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INDUCTION HEATING APPARATUS

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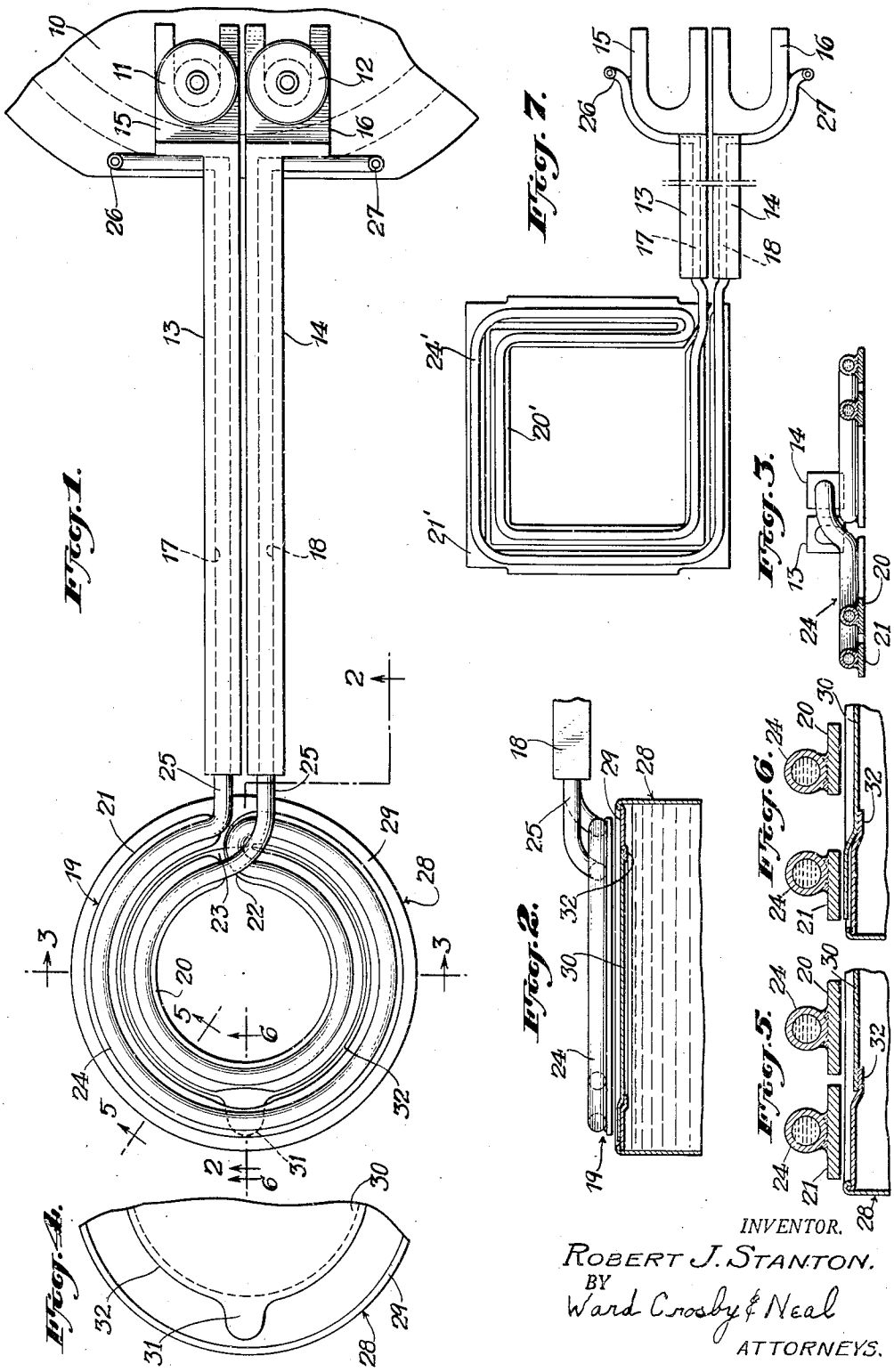

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INDUCTION HEATING APPARATUS

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5 Claims. (Cl. 219—47)

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This invention relates to induction heating apparatus and, more particularly, to an inductor for heating peripheral lines, bands or the like on objects such as metal plates, the inductor having spaced, substantially continuous inner and outer inductor plate portions for applying a localized high frequency field to the object, the heating effect thereby obtained being substantially confined to such lines or bands and closely adjacent the region between said inductor plate portions.

