May 7, 1946. H. E. SOMES 2,399,896

HEAT TREATING APPARATUS

Filed Feb. 6, 1945 3 Sheets-Sheet 1

Fig. 1.

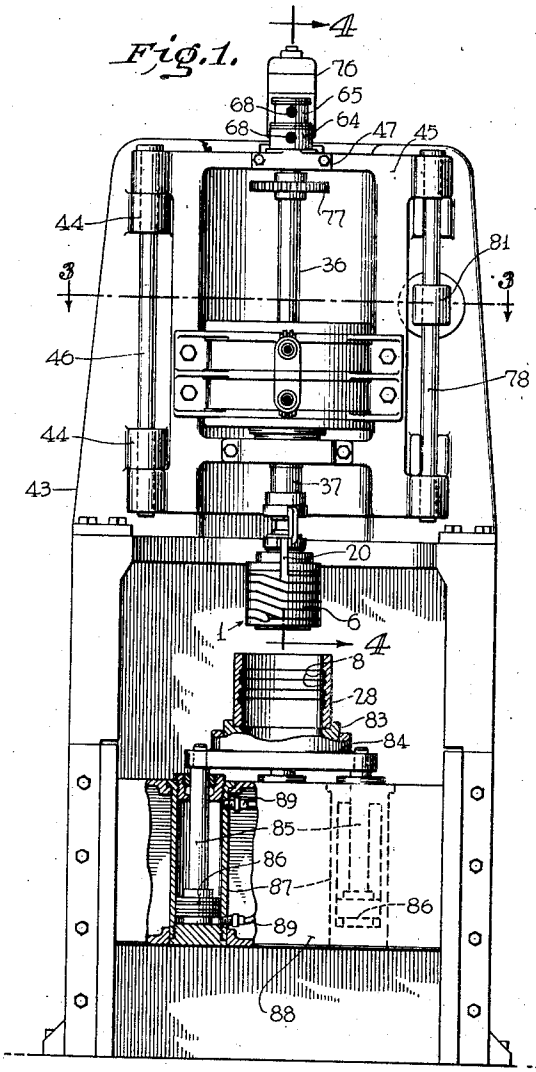


Fig. 2.

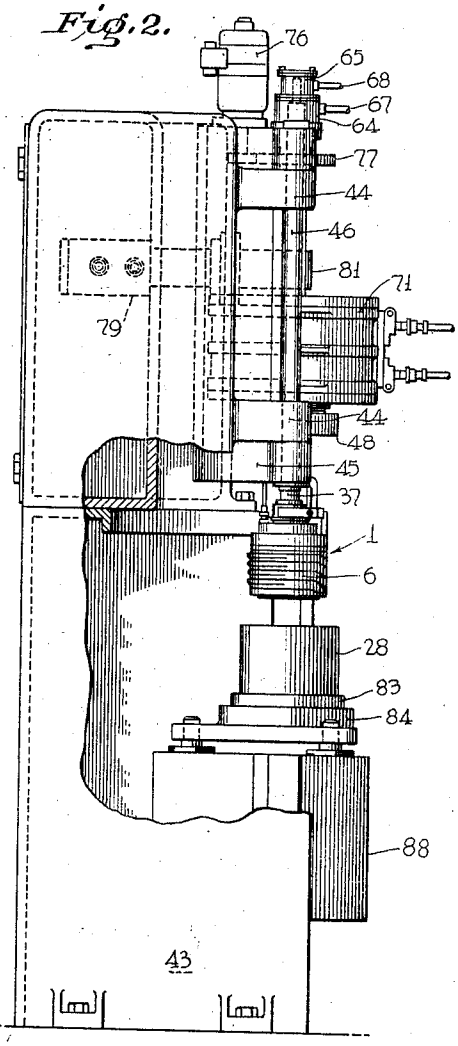
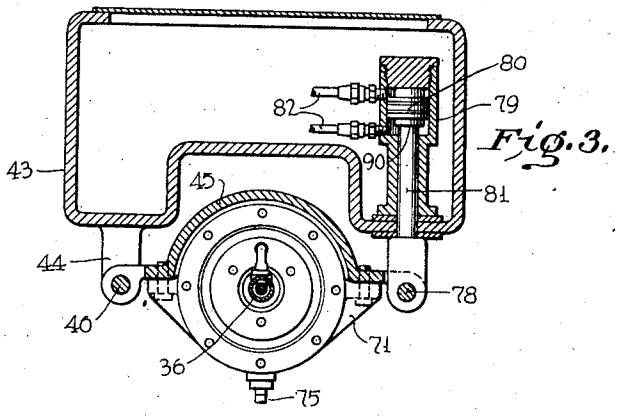


Fig. 3.



