Oct. 27, 1942. W. H. WOOD ET AL 2,300,329

METHOD OF HEAT TREATING STEEL WIRE AND APPARATUS THEREFOR

Filed Feb. 18, 1938 4 Sheets-Sheet 1

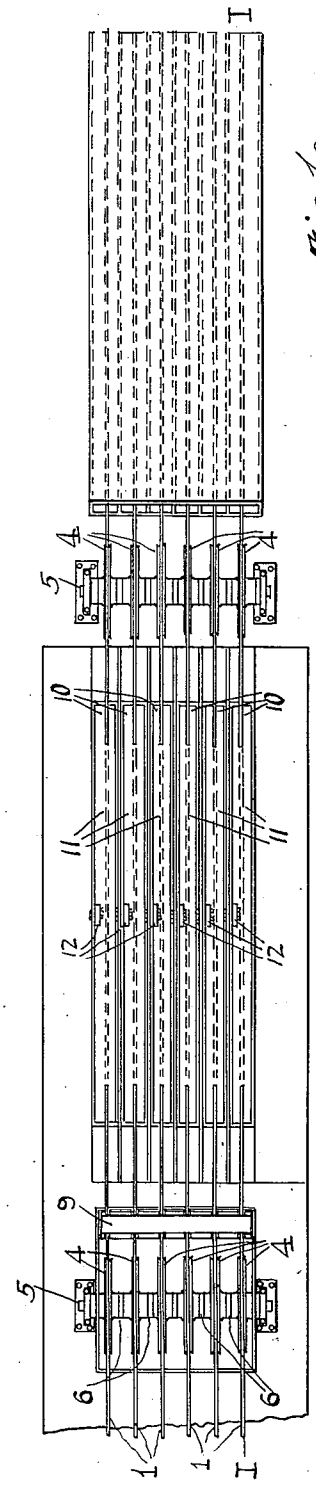


Fig. 1a

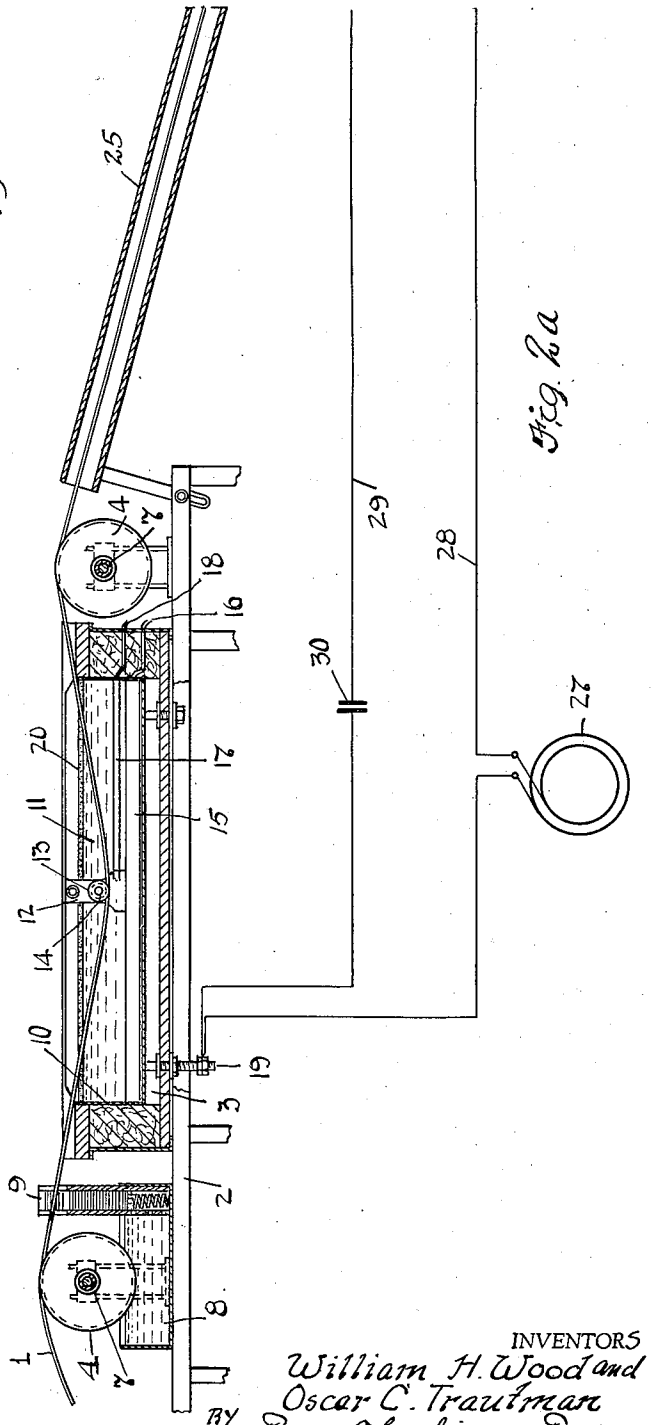


Fig. 2a

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Filed Feb. 18, 1938 4 Sheets-Sheet 2

