

April 21, 1942.

H. E. SOMES

2,280,102

HEAT TREATMENT

Filed June 8, 1939

2 Sheets-Sheet 1

FIG. 1

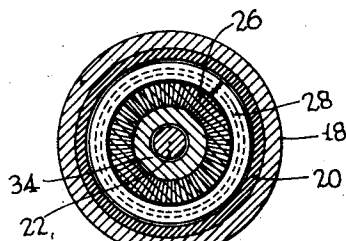
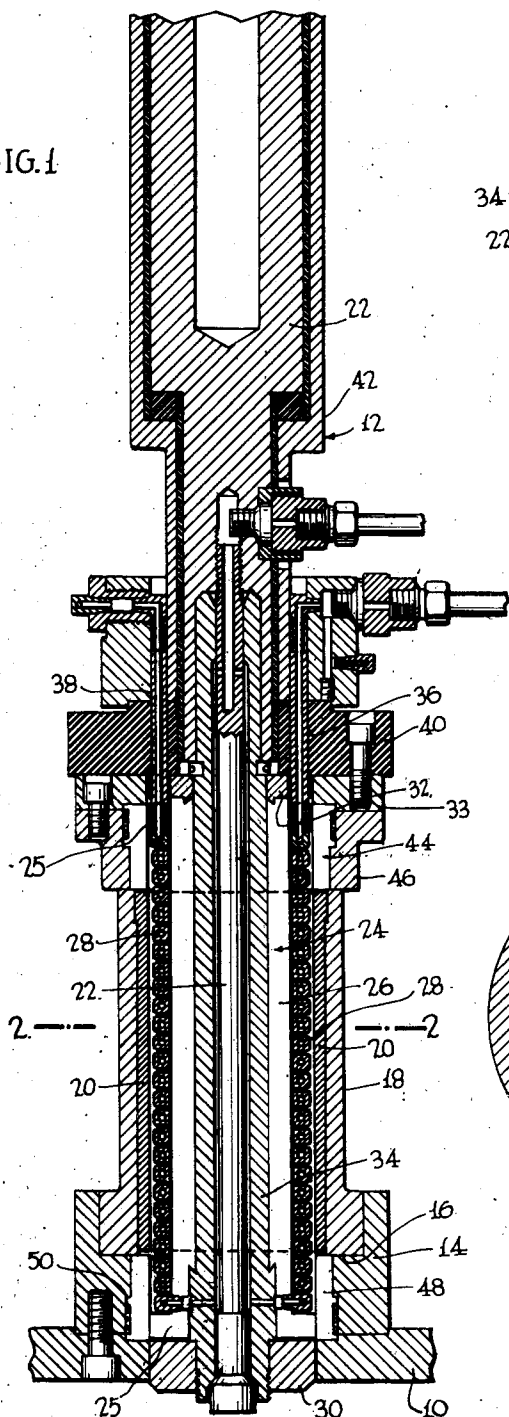


