Aug. 23, 1966 T. G. EANNARINO 3,268,218

HEAT TREATING INDUCTION COIL

Filed Sept. 10, 1963 2 Sheets-Sheet 1

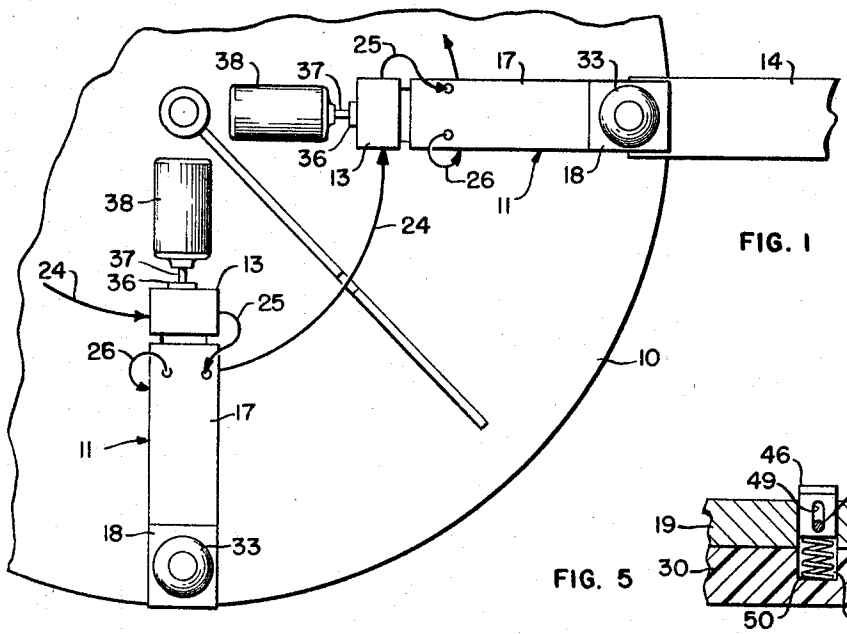

FIG. 1

FIG. 5

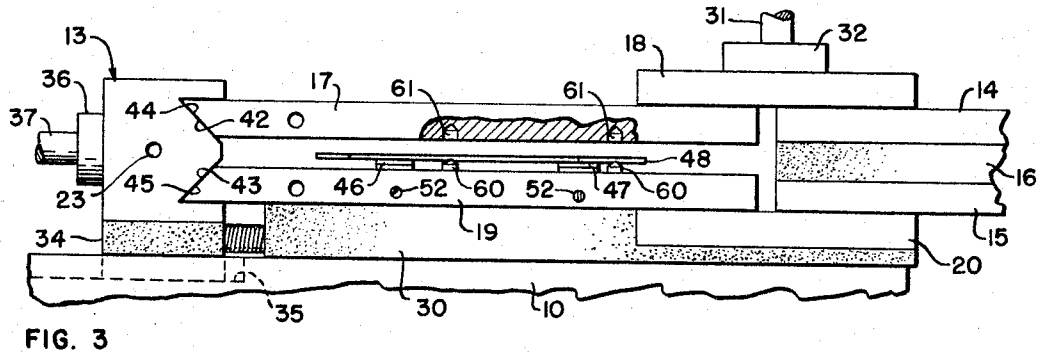

FIG. 3

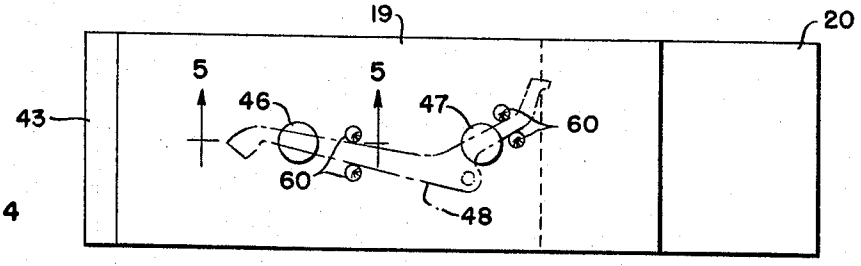

FIG. 4

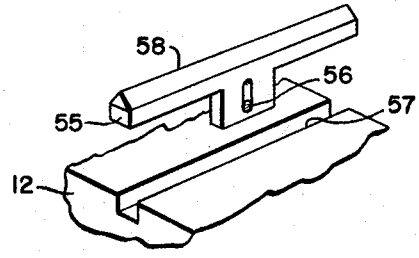

FIG. 6

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HEAT TREATING INDUCTION COIL

