

April 9, 1946.

V. W. SHERMAN

2,397,990

INDUCTION HEATING APPARATUS

Filed March 12, 1943

FIG.1.

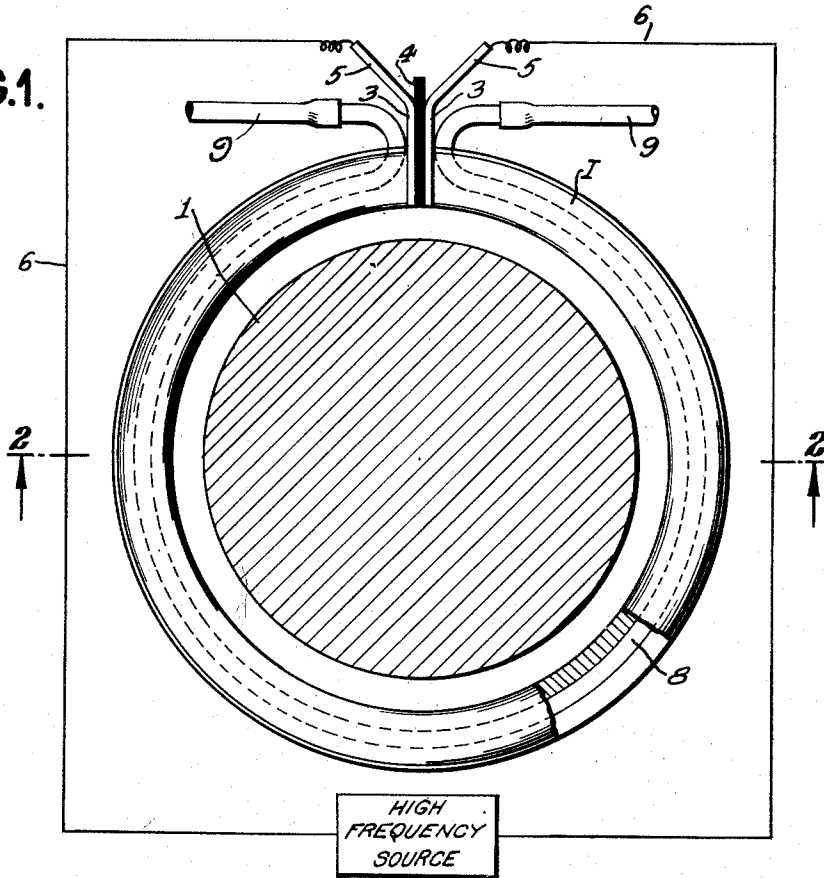


FIG.3.

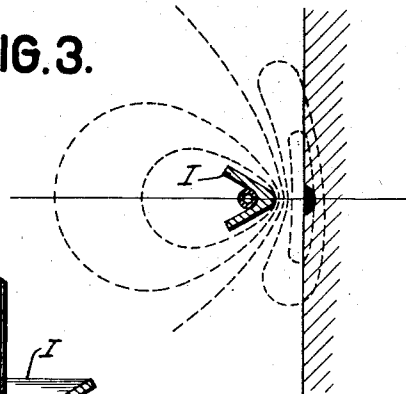
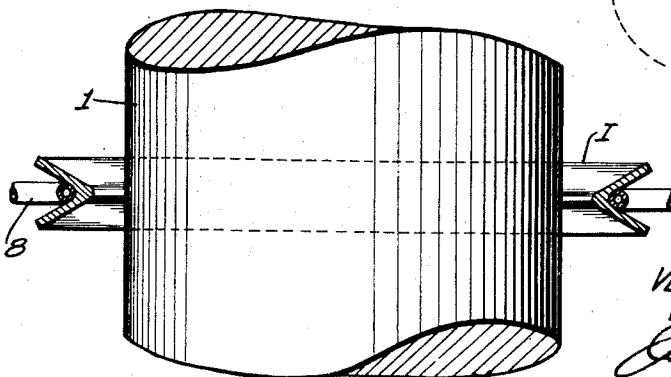


FIG.2.



