Feb. 6, 1945. F. S. DENNEEN ET AL 2,368,809

PROGRESSIVE HEAT TREATING APPARATUS

Original Filed Dec. 14, 1935 2 Sheets-Sheet 1

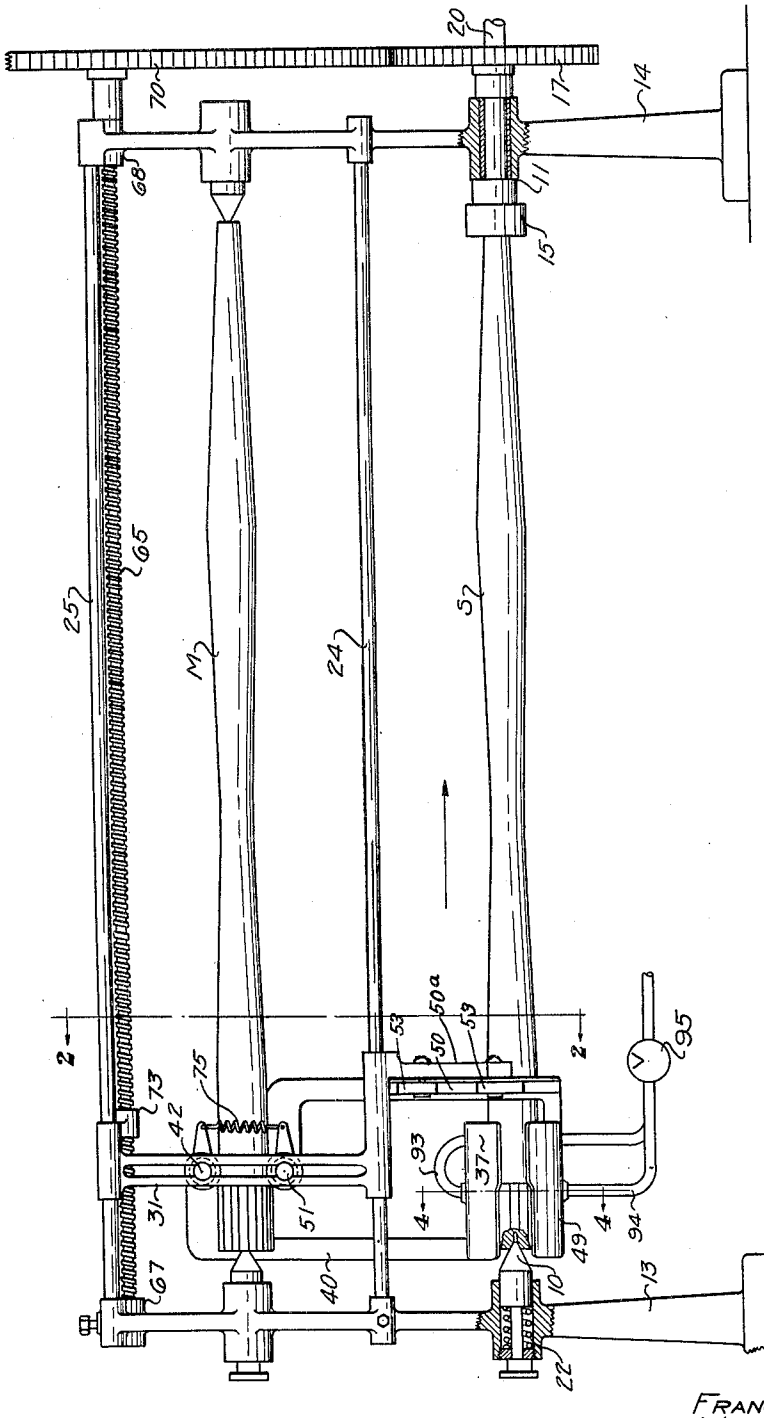

Fig. 1

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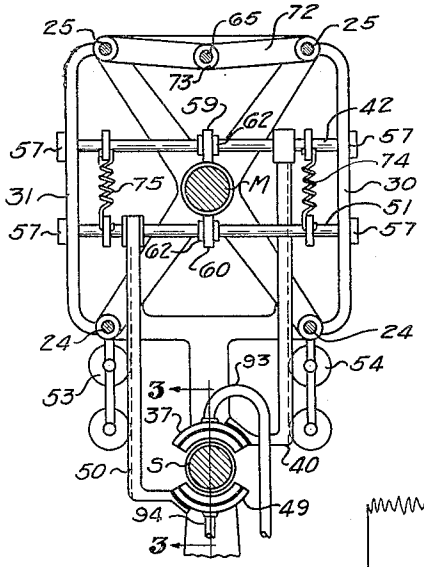

