July 10, 1956

W. B. ALBRECHT

2,754,397

MULTIPLE PLATE WORK COIL WITH OFFSET EDGES FOR INDUCTION HEATING

Filed May 22, 1953

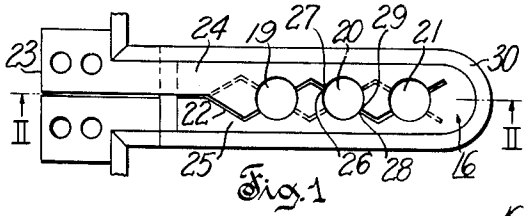


Fig. 1

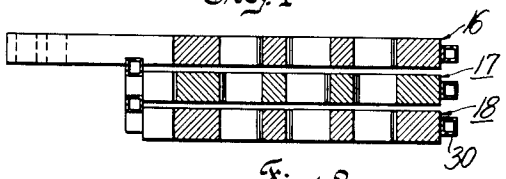


Fig. 2

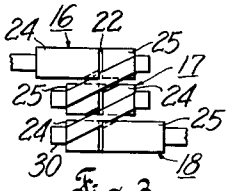


Fig. 3

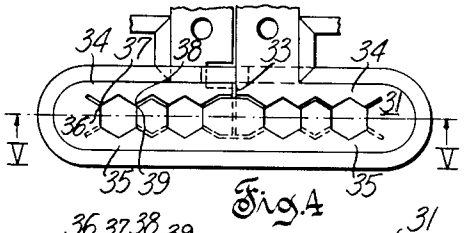


Fig. 4

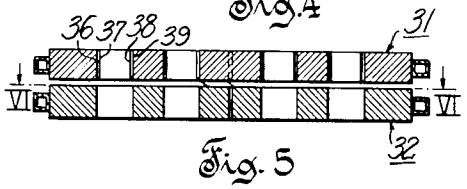


Fig. 5

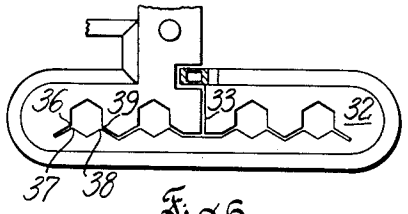


Fig. 6

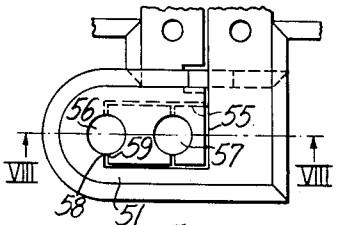


Fig. 7

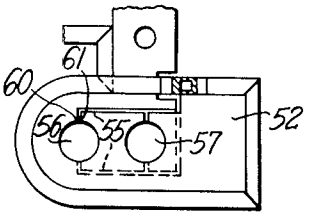


Fig. 9

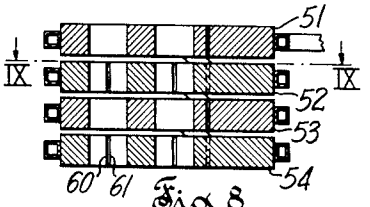


Fig. 8

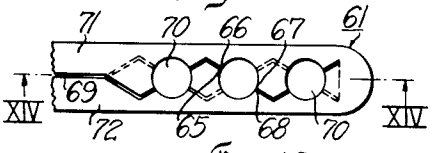


Fig. 10

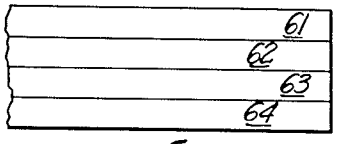


Fig. 11

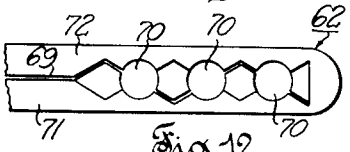


Fig. 12

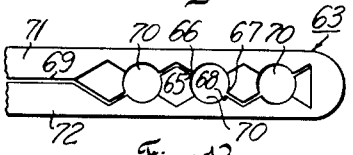


Fig. 13

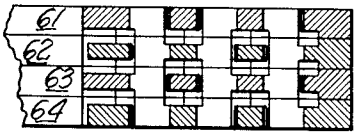


Fig. 14

Inventor
William B. Albrecht
by Joseph E. Kerwin
Attorney

United States Patent Office

2,754,397

Patented July 10, 1956

2,754,397

MULTIPLE PLATE WORK COIL WITH OFFSET EDGES FOR INDUCTION HEATING

William B. Albrecht, Wauwatosa, Wis., assignor to Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Application May 22, 1953, Serial No. 356,667

5 Claims. (Cl. 219—10.79)

This invention relates in general to work coils for high frequency induction heating of a workpiece and more particularly to an improved work coil of the type having each turn of the work coil formed from a flat plate.

