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H. E. SOMES

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HEAT TREATING APPARATUS

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FIG. 1

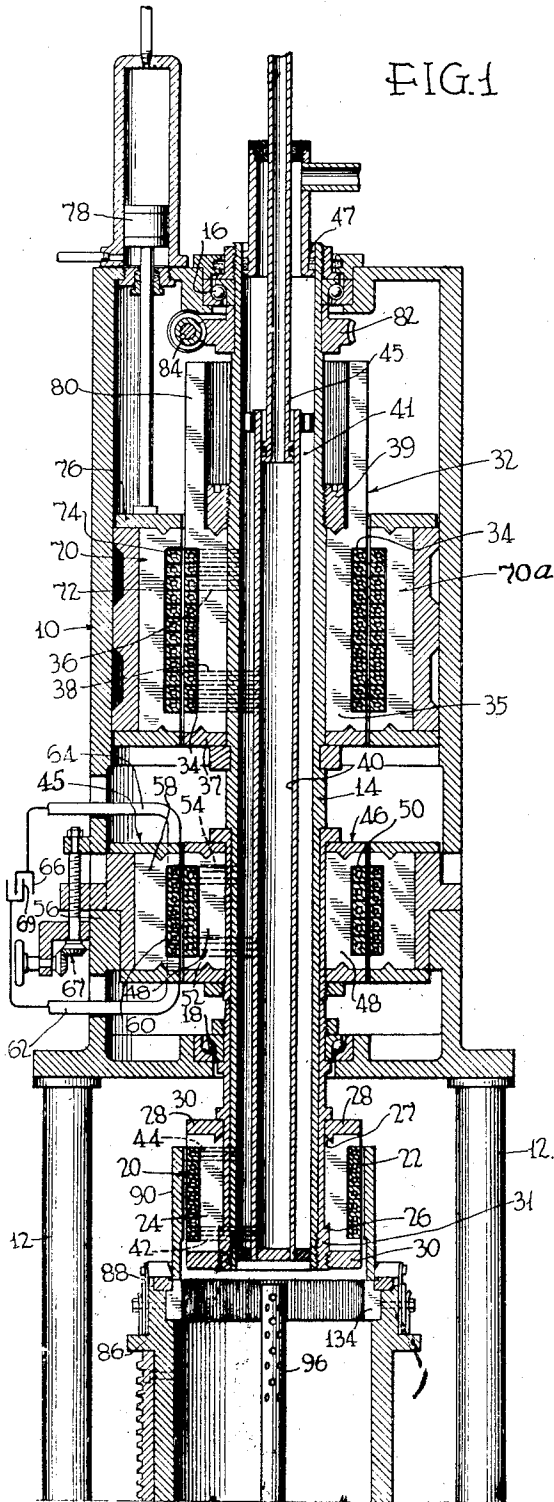
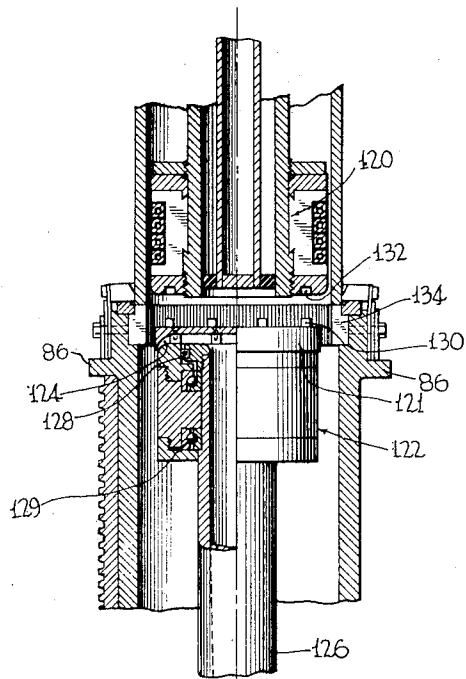


FIG. 2



INVENTOR
Howard E. Somes

BY *John P. Tarboys*
ATTORNEY

UNITED STATES PATENT OFFICE

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HEAT TREATING APPARATUS

Howard E. Somes, Detroit, Mich., assignor to Budd
Induction Heating, Inc., Philadelphia, Pa., a
corporation of Michigan

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11 Claims. (Cl. 219—13)

This invention relates to electromagnetic induction heat treating apparatus and more particularly to an organization of apparatus and control transformer in which simplification of movements and electrical connections is effected through the use of relatively rotating inducing coils.

