

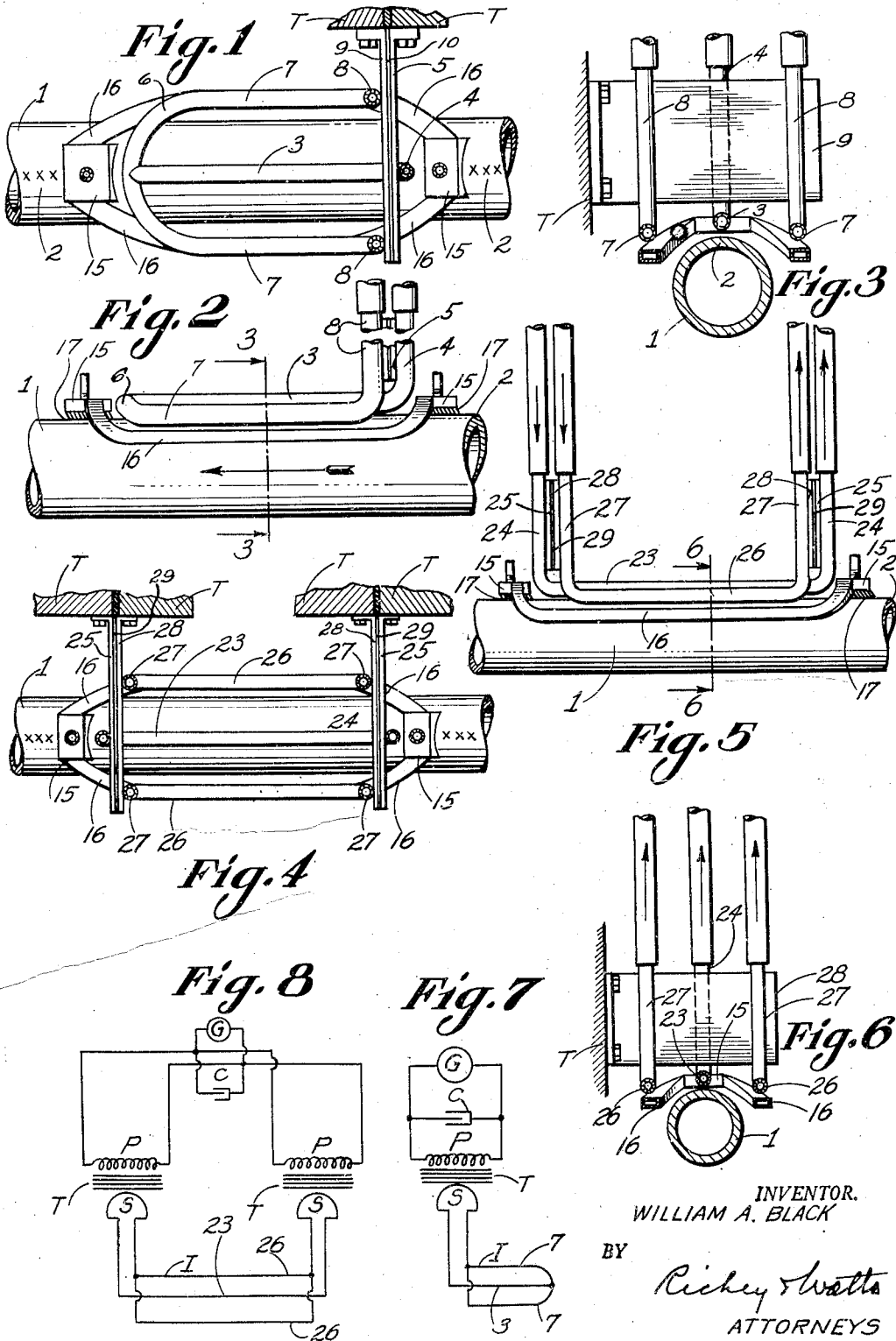
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APPARATUS FOR AND METHOD OF INDUCTION HEATING

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APPARATUS FOR AND METHOD OF
INDUCTION HEATING

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The present invention relates to the art of induction heating and is particularly concerned with a new heater for and method of induction heating an elongated metal article and confining the heating effect to an extremely narrow portion of the article.

The copending application of Norbert E. Fuchs, Ser. No. 589,973 filed March 31, 1945 (now Patent No. 2,460,687, dated Feb. 1, 1949), describes and claims new induction heaters which are capable of heating rather narrow portions of a metal article. Those heaters comprise main conductors which have portions disposed closely adjacent to the article to be heated and other conductors so constructed and positioned relative to the article being heated as to serve as return conductors. Altho the devices of that application have proven to be quite satisfactory in use, I have discovered that it is possible to provide even better return paths for the induced current and to localize the heating effect to a smaller portion of the article being heated. Thus, by my invention I obtain greater efficiency and a narrower zone of heating in the article being heated. The present invention and the foregoing and other advantages will be better understood by those skilled in the art from the following description and the drawings which accompany and form a part of this specification and in which:

Figure 1 is a top plan view of one form of apparatus embodying the present invention;

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

Figure 3 is a cross-sectional view taken on line 3-3 of Fig. 2;

Figure 4 is a top plan view of a modified form of the present invention;

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

Figure 6 is a cross-sectional view taken on line 6-6 of Fig. 5;

Figure 7 is a diagram showing an electrical circuit which may be employed with apparatus of Figs. 1, 2 and 3; and

Figure 8 is a diagram showing an electrical circuit which may be employed with the apparatus of Figs. 4, 5 and 6.

