

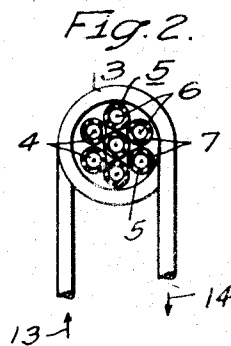
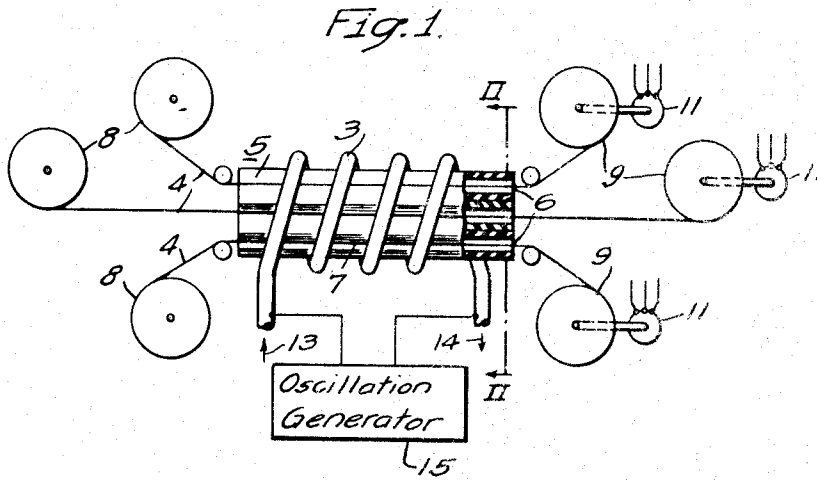
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MULTIPLE-CHANNEL INDUCTIVE HEATING APPARATUS

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MULTIPLE-CHANNEL INDUCTIVE HEATING APPARATUS

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Our invention relates to apparatus for simultaneously inductively heating a plurality of electrically conductive, and preferably magnetizable, wires, strips, or other objects, preferably elongated articles which are substantially continuously moving in the direction of their length, while passing through the inductive heating coil. Our invention has particular relation to the inductive heating of fine wires, or other objects which, by reason of their small size, or peculiarities of shape, make it difficult to build an inductive heating coil of such size or shape that the object or objects to be heated make up a reasonable proportion of the total cross sectional area encircled by the coil, or in applications where considerable difficulty from the standpoint of corona would be encountered if only one object were heated at a time.

A more specific object of our invention is to provide an inductive heating apparatus in which an insulating means is provided within the inductive heating coil, said insulating means having a plurality of separate holes, each surrounded by insulating walls, for receiving the several articles to be heated, which articles may be iron or steel wires, or thin strips, or electrically conductive articles of other shapes and materials. In this way, a separate space or channel is provided for each of the several objects which are to be inductively heated, preventing said objects from being welded together or otherwise coming into contact with each other or with the inductive heating coil.

We have found, in the forms in which we have heretofore used our invention, that no difficulty is discernible from the standpoint of any unequal distribution of the magnetic fluxes, and hence the inductive heating, among the several objects being passed simultaneously through the inductive heating coil; while the tendency to produce corona is very considerably reduced by the presence of a plurality of spaced objects, which have a corona-effect approaching the general overall contour of the whole assembly of objects, as distinguished from a corona-effect which is characteristic of the size or shape of each individual object being heated. At the same time, the utilization of a multiple-channel insulating material or guard or guide-means makes it possible to more economically utilize the cross-sectional area embraced by the heating-coil, thus improving the ratio of kilowatts to kilovolt-amperes, thus increasing the overall efficiency of the heating.

With the foregoing and other objects in view, our invention consists in the apparatus, parts, 55

combinations, assemblies, systems, and methods hereinafter described and claimed, and illustrated in the accompanying drawing, wherein

Figure 1 is a diagrammatic plan-view of circuits and apparatus illustrating our invention in an exemplary embodiment, with parts broken away to illustrate the construction, and

Fig. 2 is a cross-sectional view on the line II—II of Fig. 1.

In the form of embodiment of our invention shown in the drawing, we utilize a single inductive heating coil 3 through which seven wires 4 are passed simultaneously, in order to heat the wire to the Curie point (about 1400° F.) or to any other desired temperature. The number of wires to be simultaneously heated is not critical; neither is the shape or the size of the wires or other objects to be heated, which might well be thin strips, for example tinplated strips, or a plurality of metal or conducting articles of any size or description. While we particularly have in mind iron or steel wires or other magnetizable objects, our invention is not altogether limited to the use of magnetizable materials, so long as the frequency of the inductive heating current is properly chosen. We have also particularly had in mind the heating of small-diameter wires in the range from a diameter of 0.005" to a diameter of 0.035", although here, again, we are not limited to any particular diameter, or even to a cylindrical shape such as is characteristic of wires.

In accordance with our invention we provide an insulating member 5 which is provided with a plurality of separate holes 6, one for each wire 4 or other elongated object being heated, said holes running lengthwise through the coil, substantially parallel to each other and substantially parallel to the axis of the coil 3. The insulating member 5 preferably has an axial extent somewhat longer than the coil 3, so that it extends a short distance beyond each end of the coil. The several axially extending holes 6 are thus each surrounded by insulating walls, so as to effectually prevent the several wires 4 from coming in contact with each other, or in contact with the coil 3.

