Aug. 23, 1966 L. B. CORNWELL 3,268,704

ELECTRIC DEVICES FOR HEAT TREATMENT OF WINDABLE MATERIAL

Filed June 18, 1963 2 Sheets-Sheet 1

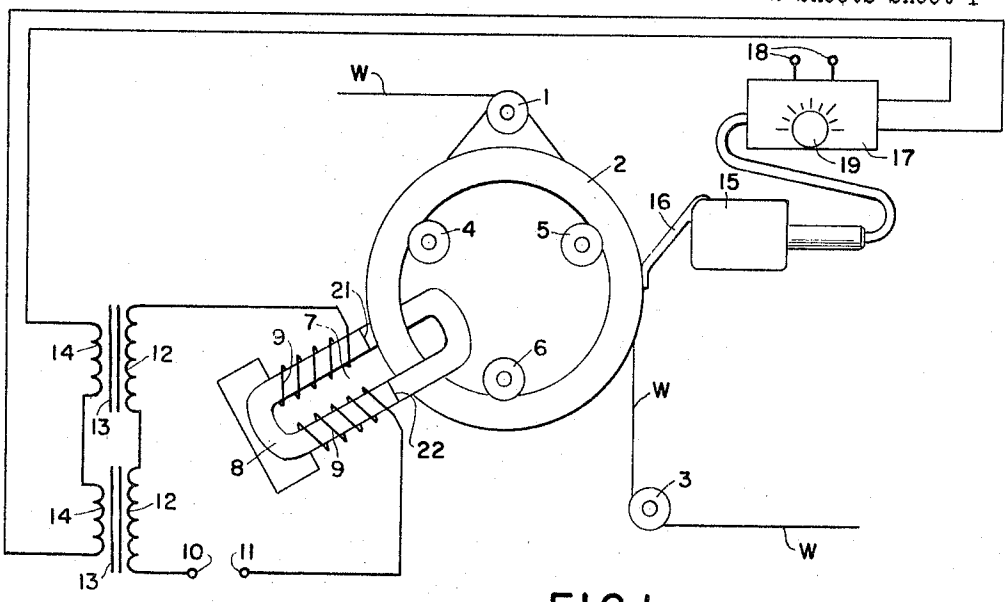


FIG. 1

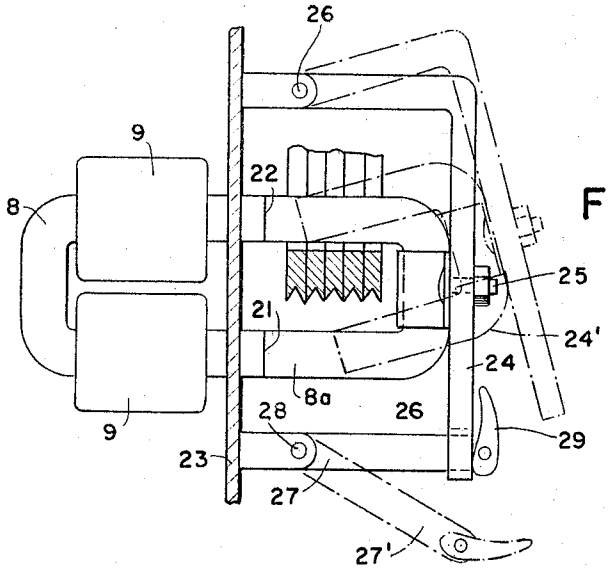


FIG. 3

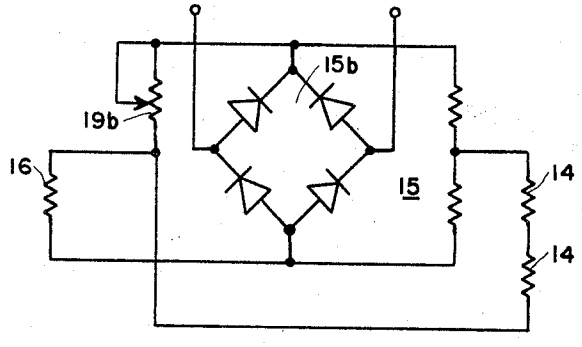


FIG. 4

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ELECTRIC DEVICES FOR HEAT TREATMENT OF WINDABLE MATERIAL

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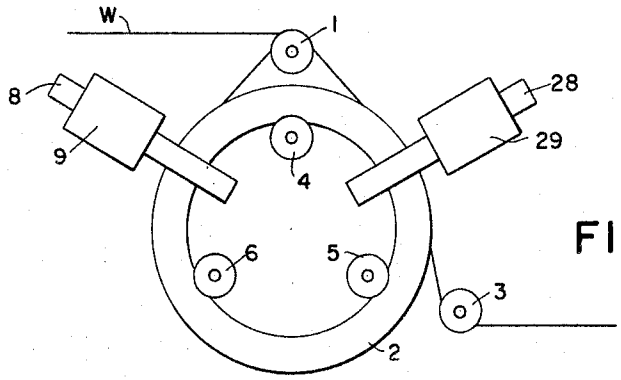
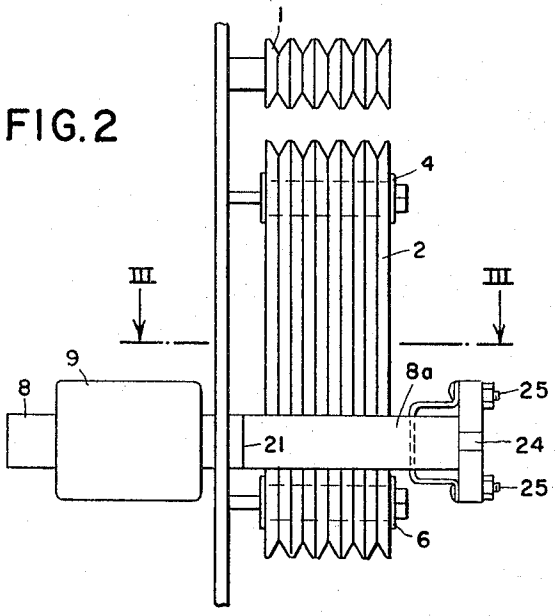


FIG. 5

FIG. 2



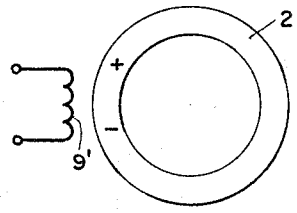


FIG. 7