Fig. 2

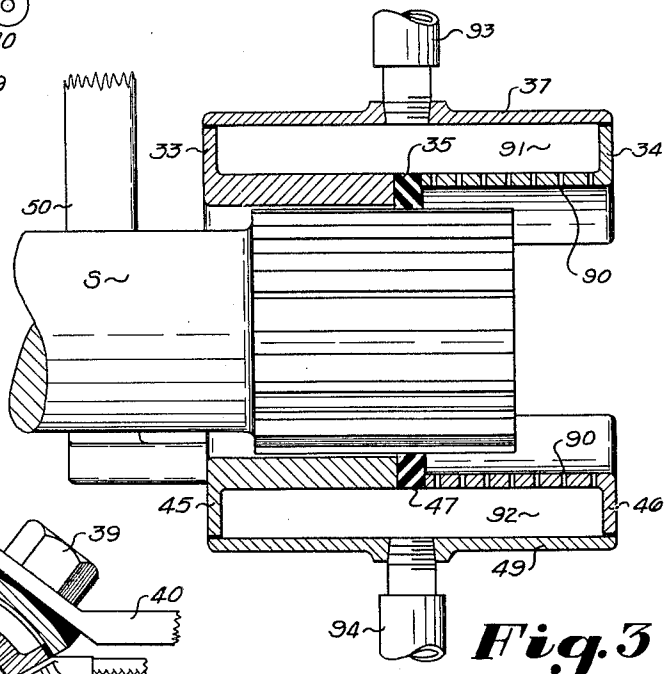

Fig. 3

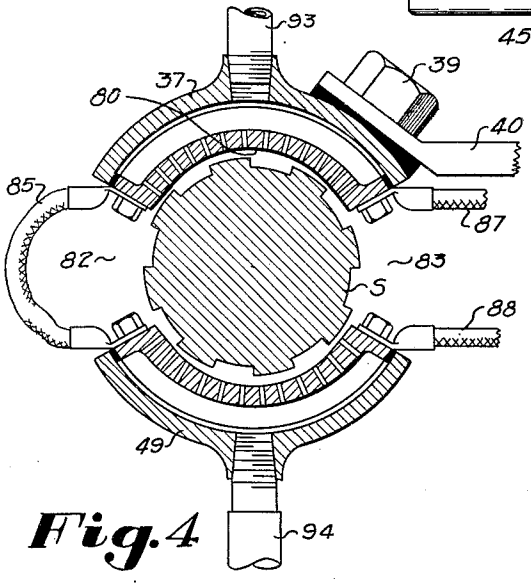

Fig. 4

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2,368,809

PROGRESSIVE HEAT-TREATING APPARATUS

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Original application December 14, 1935, Serial No. 54,388, now Patent No. 2,202,759, dated May 28, 1940. Divided and this application March 9, 1940, Serial No. 323,108

6 Claims. (Cl. 219—13)

The present application is a division of our copending application Serial No. 54,388, filed December 14, 1935, now Patent No. 2,202,759, issued May 28, 1940, and as such is directed to an apparatus for heat treating an elongated article by moving it and a heat treating fixture progressively with respect to each other. The fixture is guided in such a manner that its path of movement corresponds to the configurations of the surface to be treated and a part of the fixture is adapted to move relative to another part to change the shape and size of the fixture during movement to facilitate its conformation as above indicated.

Elongated articles, such as shafting and the like, are frequently of such cross-sectional shape that an irregular contour is presented in the portion to be hardened. The simplest example of this would be a tapered shaft and a more complex example would be a shaft with one or more tapered surfaces thereon.

In inductively heating such a shaft either as a preliminary to a quenching step, or in the treatment without quenching, it is very desirable that the inductor member, as it progressively covers the article, travel through a path, such that the spacing between the inductor surface and the article surface is controlled throughout the relative movement therebetween. In other words, if it is desired to treat an elongated surface zone of the article to the same depth at all points, the inductor should at all points in its travel lie as closely as practicable to a predetermined fixed distance from the surface zone undergoing heating.

The general object of our invention therefore has been to provide a mechanism by which an inductor and elongated article may be shifted relatively to each other during the treating operation such that the path of the inductor generally corresponds to the surface shape of the work piece. An additional object of the invention has been to guide the treating fixture during movement from a master article corresponding to the article to be treated. Still another object of the invention has been to rotate the article during treatment in order that a uniform effect may be obtained at all points about a plane perpendicular to the longitudinal axis.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means and steps hereinafter fully described and particularly pointed out in the claims; the annexed drawings and the following description setting forth in detail certain means and one mode of carrying out the invention, such disclosed means and mode illustrating, however, but one of various ways in which the principle of the invention may be used.