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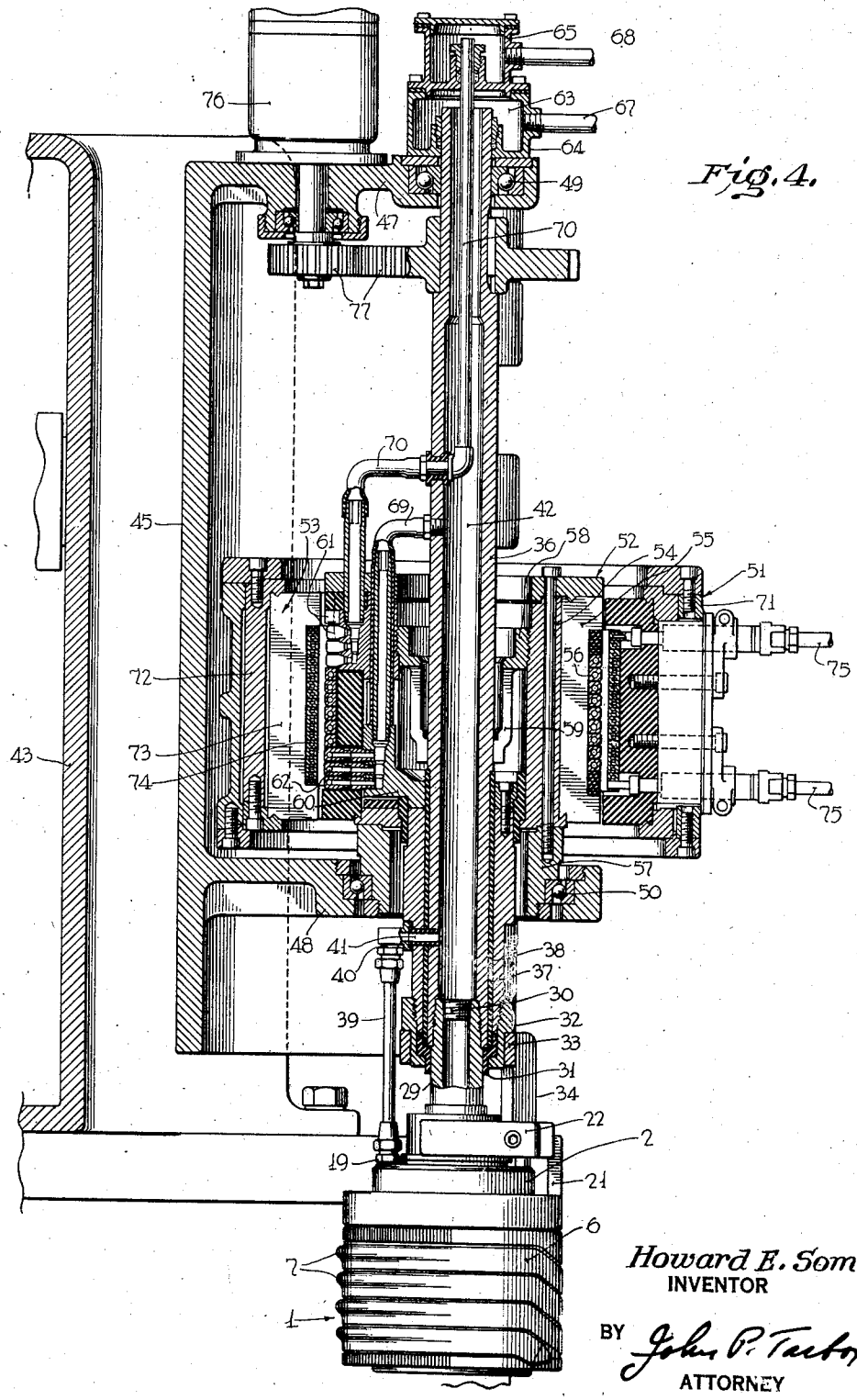


Fig. 4.

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HEAT TREATING APPARATUS

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Fig. 5.

