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RADIO FREQUENCY APPARATUS FOR HEATING METALLIC ARTICLES OF LARGE SURFACE AREA TO VOLUME RATIOS

Filed March 30, 1944

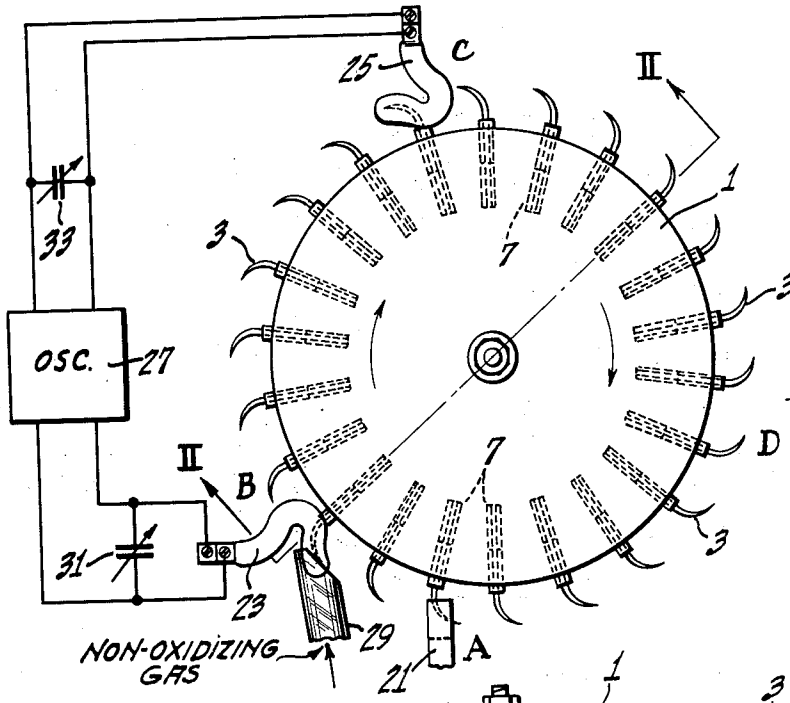


Fig. 1.

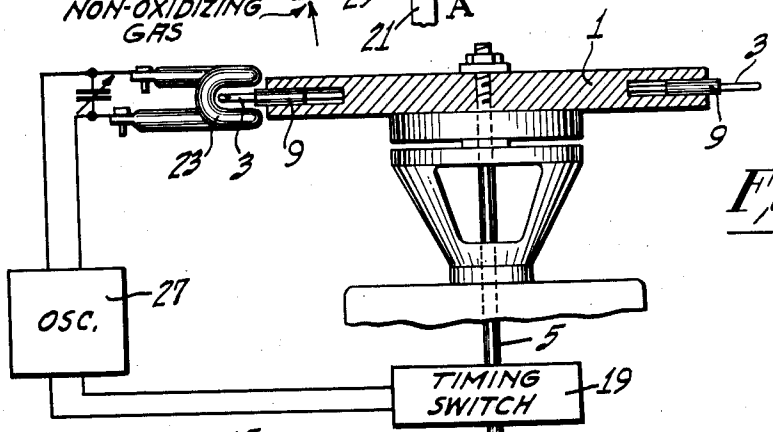


Fig. 2.




Fig. 3.

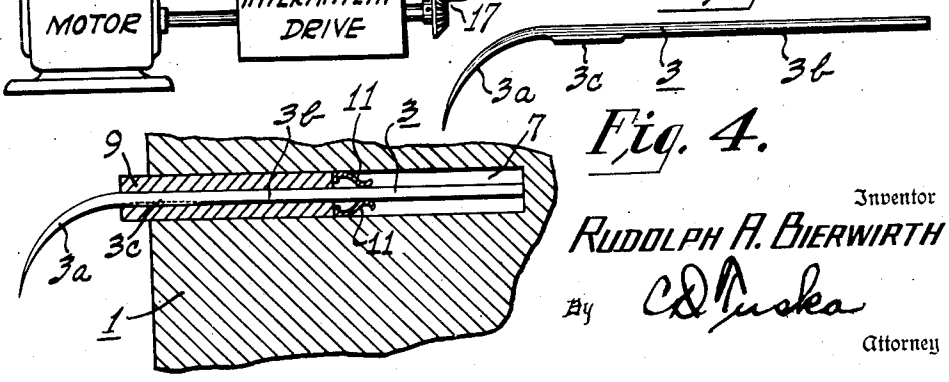


Fig. 4.

