United States Patent [19]

Cachat

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[54] **METHOD FOR INDUCTIVELY HEATING AN ELONGATED, SLOTTED WORKPIECE**

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[73] Assignee: **Parker-Ohio Industries, Inc.,** Cleveland, Ohio

[22] Filed: **Dec. 8, 1972**

[21] Appl. No.: **313,505**

Related U.S. Application Data

[62] Division of Ser. No. 177,963, Sept. 7, 1971, abandoned.

[52] **U.S. Cl.** **219/10.43,** 219/10.57

[51] **Int. Cl.** **H05b 5/08**

[58] **Field of Search** 219/10.41, 10.43, 10.57, 219/10.67, 10.79

[56] **References Cited**

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[57] **ABSTRACT**

A method and apparatus for inductively heating an elongated slotted tube preparatory to subsequent forming of said slotted tube comprising providing an inductor having a pair of parallel spaced apart heating conductor legs having a length at least as long as the length of the slot. The slotted tube is positioned between the conductor legs so that the side walls of the slot are positioned immediately adjacent and parallel to one of the legs. The inductor is then conventionally energized as the tube is rotated about its longitudinal axis to effect the desired heating.

1 Claim, 3 Drawing Figures

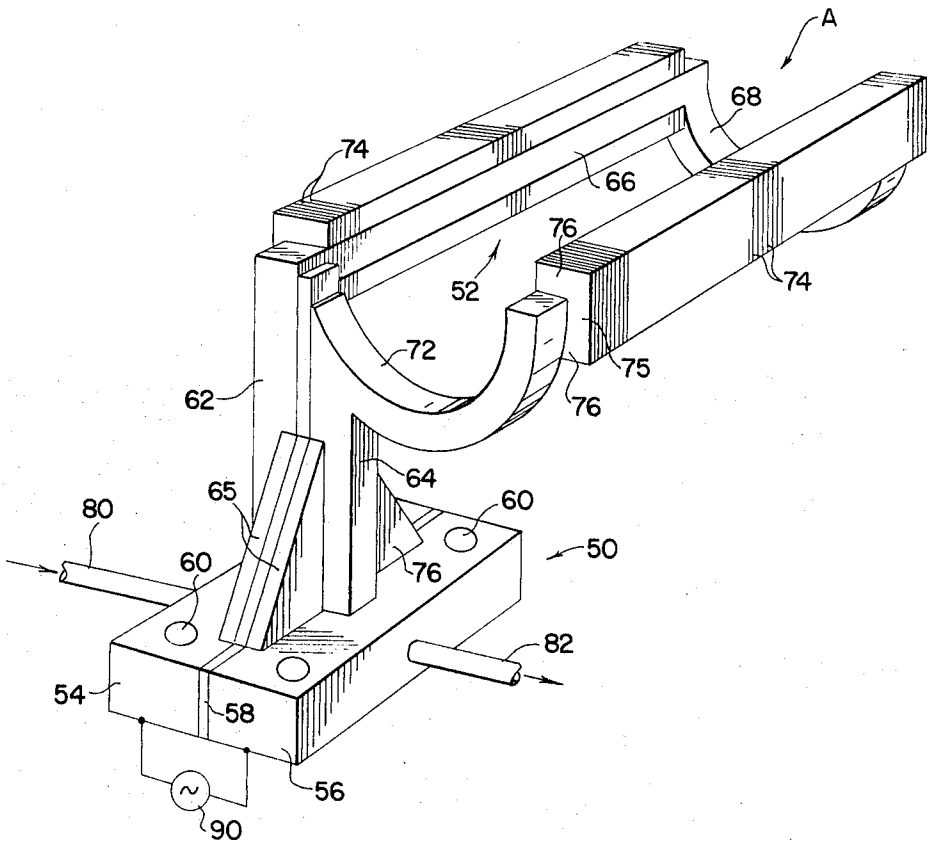


FIG. 1

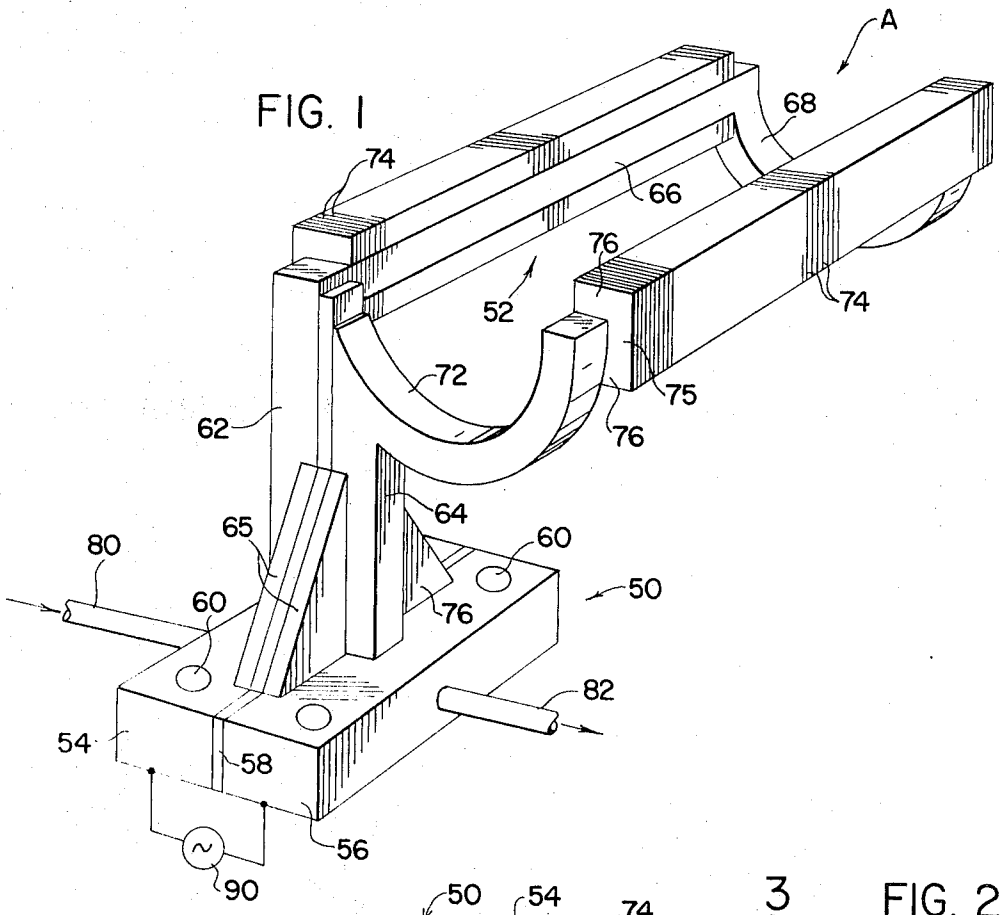


FIG. 2

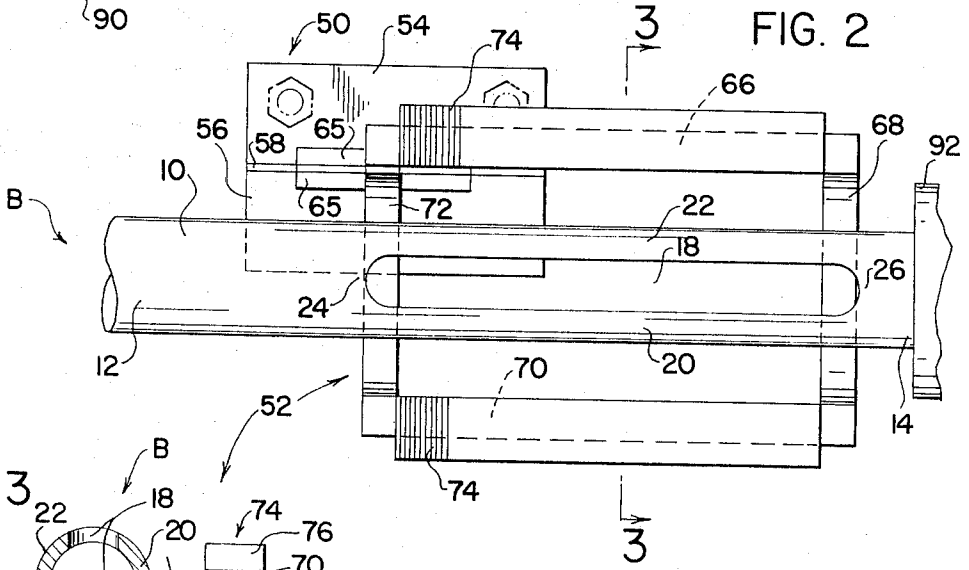
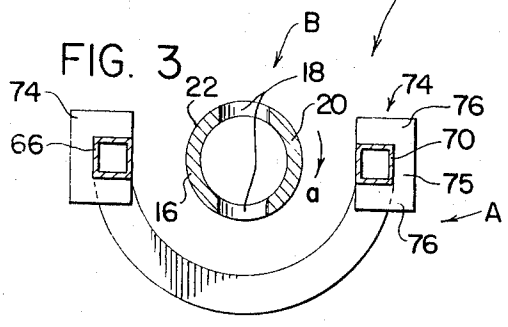


FIG. 3



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METHOD FOR INDUCTIVELY HEATING AN ELONGATED, SLOTTED WORKPIECE

This is a division of application Ser. No. 177,963 filed Sept. 7, 1971, now abandoned.

This application pertains to the art of induction heating and more particularly to a method and apparatus for inductively heating an elongated slotted workpiece.

