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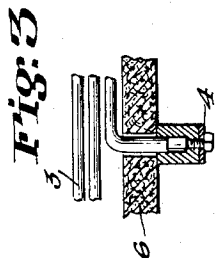
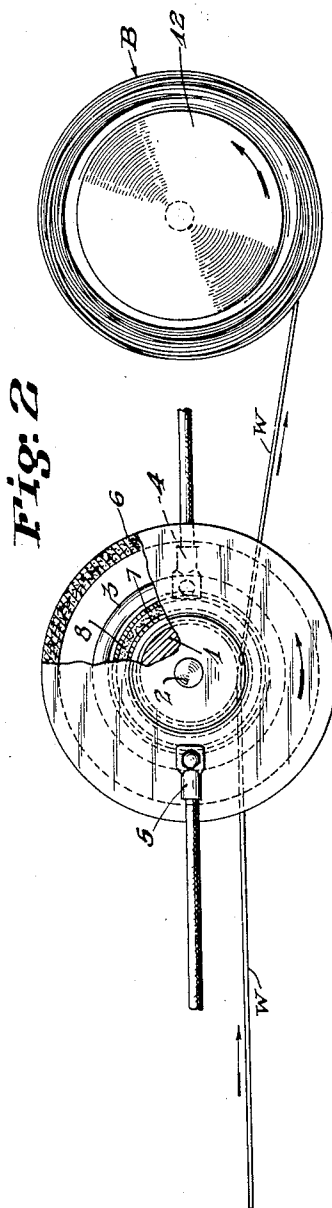
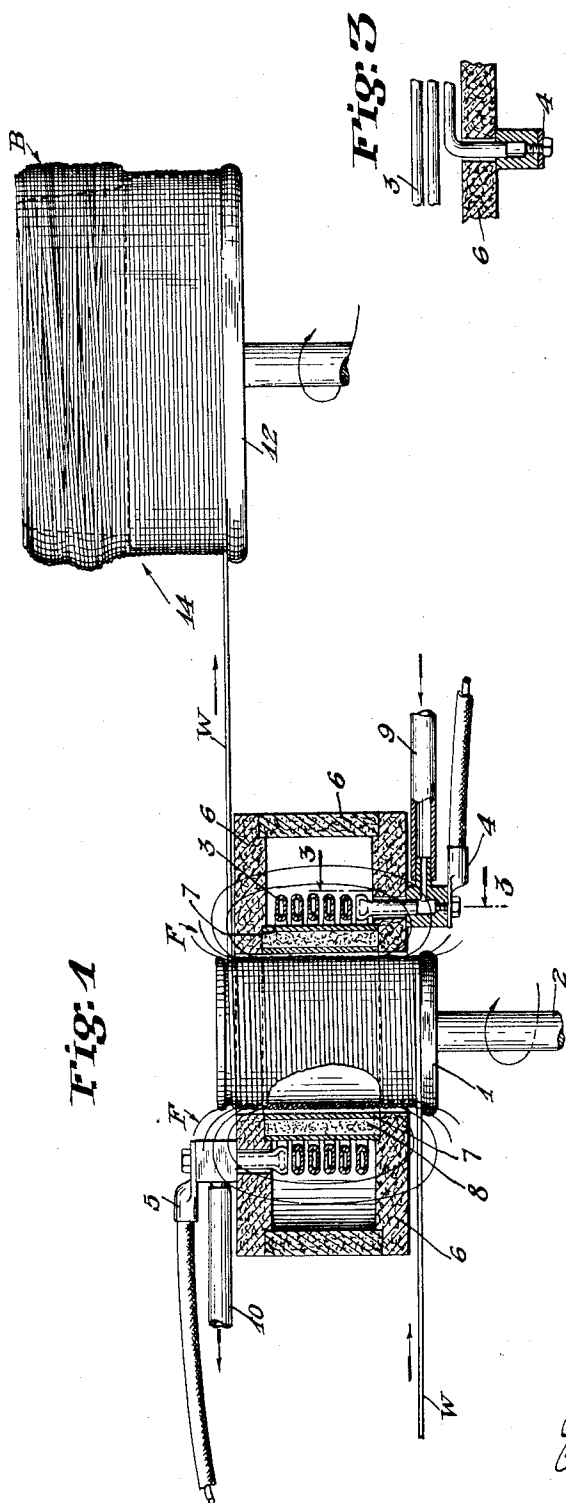
A. SIMONS ET AL