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## RADIO FREQUENCY APPARATUS FOR HEATING METALLIC ARTICLES OF LARGE SURFACE AREA TO VOLUME RATIO

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4 Claims. (Cl. 219—13)

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This invention relates to the heat treatment of metallic articles, and more particularly to a method of and apparatus for hardening metallic articles in which the surface area to volume ratio is large.

There are many articles of commerce which it is necessary to harden in order to provide a long, useful life therefor. Among such articles are some which have a large length dimension compared to the largest cross-sectional dimension, so that the ratio of the surface area to the volume thereof is quite large. Examples of such articles are needles of various sorts.

The customary practice of hardening needles in accordance with prior art methods involves heating the needles in a furnace to the required hardening temperature. Furnace heating includes a number of disadvantages, perhaps the most important of which is that the temperature of the furnace is difficult to control within narrow limits so that uniform results cannot always be obtained. Also, with certain types of needles, such as surgical needles, where it is desired to harden only the pointed end portion thereof, the disadvantage has been encountered with prior art practices that the entire needle is first hardened and then the portions not intended to be hardened must be annealed.

The primary object of my present invention is to provide an improved apparatus for hardening metallic articles of the type in which the ratio of surface area to volume is large and from which the heat developed therein is therefore quickly dissipated.

Another object of my present invention is to provide an improved apparatus for hardening relatively thin, elongated metallic articles in a rapid and efficient manner.

Still another object of my present invention is to provide an improved apparatus for hardening articles of the type set forth whereby the hardening may be confined to desired or preselected portions.

A further object of my present invention is to provide an improved apparatus for hardening thin, elongated metallic articles of the type set forth above, which apparatus readily lends itself to continuous, high speed operation.

It is also an object of my present invention to provide an improved apparatus as above set forth which is economical and very efficient in use and which is simple in construction and inexpensive in cost.

In accordance with my present invention, I heat the metallic articles inductively by subjecting them in succession to a radio frequency magnetic field. Now, I am aware that it has been proposed heretofore to heat metallic articles by radio frequency current induced therein, but conventional methods of heating metallic articles by means of radio frequency energy are not applicable to the type of article under consideration. This is due to the fact that the volume of the article to be hardened is so small in comparison with its surface area that the relatively large surface area permits rapid dissipation of the heat developed in the article. I have found, however, that if the articles are heated with such extreme rapidity that the entire volume of the portion thereof to be hardened is substantially instantaneously brought to the hardening temperature, then there will be insufficient time afforded for the heat developed therein to become dissipated too rapidly. I have found that conventional needles used for surgical work, sewing, weaving and the like can be hardened without difficulty if power is delivered thereto at approximately 100 kw. per cubic inch. This may be done effectively by supplying the power at frequencies of the order of 30 to 300 megacycles per second. Radio frequency power applied to the work in this way will generate heat therein so rapidly that the entire mass is substantially instantaneously uniformly heated to the required hardening temperature before sufficient heat has been lost through dissipation to defeat the desired purpose. At the same time, because the work is heated with extreme rapidity, there is a large temperature gradient set up between the heated work and the ambient, so that quenching can take place very effectively by the ambient and without the necessity for additional quenching means, as is necessary with most prior art methods. If desired, the work may be subjected to a non-oxidizing medium while being heated so that oxidation thereof will be prevented.