The invention is particularly applicable to inductively heating elongated slotted tubes which are to be subsequently formed at the slotted area and will be described with particular reference thereto; however, it will be appreciated that the invention has broader applications and may be employed in any instance where elongated workpieces having at least one aperture area therein are desired to be uniformly heated over at least the aperture area therein.

In induction heating it is known to pass elongated tubes through a multi-turn induction heating coil to effect the desired heating. This type of apparatus and method are satisfactory for tubes and shafts which have a continuous peripheral surface; however, they are unsatisfactory when the workpieces being heated include a slotted or other recess area therein. The difficulty encountered is that in using a multi-turn coil to effect induction heating, the induced current flow is generally around the workpiece in a direction normal to the workpiece longitudinal axis. However, the induced current is unable to flow in this desired path along the slotted area as there is no workpiece area there through which it may travel. Therefore, the current seeks other paths through which to flow, such as for example, along the sides and around the ends of the slot. This interruption and alteration of the induced current flow has the effect of establishing "cold spots" along the workpiece at the slotted area. These spots are particularly undesirable when the workpiece is to be formed subsequent to heating.

The present invention contemplates a new method and apparatus which overcomes the above referred problems and provides a new method and apparatus for inductively heating elongated slotted tubes which is economical to employ, provides uniform heating over at least the slotted area and is readily adaptable for use with other elongated workpieces having slotted or other apertures therein.

In accordance with the present invention there is provided a method of heating an elongated workpiece having first and second terminal end portions and an intermediate portion including an aperture therethrough. The method comprises the steps of positioning the workpiece between a pair of parallel spaced apart electrically interconnected heating conductors such that at least said intermediate portion is in an inductive coupling relationship therewith; selectively energizing the heating conductors by passing an electrical current therethrough; and, rotating said workpiece abouts its longitudinal axis at least during said energizing to effect heating of the entire of at least said intermediate portion.

In accordance with another aspect of the present invention, there is provided an induction heating apparatus for heating an elongated workpiece having terminal end portions and an intermediate portion including an aperture therethrough. The apparatus comprises an inductor having two elongated spaced apart parallel heating conductors defining an elongated heating zone therebetween, the heating conductors having a length at least as long as the intermediate portion. The apparatus further includes means for electrically interconnecting the heating conductors and means for selectively supplying an electrical current flow through the heating conductors. Means are provided for locating the workpiece in a heating zone with at least the intermediate portion in an inductive coupling relationship with the heating conductors.

