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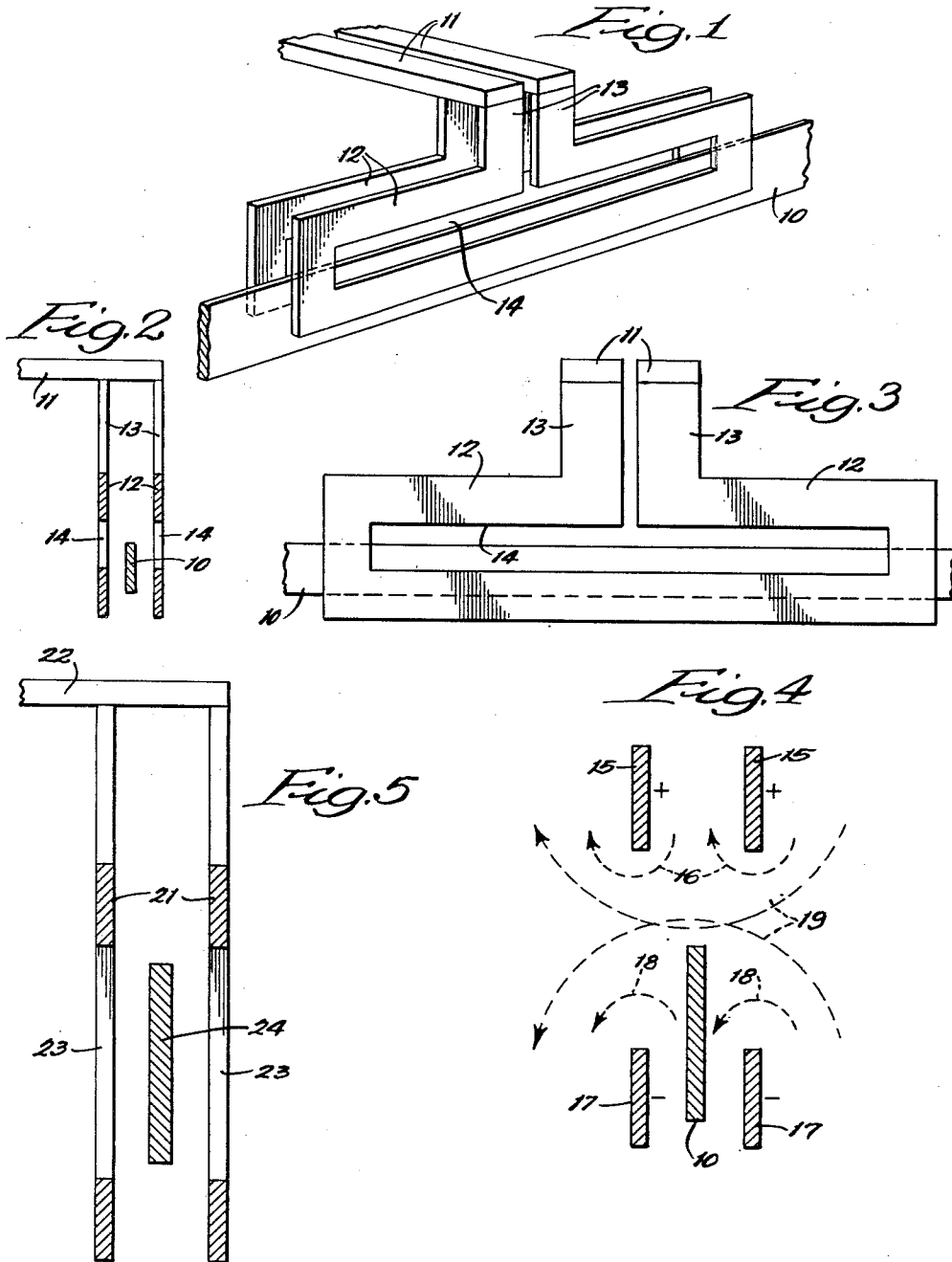
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ELECTRIC HEATING COIL STRUCTURE