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In one form of apparatus according to my present invention for practicing the method above set forth, there is provided a supporting member which carries a plurality of articles in an endless path past an operating station at which a heating inductor is located, the inductor being connected to a suitable source of radio frequency energy. The supporting member is preferably driven intermittently to bring the successive articles momentarily at rest at the operating station. To conserve power, a suitable synchronizing mechanism may be provided for synchronizing the driving means for the article supporting member and the power source so that

power will be delivered thereby only during the periods when the article supporting member is at rest.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawing, in which

Figure 1 is a plan view, partly diagrammatic, of one form of apparatus according to my present invention,

Figure 2 is a sectional view thereof taken along the line II—II of Fig. 1,

Figure 3 is a side elevation of a surgical needle which may be treated in accordance with the present invention, and

Figure 4 is an enlarged sectional detail showing one way of mounting the needles in the apparatus of Fig. 1.

Referring more particularly to the drawing, wherein similar reference characters designate corresponding parts throughout, there is shown a supporting member 1 for supporting in spaced relation thereon a plurality of articles 3 which are to be hardened. In the illustrated embodiment, the supporting member 1 comprises a turntable mounted for rotation on a shaft 5 and provided with a plurality of radially extending bores or slots 7 for receiving the articles 3. During rotation of the turntable 1, it carries the articles 3 in an endless path past a plurality of operating stations A, B, C and D.

The articles 3 comprise relatively thin, elongated members in each of which the greatest cross-sectional dimension is small compared to the length thereof, so that the ratio of the surface area to the volume thereof is large. By way of illustration, I have shown the articles 3 as comprising steel surgical needles having a curved region 3a at the pointed end and a shank portion 3b. For mounting each needle 3 on the turntable 1, it may be placed in a holder 9 provided with a pair of cooperating spring clips 11 which firmly grip the shank 3b, the entire assembly being snugly received in a slot or opening 7. The holder 9 may be a copper sleeve for shielding the shank portion 3b, and particularly a thread receiving grooved portion 3c, against substantial heating and consequent hardening. The turntable 1 is driven by a motor 13 through any suitable type of intermittent driving mechanism 15 and gearing 17. The turntable is thus intermittently driven to alternately first advance the articles 3 one step and then to temporarily halt the turntable and needles 3 for a period of rest. A timing switch 19 of any suitable or approved form may be connected to the shaft 5 for operation therewith for a purpose shortly to be set forth.

As the turntable 1 is rotated to advance the needles or other articles 3 step by step, as above described, the needles or the like 3 are first advanced through the station A where any suitable form of guide 21 may be provided for lining up the articles with respect to a first heating device 23 located at the station B and a second heating device 25 located at the station C. The heating devices 23 and 25 are suitably formed inductor coupling elements shaped to embrace the article portions 3a within the magnetic fields set up thereby as a result of high frequency electric current supplied thereto by any suitable source of electrical energy 27, such as a vacuum tube, radio frequency generator. The magnetic field set up



by the coil 23 induces a current in the exposed portion 3a of each needle to heat the same to the requisite hardening temperature. A non-oxidizing gas, such as nitrogen, may be directed onto each article at the station B through a nozzle 29.

In order that the needle portion 3a may be heated to the requisite hardening temperature before there is any appreciable loss of heat therefrom, it is necessary to apply the radio frequency energy thereto at high power. To accomplish this, the oscillator may be operated at frequencies from about 30 megacycles per second to about 300 megacycles per second and should deliver power to the work at the rate of from about 50 kw. per cubic inch to about 500 kw. per cubic inch. I have found that for surgical needles of the type referred to which have a length of about ¾ inch and a shank diameter of about .025 inch, current supplied at a frequency of about 30 megacycles per second with a power input to the work of about 100 kw. per cubic inch suffices for this purpose. On the other hand, for knitting needles of the type used in weaving machines for knitting fabrics and having a length of about 1¾ inch, a shank diameter of about .025 inch and a thin beard at one end which has a diameter of about .008 inch, a frequency in the neighborhood of about 300 megacycles per second should be employed in order to provide the same heating effect per unit of surface area over the entire surface thereof and thus prevent overheating of the relatively thick shank before the beard has been heated to the proper hardening temperature. A tuning capacitor 31 may be connected across the inductor 23 for tuning the load on the oscillator to provide greatest efficiency. In any case, the needle portion 3a or other article to be hardened is heated so rapidly that it is brought substantially instantaneously to the requisite hardening temperature, each successive article 3 being heated instantaneously while at rest at the station B. The turntable is then advanced periodically to bring the articles out of the field of the inductor 23. Due to the large temperature gradient which is set up between the heated region 3a and the ambient, the heat developed in the portion 3a is quickly dissipated into the ambient to quench the work. The cool gas supplied through the nozzle 29 may also aid in the quenching. To conserve power, the timing switch 19 is connected to the oscillator 27 and synchronizes the oscillator with the rotation of the turntable 1 to turn the oscillator on only during periods of rest of the turntable. Thus, power is delivered by the oscillator 27 to the inductor 23 only when an article 3 is at rest at the station B.

