Aug. 22, 1967 N. R. BALZER 3,337,200

APPARATUS FOR HARDENING THE AXIAL END OF A WORKPIECE

Filed March 8, 1965

2 Sheets-Sheet 1

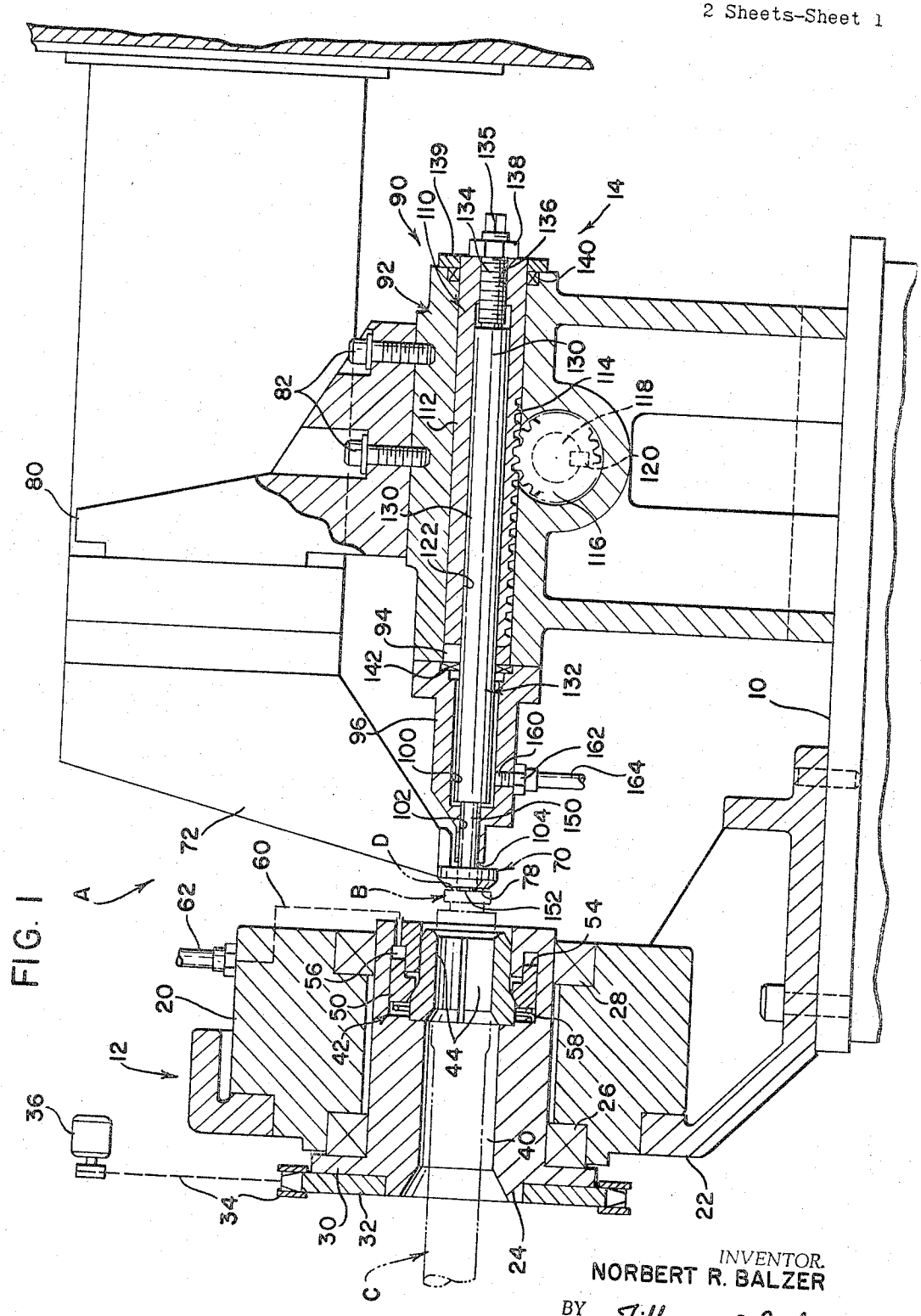


FIG. 1

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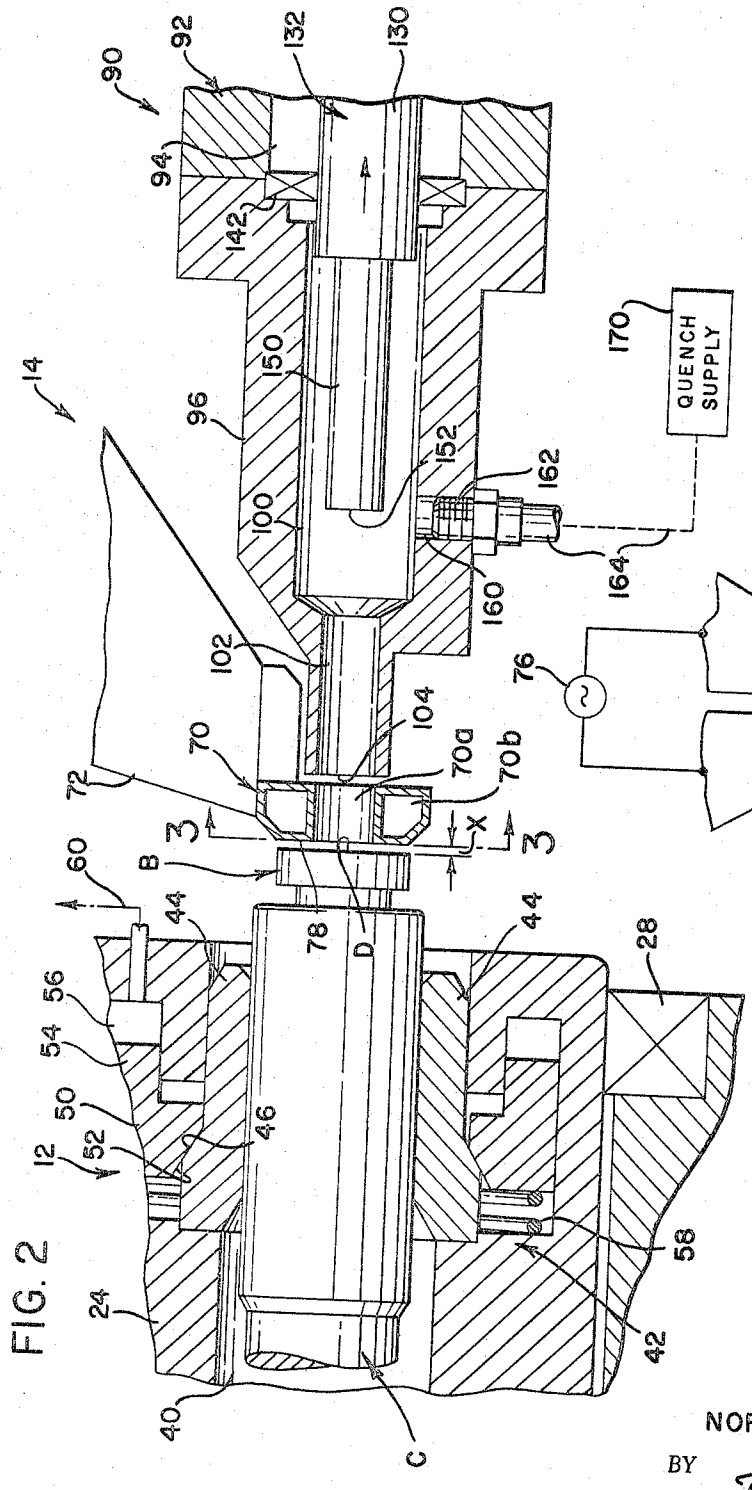


