Feb. 1, 1949. N. E. FUCHS 2,460,687

INDUCTION HEATER

Filed March 31, 1945

Fig. 1

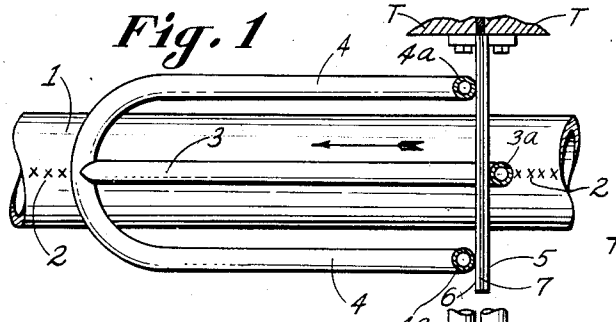


Fig. 2

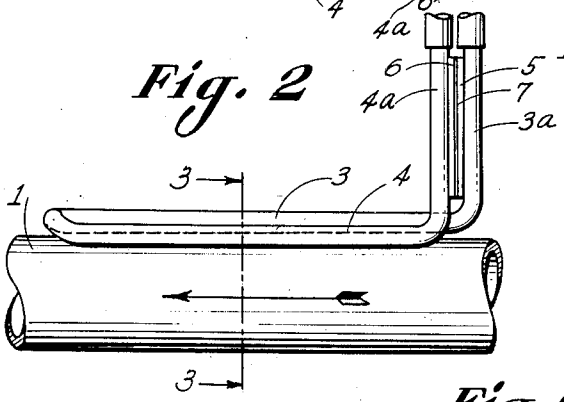


Fig. 3

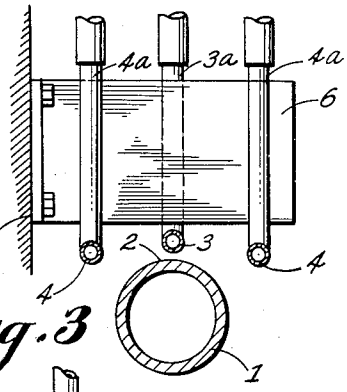


Fig. 6

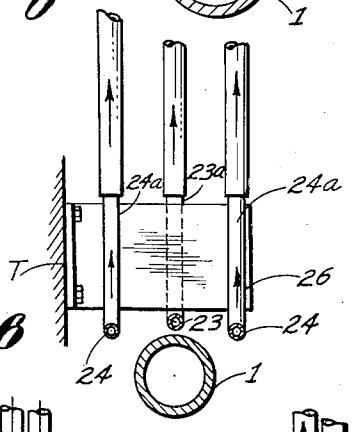


Fig. 4

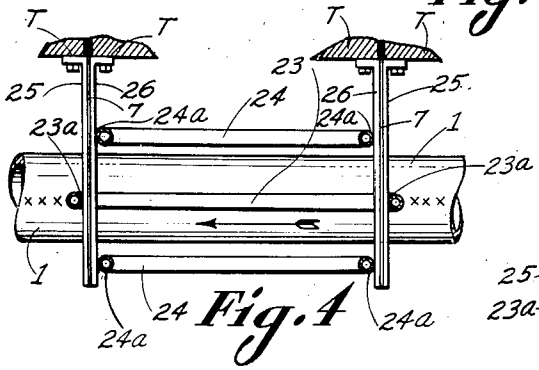


Fig. 5

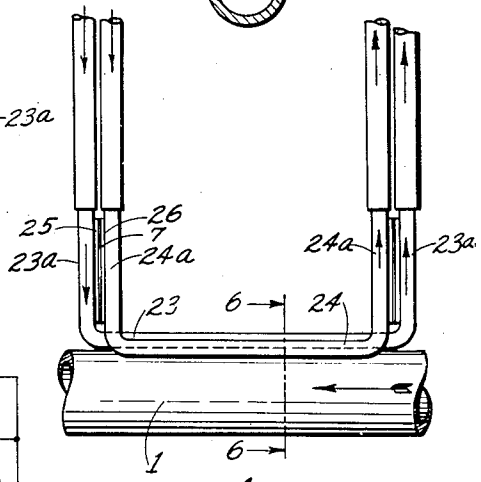
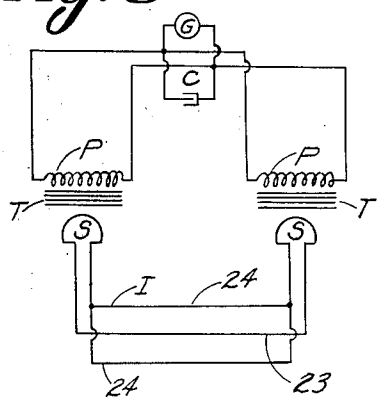


