

April 14, 1953

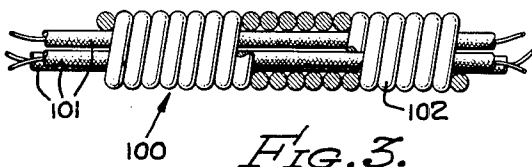
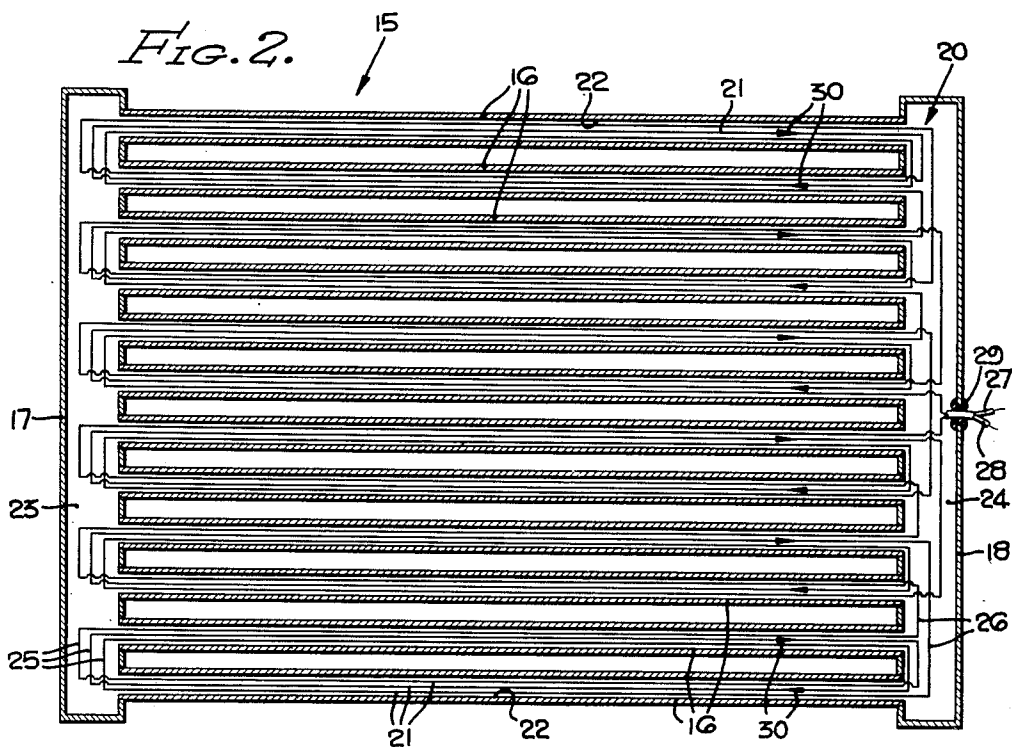
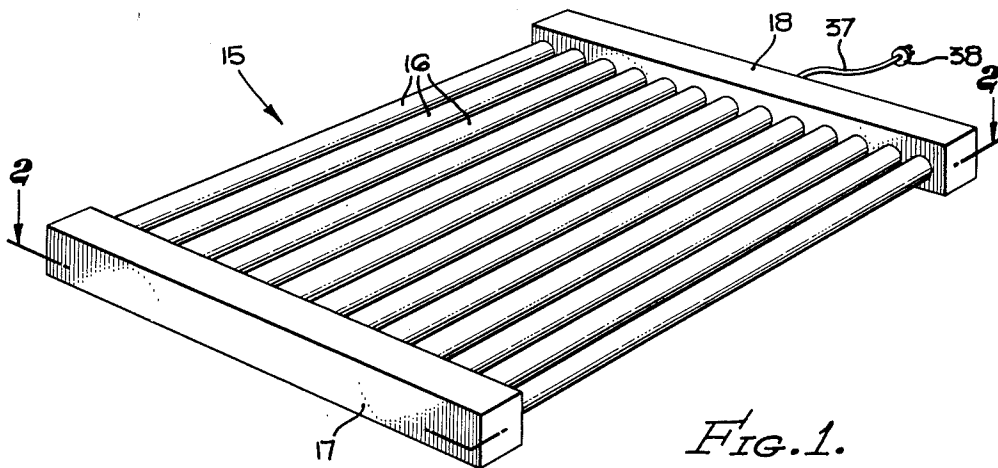
F. F. LERZA ET AL

2,635,168

EDDY CURRENT HEATER

Filed Nov. 4, 1950

3 Sheets-Sheet 1



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FIG. 4.