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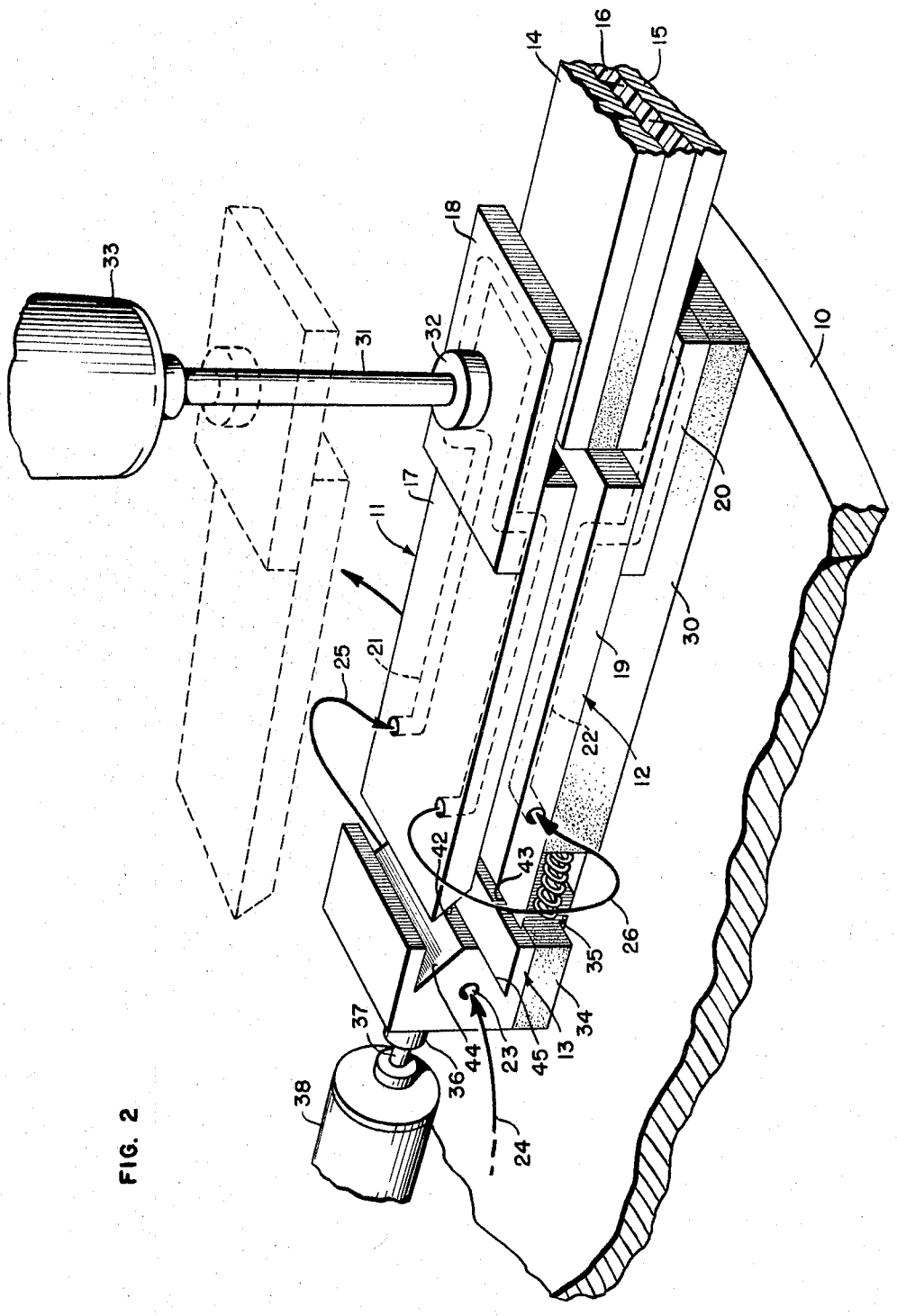

FIG. 2

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HEAT TREATING INDUCTION COIL

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10 Claims. (Cl. 266—5)

This invention relates to heat treating methods and apparatus and more particularly to a method of and apparatus for induction heating parts and for rapidly quenching or chilling the parts to impart hardness to them.