2,040,343

APPARATUS AND METHOD FOR HEAT TREATING WIRE

Filed May 17, 1935

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

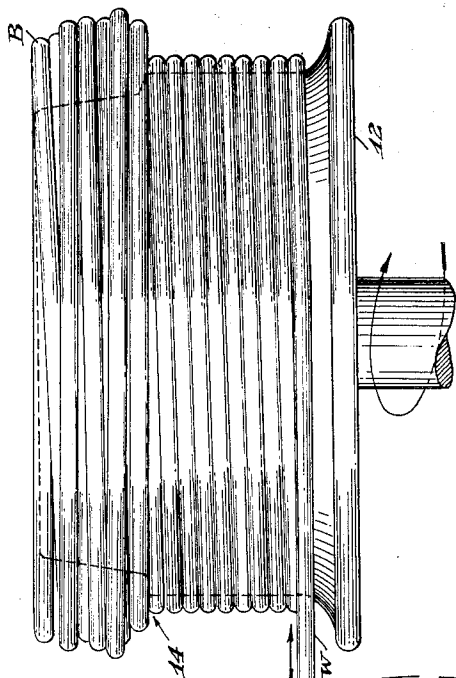


Fig. 4

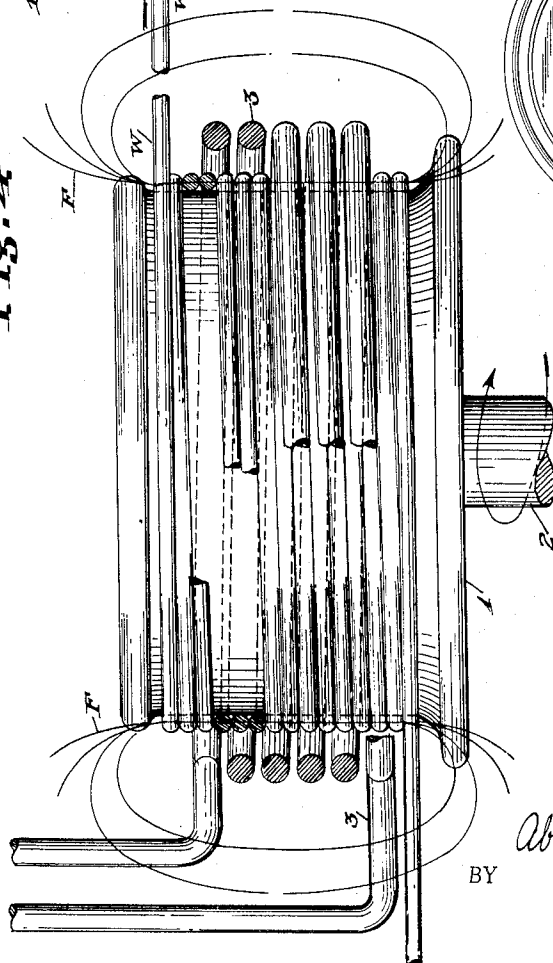
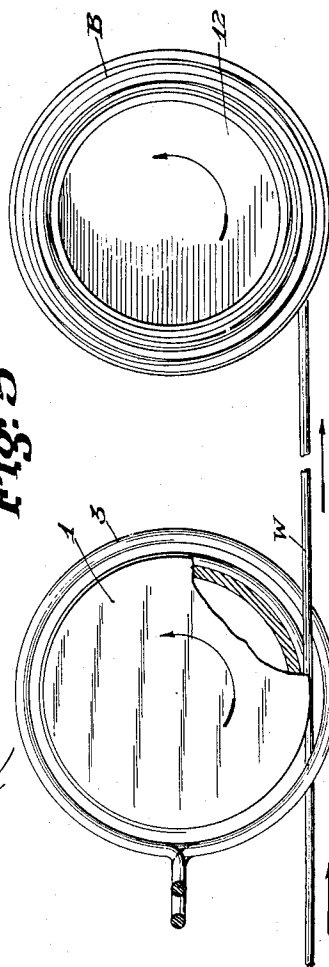