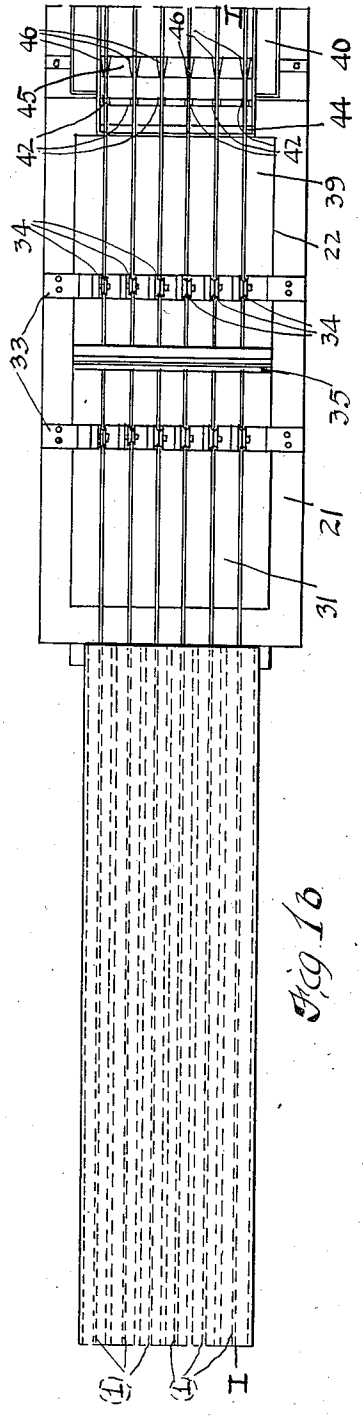


Fig. 1a

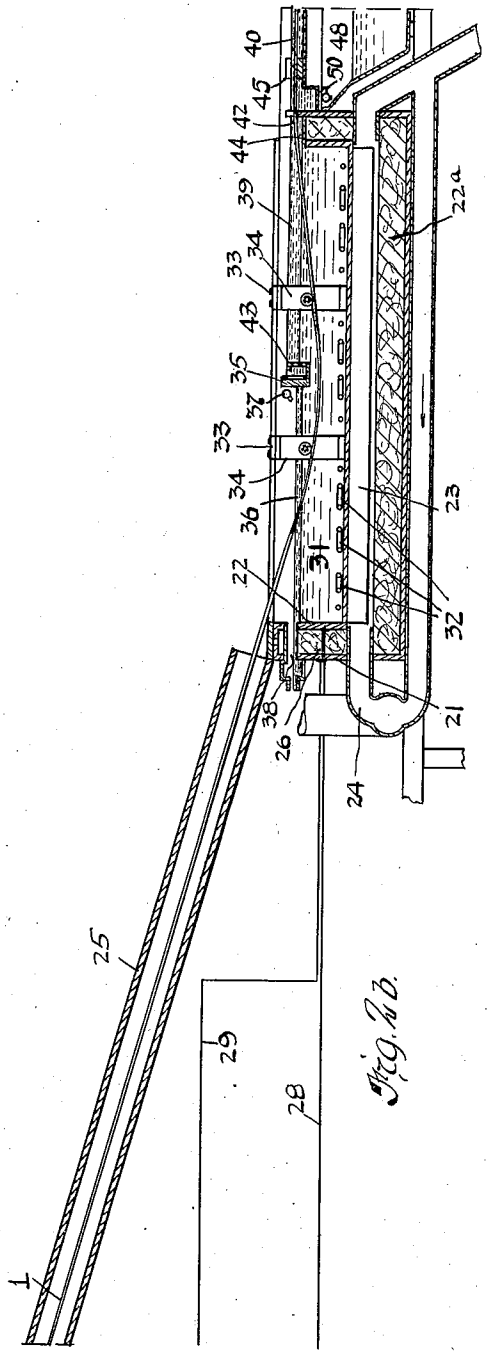


Fig. 1b

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METHOD OF HEAT TREATING STEEL WIRE AND APPARATUS THEREFOR

Filed Feb. 18, 1938 4 Sheets-Sheet 3

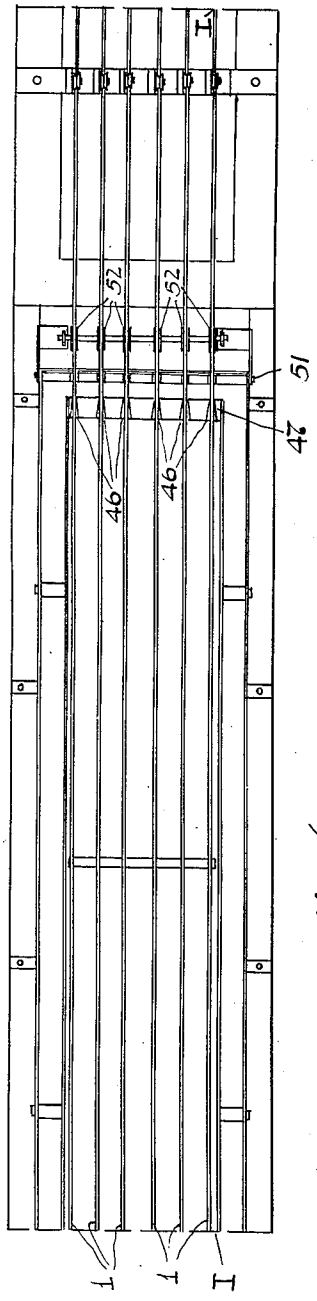


Fig. 1C

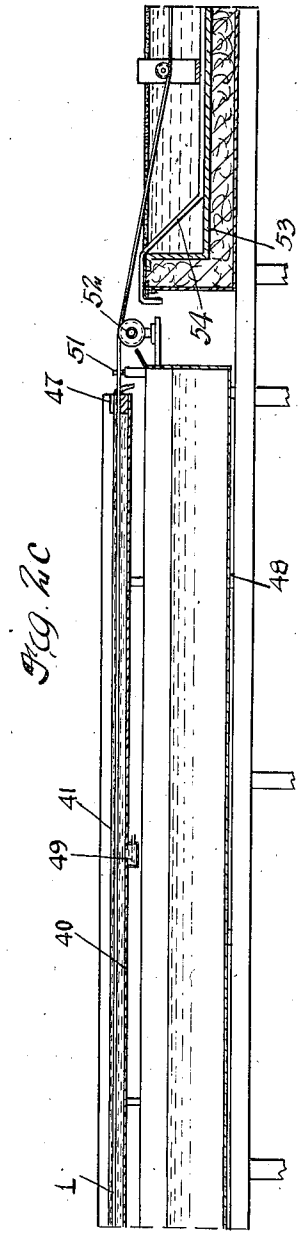


Fig. 1C

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METHOD OF HEAT TREATING STEEL WIRE AND APPARATUS THEREFOR

Filed Feb. 18, 1938 4 Sheets-Sheet 4

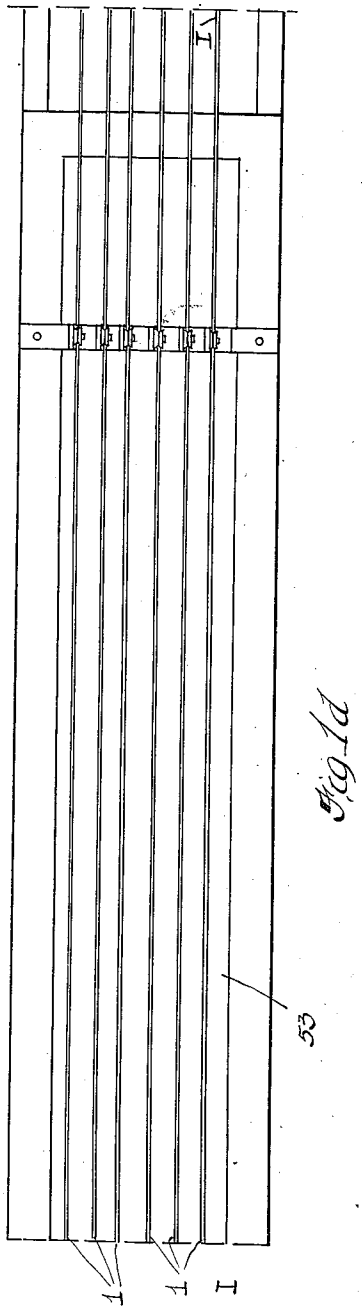


Fig. 1d

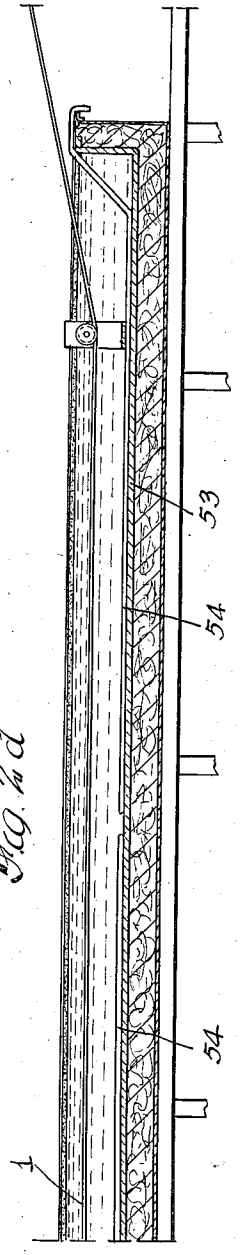


Fig. 2d

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2,300,329

UNITED STATES PATENT OFFICE

2,300,329

METHOD OF HEAT TREATING STEEL WIRE AND APPARATUS THEREFOR

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Application February 18, 1938, Serial No. 191,292

9 Claims. (Cl. 148—10)

Our invention relates to apparatus for and method of heat treating steel in the form of wire and the like, in continuous operation. In the heat treatment of steel in continuous operation as practiced by the usual methods, the heating is effected by passing the material through a heating furnace which is preferably gas fired. Many objectionable features attend this method. The surface of the wire becomes decarburized in spots, the heating is accomplished at a slower rate than is desirable, and it is necessary to heat the material to a substantially higher temperature than that at which it is desired to quench for hardening. Others have recognized these disadvantages and have sought to heat the material under treatment by its resistance to the passage of an electric current therethrough. For fifty years such attempts have been made, but none of the methods have gone into use, and the devices of these earlier attempts have made no impression on the practices of the industry.

The object of our invention is to provide apparatus and method whereby in continuous operation steel wire and the like is heated by its electrical resistance to a temperature at which its iron content assumes the gamma form, and is then rapidly partially quenched from its maximum temperature to a desired controlled temperature, from which it may be further treated or allowed to cool to atmospheric temperature.

A further object is to provide apparatus and method whereby the material thus partially quenched to a controlled temperature is immediately in continuous operation further quenched to atmospheric temperature under controlled conditions which impart to the steel the qualities demanded in spring steel.