FIG. 2

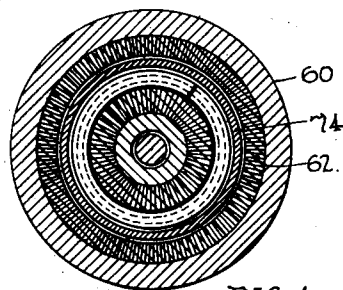


FIG. 4

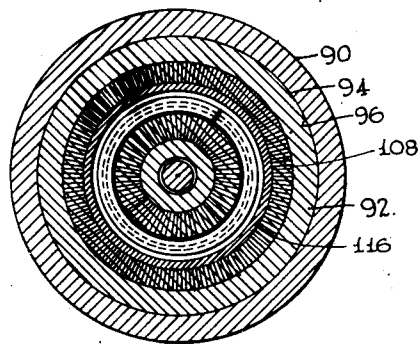


FIG. 6

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2 Sheets-Sheet 2

FIG. 3

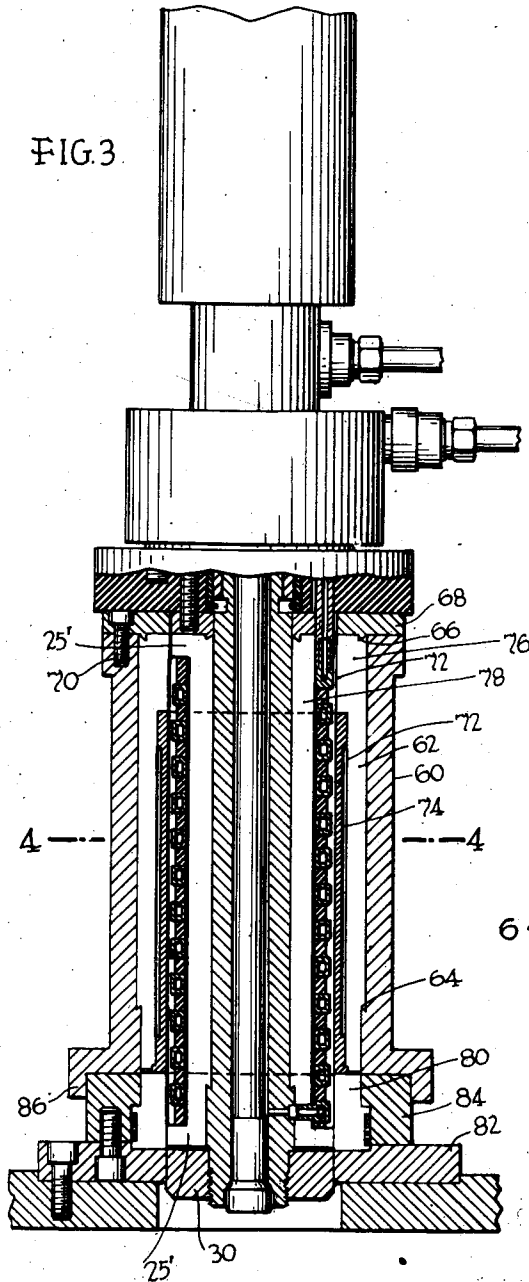
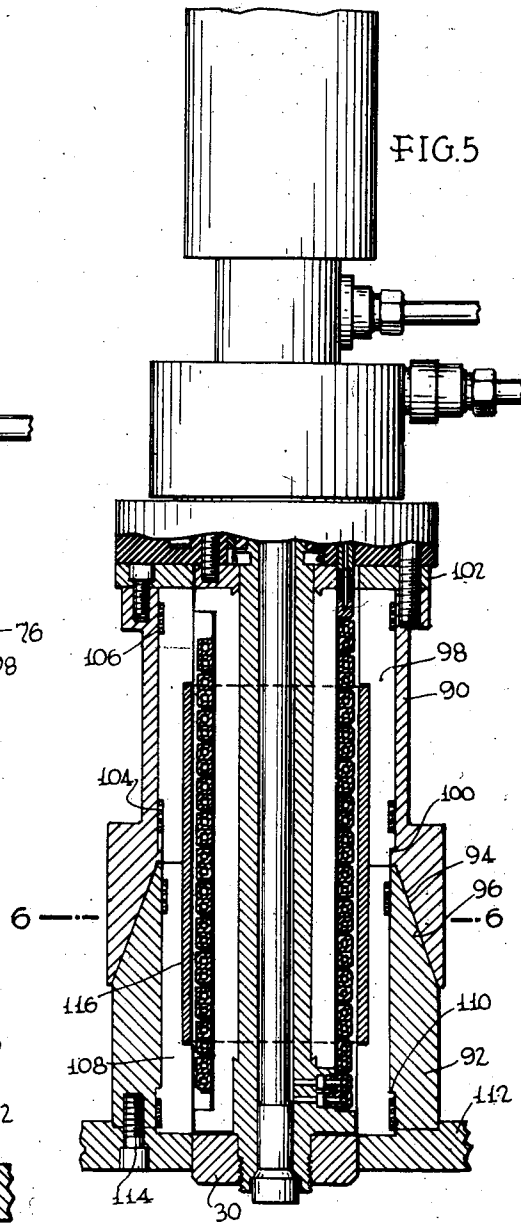


FIG. 5



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HEAT TREATMENT

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Application June 8, 1939, Serial No. 277,995

21 Claims. (Cl. 219—13)

This invention relates to heat treating by electro-magnetic induction and more particularly heat treatment of the internal surface of relatively thin metallic sleeves.