Fig. 5



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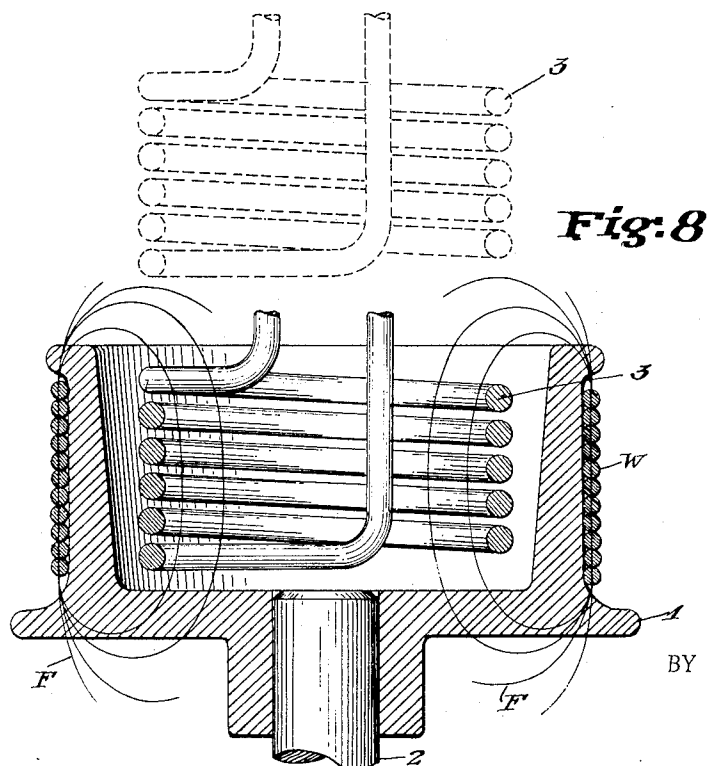
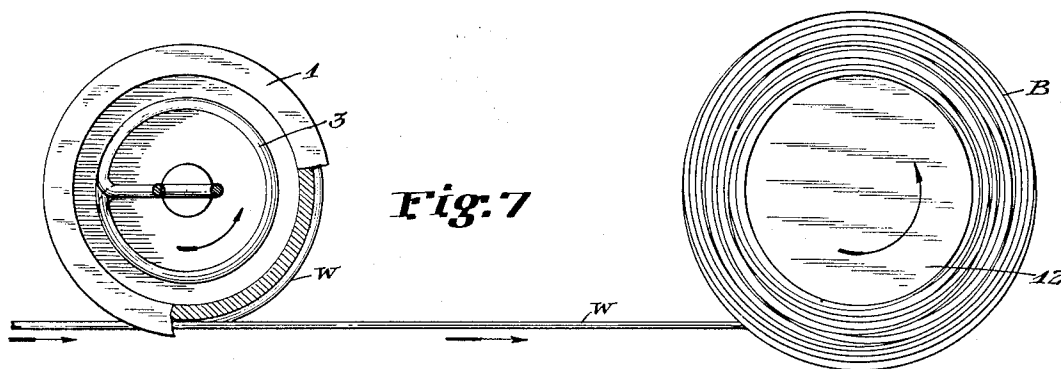
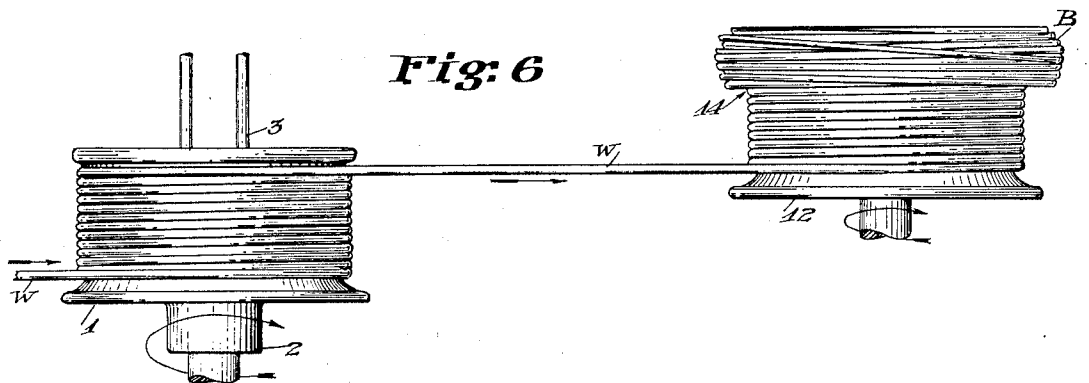
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APPARATUS AND METHOD FOR HEAT TREATING WIRE