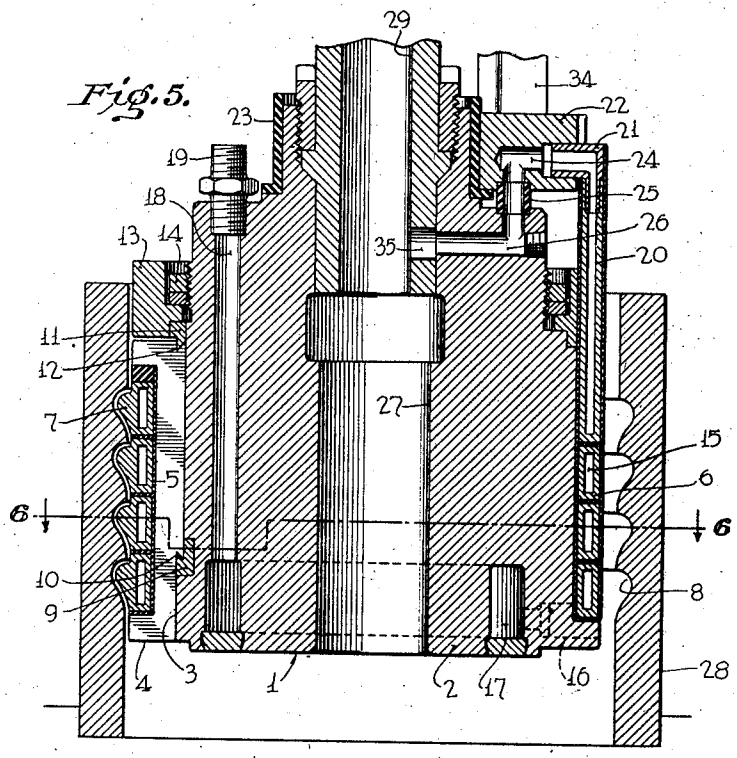
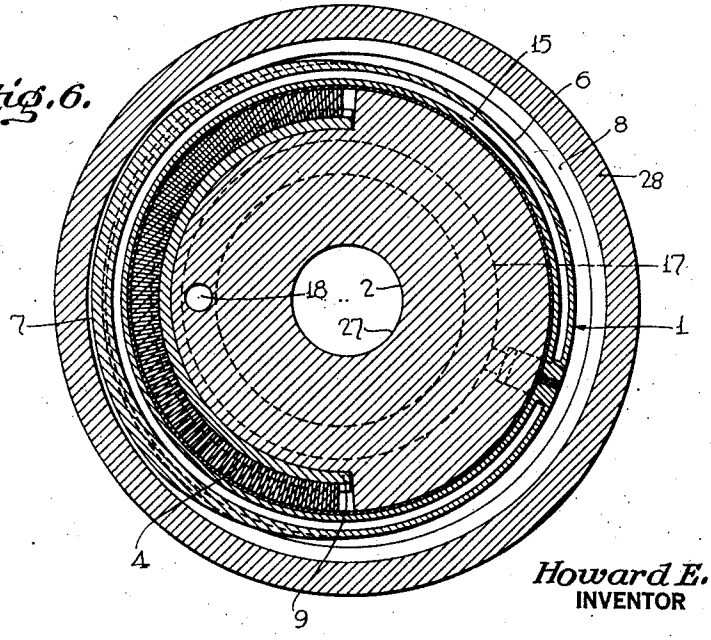


Fig. 6.



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Patented May 7, 1946 2,399,896

UNITED STATES PATENT OFFICE

2,399,896

HEAT-TREATING APPARATUS

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

Application February 6, 1945, Serial No. 576,410

6 Claims. (Cl. 219—13)

This invention relates to heat treating apparatus, particularly to apparatus for heating grooved or recessed surfaces by electromagnetically induced heating currents.

In my Patent No. 2,281,331, dated April 28, 1942, apparatus is shown for heating the bores of tubular articles. In such apparatus, an induction heating head is arranged to be concentrically disposed within the bore of the article to be heated. In the case of an article having internal circumferential grooves or recesses, such as ball bearing grooves, desired to be hardened, it has been the practice heretofore to use an induction heating head of the general character of that shown in my patent aforesaid. In such case, due to the variable spacing of the surfaces of the grooves from the inducing coil, it has not been possible to obtain a hardened zone of uniform depth. This non-uniform depth of hardness gives rise to undesirable non-uniform stress distribution.

The primary object of the present invention is to provide an inducing head with a winding or coil having for a portion of the peripheral extent of the coil turns projecting portions of a contour similar to the circumferential recesses of the article to be heat treated, which head is arranged to be coaxially disposed with the article transversely shifted to register the projecting portions of the winding with the grooves and then rapidly rotated relative to the article.