Heretofore, it appears to have been generally assumed that passage of a high frequency current through a one-turn coil placed directly above a conductive plate or the like would produce a localized heating effect confined to the portions of the plate directly beneath and along the line of the conductor. Thus, in U. S. Patent 2,024,906 to Bennett, a circular one-turn coil is shown connected to a suitable transformer, the patentee indicating that the heating effect is confined to a narrow band along and beneath the conductor, and that the area beneath the coil within said band is unheated. This patentee further states that "the degree to which the induced heating current concentrates in a predetermined strip of desired width depends primarily on the degree of proximity of the inducing coil to the work in this respect that the degree of proximity determines the selection of the proper frequency for the purpose, which purpose is to effect the desired location and temperature of the heat developed." However, I have discovered that such a one-turn coil causes inductive heating not only along the line below the coil but also to a considerable degree throughout the area surrounded by such line even though the spacing of the coil from the object to be heated and the frequency utilized are varied within wide limits. Accordingly, when using a one-turn coil, for example, to heat the peripheral portions of an object such as a sheet metal plate, a substantial portion of the current is wasted in heating the central portions since the heating effect is not confined to the peripheral portions, and the heating of the central portion may cause prohibitive warping. When brazing a cover upon a can or the like, for example, if a substantial amount of heat is thus applied to the central portions of the cover, it may become warped or bent out of shape.

The objects of this invention include the provision of an inductor for eliminating or substantially minimizing the above-noted difficulties. According to the present invention, I provide an

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inductor comprising a substantially continuous inner inductor plate portion surrounded by a substantially continuous outer return inductor plate portion closely spaced therefrom and substantially concentric or parallel thereto. In this manner, the high frequency electromagnetic field causing the heating effect is highly concentrated and largely confined within the region between and surrounding the inner and outer inductor plate portions.

Accordingly, most of the central area or region surrounded by the inner inductor plate portion has a relatively weak or negligible magnetic field induced therein whereby substantially no heat is applied to that portion of an object placed along and adjacent said central area or region, whereas a line or narrow band surrounding such area on the object and opposite the region between the inductor plate portions is strongly heated. It will be understood that the substantially continuous inner and outer inductor plate portions may have openings or gaps therein where high frequency current may be applied thereto. Alternatively, the inner and outer inductor plate portions may be interconnected at such openings or gaps.

Various further or more specific objects, features and advantages of the invention will appear from the following detailed description taken in connection with the appended drawings which form a part of this specification and illustrate, merely by way of example, preferred forms of the invention. The invention consists of such novel features and combinations of parts as may be shown and described in connection with the apparatus herein disclosed.

In the drawings,

Fig. 1 is a plan view showing a present preferred form of the invention;

Fig. 2 is a vertical sectional view taken substantially along the line 2—2 of Fig. 1;

Fig. 3 is a transverse, vertical sectional view taken substantially along the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary plan view of the object to be heated shown in Fig. 1;

Figs. 5 and 6 are enlarged, sectional views taken along the lines 5—5 and 6—6, respectively, of Fig. 1; and

Fig. 7 is a plan view illustrating another embodiment of the invention.

Referring to the drawings in detail and particularly to Fig. 1, portions of a high frequency step-down transformer are shown at 10, the secondary terminals of the transformer being indicated at 11, 12. Closely spaced copper bars 13, 14

are attached, respectively, to the terminals 11, 12 as by lugs 15, 16. As shown, the bars 13, 14 are of equal length and they are bored to form the respective longitudinally extending passages 17, 18 which extend from end to end thereof.