The apparatus of Figs. 1, 2 and 3 is shown in operative relation with respect to an elongated tube 1 having a longitudinally extending weld 2 of short circumferential length which is to be heated to anneal it, or to produce physical properties therein which are obtainable by heating to various temperatures.

In Figs. 1 to 3 the main conductor comprises

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a straight portion 3 and an end portion 4 at substantially right angles thereto for attachment to one side of the secondary of a transformer (not shown) thru member 5. The return conductors are in the form of a U-shaped member comprising a mid-portion 6 connected to one end of the main conductor 3 and legs 7 which include straight portions disposed parallel to and preferably on opposite sides of the straight portions 3 of the main conductor. These legs have right angled end portions 8 which are connected to the other side of the secondary of the transformer thru member 9. The connecting members 5 and 9 are positioned close to each other but are maintained out of contact with each other by electrical insulating member 10 disposed therebetween.

It will be noted from Fig. 3 that main conductor 3 is disposed parallel and closely adjacent to the weld 2 of tube 1 and that the straight portions of legs 7 are disposed at greater distances away from tube 1. These portions of legs 7 are preferably from four to eight or more times as far away from the article being heated as is the straight portion 3 of the main conductor.

A closed loop is disposed between the conductors 7 and tube 1, and comprises end members 15 and side members 16. The end members 15 extend transversely of the long axis of tube 1 and are disposed near to the ends of main conductor 3, and may, and preferably do, include suitable brushes 17 to make electrical contact with the tube. These two end members 15 are connected by side members 16 which lie between the tube 1 and the legs 7 of the return conductors.

The circuit shown in Fig. 7 may be used with the apparatus of Figs. 1 to 3. In this figure G is a high frequency generator, C is a condenser, T is a transformer, P is the primary winding of the transformer, S is the secondary winding of the transformer and I is the heater consisting of the main and return conductors of Figs. 1 to 3.

In Figs. 4, 5 and 6 the main conductor has a straight portion 23 which may be positioned close and parallel to the weld 2 of tube 1. The main conductor has right angled portions 24 extending from each end thereof and connected to one side of the secondary of each of two transformers (not shown) thru members 25. The return conductors comprise straight portions 26 each having right angled end portions 27 which are connected to members 28 and thence to the other sides of the secondaries of the transformers. Electrical insulating material 29 serves to prevent short circuiting between members 25 and 28. The portions 26 of the return conductors

are preferably disposed, as indicated, parallel to each other and to portion 23 of the main conductor and on opposite sides of the latter. However, it will be understood that both portions 26 may be on the same side of main conductor portion 23 if desired.

A closed loop similar to that shown in Figs. 1 to 3 and described in connection therewith is operatively associated with the main and return conductors of Figs. 4 to 6 and further description thereof at this point is believed to be unnecessary.

Fig. 8 shows a circuit which may be used with the apparatus of Figs. 4 to 6. In this figure the high frequency generator G is in a circuit which includes a condenser C and the primary coils P of two transformers T. The secondaries of these two transformers are connected with the heater I which includes the main conductor 23 and the return conductors 25. As here shown, the main and return conductors are connected in series parallel.

It will be understood by those skilled in the art that current flowing in the main conductors will be substantially twice the current flowing in the secondary conductors, and that this current flow in the main conductor will induce current flow in tube 1 in the zone of weld 2. Since the main conductor 3 carries twice the current of each of the return conductors 7 and since it is closer to the article than are the return conductors, there is a strong induced current in the articles directly under the main or central conductor. It is this induced current which is largely responsible for the heating of the article. The brushes 15 make electrical contact with the article at each end of the main conductor. These brushes are connected by a pair of auxiliary conductors 16 which serve as a branched return path for the current induced in the article flowing longitudinally along the seam 2. The current flow through the article longitudinally along the seam 2 is reinforced, because the current has a return path through the auxiliary conductors 16, and the auxiliary conductors or loops 16 are placed in inductive relation to the conductively connected return conductors 7, between the return conductors 7 and the tube 1. Furthermore, the field created by the current in the loops 16 in conjunction with the field created by the current of the return conductors 7 serves to restrict the field induced by the main conductor 3 to the area directly under the main conductor 3. This sharply localizes the heating effect and produces greater heat where it is needed with less current than the prior art devices. Furthermore, since the loops 16 are made of low resistance material, they provide a low resistance return path for the current induced at the seam and thereby increase the electrical efficiency of the heater unit making it possible to obtain the same extent of heating with less expenditure of electrical energy or a greater degree of heating with the same energy. The location of the brushes 15 adjacent the ends of the main conductor is an important feature of my invention because with the brushes in this location the auxiliary loops 16 can act as a return for the current induced in the article at the seam without that current having to pass through any appreciable portion of the article itself other than the seam. This greatly increases the effectiveness of the device particularly where the article offers high resistance to current flow. The use of two transformers makes it possible to use smaller transformers

for the same amount of power that would be furnished by a single transformer, and these smaller transformers are easier to design, build and operate than a larger transformer having the same power output.