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3 Sheets-Sheet 3



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2,040,343

APPARATUS AND METHOD FOR
HEAT-TREATING WIREAbraham Simons, New York, N. Y., and
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Application May 17, 1935, Serial No. 21,966

8 Claims. (Cl. 266—3)

Our invention relates to a new and improved method and a new and improved apparatus for annealing or heat-treating metal wire, strip or the like.

One of the objects of our invention is to anneal or heat-treat high-carbon steel, such as high-carbon steel wire. This high-carbon steel wire or material may be defined as a steel which has at least substantially 0.30% of carbon. However, the invention includes the treatment of low-carbon steel, and it also applies generally to the treatment of all other metals, alloys or the like, including copper and other non-ferrous metals and alloys.

Another object of our invention is to provide a method for annealing steel wire, in order to render such wire suitable for use in making springs, for making rubber tires, wire for making cables, wire for use in aeroplanes, and for numerous other purposes. The invention is particularly useful in treating wire which is to be used in making springs for the valves of internal combustion engines which are used in automobiles, etc.

Another object of our invention is to provide an efficient and reliable method for annealing or heat-treating the metallic material by means of heat which is generated internally in the material as distinguished from the surface application of heat.

Another object of our invention is to produce the heat, either in whole or in part, by subjecting the material to be treated to an alternating magnetic flux. The material to be treated is also heated, either in whole or in part, by producing an electric current such as an alternating current, or an eddy current or currents in said material.

Another object of our invention is to provide a continuous method which can be carried out rapidly, thus lowering the cost of manufacture.

Other objects of our invention will be set forth in the following description and drawings which illustrate a preferred embodiment thereof, it being understood that the above statement of the objects of our invention is intended to generally explain the same without limiting it in any manner.

Fig. 1 is an elevation, partially in section, which illustrates one form of apparatus which may be used for carrying out the improved method. It is to be understood that this illustration is diagrammatic.

Fig. 2 is a top plan view of Fig. 1.

Fig. 3 is a sectional view on the line 3—3 of Fig. 1.

Fig. 4 illustrates the essential parts of Fig. 1 in larger detail.

Fig. 5 is a top plan view of Fig. 4.

Fig. 6 is a view similar to Fig. 1, but showing a different embodiment in which the coil which produces the electro-magnetic field is located within the wire helix which is being treated.

Fig. 7 is a top plan view of Fig. 6.

Fig. 8 is a detail sectional view, illustrating in full lines and in dotted lines, how the primary coil may be raised or lowered, in order to vary the electro-magnetic field which is imposed upon the wire helix.