FIG. 2

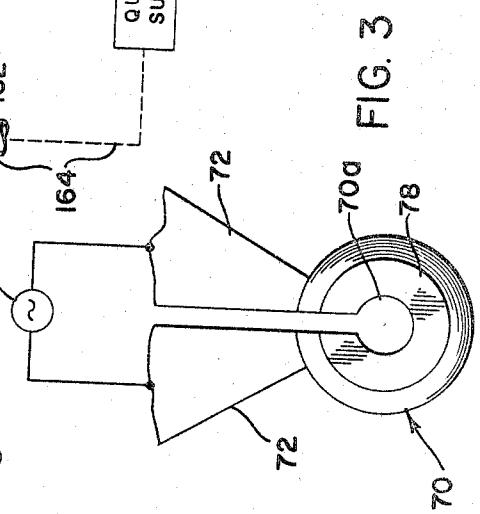


FIG. 3

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APPARATUS FOR HARDENING THE AXIAL END OF A WORKPIECE

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7 Claims. (Cl. 266—6)

This invention pertains to the art of induction heating and more particularly to an apparatus for hardening the axial end of a workpiece.

The invention is particularly applicable to an apparatus for hardening the end of a motor vehicle axle shaft, and it will be described with particular reference thereto; however, it will be appreciated that the invention has much broader applications and may be used for heating and/or hardening other workpieces.

An axle shaft for a motor vehicle often includes, at one end thereof, a protuberance, known in the trade as a button, which is used for connecting the axle shaft within the differential of a motor vehicle. In order to increase the life of this button, it must be surface hardened in generally the same manner as the other parts of the axle shaft. Heretofore, hardening of this button has caused processing difficulties.

The inductor for hardening the axle shaft is a circular inductor having a central opening, somewhat larger than the diameter of the shaft and adapted to surround the shaft during the heating operation. This inductor could not be used to harden effectively the button, especially the flat, axially facing, surface of the button. Consequently, a separate inductor was required to perform this particular hardening operation. Heretofore this separate inductor was pancake-shaped and somewhat resembled the burner on an electric range. This pancake-shaped inductor was mounted in a fixed position and the flat end surface of the button was positioned directly opposite the inductor, with the axis of the shaft being substantially perpendicular to the flat surface of the inductor. This procedure was not satisfactory. Since the spacing between the end surface of the button and the inductor had to be accurately controlled, the dimensional variations between this surface and other points on the axle shaft prevented such other points from being used to locate the surface of the button with respect to the inductor. Consequently, it was necessary to visually space the button from the inductor or use a feeler gage to space the button accurately from the flat face of the inductor. This involved a substantial effort and increased the cost of hardening the shaft button.

Since the flat surface of the inductor was only slightly spaced from the flat end surface of the button, there was no way of rapidly quenching the button surface while it remained in the heating position. For this reason, the shaft had to be removed from its heating position before the button could be quenched to provide the necessary surface hardness. To obtain uniform hardness and a uniform hardness pattern, it was necessary to accurately control the time between heating and quenching of the button. It was difficult to remove the shaft and quench the button without substantial variations in this time.

These and other disadvantages of prior apparatus for hardening the end of a workpiece have been completely overcome by the present invention which is directed toward an apparatus for hardening the end of a workpiece, such as the button on an axle shaft, without requiring substantial effort in locating the workpiece and without requiring removal of the workpiece before it is quenched.

In accordance with the present invention, there is provided an apparatus for hardening the axial end of a workpiece. This apparatus comprises an inductor having a central opening, first and second axial ends, and energizing leads adapted to be connected to a high frequency power source, a locator abutment, means adjacent the first axial end of the coil for moving the abutment between a first position where the abutment extends through the inductor opening and protrudes from the second axial end of the inductor a predetermined distance to form a locator for the axial end of the workpiece with respect to the inductor and a second position where the abutment is retracted from the first position. Also included in the apparatus is a means for introducing quenching fluid into the inductor opening when the abutment is in the second position whereby the fluid flows through the opening and onto the axial end of the workpiece for quenching the same.