In said annexed drawings:

Fig. 1 is a side elevation of apparatus embodying our invention;

Fig. 2 is a section through Fig. 1 as indicated by the lines 2—2 thereon;

Fig. 3 is a fragmentary section through Fig. 2 as indicated by the lines 3—3 thereon; and

Fig. 4 is a section through Fig. 1, as indicated by the lines 4—4 thereon.

Referring now to the drawings, a shaft or the like S to be heat treated is supported on a center 10 at its one end and at its other end is carried by the rotating support 11 with which it is centered and by which it is driven. The center and support are carried by upright frame members 13 and 14 respectively. A driving connection 15 is driven by a gear 17 secured to a shaft 20 which carries the driving connection. Other gearing, not shown, drives this gear from a motor or other driving means.

The center 10 is slidable in the frame member 13 and may be retracted for removing or inserting the shafts. To this end a spring 22 urges the center into position to engage the shaft.

The frame members are held in spaced relationship by the rods or bars 24 and 25 and these in turn support a pair of traveling frame members 30 and 31 (Fig. 2) which are connected by cross-members hereafter described.

A compound induction heating and quenching member is carried by the traveling frame members as more clearly shown in Figs. 3 and 4. This member is made in two parts, an upper and a lower. The upper part comprises two arcuate members 33 and 34 separated by a shield plate 35. These members are secured to a carrier shell 37 and are insulated therefrom. The carrier shell is bolted at 39 to a supporting member 40 which is secured to a cross-bar 42 which in turn is held by the frame members 30 and 31.

The lower inductor, in like manner, comprises two arcuate members 45 and 46 separated by a shield 47. They are secured to a carrier shell 49 which is attached to the carrier arm or support 50. The support 50 is secured to a cross-bar 51 which, like cross-bar 42, is held in place by the frame members 30 and 31.

The upper and lower inductor parts are mounted for movement toward and from each other in a vertical plane. To maintain the parts in position and guide the same, two sets of guide rolls 53 and

54 are provided for the carrier arms 40 and 50, each pair of rollers being carried by a bracket such as 50A which comprises a part of frame member 31. Alignment of the parts is maintained by channel grooves in these arms in which the rollers ride. The crossbars 42 and 51 enter slotted openings in frame members 30 and 31 and end collars 57 hold these bars against axial movement. Rotatably carried on the bars 42 and 51 are rollers 59 and 60 which engage opposite sides of a master shaft or cam M. These rollers are held in position on the bars by collars 62.

To advance the inductors along the shaft to be heat treated, a lead screw 65 is provided, mounted in bearings 67 and 68 in the pedestals 13 and 14. A gear 70 at its right-hand end (Fig. 1) is mounted in driving engagement with gear 17. An upper cross-member 72 connecting members 30 and 31 is provided with a tapped boss 73 threadingly engaging the lead screw. Thus as gear 17 is driven the lead screw 65 rotates and causes the traveling frame members to advance axially, moving the inductors along the shaft S.

As the inductors 33 and 45 move axially along the rotating shaft S the distance of the faces of the inductors from the surfaces of shaft changes due to the changing diameter of the master shaft M. As it is essential for uniform heating that the spaces between the inductors and the shaft be kept as nearly constant as possible, we have provided the above described means to cause the inductors to approach and recede from each other to cause the spacing of their faces to correspond with the shape of the shaft during the axial movement of the inductors. This is accomplished by the displacement of rollers 59 and 60 as they are moved along the master shaft M and conform in position to its contour. The rollers are held in contact with the master shaft by springs 74 and 75.

The movement of the inductors being thus controlled by the movement of the rollers, the inductors advance and recede from the shaft S according to the shape of the master shaft. The spacing of the inductors from the shaft S is thus maintained very nearly constant. Where necessary, as in cases of shafts with abrupt changes in diameter, the inductors are shortened and curved.

Since the rigid inductors cannot be made to conform with the varying diameters of the shaft, their form is such as to represent an average condition, the curvature being too small by a small amount for large parts of the shaft, as indicated at 80 in Fig. 4, and too great by a small amount for the small parts of the shaft. To provide space for the two inductors to approach and recede from each other, spaces such as 82 and 83 are provided between them to allow clearance for the required movement. A flexible conductor 85 joins the two inductors to carry heating current from one to the other. Heating current to energize the inductors is supplied through terminals 87 and 88.

Unless shaft S is rotated during heating, the varying clearances caused by differences in curvature as at 80 and the spaces at 82 and 83 prevent uniform differential heating circumferentially of the article. To effect a uniform heating the shaft S is therefore rotated at a relatively rapid rate during the heating interval.