Another object is to provide improved mechanism for effecting the shifting and rotation of an induction heating head of the foregoing character.

With the above and other objects in view, which will be obvious from the following detailed description to those skilled in the art to which the invention appertains, the present invention consists in certain features of construction and combinations of parts to be hereinafter described with reference to the accompanying drawings and then claimed.

In the drawings, in which one embodiment of the invention is shown for illustration:

Figure 1 is a front elevation of the heat treating apparatus, a portion of the same being shown in section;

Figure 2 is a side elevation of the apparatus shown in Figure 1;

Figure 3 is a transverse section taken approximately on line 3—3 of Figure 1;

Figure 4 is an enlarged vertical section taken approximately on line 4—4 of Figure 1;

Figure 5 is an enlarged vertical section of the induction heating head showing the same in operative heating relation with an internally grooved article; and

Figure 6 is a transverse section taken approximately on line 6—6 of Figure 5.

Referring to the accompanying drawings in which like numerals refer to like parts throughout the several views, and first to Figures 4, 5 and 6, the induction heating head 1 includes an annular support 2 formed with a semi-circular recess 3 which receives a magnetic core 4 comprised of a plurality of tapered laminations. The core 4 is provided with a recess or window 5, and the helical coil 6 which surrounds the support 2 is seated in this pocket, the coil turns being insulated from each other and from the support 2 as shown. The coil turns are each provided for approximately one-half the circumferential extent thereof with a transversely offset portion 7, the external cross-sectional contour of which is substantially the same as that of the grooves 8 of the article to be heat treated. The laminated core is held in position by a lower arcuate element 9 having a dovetailed connection 10 therewith and an upper arcuate clamping element 11 having a similar dovetailed connection 12 therewith. Disposed above the element 11 is a clamping ring 13 having shouldered engagement with the element 11 and the support 2, the ring 13 being held in clamping position by a nut 14 threaded on the support 2.

As shown, the coil 6 is provided with a cooling passage 15. One end 16 of the coil (shown in broken outline in Figure 5) is electrically connected with the support 2 and receives cooling fluid from a closed annular recess 17 in the support 2. The support 2 is provided with a longitudinal passage 18 extending from the recess 17 and opening through the upper end thereof and provided with a tubular fitting 19. The other end 20 of the coil extends upwardly and through a fitting 21 and is electrically connected with an arcuate element 22 insulated by a ring 23 of electrical insulation from the support 2. The element 22 is provided with a passage 24 to receive cooling fluid from the coil and discharge the same through a tubular connector 25 to a passage 26 leading to the bore 27 of the support 2.

Secured to the upper end of the support 2 is a tubular connector 29 which is closed by a plug 30 and surrounding the connector 29 but insulated therefrom by an insulating ring 31 is an annular internally threaded nut 32. Clamped about the nut 32 is a ring 33 having a depend-

ing portion 34 which forms an integral support for the arcuate element 22. The upper end of the connection 29 is externally threaded as shown in Figure 4. The connector 29 is provided with an aperture 35 through its wall which registers with the passage 26.

The head 1 is supported by a vertical arbor comprised of an inner tubular conductor 36 and a short outer conductor 37 insulated from the inner conductor by insulation 38, the connector 29 being threaded to the inner conductor 36 and the nut 32 being threaded to the outer conductor 37 as shown in Figure 4. The cooling fluid fitting 19 is connected to a conduit 39 which is connected through a fitting 40 to an insulated passageway 41 leading to the bore 42 of the inner conductor 36.

The axis of the arbor is coincident with the axis of projecting portions of the coil.

As shown in Figures 1, 2 and 3, the machine base 43 is provided at one side of its front face with a pair of lugs 44. A bracket 45 is hinged by a pivot rod 46 to the lugs 44.

The bracket 45 is provided with upper and lower arms 47 and 48, respectively, which carry anti-friction bearings 49 and 50, respectively. The upper end of the inner conductor 36 is supported for rotation by the bearing 49.

High-frequency current is supplied to the coil 6 of the head 1 by a transformer 51 having a secondary unit 52 and a primary unit 53. The secondary unit 52 is arranged to rotate with the arbor and embodies an annular support 54 which carries a laminated core 55 the core in turn supporting the tubular secondary winding 56. This secondary unit is bolted to an anular ring 57 which is supported by the bearing 50. Arranged within the annular support 54 is an upper conductor element 58 which is provided with fingers 59 in electrical contact with the inner conductor 36 and a lower annular conductor element 60 which is insulated from the support 54 and is bolted to the outer conductor 37 as shown in Figure 4. One terminal 61 of the winding 56 is connected to the conducting element 58, and the other terminal 62 of this winding is connected to conductor element 60.