In heat treating the internal surface of sleeve-like bodies by electro-magnetic induction the inside layers are brought to a relatively high temperature quickly and thereafter quenched to produce the desired surface hardness or other characteristics. Where the sleeve is thin the heat treatment may extend a substantial distance into the sleeve thickness and the portion undergoing heat treatment being plastic may not have sufficient backing or unheated portion to maintain the sleeve in shape. Also in the case of thin sleeves particularly if the same should not be of magnetic material is of considerable advantage to supply a magnetic path of low reluctance outside the sleeve which may cooperate with the magnetic path of low reluctance associated with the heat treating inducing coil thus permitting rapid heating because of the ability to induce exceedingly great currents in the sleeve being treated.

The present invention relates to a supporting sleeve adapted for use in connection with sleeves which are to be heat treated, the supporting sleeve being formed of magnetic material and adapted to not only lower the reluctance of the magnetic path but in addition is adapted to render physical support to the sleeve itself to the end that its shape may be positively maintained regardless of the degree or depth of heat treatment in the internal surface or the thinness of the sleeve.

An object of the invention, therefore, is to provide a supporting sleeve adapted to cooperate with a work-piece in the form of a sleeve to be heat treated by electro-magnetic induction.

Another object of the invention is to provide a sleeve as herein above suggested which will be readily removable from the work sleeve which is to be treated.

A further object of the invention is to provide an auxiliary sleeve of magnetic flux conducting material which may operate in conjunction with a work sleeve to be heat treated and assist in concentrating the heat treating currents induced in the work sleeve.

Yet another object of the invention is to provide a method of heat treating thin walled sleeves by electro-magnetic induction which method may afford a maximum rate of heating as well as render support to the sleeve during such treatment.

The above and other novel features of the

invention will appear more fully hereinafter from the following detailed description when taken in connection with the accompanying drawings. It is expressly understood, however, that the drawings are employed for purposes of illustration only and are not designed as a definition of the limits of the invention, reference being had for this purpose to the appended claims.

In the drawings wherein similar reference characters refer to similar parts throughout the several views:

Figure 1 is a longitudinal section taken through a work sleeve and supporting sleeve and an electro-magnetic induction heating unit.

Figure 2 is a section taken on the line 2—2 of Figure 1.

Figure 3 is a longitudinal section through a modified form of the invention.

Figure 4 is a section taken on the line 4—4 of Figure 3.

Figure 5 is a longitudinal section through another modification of the invention and,

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

Referring to Figure 1 there is shown a work supporting member 10 and a heat treating head 12 which are relatively movable with respect to each other. The work supporting member in this case is provided with an annular internally shouldered member 14 bolted to the work support member 10. The internal annular shoulder 16 is shown as receiving a sleeve or external jacket 18 of magnetic material such as Armco iron which sleeve has an internal bore adapted to fit and support a work cylinder sleeve 20 for heat treatment. The jacket 18 with the work cylinder sleeve 20 therein is adapted to be removed from the annular shouldered member 14 after each operation and a new sleeve 20 inserted and the jacket thereafter replaced in the position shown.

The heat treating head is of the electro-magnetic induction type and comprises a central supporting arbor 22 and carries thereon an annular magnetic core 24 of spool shape having end flanges 25 and composed of radially tapered laminations 26. Around the magnetic core is an inducing coil 28 which is insulated from the core and which is composed of hollow water-cooled conductors, in the present instance two conductors in parallel being shown.

