United States Patent

Gillick

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[54] APPARATUS AND METHOD OF INDUCTIVELY HEATING AND QUENCH HARDENING AN ELONGATED WORKPIECE

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[52] **U.S. Cl.**.....**266/4 E**, 148/150, 219/10.79, 266/4 S

[51] **Int. Cl.**.....**C21d 1/66**

[58] **Field of Search**.....219/10.79; 266/4 E, 4 S; 148/150, 153, 154

[56] **References Cited**

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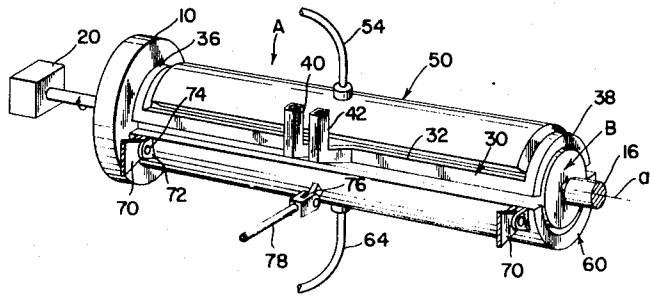
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[57] **ABSTRACT**

There is provided an apparatus and method for inductively heating and quench hardening a relatively long elongated workpiece wherein the workpiece is inductively heated by an inductor extending substantially the total length of the workpiece while the workpiece is rotated and a quenching head for quench hardening the rotating inductively heated workpiece over its complete length while the workpiece remains in the heating position.