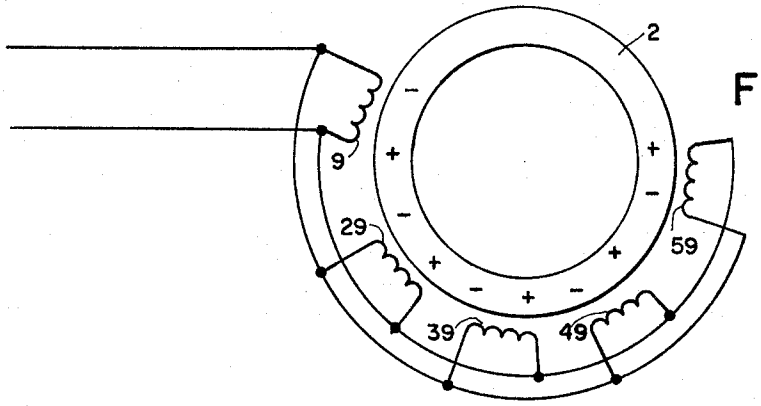


FIG. 6

United States Patent Office 3,268,704 Patented August 23, 1966

3,268,704

ELECTRIC DEVICES FOR HEAT TREATMENT OF WINDABLE MATERIAL

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6 Claims. (Cl. 219—10.61)

My invention relates to an electric device for heat treatment of wire, yarn, thread, cord, tapes, webs and other windable material that requires annealing, preheating, drying, curing, or other heat processing while travelling in continuous motion from a supply, such as a roll or spool of material, to a take-up device or to a location of subsequent fabrication.

