March 15, 1949. H. F. STORM 2,464,727

HIGH-FREQUENCY INDUCTOR HEAT-TREATING APPARATUS

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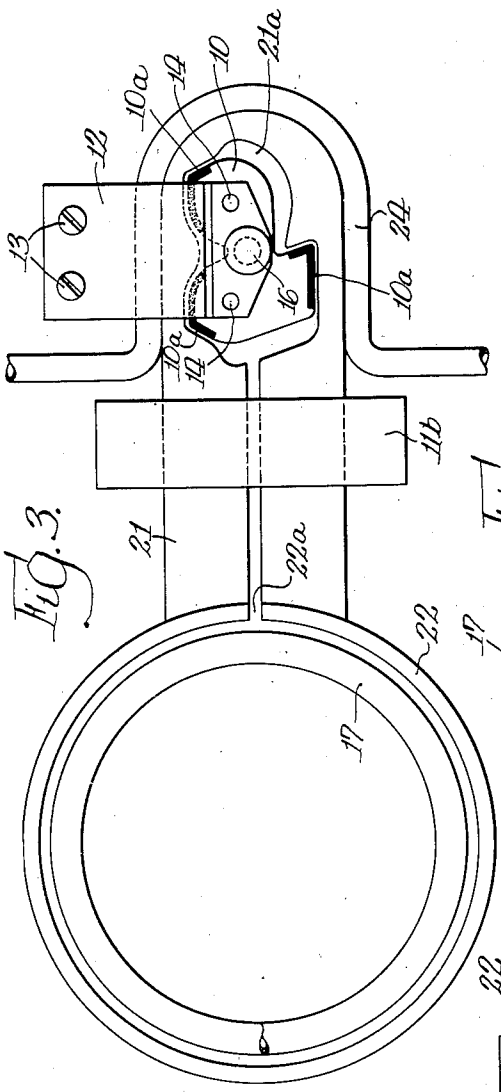


Fig. 3.

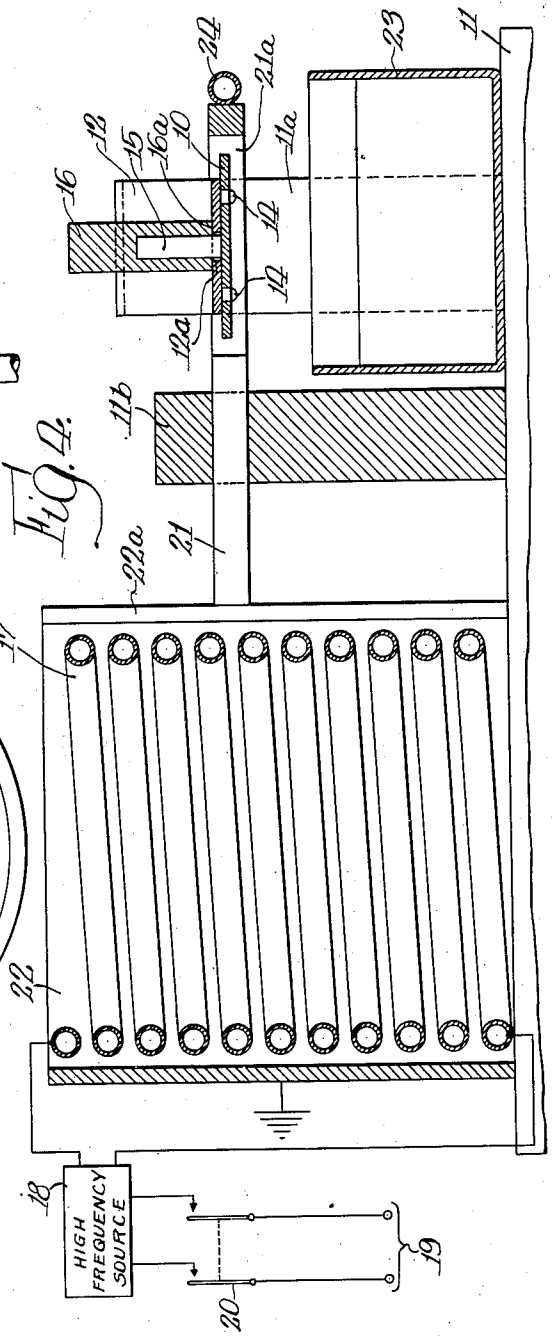


Fig. 2.