It has heretofore been well known to anneal metal wire, metal strip or the like, by inducing a secondary current in said metal wire or metal strip. Such methods have been slow and expensive and they did not produce the desired result.

According to my invention, I utilize an alternating magnetic flux for producing the desired heat, either in whole or in part. Likewise I may produce the desired heat, either in whole or in part, by inducing an alternating electric current, or an eddy current or currents, in said material.

Referring to Fig. 1, this shows a mandrel 1 which is mounted upon a shaft 2, so that the mandrel 1 turns in unison with the shaft 2. This mandrel is made of any suitable strong and refractory material such as porcelain or the like. This is a good non-conductor of both heat and electricity.

The wire or strip W is led from a suitable reel or other source to the revolving mandrel 1. The wire which is led to the revolving mandrel has preferably little or no inherent resilience or elasticity. This can be accomplished by suitably treating or dressing the wire before it is treated according to my method. Since such dressing methods are well known in the trade, they require no specific discussion. However, the wire or strip may have any desired resilience or spring before it is heated. Upon heating, the wire loses its resilience or spring.

As the wire is wound upon the revolving mandrel 1, a helix of wire is formed upon the mandrel 1, and the lowest turn of the wire may continually force the superposed coils of the helix upwardly. It is well-known to wind wire in helical form upon a mandrel, either a revolving mandrel or a stationary mandrel, and to maintain a helix of constant height upon the mandrel, by removing the wire from the mandrel, as fast as the wire is fed

to the mandrel. Hence machines of this type require no specific illustration.

In the particular embodiment illustrated, the turns of the wire helix are caused to move upwardly and in a direction parallel to the vertical axis of the mandrel 1. At the upper end of the mandrel, the wire is led off continuously.

As shown in Fig. 1, the mandrel may be provided with spaced upper and lower enlarged heads. The height of the helix is equal to the distance between the inner surface of said heads. Likewise we prefer to have the coils of the helix in conducting contact with each other so that the helix forms, in effect, a cylindrical metal shell upon the revolving mandrel 1.

It would not be departing from the invention if the coils of the helix were somewhat spaced from each other, upon the mandrel 1, but we prefer to have said coils contacting, so as to short-circuit the respective turns of the helix, thus forming, in effect, a metal cylinder.

We do not wish to be limited to any particular method or device, for short-circuiting all or some of the turns of the helix, within the zone of heating. For example, if the turns of the helix are spaced, said turns can be caused to contact with brushes or stationary vertical connectors or contact members, in order to short-circuit some or all of said turns. The mandrel can have a thin metal jacket, if desired, in order to short-circuit the turns.

In order to treat a high-carbon steel or other material, we prefer to supply the primary coil 3 with a high frequency alternating current.

While it is to be understood that all specific figures herein are stated by way of example and not for purposes of limitation, the primary current may have a frequency of between 5,000 cycles per second to 100,000 cycles per second. The frequency may be varied, depending upon the kind of material which is being treated, and the thickness of the wire or strip which is being treated.

Likewise we can use relatively low frequencies such as the ordinary commercial frequency of sixty cycles per second and we can use frequencies much higher than those specifically stated. For example, the primary coil 3 can be connected to the output circuit of a high frequency generator. This generator may be of any suitable type. For example, we may use the well known mercury-arc type of converter in which the ends of the primary coil 3 are connected to condensers, and the circuit of said condensers and of said primary coil includes a spark gap which is located in a closed chamber which contains mercury.

Said condensers can be supplied with a suitable high voltage, such as 1,000 volts or more. The discharge of the condensers through the gap produces an oscillatory damped discharge of high frequency.

However, the primary coil 3 may be connected to a high frequency alternator or to any suitable source of high frequency and high voltage continuous-wave current.