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2 Sheets-Sheet 1



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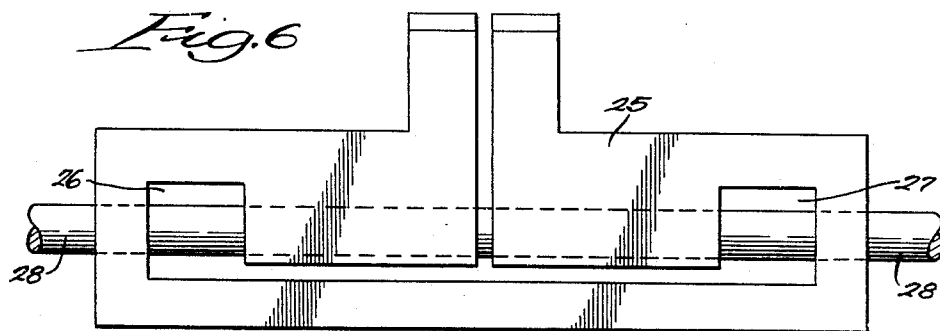
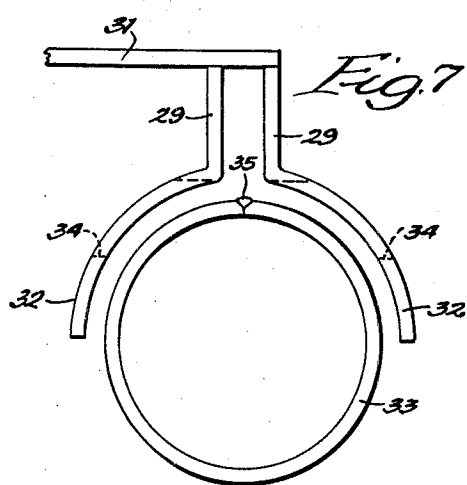
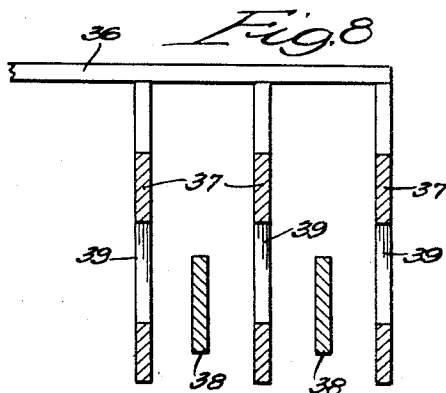
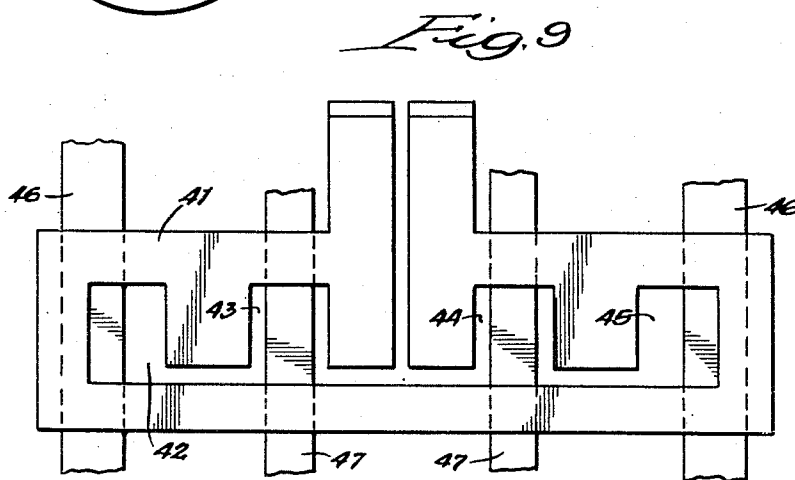
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ELECTRIC HEATING COIL STRUCTURE

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2 Sheets-Sheet 2



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ELECTRIC HEATING COIL STRUCTURE

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5 Claims. (Cl. 219—10.79)

This invention relates to an electric heating coil structure, and more particularly to an induction heating coil structure for heating the edge portion only of a work piece.

In many cases it is desirable to heat only a relatively narrow edge portion of a work piece for hardening, annealing, brazing, welding or the like. For example, it may be desirable to harden the edge portion only of a relatively thin strip or to harden the toothed edge only of a saw blade. It is also desirable in many instances to case harden shafts or tubes, or to effect welding or brazing operations on tubes or on the edge portions of various other shapes.

According to current practices, it is difficult to shape the coils to obtain the desired distribution of the inductive heating effect without creating hot spots where the metal is overheated. It is also difficult to provide a coil capable of sufficient loading to heat the work rapidly enough so that the heating will be confined to the desired edge portions of the work and will not have time to extend the heated area by conduction through the work.

It is one of the objects of the present invention to provide a heating coil structure in which the heating effect is confined to a narrow edge portion only of the work.

Another object is to provide a coil structure whose impedance is low so that the coil is capable of high loading and therefore rapid heating.

Still another object is to provide a coil structure which is extremely simple and inexpensive to manufacture and which can be made in substantially any desired shape to produce any desired distribution of the heating effect.

A further object is to provide a coil structure in which cross-flows between portions of the coil are eliminated to eliminate hot spots.