It is an object of my invention to devise an electric heat treating device of the above-mentioned type that affords the desired performance in a particularly simple and reliable manner regardless of whether the material is metal, textile, paper, plastic or other substance.

Another object is to afford a reliable operation within an extreme range of travelling speeds or at greatly different travelling speeds of the material, such as at standstill, creeping speed, or up to speeds of 5000 feet per minute or more. It is a further object of my invention to provide a heating apparatus of the type mentioned, that is capable of producing extremely high heating power in an annular heater of relatively small size peripherally engaged by the material being heated; and it is also an object of the invention to devise a heating apparatus for windable materials, that is suitable for instantaneously changing the electric heating power between extreme limits such as from 30,000 watts to 900 watts for example, when and if necessary for maintaining the processing temperature constant or below a given maximum limit.

Another object, akin to those mentioned above, is to permit a considerable change in travelling speed of the material, down to complete stoppage, without melting or burning the material.

To achieve these results, and in accordance with a feature of my invention, I provide a circular electric heater member which is rotatable about its center axis and cooperates with guide means that, together with the periphery of the circular heater member, define a loop-shaped travel path for the material around the heater member and in contact therewith.

According to another feature of my invention, the heater member has annular shape and forms part of a transformer having a stationary core extending through the opening of the annular member and having a primary winding on the core, whereby the annular member forms a short-circuited secondary winding of the transformer and is heated by induced secondary current circulating in the member.

According to a further feature of my invention, the heating power induced in the annular heater member is increased by inductively linking two or more primary coil units with the same member, each two sequential primary units being preferably poled in mutually opposed relation as to the simultaneous respective polarities which they induce in the annular heater member.

According to still another feature, the above-mentioned guide means for passing the material around the heater member comprise a capstan pulley mounted adjacent to the rotatable member and having a roller axis parallel to the axis of the member. When the device is in operation, the wire, yarn, or other material to be heat-treated passes over the capstan pulley and around the other periphery of the heater member, then back to the capstan pulley, and, ultimately, along a guide roller away from the heating device.

The foregoing and more specific objects, advantages and features of my invention, said features being set forth with particularity in the claims annexed hereto, will be

apparent from, and will be mentioned in the following, with reference to the accompanying drawings, in which:

FIG. 1 is a front view of a device according to the invention in connection with associated electric components.

FIG. 2 is a part-sectional side view of the same device.

FIG. 3 is a top view of the device.

FIG. 4 exemplifies a circuit diagram of a temperature controller which constitutes one of the electric components shown in FIG. 1.

FIG. 5 illustrates a modified embodiment provided with two transformers.

FIG. 6 shows diagrammatically a multiple-primary device otherwise similar to that of FIGS. 1 to 3; and

FIG. 7 is a diagram relating to a modification operating with inductance heating.

The material to be heat treated is assumed to be a metal wire that requires annealing. The wire W passes over a capstan pulley **1** and around a ring member **2** of copper or steel, thence up over the same pulley **1** and again around the ring **2**. Such loops of wire may be repeated as many times as may be desired, depending upon how long the material is to be exposed to the heat. The wire ultimately leaves the ring member **2** and passes over a guide roller **3** to a take-up spool or to other fabricating equipment. The ring member **2** is rotatable about its center axis and is guided by three rollers **4**, **5** and **6** whose respective journal pins are stationarily mounted.