The term workpiece as commonly used in the induction heating art and as used here refers to an object which is heated by eddy currents which flow in the object, the eddy currents being produced through induction by a high frequency current. The inductor which carries the high frequency current is termed the work coil.

The utilizing of flat plates to form conductor turns of a work coil is well known and has proved successful in the heat treating of various kinds of objects. This type of work coil is advantageous because it is simple to manufacture, mechanically strong and dissipates heat rapidly.

In the construction of this type of work coil each turn is usually made from a separate flat plate with each plate provided with an aperture or a group of apertures for receiving the workpiece to be heated. For high heating efficiency it is necessary that the work coil and the workpiece be closely coupled together, that is in closely spaced relationship to each other, therefore, the size and shape of the apertures depend on the size and shape of the workpiece to be heated.

In order to have a continuous path for the high frequency current, the plate is further provided with a slot or a cut which extends from the peripheral surface of the plate and intersects the aperture or apertures thereby forming a single conductor turn having first and second leg members to allow the current to flow from the source through the leg member of the conductor on one side of the slot and return to the source through the leg member of the conductor on the other side of the slot. If the work coil is to have a number of turns the plates are assembled with corresponding workpiece receiving apertures in axial alignment forming a passage and the plates connected together electrically, either in series or in parallel.

When the work coil is energized the current flows through each plate but has a tendency to concentrate more at the edges formed by the sides of the slot intersecting the wall of the aperture causing portions of the workpiece nearest these edges to become overheated. The overheated portion of the workpiece is commonly referred to as a hot spot. Work coils constructed from the teaching of the prior art are assembled with these edges aligned along a common axis which results in the workpiece having a number of hot spots substantially in a straight line. This alignment of hot spots adversely changes the metallurgical characteristics of the workpiece because of the intense heat concentration along a relatively narrow strip of the workpiece.

To overcome this disadvantage, it is proposed according to the present invention to offset in adjacent plates the corresponding edges formed by the intersection of the slot with each aperture, thereby providing for more uniform heat distribution in the workpiece. In other words, when the plates are assembled with corresponding

workpiece receiving apertures in axial alignment these formed edges, instead of lying along a common line are offset perimetrically with respect to each other. By offsetting these edges perimetrically in adjacent plates the areas previously subject to overheating are now more widely spaced apart, thus allowing the heat to dissipate more evenly. Further, by offsetting these edges any adverse change in the metallurgical characteristics of that portion of the workpiece which is nearest the edge will not appreciably affect the overall mechanical characteristics of the workpiece.

It is therefore an object of the present invention to provide an improved work coil for uniformly heating a workpiece by high frequency induction.

Another object of the present invention is to provide an improved work coil in which points of unequal heating, caused by edges formed by the intersection of a slot and the apertures, are offset so that these points of unequal heating are more widely spaced apart.

Objects and advantages other than those mentioned above will be apparent from the following description when read in connection with the drawing in which:

Fig. 1 is a plan view showing a work coil embodying the present invention;

Fig. 2 is a sectional view of the work coil shown in Fig. 1 taken along the line II—II;

Fig. 3 is an end view of the work coil shown in Fig. 1;

Fig. 4 is a plan view of a T-shaped work coil embodying the present invention;

Fig. 5 is a sectional view of the T-shaped work coil shown in Fig. 4 taken along the line V—V;

Fig. 6 is a sectional view of the T-shaped plate shown in Fig. 5 taken along the line VI—VI;

Fig. 7 is a plan view of an L-shaped work coil embodying the present invention;

Fig. 8 is a sectional view of the L-shaped work coil shown in Fig. 7 taken along the line VIII—VIII;

Fig. 9 is a sectional view of the L-shaped work coil shown in Fig. 8 taken along the line IX—IX;

Fig. 10 shows another modification of the work coil shown in Fig. 1;

Fig. 11 is a view in elevation of the coil shown in Fig. 10.

Figs. 12 and 13 are plan views of the second and third plates, respectively, of the work coil shown in Fig. 10; and

Fig. 14 is a sectional view of the work coil shown in Fig. 10 taken along the line XIV—XIV.