In accordance with the invention, an inductor 19 of novel character is utilized for directing and localizing a high frequency field to and in a desired heating or brazing zone. Inductor 19 consists of essentially "loop-like" circular concentric inner and outer plate portions 20 and 21 joined by a U-shaped portion 22 in such manner that, except for insignificant air gaps as at 23, each portion 20, 21 of inductor 19 forms a continuous circular path for the production of magnetic flux, these circular paths being disposed in a single plane, Fig. 1. Alternatively, the inner and outer inductor plate portions 20 and 21 may be formed separately and connected together in any suitable manner.

The hereinbefore described inductor plate portions 20 and 21 as shown particluarly in Figs. 5 and 6, in accordance with a detailed feature of the invention, preferably should be disposed in plane relation or substantially so. These inductor plate portions 20, 21 form or define the desired flux gap between them and direct the flow of current in opposite directions with respect to said gap so as to accurately define the desired line or band of heating along said gap.

Inductor 19 is supported in fixed position relative to copper bars 13, 14 by tube portions 24 formed preferably from copper tubing, the respective end portions 25, 25 of tube portion 24 being suitably secured as by brazing or soldering to the bars 13, 14 in such fashion that the portions 25, 25 communicate with the respective passages 17, 18. Tube portions 24 are shaped to fit on top of inductor 19 and are suitably secured thereto as by soldering or brazing so as to form a rigid unitary structure therewith.

The passages 17, 18 may have copper or other non-ferrous tubes 26 and 27, respectively communicating therewith adjacent lugs 15, 16, these tubes, 26, 27 leading respectively, to an inlet and outlet, not shown, for water or other cooling fluid. Thus, during operation of my novel inductor, a continuous stream of cooling fluid may be passed through copper tube 26, passage 17, tube portions 24, and passage 18 to outlet 27 to thereby cool inductor 19 and the copper bars 13, 14.

Referring particularly to Fig. 2, a cylindrical can or other object is shown at 28 which has a circular flanged top portion 29. A cover 30 is shown resting upon and supported by the flanged portion 29. The cover 30 may, if desired, have a lug extending therefrom as at 31, Fig. 4. As is apparent from the drawing, the region or zone 32 where cover 30 contacts the flanged portion 29 is circular and is positioned below and closely adjacent the region between the inner inductor plate portion 20 and the outer inductor plate portion 21. High frequency current applied to the secondary terminals 11, 12 of the transformer 10 flows through copper bar 13, outer inductor plate portion 21, U-shaped bend 22, inner inductor plate portion 20 and copper bar 14 to thereby establish a localized highly concentrated magnetic field in the aforesaid region or zone 32, this field causing an induction heating effect which may, by proper choice of the frequency and current, be made sufficient to solder together the cover 30 and the flanged portion 29 of the can 28. Localization of the magnetic field occurs to a large extent as a result of the current flow being

in opposite direction in the respective inner and outer inductor plate portions 20 and 21. Due to the novel construction of the inductor, substantially no electromagnetic field is induced in the central portions of the cover 30 and, consequently, little or no heat is applied to this portion of the cover which would tend to cause warping or bending thereof.

In some applications of the invention, it may be desirable to apply a higher degree of heat to the lug 31 than to the periphery of the cover 30. To this end, the normal spacing between the inner inductor plate portion 20 and outer inductor plate portion 21, as indicated by Fig. 5, may be increased in the region of the lug 31 by cutting away portions of the respective inductor plate portions 20 and 21. In this manner, the spacing between the inductor plate portions 20 and 21 is increased, as indicated by Fig. 6, whereby a greater heating effect is obtained in the region of the lug 31.

A modification of the invention is illustrated in Fig. 7, in which the construction and arrangement of parts is essentially similar to the construction illustrated in Fig. 1, like parts being denoted by similar reference characters. In this modification, the respective inner and outer inductor plate portions 20' and 21' are also both "loop-like" although of square or rectangular shape rather than of circular configuration. It will readily be appreciated that this construction may be used, for example, to solder together a square cover and a can or other object having a square or rectangular surface.

It will be further apparent that the invention disclosed herein is not to be restricted to the application of covers to cans or other objects of circular or rectangular configuration. Thus, for example, the principles of the invention may be applied where it is desired to heat narrow bands of various configurations enclosing an area in which heating is to be avoided. The invention is not to be restricted to objects having a square or circular surface to be heated as my coil construction may be easily modified for purposes of heating objects of different or irregular shape as those skilled in the art will readily understand.