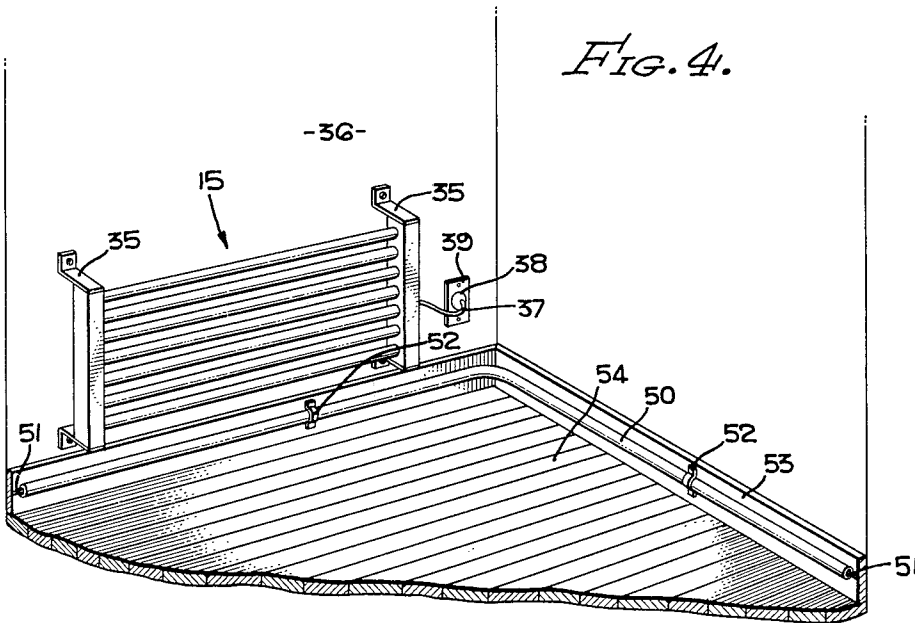


FIG. 5.

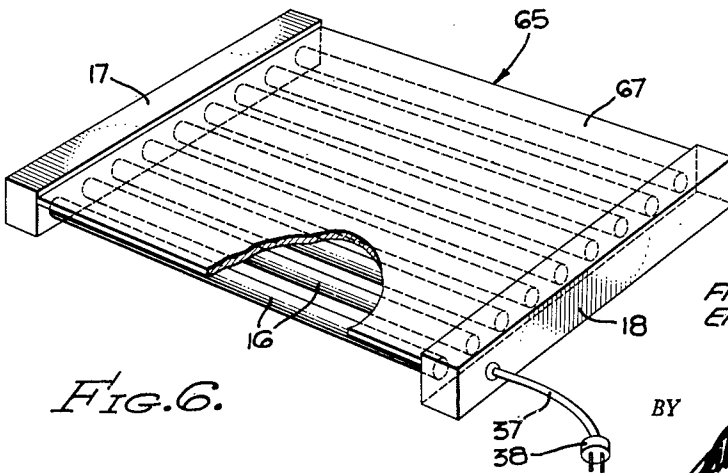
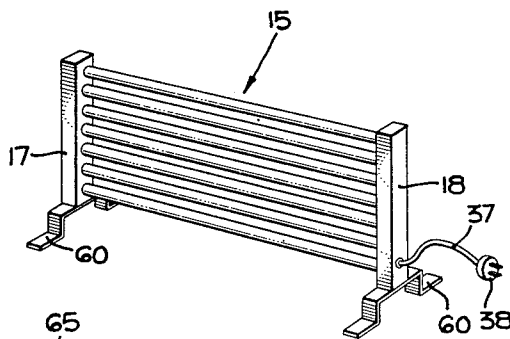


FIG. 6.

