May 9, 1944. W. C. RUDD ET AL 2,348,361

ADJUSTABLE WORK COIL CONSTRUCTION FOR INDUCTION HEATING

Filed June 24, 1943 2 Sheets-Sheet 1

Fig. 1.

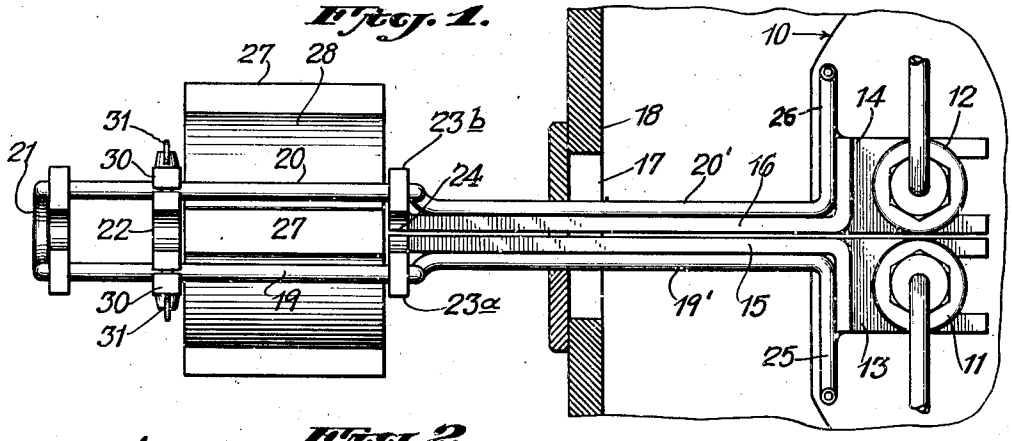


Fig. 2.

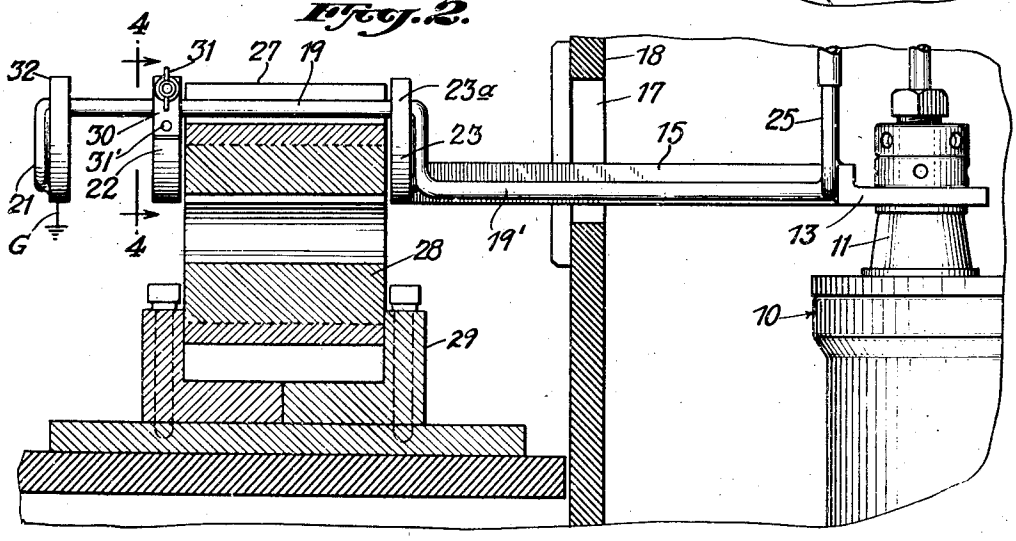


Fig. 3.

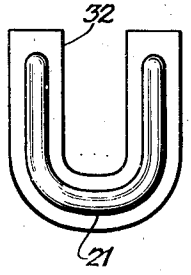
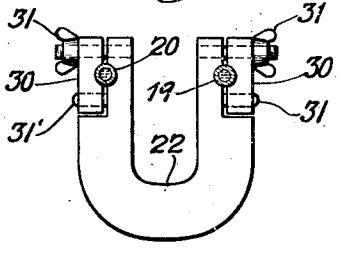


Fig. 4.



