June 30, 1942. H. E. SOMES 2,288,036

INDUCTION HEAT TREATING

Filed May 20, 1940

Fig. 1.

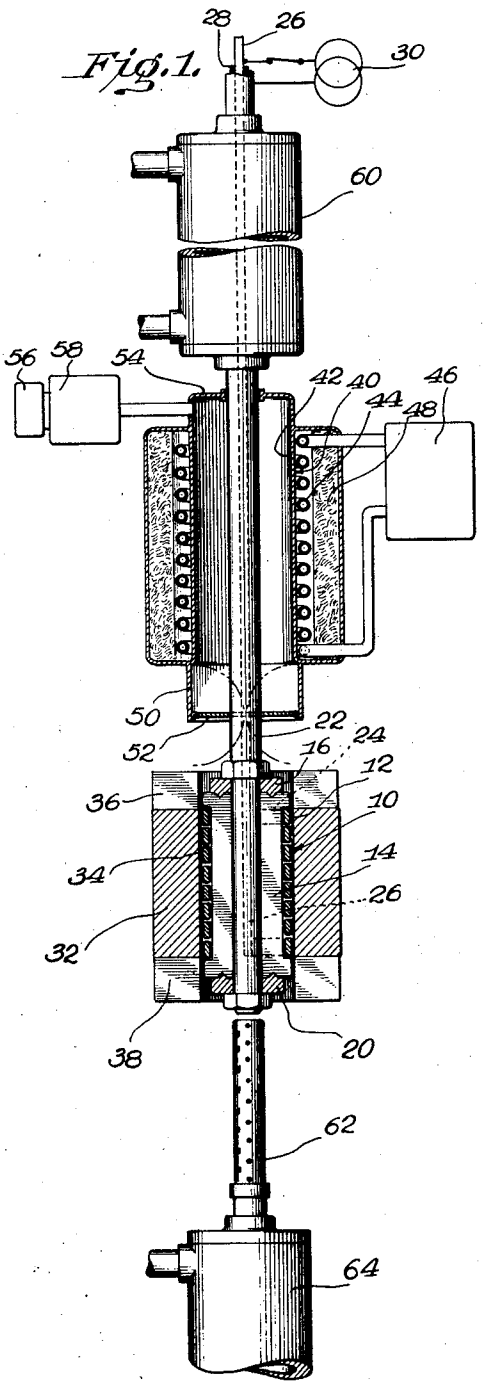
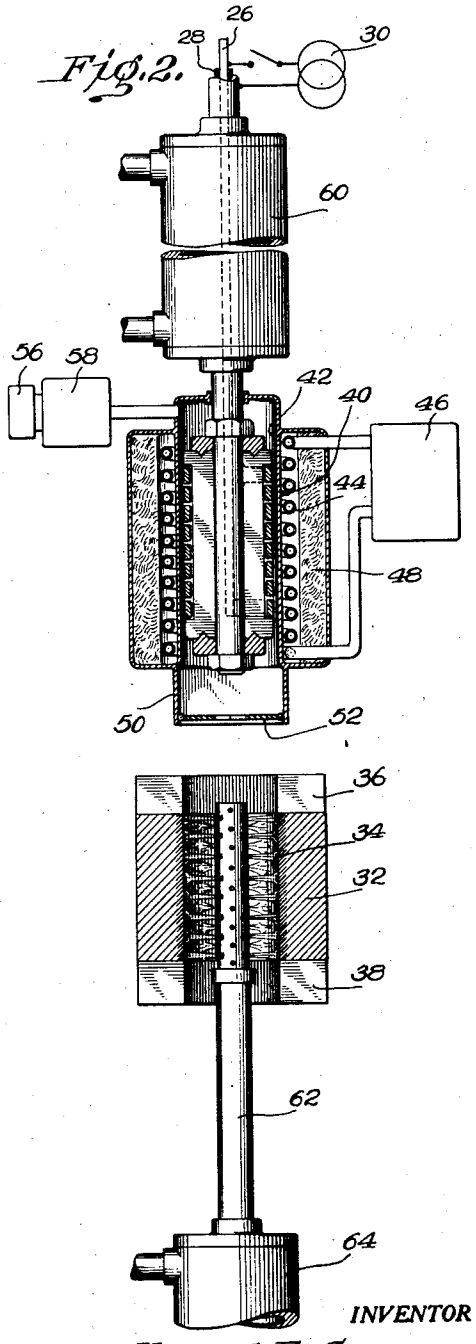


Fig. 2.