The other objects and advantages of the present invention may be more clearly seen by reference to the attached drawings, in which:

Figure 1 is a perspective view of one form of coil structure embodying the invention;

Figure 2 is a transverse section through the coil structure of Figure 1;

Figure 3 is a front elevation;

Figure 4 is a sectional view illustrating distribution of flux;

Figure 5 is a view similar to Figure 2 illustrating an arrangement for heating both edges of a strip;

Figure 6 is a front elevation of an alternative coil structure;

Figure 7 is an end elevation of still another coil structure;

Figure 8 is an end elevation of a multiple coil structure, and

Figure 9 is a front elevation of still another coil structure embodying the invention.

As shown in Figures 1 to 3, the coil structure is adapted to heat the edge portion only of a relatively narrow elongated strip 10 either in a continuous operation or in sequential operations on separate pieces.

The coil structure includes a pair of bus bars 11 which are adapted to be connected to a source of heating current, such for example, as a standard inductive heating generator. The bus bars 11 are mounted closely adjacent to each other in parallel relationship and normally project horizontally from the front of the generator to carry the coil structure at the front side of the generator where it is conveniently accessible.

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The coil structure, itself, comprises a pair of identical plate members 12 formed of conducting material, such as copper, and which, as shown in Figures 1 to 3, are flat relatively thin plates. Each of the plates is formed with a pair of upstanding leg members 13 which lie closely adjacent to each other in parallel relationship and which are connected to the bus bars 11 by welding, brazing, or the like. This not only establishes an electrical connection between the plate members and the bus bars but supports the plate members from the bus bars in parallel spaced relation to receive the work piece 10 between them. Each plate member is further formed with an enlarged window 14 defined by a strip like body portion extending completely around the window and joined to the legs 13. In this way, each plate member is split to define a single turn loop and the loops for the two plate members are connected in parallel to the bus bars 11.

The work piece 10 which is intended to have only one edge portion thereof heated is positioned between the plate members as shown in Figures 2 and 4, so that the upper edge thereof lies in registry with the windows 14 in the plate members. For continuous heating, the strip may be drawn continuously between the plate members on any suitable guides or for individual pieces the pieces may be placed between the plate members and removed after treating.

As shown in Figure 4, an instantaneous polarity may be assumed in which the top conductors and the plate members are positive and the bottom conductors are negative. Assuming that positive potential will cause flow of current into the plane of the paper each of the upper conductors indicated at 15, will produce individual fluxes in the direction of the dotted arrows 16.

The lower conductors indicated at 17 will at the same time produce individual fluxes as shown by the dotted arrows 18. These fluxes all being in the same direction produce an over-all flux for the entire coil formed by the two parallel turns as indicated by the dotted arrows 19. It has been found that these fluxes apparently tend to cut only the edge portion of the work piece 10 so that a high degree of heating is produced in a relatively narrow part of the work piece at its edge and the body portion of the work piece remains cool. Also, because the coils are both single turn loops connected in parallel their impedance is relatively low and they are capable of very substantial loading to produce an extremely rapid heating effect. Supporting of the coils in parallel through the legs 13 eliminates any cross flows between the coils which might produce hot spots in the work and when the window 14 is of symmetrical shape a uniform symmetrical heating effect is produced.

In one coil structure made substantially in accordance with Figures 1 to 3 for treating the edges of steel strips through approximately 5 inches of the edge portion and in which the strips were approximately $\frac{3}{32}$ inch thick, it was found that a loading of 25 kw. could be used. In this operation the strip was heated for a distance of approximately $\frac{1}{16}$ inch from its edge to a very high temperature in less than one-half second.

When it is desired to heat both edges of a strip the construction as shown in Figure 5 may be employed. This embodies a pair of plates 21 constructed substantially exactly like the plates 12 of Figure 1, and connected in the same manner to bus bars 22. The plates 21 have relatively large windows 23 therein whose width is greater than the width of the work piece 24 to be treated. The work piece is positioned between the plates such that both edges thereof fall within the line of the windows as shown. When current is supplied to the plates 21 the flux pattern similar to that shown in Figure 4 will be produced except that the flux lines will divide and pass over both edges of the work piece. Therefore, both

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edges of the work piece will be heated simultaneously in the same manner as the single edge of the work piece 10 is heated in operation of Figures 1 to 4.

Figure 6 illustrates a construction wherein spaced portions of a work piece are heated simultaneously. As shown in this figure, plates 25 are provided which are similar to the plates 12 of Figures 1 to 3 except that two spaced windows 26 and 27 are formed therein. The work piece may be an elongated rod or tube 28 which extends between the plates 25 with its edges exposed in the windows 26 and 27. When the plates are supplied with current in this construction only those portions of the work piece which are exposed in the windows 26 and 27 will be heated and only the edge portions of the work piece will be heated.