3 Claims, 4 Drawing Figures



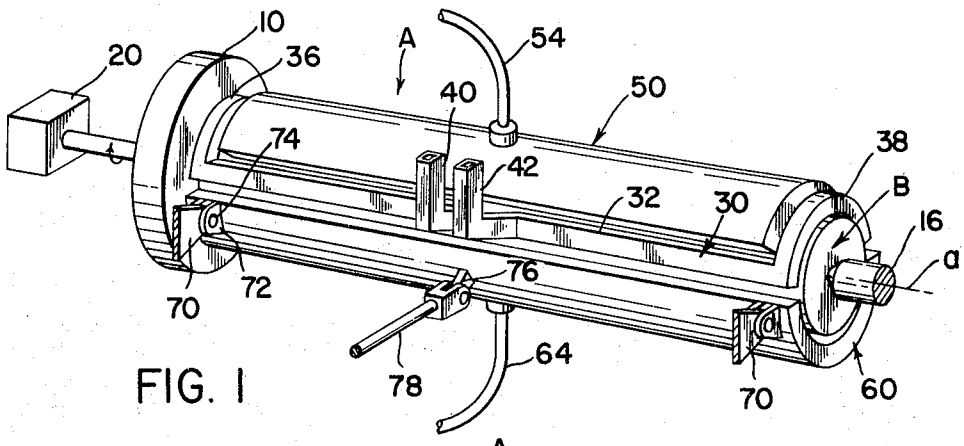


FIG. 1

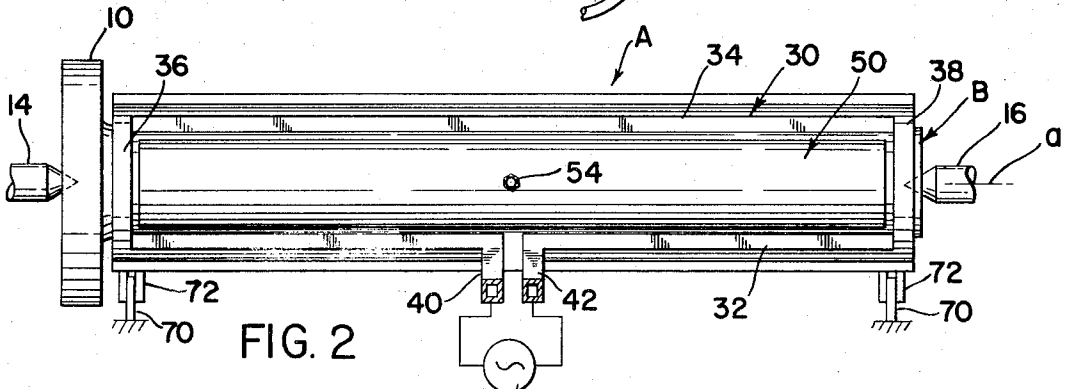


FIG. 2

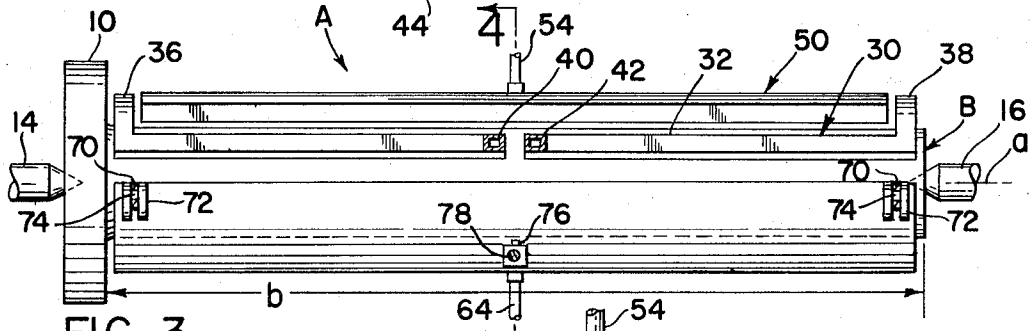


FIG. 3

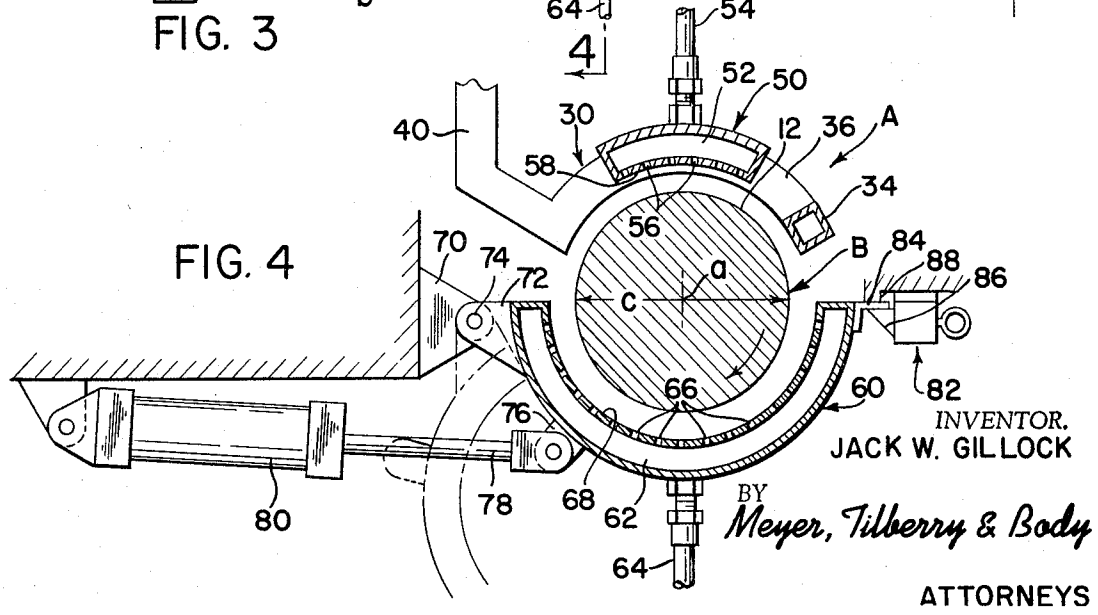


FIG. 4

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APPARATUS AND METHOD OF INDUCTIVELY HEATING AND QUENCH HARDENING AN ELONGATED WORKPIECE

The present invention relates primarily to the art of induction heating and more particularly to an apparatus and method of inductively heating and then quench hardening a relatively long, elongated workpiece.

The invention is particularly applicable to inductively heating and then quench hardening an axle shaft, and it will be described with particular reference thereto; however, it should be appreciated that the invention has much broader applications and may be used for inductively heating and quench hardening various other relatively long, elongated workpieces.

For some time it was generally accepted practice in manufacturing axle shafts to inductively heat the axle shaft by a surrounding inductor which progressed slowly along the length of the axle shaft. A quenching unit directly behind the inductor progressively quench hardened the previously heated portions of the axle shaft. Recently, there has been developed certain machinery in the induction heating art for inductively heating an axle shaft by a single inductor having two parallel conductors extending substantially over the complete length of the axle shaft. In this manner, by energizing the inductor and rotating the workpiece, the total length of the axle shaft was heated at the same time. This decreased the time necessary to inductively heat the workpiece prior to quench hardening. After the workpiece was heated, it was then removed to a quenching station wherein the heated workpiece was quench hardened by spraying a quenching liquid against the surface as the workpiece was rotated. This type of apparatus is now being developed for general use in heating relatively long, elongated workpieces, such as axle shafts. The term "relatively long" as used herein indicates that the length of the axle shaft, or workpiece, is at least approximately 10 times the diameter of the cylindrical portion of the axle shaft being heated. Consequently, when the term "elongated workpiece" is used herein it refers to this type of an elongated workpiece wherein the ratio of length to diameter of the cylindrical portion being heated is at least 10:1.