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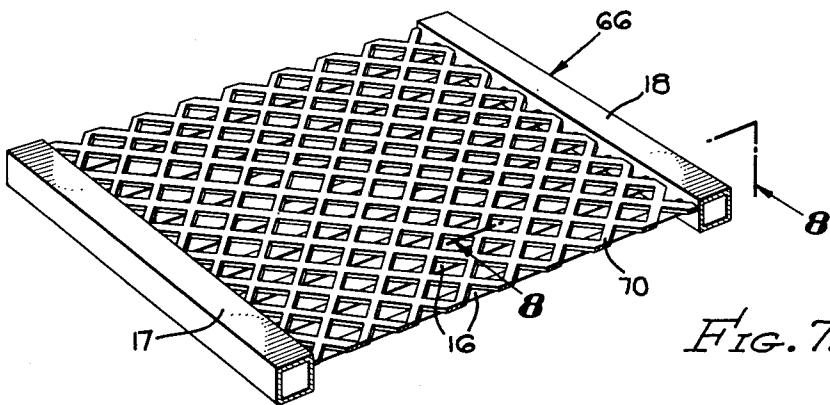


FIG. 7.

FIG. 8.

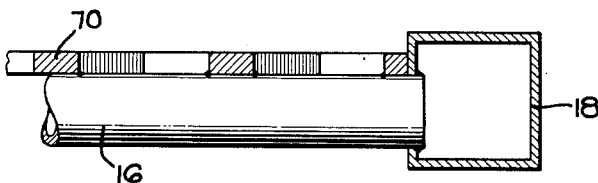


FIG. 9.

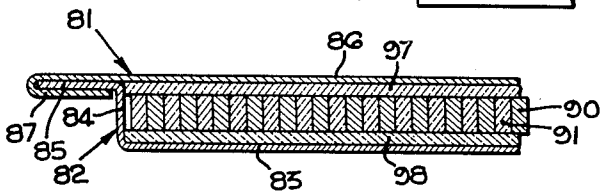
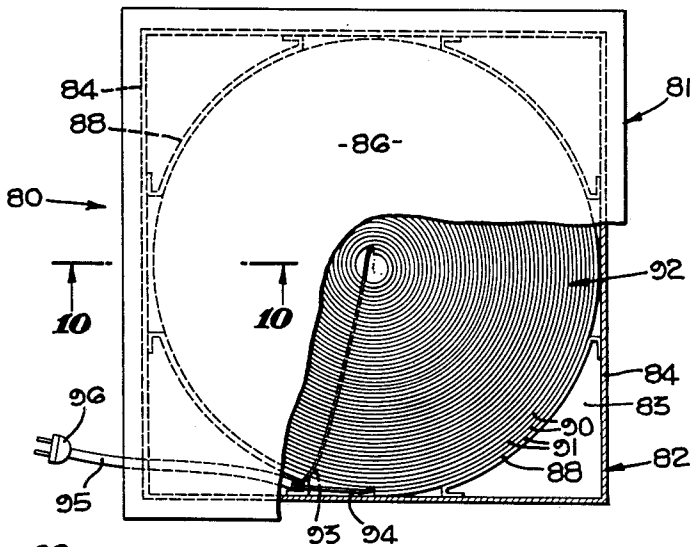


FIG. 10.

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EDDY CURRENT HEATER

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6 Claims. (Cl. 219—19)

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This invention relates to the art of diffusive electric heating and is of especial utility in heating buildings, walkways, seats, beds, etc. to temperatures conducive to the comfort of persons using the same.

Heating with electricity can be divided generally into conductor resistance, and induction heating. The principal application of induction heating heretofore has been in the fusing or heat treatment of metals requiring high temperatures. Here the charge is surrounded by a coiled conductor such as a copper tubing, through which water is circulated for cooling purposes and which is protected from the heat in the charge by a crucible or asbestos wall disposed therebetween. Low temperature heating by electricity in the diffusive field has been accomplished almost entirely by conductor resistance as in heating pads, heated clothing, electric blankets and the like.