A further object is to provide apparatus and method whereby the said material, partially quenched to a controlled temperature, is immediately reheated by its electrical resistance and held in a desired temperature range whereby the steel is given the qualities desired in wire which is to be further reduced by drawing.

And a further object is to provide apparatus and method whereby material is heated by its electrical resistance, is partially quenched to a controlled temperature in the molten metal of an advance electrode, and is held at such temperature for a controlled period of time, whereby a heat treatment practically identical with that known as patenting is given the material, but with decidedly marked increase in those qualities desired in a wire which is to be reduced by drawing.

Other objects of our invention will appear from the description hereinafter given and include apparatus and method whereby we can combine in continuous operation with said heating and quenching steps such treatments as tempering the spring steel wire, or such as pickling, coating, etc., of the patented wire in preparation for the draw.

In addition to avoiding the disadvantages of furnace heating hereinabove set forth, we have in our new method distinct advantages which will be readily recognized. The equipment for the practice thereof is cheaper and is not subject to depreciation in use except in the slightest degree. Such equipment is ideally adapted for combination with that which is required to give the heat treated wire further processing in preparation for any particular use. The heating of the wire is so rapid, being at a uniform rate throughout any cross-section, and the wire is at a high temperature so short a time that little or no scale is formed. Such as may be formed we have removed by an 8 to 10 second dip in a 5% acid solution which was given in continuous operation and followed in continuous operation by a reheating of the wire to about 400° F. by electrical resistance, whereby the occluded hydrogen was driven off. The wire during heating may be easily enclosed for the conservation of heat or for the use of any special atmosphere which may be desired.

This application is a continuation of our copending application Serial No. 132,580, filed March 23, 1937, now Patent No. 2,224,998, issued December 17, 1940.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means and steps hereinafter fully described and particularly pointed out in the claims; the annexed drawings and the following description setting forth in detail certain means and modes of carrying out the invention, such disclosed means and modes merely illustrating various ways in which the principle of the invention may be used.

It is believed that our explanations of method will be more readily understood if the apparatus which we have invented for the practice of said method is first described. This apparatus is shown diagrammatically in the drawings, in which Figs. 1*a*, 1*b*, 1*c* and 1*d* combined show a plan view of our apparatus as used to heat-treat wire for use in springs; Figs. 2*a*, 2*b*, 2*c*

and 2d combined show an elevational view of the same in cross-section on line I—I.

The embodiment of our novel apparatus shown in the drawings has proven highly efficient in operation. It is designed to handle a maximum of six wires at a time. The wires 1 being treated are each drawn through the apparatus from left to right by constant speed reels of standard type, which reels are not shown. The wires are supplied to the machine from feed reels of the usual type which are not shown, but preferably will be of capacity such that each will hold a day's run of wire in a single continuous strand.

On a suitable frame 2 a contact pot 3 is mounted at a slight elevation. At either end of said pot is positioned a set of sheave wheels 4 mounted on a common bearing shaft 5, said wheels being insulated from each other and from said shaft by spacers 6 and bushings 7. Beneath the set of sheave wheels over which the wires first pass in entering the machine is a pan 8 of oil so positioned that the peripheries of the wheels 4 will touch the oil and, on revolving, will carry it upward and coat the wires passing thereover. Between said set of sheave wheels and the said contact pot a wire wiper 9 of felt is so placed that the said wires are drawn therethrough before they enter said contact pot 3.

The sides, ends and bottom of said contact pot 3 are heat insulated and are of di-electric material. Within said pot 3 are nested long narrow metallic troughs 10, of which there is one for each wire to be treated, and each of which is substantially filled with a metal or alloy 11 of low melting point. These troughs are electrically insulated from each other and each has mounted on one side at the mid-point a wire sinker 12, which is electrically insulated from the supporting side of the trough. These sinkers 12 each comprise a depending arm 13 of flat heat-resisting material, having a small roller 14 rotatably mounted on one face thereof, so positioned and mounted that it will rotate, below the surface of the molten alloy, and in a plane parallel to that of the flat arm.