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Patented June 30, 1942 2,288,036

UNITED STATES PATENT OFFICE

2,288,036

INDUCTION HEAT TREATING

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Application May 20, 1940, Serial No. 336,128

12 Claims. (Cl. 219—13)

This invention relates to electromagnetic induction heat treatment and more particularly to an improved method and apparatus for cooling the heat treatment inductor coil.

In electromagnetic induction heat treatment apparatus it has heretofore been the practice generally to provide a water cooled tubular inductor coil so that during use of the inductor coil the same may be cooled to prevent excessive heating thereof. In such apparatus where heavy low power factor currents are often present and in which the coil is exposed to an object having its internal surface heated to a temperature of 1700° F. or more, it can readily be seen that some cooling means is necessary. However, the use of such a tubular conductor in a coil tends to restrict the minimum diameter of the coil which may be used. In such heat treating operations the use of high frequency current is resorted to and consequently the current flow in the inductor is substantially concentrated upon the exterior surface and, therefore, the radial depth of the conductor made necessary by the tubular cooling passage is required solely for the purpose of forming a tube to carry a coolant rather than as an assistant in conducting current. In many heat treating operations such as inductor coil is exposed to the extreme temperature conditions but for a few seconds and allowed to rest in a position removed from the heating causes during the remainder of the operating cycle, which may be ten or fifteen seconds.

The present invention is directed toward providing a coil of unusually small diameter in which the direct cooling thereof is done away with but in which, as a substitute, there is provided a cooling chamber for the coil into which the coil is adapted to be placed during the period at which it is at rest. Thus the coil is super-cooled prior to a treatment and after the treatment returned to the cooling chamber so that the heat generated or absorbed by the coil during the treatment may be removed during such rest period and prior to the next heat treatment.

It is, accordingly, an object of the present invention to provide an electromagnetic induction heat treating coil of relatively small external diameter and in which the cooling thereof is effected during the rest period rather than the working period.

A further object of the invention is to provide an apparatus for cooling a heat treating head during its rest period preparatory to a heat treatment and for removing the heat generated in and absorbed by the heat treat head after each heat treatment.

Still another object of the invention is to provide a heat treat head of small diameter unemcumbered by cooling means in the head itself.

The above and other novel features of the invention will appear more fully hereinafter from the following detailed description when taken in conjunction with the accompanying drawing. It is expressely understood, however, that the drawing is employed for purposes of illustration only and is not designed as a definition of the limitation of the invention, reference being had for this purpose to the appended claims.

In the drawing wherein like reference characters indicate like parts,

Figure 1 illustrates in section the general organization of the heat treat head and a rest chamber for cooling the same when not in use, the head being illustrated in heat treating position, and

Figure 2 illustrates the same apparatus but with the heat treat head in rest position in the cooling chamber and the quenching fixture in operative position.

Referring to the drawing, there will be seen a heat treat head 10 having a spiral inductor coil 12 thereon composed of flat strip material, the inductor being wound about a laminated core 14 composed preferably of radial wedge-section laminations clamped in position between collars 16 and 20 carried on the central hollow arbor or support rod 22. The end connections to the inductor coil may be made to the arbor as diagrammatically illustrated at 24 and to a central inductor 26 extending through the arbor and insulated therefrom as illustrated at 28. A source 30 of high frequency high power alternating current is provided and suitable apparatus, not shown in detail, is adapted to control the application thereof to the heat treat head.

In the position shown in Figure 1 the heat treat coil is illustrated inserted within a workpiece 32 having a bore 34 in close proximity to the exterior surface of the work coil and which bore is adapted to be differentially heated to a high tempertaure sufficient for hardening upon subsequent quenching. If desired in conjunction with the workpiece, suitable magnetic circuit end pieces 36, 38 likewise preferably formed with radial laminations may be employed to assist the flow of magnetic flux through the central core 14 and outwardly over the ends of the coil into the work.

Through the use of high frequency high power induction heating, the internal surface of the workpiece may be heated to a hardening temperature in the course of one or two seconds, during which time considerable heat is absorbed by the copper conducting coil as well as being generated within the coil due to the heavy current flow. Additionally, eddy and hysteresis current losses in the core produce heat, which heat likewise tends to flow outwardly into the coil. Thus, if the operation of the apparatus were extended over a sufficient period of time, damage to the coil from overheating would surely result. However, since the period during which heating is effected is relatively short, the coil may be removed from the work substantially instantaneously after a short heating period, whereupon the damaging heat conditions are removed.