By utilizing an apparatus as defined above, the axial end of the workpiece can be moved to a position determined by the abutment extending through the inductor. After the workpiece is clamped in this position, the abutment is withdrawn from the inductor and the inductor is energized to heat the workpiece. Thereafter, a quenching fluid is directed through the opening in the inductor which is vacated by the retracted abutment. This provides a convenient and highly efficient arrangement for locating and quench hardening the axial end of a workpiece, such as the button on the end of an axle shaft.

The primary object of the present invention is the provision of an apparatus for hardening the axial end of a workpiece which apparatus is efficient in operation and economical to produce.

Another object of the present invention is the provision of an apparatus for hardening an axially facing flat surface on a rod-like workpiece, which apparatus accurately positions the flat surface from the surface of a heating inductor positioned opposite thereto.

A further object of the present invention is the provision of an apparatus for hardening an axially facing flat surface on a workpiece, which apparatus quench hardens the flat surface without requiring removal of the workpiece from the heating position.

These and other objects and advantages will become apparent from the following description used to illustrate the preferred embodiment of the invention as read in connection with the accompanying drawings in which:

FIGURE 1 is a side elevational, partially cross-sectioned view illustrating, somewhat schematically, the preferred embodiment of the present invention;

FIGURE 2 is an enlarged, partially cross-sectioned view illustrating certain operating characteristics of the preferred embodiment shown in FIGURE 1; and,

FIGURE 3 is a partial view taken generally along line 3—3 of FIGURE 2.

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 hardening the protuberance or button B on the end of an elongated workpiece, such as axle shaft C. Basically, apparatus A includes a lower frame **10** for supporting a clamping and rotating device **12** and a locating, heating and quenching mechanism **14**.

In accordance with the illustrated embodiment of the invention, the clamping and rotating device comprises a relatively fixed support **20** secured onto frame **10** by an appropriate bracket **22**. Within the support **20** there is provided a spindle **24** rotatably mounted on spaced bearings **26**, **28**. Adjacent one end of spindle **24** there is provided a drive flange **30** having secured thereto a sprocket **32** adapted to be rotated by a chain **34**, or a similar device, which is driven by motor **36**. Spindle **24** is provided with an axially extending workpiece passage **40** and a collet **42**. The collet is somewhat schematically illustrated

and includes a plurality of circumferentially arranged gripping segments **44**, each having an outwardly facing cam surface **46**. A ring shaped piston **50** encircles segments **44** and has a conical cam surface **52** which coacts with the cam surfaces **46** on the individual segments **44**. Movement of the ring piston **50** toward flange **30** forces segments **44** radially inward to clamp against the outer surface of workpiece C, as is conventional in the art of clamping workpieces to be inductively heated. A rearwardly extending flange ring **54** is reciprocally mounted within fluid chamber **56** so that an increased fluid pressure within the chamber will force the ring piston **50** in the workpiece clamping direction. At the forward end of piston **50** there is provided a coil spring **58** which biases the piston **50** against the fluid within chamber **56**. A conduit **60**, schematically represented as a dashed line, connects the chamber **56** with conduit **62**. Hydraulic pressure may be created within the chamber **56** to actuate the piston **50** by supplying pressurized fluid to conduit **62** from a pump, not shown.

It should be appreciated that the illustrated embodiment of the clamping and rotating device is only representative of many such devices which would be appropriate for axially clamping the workpiece C and rotating the same for the purpose to be hereinafter described in detail.

Referring now to the locating, heating and quenching mechanism **14**, this mechanism includes an inductor **70** having a central opening **70***a* and an internal coolant passage **70***b*. As is common practice in the art, a coolant, such as water, is circulated through passage **70** for the purpose of reducing the operating temperature of the inductor. As best illustrated in FIGURE 3, inductor **70** is connected by spaced power leads **72** onto an appropriate high frequency power source, schematically represented as a generator **76**. The inductor **70** has a flat axially facing surface **78** which is fixedly secured with respect to the workpiece passage **40** by an inductor support bracket **80** fastened, by bolts **82**, onto a locating and quenching head **90**.

