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D. PISAREV
END HEATING DEVICE
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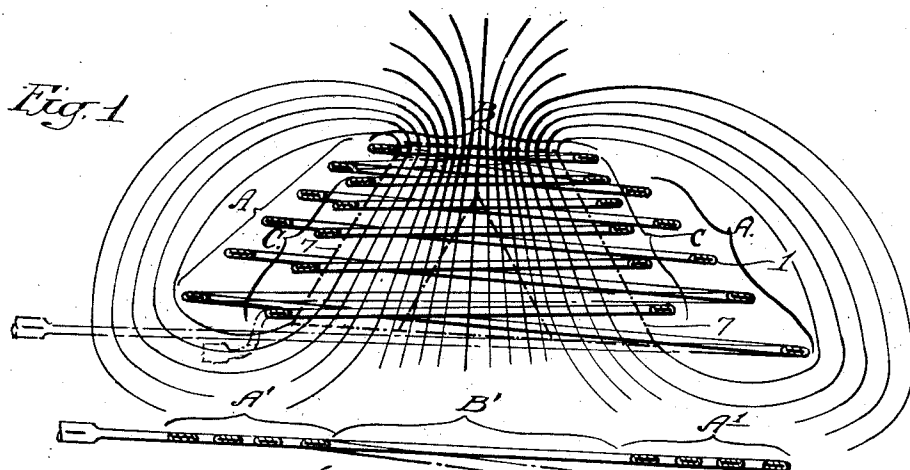


Fig. 2

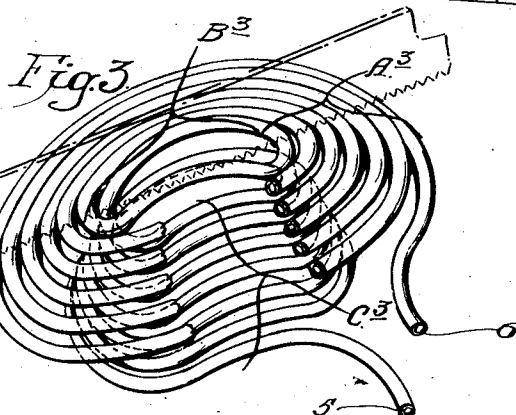
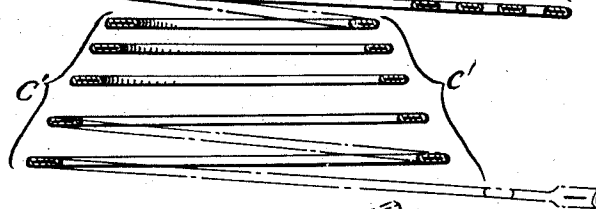
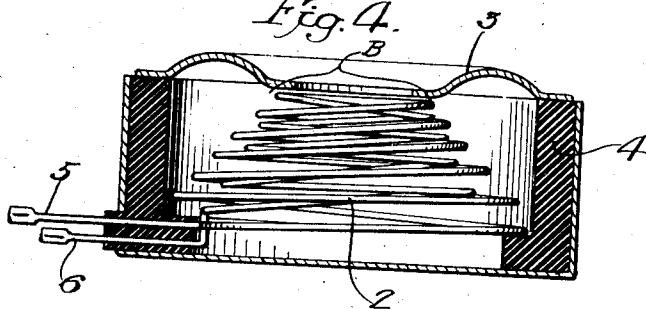


Fig. 4



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END HEATING DEVICE

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5 Claims. (Cl. 219—13)

This invention relates to new and useful improvements in induction coils and more particularly to a novel induction coil which is particularly adapted for use in high frequency induction heating apparatus to heat objects positioned in a region adjacent the end of the coil.

At the present time, the induction coils employed in high frequency heating apparatus for heating objects or portions of objects which cannot very well be disposed within or about an induction coil are generally of the helix (cylindrical) or pancake type. A helix form of coil can heat an object disposed centrally along its axis within it with a reasonable degree of efficiency as the strongest field of the coil (high flux density) is at that point, but the end regions of such a coil become progressively weaker outwardly from the center and are quite weak even a short distance beyond the ends of the coil.

Thus the strength of the field falls off tremendously at the ends of the coil due to its rapidly decreasing and ultimately very low flux density and the conversion of energy into heat in an object placed externally endwise of a helix type induction coil, and especially a short distance beyond the end of such a coil, is so low that the efficiency of the device is not considered practical for ordinary purposes.

The pancake type of coil is sometimes used for heating such objects. This pancake type of coil consists of a winding of a succession of turns of wire residing essentially in one plane with the result that the object, when placed adjacent to this coil, lies in closer proximity to the region of the coil of greatest field strength than does an object in the case of the helix type of coil.

However, the flux distribution or field of both these types are different and the flux density is also quite low at a practical distance adjacent the pancake coil while the flux distribution is such that this type of coil is limited to highly restricted control of the distribution of heat in a susceptor or portion thereof. The efficiency of both of these types of coil are so relatively low that an inordinate amount of power is necessary to heat even small objects, and this power requirement increases as the distance between the object and the end of the coil is increased to such a degree that even at a comparatively short distance beyond the coil, the heating of an object inductively with economic justification for the power equipment expendi-

ture is beyond any reasonable limits for practical use.