In the bottom of each trough 10 is mounted an electric heating element 15 to which current is supplied from a source of electricity (not shown) by means of the lead wires 16 mounted through the end wall of the pot 3. Also mounted in each trough 10 is a thermostatic bulb protective tube 17, in which a thermostatic bulb is placed which, through the lead 18, mounted through the wall of pot 3, controls the supply of heating current to the lead wires 16 connected with the heating element by devices and connections well understood in the art.

Mounted through the bottom of the pot 3 and in electrical connection with the alloy 11 in the troughs 10 are electrical connector studs 19, of which there is at least one for each trough 10.

A layer of fine granular carbon 20 over the surface of the alloy 11 protects it from oxidation when molten.

In spaced longitudinal relation with the contact pot 3 is a quenching pot 21 containing molten metal, but at a lower elevation. Said quenching pot 21 comprises a single container 22 formed of metal which is electrically insulated, and also protected by heavy heat insulation 22a. Copper cooling fins 23, mounted longitudinally on the bottom of the metal container 22 extend into a passage 24 through which cooling air is circulated for the control of temperature in said container 22.

Mounted between the said contact pot 3 and said quenching pot 21 with an end supported by each is a long open ended box 25 formed of di-electric material having a low value as a conductor of heat, which box is divided by partitions into separate closures for the passage of the several wires. Said box 25 conserves heat but is also most useful when a wire breaks, as it prevents the end of the broken wire from contacting the other wires in the heating zone.

For convenience in varying the length of the heating space between the contact pot 3 and the quench pot 21, these may preferably be so mounted as to be longitudinally adjustable. When said heating space is shortened, the box 25 will be omitted or a shorter one substituted.

An electrical connector 26 mounted through the wall of the pot 21 makes electrical contact with the metal container 22. A suitable source 27 of electric heating current is connected in series between the said connector 26 and the said studs 19, in a circuit 28 which is completed through the medium of the molten metal in said pots 3 and 21 and the wires 1 being heated therebetween.

Other circuits 29 connect the said connector 26 with each of the contact plugs 19 and in each of these circuits is a condenser 30 which provides a by-pass for potentials of E. M. F. which without such path would cause an arc between the molten metal of the bath and the wire drawn therefrom. In the embodiment shown such condensers are of the paper wound type and are of 10 micro-farad capacity.

In the quench pot 21 is a bath 31 of molten solder. In the embodiment shown we have used eutectic PbSn. This solder is maintained at the desired temperature of quench by electrical heating units 32 submerged therein, which are controlled in a manner well understood in the art and which in combination with the cooling effect of the fins 23, exposed as explained to the air driven through the passage 24, maintain the temperature of the molten solder within a narrow range.

A pair of spaced bars 33 mounted transversely of the quenching pot 21 each support a plurality of sinkers 34, one being provided on each bar for each wire to be treated. These sinkers 34 are similar in construction to the sinkers 12 used in the contact troughs 10. Provision may be made for moving these bars longitudinally of the pot, whereby it is possible to modify the time interval wires will stay in the quench of molten metal when running at a particular speed.

The surface of the molten solder bath 28 is protected from oxidation by a covering of oil which covering is divided into two sections by a dam 35 positioned in the surface of the solder midway the pot 21 and between the two sets of sinkers 34. On the surface of the solder at that end of the pot 21 in which the wires 1 enter we maintain a thin covering of tempering oil 36, which is supplied by nozzles 37 positioned near the dam 35 and escapes through an outlet 38 in the end wall of the pot 21. This oil is circulated through tubing and a pump which are not shown but are connected with said outlet 38 and nozzle 37 in a conventional manner. On the other section of the bath surface we maintain a substantial thickness of quenching oil 39 which oil has purposes other than protecting the bath surface and is continuous with the body of oil in an oil quench pan 40 with which it will be next described.