In the heat treating of metallic parts to impart hardness to them, strains are frequently introduced into the part in the heating of it which upon the sudden cooling of the part cause it to become distorted thereby necessitating a straightening operation. This is particularly true when parts are of rather thin cross section. Furthermore, when such parts are heated by an induction heating coil, a problem is posed, particularly with parts of relatively small cross section, in quenching the part with sufficient rapidity to prevent partial annealment of it.

In the past, parts have been induction heated and then discharged from the heating coil into a quenching bath. This process is not highly satisfactory since the parts in moving from the heating coil to the quenching bath may be bent slightly while moving from the coil to the bath due to the fact that they are pliable when they are at a temperature high enough to serve the intended purpose.

It is an object of the present invention to provide a simple, highly efficient heat treating apparatus.

Another object of the invention is to provide a heat treating apparatus which will prevent the introduction of distortion in the part during the quenching or chilling of it.

A further object of the invention is to provide a simple and inexpensive method of heat treating metal parts.

In accordance with one embodiment of the invention a single turn induction coil is provided which is comprised of three parts, two of which comprise upper and lower halves of the coil and the third of which comprises a shunt for interconnecting the ends of the two halves to form a complete single turn coil. Suitable bus bars are provided for engagement with the two coil halves or members to serve as spacing elements for cooperation with the shunt member to properly space the coil halves with respect to a part supported in spaced relation to the coil halves and in a position between them. The coil halves are movable relative one to another and to the bus bars so that they may be engaged with the bus bar and then shunted by the shunt member to complete the formation of the single turn coil. The retraction of the shunt member from engagement with the two coil halves and the disengagement of the coil halves from the bus bars will permit the two coil halves to be moved together so that the part which has been heated between the coil halves by induced current may be chilled by the coil halves through which a coolant is constantly circulated.

A complete understanding of the invention may be had by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a diagrammatic view of an apparatus made in accordance with the present invention;

FIG. 2 is a view in perspective of a set of coil halves and a shunt member shown in operative relation to a pair of current feeding bus bars;

FIG. 3 is a side elevational view of a coil with a part to be treated positioned between the halves of the coil;

FIG. 4 is a plan view of the lower half of the coil with a part positioned thereon shown in dot and dash lines;

FIG. 5 is a fragmentary cross sectional view taken substantially along the line 5—5 of FIG. 4 in the direction of the arrows showing details of the mounting of the support for the part to be heat treated; and

FIG. 6 is a fragmentary perspective view of another type of support for a part to be heat treated.

Referring now to the drawings wherein like reference numerals designate the same parts throughout the several views, particular reference being had to FIG. 1, it will be seen that an apparatus is provided comprising a turntable **10** which may be indexed step-by-step to present a pair of induction coil components or coil halves **11** and **12** into association with a third induction coil component or shunt member **13** and a pair of bus bars **14** and **15** and then to move the coil halves out of association with the shunt member **13** and bus bars **14** and **15**. The bus bars **14** and **15** are spaced apart by a suitable insulator **16** and may be fed with high frequency current from any suitable source (not shown). The pair of bus bars **14** and **15** are radially aligned with the shunt member **13** at one station of the turntable **10**.

The coil halves **11** and **12** are each made up of a pair of plate members **17** and **18**, and **19** and **20**, respectively, suitably brazed together and having coolant passages **21** and **22**, respectively, formed through them. The coolant passage **21** extends longitudinally adjacent to one side of the plate member **17** and then upwardly to communicate with a continuation thereof in plate member **18** and thence across the plate member **18** and longitudinally of the plate members **18** and **17** in a manner the reverse of the other course of the passage **21**. The passage **22** through the plate members **19** and **20** is the opposite of that in the members **17** and **18**. The shunt members **13** have coolant passages **23** extending through them. Coolant may be pumped, in the direction shown by the arrows **24**, **25** and **26**, through the plate members and shunt members. The arrows represent flexible hose connections made of a nonconducting material. The coil halves **12** are mounted on suitable insulators **30** on the turntable **10** and the coil halves **11** are suspended on piston rods **31** by insulator members **32**. Each piston rod **31** cooperates with a cylinder **33** individual to the coil half **11** for imparting reciprocation to the coil half **11** to clamp it into tight engagement with bus bar **14** and also to insure good electrical contact between the plate member **20** of coil half **12**. The cylinder **33** may be supplied with fluid to move the piston rod **31** from the position shown in FIG. 2 in solid lines to the position shown in dotted lines to permit a part to be heat-treated to be mounted between the coil halves **11** and **12**. The shunt members **13** are each mounted on suitable insulators **34** that are slidable in ways **35** formed in the turntable **10**. When the turntable **10** is indexed it will carry one set of coil halves **11** and **12** and their associated shunt member **13** into position between the bus bars **14** and **15** and an insulator member **36** mounted on the end of a piston rod **37** which may be reciprocated upon the admission of fluid under pressure to a cylinder **38**.