INVENTORS
WALLACE C. RUDD.
NATHAN LEVIN.
BY
Ward, Crosby & Neal
ATTORNEYS.

Patented May 9, 1944

2,348,361

UNITED STATES PATENT OFFICE

2,348,361

ADJUSTABLE WORK COIL CONSTRUCTION FOR INDUCTION HEATING

Wallace C. Rudd, Yonkers, and Nathan Levin, Brooklyn, N. Y., assignors to Induction Heating Corp., New York, N. Y., a corporation of New York

Application June 24, 1943, Serial No. 492,042

8 Claims. (Cl. 219—13)

This invention relates to work coil constructions for induction heating purposes.

The invention is particularly adapted among other possible uses, for applying heat by high frequency electromagnetic induction, to braze objects such as milling cutter teeth or other elongated elements, onto slotted body members therefor. The invention in its preferred forms comprises a so-called work "coil" which usually has a single "turn." Such turn may comprise a pair of elongated generally parallel conductor portions for respectively extending along opposite sides of the elongated element to be heated. Other conductor portions are provided for extending generally around the spaces at the two ends of the element to be heated. The latter portions at one end of the coil may be connected to the terminals of a high frequency source of power, whereas at the other end of the coil one of said portions serves to interconnect the parallel portions to complete the active portion of the "turn." The various portions of the turn are thus arranged to provide a heating pattern adapted to embrace and cause efficient heating of all of the surfaces of each tooth member or the like which is to be brazed to a body member, as well as the entire region of the slot on the body member in which the tooth member is to be brazed.

Inasmuch as various milling cutters or the like devices which are to be heated by the apparatus, vary in width, and since it is desirable to bring the various active conductor portions of the work coil turn into close inductive relation at the sides and ends of the region to be heated, it has heretofore been the usual practice to provide interchangeable work coils of different shapes and sizes, in an effort to accommodate various different work pieces. The conductor turn must be accompanied also by a cooling fluid conduit, usually forming an integral part of the turn or brazed thereto in good heat conductive relation. This fact makes it difficult to provide any simple form of work coil adapted to be easily adjusted to receive objects of various dimensions without disconnecting the cooling fluid or without leakage thereof. One of the important features of the present invention is the provision of water-cooled work coils of the type indicated, and of simple inexpensive constructions which may be easily and quickly adjusted in length, thereby avoiding the necessity of using a variety of different coils for heating objects of different sizes. The adjustable features also permit the coil in its extended condition, to be easily applied to work pieces having overhanging portions, so that after the coil is in position it may be adjusted to a shorter length for more closely embracing the work.

Various further and more specific objects, the features and advantages of the invention will appear from the detailed description given below taken in connection with the accompanying drawings which form a part of this specification and illustrate merely by way of example, preferred forms of the invention. The invention consists in 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 top or plan view of one embodiment of the invention;

Figs. 2 and 3, respectively, are side and end views of the same;

Fig. 4 is a view taken substantially along the line 4—4 of Fig. 2;

Figs. 5, 6 and 7, resepctively, are top, side and end views of an alternative embodiment of the invention, and

Fig. 8 is a sectional view taken substantially along line 8—8 of Fig. 6.

In the construction shown in Fig. 1, a high frequency source of power is indicated at 10 in the form of a high frequency transformer having secondary terminals as at 11, 12. A pair of supporting and connecting lugs 13 and 14 for the work coil are shown mounted on the transformer terminals. A pair of rigid conductor bars as at 15, 16, respectively, are connected to or integrally formed with the lugs 13 and 14 and extend out in closely spaced relation from the transformer and through an aperture 17 in an insulation panel board 18.

The active parts of the coil turn may comprise a pair of spaced parallel non-magnetic metal tube portions 19 and 20 interconnected at their outer ends by an integral U-shaped tube portion 21; also U-shaped portions 22, 23*a*, 23*b*, the branches of which are adapted respectively to depend from said parallel portions. The portions 23*a*, 23*b* as shown are formed at the base of the U, with a gap as at 24, and the conductor bars 15, 16 respectively are brazed respectively at each side of this gap. The tube portions 19 and 20 may extend through apertures in the upper ends of the portions 23*a*, 23*b*, thence down along these portions, and then as at 19', 20', back along the conductor bars 15, 16 to cooling fluid inlet and outlet connections as at 25, 26.