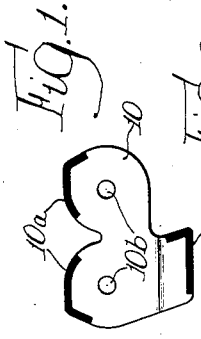


Fig. 1.



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HIGH-FREQUENCY INDUCTOR HEAT-TREATING APPARATUS

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Application June 7, 1944, Serial No. 539,109

1 Claim. (Cl. 219—13)

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This invention relates to high-frequency induction heat-treating apparatus and more particularly to apparatus of the type adapted to heat treat rapidly one or more restricted surface portions of a work piece of given configuration and also adapted to concentrate the heating over one or more of such predetermined surface portions.

In the heat treatment of certain machine elements, for example links of a link-belt or chain, it is often desirable to be able to heat treat predetermined restricted surface portions of the links subject to a maximum wear, at the same time avoiding heating of the interior portions of the link which might tend to impair its toughness and elasticity. In order to minimize such interior heating, it is desirable to concentrate the heating on only those surface portions requiring wear-resisting properties. Further, in the case of heating of links or other elements of relatively small mass and thermal inertia, it is desirable to effect the heat treatment as rapidly as possible in order to prevent conduction of the heat from the predetermined surface portions to the interior portions of the element.

It is an object of the invention, therefore, to provide a new and improved high-frequency induction heat-treating apparatus by means of which there may be procured one or more of the advantageous characteristics described.

It is another object of the invention to provide a new and improved high-frequency induction heat-treating apparatus for heat treating a work piece of a given configuration and concentrating the heating over one or more predetermined peripheral surface portions thereof.

It is another object of the invention to provide a new and improved high-frequency induction heat-treating apparatus for rapidly heat treating one or more restricted surface portions of a work piece in order to minimize the conduction of the surface heating into the interior portions of the work piece.

In accordance with the invention, a high-frequency induction heat-treating apparatus for heat treating a work piece of given configuration and concentrating the heating over one or more predetermined peripheral surface portions thereof comprises a support, means for positioning the work piece with respect to the support, and a heating inductor having an opening of the same general configuration as the work piece and disposed to surround the same. The exact configuration of the the opening in the heating inductor is such that the spacing between the predetermined surface portions of the work piece,

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when positioned by the positioning means, and the surrounding inductor is substantially less than the spacing between the other surface portions of the work piece and the inductor.

Further in accordance with the invention, a high-frequency induction heat-treating apparatus for rapidly heat treating one or more restricted surface portions of a work piece comprises a primary high-frequency inductor having connections for excitation from a high-frequency source, and a secondary heating inductor comprising a single turn of conductive material proportioned to surround the work piece and inductively coupled to the primary inductor.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the specification taken in connection with the accompanying drawings, in which:

Figs. 1 and 2 are a top plan view and side elevation, respectively, of a link of a link-belt to the heat treatment of which the invention is particularly suitable; and

Figs. 3 and 4 are a top plan view and a longitudinal section, respectively, of a heat-treating apparatus embodying the invention for effecting the heat treatment of the link of Figs. 1 and 2.

Referring now to Figs. 1 and 2 of the drawing, there is represented a plate-like work piece of given configuration, specifically a link 10 of a link-belt or chain. The portions 10*a* of the link 10 heavily shaded are the portions which in use are subjected to intensive wear. The link 10 is also provided with pin holes or apparatus 10*b* for assembly into a link-belt or chain.