In heat treating apparatus of the type disclosed in a copending application Serial No. 164,320, filed September 19, 1937, there is disclosed an apparatus in which objects may be internally differentially heat treated and in which the transmission of high frequency, high power current to the inducing coil is effected through a switching transformer. Provision is therein made for rotating the work coil relative to the work either through the rotation of work itself or through the rotation of the coil. However, with the rotation of the coil there is necessarily provided sliding connections between the arbor supporting the rotatable coil and the transformer secondary from which current is derived to feed the coil.

The present invention is adapted to eliminate all such sliding connections and at the same time permit the work support to remain stationary. With heavy workpieces the rotation of the work support which must be stopped and started for loading purposes is avoided together with the elimination of such torsional stresses as might be set up in the workpiece in such rotation thereof.

The existence of torsional stresses within the workpiece at such time as it is proceeding through a heat treating cycle, which of itself internally stresses the workpiece to a considerable extent, may in some instances be exceedingly detrimental, particularly if the wall of the workpiece is relatively thin.

It is accordingly an object of the present invention to provide a high frequency heat treat apparatus in which the work may be retained stationary and the work coil rotate and in which the work coil may be fed with energy from a transformer secondary rotatable therewith.

A further object of the invention is to provide an apparatus in which a high frequency high power work coil is supplied with energy from the rotating transformer secondary rotatable with the work coil and in which the primary of the transformer may be axially moved into and out of inductive relation with the rotating secondary.

A further object of the invention is the provision of power factor correcting capacitors acting upon the rotating work coil circuit through pref-

erably a step-up transformer, the primary of which rotates with the work coil and the secondary of which is stationary.

The above and other novel features of the invention will appear more fully hereinafter from the following detailed description when taken in conjunction with the accompanying drawing. It is expressly understood, however, that the drawing is for purposes of illustration only and is not designed as a definition of the invention, reference being had for this purpose to the appended claims.

In the drawing wherein like reference characters indicate like parts:

Figure 1 is a longitudinal section through one form of the apparatus illustrating diagrammatically the organization thereof and

Figure 2 is a sectional view of the lower portion of the apparatus modified so as to permit progressive heat treatment.

Referring to the drawing and particularly Figure 1 thereof there will be seen a frame structure 10 supported on suitable uprights 12 from a foundation, not shown. Journaled in the preferably vertical frame is a tubular arbor 14 having spaced bearings 16 and 18 assuring accurate alignment of the arbor during rotation. Supported at the lower end of the arbor and on the outside thereof is a heat treat coil 20 composed of a plurality of turns 22 arranged about an annular core 24 composed of radial laminations, the core being secured upon the arbor through dovetail notches 26 and 27 and the mating collars 28 and 30 axially thrust against the core through the threaded engagement of collar 30 upon the arbor sleeve 31.

Upon the upper end of the arbor 14 is rotatably supported the secondary 32 of the power transformer 70. The secondary is preferably a heavy current, relatively low voltage secondary, the turns 34 thereof being arranged in multiples of three in parallel as is indicated. The secondary is provided with a core 35 composed of radial laminations similar to the laminations 24 disclosed in conjunction with the coil 20, the same being secured upon the arbor between collars 37 and 39. The secondary is connected to the work coil through leads 36 and 38 extending through the core 35 and to the arbor and to a conductor 40 within the arbor and concentric therewith.

The leads 36 and 38 where they pass through the core may be insulated in any suitable manner.

The heat treat coil 20 is connected to the ar-

bor and a concentric conductor 40 therein through a pair of leads 42 and 44 as is diagrammatically illustrated.

