Aug. 14, 1945. F. S. DENNEEN ET AL 2,382,779

APPARATUS FOR VARIABLE HEATING

Filed June 25, 1942

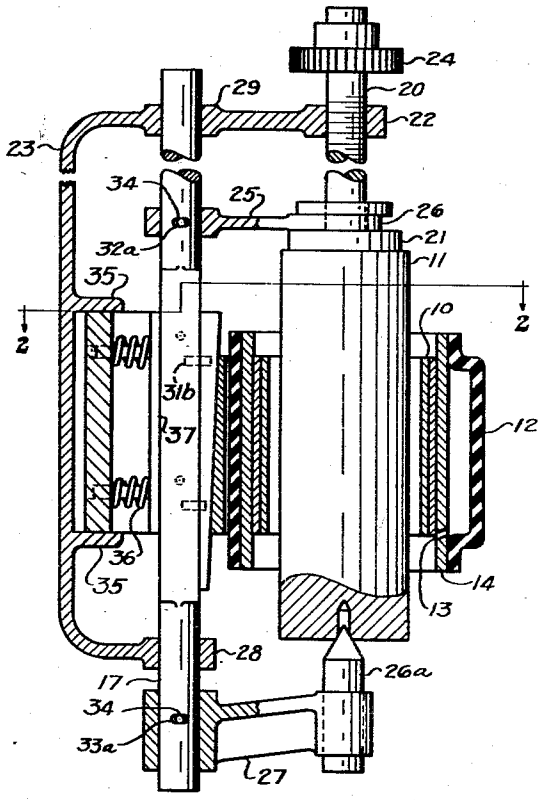


Fig. 1

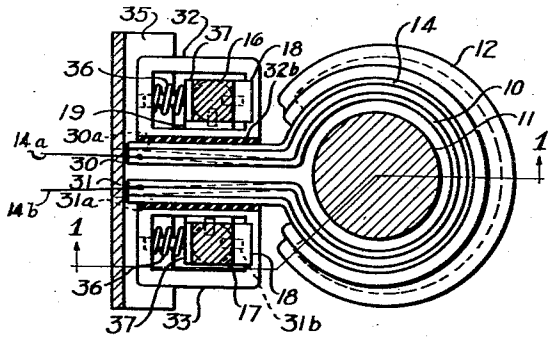


Fig. 2

INVENTORS.

Francis S. Denneen

William B. Brann

Patented Aug. 14, 1945

2,382,779

UNITED STATES PATENT OFFICE

2,382,779

APPARATUS FOR VARIABLE HEATING

Francis S. Denneen, Cleveland, and William C. Dunn, Shaker Heights, Ohio, assignors to The Ohio Crankshaft Company, Cleveland, Ohio, a corporation of Ohio

Application June 25, 1942, Serial No. 448,504

11 Claims. (Cl. 219—13)

The present application is a continuation in part of our co-pending application Ser. No. 337,423, filed May 27, 1940, now Patent No. 2,315,508, dated April 6, 1943, for Means for controlling inductive heating, the last said application being a continuation in part of original application Ser. No. 745,194, filed September 24, 1934, for Apparatus for progressive heat treatment, now Patent No. 2,202,758, dated May 28, 1940, and is directed to apparatus for heat treating elongated metallic articles of varying form. Application Ser. No. 337,423 is concerned primarily with the use of a flexible inductor of helical form. In the present case the flexible inductor or inductors are formed from flexible elements of circular or approximately circular form.

It will be obvious when an article of varying form passes an inductor of fixed contour, that uniform spacing between the surface of the article and all parts of the adjacent surface of the inductor cannot be maintained due, mainly, to varying curvatures in the article. Also when approaching a limiting position on the article, such as a shoulder, where only a part of the inductor would come into heating relation with the article a change in the form of the inductor is needed to concentrate more current in the region affected by the limited movement.

Whether a deficiency in heating tends to be caused by an increasing air gap or by failure of sufficient ampere turns of the inductor in the region of the part of the article to be heated, the deficiency can be overcome by deforming the inductor to bring a closer coupling between the inductor and the article to increase the concentration of magnetic flux in the desired region.

The principal object of this invention is to provide an inductor which is readily deformed to concentrate magnetic flux to a predetermined extent in a selected part of an article progressively or otherwise heat treated. A further object is to provide automatic means for deforming the inductor while a part of the article moves past the inductor. A still further object is to provide an inductor constructed to maintain a substantially constant form while varying in size. An additional object is to provide conveniently associated means for quenching the article being heated by current induced therein.

While in the accompanying drawing and specification we have illustrated and described our invention as applied to certain purposes, we do not limit ourselves to the constructions shown and described. From the disclosure herein, obviously, many modifications and other uses would readily suggest themselves to those skilled in the art.