Fig. 8



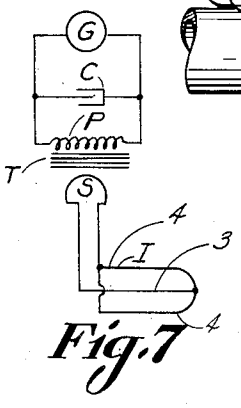


Fig. 7

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INDUCTION HEATER

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Application March 31, 1945, Serial No. 585,973

3 Claims. (Cl. 219—13)

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The present invention relates to the art of induction heating and is particularly concerned with new induction heaters for heating elongated, narrow portions of a metal article.

Heretofore, induction heaters have been proposed for heating elongated portions of metal articles but the heated zone was wider than was desired in many cases. The present invention makes it possible to localize the heating in a comparatively narrow zone and yet to obtain high electrical efficiency. The possibility of localizing the heating permits the production of desired physical properties in the heated metal and prevents the development of undesired properties in the metal in the parts of the article adjacent to the heated zone. Also, this invention makes it possible to use transformers which are small and easy to design, build and handle, and highly efficient as compared with larger transformers required by prior induction heaters of comparable heating capacity.

The present invention will be better understood by those skilled in the art from the following description and the drawings which form a part of this specification and in which,

Figure 1 is a top plan view of an induction heater of the present invention;

Fig. 2 is a side elevational view of the heater of Fig. 1;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2, showing parts in elevation;

Fig. 4 is a top plan view of another modified form of the invention;

Fig. 5 is a side elevational view of the apparatus of Fig. 4;

Fig. 6 is a sectional view taken on line 6—6 of Fig. 5 showing certain parts in elevation;

Fig. 7 shows a wiring diagram which may be used with the apparatus of Figs. 1 to 3, inclusive; and,

Fig. 8 shows a wiring diagram which may be used with the apparatus of Figs. 4 to 6, inclusive.

Figs. 1, 2 and 3 show an elongated metal article, specifically tube 1, which has a longitudinal weld 2 to be inductively heated. It will be understood that the tube 1 may move endwise relative to the heater as indicated by the arrow.

The induction heater of Figs. 1 to 3 is U-shaped in top plan view and comprises a main, elongated, straight conductor 3 which at one end is joined to the mid-portion of a U-shaped supplemental conductor having legs 4 which are parallel to each other and also to main conductor 3. The adjacent ends of conductors 3 and 4 are bent at right angles as at 3a and 4a.

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The end portion 3a constitutes a terminal which is electrically connected thru member 5 to one side of the secondary of a transformer, and the portions 4a constitute terminals which are similarly connected thru member 6 to the other side of the transformer secondary. Insulating means 7 is disposed between members 5 and 6. Conductors 3 and 4 are preferably metal tubes thru which a cooling fluid, such as water, may flow for controlling their temperatures. The wiring diagram of the apparatus of Figs. 1 to 3 is indicated in Fig. 7, where G is a high frequency generator, C is a condenser, T is a transformer, P is the primary winding of transformer T, S is the secondary winding of that transformer and I is the induction heater of Figs. 1 to 3, inductively heating the longitudinal weld 2 of the tube 1. As is better shown in Figs. 2 and 3, the heater is disposed along the tube or cylinder 1 with conductor 3 closely adjacent to the longitudinal seam 2 of the tube and with conductors 4 spaced several times as far away from tube 1 as is tube 3. In Fig. 3 a plane drawn thru the longitudinal centers of conductors 4 lies between the tube 1 and the longitudinal center line of conductor 3, and the center of conductor 3 lies outside of that plane. The conductors 3 and 4 lie in the surface of an imaginary cylinder of greater radius than the tube or cylinder 1. By reason of this relative spacing of conductors 3 and 4 from tube 1, and the fact that the current flowing in conductor 3 is twice as much as that flowing in either of conductors 4, it will be understood that the heating of tube 1 immediately adjacent to conductor 3 will be considerably greater than it will be on the lines closest to conductor 4. Preferably, the spaces between conductor 4 and tube 1 should be from four to eight times the space between conductor 3 and tube 1. A heater constructed and positioned relative to a tube substantially as shown in Figs. 1 to 3 will heat the tube along a narrow zone measured circumferentially of the tube and the heating will be confined closely to the metal of the weld 2. By properly controlling the heating effect the weld metal may be annealed, normalized, or various other physical properties traceable to heat treatment may be produced in it, while at the same time the heating effect on the remainder of the tube and particularly along the lines adjacent to conductor 4 will not be appreciable.