As shown in Figs. 1 and 2, the apparatus is arranged for brazing milling cutter teeth as at 27 into slotted body or core members therefor

as at 28. An end view of a portion of one of such milling cutter assemblies is shown in Fig. 8. As shown in Fig. 1, the parallel portions 19 and 20 of the work coil turn are adapted to extend along respectively at each side of a tooth 27, whereas the depending U-shaped portions 22, 23 are adapted to extend down around the spaces at each end of the tooth for applying heat to the body of metal in which the slot is formed. Thus when the high frequency current source is connected, a heating pattern is provided fully embracing the cutter tooth and also the slotted region on the core member to which the tooth is to be brazed. Shim brazing stock may be placed along the walls and bottom of the slot in the steel core or body member and between such walls and the surfaces of the cutting tooth which are to be brazed thereto. Upon then applying the high frequency power, the abutting surfaces of the core and tooth are quickly heated to brazing temperature.

Suitable supporting means may be provided as shown at 29 for retaining the body portion of the cutter in position during the brazing operation.

In practice it will often be found necessary to conduct such brazing operations in rapid succession on milling cutters, etc., of varying widths, i. e., with teeth of one cutter differing in length considerably from others. To meet these conditions without using various different work coils and without interrupting the flow of cooling water through the work coil turn, and to still be able to bring the active portions of the turn all in closely spaced relationship to the work, in accordance with the present invention, the U-shaped member 22 may be adjustable along the parallel portions 19 and 20. As shown in Fig. 4, such adjustment may be effected by providing the upper ends of the branches of the member 22 with clamping blocks as at 30 for embracing the parallel portions 19, 20, the blocks 30 being held in place by clamping thumb screws as at 31 and retaining pins as at 31'. Thus the U-shaped member 22 may be quickly adjusted slidably with respect to the position of portions 23*a*, 23*b*, and thereby accommodate work pieces or assemblies of a wide variety of different widths.

In the particular form shown in Figs. 1–4, the U-shaped member 22 comprises a conductor of relatively large cross section which effectively short-circuits the outer interconnecting end portion 21 of the cooling conduit. The distribution of high frequency current over the surfaces of the various portions of the work coil will be such that the greater part of the current in passing from portion 19 to portion 20 will travel along the surface of the member 22 nearest the work piece and thus the portions of the assembly extending out beyond the member 22 will be substantially inactive electrically, yet providing means permitting circulation of the cooling fluid regardless of the adjustment of the construction.

If desired, the portion 21 of the cooling fluid tube may as shown be brazed to a third U-shaped member 32, which lends rigidity to the outer portions, preventing same from being bent upon adjusting the member 22, etc. Also the U-shaped member 32 may sometimes be used to take the place of U-shaped member 22, upon omitting or removing the latted, as may be required in the case of larger work piece assemblies.

In the form shown in Figs. 1–4, it will be apparent that all of the portions of the work coil turn, except for the U-shaped member 22, either comprise or are brazed to accompanying portions of the cooling fluid conduit. The member 22 may as above indicated be formed with a relatively large cross section, and of a good heat-conductive metal such as copper, and accordingly will be satisfactorily cooled, since its two branches are clamped directly to the cooling fluid conduit portions 19, 20.

In Figs. 5–8, a preferred form of the invention is shown wherein the parallel portions of the work coil turn comprise two pairs of spaced portions as at 40, 41 and 42, 43. These portions are provided with cooperating inter-engaging ridge and groove formations as at 44, thereby providing slidably engaging "ways" so that the pair of members 42, 43 is slidable with accurate alignment, along the pair of members 40, 41. As shown in Fig. 5, portions 42, 43 may be slotted as at 45 to receive clamping thumb screws as at 45' mounted in portions 40, 41. The portions 42, 43 at the outer end of the assembly may be rigidly interconnected by a depending U-shaped portion 46. At the opposite end of the assembly the portions 40, 41 may be rigidly connected to depending portions 47*a*, 47*b* forming another U-portion having a gap 48 at its base (Fig. 8) corresponding to the gap 24 in the example of Fig. 1.