Referring to the drawing the work coil shown in Fig. 1, illustrating the preferred embodiment of the present invention, comprises similar plates 16, 17 and 18 which are made of electrically conductive material. Each plate is provided with three similar cylindrically shaped apertures 19, 20 and 21 and a slot 22 which extends from the peripheral surface 23 and intersects each aperture to cause the plate to form a conductor turn having first and second leg members 24 and 25, respectively, which are disposed on opposite sides of slot 22 and are integrally joined adjacent the end of slot 22. The unjoined end of each leg member is adapted to be connected to a suitable source of high frequency current. Slot 22 intersects each aperture resulting in a plurality of edges being formed. As shown, edges 26 to 29 are formed by slot 22 intersecting aperture 20. Similar edges are formed in a like manner by slot 22 intersecting apertures 19 and 21.

The work coil is formed by assembling the plates in parallel spaced relationship with corresponding apertures in axial alignment, that is, the apertures 19 of the different plates have a common axis, thereby forming a passage for substantially surrounding the workpiece which is to be heat treated. However, in order to offset edges 26 to 29 in adjacent plates around the perimeter of the

passage, plate 17 is inverted with respect to the position of plates 16 and 18, so that leg member 25 of plate 17 is sandwiched between leg members 24 of plates 16 and 18, resulting in these edges 26 to 29 being spaced or offset around the perimeter of the passage.

Any suitable known means may be used to connect the plates together. As shown, the plates are connected electrically in series by means of a conduit 30 which is brazed to the peripheral surfaces of each plate and which serves to mechanically brace the plates and to cool them since conduit 30 may be connected to a source of cooling liquid.

While the work coil illustrated in Fig. 1 shows three plates each provided with a set of three cylindrically shaped apertures of like size, if desired, the work coil could have any suitable number of plates and the plates could be provided with any suitable number of apertures of different sizes and shapes.

The work coil illustrated in Fig. 4 shows another embodiment of the present invention. The work coil of Fig. 4 comprises two T-shaped plates 31 and 32. Each plate is provided with a plurality of polygonal apertures and a T-shaped slot 33 which cooperates with the apertures to form a conductor turn having pairs of first and second leg portions 34 and 35, respectively, disposed on opposed sides of slot 33 in a manner similar to that described in relation to the work coil of Fig. 1. Leg portions 35 are integrally joined intermediate the ends of the plate.

Slot 33 intersects each aperture to form a plurality of edges 36 to 39. In plate 31 the edges 36 to 39 lie on one side of the plane of symmetry which contains the axes of the apertures while in plate 32 these edges lie on the other side of that reference plane. The plates are assembled with corresponding apertures in axial alignment, thereby forming a passage to substantially surround the workpiece to be heated. The edges 36 to 39 associated with corresponding apertures are therefore offset around the perimeter of the passage.

Fig. 7 illustrates an L-shaped work coil embodying another modification of the present invention. The work coil comprises a plurality of electrically conductive plates 51 to 54, alternate plates being similar. Each plate is provided with apertures 56 and 57 which are cylindrical and a slot 55 which extends from the peripheral surface of the plate and intersects each aperture, thereby forming a conductor turn having first and second leg members disposed on opposite sides of the slot. As shown, slot 55 intersects each aperture only once, thereby forming two edges. The slots are disposed in adjacent plates so as to intersect corresponding apertures substantially on opposite sides of the passage formed when corresponding apertures are in axial alignment. Slot 55 intersects aperture 56 to form a pair of edges 58, 59 in plate 51, and in plate 52 intersects aperture 56 to form another pair of edges 60, 61 which are offset 180° arounds the periphery of the passage from edges 58, 59. The plates are connected together in series in a manner similar to that shown in Fig. 1, but if desired any suitable means for connecting the plates together may be used.

Fig. 10 shows another modification of the present invention applied to a work coil arranged to have a number of parallel paths. The work coil shown in Fig. 10 comprises a plurality of parallel plates 61 to 64 which are similar to the plates of the work coil shown in Figs. 1 and 2. However, in the work coil shown in Fig. 10 the plates are not in spaced relationship with each other but are superposed one on another. As in Fig. 1 edges 65 to 68 formed by the intersection of the slot 69 with each aperture 70 are offset around the perimeter of each passage formed by corresponding apertures. Since adjacent plates are reversed with respect to each other the first leg member 71 of one plate is superposed on the second leg member 72 of an adjacent plate. Further, since the width of each leg member varies in a predetermined manner as determined by the position of the slot 69, part of each leg member overlaps the slot in adjacent plates. In order that the first and second leg members of each plate are not shorted together by the overlapping parts, the latter are made of a smaller thickness than the non-overlapping parts of the leg members which provides a spaced relationship between them. The work coil as formed, then as a plurality of parallel current paths, each path comprising a single plate. The work coil may be energized and cooled in any suitable manner.