Figs. 4, 5 and 6 show an induction heater which may be operatively associated with two transformers according to the manner shown in Fig.

8. In those figures the main conductor 23 corresponds generally to conductor 3 of Figs. 1 to 3 but both of its ends are bent at a right angle to the main portion thereof as at 23*a* and are operatively connected to terminals 25 which are joined to secondaries of each of two transformers T (Fig. 8). The return conductors 24 are similar to conductors 4 of Figs. 1 to 3 but, at their ends, are bent at right angles to the body portion, as at 24*a*, are electrically connected to terminals 26 which are connected to the secondaries of transformers T, and are not directly connected to the main conductor. Terminals 25 and 26 are insulated from each other by insulation 7. The wiring diagram of Fig. 8 shows that the main conductor 23, the return conductors and the two transformers S are connected in series. Thus the voltage from one transformer supplements that from the other even when the two voltages are not exactly in phase. As a result, each transformer may be much smaller than a single transformer would have to be for the same power and these small transformers will be easy to design, build and operate. Furthermore, the electrical efficiency of these small transformers and this arrangement of them and the conductors constitutes a system which is much more efficient electrically than if a single transformer were used.

While the heater of Figs. 1 to 3, inclusive, is quite efficient and effective, it tends to heat non-uniformly the metal adjacent to conductor 3, that is, the heating effect is greater near terminals 5 and 6 than it is at the opposite end thereof due to the fact that the effective field drops to a low value in the vicinity of the junction of conductor 3 with conductor 4. This is not objectionable in the progressive heating of a relatively moving article but may be objectionable in heating an article while the heater and article are stationary. However, in the apparatus of Figs. 4 to 6 there is a uniform field for substantially the full distance between each set of terminals 25 and 26, that is, for the full length of conductors 23 and 24 and this uniformity of field results in uniformity of heating of the tube adjacent to conductor 23. In other words, the flux linkage at the junction of conductors 3 and 4 is low compared with the flux linkage at other parts of the heater of Figs. 1 to 3, while in the apparatus of Figs. 4 to 7 the flux linkage is uniform for the full length of conductors 23 and 24. Thus, this apparatus may be used for either progressive or stationary heating.

Altho the return legs 4 of Figs. 1 to 3, and 24 of Figs. 4 to 6 are shown as lying on opposite sides of main legs 3 and 23 respectively, it will be understood that they may be located on the same side of the main leg if desired. Nor is it essential that the straight portions of the return conductors or legs 4 and 24 should be disposed exactly parallel to the straight portions of the main conductor, altho it is preferable to maintain the return conductors parallel to the part of the main conductor which is adjacent to the article being heated.

Having thus described my invention so that

others skilled in the art may be able to understand and practice the same, I state that what I desire to secure by Letters Patent is defined in what is claimed.

What is claimed is:

1. An induction heater comprising first and second associated transformer secondary terminals, third and fourth associated transformer secondary terminals, a main conductor having a straight portion and return conductors having straight portions beside the straight portion of said main conductor, said main conductor being mechanically and electrically connected at one end to said first transformer terminal and at the other end to said third transformer terminal, said return conductors each being connected at one end to said second transformer terminal and at the other end to said fourth transformer terminal.

2. An induction heater comprising a main conductor having terminals at each end, return conductors having terminals at each end, said return conductors each being positioned with one end terminal adjacent one end terminal of the main conductor and the other end terminal adjacent the other end terminal of the main conductor, and secondary windings of two transformers operatively connecting each main conductor terminal to the adjacent return conductor terminals, said secondary windings being connected in series to the main conductor and said return conductors being connected in parallel as a unit which unit is also connected in series with said secondary windings.

3. An induction heater comprising a main conductor, return conductors, and secondary windings of two transformers connecting said conductors in series parallel, each secondary winding having a pair of terminals, one terminal of one winding being connected to one end of the main conductor, one terminal of the other winding being connected to the other end of the main conductor and each of the return conductors being connected at one end to one of said remaining terminals and at the other end to the other of said remaining terminals.

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