If it is desired to case harden spaced portions on a shaft or tube such as 28, the tube or shaft may be rotated while the plates are energized so that the surface thereof which is exposed in the windows 27 will be heated throughout the full periphery of the work piece. In this way spaced portions on a shaft or tube can easily be case hardened. With similarly shaped plate members provided with windows of the proper size and shape any other desired type of work piece can be treated at spaced points therein.

Figure 7 illustrates a construction which is particularly adapted to brazing seams in tubes or the like. As shown in this figure, plate members 29 are provided with straight parallel legs attached to bus bars 31 in the same manner as the legs 13 of Figure 1 are attached to the bus bars 11. Below the legs, the plates are curved outwardly as indicated at 32 in opposite directions to fit over a tube 33 in spaced relationship therewith. The body portions 32 are formed with windows 34 with which the upper part of the tube registers when the tube is placed between the plates.

When current is supplied to the plates the upper edge portion of the tube which registers with the windows 34 will be heated and may be supplied with brazing material indicated at 35, to form a brazed seam in the tube. By curving the plates outwardly as indicated at 32, relatively large work pieces can be accommodated with a minimum size and spacing of plates so that concentration of the heating flux in the desired areas can be controlled.

For accommodating several work pieces at the same time a construction as shown in Figure 8 may be employed. In this figure, bus bars 36 support a plurality of plate members 37, three such members being shown. The plate members are spaced apart to receive work pieces 38 between each pair of plate members and the plate members are formed with windows 39 registering with the edge portions of the work pieces. This construction functions in the same manner as described above in connection with Figures 1 to 4, but is capable of treating two or more work pieces simultaneously.

Figure 9 illustrates an arrangement for treating a larger number of continuous elongated work pieces simultaneously in slightly different manners. As shown in this figure, plates 41 are provided and are formed with four windows 42, 43, 44 and 45. Elongated strips 46 are passed transversely between plates 41 with their edges exposed in the windows 42 and 45 as shown so that one edge of each strip will be heated. Similar strips 47 which are narrower than the windows 43 and 44 are passed between the plates in registry with the windows 43 and 44 and with both edges of the strips exposed in the windows so that both edges will be heated.

It will be readily understood that for different types of work plates can easily be shaped to provide the desired distribution of heat. It will also be understood that the plates can be water cooled in the usual way by brazing or otherwise securing water circulating tubes thereto for circulation of cooling water in heat transferring relationship therewith. Therefore, while several different coil

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structures have been illustrated and described, it is not intended that these should be taken as an indication of the scope of the invention, reference being had for this purpose to the appended claims.

What is claimed is:

1. An electric heating coil structure comprising a plurality of relatively thin plates of conductive material mounted in spaced relation to receive work to be heated between them, the plates being shaped to lie substantially parallel to opposite sides of the work, each of the plates being split to form a complete single turn coil lying wholly at one side of the work and the splits on the plates being narrow at points where no heating is desired and being enlarged at at least one point to form registering windows to register at least partially with the work when it is between the plates, and conductor legs on each of the plates lying closely adjacent to each other and connecting the coils formed by the plates in parallel to a source.

2. An electric heating coil structure comprising a pair of flat plates of conductive material mounted in parallel spaced relationship to receive work to be heated between them, each of the plates being split to form a single turn coil and the splits in the plates being widened at at least one point to form windows which are in registry with each other, and conductor legs on each of the plates lying closely adjacent to each other and connecting the coils formed by the strips in parallel with each other.

3. An electric heating coil structure comprising a pair of flat plates of conductive material mounted in parallel spaced relationship to receive work to be heated between them, each of the plates being formed with an enlarged body portion and a pair of closely spaced leg portions, the body portion being separated to form with the legs a single turn coil with the separation at at least one point being relatively wide to define a window, the plates being arranged with the windows therein in registry, and conductors connecting the leg portions of the plates in parallel with each other.

4. An electric heating coil structure comprising a pair of flat plates of conductive material mounted in parallel spaced relationship to receive work to be heated between them, each of the plates being formed with an enlarged body portion and a pair of closely spaced leg portions, the body portion being separated to form with the legs a single turn coil with the separation at a plurality of spaced points being relatively wide to define spaced windows, the plates being arranged with the windows therein in registry, and conductors connecting the legs portions of the plates in parallel with each other.

5. An electric heating coil structure comprising a pair of parallel closely spaced conductor bars, a pair of single turn coils each having closely spaced legs connected to the conductor bars respectively with the legs of the two coils spaced from and parallel to each other so that the coils are connected to the conductor bars in parallel, the coils defining open registering windows spaced from the conductor bars by the legs, the coils being spaced apart to receive the work to be heated between them with at least a portion of the work lying between the windows and with the window forming portions of the coils lying substantially parallel to the work on opposite sides thereof.

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