Terminal structure and supporting means for the active portions of the work coil of Figs. 5–8 may be the same as of Figs. 1 and 2, the same reference numerals being used in each case.

The cooling fluid conduit arrangement in Figs. 5–8 may comprise an inlet connection 25, from which the conduit extends as an integral metal tube 50 brazed along conductor bar 15, thence as at 51 up along portion 47*a*. The conduit may then be continued in the form of a flexible hose portion 52, which in turn is connected to a metal conduit 53 extending along slidable portion 43, thence as at 54 down around U-shaped member 46, and then as at 55 back along portion 42 to another flexible hose portion 56, and to a metal conduit portion 57 running down along portion 47*b*, and thence as at 58 along conductor bar 16 to outlet 26. Thus a conduit arrangement is provided extending along all of the active portions of the work coil turn and yet permitting slidable adjustment of the length of the coil without interruption of the flow of cooling fluid.

If the work piece assembly which is to be heated comprises a milling cutter as shown in Fig. 8, the slots into which teeth as at 27 are to be brazed will ordinarily be deeper at one side than at the other. Hence in order to bring the parallel portions of the work coil turn into as close inductive relation as possible to the areas to be brazed at the base of the tooth, the portions 40, 42 are preferably arranged at a higher elevation than portions 41, 43. This may be readily accomplished by forming the U-shaped portions each with one branch longer than the other (Figs. 7 and 8), while still making it possible to support each of the U-shaped portions with its vertical center line parallel to the side walls of the slot.

As shown in Figs. 2 and 6, the middle base portions of the outer U-shaped members 32 and 46 may preferably be grounded as indicated at G. This location of the sole ground connection for the work circuit makes it possible to maintain the two sides of the work coil structure sym-

metrical electrically, regardless of adjustments of its length. The maintenance of these ground connections at points midway between the high frequency power supply terminals, despite the coil adjustments, is important for a number of reasons. The voltage drop across such terminals may amount for example to several thousand volts and since the coil structure is elongated, and portions thereof are closely spaced or are close to the work piece which is usually grounded, there is danger of destructive arcing upon short-circuiting of such closely spaced points, if the ground connection is applied at any other point such as at one of the transformer terminals. With the ground connections as shown, the portions of the work coil closest to the work piece will have the lowest voltage drops with respect to each other and with respect to the grounded work piece. Consequently the danger that arcing will start is considerably reduced and if arcing occurs, its destructiveness is also minimized. Furthermore, with the grounds as shown, the outer portions of the work coils nearest the workman may be safely touched without danger. Adjustment of the length of the coil does not alter these safe conditions.

The apparatus may be used for a variety of operations other than brazing milling cutter teeth in place; for example, the brazing of gear teeth in place, or for selectively heat-treating desired portions of any form of work piece adapted to be embraced by the coil structure.

The U-shaped conductor portions have been referred to above as "depending" from the parallel side portions. It will be understood that this language is intended to be applicable even though the structure is used in an inverted or other position. The term "brazing" as used herein is intended to include similar operations such as soldering.

While the invention has been described in detail with respect to particular preferred examples, it will be understood by those skilled in the art after understanding the invention, that various changes and further modifications may be made without departing 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. An induction heating work coil construction adapted for brazing elongated objects of various lengths, within slotted supporting members therefor, comprising a pair of generally parallel conductor portions for extending along opposite sides of the objects, a pair of generally U-shaped conductor portions, the branches of which are electrically connected with said paralele portions and adapted respectively to depend therefrom down around the regions at each end of the objects, means slidable along said parallel portions for adjustably fixing the branches of one of said U-shaped portions along said parallel conductor portions to accommodate objects of different lengths, the other of said U-shaped portions being divided by a gap at its base, and means for electrically connecting the terminals of a high frequency source of power respectively at each side of said gap.