The upper end of conductor 36 projects above the upper bracket 47 and has a sealed rotatable bearing fit with a surrounding chamber 63. Mounted above and supported by the casing 64 which forms chamber 63 is a second casing 65 which forms a chamber 66. The casings 64 and 65 are provided with conduits 67 and 68, respectively. Cooling fluid supplied to the chamber 63 through conduit 67 flows into the open end of the inner conductor 36.

A portion of this cooling fluid flows through passageway 41 and thence through conduit 39 to the coil 6, and after cooling the coil flows through passages 24, 26 and 35 to the bore 27 of the support 2 where it exhausts to the atmosphere. A portion also of the cooling fluid leaves the conductor 36 through an insulating conduit 69 extending through the conducting element 58 and connected to the lower conducting element 60 and enters the secondary winding. After cooling the secondary winding, this branch cooling fluid leaves terminal 61 through but is insulated from the wall of conductor 36 and extends upwardly axially within the conductor 36 into the chamber 66 and is discharged from chamber 66 through conduit 68. The conduit 70 has a rotatable sealed bearing engagement with the casing 65.

The primary unit 53 of the transformer 51 is supported by the bracket 45 above arm 48 by a two-part support 71, and includes an annular member 72 which carries a laminated core 73, this coil, in turn, supporting the primary winding 74 in concentric relation about the secondary unit 52. The insulated terminals 75 of the winding 74 are connected with a suitable source (not shown) of alternating current.

The arbor, including the secondary transformer unit 52 and heating head 1, is rotated within the bearings 49 and 50 by a motor 76 through suitable gearing 77, the motor 76 being supported by the upper arm 47.

The unhinged side of bracket 45 is provided with a vertical rod 78 and supported within the base 43 is a horizontal fluid pressure cylinder 79 having a piston 80 therein. The piston 80 is provided with a piston rod 81 which extends through the front wall of the base 43 and is pivotally connected to the rod 78. Fluid under pressure admitted to one side or the other of the piston 80 through conduits 82 causes the piston to swing the bracket 45 to transversely move the inducing head and arbor a predetermined amount.

The tubular workpiece 28 selected for illustration is supported upon a suitable annular support 83 mounted on a reciprocable carriage 84. The carriage is supported by a plurality of depending piston rods 85, each of which carries a piston 86 operatively associated with a cylinder 87. The cylinders are fixedly supported by a cross piece 88 mounted on the front of the base 43 for vertical adjustment. The cylinders 87 are provided with conduits 89 for admitting and discharging fluid under pressure to and from the cylinders at opposite sides of the pistons 86.

Normally in the inoperative position, the bracket 45 is in its outermost position, that is, it is swung outwardly from the position shown in Figure 3, a shoulder 90 on the piston 80 being in engagement with the end of the piston 79 to predetermine this outermost position. In this position, the inducing head 1 is so related to the tubular workpiece 28 that upon admission of fluid under pressure to the lower sides of the pistons 86, the carriage 84 is elevated. During elevation of the carriage, the workpiece 28 is caused to surround the inducing head 1 with the axis of the head offset from the axis of the workpiece. The elevation of the carriage is such that in its uppermost position the transverse projections 7 of the coil 6 are in alignment with the circumferential grooves 8 of the workpiece 28.

After the workpiece is so elevated, fluid is admitted to cylinder 79 which causes the piston 80 to swing the bracket 45 inwardly into the position shown in Figure 3. This coincides the axis of the projections 7 with the axis of the workpiece. The inducing head 1 is then caused, through the motor 76, to rotate rapidly about the workpiece axis, and the head is energized through the supply of high-frequency, high-power alternating current to the transformer. Due to this coaxial positioning of the inducing head and the workpiece, the projecting portions 7 of the head are caused during rotation to rotate within the grooves 8. During this rotation, heating currents are electromagnetically induced in the surface metal of the grooves 8 to a predetermined depth by the eccentric portions of the coil 6. By the use of the semi-circular core 4 and eccentric coil portions 7, and by reason of the greater spacing of the balance of the coil from the bottoms of

the grooves, the balance of the coil has little, if any, heating effect on the workpiece.

It is by this arrangement that I am enabled to heat the grooves inductively to a predetermined depth, this depth being uniform, as desired, throughout the groove contour with the result that following a quenching operation, the residual stresses in the workpiece will be uniformly distributed.