By the present invention these deficiencies are materially minimized and at the same time all of the advantages of a multiple turn helix type of coil are retained. The present invention contemplates essentially the provision of an inductive heating device comprising an induction coil having a section at and about which maximum flux density or field concentration is sought, and other sections in association therewith which function to direct the magnetic field or flux more toward the first-mentioned section so as to effect a maximum flux density and field concentration in a region adjacent such section so as to obtain maximum efficient heating of an object positioned in such region.

More particularly the present invention contemplates an inductive heating device comprising an induction coil wherein the heating section of the coil is located at one end or side of the coil so that an object or susceptor to be heated may be placed relatively adjacent such section, the other or flux directing sections of the coil being disposed at an angle with respect to each other and extending away from the said heating section at one side or end thereof.

An induction coil embodying the invention may, for example, comprise a winding of wire arranged to include flux directing sections disposed in angular relation to one another and each consisting of a plurality of turns wound so as to terminate in a common section which constitutes the heating section of the coil and is disposed or located at one end or side of the coil.

In such a coil the angularly related sections thereof function to direct the magnetic flux more toward the heating section of smallest size with the result that the strength or density of the field is increased in the region adjacent that section permitting extremely efficient heating of an object or susceptor, or a portion thereof, as desired, which may be positioned either within such section or externally of the coil in the region endwise of said section.

With the foregoing observations in mind, the principal object of the present invention is to provide an induction coil of the character set forth and this and other objects of the invention, as well as the features and details of its construction and arrangement are hereinafter fully set forth and shown in the accompanying drawing, in which:

Figure 1 is a view in section vertically through

an induction coil embodying the present invention;

Figures 2 and 3 are diagrammatic illustrations of modified forms of induction coils within the contemplation of this invention; and

Figure 4 is a view in section showing an inductive heating device comprising a coil of the present invention.

As pointed out above, the invention consists essentially in the discovery that by constructing an induction coil to provide therein angularly related sections each comprising a plurality of turns wound so as to terminate at one end of the coil in a common heating section of predetermined size in contrast to the cylindrical and pancake forms of coil, the flux or magnetic field set up within the coil is directed by the angularly related sections more toward an object or susceptor located within, or externally of said heating section at such end of the coil, and referring to the drawing, one form of induction coil made according to the present invention is composed of a wire 1 wound to form angularly related portions A and C, respectively, which converge axially of the coil and terminate at one end thereof in a heating section B of predetermined shape and size.

The induction coil is preferably wound upon a suitable mandrel or mandrels, as the case may require, having surface configurations conforming to the desired shape of the coil, and the winding may be single or multiple layer, honeycomb, or otherwise so long as the aforementioned surface configuration is maintained. A circular, square, rectangular or other cross-section shape of tubing may be used for winding the coil edgewise, lengthwise or otherwise spaced to permit desired inductance effects.

The number of turns or coils of wire in the angularly related sections A and C of the coil, as well as the spacings between such turns, may vary as desired or to meet any particular performance requirements. Likewise, the angle between the two angularly related sections A and C may be varied and determined to suit any given operating characteristics while the shape or configuration of each such turn may be circular, oval, elliptical, square, rectangular, or otherwise, as may be required to most efficiently generate and control the inductive heating of a particular shaped object or portion thereof disposed within or in the region endwise of the heating section B of the coil. Thus with a heating section B of correctly designed shape the contour or configuration of the area heated upon a substantially flat surface of a susceptor will be determined by the shape of said heating section B. So far as concerns the angular relation of the flux directing sections A and C of the coil are concerned, the limiting angular relations or positions thereof are approximately those shown in Figures 1 and 2 of the drawing wherein, in Figure 1 the included angle between said sections is relatively small and in Figure 2 the section A' is disposed substantially in the plane of the heating section B' and at an angle with respect to section C' which is relatively large. However, the included angle between sections A and C of said coil may be 90° or more so long as the sections A do not extend or reside at the other side of the plane of the heating sections B from the other angular sections C.

The induction coil contemplated by the invention is not restricted to the particular configuration or shape illustrated in Figure 1 of the

drawing and similar results are obtained, for example, by constructing the induction coil so that the several sections A³, B³ and C³ thereof are of generally concavo-convex configuration, as shown in Figure 3 of the drawing, for use in obtaining various magnetic field distribution requirements in the heating susceptors or portions thereof having either curved or plane surfaces. Transversely, the shape of the smallest turn or turns constituting the heating section B³, as well as the turns of the angularly related sections A³ and C³, may be oval, elliptical, rectangular, square, circular, or otherwise as may be required to provide most efficient heating of a susceptor or portion thereof according to a given set of requirements. One such form is shown in Figure 3 of the drawing wherein the heating section B is of such configuration as to receive the teeth of a hand saw between portions thereof in order to heat-treat the same. Still other forms or shapes may, however, be employed with satisfactory results.