In some cases, it may be desired to temper the hardened portion 3a. For this purpose, a second inductor 25 is provided at the station C. The oscillator 27 supplies energy to the inductor 25 similarly to the inductor 23, and a second capacitor 33 may be connected across the inductor 25 for tuning the load on the oscillator at the station C. In general, less power will have to be delivered to the work at the station C than at the station B. Here, again, the work is heated extremely rapidly and is quenched rapidly by the ambient due to the large temperature gradient that is set up practically instantaneously. The hardened articles 3 are eventually brought to the station D where they are unloaded and replaced by fresh articles. Thus, the operation of the apparatus is continuous.

From the foregoing description, it will undoubtedly be apparent to those skilled in the art

that I have provided a very simple, yet very effective way of hardening at least portions of articles of the type indicated above. Although I have shown but one form of apparatus capable of carrying out the present invention, it should be apparent that many other forms, as well as variations in the embodiment herein disclosed, are possible. Furthermore, while I have indicated certain preferred limits for the power input to the work and the frequency at which the generator 27 is operated, I do not intend these to be limiting, but rather illustrative, the important thing being that power is delivered to the work at such a high rate as to substantially instantaneously heat the work to the desired temperature and in a period of time insufficient to permit any great amount of heat developed in the work from being dissipated into the ambient while it is being heated. Also, while I have chosen, for purposes of illustration only, to describe my invention specifically with reference to a surgical needle, it should be understood that the present invention is applicable to the hardening of other articles wherein the ratio of surface area to volume is large. Accordingly, I desire that my invention shall not be limited except insofar as is made necessary by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. Apparatus for heat treating ferro-magnetic articles to alter the hardness thereof which comprises a turntable adapted to support a plurality of said articles thereon in radially extending, circumferentially-spaced relation with the end portions of said articles extending beyond the periphery of said turntable whereby to expose said portions for heat treatment thereof, said turntable being rotatably mounted for conveying said articles along a path which includes an operating station, an induction heating device at said station spaced radially from said turntable and disposed on the same level as said articles for receiving and heating said exposed article end portions when they are in the magnetic field provided by said device, means for intermittently moving said turntable to periodically alternately first advance said articles along said path and then bring said articles to rest in said path with the exposed end portion of at least one of said articles in cooperative relation with said heating device, a source of high frequency current coupled to said heating device, and means associated with said current source for controlling the supply of current by said source to said heating device, said last named means being synchronized with said turntable moving means to cause said current source to deliver current to said heating device substantially only during rest periods of said articles whereby to heat the exposed end portions of the articles successively at rest at said station.



2. Apparatus according to claim 1 characterized in that said turntable is provided with a plurality of radially extending slots for receiving said articles.

3. Apparatus according to claim 1 characterized in that said turntable is provided with a plurality of radially extending slots, and characterized further by the addition of means in each of said slots for holding one of said articles therein.

4. Apparatus according to claim 1 characterized in that said path includes a second station in advance of said first named station, and characterized further by the addition of means at said second station for arranging said articles successively in predetermined relation to said heating means.

RUDOLPH A. BIERWIRTH.


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## Certificate of Correction

Patent No. 2,470,285. May 17, 1949.

RUDOLPH A. BIERWIRTH

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 3, line 41, for "curyed" read *curved*; column 6, line 36, list of references cited, for the number "22,322" read *Re. 22,322*; line 45, for the patent number "2,320,572" read *2,320,573*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 25th day of October, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
*Assistant Commissioner of Patents.*

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[SEAL]

THOMAS F. MURPHY,
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