Furthermore, it will be apparent that the respective end portions of the inner and outer inductor plate portions 20 and 21 may be referred to as terminal portions adapted to be connected to the respective terminals of a source of high frequency current. This connection may, of course, be made in any suitable manner and I do not intend to restrict myself to the use of the end portions 25 of tube portions 24 for this purpose. Current may also be applied to the lugs 15, 16 in any suitable manner. Thus, for example, it is within the purview of the invention to connect several inductors in series or parallel in order that several objects may be heated at once.

While my invention has been described in detail with respect to certain preferred examples, it will be understood by those skilled in the art after understanding the invention that various other changes and modifications may be made without detracting from the spirit and scope of the invention and it is intended, therefore, in the appended claims to cover all such changes and modifications.

What is claimed as new and desired to be secured by Letters Patent is:

1. Method for inductively heating a narrow border zone surrounding an area on an object without substantial heating of the area within

such zone which method comprises placing in closely spaced relation to said zone an inductor shaped to provide a conductive path from one terminal of a source of high frequency current along such border zone substantially around said area, the conductive path then reversing and extending along the border zone in the reverse direction back around said area to the other terminal of the source of high frequency current, the outgoing and return conductive paths being closely spaced and one of same substantially surrounding the other, and then passing sufficient high frequency current from such source through the inductor to cause said zone to be rapidly heated by reason of the resulting electromagnetic field of high flux density along said zone, while said area surrounded by said zone remains relatively cool.

2. In induction heating apparatus, an inductor having the respective end portions thereof adapted for connection to two closely spaced terminals of a source of high frequency current, said inductor being constructed and arranged to form an inner loop portion extending from one terminal around in a loop formation back to a point near such terminal and from there extending in the reverse direction to form an outer loop portion surrounding and closely spaced with respect to said inner loop portion and extending back around in a like loop formation to the other terminal, said inductor portions including a conduit adapted for passage of cooling fluid therethrough.

3. In apparatus for inductively heating portions of an object having a central area where substantial heating is undesired bordered by a surrounding area to be effectively heated, an inductor comprising closely spaced inner and outer loop-like inductor plate portions, each loop-like portion having a terminal at one end thereof adapted for connection to a source of high frequency current, the inductor being adapted to be positioned with the region between said inner and outer inductor plate portions extending along adjacent said bordering area to be heated, the other ends of said inductor plate portions being conductively connected together and closely spaced with respect to said terminals, the connections being so arranged that the current will flow in opposite directions, respectively, in said loop-like portions whereby passage of current through said inductor plate portions induces an electromagnetic field of relatively high flux density in said bordering area as compared with said central area.

4. In induction heating apparatus, an inductor for heating a border zone surrounding an area on an object without substantial heating of the

area within such zone, said inductor comprising a ribbon-like metal strip shaped to extend flatwise along such zone from one terminal of a source of high frequency current in a loop-like formation back to a point adjacent such terminal and there joined to another similar loop-like formation which extends around back to the other terminal of the source of high frequency current adjacent the first terminal, the ribbons of said loop formations being positioned in closely spaced edge-to-edge relationship, and being connected to respectively conduct current in opposite directions along such zone whereby a relatively high flux density is provided along therebetween and adjacent said zone, as compared with the flux density over the area surrounded by such zone.

5. In induction heating apparatus, an inductor for heating a border zone surrounding an area on an object without substantial heating of the area within such zone, said inductor comprising a ribbon-like metal strip shaped to extend flatwise along such zone from one terminal of a source of high frequency current in a loop-like formation back to a point adjacent such terminal and there joined to another similar loop-like formation which extends around back to the other terminal of the source of high frequency current adjacent the first terminal, the ribbons of said loop formations being positioned in closely spaced edge-to-edge relationship, and being connected to respectively conduct current in opposite directions along such zone whereby a relatively high flux density is provided along therebetween and adjacent said zone, as compared with the flux density over the area surrounded by such zone, and a metal cooling fluid conduit extending along said loop formations and secured to the surfaces thereof opposite the surfaces which are adapted to face the work.

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