The successive surface zones of the shaft S are first heated to the desired temperature and thereafter quenched to rapidly cool the heated portion. In this connection as the inductors move along the shaft S in the direction of the arrow, circumferential surface bands are rapidly brought to relatively high temperatures. As these heated bands pass the shields 35 and 47 and emerge from the heating region they are vigorously sprayed with a quenching fluid which is delivered by orifices at 90 from the jacket spaces 91 and 92, the latter being supplied from the hoses 93 and 94 and through valve 95.

In the operation of this apparatus the main heating current, which is usually derived from a suitable transformer, is delivered to the inductor members and heating then takes place in that portion of the shaft S which is adjacent to these inductors. As the inductor travels from left to right over the shaft the heated portion passes the shields 35 and 47 and the quenching medium, which flows continuously during the operating period, is projected from the orifices 90 onto the heated surface rapidly cooling the same. The shields prevent the quench from prematurely trespassing onto the heating portion of the shaft. For the purpose of insuring against too great a drop in temperature at the shields, some heating current is supplied to the inductor members 34 and 46, thus causing additional heating currents to flow at the region of the shields. This counteracts to a marked degree the harmful conduction of heat from the shaft portion being heated on one side of the shield, into the already quenched portion of the shaft immediately adjacent to the opposite side of the shields.

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

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

1. In apparatus of the class described for heat treating a substantially cylindrical article, a pair of substantially semi-cylindrical complementary inductors adapted to lie on opposite sides of the article and in spaced relation thereto, flexible conductors connecting said inductors to each other in series and to a source of periodically varying current to cause inducing current to flow in the inductors peripherally of the article, means supporting the inductors, means for moving the inductors toward each other to vary a space between the inductors through which the article passes, a guide member for directing the movement of the inductors toward and away from each other, means for moving the guides and the inductors along the articles, and means extending longitudinally of the article and engaging the inductor supporting means for limiting the movement of the inductors toward each other to control spacing between the inductors and the article.

2. In apparatus of the class described for heat treating a longitudinally extending article, a pair of complementary inductors adapted to lie on opposite sides of the article and in spaced relation thereto, flexible current conducting means connecting the inductors to each other and to a source of inducing current in series to cause the inducing current to flow in the inductors peripherally of the article, resilient means for moving the inductors toward each other to vary a space between the inductors through which the article passes, supporting means for the inductors including a guide for directing the movement of the inductors toward and away from each other, means for moving said supporting means longitudinally of the aforesaid article to successively

heat peripherally extending increments of the article, and cam means extending longitudinally of the article to limit the movement of the inductors toward each other to control variable spacing between an inductor and the article.

3. In apparatus of the class described for heat treating a longitudinally extending article, a pair of complementary inductors adapted to lie on opposite sides of the article and in spaced relation thereto, conductor means connecting the inductors to each other and to a source of inducing current in series to cause the inducing current to flow in the inductors peripherally of the article, resilient means for moving one of the inductors toward another of the inductors to vary a space between the inductors through which the article passes, supporting means for the inductors including a guide for directing the movement of the one inductor toward and away from the other inductor, means for moving said supporting means to carry the inductors longitudinally of the aforesaid article to progressively heat peripherially extending increments of the article, and cam means extending longitudinally of the article for varying the movement of the one inductor along its guide toward the other inductor to control spacing between the inductors and the article.

4. In apparatus for heat treating an axially extending article, an inductor adapted to extend along a periphery of the article, means for causing inducing current to flow in the inductor peripherally of the article, means for moving the inductor radially toward and away from an axis of the article, the movement being according to a predetermined pattern, means movably interconnected with the radially moving means for moving the inductor axially along the article while the said inductor is being moved radially, and means interconnected with the radially moving means for rotating the article.

5. In apparatus for heat treating a shaft, means for supporting the shaft at its opposite ends, a pair of substantially semicylindrical complementary inductors, carriers supporting said inductors in spaced relation to provide a passage between the inductors for the shaft to pass, threaded means engaging the carriers to move the inductors along the shaft, gearing connecting the threaded means and the shaft supporting means to rotate the shaft when the threaded means rotates, means to move the carriers relative to each other to change the spaced relation of the inductors according to a predetermined pattern to control the spaced relation of the shaft and the inductors while the carrier moves, and means for supplying periodically varying current to the inductors.

6. In apparatus of the class described, two arcuate and complementary inductors angularly spaced to lie in series along a periphery of an axially extending work piece, means to cause the inductors to move substantially simultaneously and in opposite directions alternately toward and away from the axis of the article, the movements being controlled by a template and being substantially along radial lines extending from the axis to alternately decrease and increase a space between parts of the inductors adapted to be occupied by the work piece, and means for supplying inducing current to the inductors during radial movement.

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