Although but a few embodiments of the present invention have been illustrated and described it will be apparent to those skilled in the art that various modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. A work coil adapted to be energized with a high frequency current for heat treating a workpiece by induction, said work coil comprising a plurality of electrically conductive plates, each said plate having an aperture and a slot extending from the peripheral surface of said plate and intersecting said aperture to cause said plate to form a conductor turn having first and second leg members disposed on opposite sides of said slot, each intersection of said slot with said aperture forming a pair of edges on the wall surface of said aperture, said plates being assembled with corresponding apertures in axial alignment defining a passage for substantially surrounding said workpiece to be heated and with each said pair of formed edges in one plate offset around the perimeter of said passage with respect to another pair of similarly formed edges in an adjacent plate, and means for electrically connecting said plates together.

2. A work coil adapted to be energized with a high frequency current for heat treating a plurality of workpieces, said work coil comprising a plurality of electrically conductive plates, each said plate having a plurality of apertures and a slot extending from the peripheral surface of said plate and intersecting said apertures to cause said plate to form a conductor turn having first and second leg members disposed on opposite sides of said slot and integrally joined adjacent the end of said slot, each intersection of said slot with each said aperture forming a pair of edges on the wall surface of said aperture, said plates being assembled in parallel spaced relationship with corresponding apertures in axial alignment defining a passage for substantially surrounding said workpiece, adjacent plates being inverted with respect to each other to cause each said pair of formed edges in one of said adjacent plates to be offset around the perimeter of said passage with respect to each said pair of formed edges in the other said adjacent plate, and means for connecting said plates in series.

3. A work coil adapted to be energized with a high frequency current for heat treating a plurality of workpieces, said work coil comprising a plurality of electrically conductive T-shaped plates, each said plate having a plurality of apertures and a T-shaped slot extending from the peripheral surface of said plate and intersecting said apertures to cause said plate to form a conductor turn having pairs of first and second leg portions disposed on opposite sides of said slot, said pair of second leg portions being integrally joined intermediate the ends of said plate, the intersection of said slot with each said aperture forming a plurality of edges, said plates being assembled in parallel spaced relationship with corresponding apertures in axial alignment forming a passage for substantially surrounding said workpiece, said formed edges in said plates being offset around the perimeter of said passage, and means for connecting said plates in series.

4. A work coil adapted to be energized with a high frequency current to simultaneously heat treat a plurality of workpieces by induction, said work coil com-

prising a plurality of electrically conductive L-shaped plates, each said plate having a plurality of apertures and a slot extending from the peripheral surface of said plate and intersecting said apertures to cause said plate to form a conductor turn having first and second leg portions disposed on opposite sides of said slot and integrally joined adjacent one of said apertures, the intersection of said slot with each said aperture forming a plurality of edges, said plates being assembled with corresponding apertures in axial alignment forming a passage for substantially surrounding one of said plurality of workpieces to be heated, said formed edges associated with corresponding apertures in adjacent plates being offset around the perimeter of said passage, and means for connecting said plates electrically in series.

5. A work coil adapted to be energized with a high frequency current to simultaneously heat treat a plurality of workpieces by induction, said work coil comprising a plurality of electrically conductive plates, each said plate having a plurality of apertures and a slot extending from the peripheral surface of said plate and intersecting said apertures to cause said plate to form a conductor turn having first and second leg members disposed on opposite sides of said slot and integrally joined adjacent the end of said slot, the intersection of

said slot with each said aperture forming a plurality of edges, said plates being assembled with corresponding apertures in axial alignment forming passages for substantially surrounding said plurality of workpieces to be heated, adjacent plates being reversed with respect to each other to cause similar portions of said leg members of said adjacent plates to overlap, said overlapping similar portions having a smaller thickness than the non-overlapping portions to provide for a spaced relation between said overlapping portions, said formed edges associated with corresponding apertures in adjacent plates being offset around the perimeter of said passage.

References Cited in the file of this patent

UNITED STATES PATENTS

2,271,916	Denneen et al.	Feb. 3, 1942
2,394,944	Stanton	Feb. 12, 1946
2,408,229	Roberds	Sept. 24, 1946
2,481,071	Bowlus	Sept. 6, 1949
2,643,325	Body et al.	June 23, 1953
2,689,296	Sabol	Sept. 14, 1954

FOREIGN PATENTS

684,495	Great Britain	Dec. 17, 1952