The locating and quenching head **90** includes a housing **92** supported directly onto lower frame **10** and having a longitudinally extending bore **94**, which is generally in alignment with the workpiece passage **40** and opening **70***a*. At the forward end of housing **92** there is provided an extension **96** having a larger, rear bore **100** and a smaller, forward bore **102** which bores **100**, **102** are generally concentric with bore **94**. An outlet aperture **104** in the smaller bore **102** is positioned directly opposite opening **70***a* in inductor **70**. Reciprocally mounted within housing **92** and extension **96** there is provided a locator assembly **110** including a carrier **112** with a lower rack gear **114**. A pinion gear **116** secured onto shaft **118** by an appropriate key **120** is adapted to mesh with rack gear **114** whereby rotation of shaft **118** reciprocates carrier **112**. A bore **122** extends substantially the complete length of carrier **112** and receives a shank **130** of a rod **132**. The rearwardmost portion of rod **132** terminates in a threaded extension **134** having a head **135** for rotation of the rod **132**. The extension **134** is threadably received within an aperture **136** so that a lock nut **138** can secure the rod **132** in a variety of axial positions with respect to carrier **112**. The inwardmost position of carrier **112** is limited, in accordance with the illustrated embodiment of the invention, by a washer **139** fixedly secured onto the end of the carrier and adapted to abut the rearward end of housing **92**. It is appreciated that other such stopping arrangements could be provided. A bearing seal **140** supports the assembly **110** at one end and seals the bore **94** with respect to carrier **112** and a bearing seal **142** supports the assembly **110** at the other end and seals the rod **132** with respect to bores **94**, **100**.

At the forwardmost end of rod **132** there is provided a locator tip **150** having a size generally matching the internal configuration of bore **102**. The terminal end of tip **150** forms an abutment **152** which provides the workpiece locating arrangement for mechanism **14**, in a manner to be hereinafter described in detail. Bore **100** is provided with a radially extending port **160** having a nipple **162** for communicating bore **100** with a line **164**, schematically represented as a dashed line in FIGURE 2, which line is connected to the output of a quench supply **170**.

In operation of the locating, heating and quenching mechanism **14**, the carrier **112** is reciprocated by shaft **118** toward the inductor **70** to a position determined by the washer **139**. This protrudes locator tip **150** through aperture **104** and through inductor opening **70***a*. By properly adjusting the axial position of rod **132** within bore **122**, by rotating head **135**, the abutment **152** at the end of the tip will extend through the inductor **70** a distance x as shown in FIGURE 2. This distance x is the desired spacing between the axial surface D of button B and the axial surface **78** of inductor **70**. After the abutment **152** is properly positioned with respect to inductor **70**, the workpiece C is forced through passage **40** until the surface D contacts abutment **152**. Then, hydraulic fluid is introduced into chamber **56** and segments **44** clamp the workpiece in this located position. The shaft **118** is rotated to retract tip **150** from opening **70***a* and aperture **104** so that the tip is in the position shown in FIGURE 2. This leaves the surface D accurately positioned with respect to the inductor surface **78**. Motor **36** then rotates the workpiece and inductor **70** is energized by generator **76**. This inductively heats the button B to the desired hardening temperature. After a predetermined time, which allows for equalization of the heat within the button B, the inductor is de-energized and a quenching fluid, such as water or oil, is introduced from supply **170** through port **160** into the bore **100**. From this bore, the quenching fluid flows through aperture **104**, opening **70***a* and impinges upon the heated button B. In this manner, the workpiece is immediately quenched without requiring removal of the workpiece from its heating position. After the button B is quenched, pressure is released from the fluid within chamber **56** and spring **58** releases the workpiece C. This cycle is repeated for each workpiece to be heated.

The present invention has been described in connection with certain structural embodiments; however, it should be appreciated that various changes may be made in these structural embodiments without departing from the intended spirit and scope of the present invention as defined by the appended claims.