Inasmuch as the quenching apparatus forms no part of the present invention, the same has not been shown.

While I have shown a specific means for rotating the arbor and a specific transformer for energizing the inducing head 1, the secondary of which is rotatable with the head supporting arbor, it is to be understood that various other rotating means, well known in the art, and that other well known means for transmitting current to the inducing head coil may be employed.

It is to be understood, also, that the principles of the present invention are applicable to cylindrical articles having external circumferential grooves.

The heating head per se is claimed in my concurrently filed application Serial No. 576,411.

It is to be understood, further, that various changes may be made in the detailed construction and arrangement of the parts described without departing from the spirit and substance of the invention, the scope of which is defined by the appended claims.

What is claimed is:

1. In an apparatus for inductively heating the surface of a circumferentially grooved cylindrical workpiece, an inductor having a transversely projecting portion substantially conforming in contour to the contour of the workpiece groove to be heated, a support for holding the workpiece, the workpiece as held by said support and said inductor being relatively axially movable to surround the one by the other with said projecting portion in alignment with the workpiece groove, means for effecting said relative movement, means for relatively transversely shifting said inductor and the workpiece as held by said support, and means for effecting relative rotation between said inductor and the workpiece, the degree of relative transverse shifting movement being such that during relative rotation said projecting portion is disposed within the workpiece groove.

2. In an apparatus for heating the wall of a groove of a circumferentially grooved cylindrical workpiece, an energizable electromagnetic induction inductor having a circumferentially extending projecting portion conforming in cross-sectional contour substantially to the cross-sectional contour of the groove of the workpiece to be heated, said inductor and the workpiece being of such relative size as to permit the one to be disposed within the other with the projecting inductor portion in alignment with the workpiece groove, means for effecting such disposition, means for relatively transversely moving said inductor and the workpiece to position the axis of said projecting portion in coaxial alignment with the axis of the workpiece groove, means for relatively rotating the workpiece and said inductor, the degree of relative transverse shifting movement being such that said projecting inductor portion is disposed within the workpiece groove during said relative rotation, and means for energizing said inductor during said relative rotation.

3. In an apparatus for heating the wall of a groove of an internally circumferentially grooved tubular article, an energizable electromagnetic induction inductor having a circumferentially extending transversely projecting portion, a current conducting arbor connected at one end to one end of said inductor for supporting and conducting energizing current to said inductor, a support for supporting the workpiece to be heated in axially spaced relation with respect to the other end of said inductor with the axis of the workpiece offset from the axis of said inductor, the maximum transverse dimension of said inductor being less than the minimum internal diameter of the workpiece and the radius of said projecting portion being only slightly less than the radius of the workpiece groove, means for axially moving the workpiece support toward said inductor to position the workpiece in surrounding relation with respect to said inductor with the workpiece groove in alignment with said projecting portion, means for transversely moving said arbor to coaxially align said inductor projection and the workpiece, means for rotating said arbor and inductor about the workpiece axis whereby the projecting portion rotates within the workpiece groove, and means for conducting electrical current to said arbor during rotation thereof.

4. In an induction heating apparatus, a base, a bracket, a hinged connection between one side of said bracket and said base, means between the other side of said bracket and said base for swinging said bracket between predetermined limits, an electromagnetic induction heating head, a current conducting arbor connected to said head, means rotatably supporting said arbor on said bracket, means on said bracket for rotating said arbor, and means for conducting current to said arbor during rotation thereof.

5. In an induction heating apparatus, a base, a bracket having a hinged connection at one side with said base, a current conducting arbor having an induction heating head thereon, means rotatably supporting said arbor on said bracket, a fluid pressure motor carried by said base, said motor having a movable part connected with said bracket for moving said bracket about said hinged connection between predetermined limits, and means for conducting electric current to said arbor.

6. In an induction heating apparatus for heating the wall of a groove of an internally circumferentially grooved tubular workpiece, an electromagnetic induction inducing element having a transversely projecting portion corresponding in cross-sectional contour substantially to the cross-sectional contour of the groove of the workpiece to be heated, a support for the workpiece, said support being movable axially toward said inducing element to position the workpiece around said inducing element with the groove thereof in alignment with said transversely projecting portion, means for transaxially shifting the workpiece and said inducing element, and means operative in the shifted position of the workpiece and said inducing element for effecting relative rotation between the workpiece and inducing element, the degree of shifting movement being such that during said relative rotation said projecting portion is disposed in induction heating relation with the workpiece groove.

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