In accordance with a limited aspect of the present invention, the workpiece is rotated about its longitudinal axis by the locating means during heating.

The principal object of the present invention is the provision of a method and apparatus for inductively heating elongated workpieces having an aperture extending therethrough which provides for efficient induction heating.

Another object of the present invention is the provision of a method and apparatus for inductively heating elongated workpieces having an aperture extending therethrough which are readily adaptable to workpieces having any cross sectional configuration.

Still another object of the present invention is the provision of a method and apparatus for inductively heating the elongated workpieces having an aperture extending therethrough which are economical to employ.

The invention may take physical form in certain parts and arrangements of parts, a preferred embodiment of which will be described in detail in this specification and illustrated in the accompanying drawings which form a part hereof and wherein:

FIG. 1 is a perspective view of the apparatus employing the concepts of the subject invention;

FIG. 2 is a plan view of the apparatus in FIG. 1 and showing an elongated slotted workpiece in an operative relationship therewith; and

FIG. 3 is a cross sectional view taken along lines 3—3 in FIG. 2.

Referring now to the drawings wherein the showings are for the purposes of illustrating the preferred embodiment of the invention only and not for purposes of limiting same, the Figures show inductive heating apparatus A and elongated slot workpiece B.

In the preferred embodiment, the workpiece is an elongated piece of thin walled steel tubing **10** having end portions **12,14.** Wall **16** may be of any desired thickness in order that the workpiece may be used for a particular desired purpose. Disposed to extend longitudinally along tubing **10** is an elongated slot **18** having side wall portions **20,22** and radiused end wall portions **24,26** although the invention may be used with a workpiece having any shape aperture therein. In accordance with the concepts of the subject invention, it is desired to uniformly heat at least the side wall portions and radiused end wall portions to an elevated temperature of approximately 2,000° F. in order that tubing **10** may be formed into a final desired configuration.

The induction heating apparatus A employed to perform this desired heating is comprised of a base portion **50** and conductor portion **52.** The base portion is comprised of a pair of base plates **54,56** constructed from an electrically conductive material such as copper and are disposed in any convenient manner with an insulating material **58** therebetween. These base plates further include mounting holes **60** therethrough to facilitate

rigidly affixing induction heating apparatus A in a desired position. Further included are a pair of upstanding conductor legs **62,64** mounted to plates **54,56** respectively in a known fashion. Legs **62,64** are constructed from an electrically conductive material which, in the preferred embodiment, comprises a hollow rectangular copper tubing. To provide rigidity of construction between the upstanding conductor legs and the base plates, wedge-shaped supports **65** are provided to extend between them in a known manner. It should be noted that insulating material **58** also extends between upstanding conductors legs **62,64** and their respective wedge-shaped supports **65.** This insulating material is merely to prevent short circuiting of the induction heating apparatus as will hereinafter become apparent.

Affixed to legs **62,64** are the conductors which make up the actual heating zone and which comprise a generally normally extending heating conductor leg **70** and a second cross-over leg **72.** Leg **72** is affixed to upstanding leg **64** and is generally parallel to and identical in shape with cross-over leg **68.** Further, legs **66,70** are generally parallel to each other and are each at least as long as the length of slot **18.** Legs **62,66,68,70,72** and **64** establish a circuit adapted to carry a current flow to effect induction heating as will hereinafter become more apparent and are, in the preferred embodiment, constructed from rectangular copper tubing.