Positioned adjacent the discharge end of said quench pot 21 and in longitudinal relation therewith is an oil quench pan 40 containing a quenching oil 41. Through the wall of the quench pot 21 at the discharge end above the molten solder are a plurality of apertures 42 affording access to the adjacent pan 40, one being provided for the passage of each wire 1. The quenching oil 41 flows through said apertures 42 onto the surface of the molten solder bath 31 to an over-flow trough 43 adjacent the dam 35. Near the apertures 42 and within the quench pot 21 a small roller 44 is so mounted that the wires 1 passing thereover are guided centrally through the apertures 42. Placed within the quench pan 40 near said apertures 42 is a dam 45 over which the quenching oil 41 flows to and through said apertures 42 onto the molten solder bath 31. The top of said dam 45 has tapered grooves 46 through which the oil 41 flows and which are so positioned that the wires 1 pass therethrough as they are drawn from the apertures 42. Similarly the quench oil 41 overflows a second similar dam 47 at the discharge end of the quench pan 40. The oil so overflowing and the oil from the overflow 43 is collected in a reservoir 48 positioned below the pan 40, and after cooling is returned to the pan 40 by the inlet 49 midway of the pan 40. The connections for this circulating, and the cooling and pumping means are conventional and are not shown. A valved sump 50, positioned adjacent the quench pot 21, in the pan 40, permits by-passing oil instead of flowing it through the apertures 42 to the over-flow trough 43. This valved sump 50 discharges direct to the reservoir 48.

An oil wiper 51 is positioned adjacent the discharge end of the pan 40 and rollers 52 are provided over which the wires are guided into a temper pot 53 as they are drawn from the oil 41 and through the wiper 51. The temper pot 53 is conventional and is heated by electric heating elements 54 in a conventional manner.

It will be understood that standard reels taking up a constant speed are placed beyond the temper pot 53 which reels draw the several wires 1 through the several sections of the described apparatus.

The several parts of our apparatus have been described in the relation in which they are used in heat-treating steel wire for springs according to our new method which will now be described.

New method of heat treatment

The essential steps, used in all applications of our method of heat-treating steel in the form of wires and the like, however said method may be modified to secure a particular desired final result, are the following: (1) the wire under treatment is heated by its resistance to the flow therethrough of an electric current supplied thereto by two spaced electrodes with which it maintains contact as it is advanced at constant speed, the more advanced of said two electrodes consisting of a vessel of molten metal or alloy, and (2) the wire thus heated is quenched at the moment it attains its highest temperature by plunging into the molten metal of said advance electrode, which metal is maintained at a temperature such as will reduce the temperature of the treated wire quickly to a temperature within a desired narrow range.

It is obvious that the speed of wire travel, distance between electrodes, or strength of current may be so modified that the wire will be heated to any desired temperature as it is quenched in the molten metal of the advance electrode. In general, it may be said that it is desirable to so proportion these factors that the wire will attain the desired temperature at the greatest speed consistent with the limitations of steps following in the continuous operation. In practice, this heating will be at a speed such that the wire will have no decarburized surface spots even when unprotected by special atmospheres.

It is our belief that the superior qualities of steel wire heat-treated by our method, whether for drawing, use in springs, or other purpose is to be attributed in large measure to said described initial steps. In particular, wire heated by our method is much more satisfactory in respect to grain structure than that which results from conventional heating, since the uniform heating from the inside and the limited exposure to high temperature results in a product showing little evidence of grain growth.

The oil left on the wires 1 by the wiper 9 will present a surface to which the metal of the molten alloy bath will not adhere. Also the oil 36 on the molten metal of the quench pot 21 will form a thin coat of burnt oil on the hot wires as they enter, which will prevent molten metal from adhering to the wires as they are advanced through the pot. The method of using such oil coatings is the subject matter of our co-pending application No. 320,774, filed February 26, 1940.

Heat treatment of spring steel

In heat treating steel wires by our method, and using our disclosed apparatus, to secure the qualities desired in springs, we advance the wires 1 through the molten alloy contained in contact troughs 10 and to and through the molten alloy in the quench pot 21, while maintaining a desired difference of electrical potential between the alloy of said troughs and the alloy of said pot by means of a suitable source 27 of E. M. F. in the circuit 28. The factors of length of span, speed of travel and strength of current will be so adjusted that the wires will enter the molten alloy in the quench pot at a temperature at which the iron content of the steel will be in the form of gamma iron dissolving all the carbon. In practice, this temperature will be kept slightly above the critical temperature or in the case of commercial steels of ordinary analysis the wires will be quenched when at a temperature of approximately 1475° F.