If the material which is being treated is permeable to magnetic flux, the alternating magnetic flux heats said material, due to the hysteresis effect. Since the respective turns of the helix are preferably in contact with each other, said helix forms a magnetic shell, in effect, so that the hysteresis produces a strong heating effect. Likewise the closed metal shell upon the mandrel has

an alternating secondary current induced therein, which increases the heating effect.

It will be noted that we prefer to have the number of turns in the wire helix much more numerous than the number of turns in the primary coil, but we do not wish to be limited to this feature, as the number of turns in the helix may be equal to, or less than, the number of turns in the primary coil.

However, if the turns of the helix are short-circuited, the alternating current which is induced in the helix does not have a voltage which is higher than the voltage which is impressed upon the primary coil. Hence a current of high heating effect can be induced, without inducing a secondary voltage which is too high. Ordinarily, the turns in the helix are more numerous than in the primary. If the turns of the helix were separated, a very high secondary voltage would be induced.

The alternating current which is induced in the wire helix, is essentially an eddy current and its direction is substantially parallel to the direction of the turns of the primary coil 3.

However, the height of the wire helix within the heating zone, and the number of turns therein, may be varied, depending upon the material. Likewise, the speed of movement of the wire through the heating zone may be varied, depending upon the kind of material which is being treated. For example, in treating copper wire or other non-ferrous material or alloy, a longer period of heating is required, because there is then no hysteresis effect.

We prefer to have the mandrel 1 of substantial height, so that it has an effective height of about six inches. This height may be varied and it may be made much greater than six inches. Without limiting ourselves to any specific thickness of wire, we can treat cylindrical wire having a diameter of about 0.10 inches. We have found it possible to treat high-carbon steel wire efficiently, if its thickness was about 0.020 inches, and the height of the helix was only about one-half inch. The diameter of the mandrel may be 18 inches, and this diameter can be varied.

The lower turns of the wire helix may grip the smooth surface of the mandrel 1, with a certain amount of frictional force. However, the heating effect may be so rapid as to cause the upper turns of the wire helix to expand under the heat so that said upper turns may fit loosely upon the solid mandrel 1, thus minimizing or eliminating friction. The wire of the helix may be subjected to tension upon the mandrel, if desired, but we prefer to exert little or no tension on the wire, while it is in the zone of heating.

The high-carbon steel wire may be heated to any final suitable temperature, as for example, to a temperature of between 1200° F. to 1500° F. The upper or end turns of this helix have such final desired temperature, and the lower or initial turns have a lower temperature.

The primary coil 3 is provided with heat insulation and electrical insulation between its inner surface and the wire helix. This may be of any suitable type. For example the primary coil may be located within a casing 6, made of any suitable material which is an insulator of heat and electricity.

The inner wall of said casing 6 may have spaced walls 7, made of quartz or other highly refractory material. The quartz walls 7 may be separated by a filling 8 which may be a non-conductor of both heat and electricity.

The casing 6 may be made of any suitable asbestos composition. The interior of the primary coil should be close as possible to the wire helix, so that very efficient insulation is desirable between the helix and the primary coil.

We prefer to cool the primary coil 3, and for this purpose, the turns of said coil 3 are made of copper pipe. Said copper pipe has an elliptical cross-section as shown in Fig. 1. The ends of said pipe may be cylindrical so that said ends can be inserted into couplings to which an inlet pipe 9 and an outlet pipe 10 can be connected.

Water or any other cooling liquid or gas or vapor can be forced through the hollow primary coil 3, by means of said pipes 9 and 10. The cooling system may be suitably insulated.

It will be noted that the enlarged heads of the mandrel 1 are substantially close to the ends of the heating chamber, so that there is little or no loss of heat in said heating chamber or zone. Any suitable means may be utilized for preventing the loss of heat from the heating zone.

After the wire W has been heated to the desired temperature, it may be quenched or handled in any other suitable manner. For example, said wire can be quenched and its temperature can be lowered to about 600° F.-700° F., by means of an oil bath, a bath of molten lead, or the like.