The device further comprises a transformer **7** whose loop-shaped core, preferably of laminated iron, passes through the opening of the ring **2** and carries a primary winding **9** which, when in operation, is energized from alternating-current terminals **10**, **11** to be connected to an alternating-current line of 220 volts and 60 cycles per second, for example. Connected in series with the transformer primary **9** are the alternating-current windings **12** of a saturable reactor assembly whose magnetizable cores **13** carry respective direct-current control windings **14** (FIGS. 1, 4). Depending upon the amount of direct current passing through the control windings **14**, the reactive impedance of the reactor can be given different effective magnitudes, thus controlling or regulating the current flowing through the transformer primary winding **9**. The ring member **2** constitutes a short-circuited single-turn secondary winding of the transformer **7**. The current induced and circulating in ring member **2** provides the heat required for heat treatment of the wire material. By correspondingly controlling the primary current with the aid of the saturable reactor assembly **13**, the heat applied to the wire material can be adjusted, controlled or regulated.

For regulating purposes, the device is preferably provided with a heat sensing device **15** (FIG. 1) whose temperature-responsive feeler **16** provides an output voltage which is compared with an adjusted datum voltage in a temperature controller **17** energized at **18** from the above-mentioned alternating current line. The datum voltage is adjustable to the desired value by means of a knob **19**. When the temperature sensed by the feeler **16** departs from the adjusted datum value, the controller issues a corresponding direct voltage to the control windings **14** of the reactor assembly thereby changing the reactance in the sense and by the amount required to maintain or reestablish the correct processing temperature.

The particular types of the temperature gage **16** and of the controller **17** are not essential to the invention proper. In the embodiment exemplified by FIG. 4, the sensing gage **16** is a resistance thermometer, and the controller

17 supplies the control windings 14 of the saturable reactor with rectified current from a full-wave rectifier bridge 15*b* through a Wheatstone bridge network whose output is controlled in dependence upon the departure of the temperature-responsive resistance of gage 16 from the adjusted datum value set by means of a control rheostat 19*b* manually set by means of the knob 19 (FIG. 1). It will be understood that other temperature-responsive controllers and sensors, such as thermocouple devices, may be used instead.

The ring member 2 as well as the capstan pulley 1 are preferably provided with a number of peripheral grooves, as is apparent from FIGS. 2 and 3. The loops of wire to be heated pass through these grooves, and as many of the grooves may be used at a time for accommodating a wire loop, as may be needed for maintaining the heat treatment effective during a desired period of time, depending upon the travelling speed of the wire.

In cases where the material appreciably expands or contracts, the pulley 1 and the ring member 2 are preferably subdivided into a multiplicity of individual coaxially aligned components, as is the case in the illustrated embodiment. The individual components are then free to rotate at progressively different speeds to compensate for the linear expansion of contraction of the material being treated. Whether the ring member 2 is a single integral body or a multiplicity of components is irrelevant to the heating operation of the transformer assembly.

The driving power for moving the wire through the heating device may be supplied entirely by the pull imposed upon the wire at its end leaving the guide roller 3. If desired, however, one or more of the rollers 4, 5, 6 may be driven in order to impart driving torque to the ring member 2.

During operation the wire or other material passing through the device is heated by direct contact with the peripheral surface or the grooves of ring member 2. The heat generated in the ring by transformer action can be made as intense as desired because a high current, for example hundreds or thousands of amperes, can be induced, particularly with the aid of a plurality of primary transformer units as will be described below with reference to FIGS. 5 to 7. The inductive generation of heat does not require physical contact of any transformer core or other stationary electric structure with the ring member and thus permits free spinning of the ring member without change in heating power.