In the annexed drawing:

Fig. 1 is a vertical sectional elevation showing the preferred form of my invention on line 1—1 of Fig. 2.

Fig. 2 is a section substantially on line 2—2 of Fig. 1.

Referring now to Figs. 1 and 2 of the drawing, the inductor is a single turn loop which may be made in numerous ways, either from a single piece of material or in composite form as shown. The inner portion 10, which may be a laminated member comprising conductors 10 and 14, conducts current in a close heating relationship to the cylindrical article 11 being heated. This heater is bent to the form shown in part from resilient material, its resiliency tending to open it to provide greater space for the article to be passed therethru. Means for controlling the opening movement and for providing the required closing movement is described hereinafter.

The outer supporting element 12 being resilient serves not only as a cooling jacket but usually as means for opening or expanding the inner current conducting members 10 and 14. These members are usually selected to vary in radial thickness so that the heater as a whole in expanding and contracting through a reasonable range, will maintain a substantially circular interior form, thus making it possible to provide for a uniform air gap and uniform heating, even if the cylindrical article were not rotated during the heating interval. The inner conductor members 10 are made of thinner and narrower material than outer conductor member 14, the conductor members thus varying in both width and thickness as measured along a radius of the inductor. Inducing current is derived from a circuit indicated by lines 14a and 14b.

The outer supporting member 12 is preferably made of a rubber or similar composition vulcanized or connected by other suitable means to the outer lamination 14 of the inductor. Passages 13 which extend through a laterally extending and overhanging part of lamination 14 serve as means for flowing cooling fluid from the supporting jacket 12 onto heated parts of the cylindrical article 11 to quench these parts.

To maintain a desired air gap as the heater expands and contracts, this expansion and contraction is definitely controlled by guide bars 16 and 17 which are provided with cam members such as 18 and 19.

The cylindrical article 11 and bars 16 and 17 carrying cams 18 and 19 are progressively moved downwardly by supporting screw 20 to the flange 21 of which the article 11 is attached. This screw threadedly engages the boss 22 on the frame 23 of the apparatus and is rotated by gear 24, to move the article longitudinally. Arm 25 carrying bars 16 and 17 engages the groove 26 in the flange 21 to constrain these bars to move at the same rate as and parallel with the article 11. Article 11 is supported and guided at its lower end by a center 26a carried by arm 27 which also engages bars 16 and 17. Bars 16 and 17 are guided in bosses 28 and 29 which bosses are a part of frame 23. The natural movement of the laminated conductor 10, in being expanded by cover 12 to provide more space for article 11, will move terminals 30 and 31 farther apart to form an increasing included angle diverging outwardly as indicated by the directions of broken lines 30a and 31a in Fig. 2. Since brackets 32 and 33 are attached to these terminals through insulation 32b they will move with them and turn through corresponding angles. Since cams 18 and 19 held in place on bars 16 and 17 by means of pins 31b have flat faces disposed to engage corresponding flat faces of brackets 32 and 33, it is necessary that these bars and cams be permitted to turn through these corresponding angles also, as otherwise, their surface to surface contact cannot be maintained. It is for this reason that bars 16 and 17 are permitted to rotate on their axes through a somewhat limited angle while they are constrained to move axially carrying the cams through the brackets 32 and 33 to increase or decrease the space within the conductor 10 to change the air gap between this conductor and the surface of article 11. This rotative movement of bars 16 and 17 is permitted by the elongated openings as shown at 32a and 33a for pins such as 34. Springs 36 and spring seats 37 are provided to maintain contact of cams 18 with the bars 16 and 17 and with brackets 31 and 32. Due to the form and resilient material of outer supporting member 12 and of conductor 10 to which this member is secured, the expanding movement which is permitted and controlled by the movement of cams 19 does not detract from the roundness of the interior of the conductor 10 but tends to move this conductor into an eccentric position relative to the article 11 by increasing the distance between terminals 30 and 31, and as a result, increasing the distance between the conductor 10 at the inner ends of terminals 30 and 31 and the surface of article 11 at this point, while very little change in the distance of the conductor from the article at the opposite side of the article takes place.

It is to compensate for the change in air gap resulting from this eccentricity that cams 18 are provided which together actually shift the entire conductor in a direction substantially at right angles to the direction of movement of the terminals 30 and 31 caused by cams 19. The supporting brackets 32 and 33 which are attached to the inductor members 30 and 31 slidably engage guide members 35 to permit the shifting of the conductor.

The cams 18 and 19 are both of the same general form as indicated.

Other modes of applying the principle of our invention may be employed instead of the one explained, change being made as regards the means herein disclosed, provided those stated by any of the following claims or their equivalents be employed.