The coil halves **11** and **12** have their left ends (FIGS. 2 and 3), oppositely tapered as shown at **42** and **43**, respectively, for cooperation with beveled surfaces **44** and **45** formed on the shunt member **13** whereby when the piston rod **31** is actuated to clamp the coil halves **11** and **12** into electrically conductive engagement with the bus bars **14** and **15** and the piston rod **37** is actuated to move the shunt member **13** to the right, the tapered portions **42** and **43** of the coil halves **11** and **12** and the spacing of the bus bars **14** and **15** will cause the upper coil half **11** and lower coil half **12** to be aligned and

spaced a predetermined distance one from another in substantial parallelism. The plate member **19** of the lower coil half **12** has a pair of support members **46** and **47** mounted in it for resiliently supporting a part **48** in spaced relation to the lower coil half **12**. The support members **46** and **47** may be of any suitable construction and in the example illustrated in FIGS. 4 and 5, are comprised of a cylindrical member **46** having a slot **49** formed in it. The member **46** is normally urged upwardly to the position shown in FIGS. 3 and 5 by a compression spring **50** seated in a socket **51** in the insulator **30**. The support member **46** is made of a nonconducting material and a pin **52** extending through the slot **49** regulates the amount that the spring **50** can raise the support member **46** with respect to plate member **19**.

In the embodiment shown in FIG. 6 a support member **55** is shown which is generally of "T" shaped configuration and has a slot **56** formed in it for cooperation with a pin similar to the pin **52**. This support member **55** is shown removed from the coil half **12** more clearly to illustrate it but is designed to move into a slot **57** in the coil half **12** and to support a part on its upper tapered edge **58**.

In the operation of the apparatus the upper coil half **11** may be moved to the position shown in dot and dash lines in FIG. 2 and a part **48** may be placed upon the support members **46** and **47**. Thereafter, the table may be indexed to carry the coil halves **11** and **12**, with which a part to be heat treated has been associated, into position between the piston rod **37** and bus bars **14** and **15**. After the coil halves **11** and **12** and shunt member **13** have thus been aligned between the piston **37** and bus bars **14** and **15**, the piston rod **31** may be moved downwardly to clamp the plate members **18** and **20** into good conducting engagement with the bus bars **14** and **15** and thereupon the piston rod **37** may be actuated to move the shunt member **13** into tight engagement with the coil halves **11** and **12**. Due to the large flat surfaces of the members **18** and **20** and the bus bars **14** and **15** a good electrical conducting connection will be made between the bus bars **14** and **15** and the surfaces of members **18** and **20** and due to the tapered configuration of the left ends of the plates **17** and **19** of coil halves **11** and **12** and the beveled surfaces **44** and **45** of the shunt member **13** a good electrical conducting connection will be made between the shunt member and coil halves thereby to complete the single turn induction coil.

With a part **48** thus positioned within the single turn induction coil, current may be supplied to the bus bars **14** and **15** to induce a heating current in the part **48**. As soon as the induced current in the part **48** has raised the part to the desired temperature, the piston rod **31** may be moved upward slightly and the piston rod **37** may be moved leftward sufficiently to release the shunt member **13** from the coil halves **11** and **12** and the table may be indexed one step. After this indexing of the table the piston rod **31** may be actuated to move the coil halves **11** and **12** toward each other to compress the springs **50** and clamp the part **48** between the flat bottom surface of the plate **17** of coil half **11** and the flat upper surface of the plate **19** of coil half **12** thereby to chill the part since coolant is continuously being circulated through the plate members **17** and **19** which comprise the cooling surfaces. With this particular type of structure the coil halves **11** and **12** will serve to chill the part quickly while holding it against warping or other distortion. The plate members **17** and **19** may be held in clamping engagement with the part **48** until it is properly chilled or quenched and then the piston **31** may be actuated to retract the coil half **11** to its uppermost position as shown in dotted lines in FIG. 2 whereupon the heat treated part may be removed and another part placed in position to be heat treated.