Repeated use of the coil even for short spaced periods would soon overheat the same and there is, therefore, provided as a novel feature of the present invention, a refrigerated chamber **40** into which the heat treat head is substantially instantaneously placed as soon as it is withdrawn from the workpiece. The chamber illustrated is provided with a cylindrical wall **42**, a cooling coil **44** surrounding the same, connected to a refrigeration apparatus **46**, and the chamber is insulated suitably in any desired manner as by insulation **48**.

In practice it may be desirable to retain the chamber at a temperature many degrees below zero Fahrenheit dependent upon the amount of heat which it is desired to extract from the coil and the length of its rest period, during which such heat may be extracted. In order to prevent the chamber from unduly frosting or collecting moisture from the atmosphere during operation, the chamber is preferably closed as tightly as permissible, the lower end thereof being provided with a relatively square entrance compartment **50** having normally closed reverse swinging doors **52** and its upper end is closed as at **54**. In order to offset the tendency for damp atmospheric air to leak in through the various cracks in the chamber or through the doors during emergence and retraction of the heat treat head out of and into the chamber, a continuous flow of dry air is supplied to the chamber by means of a blower **56** and a moisture absorbing dryer **58**, which dryer may be of the silica gel type or equivalent thereof.

In practice, it will, of course, be obvious that in some cases the blower and dryer for supplying a continuous flow of dry air into the chamber may be dispensed with, in which case any tendency for the chamber to frost over can be offset by a temporary use of the heat treat head to induce a heating current within the coil of the chamber itself whereby condensed moisture and frost can be evaporated. Such a heating operation might be resorted to as often as required, for example periodically after ten or fifteen heat treatments depending upon conditions.

In Figure 2 the heat treat head is shown as retracted into the rest cooling chamber through the operation of the lowering and elevating cylinder **60** and the quench **62** has been elevated into quenching position within the workpiece through the operation of the quench elevating cylinder **64**. Quenching operation is effected immediately upon the withdrawal of the heat treat head so that the internal layer heated to hardening temperature may be quenched before any substantial amount of heat can flow into the unheated back metal. Generally speaking the quenching period need not be more than five or ten seconds if sufficient water is supplied under pressure. Thereafter the quenching head may be lowered leaving a free space for the removal of the workpiece and the insertion of another workpiece into position. During the period of quenching and unloading and reloading, the heat treat coil gives up such heat as was developed therein during the actual heating of the previous workpiece and is brought to a suitable temperature such that upon insertion of the next workpiece into the apparatus, the heat treat head is sufficiently cooled so that it may be safely subjected to the heat of the heated wall of the workpiece as well as the other heating conditions inherent in the work coil itself for a period long enough to heat the internal layer of the workpiece to a hardening temperature. The coil is thereafter removed and the workpiece quenched, the coil in the meantime having the heat thereof extracted by the refrigeration of the rest chamber.

It will thus appear that the heat treat coil itself, because of the high frequency currents and skin effect, may be relatively flat or thin in radial dimension and that, therefore, the external diameter of the heat treat coil may be reduced to a minimum necessary, that minimum necessary being dependent upon the thickness of the conductor required to carry the heavy skin currents flowing therein, the cross-section of core required to carry the necessary flux which must be produced in order to induce a suitable voltage within the workpiece to cause the heating currents to flow, and the cross-section of the supporting arbor.

The use of dry gas tends to prevent the formation of frost and the momentary inductive heating is not so much a preventive as it is a cure for any frost that may have been formed. It will be apparent that when the absorbing material becomes partially spent there may be some likelihood of frost forming. At such time if the residual heat in the inducing coil is not enough to remove any frost in the refrigerating space, then in the event the collection of frost be substantial, a short use of inducing current will suffice to remove all frost that has been formed.

Though a single embodiment of the invention has been illustrated and described, it is to be understood that the invention is not limited thereto but may be embodied in various other mechanical and electrical arrangements. Various changes may be made in the construction and arrangement of parts and in the operation thereof without departing from the spirit of the invention as will be apparent to those skilled in the art and reference, therefore, should be had to the appended claims for a limit of a definition of the invention.