This type of induction heating and quench hardening apparatus is well adapted for high production; however, the equipment necessary to effect this operation is expensive. In some instances, the cost of this equipment for conveying a workpiece from the heating station to a quenching station and for rotating the workpiece in these two stations is not justified by the volume of production required. Consequently, the use of an elongated inductor extending along the complete length of an axle shaft has not been contemplated for low production rates.

The present invention relates to an apparatus and method for quench hardening a relatively long elongated workpiece wherein the equipment necessary for effecting the method can justify relatively short production runs.

In accordance with the present invention, there is provided an improvement in a device for inductively heating an elongated workpiece of the type described above. This improvement incorporates a quenching means for simultaneously quenching the total length of the cylindrical surface of the workpiece being heated which quenching means includes a quench head extending along the surface of the workpiece and at the heating station. By using this apparatus, the inductively heated workpiece need not be moved to a quenching fixture for the subsequent quench hardening of the workpiece. This substantially reduces the overall cost of the apparatus employing the principle of inductively heating the total length of the workpiece by a single inductor having conductors extending substantially over the complete length thereof.

In accordance with another aspect of the present invention, there is provided a method of quench hardening an elongated workpiece which method includes the steps of rotating the workpiece about its axis, simultaneously heating the complete length of the workpiece by an inductor having two parallel conductors extending over this length, and then quenching the surface of the workpiece over the complete length while the workpiece is still in the heating position.

The primary object of the present invention is the provision of an apparatus and method of inductively heating and then quench hardening a relatively long, elongated workpiece which apparatus and method uses an inductor with two generally parallel conductors extending the length of the workpiece and means for quenching the workpiece without removing the workpiece from the heating position.

Another object of the present invention is the provision of an apparatus and method of inductively heating and then quench hardening a relatively long, elongated workpiece which apparatus and method incorporate the use of an inductor having two parallel conductors extending the length of the workpiece and employ relatively inexpensive equipment for effecting the heating and quenching.

Still another object of the present invention is the provision of an apparatus and method of inductively heating and then quench hardening a relatively long, elongated workpiece, which apparatus and method use an inductor with two parallel conductors extending the length of the workpiece and wherein the heating and quenching takes place at a single position without changing the position of the workpiece.

These and other objects and advantages will become apparent from the following description taken together with the accompanying drawings in which:

FIG. **1** is a pictorial view illustrating, somewhat schematically, the preferred embodiment of the present invention;

FIG. **2** is a top plan view of the device illustrated in FIG. **1**;

FIG. **3** is a side plan view illustrating the apparatus shown in FIG. **1**; and,

FIG. **4** is a cross-sectional vie taken generally along line **4**—**4** of FIG. **3**.

Referring now to the drawings wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only and not for the purpose of limiting same, the figures show an apparatus A for inductively heating and then quench hardening a relatively long, elongated workpiece, such as axle shaft B, having a flange **10** at one end and a cylindrical portion **12** extending therefrom. This cylindrical portion includes an outer surface having a concentric internal axis *a* and a given length *b*, shown in FIG. **3**. The diameter *c* of cylindrical portion **12** is relatively small compared to its length *b*. In practice, the ratio of the length *b* to the diameter *c* is at least 10:1 which distinguishes this workpiece from relatively short workpieces. In the past, these relatively long workpieces have been heated by progressively moving an encircling inductor along the length *b* to heat progressively the surface of the cylindrical portion **12** and then progressively quench the surface for hardening the same.

The apparatus A may take a variety of forms; however, in accordance with the preferred embodiment of the invention, two support means **14**, **16** engage the opposite ends of the workpiece B for rotatably mounting the workpiece about its axis *a*. Appropriate means, schematically illustrated as box **20**, is used to rotate the workpiece B as it is being heated and quenched, as hereinafter described. The device for rotating the workpiece does not form a part of the invention and may take a variety of forms, such as a clamp for the flange **10** which is rotatably driven by a motor. The invention relates to an apparatus wherein the induction heating of portion **12** is done simultaneously along its length. This is accomplished by an inductor **30** having parallel conductors **32**, **34** and crossover conductors **36**, **38**. Of course, laminations could be provided on all of these conductors to modify the flux pattern emanating from the conductors when they are energized through leads **40**, **42** connected across the output of a power supply **44**. Leads **40**, **42** interrupt conductor **32** at its general midpoint; however, leads could be brought into either parallel conductor **32**, **34** at various positions along their lengths. By energizing the inductor **30** and rotating the workpiece B, the outer surface of the cylindrical portion **12** is inductively heated. Heretofore, the workpiece was then shifted to a

quenching station for quenching. Often, the workpiece was to be dropped into a quench tank. This did not provide uniform quenching because steam pockets could form on the surface of portion **12**. In accordance with the present invention, the operation of shifting the workpiece to a remote quench station is eliminated.