Because of the low power factor generally present in apparatus of the type herein disclosed it is preferable to correct the power factor to a certain extent through the use of capacitors and it is highly desirable that the capacitors be connected to the coil in as direct and close a manner as is possible so that the transformer secondary circuit will be relieved from carrying heavy reactive currents. In order to provide such a power factor correction and yet make connections to the coil in as direct a manner as possible a novel feature of the present invention relates to a second transformer 45 having relatively rotating primary and secondary parts, the primary being rotatable with the arbor and work coil. As illustrated the primary 48 of the transformer is supported upon the arbor as near to the heat treat coil as possible, the primary being composed of radial laminations and a coil 50, the latter being connected through suitable leads 52 and 54 to the arbor and the connecting conductor therewithin. The secondary 58 of the transformer 45 is non-rotatable and supported by the frame 10 by a guide 56 and comprises a core of radial laminations 58 and the secondary winding 60, the latter being connected through suitable leads 62 and 64 to a suitable capacitance 66. The ratio of turns between primary and secondary may be such as to give a step-up effect thereby permitting a more efficient use of the capacitance if desired, and the secondary 58 may be axially shiftable through the adjustment 67 to vary the coupling between the coils to the condenser 69.

Through the use of a primary 70a adapted to be reciprocated coaxially with respect to the arbor into and out of inductive relation with the secondary 32, current is switched on and off. The primary 70a of the transformer 70 is similar in many respects to the secondary hereinbefore described, the same being composed of a radially laminated core 72, primary coil 74, and casing 76 for holding the parts in assembled relation. The primary 70a is adapted to be reciprocated upon the frame 10 by an air cylinder and piston 78. The primary 70a when uncoupled from the secondary 32 is preferably coupled with an annular laminated iron extension 80 arranged for convenience upon the upper end of the secondary member although the extension could be stationary.

Any suitable sliding or flexible lead connections (not shown) may be made to the primary to supply the same with high frequency high power from a suitable generator.

Rotation of the arbor with its power transformer secondary, and power factor correction transformer primary, and work coil may be effected by any suitable arrangement, such as for example, a worm wheel 82 and worm 84, the latter being driven by a suitable motor not illustrated. It will of course be understood that the arbor must be of sufficient rigidity so as to maintain the parts in accurate alignment during rotation since close clearance between the heat treat coil and the workpiece is desirable.

To support a workpiece for reciprocation into and out of heat treating position, any suitable device may be employed. As illustrated the support may consist of an axially reciprocating work supporting member 86 provided with a clutch 88 for resiliently receiving the workpiece

90. Any suitable means may be employed for axially reciprocating the work-supporting member 86 relative to the heating head 20. In order to quench the workpiece 90, differentially heated for hardening purposes, the quench fixture 96 is provided to be moved axially into quenching position after which the workpiece 90 is lowered into position to be quenched by lowering the supporting member 86. After quenching, the supporting member 86 and the quenching fixture are moved axially to a lower position to permit removal of the heat-treated workpiece and the insertion of a subsequent workpiece for heat treatment.

In heat treating long tubular objects it is desirable to progressively heat and quench the article, heating a small annulus at a time and subsequently quenching the heated annulus. The lower end of the apparatus of Figure 1 may be modified in the manner illustrated in Figure 2 so that such progressive operation may be effected. For example, the heat treat head 120 may be reduced in length so that its underside may be provided with a rotatable quenching fixture 122 having an annular quenching orifice 124 rearwardly directed away from the head 120. The quench head portion 121 may be rotatably mounted upon the end of the quench supply pipe 126 and a suitable packing 128 and bearing 129 provided between the relatively rotatable parts. In order to assure rotation of the quench head, it is provided with interlocking tongues such as at 130 adapted to engage recesses at 132 at the end of the heat treat head 120 when elevated into proper position. Gradual progressive movement of the work axially with relation to the heat treat head and quench may be effected through the lowering of the work support member 86 in any desired manner.

It will of course appear in both modifications that the various coils are preferably water cooled and for this purpose the central tubular conductor 40 may act as a supply conduit for cooling fluid and the annular space between the conductor and tubular arbor constitute a space 41 for returning fluid after it has passed through the various coils. A swivel connection to the interior of the hollow conductor 40 and to the annular space 41 between conductor and tubular arbor 14 may be effected as is illustrated at 45 and 47 respectively.