It is, therefore, desired to subject the link 10 to a heat treatment and to concentrate the heating over one or more predetermined restricted peripheral surface portions thereof, such as the portions 10*a*. In accordance with the present invention, there is provided a high-frequency induction heat-treating apparatus for rapidly heat treating the plate-like work piece or link 10 of Figs. 1 and 2 and for concentrating the heating over the restricted surface portions 10*a*, as described. This apparatus is illustrated in Figs. 3 and 4 and comprises a base or support 11 having an upright standard 11*a* on which is mounted means for positioning the work piece with respect to the support but preferably without supporting the work piece.

This means consists of a Z-shaped bracket 12, one end of which is fastened to the standard 11*a* by suitable means such as the screws 13. The

bracket 12 depends from the standard 11a and on its lower arms is provided with a plurality of positioning pins 14 projecting downwardly from the supporting bracket 12 and spaced to engage the apertures of the work piece 10 and position it with respect to the support. Since the work piece 10 is usually of magnetic material, it may be releasably retained on the positioning pins 14 by means of a small magnet, either an electromagnet or a permanent magnet 15, as illustrated. The magnet 15 projects through an aperture 12a of the supporting bracket 12 and is disposed in a handle 16 provided with a shoulder 16a engaging the upper face of the bracket 12 to hold the magnet 15 in the proper position for supporting the work piece 10.

The heat-treating apparatus includes also a primary high-frequency inductor such as an elongated solenoid 17 having connections for excitation from a high-frequency source 18 in turn excited from power-supply terminals 19 through a switch or circuit breaker 20. Preferably the high-frequency source or generator 18 is of the improved form disclosed and claimed in copending application Serial No. 539,106, filed June 7, 1944, Herbert F. Storm, and assigned to the same assignee as the present invention. Associated with the primary high-frequency inductor is a secondary heating inductor. The secondary inductor comprises a loop 21 formed of a strip of conductive material bent double on itself edgewise and formed with an opening 21a therein of the same general configuration as the work piece 10 and supported in a standard 11b from the support 11 and so disposed as to surround the work piece when positioned by the pins 14.

While the general configuration of the opening in the loop 21 is similar to that of the work piece, they do not correspond exactly, so that the spacings between successive portions of the work piece and the surrounding loops 21 are unequal. Specifically the spacings between the predetermined surface portions of the work piece, when positioned by the positioning pins 14, which are to be subjected to the concentrated heating and the surrounding inductor 21 are substantially less than the spacings between the other surface portions of the work piece and the inductor. Preferably the spacings between the several surface portions and the surrounding inductor vary inversely with the desired heating of such portions. In other words, the configuration of the opening 21a in the inductor 21 is such that it follows closely the contour of the work piece only over the predetermined surface portions 10a to be subjected to concentrated heating.

The secondary heating inductor 21 in inductively coupled to the primary inductor 17 preferably by a single turn conductor surrounding the primary inductor. This single turn conductor is constructed in the form of a cylindrical conductive member 22 substantially enclosing the primary inductor 17 and having a longitudinal gap 22a therein, the open ends of the loop 21 being connected to the cylindrical member 22 at opposite sides of the gap, as illustrated. The center point of the member 22 opposite the gap 22a is preferably grounded, as indicated, thus shielding the primary inductor 17.

The heat-treating apparatus also includes a quenching bath container 23 disposed immediately below the supporting bracket 12 of the work piece 10 so that, upon release of the latter, the bath within the container 23 receives the work piece as it drops from the pins 14.

Preferably the portion of the loop 21 surrounding the work piece is cooled by a quenching-fluid means such as a copper tubing 24 soldered or otherwise bonded directly to the periphery of the loop 21 and connected to any suitable source of cooling fluid, not shown. Also the primary inductor 17 may be constructed from hollow copper tubing and cooling fluid may be circulated therethrough during operation in a conventional manner from a source of cooling fluid, not shown.

