace in accordance with the invention adapted for heating large samples, for example, large magnetic core rings, this view being shown partly in section to give a better idea of the details of the furnace construction, Fig. 2 is a cross section taken through the furnace of Fig. 1 at 2-2, Figs. 3 and 4 are views corresponding to those of Figs. 1 and 2, of a furnace in accordance with the invention which is adapted to heat a small sample.

Referring first to Figs. 1 and 2 a furnace is shown comprising two sections, 1 and 2, in spaced relation with respect to each other. Both the upper and lower furnace sections are composed of refractory material confined within a suitable casing comprising the top plate 3, upper and lower side casings 4 and 5 and the base plate 6. The refractory material is held in position by means of a

plurality of screw bolts 7 and 8 which extend through the upper and lower sections respectively and clamp the retaining plates 9 and 10 in position.

5 A high frequency heating coil wound in the form of a toroid is built in two sections 11 and 12 which are embedded, one each in the upper and lower sections of the furnace. The coil is preferably made of copper tubing
10 suitable for the conduction of high frequency current which also provides for the circulation of water or some other cooling fluid should this method of cooling be desirable. The terminals 13 and 14 of the coil 11, 12
15 (Fig. 1) are adapted to be connected to some source of high frequency current and also to the supply of cooling fluid. Since the material to be heated must necessarily be placed within the toroid, the furnace is arranged so
20 that the whole top section 1 including the upper section of the coil 11 may be removed.

The material to be heated, which in this instance is represented by the toroidal ring 15, is placed upon the top of the lower furnace section so as to be confined within the
25 links of the coil. When the top of the furnace is again replaced, the material to be heated constitutes the metallic core of the high frequency heating coil. Any method
30 of making the joint 16 for connecting both halves of the coil, which will give a tight connection, may be used. It has been found that a very excellent joint results if the ends
35 of the top section of the coil are swaged so as to make a tight sliding fit for a suitable distance into the ends of the lower coil section.

In order to avoid difficulty in aligning the coil sections four guide rods 17 are embedded
40 in the upper section of the furnace and extend through suitable holes in the lower section to a bearing ring 18 in the base. The ring is notched to receive the guiding rods and each notch has an inclined side so that
45 as the ring is rotated through a small arc by means of the handle 19 the lower ends of the guiding rods slide along the incline. These rods have sufficient length to enable the ends
50 of the top coil section to clear the ends of the lower coil section when the guiding rods are resting on the top of the bearing ring. Thus in the embodiment shown the top section of the coil can be removed or replaced
55 without binding by simply moving the handle 19 in the proper direction.

Since the voltage applied to the terminals of the coil is fairly large, consideration must be given to the proper spacing of the links of the coil to prevent sparking from one turn
60 to the other.

In operation the material to be heated is placed within the toroidal coil in the manner heretofore described and a frequency around
65 20,000 cycles at a voltage of about 6,000 is applied to the terminals of the coil. The re-

sulting field is confined within the heating coil and since the material has a much higher permeability than the surrounding air a very high percentage of the flux generated is within the sample. The eddy currents produced in the sample heat it to a high temperature uniformly and rapidly, and in the case of annealing magnetic materials much higher temperatures without accompanying deleterious effects may be obtained than
70 heretofore.