It is an object of the present invention to provide a method of and apparatus for diffusive heating inductively, with electricity, at relatively low temperatures which will be less expensive in first cost and maintenance and less hazardous to operate than resistance conductors employed for this purpose.

The drilling of oil wells and the pumping of oil therefrom after they have been brought in, are outdoor operations and it has been found highly desirable to provide heaters for the comfort of workers involved therein during the cold season. This has been extremely difficult, however, because of the prevalence of highly combustible gases and vapors against the ignition of which every precaution must be taken.

It is, accordingly, another object of this invention to provide an electric heater suitable for use under the working conditions above described and which will offer practically no fire hazard under those conditions.

A still further object of the invention is to provide an electric heater for diffusive heating which will be sturdy in construction, which will be adaptable to use in many different situations, and which will have a relatively long useful life.

Yet another object of the invention is to provide an electric heater having a large capacity for transforming electric energy into heat and diffusing this heat by radiation which will have special utility as a resistor, and which can be employed either as a loading rack, the prime function of which is to dissipate electrical power when the latter is unwanted, or as a starting and speed control resistor for wound rotor induction

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motors or as a starting resistor for synchronous motors.

The manner of accomplishing the foregoing objects as well as further objects and advantages will be made manifest in the following description taken in connection with the accompanying drawings in which—

Fig. 1 is a diagrammatic perspective view of one embodiment of the invention.

Fig. 2 is a horizontal cross-sectional view taken on the line 2—2 of Fig. 1 and diagrammatically illustrating the wiring employed in this heater.

Fig. 3 is a fragmentary elevational view of a modified form of the invention in which a plurality of insulated conductors extend through a heavy coil of magnetically permeable wire.

Fig. 4 is a fragmentary perspective view of a corner of a room in the interior of a building and illustrating the manner in which one of the heaters shown in Fig. 1 may be mounted on a wall of said room. This view also shows an installation of one form of heater of this invention which is embodied in a conduit tube the latter being applied to the baseboard of the room and extending around the room.

Fig. 5 is a perspective view and shows how the heater illustrated in Fig. 1 may be provided with legs so as to support this portably in vertical position.

Fig. 6 is a diagrammatic perspective view of a modified form of the heater shown in Fig. 1 with this heater provided with a metallic platform on which a person may stand.

Fig. 7 is a perspective view of still another modification of the heater shown in Fig. 1 in which said heater had a grid on which a person may stand to warm his feet, heaters of the types shown in Figs. 6 and 7, being very useful in keeping warm the feet of workers who are working outdoors in cold weather or in unheated buildings.

Fig. 8 is an enlarged vertical sectional detail view taken on the line 8—8 of Fig. 7.

Fig. 9 is a plan view of another modified form of the invention in which the conductor employed in the heater is disposed in spiral conformation between upper and lower iron plates in which heat is developed by magnetic fields induced in these plates by the flow of current along said conductor.

Fig. 10 is an enlarged vertical sectional view taken on the line 10—10 of Fig. 9.

Referring specifically to the drawings, the preferred embodiment of the invention illustrated in Fig. 1 comprises a heater 15 which includes a series of tubes 16 made of a magnetically

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permeable material such as iron or steel and connected at their opposite ends by tubular headers 17 and 18 into which opposite ends of tubes 16 open and to which said opposite ends are preferably secured as by welding.

Fig. 2 shows heater 15 in section and diagrammatically illustrates the wiring system 20 of the invention which preferably includes a single continuous insulated electrical conductor 21 which may be in the nature of an inexpensive gutta-percha covered copper wire such as is commonly employed in commercial house wiring practice. The conductor 21 is wound through the various passages 22 provided within the tubes 16 and lateral passages 23 and 24 provided in the headers 17 and 18 so that a plurality of conductors 21 extend through each of the passages 22 and have their ends joined in the passages 23 and 24 by connecting conductors 25 and 26 which lie respectively in the passages 23 and 24 of the headers 17 and 18. Opposite ends 27 and 28 of the conductor 21 extend outwardly through a suitable opening provided in the header 18 and surrounded by an insulating grommet 29. The terminal conductor ends 27 and 28 lead to alternating current power line terminals through which the circuit represented by the conductor 21 is energized.