By thus directing the flux or magnetic field more toward a susceptor disposed or positioned within or externally endwise of the heating section of the coil at one end thereof, a coil constructed in accordance with the invention may be employed to advantage to materially increase the efficiency of inductive heating devices and equipment such as, for example, of the form as shown in Figure 4 of the drawing which comprises an induction coil 2 having an object 3, in this case an annular disk supported externally endwise of the heating section B of the coil 2 by means of insulation or other suitable support indicated by reference numeral 4. In some cases insulation may be disposed between the susceptor and heating section of the coil while in others no insulation is needed or desirable.

The induction coil 2 is of the same general form and arrangement shown in Figure 1 and a high frequency current is supplied thereto at the extremities 5 and 6 of the wire or at intermediate points therealong as desired. The wire is preferably tubular and for the purpose of cooling the coil 2, water or other cooling fluid may be circulated therethrough from the openings afforded at the extremities 5 and 6 of the wire or at intermediate points.

Use of the coils of the present invention for heating purposes is confined essentially to the region bounded by the heating section B or that externally adjacent thereto in order to obtain a stronger external magnetic field and consequently maximum heating of an object, the converging angularly related sections A and C functioning to direct and concentrate the magnetic field more toward and at this region with the result that most efficient heating of an object so located is assured. Thus the heating efficiency of the coil and control of heat distribution in the object is materially increased with the result that the length of time required to heat an object, the amount of power consumed and equipment necessary are each substantially reduced. In some instances of use of the coil under certain conditions of frequency, it may be desirable to further aid in the control and intensity of the magnetic path through and about the coil in which event iron or steel laminae may be disposed within the coil as a core 7 as shown in Figure 1 or arranged to conform approximately to the angular contour of the converging sections of the coil.

Use of the term "adjacent" herein and in the

appended claims regarding the location of the susceptor with respect to the heating section of the coil is, of course, relative and is intended to cover and include that spacing of the susceptor within the heating range of heating section of the coil either with or without intermediate insulation and while the description of the invention has been confined to the embodiment or adaptation thereof to high frequency induction heaters and furnaces, it will be obvious, of course, that use of said invention is not limited to a device of that nature, but may be employed to advantage in any instance where it is desired to obtain a maximum magnetic field strength in a susceptor located in a region local to or external from the end of the coil and likewise, changes and modifications may be made and incorporated in the invention within the scope of the annexed claims.

I claim:

1. An inductive heating device comprising an induction coil consisting of a winding of wire wound to provide inner and outer angularly related sections which converge toward one end of the coil, at least said outer section being composed of a plurality of turns of progressively decreasing size in the direction of convergence thereof and both of said sections terminating at said end of the coil in a common heating section, the said common end heating section being arranged for disposition adjacent a susceptor to be heated and said angularly related converging sections of the coil functioning to control the distribution of heat in and direct the magnetic flux more toward said susceptor to be heated.

2. An inductive heating device comprising an induction coil consisting of a winding of wire wound to provide inner and outer angularly related sections which converge toward one end of the coil, at least said outer section being composed of a plurality of turns of progressively decreasing size in the direction of convergence thereof and both of said sections terminating at said end of the coil in a common heating section of lesser size than any of the turns in the angularly related converging sections of said coil, the said common end heating section being arranged for disposition adjacent a susceptor to be heated and said angularly related converging sections of the coil functioning to control the distribution of heat in and direct the magnetic flux more toward said susceptor to be heated.

3. An inductive heating device comprising an induction coil consisting of a winding of wire wound to provide inner and outer concentrically arranged angularly related sections which converge toward one end of the coil, said angularly related sections being each composed of a plurality of turns of progressively decreasing size in the direction of convergence thereof and terminating at said end of the coil in a common heating section, the said common end heating section being arranged for disposition adjacent a susceptor to be heated and said angularly related converging sections of the coil functioning to control the distribution of heat in and direct the magnetic flux more toward said susceptor to be heated.

4. An inductive heating device comprising an induction coil consisting of a winding of wire wound to provide inner and outer angularly related sections which converge toward one end of the coil, said angularly related sections being each composed of a plurality of turns of progressively decreasing size in the direction of convergence thereof and terminating at said end of the coil in a common heating section of lesser size than any of the turns in the angularly related converging sections of said coil, the said common end heating section being arranged for disposition adjacent a susceptor to be heated and said angularly related converging sections of the coil functioning to control the distribution of heat in and direct the magnetic flux more toward said susceptor to be heated.

5. An inductive heating device comprising an induction coil consisting of a winding of wire wound to provide inner and outer concentrically arranged angularly related sections which converge toward one end of the coil, said angularly related sections being each composed of a plurality of turns of progressively decreasing size in the direction of convergence thereof and terminating at said end of the coil in a common heating section composed of a single turn of lesser size than any of the turns in the angularly related converging sections of said coil, the said common end heating section being arranged for disposition adjacent a susceptor to be heated and said angularly related converging sections of the coil functioning to control the distribution of heat in and to direct the magnetic flux more toward said susceptor to be heated.

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