Some parts, such as the part **48** illustrated in FIGS. 3 and 4, may either distort slightly in a lateral direction or in the forming or handling of the part they may be bent slightly and since it is possible that the angularity of one leg of the part **48** with respect to the other leg may be critical, the lower die may be provided with pins **60** that have conical tips so that as the part **48**, after having been heated, may be re-formed to its proper shape as it is clamped between the plates **17** and **19**. When the plates **17** and **19** are clamped together, these pins **60** which are fixed to plate **19**, will enter suitable indentations **61** formed in the plate **17**. The location of the pins **60** as shown in FIG. 4 is simply for purposes of illustration and the pins could be placed at any desired location so that the part in its heated and semi-plastic condition may readily be restored to its proper form.

Although only one embodiment of the invention is shown in the drawings and described in the foregoing specification it will be understood that invention is not limited to the specific embodiment described but is capable of modification and rearrangement and substitution of parts and elements without departing from the spirit of the invention.

What is claimed is:

1. In a heat treating apparatus,

(a) a pair of bus bars spaced one from the other for supplying high frequency current to the apparatus,

(b) a first induction coil component of conducting material engageable with one of said bus bars,

(c) a second induction coil component of conducting material engageable with the other of said bus bars,

(d) a shunt member of conducting material engageable with said first and second induction coil components to form a single turn induction coil,

(e) means for supplying coolant to the interior of said induction coil components and shunt member,

(f) means resiliently mounted on said first induction coil component for supporting a part to be heat treated in spaced relation to said first and second induction coil components when they are in engagement with the bus bars and with said shunt member,

(g) means for moving said first and second induction coil components into and out of a communicating position with respect to said pair of bus bars, and

(h) means for actuating said induction coil components when they are out of said communicating position with respect to said pair of bus bars to compress said resiliently mounted supporting means, thereby causing intimate clamping engagement of said first and said second induction coil components with said part to chill it by conduction.

2. An apparatus according to claim **1** wherein the means for actuating the first and second induction coil components is operative to move said means for supporting the part to a position flush with a surface of the first induction coil component when said induction coil components are out of said communicating position with respect to said bus bars and also operative to clampingly engage the first and second components with their respective bus bars when said induction coil components are in said communicative position with respect to said bus bars.

3. In a heat treating apparatus,

(a) a pair of bus bars spaced one from the other for supplying high frequency current to the apparatus,

(b) a first induction coil component of conducting material engageable with one of said bus bars and having coolant passages through it,

(c) a second induction coil component of conducting material engageable with the other of said bus bars and also having coolant passages through it,

(d) a third induction coil component of conducting material engageable with said first and second components to form a single turn induction coil,

(e) means for supplying coolant to the passages of said first and second components,

(f) means for resiliently supporting a part to be heat treated in spaced relation to said first and second

components when they are in engagement with the bus bars and with said third component,

(g) means for moving said third component and said pair of bus bars into and out of communicating position with respect to said first and second induction coil components,

(h) means for moving said first and second induction coil components into and out of engagement with said bus bars and said third component when said third component and bars are in said communicating position with respect to said first and second components and into and out of clamping-chilling engagement with said part by compressing said resilient supporting means when said third component and bars are out of said communicating position with respect to said first and second components.

4. An apparatus according to claim **3** wherein said first and second components have flat, relatively large, tapered surfaces formed on ends of them for engagement with flat, relatively large, beveled surfaces on the third component to provide good electrical contact between these components and to accurately locate the first and second components in a predetermined spaced relation one to the other.