The transformer core 9 is preferably of the tape-wound type. That is, it is wound up from iron tape. The resulting turns or layers are bonded by cement and then preferably cut into two portions along the lines denoted by 21 and 22. This permits attaching the base portion of the transformer core 8 to a mounting panel 23, and securing the removable core portion 8*a* to a bracket 24 by means of bolts 25. The bracket 24 is hinged to the mounting panel 23 at 26. Normally the bracket is secured and locked in position by means of a strut 27 which is likewise hinged to the panel 23 at 28 and carries a latching toggle 29. When opening the toggle 29 and pivoting the strut 27 to the position shown in broken lines at 27' in FIG. 3, the bracket 24 and the core portion 8*a* secured thereto can be turned to the position shown by broken lines at 24'. This affords easy access to the ring member 2 when the material to be heated is being wound around the ring member and the capstan pulley 1 before commencing the heat treatment. The hinged bracket 24 is constructed to bring the core portion 8*a* in full contact with the base portion of the core over the entire butt surfaces at the junctions 21, 22 and to hold the core portions tightly together by the toggle latching device 29.

If desired, the heating temperature may be controlled manually, only. This can be done either by varying in any suitable manner the current in the circuit of the transformer primary winding 9, or by manually setting a rheostat for changing the control voltage applied to the control coil 14 of the saturable reactor. However, superior results are secured by providing for automatic temperature regulation as described above. With such temperature regulation, no impairment in quality of the material treated is encountered, even if the linear speed of the travelling material varies considerably, or if the power-line voltage fluctuates, or the material entering the device is subjected to considerable change such as regards its thickness, cross section, or thermal behaviour. This is accomplished by the above-described automatic controller 15–19, due to the fact that the heat capacity of the ring member 2 is relatively small so that the ring temperature follows any changes in primary power input with extreme rapidity.

As mentioned above, the heater member may comprise a number of individual coaxial components. Analogously, the single-piece or composite heater member may be acted upon by a plurality of primary windings on respective transformer cores and thus may form a short-circuited secondary winding common to the plurality of such primary units. An embodiment of this type is schematically illustrated in FIG. 5. The ring member 2, otherwise designed and operating in the manner described above, is inductively linked with the cores 8 and 38 of two transformer units whose respective primary windings are denoted by 9 and 29. The two primary windings may be electrically connected in parallel or in series as may be desirable for obtaining the necessary heating power.

It has been found that by thus inductively linking one and the same annular heater member with a number of simultaneously energizable primary windings, the heating power is increased more than proportionately if the poling of each two successive primaries is reversed relative to the instantaneous polarities induced in the heater member. This will be explained with reference to FIGS. 1 and 6.

As described, the annular heater member 2 according to FIG. 1 is coupled with a single primary winding 9. Indicated by (+) and (−) are the polarities assumed by the induced potential in the member 2 at a chosen instant. The distance around the circumference is considerable, and imposes a limitation upon the attainable current flow.

By using a multiplicity of primary units 9, 29, 39, 49, 59 according to FIG. 6, and phasing them for the instantaneous polarities as shown in FIG. 6, the annular member 2, constituting a short-circuited secondary turn common to all of the primaries, produces an alternating succession of positive and negative potentials. The voltages induced in each two successive segments are equal, so that the results correspond to a reduction in length and resistance in each of the multiplicity of short-circuited paths now effective. That is, the result appears to correspond to a reduction of resistance substantially in inverse relation to the number of primary units used. This is exemplified by the following readings:

Number of Primary Units	Amperes	Watts in ring
1	16	160
2	32	320
3	152	1,520
4	970	9,700
5	2,200	22,000

These readings constitute relative values and are presented by way of example. It will be obvious that the absolute data in each case will depend upon dimensions and other parameters. However, the tabulated data illustrate the extraordinary increase in heating power developed by the use of multiple primary units.

While in the embodiments so far described the annular heater member 2 constitutes the secondary of a transformer energized from a utility power supply, for example of 60 c.p.s., the heating of member 2 may also be effected

by induction heating. For this purpose, an induction heater coil, as shown in 9' in FIG. 7, directly surrounds a portion of the ring member 2 and is energized by alternating current of suitable high frequency, for example 5 to 100 kilocycles. The ring member 2 consists of metal. No iron core is used in the coils of such devices, although the ring member may be made of iron. In other respects the devices may correspond to the one described with reference to FIG. 1. If desired, a plurality of primary coils 9' may also be provided for heating a single ring member 2.