The wire or other material can be protected against oxidation during the heating and quenching thereof. For this purpose we can use an atmosphere of any suitable inert gas, such as carbon dioxide or the like.

After the wire has been fully treated, it may be wound upon a revolving reel 12. The wire which is collected upon the reel 12 forms an upwardly moving helix up to about the point 14 at which point the helix leaves the upper edge of the mandrel 12, thus forming a bundle B, which is collected in any suitable manner above the mandrel 12.

If desired, the incoming wire W may be mounted upon a suitable magazine reel. The take-up reel can be revolved, thus turning the mandrel 1 and drawing wire from the magazine reel. This method of operating the mandrel causes the wire to be subjected to some tension, while it is located upon the mandrel. This tension can be regulated by imposing suitable frictional resistance to turning of the magazine reel. However, and if desired, the magazine reel can be driven positively so that the wire is subjected to little or no tension while it is being heated, and subsequent to said heating.

Whenever we refer to the heat-treating or annealing in the claims, it is to be understood that we include the heat treatment or annealing of strips or bands of metal, or of metal in any continuous form.

While we have referred specifically to the treatment of steel wire, the invention generally also applies to wire made of other iron alloys, and to wire made of copper and other non-ferrous metals or alloys.

In treating steel wire, or wire which is made of an alloy which is subject to a hysteresis effect, a large portion of the heating effect results from the hysteresis when the wire is in the form of a shell having a substantially continuous outer wall, by reason of the fact that the respective turns of the wire are in conducting contact with each other.

The wire may be passed through the zone of heating quite rapidly. For example, in treating high-carbon steel wire, it may be heated in said

zone, to the necessary temperature, in about sixty seconds to ninety seconds, depending upon the thickness of the wire, and the kind of wire. The time of heating may be as low as six seconds, for fine high-carbon steel wire. The wire may be fed into and out of the zone at a speed of five feet per second, although this speed is variable. In treating wire made of copper or other non-ferrous material, the heating is caused by the induced current alone, and a longer period of heating is required. For this purpose, the closed helix in the zone of heating may be of a suitable height.

It is possible to utilize substantial electrical power.

If the wire is made of an iron alloy, the induced magnetic polarity of the metal shell is changed rapidly in the zone of heating, and the molecular movement which results, produces the desired internal heat. If we treat copper wire or the like, a high secondary current is induced, because I use a high voltage and the shell has very low electrical resistance.

By increasing the height of the closed metal shell upon the mandrel, the electrical resistance thereof can be lowered, so that a large alternating current can be induced in the helix.

By regulating the rate of movement of the material through the heating zone, said material can be raised to any desired temperature, while it is being moved continuously into and out of the heating zone.

We do not wish to be limited to the use of a revolving mandrel.

If desired, the turns of the helix can be subjected to any substantial pressure, in a direction parallel to the axis of the helix, in order to insure good conducting contact.

We prefer to insulate the wire which is being treated, from the ground and for this purpose the magazine reel and the take-up reel may be mounted on insulating supports and the wire can be held insulated from the ground during the treatment thereof.

Likewise, an intermittent electromagnetic field is to be considered as equivalent to an alternating magnetic field.

The apparatus described herein provides a convenient method for producing the desired high heating effect in the wire. Since the helix has a plurality of turns which contact with each other or which are electrically connected, the resistance of the wire is lowered in the zone of heating. In addition, and since the wire is held insulated from the ground, there is little or no leakage of current from the wire so that the heat-effect is concentrated in the desired zone.

While we prefer to induce a secondary current in the helix, as a convenient method of producing an electrical heating current in said helix, we do not wish to be limited to a heating current which is an induced alternating current.

Since the wire can be made quite thin, the conduction of heat from the heating zone to the wire which is not in the heating zone is too small to be a serious commercial disadvantage.