INVENTOR.
VERNON W. SHERMAN

BY

J. P. Williams
ATTORNEY

UNITED STATES PATENT OFFICE

2,397,990

INDUCTION HEATING APPARATUS

Vernon W. Sherman, Summit, N. J., assignor to
Federal Telephone & Radio Corporation, New
York, N. Y., a corporation of Delaware

Application March 12, 1943, Serial No. 478,866

4 Claims. (Cl. 219-13)

The present improvements relate to high frequency, induction heat treatment of steel bearing surfaces and the like and is particularly directed to the production of an improved apparatus designed for the case hardening of work pieces having enlarged bearing or surface areas to be treated and to be operative with a concentration of the heating energy in a narrow band on the surface of the work and with the progression of the heating band over the surface area of the work by relative, uniform and progressive axial movement of the conductor coil with respect to the surface under treatment. By means of the resulting improved method of progressive or scanning action heat treatment very substantial economies in the energy and power consumption obtains with the generation of heat in the iron at a higher rate for the given power than where the heating is spread over a wider area or over the full surface as in the customary practice. The present improvements contemplate the employment of an induction heating element specially designed to operate with a high degree of heat concentration and rapid rate of heating by the employment of ultra high frequency currents in the megacycle range.

The frequency employed is desirably of from 5,000,000 to 15,000,000 cycle energy by the employment of which it is possible to reduce the heat treatment time to a period of one second or less. From this certain important advantages are obtained including the avoidance of undesirable depth of heating and the effecting of a self-quenching action by the colder body metal with substantial non-interference with the temper of the metal immediately underlying the resulting case hardened surface.

The improved inductor element, to permit effective heating of the work under the severe conditions prescribed by the high heat concentration, consists of an inductor of special form to permit a substantial degree of radiation of the heat from the inductor element which might otherwise become heated to the melting point. In its preferred form the improved inductor heating element is of annular or single coil formation of substantially V-form with the apex of the V-formation employed as the active heating portion and with the horns or tangent portions thereof operating as cooling elements by the radiation of heat from the active portion. In association therewith there is likewise provided supplemental cooling means consisting of a cooling coil of copper tubing closely fitted within the groove of the

V-inductor and through which a cooling medium or fluid such as water is circulated.

The described, and other important features and advantages of the present improvements will be better understood by reference to the accompanying drawing wherein like reference characters of the description are applied to the corresponding parts in the several views.

In the drawing:

Fig. 1 is a plan view of the improved induction heating apparatus of the present invention;

Fig. 2 is a horizontal cross-sectional view thereof and;

Fig. 3 is an enlarged, detailed, sectional view diagrammatically illustrating the approximate path of flux flow in the induction heating operation.

In the preferred embodiment of the features of the present invention as here shown, 1 indicates the work piece to be heat treated for case hardening which may be the bearing portion of a shaft of the usual uniform diameter. The shaft is shown positioned vertically and, as will be understood, will be supported by a suitable movable carrier (not shown) adapted for and operated progressively to move the work piece vertically or co-axially of the shaft during the heating operation. The inductor heating element 1 is as shown of a substantially annular or split ring formation and is positioned concentrically with and surrounding the shaft being treated thereby; the inductor element in the present instance being supported to be stationary by suitable rigid supporting means not shown. Structurally the single coil type of inductor element is of V cross-sectional form as shown with the apex of the V formation disposed inwardly in close proximity to the surface of the work piece and having the extremities at the split portion in a closely spaced relation with interposed conductor terminal members 2-3 united with the inductor element or ring end portions and closely spaced with a mica insulating sheet 4 interposed therebetween. The inwardly directed ends of the terminal members 3 conform to the V contour of the inductor element and these members are extended radially outward as shown with outwardly turned or flared outer ends 5-5 for connection with the leads 6 of the energizing circuit. In addition there is provided as shown a supplemental cooling element consisting of a copper tube 8 bent to be complementary in form to the curvature of the inner portion of the groove formed in the inductor and fitted closely therein with the outer end portion thereof formed with oppositely extended

turns for connection with conduits of a cooling fluid circulating system. The conduits are indicated as rubber hose connections 8-9 whereby cooling fluid such as water is circulated through the cooling coil as is readily understood.