Referring now to one aspect of the present invention, an upper quench head **50** is located within the space defined by the various conductors of inductor **30**. This quench head includes an internal fluid chamber **52** receiving quenching fluid from a liquid inlet means **54**. The quenching fluid is directed toward the outer surface of the workpiece by a plurality of liquid outlet means, or apertures, **56** provided on the arcuate surface **58** which generally conforms to the outer surface of the workpiece portion **12**. This quench head **50** is operated after the workpiece B has been inductively heated and while the workpiece is being rotated. Of course, head **50** could be formed of a series of heads spaced along portion **12**. The same is true of lowe head **60**.

To decrease the quenching time, another aspect of the present invention is illustrated. In accordance with this aspect, a lower quench head **60** is provided in the space between the parallel conductors **32**, **34**, but on the opposite side of these conductors from the quench head **50**. Quench head **60** includes an inner quenching fluid chamber **62**, fluid inlet means **64** for directing a quenching fluid into the chamber, and a plurality of fluid outlet means **66** spaced along arcuate surface **68**. The outlet means directs the fluid against the surface of the workpiece B after it is heated for quenching the same. The surface **68** generally conforms to the shape of the workpiece so that the quenching fluid impinges directly upon the heated surface of portion **12**.

To load and unload the workpiece B, the quench body **60** is shiftable between the quenching position shown in solid lines in FIG. **4** and a remote position shown in phantom lines in FIG. **4**. Various arrangements could be provided for allowing this shifting motion; however, in accordance with the preferred embodiment of the present invention, quench body **60** is pivotally secured onto brackets **70** by trunnions **72** and pivot pins **74**. To shift the quench head **60**, there is provided a lug **76** secured onto the quench body, a rod **78** and a cylinder **80** for actuating the rod. By appropriate operation of cylinder **80**, the quench head **60** is pivoted away from inductor **30** to load and unload a workpiece B. To accomplish this, the support means **14**, **16** must also be shiftable in an axial direction. This is a well known function in the induction heating art and the structure is omitted for simplicity. Locking device **82** is used to secure the quench body in its proper quenching position. A variety of arrangements could be used for this purpose; however, in accordance with the illustrated embodiment of the invention, the locking device includes a bracket **84** secured to the quench body, a spring loaded keeper **86** and an abutment **88** against which the bracket **84** rests when the quench body is in the proper position. Retracting the keeper **86** allows the quench body to be shifted into the phantom line position. Of course, bracket **84** and abutment **88** could be used without the keeper **86** with a bias being provided through the use of cylinder **80**. Various other arrangements could be used without departing from the present invention.

Having thus described my invention, I claim:

1. In a device for inductively heating a relatively long, elongated workpiece having an elongated cylindrical portion of a given length *b* and a given diameter *c* and a central axis concentric with said surface, with the ratio of *b:c* being at least 10, said device comprising an inductor including two generally parallel conductors extending along said surface for generally said given length and cross-over conductors joining said parallel conductors; means for energizing said inductor; means for supporting said workpiece for rotation about said axis; and, means for rotating said workpiece about said axis while it is being heated, the improvement comprising: a quenching means for quenching said surface over said given length and as a unit, said quenching means including a quench head extending along said surface for substantially said given length, said head having a plurality of quench fluid outlet means for directing a quench fluid against said surface over said given length, and means for supporting said head with said outlet means closely spaced from said surface whereby said workpiece is quenched in its heating position wherein, said quench head includes a surface in which said outlet means are located, said head surface extending generally arcuately between said parallel conductors and spaced from said workpiece surface.

2. The improvement as defined in claim **1** wherein said cross-over conductors extend between said parallel conductors in a first circumferential direction around said workpiece and said quench head extends between said parallel conductors in a second circumferential direction around said workpiece, said second direction being opposite to said first direction.

3. The improvement as defined in claim **2** including means for allowing said quench head to be shifted between a first position adjacent said workpiece surface and a second position remote from said workpiece surface.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,674,247 Dated July 4, 1972

Inventor(s) Jack W. Gillock

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet [72] "Gillick" should read -- Gillock -- .

Signed and sealed this 20th day of March 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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