It will be obvious to those skilled in the art, upon a study of this disclosure, that devices according to my invention may be modified with respect to details and may be given embodiments other than particularly illustrated and described herein, without departing from the essential features of my invention and within the scope of the claims annexed hereto.

I claim:

1. An electrical device for heat treatment of windable material, comprising a heater member of electrically conducting metal having the shape of a closed ring, supporting rollers engageable with, and distributed over the inner periphery of said member to journal said member for rotation about its center axis, electric means for heating said member, a rotatable capstan pulley radially spaced from said member and having a capstan axis parallel to said center axis, said capstan pulley defining together with the outer periphery of said annular member a loop-shaped travel path for the material around said capstan pulley and around the outer periphery of said member, whereby the material traveling on said path is heated by contact with said member when the device is in operation.

2. An electrical device for heat treatment of windable material, comprising an annular heater member of electrically conducting metal having a circumferentially closed shape, supporting rollers engageable with and distributed along the inner periphery of said member for journalling said member for rotation about its center axis, a transformer having a stationary core with a loop portion extending through the opening of said annular member in spaced relation thereto, said transformer having a primary winding on said core whereby said member forms a short-circuited secondary winding of said transformer to be heated by induced secondary current circulating in said member, a rotatable capstan pulley radially spaced from said member and having a capstan axis parallel to said center axis, said capstan pulley defining together with the outer periphery of said annular member a loop-shaped travel path for the material around said pulley and around the outer periphery of said member, whereby the material travelling on said path is heated by contact with said member when the device is in operation.

3. In a heat treating device according to claim 1, said heater member and said capstan pulley having each a plurality of peripheral grooves located coaxially beside each other, whereby the material can be passed in a plurality of loops around the capstan pulley and around said member.

4. An electrical device for heat treatment of windable material, comprising a heater member of electrically conducting metal having the shape of a closed ring, supporting rollers engageable with, and distributed over, the inner periphery of said member to journal said member for rotation about its center axis, electric means for heating said member, a rotatable capstan pulley radially spaced from said member and having a capstan axis parallel to said center axis, said capstan pulley defining together with the outer periphery of said annular member a loop-shaped travel path for the material around said capstan pulley and around the outer periphery of said member, said annular heater member comprising a plurality of coaxially adjacent components each having a peripheral groove and being rotatable relative to the adjacent component for compensating changes in length of the travelling material, whereby the material travelling on said path is heated by contact with said respective components of said heater member when the device is in operation.

5. An electrical device for heat treatment of windable material, comprising a heater member of electrically conducting metal having the shape of a closed ring, supporting rollers engageable with, and distributed over, the inner periphery of said member to journal said member for rotation about its center axis, electric means for heating said member, a rotatable capstan pulley radially spaced from said member and having a capstan axis parallel to said center axis, said capstan pulley defining together with the outer periphery of said annular member a loop-shaped travel path for the material around said capstan pulley and around the outer periphery of said member, said heater member and said capstan pulley having each a plurality of coaxially adjacent components, each of said components having a peripheral groove and being rotatable relative to the adjacent component for compensating changes in length of the travelling material, whereby the material travelling on said path is heated by contact with said member when the device is in operation.

6. An electrical device for heat treatment of windable material, comprising a heater member of electrically conducting metal having the shape of a closed circular ring and being rotatable about its center axis, electric means for heating said member, means for supplying heating power to said ring member, guide means defining together with the periphery of said member a loop-shaped travel path for the material and adapted to hold the travelling material in contact with the periphery of said member, whereby the travelling material is heated by peripheral contact with said member during rotation of said member, said ring-shaped heater member having a plurality of peripheral grooves coaxially beside each other, for engagement by a number of respective loop turns of the material, and said guide means comprising a rotatable capstan pulley from which the material to be treated passes around said member and through said grooves when the device is in operation.

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