The magnetic core 24 is held on the arbor by clamping the same between the nut 30 and the shoulder formed by the disc 32. The nut 30 also act as a pilot to center the head with respect to the supporting member 10. The coil connec-

tions are made at the lower end to the central sleeve 34 which forms a part of the arbor and upon which the core 24 is directly mounted and the connections to the other end of the coil are made through leads 36 and 38 extending through an insulating block 40 and connecting to an external insulated shell 42 forming a part of the arbor 22. The particular details of the heating tool do not form a part of the present invention and the same may be constructed as hereinbefore described or in any suitable manner such as described in my copending application Serial No. 96,346, filed August 17, 1936.

The work cylinder sleeve 20 which is adapted to be heat treated by the present apparatus is illustrated as of shorter length than the heating coil threaded therethrough and consequently in order to assist in the concentrating of flux, magnetic end pieces are required to complete a magnetic path of high permeability to the flanged ends 25 of the magnetic core 24. For this purpose a plurality of radially arranged tapered laminations 44 are secured in place between a shouldered sleeve 46 and disc 33 and bridge the gap between the upper flanged end of the magnetic core 24 and the upper edge of the cylinder sleeve 20 and its jacket 18. In a similar fashion the lower end of the cylinder sleeve 20 is provided with a laminated magnetic sleeve 48 composed of radially arranged tapered laminations which are secured in place by the shoulder 50 on the annular member 14 and the work support member 10.

The Armco iron jacket 18, in practice, is arranged to be closely sleeved upon the cylinder sleeve 20 so that the two elements together form a unit having a sufficient thickness to readily carry a high flux concentration, whereas the cylinder sleeve by itself would be too thin. Also they are of the same length so that their ends may be substantially flush. In practice, a sleeve is arranged in a jacket and the jacket seated upon the internal annular shoulder 16 of the annular member 14. The heat treating tool is then inserted within the cylinder sleeve and brought to the position in Figure 1. The heating coil is then energized from a suitable source of high frequency current such as 2,500 cycles and the internal surface of the cylinder sleeve is immediately brought to a plastic heat preferably in less than two seconds. Thereafter the heat treating tool is removed from the sleeve and the jacket and sleeve removed from the work support member or if desired, quenched in position and thereafter removed. While the cylinder sleeve and its jacket will have a close fit when initially assembled for heat treatment, subsequent to the heat treatment no difficulty will be found to exist in removing the sleeve from the jacket for the reason that the sleeve will be found to have shrunk slightly away from the jacket as a result of the heat treatment. The jacket in addition to providing a magnetic path and thereby assisting in the concentration of the flux also maintains the cylinder sleeve while undergoing treatment in its proper shape regardless of the depth of heat treatment. It will be understood that in such heat treatment of thin walled members as the cylinder sleeves herein described the sudden rendering plastic of as much as half the thickness of the member would normally weaken the member and possibly cause the same to lose its shape were it not for the supporting jacket therearound. It will also be understood that during heat treatment the heat-

ing of the cylinder sleeve will cause the same to expand into exceedingly tight engagement with the surrounding jacket so that its shape will absolutely be maintained true to the shape of the jacket. For this reason it is not entirely essential that the sleeve and jacket be closely fitted before insertion in the apparatus but that a reasonably close fit be provided which will still permit ready assembly of jacket upon sleeve.

A plurality of jackets may be provided for each apparatus and sleeves inserted in each jacket prior to treatment and the jackets may be removed from the sleeves after treatment and cooling. In many cylinder sleeves a shoulder such as is illustrated may be provided and this shoulder may conform to a complementary recess formed in the jacket so that the parts when assembled will remain assembled during the insertion into and out of the machine.

In Figure 3 there is shown a modified form of the invention. The jacket surrounding the sleeve to be heat treated in this instance is composed of an external sleeve 60 having arranged along its inner surface a plurality of radially positioned and tapered laminations 62. The laminations are held in position by the complementary notches 64 on the internal surface of the external sleeve 60 and the outer edges of the laminations respectively and also by a complementary notch and annular ridge 66 in the upper end of the laminations and a disc member 68 respectively, the latter being fastened to the external sleeve 60 by screws 70. The inner edges 72 of the laminations 62 are cut to fit a work cylinder sleeve such as 74 in much the same manner as the jacket 18 in sleeve 20 in the modification of Figure 1. In the present modification, however, the laminations 62 are extended at the upper end as at 76 so as to provide the necessary annular bridge to complete the magnetic circuit to the flanged end 25' of the inductor magnetic core 78. At the lower end, the magnetic circuit is completed by a plurality of radially arranged tapered laminations 80 which are clamped between the work support member 82 and an annular shouldered ring 84 bolted thereto. The external sleeve 60 of the supporting jacket is provided at its lower end with a flange 86 cooperating with the shouldered ring of annular member 84 so as to correctly position the supporting jacket and the cylinder sleeve to be treated in a correct position with respect to the axis of the heat treating inductor.