It is to be noted that the conductor 21 is so wound through the various passages 22, 23 and 24 of the heater 15 that the current with which said current is energized passes in the same direction along all of the conductors 23 which extend through any one of the tubes 16. The direction of the flow of current at a given moment in the respective tubes 16 is indicated by arrowheads 30, one of which is supplied to a conductor 23 in each of these tubes shown in Fig. 2.

The result of so energizing the winding thus effected with the conductor 21 is to set up eddy currents in the magnetically permeable material of the tubes 16 which will be transformed into heat by the resistance of the material of the tubes to these currents.

The heater 15 is adapted to many uses. It may be provided with brackets 35 as shown in Fig. 4 and applied to a wall 36 of a room to be heated thereby. The terminal ends 27 and 28 of the conductor 21 may be united in electric service cord 37 terminating in a plug 38 which may be plugged into any service outlet 39 as shown in Fig. 4.

Fig. 4 also illustrates another permanent installation of the present invention in the form of a conduit tube 50 which is of magnetic permeable material and which contains a plurality of insulated conductors 51, the ends of which are suitably connected to place these in an electric circuit whereby an alternating current is caused to flow through the conductors 51 and in the same direction. The conduit 50 may be secured by brackets 52 to the baseboard 53 of a room to be heated and may extend entirely around the room. Such a heater conduit may also be buried in the walls 36 or placed under the floor 54 of the room to be heated, it being contemplated that this form of heater of the present invention would be constantly energized during the colder seasons when it is necessary to keep the interior of the building heated to maintain a comfortable temperature therein.

As shown in Fig. 5 the heater 15 of the invention may be provided with legs 60 which are attached to the tubular headers 17 and 18 in a

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manner to hold the heater in an upright position and render this portable.

Figs. 6 and 7 illustrate two types of heaters 65 and 66 which are especially designed for use as standing platforms for workers who are employed out-of-doors or in unheated buildings in cold seasons so that it is highly advisable that heat be furnished for the feet of the worker. The heater 65 is similar in all respects to the heater 15 excepting that it has a metal plate 67 which lies on top of the tubes 16 and between the headers 17 and 18 and may be secured to said tubes and headers as by welding or by suitable clamps if desired. The plate 67 is heated by the tubes 16 and thus in turn heats the feet of the worker standing thereon.

The heater 66 is similar to the heater 65 excepting that a metal grate 70 takes the place of the plate 67 to provide a walking platform for the worker using this heater. Only a section of the heater 66 is shown in Fig. 7 and it is to be understood that this is provided in varying lengths so that a single heater 66 may serve an entire line of workers where it is necessary for them to stand and work in a line as is often the case in canneries, factories, packing houses, and the like.

Another form of the invention is shown in Figs. 9 and 10 as comprising a heater 80 which includes a shell 81 which is preferably made of heavy sheet iron and includes a shallow pan 82 having a bottom 83, side walls 84 and a horizontal external flange 85 extending outwardly from its upper edge. The shell 81 also includes a top plate 86, the outer edge portion 87 of which is bent downwardly around the flange 85 to unite the top plate 86 to the pan 82. The pan 82 is provided with internal corner brackets 88 which are arcuate in shape as shown in Fig. 9. Before the final assembly of the top plate 86 on the pan 82, a conductor 90 which is preferably in the form of a flat strip of conductive material such as copper or aluminum is coiled spirally along with a similar strip of insulating material 91 to form a spiral electric element 92 as shown in Fig. 9 adjacent turns of which are insulated from each other by the strip 91. Inner and outer ends of the conductor 90 are connected to insulated wires 93 and 94 which enter an insulated service cord 95 terminating in a service connection plug 96.

The cross-section and length of the conductor 90 is such that the plug 96 may be plugged into any 110 volt service outlet for alternating current, thus causing this current to flow through the conductor 90 from one end thereof to the other, this resulting in a current flowing through all of the turns of the spiral electric element 92 in the same direction. The spiral electric element 92 is insulated from the shell 81 by upper and lower sheets of insulating material 97 and 98, each turn of the electric element 92 therefore acting independently of the others to set up magnetic fields in the bottom 83 and top 86 of the shell 81. As the current flowing through the adjacent turns of the conductor 90 is always, at any given moment, travelling in the same direction, eddy currents are developed by these magnetic fields which results in a transformation of this magnetic energy into heat which raises the temperature of this shell.