Figs. 3 and 4 are views of another type of furnace which may be used when it is desired to heat a sample which is too small to accommodate the large heating coil. In this embodiment a secondary winding of one turn links with the primary winding and the sample to be heated. With such an arrangement it is well known that the magnetic field effective in the sample is approximately equivalent to what it would be if the sample were directly within the primary coil. In Fig. 4, the sample 1 to be heated is shown resting in an annular trough 2 of some refractory material. A secondary winding comprising the elements 4 to 7 which is effectively a single turn links with the sample 1 and the primary coil 3 which comprises a suitable number of turns of copper tubing as in the embodiment previously described. If necessary the primary coil may be cooled by the circulation of water or some other suitable cooling fluid. The element 4 which encircles the trough containing sample 1 comprises an annular shaped tube of suitable cross section concentrically arranged with respect to the heating coil and having a surface sufficiently large to provide adequate cooling. If desired this also may be cooled by the circulation of water. Attached at regular intervals to the lower side of the tube 4 are a plurality of cables 5 which link the primary coil 3 and are connected to a hollow cylinder 6 of similar material and cross section as the tube 4. The secondary coil is completed through the spring members 7 which make good contact with the elements 4 and 6 by virtue of their being attached to the heavy cover 8 of the trough 2. With this construction the same field threads through the secondary winding as through the primary winding so that the flux induced in the sample 1 will be approximately the same as that in the previously described furnace and will produce similar results.

Although this invention has been described with reference to two specific types of furnaces it is not limited in its application thereto, but only in accordance with the spirit of the invention as defined in the appended
10 claims.

What is claimed is:

1. In a furnace for heating a core to a high temperature, a toroidal coil comprising a plurality of split turns, adapted to be sepa-
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rated to permit the insertion of the core to be heated, means for maintaining both halves of said coil in accurate alignment as they engage and disengage, said means comprising a plurality of guide rods, and actuating means therefor comprising a plurality of wedge shaped surfaces for evenly moving said guide rods.

2. In a furnace for heating a toroidal core to a high temperature, a high frequency toroidal coil comprising a plurality of turns of copper tubing, said turns each having a sliding joint for separating the coil into two parts to permit the insertion of the core to be heated, a plurality of guide rods for engaging and disengaging the respective halves of said coil in alignment, and means for evenly actuating said guide rods in a longitudinal direction, said means comprising a rotatable bearing ring having a series of inclined bearing surfaces along which said guide rods slide as the bearing surfaces move perpendicularly to the direction of the rod upon rotation of its bearing ring.

3. In a furnace for uniformly heating a magnetic body at a high temperature, a toroidal coil comprising a plurality of split turns adapted to be separated to permit the insertion of the magnetic body to be heated, and means for maintaining both parts of said coil in accurate alignment as they engage and disengage, said means comprising a plurality of guide rods having a fixed relation with respect to one part of said coil, and means for quickly adjusting said guide rods to a desired position with respect to the other part of said coil.

4. A furnace for uniformly heating a magnetic body to a high temperature, comprising two separable refractory parts, a source of high frequency alternating current, a toroidal coil supplied from said source and comprising a plurality of split turns adapted to be separated to permit the insertion of the magnetic body therebetween, the two split portions of said coil being respectively embedded in the two separable refractory parts of the furnace, and means for accurately aligning the split portions of said coil when the magnetic body is placed therebetween, comprising a plurality of guide rods fixed to one refractory part of said furnace and engaging in recesses in the other refractory part of said furnace.

5. In a device for heat treating an electromagnetic material, a source of high frequency alternating current and a coil connected to said source to be supplied with current thereby, the convolutions of said coil completely enclosing said material and the magnetic path of said coil being substantially confined within said material.

6. In a device for heat treating an electromagnetic material, a source of high frequency alternating current and a coil hav-

ing the same configuration as said material and supplied with energy by said source of current, the convolutions of said coil completely enclosing said material and the magnetic path of said coil being confined substantially within said material.

7. In a device for heat treating an annular core, a source of high frequency alternating current and a toroidal coil supplied thereby with said current, the convolutions of said coil completely enclosing said material and the magnetic path of said coil being confined substantially within said material.

8. In a device for heating an annular core to a high temperature, a source of high frequency alternating current and a coil wound on said core and connected to said source so as to be supplied with said current, said core comprising a closed magnetic path for the flux produced by said coil and said path being substantially confined within said core.

In witness whereof, I hereunto subscribe my name this 16th day of October, 1928.

VICTOR E. LEGG.

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