For certain purposes, the wire may be arranged in zig-zag and contacting turns, so as to provide a non-cylindrical shell. Said shell may be planar, or curved, and it may have any shape. Hence, whenever we refer to a shell in the claims, we do not wish to be limited to a cylindrical shell. Said shell may also be conical or frusto-conical.

In the embodiments shown in Figs. 6-8, the

primary coil 3 is located within a hollow mandrel. If desired, we could use two primary coils, one in the position shown in Fig. 8, and the other in the position shown in Fig. 1 and Fig. 4.

Fig. 8 illustrates, in dotted lines, how the primary coil may be raised or lowered in order to regulate the coupling between the primary coil and the wire helix which is located upon the mandrel 1.

By heating and quenching the wire, the wire is tempered before it is wound upon the take-reel, and this tempered wire can then be used for making springs, or for any other purpose.

Likewise, the invention applies to a heat treatment in which the wire is not quenched before it is wound upon the take-up reel. The quality of the wire which is wound upon the take-up reel depends upon the temperature of the quenching bath. If the quenching bath has a sufficiently low temperature, the wire is tempered. If the quenching bath has a somewhat higher temperature, as for example, when molten lead is used in the quenching bath, the wire can be worked again after it has been wound upon the take-up reel.

In drawing wire, the wire becomes hardened as it is worked, so that for some purposes it is necessary to heat the wire in order to reduce its hardness and to permit additional working. Hence the heat treatment specified herein can be utilized for a large variety of purposes, depending upon the particular need.

In working numerous non-ferrous alloys, the heat treatment and cold quenching softens the material, so that said material can be given additional working.

We have shown preferred embodiments of my invention, but it is clear that numerous changes and omissions can be made without departing from its spirit.

We claim:

1. A method of heat-treating metal wire which consists in subjecting a wire helix to the action of an alternating electro-magnetic field, while turning said helix about its own axis so as to wind wire off one end of said helix, and to feed wire to the other end of the helix.

2. A method of heat-treating metal wire which consists in subjecting a wire helix to the action of an alternating electro-magnetic field, while turning said helix about its own axis so as to wind wire off one end of said helix, and to feed wire to the other end of said helix, the respective coils of said helix being maintained in substantially conducting contact.

3. In the art of heat-treating metal wire, that step which consists in subjecting the wire to the action of an alternating electro-magnetic field, while said wire is in the form of a shell having a substantially continuous wall.

4. In the art of heat-treating high-carbon steel wire, that step which consists in subjecting the wire to the action of an alternating electro-magnetic field, while said wire is in the form of a shell having a substantially continuous wall.

5. Apparatus for heat-treating wire comprising a revolving mandrel, means adapted to feed wire to one end of said mandrel and to take wire off the other end of said mandrel so that a wire helix is continuously maintained upon said mandrel, and a primary coil associated with said mandrel, so that said primary coil can send an alternating electro-magnetic flux through said helix.

6. A method of heat-treating metal wire which consists in subjecting a wire helix to the action of an alternating electro-magnetic field which is induced by a primary coil, while turning said helix about its own axis so as to wind wire off one end of the helix, and to feed wire to the other end of the helix, and regulating the coupling between said primary coil and the helix, by changing the relative position between said coil and said helix.

7. A method of heat-treating metal wire which consists in forming part of said wire into the form of a helix, which is intermediate the ends of the wire, while moving the wire so as to feed the same into said helix and also out of said helix, heating said helix by passing an electric current through the same, while causing a rapid heat-exchange between the turns of said helix so that the temperature of the wire of said helix is higher than the temperature of the wire which is anterior to said helix.

8. A method of heat-treating metal wire which consists in forming part of said wire into the form of a helix, which is intermediate the ends of the wire, while moving the wire so as to feed the same into said helix and also out of said helix, heating said helix by passing an electric current through the same, the turns of said helix being maintained in substantial contact with each other so that the temperature of the wire in the helix is maintained higher than the temperature of the wire anterior to said helix.

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