Referring now to Fig. 3, a flexible heater 100 is there shown embodying the invention, this heater comprising a plurality of insulated conductors 101 which are surrounded by a closely

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wrapped coil 102 of magnetic permeable material such as iron wire. The opposite ends of the conductors 101 are connected in a manner to produce a flow of alternating current in the same direction through all of these conductors. Obviously, the heater 100 is adapted to be wrapped around various objects or passed through openings varying in shape by virtue of its extreme flexibility and supply heat to the objects with which it is thus associated when this heater is energized. The alternating current passing through the conductors 101 in the same direction sets up moving magnetic fields in the surrounding coil 102 which becomes heated, thus converting the electrical energy supplied to the conductors 101 into heat and raising the temperature of the coil 102.

It is desired to point out that electric induction heating has heretofore been practically limited to the production of high temperatures in which the charge was placed within a coil and the latter energized with an alternating current of very high frequencies. The present invention operates with a charge placed externally of the conductor, in other words, surrounding the same, and with a relatively low frequency as it is designed to operate off of ordinary domestic electric systems from which alternating current of 50 or 60 cycles is delivered. It is also desired to point out that whereas large losses are suffered in many uses of electricity through unwanted eddy currents, the present invention employs all of the eddy currents produced by the electricity in the production of heat and all of the heat so produced is useful.

The impedance of the eddy current heaters above described varies with the frequency of the applied voltage, that is, as the frequency of the applied voltage is increased, the voltage required to cause a given current to flow also increases. Further, the impedance is substantially pure resistance which causes the heater current to be essentially in phase with the applied voltage. This characteristic is well suited to the starting and regulating of the speed of wound rotor induction motors.

Wound rotor motors are presently controlled by the connection of a resistor across the terminals of the rotor winding and varying the portion of said resistor which is placed within the circuit as the requirements for resistance decrease with the increasing speed of the rotor. This variation in resistance is obtained by a series of tap points on the resistor and a switch for connecting one terminal of the circuit to a selected tap point.

Any of the eddy current heaters above described is adapted to be connected as a resistor in the circuit of a wound rotor induction motor and when so connected accomplishes automatically the same change of resistance in the rotor winding by the presence of a resistance element as above described. The automatic operation of the eddy current heater of this invention in this particular use, without the necessity for any moving parts, results from the fact that the frequency of the voltage appearing at the terminals of the rotor winding is greatest when the rotor is standing still and gradually decreases to a minimum value as the rotor starts to revolve and comes up to operating speed. The resistance offered by an eddy current heater in this use starts out with a high value when the rotor is stationary and then progressively decreases to a minimum value as the speed of the rotor in-

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creases. Thus, the eddy current heater of our invention is admirably suited for use as a resistor in the starting and speed control of wound rotor induction motors.

The eddy current heater of this invention is also readily adaptable for use as a starting resistor for a synchronous motor since the frequency of the voltage appearing at the terminals of the field (rotor) winding is of high value when the rotor is standing still and decreases to zero as the rotor speeds up to its operating speed. One of the eddy current heaters of our invention is thus adapted to be employed as a starting resistor with a synchronous motor and when so used operates automatically and eliminates all of the switch mechanism at present necessary in the use of standard resistors in the starting of synchronous motors.

Assemblies of resistors, which comprise nothing more or less than plain resistance elements in series, in which heat is generated in the conductor itself and dissipated therefrom into the air, are frequently used to absorb electrical power when the latter is an unwanted byproduct of another operation, such as in dynamic breaking of moving vehicles and rotating parts of machines, and in the dissipation of power generated during the testing of electrical generators under load, or in brake testing internal combustion engines. For efficient use, such a resistance should be rugged, compact and capable of carrying heavy electrical overloads without damage. The eddy current heaters described herein possess these characteristics. The external heat dissipating members of each of these heaters are constructed of iron or steel and completely enclose all other elements thereof. It is further to be noted that the ratio of radiating surface to weight of the heat dissipating elements in the eddy current heaters of our invention is relatively high.