The device of Figs. 1 to 3 affords a substantially uniform field thruout the length of straight portion 3 of the main conductor except in the region of its attachment to the return conductors. This slight variation in field is not objectionable when there is relative movement between the heater and the article being heated but it might be objectionable in stationary heating, that is, where there is no relative movement between the heater and article. However, in the apparatus of Figs. 4, 5 and 6 the field is substantially uniform for the full length of the straight portion of main conductor 23 and such apparatus may be used for either progressive or stationary heating.

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 a main conductor having a straight portion and a U-shaped return conductor including a mid-portion and legs having straight portions substantially parallel to the straight portion of said main conductor, one end of the main conductor being connected to said mid portion of the return conductors, means connecting the remaining end of said main conductor to one terminal of a transformer, means connecting both ends of the return conductor to the other terminal of such transformer, and a conductive loop having ends disposed near the ends of the straight portion of said main conductor and having brushes engageable with an article to be heated, and sides extending substantially parallel to the straight portions of said return conductor legs in inductive relation thereto and adapted to lie between them and an article to be heated.

2. An induction heater comprising a relatively narrow main article heating conductor having a portion adapted to be disposed close to the article to be heated, return conductors substantially parallel to and spaced from said main heating conductor and adapted to be spaced from the article, and an auxiliary conductor having brushes adapted to make electrical contact with the article to be heated at points adjacent the ends of said main conductor portion whereby the current induced in the article flows in the auxiliary conductor, said auxiliary conductor having branches disposed adjacent a plurality of said return conductors and in inductive relation thereto so that the field created by the current induced in the article co-operates with the field created by the current in the return conductor to delimit the effective field of the main conductor.

3. An induction heating apparatus for selectively heating a substantially straight, elongated, narrow area along the surface of an article composed of an electrical conducting material, said apparatus comprising current conductors with substantially straight parallel portions substantially the length of the area to be heated, adapted to be disposed in inductive relation substantially parallel to the area of the article to be heated; externally thereto, an auxiliary conductor positioned substantially parallel to said current conductors in inductive relation thereto at the side of the current conductors intended to confront

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the article to be heated, having a pair of brushes electrically connected thereto spaced apart substantially the length of the area to be heated and adapted to contact the surface of the article at the ends of such area for completing a circuit with a portion of the article comprising such an elongated area, to carry current induced in the article by said current conductors.

4. An induction heating apparatus for selectively heating a substantially straight, elongated, narrow area along the surface of an article composed of an electrical conducting material, said apparatus comprising a main current conductor having a substantially straight portion, return current conductors on each side thereof, substantially parallel thereto, said conductors being adapted to be disposed in inductive relation substantially parallel to the area of the article to be heated, externally thereto, an auxiliary conductor positioned substantially parallel to said current conductors in inductive relation thereto at the side of the current conductors intended to confront the article to be heated, having a pair of brushes electrically connected thereto spaced apart substantially the length of the area to be heated and adapted to contact the surface of the article at the ends of such area for completing a circuit with a portion of the article comprising such an elongated area, to carry current induced in the article by said current conductors.

5. Apparatus as in claim 4 wherein the auxiliary conductor is in the form of an elongated loop with one side along one of the return conductors in inductive relation thereto and the other side along the other of the return conductors in inductive relation thereto.

6. The method of localizing the heating effect of an induction heater of the type having a main

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heating conductor and a return conductor, said method comprising the steps of bringing the main heating conductor substantially parallel to and in inductive relation to a linear portion of a metallic article which is to be heated in said portion, making electrical contact with said article at the ends of said linear portion and returning a current induced in said linear portion externally of the article along a path between said contact points in inductive relation to the return conductor and between the return conductor and the article to be heated, thereby causing the field from said external current path to reinforce that of the return conductor, and delimiting the field of the main conductor by means of said reinforced return conductor field.

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REFERENCES CITED

20 The following references are of record in the file of this patent:

UNITED STATES PATENTS

	Number	Name	Date
25	2,020,276	Crawford	Nov. 5, 1935
	2,086,305	Sessions	July 6, 1937
	2,125,316	Ronci	Aug. 2, 1938
	2,144,377	Kennedy	Jan. 17, 1939
	2,144,378	Kennedy	Jan. 17, 1939
30	2,223,970	Stansel	Dec. 3, 1940
	2,247,979	Von Tannenberg	July 1, 1941
	2,299,934	Sherman et al.	Oct. 27, 1942
	2,383,992	Sherman	Sept. 4, 1945
35	2,426,053	Roberds	Aug. 19, 1947

OTHER REFERENCES

Ser. No. 387,342, Gumprecht (A. P. C.), pub. June 1, 1943.