The operation of the heat-treating apparatus illustrated in Figs. 3 and 4 will be apparent from the foregoing description. In brief, upon the excitation of the high-frequency source from supply terminals 19 through switch 20, the primary inductor 17 develops a high-frequency electromagnetic field. The high-frequency voltage appearing across the inductor 17 is relatively high and the high-frequency current flowing therethrough relatively low. The secondary inductor comprising the single-turn conductive member 22 and the loop 21 comprise, with the primary inductor 17, a step-up current transformer for developing a high-frequency current of large amplitude but of low voltage. This current, flowing in the loop 21, creates an intense high-frequency electromagnetic field in the region of the work piece 10, which it is assumed is retained on the positioning pins 14 by the permanent magnet and holder 15, 16.

Due to the configuration of the opening 21a in the loop 21 of the secondary inductor, that is due to the fact that the opening 21a follows closely the contour of the work piece 10 only over the predetermined surface portions 10a and at other portions is relatively widely spaced therefrom, the high-frequency induction heating is concentrated in the regions 10a and is relatively insubstantial over the other regions of the work piece 10. Furthermore, by means of the current transformer embodying the heating inductor, the electromagnetic field at the work piece is very intense so that the predetermined portions are heated to a heat-treating temperature relatively rapidly and before the heat in such regions can be conducted to the inner portions of the work piece 10. Therefore, there is no substantial impairment of the toughness and elasticity of the work piece as a whole.

When the work piece 10 has been sufficiently heat treated, it may be released by either lifting or tilting the retaining magnet 15 in the holder 16, thereby dropping the work piece into the container 23 holding the quenching bath. It will be understood that, in place of the permanent magnet 15, there may be utilized an electromagnet under the control of a timer such as is conventional in high-frequency induction heat-treating systems. In such case, the excitation of the retaining electromagnet is controlled by the timer. For example, the system may utilize the timer forming the subject matter of copending application Serial No. 539,104, filed June 7, 1944, Herbert F. Storm, entitled Timing apparatus, now Patent Number 2,396,898, and assigned to the same assignee as the present application.

The use of a heating inductor comprising a primary inductor 17 and a secondary inductor 21, 22 constituting a current transformer in the heat treating apparatus of the invention has a number of advantages. In the first place it makes possible the development of a much higher in-

tensity high-frequency magnetic field than is furnished by commercial high-frequency sources and therefore permits the use of a high-frequency generator of comparatively small power output and yet supplies a current of sufficient amplitude for the rapid but concentrated focal heating of the restricted portions of the work piece. In addition, commercial high-frequency generators usually develop across the heating inductors a sufficiently high voltage to constitute a distinct operating hazard. In the present structure this high-voltage inductor is completely enclosed and shielded by the member **22** of the secondary inductor, which is founded and therefore eliminates all such high-voltage hazards. By grounding the center point of the member **22** remote from the gap **22***a*, the maximum high-frequency voltage induced upon the member **22** is limited to its lowest possible value, thereby minimizing the shock hazard.

In addition, the separation of the active heating portion of the secondary inductor which surrounds the work piece **10** from the high-voltage inductor **17** avoids excessive heating of the insulation associated with the high-voltage inductor by radiation from the work piece and its associated supporting parts. In the structure illustrated, the effective heating takes place at such a distance from the high-voltage primary inductor **17** that the latter is not heated to any substantial degree from the work piece and its associated parts.

While there has been described what is considered to be the preferred embodiment of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What I claim as new is:

A high-frequency induction heat-treating apparatus adapted for use in heat-treating a plate-like work piece of a given irregular configuration and concentrating the heating over one or more predetermined peripheral surface portions thereof comprising a support, means adapted specifically to position such a work piece relative to said support when supported thereby, a heating inductor consisting of a loop having a plate-like extended portion of greater axial dimension than the work piece adapted to be heated thereby, said plate-like portion having an opening of the same general irregular configuration as a work piece adapted to be heated thereby, said first mentioned means being adapted to support the work piece so that when disposed within said opening the predetermined peripheral surface portions of the work piece are spaced from the inner edge of said plate-like portion by a substantially smaller amount than other portions of the work piece, and a primary high frequency inductor having connections for excitation from a high frequency source, said heating inductor and primary inductor being inductively coupled.

HERBERT F. STORM.

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