These eddy current heaters are designed exclusively to heat within what is known as the "black" range of temperatures, which is to say that the iron or steel heat generating and dissipating elements of the heater are never heated to a temperature in which these elements become red. In fact, the maximum temperature attained in the operation of these heaters is around 400° F. while in most instances they normally operate within a range of from 100-200° F.

Heretofore induction heating has been mainly confined to heat treating or fusing metals at temperatures above the Curie point, which is the temperature point above which the permeability of a ferrous metal falls to such a low value as to gradually decrease the efficiency of the operation of heating this metal inductively.

The range of temperatures in which the present invention operates being well below the Curie point, the magnetic material surrounding the conductors thereof always has a high permeability value. The well-known principle of eddy currents is thus brought into play wherein a varying magnetic field impinging upon a conducting mass induces electric currents (so-called eddy currents) in that mass. The flow of these currents generates heat within the mass according to Joule's law, $H=KI^2Rt$. The intensity and distribution of the generated heat is a function of the intensity and distribution of the eddy currents which in turn is a function of the configuration, electrical resistivity, and magnetic permeability of the mass, and the intensity and distribution of the varying magnetic field. We

have found that surface temperatures and heat dissipation rates ideally suited to the objects of this invention may be secured by a proper selection and proportioning of the above mentioned characteristics on which the efficient conversion of electricity into heat depends.

It is further desired to point out that in the heater of our invention, the heating element is completely separated from the electrical conductors thereof and this permits the complete insulation of the conductors and the enclosure of these on the inside of the heaters so that there is no possibility of any sparking taking place, thereby reducing the fire hazard of these heaters to an absolute minimum and making their use practical in the presence of highly inflammable gases and liquids. Another advantage which these heaters possess is that the heaters of our invention may be readily hosed off with steam or water with relatively little effort, and without any danger of impairing the insulation of the circuits thereof.

What is claimed is:

1. In an eddy current heater the combination of: a tube with a solid, continuous wall of magnetically permeable material, a plurality of insulated electric conductors closely confined by and extending through said tube lengthwise substantially parallel with said tube, and means connecting to opposite ends of said conductors for supplying an alternating electric current thereto and causing the same to pass through said conductors in series and in the same direction.

2. In an eddy current heater the combination of: a pair of headers, a multiplicity of tubes each having a solid continuous wall of magnetically permeable material opposite ends of which tubes are mounted in said headers, a plurality of insulated electric conductors closely confined by and extending through each of said tubes lengthwise substantially parallel with said tube, and means for connecting opposite ends of said conductors in said tubes for supplying an alternating electric current thereto to pass through said conductors in series and through all of said conductors in each of said tubes in the same direction.

3. In an eddy current heater the combination of: a pair of tubular headers hermetically sealed at opposite ends, a multiplicity of tubes each having a solid continuous wall of magnetically permeable material opposite ends of which tubes

are mounted in said tubular headers and welded to the latter to form a completely closed unitary chamber which combines the empty spaces within said headers and said tubes, a plurality of insulated electric conductors closely confined by and extending through each of said tubes lengthwise and substantially parallel with said tube, means completely enclosed within said chamber for connecting opposite ends of said conductors in said tubes for supplying electric current to said conductors whereby said current will pass through said conductors in series and through all of said conductors in each of said tubes in the same direction, there being a hole provided in a wall of one of said headers; electric lead conductor means extending from the exterior of said heater through said hole into said chamber and connecting with said connecting means; and rubber grommet means disposed within said hole to form a packing surrounding said lead conductor means and to insulate the latter from the header having said hole.

4. A combination as in claim 3 in which legs are provided on said headers for holding said heater in vertical position and rendering said heater portable.

5. A combination as in claim 3 in which said heater is adapted to lying horizontally on a floor and having a plate which is united to said headers and to said magnetically permeable tubes to provide a platform for a person to stand upon.

6. A combination as in claim 3 provided with supporting brackets for fastening said heater to a wall.

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