What is claimed is:

1. In an electromagnetic induction heat treatment apparatus, a heat treat head, means for relatively moving said heat treat head into and out of operative position with relation to a work piece, means independently of and operatively associated with said head for abstracting heat therefrom, and means for reducing any tendency for moisture to form on said head while the head is at a temperature below that at which moisture might be deposited thereupon.

2. In an electromagnetic induction heat treat-

ment apparatus, a heat treat head comprising a coil adapted to be inserted into and out of a hollow work piece, a chamber adjacent said workpiece and including means for refrigeration thereof sufficiently low in temperature to obtain substantially increased electrical conductivity in the coil, and means for moving said head from a position within a hollow workpiece to a position within said chamber.

3. In an electromagnetic induction heat treatment apparatus, a heat treat head, means for reciprocating said head between an operative position associated with a hollow workpiece, and an inoperative position, a substantially closed chamber arranged to receive said head when in inoperative position, said chamber having means for admitting entrance of said head to and egress from said chamber, means for refrigerating said chamber to cool said coil, and means for supplying a dry non-frosting atmosphere to said chamber.

4. In an electromagnetic induction heat treatment apparatus, a heat treat head, means for reciprocating said head between an operative position associated with a hollow workpiece, and an inoperative position, and a substantially closed chamber arranged to receive said head when in inoperative position, said chamber having door means for admitting entrance of said head to and egress from said chamber, means for refrigerating said chamber to cool said head, and means for defrosting the walls of said chamber by inducing heating currents in the wall thereof while said head is received in said chamber in the said inoperative position, said last-mentioned means including said heat treat head.

5. The steps in the method of operating a relatively small electromagnetic induction heat treat head which comprise removing the heat absorbed by said head during heating operations by placing said head in a refrigerating chamber, heat treating a workpiece and removing the resultant heat absorbed by the head in repeating cycles, and inducing for a short period heating currents in the wall of the chamber from the heat treat head to evaporate condensate and frost collecting thereon from time to time.

6. The steps in the method of operating an inducing conductor of an apparatus for heating by electromagnetic induction which comprise relatively separating the heated work and conductor, moving a gas across said conductor at a temperature well below that at which moisture might be deposited upon said conductor when adjacent said work, and removing enough moisture from said gas before it is moved across the conductor to substantially reduce the tendency for any frost to form on said conductor.

7. The combination with a refrigerating device, having a chilled wall on which frost may become deposited, of means for heating said wall by electromagnetic induction to defrost the same, whereby the heat necessary for such defrosting is generated within said wall and the temperature inside said device may be raised only a minimum amount during such defrosting.

8. The method of treating an inducing conductor in an apparatus for electromagnetic inductive heating, which comprises chilling the conductor in a substantially closed dry chamber adjacent a workpiece to be heated, after rapidly and relatively moving said conductor with respect to the chamber and workpiece to effect the relative transfer of the conductor from one to the other with expedition.

9. In an electromagnetic induction heat treatment apparatus, an inducing conductor, means operatively associated with said conductor for lowering the temperature of said conductor below that at which moisture might be deposited from the atmosphere, and means independently of said conductor for reducing the tendency of moisture to form on said conductor while said conductor is at a temperature below that at which moisture might be deposited thereupon.

10. In an electromagnetic induction heat treatment apparatus, an inducing conductor, means for lowering the temperature of said conductor below that at which moisture might be deposited from the atmosphere, and means for reducing the tendency of moisture to form on said conductor, said last-mentioned means including mechanism for removing moisture from the atmosphere around said conductor during the temperature-lowering operation.

11. In an electromagnetic induction heat treatment apparatus, an inducing conductor, means for lowering the temperature of said conductor below that at which moisture might be deposited from the atmosphere, and means for reducing the tendency of moisture to form on said conductor, said last-mentioned means including mechanism for blowing dry gas in contact with said conductor during the temperature-lowering operation to facilitate the exchange of heat from said conductor to said temperature-lowering means by convection while also simultaneously lowering any tendency for the deposition of moisture on said conductor.

12. In an electromagnetic induction heat treatment apparatus, an inducing conductor, means for lowering the temperature of said conductor below that at which moisture might be deposited from the atmosphere, means for reducing the tendency of moisture to form in connection with said temperature lowering means, said moisture reduction means including mechanism for removing moisture from the atmosphere which is to be around said conductor, means for passing the moisture removed atmosphere into contact with said conductor, and means including said inducing conductor for heating the temperature lowering means at least enough to remove any frost that may have formed thereon.

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