The operation of the apparatus should appear obvious from the description thereof, hereinabove. The heat treat head of either of the figures may be continuously rotated or its rotation started or stopped as each individual treatment is to be performed. The work support upon being loaded is raised so as to bring the work into proper position with relation to the heat treat coil. Thereafter, the primary of the transformer is shifted to the position shown in Figure 1 and high frequency current is then caused to flow through the work coil thereby generating differential heating currents in the workpiece so as to heat the same to a shallow depth to a hardening temperature. In the course of a few seconds or a time interval dependent upon the power employed and other factors the work is removed from the inductive relation to the coil, the switching transformer primary moved from its position in inductive relation with its secondary and the quench is then brought into action and the heated surface of the workpiece rapidly quenched. In the case of the progressive arrangement of Figure 2, the quench and the

heating current act simultaneously as the tubular object is gradually lowered whereby successive portions are heated and substantially instantaneously quenched thereafter.

The quenching fixture, in Figure 1, has been described as an elevatable and retractable apparatus (not specially shown) so that the workpiece may be readily removed and a new one inserted. Similarly, the quenching fixture 122, illustrated in Figure 2, is elevatable and retractable into and out of operative relation with the work head, the extent to which the two may be separated being governed by the length of the tubular object which must be inserted during the loading of the apparatus. It will of course appear that in the modification of Figure 2 the workpiece will be placed in position in the work holder when the same is lowered and thereafter prior to the commencement of heating and quenching, the same is raised to the upper position from which it is thereafter gradually uniformly lowered as the progressive heating and quenching is effected.

In practice the quench operation is preferably arranged as close to the heat treat coil as possible so that as small amount of heat as possible is lost by drift from the heated zone to the unheated exterior zone in the workpiece prior to quenching. In the progressive treatment of long tubular objects in order to reduce end effects and provide substantially uniform treatment up to the very end of the tubular object, laminated magnetic flux extension pieces 134 radially arranged in the chuck 88 may be employed.

There is thus provided a novel compact heat treat apparatus in which mechanical difficulties ordinarily encountered by sliding electrical connections caused by relative rotation of the various parts are minimized and in which the high electrical efficiency heretofore present is retained and all without additional elements or complication.

While the invention has been illustrated and described with variations, it is to be understood that the invention is not limited thereto, and may be embodied in various other mechanical and electrical arrangements. Various changes may be made in the construction and arrangement of the parts without departing from the spirit of the invention as will be apparent to those skilled in the art and reference should, therefore, be had to the appended claims for a limit of the definition of the invention.

What is claimed is:

1. Apparatus for induction heating comprising a support, a member rotatably carried by said support and fixed against axial movement with respect thereto, a heat-treat head including an inducing coil carried by said rotatable member, a transformer secondary having a coil concentric with and fixedly carried by said member, electric circuit connections between said inducing coil and said transformer coil, and a transformer primary coil concentric with said secondary coil and carried on said support for coupling relation with said secondary coil.

2. Apparatus for induction heating comprising a support, a member rotatably carried by said support and fixed against axial movement with respect thereto, a heat-treat head including an inducing coil carried by said rotatable member, a transformer secondary having a coil concentric with and fixedly carried by said member, electric circuit connections between said inducing coil and said transformer coil, and a trans-

former primary coil concentric with said secondary coil and carried on said support for coupling relation with said secondary coil, said primary coil being slidably carried by said support, and means for shifting said primary coil relative to said support axially into and out of inductive relation with said secondary coil.

3. Apparatus for induction heating comprising a support, a rotatable member carried by said support, a heat-treat head including an inducing coil mounted on said member, a transformer secondary having a coil coaxial with and fixedly carried by said member, electric circuit connections between said inducing coil and said transformer coil, a transformer primary coil concentric with said member and carried on said support and being adapted for coupling with said secondary coil, a third coil concentric with and fixedly carried by said rotatable member, electric circuit connections between said third coil and inducing coil, a non-rotatable coil concentric with said third coil and coupled therewith, and a capacitance connected to said non-rotatable coil.