2. A single turn induction heating work coil construction, comprising a pair of elongated parallel conductor portions, a pair of generally U-shaped conductor portions each with its two branches in depending relation with said parallel portions respectively and electrically connected therewith, one of said U-shaped portions being adjustable along said parallel portions and the other being fixed thereon, one of said U-shaped portions also being divided by a gap at its base, and means for electrically connecting the terminals of a high frequency source of power respectively at each side of said gap, a cooling fluid cavity being formed along said connecting means, along the branches of said last-mentioned U-shaped portion, and along said parallel portions.

3. A single turn induction heating work coil construction for brazing tooth-like elements within the slotted periphery of body members therefor, comprising a pair of parallel conductor portions for extending along opposite sides of the tooth elements, a pair of spaced-apart generally U-shaped conductor portions, each having the ends of its two branches electrically connected respectively to said parallel portions, said U-shaped portions being positioned in planes transverse to said parallel portions and at locations respectively so as to extend around the slotted areas on the opposite sides of the body members at the ends of the tooth elements, one of said conductor portions being divided by a narrow gap, and means for electrically connecting the terminals of a high frequency source of power respectively at each side of said gap.

4. A single turn induction heating work coil construction for brazing milling cutter teeth in slotted body members therefor, comprising a pair of parallel conductor portions for extending along opposite sides of the tooth elements, a pair of spaced-apart generally U-shaped conductor portions, each having the ends of its two branches electrically connected respectively to said parallel portions, said U-shaped portions being positioned at locations respectively so as to extend around the slotted areas on the opposite sides of the body members at the ends of the tooth elements, the branch of each of said U-shaped members which is adapted to be positioned adjacent the advance edge of the cutting teeth being shorter than the other branch to thereby position the one of said parallel portions which is adjacent said edge, closer to the base of the slot than the other of said parallel portions, one of said conductor portions being divided by a narrow gap, and means for electrically connecting the terminals of a high frequency source of power respectively at each side of said gap.

5. A single turn induction heating work coil construction comprising a pair of elongated parallel tubular conductor portions interconnected at one end and adapted to contain circulating cooling fluid, a pair of generally U-shaped conductor portions each with its two branches electrically connected in depending relation with said parallel portions respectively, the one of said U-shaped portions which is nearest said interconnected end being adjustable along said parallel portions and the other U-shaped portion being fixed in position and being divided by a gap, and means for electrically connecting the terminals of a high frequency source of power respectively at each side of said gap.

6. An induction heating work coil construction comprising two pairs of spaced parallel elongated conductor portions, said portions being formed with slidably engaging "ways"

whereby one pair is slidable along the other to adjust the effective length of the coil, clamping means for fixing said portions in adjusted position, a generally U-shaped conductor portion having its two branches respectively fixed and electrically connected to the two portions of one of said pair of elongated conductors, another generally similar U-shaped conductor portion having its branches fixed and electrically connected to the other of said pair of elongated conductors, one of said U-shaped portions being divided by a gap, means for electrically connecting the terminals of a high frequency source of power respectively at each side of said gap, and cooling fluid circulating conduit means extending along said portions, including flexible conduit sections permitting said adjustment.

7. An induction heating work coil construction comprising two pairs of spaced parallel elongated conductor portions, said portions being formed with slidably engaging "ways" whereby one pair is slidable along the other to adjust the effective length of the coil, clamping means for fixing said portions in adjusted position, means including a metal cooling fluid conduit interconnecting one of said pair at one end, means including additional metal cooling fluid conduits for connecting at the other end of the coil, the two parallel portions of the other of said pairs respectively to the terminals of a high frequency source of power, certain of said conduits also being continued to extend along said "ways," and flexible conduits arranged to permit said adjustment while interconnecting all said conduits to form a circulating path for the fluid to and from such terminals.

8. An induction heating work coil construction, comprising a pair of parallel elongated tubular conductor portions, tubular means for interconnecting same at one end to provide a circulating cooling fluid conduit, means for electrically connecting the terminals of a high frequency source of power to the other ends of said portions, a conductor portion for extending transversely of said parallel portions and electrically connecting same, and clamping means at the ends of said latter portion slidably adjustable along said parallel portions.

WALLACE C. RUDD.
NATHAN LEVIN.