During the induction heating operation, the shaft will be slowly advanced or progressed through the inductor heating coil or ring with a uniform motion and at a rate of speed proportioned with relation to the induction heating energy employed to obtain the degree of heating as may be desired of the specific production piece.

The energizing current for the inductor heating element, as herebefore referred to is preferable in the ultra-high frequency range, desirably 5,000,000 cycles or above to effect an exceedingly rapid rate of heating. This avoids, to a maximum degree, objectionable heat conduction to the inner body of the steel such as would appreciably alter the molecular structure or tempered condition of the work piece metal.

In Fig. 3 there is diagrammatically illustrated approximate flux lines of the heating field as induced by the improved form of inductor element. Therein, as will be noted, there occurs a high degree of concentration of the primary flux lines, inward and immediately at the apex of the V from which it will result that there will be induced a correspondingly concentrated or narrow band of heat in the surface of the inductively coupled work. By this means there is obtained a maximum concentration of the heating energy and the heat is generated in the iron at a higher rate for a given power than if it were spread over a wide area.

The desirable V formation of the high frequency inductor element as referred to provides outwardly diverging flanges performing the important function as heat radiators for protectively conducting heat from the active apex portion of the inductor. In addition thereto the angle of divergence of the flange portions is desirably selected as the angle which approximates a probable line of flux concentration emanating outward from the work and along the side of the inductor coil. The purpose of this angular positioning of the flanges to conform to the normal line of flux flow is to reduce eddy current loss in the inductor coil material which in this instance is copper.

In the construction of the inductor element the ends thereof are brought as close together as is structurally and electrically permissible, the object thereof being to bring the ends so close together as to prevent a zone of reduced heat resulting from an appreciable discontinuity of the inductor coil. In this latter connection, and as will be readily understood, the support for the work piece in addition to its longitudinal movement may be arranged to rotate the work piece during the heating so as to distribute or nullify the effect of any heating variable at this point of juncture so as to be of negligible degree. As a further feature and as will be understood without illustration the inductor element may be provided with a plating or coating of silver for the purpose

of minimizing the eddy current losses in the surface of the heating coil.

While there is disclosed an approved embodiment of the features of the present invention it will be understood that varied modifications may be made therein without departing from the scope of the invention as defined in the appended claims. As illustrative, the structure may be adapted by inversion for heating the internal surfaces of cylindrical work such as sleeve bearings as will be readily understood.

What is claimed is:

1. A high frequency induction heating apparatus comprising a substantially annular inductor element of continuous V-formation channel section and wherein the apex of the V is disposed toward the work surface to be inductively heated, a tubular cooling coil closely fitted within the groove of the inductor, means for circulating a cooling medium therethrough, means for effecting relative longitudinal and rotative movement of the work with relation to the inductor and high frequency circuit connected to energize the inductor.

2. A high frequency induction heating apparatus comprising a substantially split ring form inductor element formed of continuous V-formation channel section and wherein the apex of the V is disposed toward the work surface to be inductively heated, outwardly extending terminal members connected to the respective ends of the inductor in closely spaced, insulated relation and having their connected end portions conforming to the cross sectional contour of the inductor, means for effecting relative axial movement of the work with relation to the inductor and to effect rotational, relative movement therebetween and a high frequency circuit connected to energize the inductor.

3. A high frequency induction heating apparatus comprising an inductor element formed as a split ring of continuous V formation channel section and wherein the apex of the V is disposed inwardly toward the work surface to be inductively heated, outwardly extending terminal members connected to the respective ends of the inductor in closely spaced and insulated relation, a tubular cooling coil closely fitted within the groove of the inductor and having its end portions reversely turned and engaging the terminal extensions, means for effecting relative axial movement of the work with relation to the inductor and a high frequency circuit connected to energize the inductor.

4. A high frequency induction heating apparatus comprising an inductor element formed as a split ring of continuous V formation channel section wherein the apex of the V is disposed inwardly toward the work surface to be inductively heated, outwardly extending terminal members connected to the respective ends of the inductor in closely spaced and insulated relation, a tubular cooling coil setting within the groove of the inductor and said inductor being silver plated to minimize eddy current losses.

VERNON W. SHERMAN.