4. Apparatus for induction heating comprising a support, a rotatable member thereon fixed against axial movement, a heat-treat head including an inducing coil carried by said member, means for conducting electrical energy to said inducing coil, a second coil carried by said member in concentric relation therewith, electric circuit connections between said second and inducing coils, a non-rotatable coil concentric with said second coil and being carried by said support, and a capacitance electrically connected to said non-rotatable coil.

5. Apparatus for induction heating comprising a support, a rotatable member thereon, a heat-treat head including an inducing coil fixedly carried by said member, a source of electrical energy for said coil, means electrically connecting said coil with said source, a second coil fixedly carried by said member in concentric relation therewith, a non-rotatable coil carried by said support in concentric relation with said second coil, electric circuit connections between said inducing and second coils, a capacitance connected to said non-rotatable coil, and means for adjusting the coupling between said second-named and non-rotatable coils.

6. Apparatus for induction heating comprising a support, a member rotatably carried by said support and being fixed against axial movement relative thereto, a heat-treat head including an inducing coil carried by said member, a transformer secondary having a coil coaxial with and fixedly carried by said member for rotation therewith, electric circuit connections between said inducing and secondary coils, a transformer primary coil concentric with said secondary coil and being adapted for coupling relation with said secondary coil and being carried by said support, means for shifting said primary coil axially relative to said support into and out of inductive relation with said secondary coil, and compensating means for said primary coil to increase the reactance thereof when moved out of inductive relation with said secondary.

7. Apparatus for induction heating comprising a support, a member rotatably carried by said support and fixed against axial movement relative thereto, a heat-treat head including an inducing coil carried by said member, a transformer secondary having a coil coaxial with said member and an annular transformer iron core for said secondary coil coaxial with and fixedly

carried by said member, electric circuit connections between said inducing and secondary coils, a transformer primary coil concentric with said member and being adapted for coupling relation with said secondary coil, said primary coil being provided with an annular core complementary to said secondary core, means for shifting said primary coil and core relative to said support axially into and out of inductive relation with said coil and core, and additional complementary core means for said primary coil and core for increasing the reactance thereof when moved out of inductive relation with said secondary coil and core.

8. Apparatus for induction heating comprising a support, a rotatable member mounted on said support in axially fixed relation with respect thereto, said member including concentric conductors, a heat-treat head including an inducing coil fixedly carried by said member and having its terminals connected with said conductors, a transformer secondary having a coil coaxial with and fixedly carried by said member, and having its terminals electrically connected with said conductors for transferring electrical energy from said secondary coil to said inducing coil, and a transformer primary coil in concentric relation with said member, means slidably supporting said primary coil upon said support, and means for axially shifting said primary coil into and out of coupling relation with said secondary coil.

9. Apparatus for induction heating comprising a supporting member, an arbor rotatably supported by said member, a transformer secondary coil, in inducing coil, a transformer primary coil, each of said coils being fixedly carried by and in

concentric relation with said arbor for rotation therewith, electrical connections between said coils, a second secondary coil in concentric relation with said primary coil, means for supporting said second secondary coil against rotation, and a capacitance electrically connected with said second secondary coil.

10. Apparatus for induction heating comprising a supporting member, an arbor rotatably supported by said member, a transformer secondary coil, an inducing coil, a transformer primary coil, each of said coils being fixedly carried by and in concentric relation with said arbor for rotation therewith, electrical connections between said coils, a second secondary coil in concentric relation with said primary coil, means for supporting said second secondary coil against rotation, and a capacitance electrically connected with said second secondary coil, together with means for shifting said second secondary coil axially with respect to said primary coil for adjusting the coupling therebetween.

11. Apparatus for induction heating comprising a supporting member, an arbor rotatably supported by said member, a transformer secondary coil, an inducing coil, a transformer primary coil, each of said coils being fixedly carried by and in concentric relation with said arbor for rotation therewith, said arbor comprising inner and outer concentric conductors insulated from each other, electric circuit connections between one terminal of each of said coils and one of said conductors, and electric circuit connections between the other terminal of each of said coils and the other of said conductors.

HOWARD E. SOMES.