Disposed in a side-by-side relationship longitudinally along legs **66,70** are a plurality of thin laminations **74** as is known in the inductive heating art and which may be stamped from thin sheet steel. Each lamination is generally U-shaped and includes base **75** and a pair of outwardly extending legs **76** which closely embrace the top, bottom and outer walls of the associated heating conductors **66,70.** A cooling fluid inlet **80** disposed in base plate **54** to extend therethrough to the hollow central area of upstanding leg **62** and a fluid outlet **82** is disposed in base plate **56** to extend outwardly from the hollow central portion of upstanding leg **64.** In this manner, and as known in the art, a cooling fluid such as water may be continuously pumped through the conductor legs to carry away some of the heat generated during the inductor operation. A high frequency electrical generator generally designated **90** is disposed across base plates **54,56** in order to supply a current flow through the conductor legs. Thus, insulation material **58** assures that no shorting between base plates **54,56**; upstanding legs **62,64**; or, wedge-shaped support **65** will occur during operation.

In using the above described induction heating apparatus, it is necessary to mount the apparatus via mounting holes **60** disposed in base plates **54,56.** It is most desirable that when installed, heating conductors **66,70** are disposed in a generally horizontal direction. Tube locating and supporting means generally designated **92** in FIG. **2** are utilized to maintain tubing **10** in a generally horizontal position between and in an inductive coupling relationship with inductors **66,70.** This tube locating and supporting means may comprise any convenient means such as, for example, a standard chuck arrangement and further, in order to assure that the tubing will be rigidly located, a positioning means **92** could be utilized at each end of the tubing. In addition, the locating and positioning means rotate so as to be able to continuously rotate the workpiece about its longitudinal axis. Any convenient power means may be used to effect this desired rotation of the locating means.

As shown in FIGS. **2** and **3,** tubing **10** is positioned so that slot **18** is coextensive with conductors **66,68** and rotated by locating means **92** in direction *a* (FIG. **3**). When electrical supply generator **90** is energized, there is effected a current flow through the conductor legs and laminations **74** associated with heating conductor legs **66,70** as is known in the induction heating art. The current flow, particularly through heating legs **66,70** and associated lamination **74,** causes an induced current to longitudinally flow in side wall portions **22,20** respectively in the opposite direction. As the current flow in the inductor is reversed, the direction of flow of the induced current is also reversed to effect induction heating of these portions as is known.

As the induced current flow is longitudinal of the slot, there is no current flow interruption or alteration during heating thus permitting constant and even heating of at least the slotted area. The workpiece rotation assures even heating of the entire slot area. Once the desired temperature, approximately 2,000° F., has been reached, electrical supply generator **90** may be de-energized and the workpiece removed from locating and supporting means **92** for further processing and a new tube **10** installed for heating as hereinabove described. If it is desired to heat end portions **12,14** in addition to side wall portions **20,22** the length of conductors **66,70** need only be extended as desired or conventional multi-turn coils may be employed.

The invention has now been described with reference to the preferred embodiment. Obviously, modifications and alterations will occur to others upon the reading and understanding of this specification. It is my intention to include all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

Having thus described my invention, I now claim:

1. A method of uniformly heating the metal forming an axial portion of an elongated workpiece to define to subsequent forming of said metal, said axial portion forming only a part of said elongated workpiece and including an elongated axially extending slot extending diametrically through said workpiece todefine two spaced apart, elongated ribs, said heating method comprising the steps of:

a. locating said workpiece to extend along a given axis;

b. providing a single turn inductor having two spaced, generally parallel conductors each having a length generally matching the length of said axial portion of said workpiece;

c. locating said inductor with said conductors parallel to said axis, coextensive with said axial portion and spaced outwardly from said two ribs a distance to cause magnetic coupling between said conductors and the metal forming said axial portion of said workpiece;

d. energizing said inductor until at least said ribs are heated uniformly and evenly to a subsequent processing temperature;

e. rotating said workpiece about said given axis; and,

f. forming said heated axial portion of said workpiece.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,800,115 Dated March 26, 1974

Inventor(s) John F. Cachat

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

Assignee should read ---Park-Ohio Industries, Inc.---

Signed and sealed this 26th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

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* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

UNITED STATES PATENT OFFICE

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