In Figure 5 a further modification is shown wherein the jacket is composed of two parts separating substantially in the center. As shown the jacket is composed of a pair of top and bottom shell members 90 and 92 having tapered engaging surfaces 94 and 96. Each shell member is in turn provided with a liner of magnetic laminations lying in radial planes, each lamination being tapered or of segmental form so that a substantially solid ring of laminations is formed. The laminations 98 shown in conjunction with the upper shell 90 are secured in place by the shoulder 100 in the shell 90 and the top plate 102 which is bolted to the shell. The laminations prior to assembly within the shell may be bound by wires 104 and 106 lying in shallow grooves in the outer edges of the laminations and when a set of laminations is assembled and so bound, it may be forced into their enclosing shell 90. The lower half of the shell 92 is also provided with laminations 108 similar to those in the upper shell and the laminations are held in place by

a shoulder 110 and the end plate 112, the shell and end plate being secured together by suitable fastening means 114.

It will be seen in the modification in Figure 5 that the upper half of the jacket is carried by the heat treatment tool or head and when the head is raised the upper half of the shell is separated from the lower half thereby leaving the cylinder sleeve 116 exposed for removal or the lower shell exposed for inserting a new sleeve.

In all of the modifications, since the cylinder sleeve is heated to a temperature suitable for heat treatment, the heat treating head is immediately withdrawn and the cylinder sleeve quenched internally in any suitable manner or in the manner suggested in my copending application hereinabove referred to. It will be appreciated that by employing laminations as shown in Figures 3 and 5 eddy currents therein are practically prohibited and consequently, all heating currents must flow in the cylinder sleeve itself. This assists in making the current flow within the sleeve more uniform from end to end and by reason of the employing of an inducing coil longer than the cylinder to be treated together with the bridge portions at either end of the sleeve to be heat treated, the uniformity of the induced currents is more certain assured. In the modifications of Figures 1 and 5 the sleeve is shown as directly supported throughout its external surface by the cylinder jacket. This may also be true of the sleeve in Figure 3 should it seem desirable to have such support present. For various outer surface contours of cylinder sleeves different adapters may be constructed so that there will be provided the necessary flux path as well as the necessary support in any particular case.

Although several modifications of the invention have been disclosed, it is, of course, understood that the invention is not limited thereto but that the same may be embodied in various mechanical forms and arrangements. As many changes in construction and design may be made without departing from the spirit of the invention as will be apparent to those skilled in the art, reference will be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. The method of heat treating by electro-magnetic induction the internal surface of a thin hollow cylindrical member which comprises closely embracing said member in a tubular jacket of magnetic material, including said member and jacket as a part of a magnetic circuit, inducing a heat treating current in said member, and removing the jacket from the member thereafter.

2. The method of electro-magnetic induction heat treating the internal surface and adjacent layers of a thin metallic sleeve which comprises enclosing said sleeve in an external complementary flux carrying and supporting jacket, inducing heat treating currents in said sleeve while passing flux thru said jacket, and subsequently removing the sleeve from the jacket.

3. Apparatus for heat treating a thin cylindrical sleeve internally, comprising an inducing coil lying within a cylindrical surface substantially that of the internal bore of said sleeve, a magnetic core for said coil extending thru the coil and outwardly to said surface at either end thereof, a magnetic circuit for said sleeve external thereto closely embracing said sleeve on

the radial outer side to support the same and extending around the ends of said sleeve and radially inward substantially to said cylindrical surface, said core and said circuit being substantially circularly continuous.