5. In a heat treating apparatus,

(a) a pair of bus bars spaced one from the other for supplying high frequency current to the apparatus,

(b) a first induction coil component of conducting material comprising a pair of plates fixed one to the other in conductive relation and having a coolant passage through them, one of said plates being engageable with one of said bus bars,

(c) a second induction coil component of conducting material comprising a pair of plates fixed one to the other in conductive relation and having a coolant passage through them, one of said plates being engageable with the other of said bus bars,

(d) a third induction coil component of conducting material having a coolant passage through it and engageable with the other plate of said first and second induction coil components to form a single turn induction coil,

(e) means for supplying coolant to the passages in said components,

(f) means for resiliently supporting a part to be heat treated in spaced relation to said other plates of said first and second components when said one plate of said first and second components are in engagement with the bus bars and said third component is in engagement with said other plates,

(g) means for moving said third component and said pair of bus bars into and out of a communicating position with respect to said first and second induction coil components, and

(h) means for moving said one plate of said first and second components into and out of engagement with said bus bars and said third component when said third component and bars are in said communicating position with respect to said first and second components and for moving the other plates of said first and second components into and out of chilling engagement with said part by compressing said resilient supporting means when said third component and bars are out of said communicating position with respect to said first and second components.

6. In a heat treating apparatus for metal parts,

(a) a heating and chilling assemblage comprising a pair of opposed coil halves and a shunt member for cooperation with said halves to form a single turn induction coil,

(b) current supply bus bars for supplying high frequency current to said halves,

(c) means for moving the shunt member into and out of shunting engagement with said coil halves to form said induction coil,

(d) means for moving said coil halves into and out of a communicating position with respect to said bus bars,

(e) means for supplying coolant to the interior of said halves,

(f) means for resiliently supporting a part between said halves, and

(g) means for moving said halves into and out of electrical contact with said bus bars when said coil halves are in said communicating position with respect to said bus bars to connect them to the high frequency current and for thereafter moving said halves to compress said resilient supporting means thereby clamping a part between them to chill it when said shunt member and said pair of bus bars are out of communicating position with respect to said coil halves.

7. In a heat treating apparatus for metal parts,

(a) a turntable having an electrically insulated surface and indexable to a plurality of positions,

(b) a plurality of heating and chilling assemblages each comprising a pair of opposed coil halves and a shunt member for cooperation with said halves to form a single turn induction coil, one of each of said halves and said shunt members being supported on said surface,

(c) a pair of current supply bus bars at one of said positions for supplying high frequency current to said halves,

(d) means common to all of said shunt members for moving them into and out of shunting engagement with said coil halves to form said induction coil at said one position,

(e) means for supplying coolant to the interior of said halves,

(f) means for indexing said turntable to bring said one of each of said halves and said shunt member into said one position and to other positions,

(g) means for resiliently supporting a part between and in spaced relation with said halves, and

(h) means in each assemblage for moving said halves into electrical contact with said bus bars to connect them to the high frequency current at said one position and for thereafter moving said halves to compress said resilient supporting means thereby clamping a part between them to chill it at other positions when said shunt member is moved out of shunting engagement with said coil halves.

8. An apparatus according to claim **7** wherein the means for supporting the part normally tends to hold the part in spaced relation to the halves and is movable to nest in said one half when the part is clamped between the halves.

9. The method of heat treating metal parts to harden them comprising

(a) resiliently supporting a part to be heat treated in spaced relation to a first cooled electrical conducting member,

(b) moving a plurality of other cooled electrical conducting members into conductive engagement with said first conducting member to form a single turn induction coil, the surfaces of which are in spaced relation to said part,

(c) supplying said single turn coil with current to heat the part to a predetermined temperature,

(d) disengaging one of said conducting members from its companion members forming the coil, and

(e) moving said first member to clamp the part between said first member and one of said plurality of members to chill the part.

10. The method of heat treating metal parts to harden them which comprises

(a) resiliently supporting a part to be heat treated in spaced relationship to a first electrical conducting member,

(b) moving a plurality of other electrical conducting

members into conductive engagement with said first conducting member to form a single turn induction coil, the interfaces of which are maintained in spaced relation to said part,

(c) supplying said coil with high frequency current to heat the part to a predetermined temperature,

(d) disengaging one of said conducting members from its companion members which formed the coil,

(e) continuously supplying said members with a coolant,

(f) moving said first conducting member toward one of the other conducting members to compress said resiliently supported part thereby clamping said part between said first and said one of the other conducting members, and

(g) utilizing said first member and said one of the other conducting members which had formed the coil to simultaneously chill and straighten the part.

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