We therefore particularly point out and distinctly claim as our invention:

1. In a composite inductor, a plurality of flexible current conducting laminations adapted to extend peripherally around a part of the article, means for moving the article longitudinally through the inductor, the said laminations being adapted to lie parallel with a peripheral surface of the article and being of varying widths to regulate heating, means for progressively flexing the laminations when the article moves through the inductor, and a member controlled by the movement of the article for limiting the flexing of the laminations.

2. In apparatus for heating a surface zone of a longitudinally extending article, a single turn flexible conductor having a form adapted to extend generally peripherally of a part of the article and to lie substantially parallel with the surface zone, a member being attached to an outer surface of the conductor to flexibly expand the conductor to move the said conductor away from the article, and means for limiting the flexing of the conductor.

3. In apparatus for heating a surface zone of a metal article, a flexible inductor adapted to lie in spaced relation to said zone, the inductor having two adjacent terminals, means supporting the terminals, a cam engaging the supporting means, means for moving the cam to shift a terminal and flex the inductor to control the space between the inductor and the zone of the article, and means for supplying inducing current to the inductor.

4. In apparatus for heating an article, an inductor adapted to extend around a part of the article, the inductor comprising a flexible conductor adapted to lie adjacent to the article and a flexible cooling jacket, the cooling jacket being attached to the conductor and comprising means for flexing the conductor, the conductor having adjacent movable terminals, a substantially fixed element slidably supporting the inductor, cam means engaging a terminal of the conductor to control the flexing of the conductor, and means for supplying inducing current to the inductor.

5. In an inductor adapted to extend around a part of an article to heat the article, a flexible laminated conductor adapted to lie in spaced relation with the article to provide an air gap, means for flexing the conductor to vary the air gap, slidable cam means for controlling the flexing to control the air gap, means for simultaneously moving the cam means and the article relative to the conductor, and means for supplying inducing current to the conductor.

6. In apparatus for heating a surface zone of a longitudinal article, a conductor adapted to extend peripherally of a part of the article, the conductor comprising flexible laminations of different widths, means connected to the conductor for flexing the laminations, means for relatively moving the inductor and article in a longitudinal direction, a longitudinally extending cam member engaging the conductor to control the flexing, the said cam having a surface engaging a surface of the conductor and being rotatable on an axis to keep the surfaces in engagement while the conductor is moved longitudinally relative to the cam member, and means for supplying inducing current to the conductor.

7. In an inductor for heating a surface zone of an article, a single turn flexible conductor having a form adapted to extend generally peripherally of a part of the article and to lie substantially parallel with the surface zone, the conductor comprising a plurality of laminations, the said laminations differing in width and thickness to control flexibility and current distribution in the conductor, means for flexing the conductor, means engaging terminals of the conductor for progressively controlling the flexing, and means for supplying current to the conductor.

8. In apparatus for heating a surface zone of an article, an inductor adapted to extend along a surface of the article and in closely spaced relation thereto, the inductor comprising a plurality of flexible current conducting laminations of different widths and a flexible cooling fluid jacket, the jacket being adherently attached to one of the laminations and serving as means for flexing the laminations, means for moving the inductor and article relatively to each other to progressively heat the article, one of the laminations having a portion overhanging an edge of an adjacent lamination, a passage through the overhanging portion for escape of cooling fluid from the jacket, and means for supplying inducing current to the inductor.

9. In apparatus for heating a surface zone of an article, an inductor adapted to extend peripherally around a part of the article and in closely spaced relation with the surface zone, the inductor comprising a plurality of flexible current conducting laminations of different widths and a cooling fluid jacket, one of the laminations having peripheral edge adjacent portions engaging peripheral side parts of the jacket and cooperating with the jacket to form an enclosure for the cooling fluid, a passage through the said one lamination for the cooling fluid to escape from the enclosure, and means for supplying inducing current for the inductor.

10. In apparatus for heating a surface zone of an article, an inductor adapted to extend peripherally around a part of the article and in closely spaced relation with the surface zone, the inductor comprising inner and outer current conducting laminations of different thicknesses and a cooling fluid jacket, an outer lamination having an edge portion overhanging an edge of an adjacent inner lamination, the cooling jacket engaging an exterior surface of the outer lamination in fluid sealing contact, the jacket and the laminations being adapted to flex together to vary the space between the inductor and the article, and means for supplying inducing current to the inductor.

11. In apparatus for heating a surface zone of an article, an inductor adapted to extend along a surface of the article and in closely spaced relation thereto, the inductor comprising a plurality of flexible current conducting laminations of different widths, a narrow lamination being superimposed on a wide lamination to form an enlarged current conducting section for a concentration of heating in a part of the surface zone, the wide lamination having an edge portion extending beyond an edge of the narrow lamination to form a reduced current conducting section for a reduction of heating in an adjacent part of the surface zone, means for bringing the surface zone into heating relation with the inductor, and means for supplying inducing current to the inductor.

FRANCIS S. DENNEEN.
WILLIAM C. DUNN.