4. A jacket for encasing a thin walled cylindrical sleeve for electro-magnetic induction heat treatment of the internal layers of the sleeve, comprising a plurality of radially disposed laminations of magnetic flux conducting material, arranged to form an enclosing cylinder, a supporting sleeve for said laminations, and the internal edges of said laminated material forming a wall adapted to closely embrace a sleeve to which heat treatment is to be effected.

5. A workholder comprising in combination a jacket and radially arranged laminations of magnetic material within the jacket forming a sleeve of magnetic material, means on the jacket and associated therewith for securing said laminations in place, said laminations having their inner edges formed with a recess suitable for snugly engaging a thin walled cylindrical member.

6. Apparatus for heat-treating an elongated object comprising an electro-magnetic induction heating element arranged to generate a current inducing field extending longitudinally of the object beyond the ends thereof and means composed of magnetic material arranged adjacent a lateral face of the object to form end extensions of said object extending into the extended portions of said field.

7. Apparatus for heat-treating an elongated object by electro-magnetic induction comprising low reluctance means arranged to form end extensions of said object connected by magnetic material, an electro-magnetic induction heating element of a length greater than that of the object and means for effecting relative movement between the object and the heating element to bring the object and the end extensions into the magnetic field of the heating element.

8. Apparatus for heat-treating the inner surface portion of a hollow cylindrical object comprising annular end extension pieces of laminated magnetic material arranged each to form an end extension of one end of the object with its laminae extending in radial planes parallel to the axis of the object, an electro-magnetic inducing element having an internal magnetic core element arranged to fit within the hollow of the object with the ends of the core element extending into close proximity to the said end extension pieces, means for effecting relative motion between said inducing element and said object and end pieces to bring them into inductive relation, and a mechanical connection between said end extension pieces located radially outside said object and constituting a centering guide for said object.

9. A flux carrying and supporting jacket for supporting thin sleeves for electro-magnetic induction internal heat treatment, comprising a shell, composed of two concentric parts arranged end to end and having conical mating faces, radially arranged thin sector sectioned somewhat similar laminations arranged internally of each of the two parts and adapted to provide a continuous magnetic path from top to bottom, and a smooth internal sleeve supporting surface within said laminations.

10. In the method of heat-treating a circumferentially continuous metal sleeve of substantially uniform thickness which is so thin as to be

in danger of becoming deformed under heat when somewhat plastic throughout enough of its radial depth for any remaining part of its radial depth to be incapable of supporting the heated portion against such deformation during heat treatment, the improvement which includes electromagnetically inducing heating currents into one face of the sleeve and simultaneously supporting said sleeve from its surface opposite said first-mentioned face by a wall to oppose any tendency for the sleeve to be deformed during heating, the supporting of said sleeve being from a wall surface fitting the sleeve throughout at least a substantial part of its axial extent.

11. In an apparatus for heat-treating a circumferentially continuous metal sleeve of substantially uniform thickness by electromagnetic induction when it is so thin as to be in danger of not holding its shape during heat treatment, having an inducing conductor adjacent the sleeve, the improvement which includes a supporting wall of magnetic material contiguous said sleeve on its face opposite to said conductor and having a fit with said sleeve capable of gripping and supporting the same against deformation during heating.

12. In an apparatus for heating a circumferentially continuous metal sleeve of substantially uniform thickness by electromagnetic induction when said sleeve is so thin as to be in danger of not holding its shape during treatment, having an inducing coil, and a rigid supporting annulus of magnetic material on the face of the sleeve opposite said coil and radially contiguous said sleeve for positioning it, the improvement in said annulus which consists in radially laminating at least the annulus longitudinally of said sleeve and contiguous thereto, whereby to support the sleeve through bearing of the laminations edgewise thereupon.