Having thus described my invention, I claim:

1. An induction heating apparatus for hardening the axial end of a workpiece, said apparatus comprising: an inductor having a central opening, first and second axial ends, and energizing leads adapted to be connected onto a high frequency power source; a locator abutment; means adjacent said first axial end for moving said abutment between a first position where said abutment extends through said opening and protrudes from said second axial end a predetermined distance to form a locator for the axial end of said workpiece with respect to said second axial end of said inductor and a second position where said abutment is retracted from said first position; and, means for introducing quenching fluid into said inductor opening when said abutment is in said second position whereby said fluid flows through said opening and onto said axial end of said workpiece.

2. An apparatus as defined in claim **1** including a housing adjacent said first axial end of said inductor and having a bore coaxial with said opening and having an aperture facing said opening, and said locator abutment being a rod reciprocally mounted within said bore.

3. An apparatus as defined in claim **1** wherein said fluid introducing means includes means for introducing quenching fluid into said bore when said rod is in said second position, and means for allowing flow of said fluid from said aperture toward said opening.

4. An induction heating apparatus for hardening the axial end of a workpiece, said apparatus comprising: an inductor having a central opening, first and second axial ends, and energizing leads adapted to be connected onto a high frequency power source; a housing mounted adjacent said first axial end and having a bore generally coaxial with said opening; said bore having a terminal aperture facing said opening; a rod; means for reciprocating said rod within said bore between a first position where said rod extends through said aperture, through said opening and protrudes from said second axial end a predetermined distance to form a locator for the axial end of said workpiece with respect to said second axial end of said inductor and a second position where said rod is retracted from said first position; and means for introducing quenching fluid into said inductor opening when said rod is in said second position whereby said fluid flows through said opening and onto said axial end of said workpiece.

5. An induction heating apparatus for hardening the axial end of a workpiece, said apparatus comprising: an inductor having a central opening, first and second axial ends, and energizing leads adapted to be connected onto a high frequency power source; a housing mounted adjacent said first axial end and having a bore generally coaxial with said opening; said bore having a terminal aperture facing said opening; a rod; means for reciprocating said rod within said bore between a first position where said rod extends through said aperture, through said opening and protrudes from said second axial end a predetermined distance to form a locator for the axial end of said workpiece with respect to said second axial end of said inductor and a second position where said rod is retracted from said first position and spaced from said aperture to vacate a portion of said bore adjacent said aperture; and means for introducing quenching fluid into said vacated portion of said bore when said rod is in said second position whereby said fluid flows from said aperture, through said opening and onto said workpiece.

6. An induction heating apparatus for hardening the axial end of a workpiece, said apparatus comprising: an inductor having a central opening, first and second axial ends, and energizing leads adapted to be connected onto a high frequency power source; a housing mounted adjacent said first axial end and having a bore generally coaxial with said opening; said bore having a terminal aperture facing said opening; a rod; means for reciprocating said rod within said bore between a first position where said rod extends through said aperture, through said opening and protrudes from said second axial end a predetermined distance to form a locator for the axial end of said workpiece with respect to said second axial end of said inductor and a second position where said rod is retracted from said first position; means for introducing quenching fluid into said bore when said rod is in said second position; and means for allowing flow of said fluid from said aperture toward said opening whereby said fluid flows through said opening and onto said workpiece.

7. An induction heating apparatus for hardening the axial end of a workpiece, said apparatus comprising: an inductor having a central opening, first and second axial ends, and energizing leads adapted to be connected onto a high frequency power source; a housing mounted adjacent said first axial end and having a bore generally coaxial with said opening, said bore having a terminal aperture facing said opening; a rod with a longitudinal axis; means for axially reciprocating said rod within said bore to a first position where said rod extends through said aperture, through said opening and protrudes from said second axial end a predetermined distance to form a locator for the axial end of said workpiece; means for moving said axial end of said workpiece against said rod and on an axis parallel to the longitudinal axis of said rod; means for clamping said workpiece when said workpiece is against said rod; means for axially retracting said rod from said clamped workpiece; and, means for introducing quenching fluid into said inductor opening when said rod is retracted whereby said fluid flows through said opening and onto said workpiece.

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