The insulating member 5, with its axially extending holes 6 therein, can be constructed or fabricated in any desired manner. When the objects to be heated are wires, as illustrated, so that the holes 6 will be cylindrical in cross section (being preferably considerably larger than the wires), an economical and convenient manner of forming the insulating body 5 is to provide a bundle of insulating tubes 7, one for each wire, said tubes

being suitably cemented or bound together in a substantially integral mass.

The several wires 4 are fed into and through the several perforations 6 of the insulating body 5 within the heating coil 3 from individual spools or rolls 8, and are re-wound upon other spools or rolls 9 which are driven by electrical motors 11, preferably in such a manner that all of the wires 4 pass through the inductive heating coil at the same rate.

The inductive heating coil 3 is preferably made of copper tubing, through which water, or other liquid coolant, is circulated, as indicated by the arrows 13 and 14. Alternating-current electrical energy is furnished to the terminals of the coil 3, as by means of an oscillation generator 15, which is indicated symbolically in Fig. 1. While the necessary or desirable frequency of the electrical supply is not extremely critical, nevertheless the frequency should be in the correct range, dependent upon the resistivity of the heated material, and other factors. The optimum frequency is also inversely proportional to the square of the diameter or thickness of the material being heated. For example, for iron wires of 0.005" diameter, the optimum frequency is probably somewhere in the range of 1.5 times 10^6 cycles per second, although frequencies which are a considerable percentage higher or lower might readily be utilized. This frequency is intended for heating the wire up to the Curie point. For a lower temperature of heating, a lower frequency would be perhaps more suitable, whereas, for temperatures in excess of the Curie point, or for wires or strips of non-magnetizable conductive materials, considerably higher frequencies would be required.

In operation, a plurality of wires or strips of the same diameter or gage are caused to move continuously through the same heating coil at a constant or predeterminably controllable speed, while the coil is energized with high-frequency current of a suitable frequency. The alternating magnetic flux of the coil, flowing axially, traverses all of the wires or strips 4, thus inducing circulating currents which heat the wires or strips by reason of the resistivity of the material to be heated. The length of the coil 3, and its ampere-turns, are so chosen, with respect to the amount of material to be heated per second, that the wires or strips 4 reach their predetermined, desired temperature while passing through the coil at the speed which is determined by the energization of the reeling-motors 11. By causing more than one wire or strip to pass through the coil 3 at the same time, the cross-sectional space within the coil-turns is utilized more efficiently, so that a larger percentage of the flux of the coil is put to useful work by being caused to traverse material to be heated.

The amount of electrical energy necessary to heat the wire or strips may be quite large, particularly at high speeds of travel of the wire or strips. On the other hand, the amount of current which can be utilized in the coil is limited by the amount of magnetizing force which can be efficiently utilized, so that the voltage of the coil is quite likely to be so high that measures must be adopted to avoid trouble from corona. Under these circumstances, the utilization of a plurality of fine wires, or other elongated materials to be heated, is a distinct advantage because the elec-

trostatic field surrounding the group of spaced wires or other elongated members produces a corona-effect which approaches the corona-effect which is obtainable from a solid conductor having about the same diameter as the periphery of the bundle or group of spaced parallel wires. Since the corona-effect is dependent upon the wire-diameter, being very much greater for smaller wires than for large cylinders, our use of a bundle of spaced parallel wires provides a construction which is relatively free of corona, as distinguished from the very intense and troublesome corona which would be expectable from the use of a single wire within the inductive heating coil 3.

While we have described our invention in only one form of embodiment, which is at present preferred, we wish it to be understood that our invention is susceptible of other forms of embodiment, and perhaps of other practical limits than those which have been hereinabove described. We desire, therefore, that our appended claims shall be accorded the broadest interpretation consistent with their language.

We claim as our invention:

1. Means for simultaneously inductively heating a plurality of electrically conducting articles, comprising the combination of insulating means substantially devoid of conducting material for providing a plurality of separate holes, each surrounded by insulating walls substantially devoid of conductive material, for receiving the several articles, an inductive heating-coil surrounding said insulating means, and means, including coil-terminals, for feeding alternating current into said coil.

2. Means for simultaneously inductively heating a plurality of elongated electrically conducting articles while they are substantially continuously moving in the direction of their length, comprising the combination, with the means for keeping said articles moving in the direction of their length, of insulating means substantially devoid of conducting material for providing a plurality of separate, substantially parallel, holes, each hole being open at both ends and being surrounded by insulating walls substantially devoid of conductive material, for receiving the several articles, an inductive heating-coil surrounding said insulating means, the axis of the coil being substantially parallel to said holes, and means, including coil-terminals, for feeding alternating current into said coil.

3. Means for simultaneously inductively heating a plurality of electrically conducting wires while they are substantially continuously moving in the direction of their length, comprising the combination, with the means for keeping said wires moving in the direction of their length, of insulating means substantially devoid of conducting material for providing a plurality of separate, substantially parallel, holes, each hole being open at both ends and being surrounded by insulating walls substantially devoid of conductive material, for receiving the several wires, an inductive heating-coil surrounding said insulating means, the axis of the coil being substantially parallel to said holes, and means, including coil-terminals, for feeding alternating current into said coil.

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