13. In an apparatus for heating a circumferentially continuous metal sleeve of substantially uniform thickness by electromagnetic induction when said sleeve is so thin as to be in danger of not holding its shape during treatment, an inducing coil, a rigid supporting annulus of magnetic material on the face of the sleeve opposite said coil and radially contiguous said sleeve for positioning it, the improvement in said annulus which consists in radially laminating at least the annulus longitudinally of said sleeve and contiguous thereto, whereby to support the sleeve through bearing of the laminations edgewise thereupon, and a rigid ring radially outside the laminations and longitudinally coextensive therewith, whereby any radially outward thrusts on said laminations edgewise due to internal stresses from heating said sleeve are transmitted to said ring.

14. In an apparatus for heating a sleeve when the sleeve is to be heated by electromagnetic induction substantially through its radial depth, having an inducing coil, and a rigid supporting annulus of magnetic material adjacent said coil, the improvement in said annulus which includes a circumferential recess of a size to receive said sleeve adjacent said coil and longitudinally intermediate the ends of said annulus, said annulus being transaxially split intermediate its ends for removal of said sleeve, the cooperating split portions of said annulus being provided with interaligning means.

15. In an apparatus for heat-treating a circumferentially continuous metal sleeve of substantially uniform thickness by electromagnetic

induction when it is so thin as to be in danger of not holding its shape during heat treatment, having an inducing conductor adjacent the sleeve, the improvement which includes a supporting wall of magnetic material contiguous said sleeve on its face opposite to said conductor and having a fit with said sleeve capable of gripping and supporting the same against deformation during heating, said wall having a circumferential recess into which said sleeve is received, the axially opposite walls of said recess being radially laminated and capable of separation axially for removal of the sleeve from said recess.

16. The method of heat-treating a metal sleeve which is to be heated by electromagnetic induction for substantially its full radial depth which comprises electromagnetically inducing a heating current into the sleeve in a manner to heat it substantially throughout enough of its radial depth to a plastic condition so that no radially outer unheated layers of the sleeve are strong enough to oppose its expansion, simultaneously circumferentially and uniformly compressing said sleeve to render the material thereof more compact, and subsequently cooling the sleeve to reduce its outside diameter compared to what it was before heating.

17. In an apparatus for heating a sleeve by electromagnetic induction when said sleeve is so thin as to be in danger of not holding its shape during heat treatment, having an inducing coil, the improvement which comprises an annulus of magnetic material onto which said sleeve may be slid with a fit such that said sleeve when expanded by heat to a somewhat plastic condition will be supported by said annulus against deformation due to the heat treatment, and a shoulder contiguous said annulus against which said sleeve is adapted to abut.

18. In an apparatus for heating a sleeve by electromagnetic induction, having an inducing coil, and an annulus of magnetic material including a laminated ring radially contiguous said sleeve, the improvement which comprises a member at one end of said annulus for axially aligning one end of the coil and the adjacent end of the annulus, said member and annulus being provided with interengaging aligning portions.

19. In an apparatus for heat treating a sleeve by electromagnetic induction when the sleeve to be heated is so thin that it is in danger of deformation by heat treatment, having an inducing coil, and a rigid supporting annulus of magnetic material adjacent said coil, the improvement in said annulus which includes a circumferential recess of an axial length and radial depth to receive said sleeve contiguous said annulus and adjacent said coil, said annulus being split intermediate the ends of said recess and sleeve for removal of said sleeve, at least a portion of said split being conical to provide centering surfaces for telescopic engagement of the sleeve portions, and each of the split portions of said annulus including a rigid ring contiguous radial laminations therein which are contiguous said sleeve and extend around an end portion of the sleeve to adjacent the surface of the coil.

20. An apparatus for the inductive heating of work, which includes an inducing conductor adapted to lie adjacent one face of the work, a backing of magnetic material which is non-integral with respect to the work and contiguous the face of the work opposite that to which said conductor is adjacent, said backing extending

throughout at least substantially the full length of the work being heated, and means associated with the backing for positioning the work relative thereto, whereby a flux path in addition to the work is provided when the depth of the work is relatively shallow.

21. An apparatus for the inductive heating of work in the form of a ring, which includes an

inducing coil adapted to lie adjacent one face of the work, and magnetic material contiguous the opposite face of the work from said coil and extending axially of, and adjacent and beyond each end of the work and to a position substantially flush with the work face adjacent which the coil lies.

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