The insulation of the sinker arms 12 from the metal walls of the troughs 10 will prevent arcing which otherwise would result from currents travelling through the metal walls and through the sinker arms to the rollers 13 which for permanence are made of hard metallic alloy. Likewise the condensers 30 in the circuits 29 connecting the studs 19, which make electrical connection with the troughs 10, and the connector 26, 26, which makes electrical contact with the quench pot 21, provide paths for the escape of high potentials which in the pot or the troughs would otherwise arc from the surface of the metal alloy to the surface of the wire, pitting same.

In the quench pot 21 the alloy is maintained at such a temperature that the wire temperature is dropped in a second or two to a range below those temperatures at which the carbon on transformation will assume pearlite forms, but the temperature of the wire is held by said alloy bath at a temperature above that of rapid

martensite formation. In the case of ordinary commercial steel wire the temperature of the quench bath will be in the neighborhood of 425° F.

The wire, which has been thus cooled in said quench pot **21**, is drawn from the bath after it has remained therein a few seconds and is further cooled. This further cooling is preferably done by drawing the wire from the alloy through an overlying body of quenching oil, which oil will be heated by the alloy beneath it. The wires are drawn from said quench pot and through said oil, keeping them at all times beneath the surface of such oil, into a body of quenching oil in the quench pan **40**. When the temperature of the wires has been reduced to substantially atmospheric temperatures the wire is withdrawn from the pan and heated in a conventional lead pot for tempering.

The secondary quench in oil has been found to be very critical, but by our method it may be easily controlled and maintained under constant conditions. The conditions required to give to a particular steel certain definite qualities having been established, the operation can be set for those conditions and continued indefinitely with little or no attention.

As an example, we have heat treated by our method using the described apparatus, Swedish steel wire of No. 10½ gauge (.1275 in.) having the following analysis: C—0.65–0.70, Mn—0.45–0.50, Si—0.16–0.21, S—0.020 maximum, and P—0.025 maximum. This wire was heated as described to about 1475° F. which temperature we maintained by modifications of the strength of the heating current, made automatically by a photo-electric cell unit responsive to the image of the heated wire, as is well understood in the art. The alloy of the quench bath was maintained at substantially 425° F. and the travelling wires were kept therewithin about 4 seconds. From this alloy they were drawn through quench oil as hereinabove described, which quench oil had a flash point of 455° F. and a fire point of 510° F. This oil in the portion overlying the alloy attained substantially the temperature thereof. At the end of twenty (20) seconds the wires were drawn from the oil quench at a temperature of about 125° F. and were passed through a temper pot **53** of lead maintained at approximately 900° F. in which they were retained for about 18 seconds for tempering.

Such wire so treated developed the following physical characteristics: Elastic limit (Johnson's) 214,000 lbs.; yield point (.2% method), 222,000 lbs.; tensile strength (p. s. i.) 234,000 lbs.; percentum elongation in 2 inches, 9; percentum reduction in area 60; hardness, Rockwell C, 45–47.

As another example commercial steel wire of No. 13 gauge (diameter 0.091 inch) was heat treated by conventional methods and by our method and the results compared. This steel had the following analysis: C—0.63, Mn—1.01, Si—0.19, P—0.017, and S—0.022. A bundle was divided and part No. 1 was heated conventionally in a furnace to a temperature of 1500° F., quenched in oil and temper drawn in a lead bath at 800° F. Part No. 2, heat treated by our method and apparatus, was heated to 1475° F. as it entered the alloy quench pot which was maintained at approximately 425° F. In three seconds it was drawn from the alloy quench at a temperature of approximately 425° F. and was further quenched in oil as hereinabove described, after which it was temper drawn in a lead pot at 800° F. The physical properties of the two parts so treated checked as follows:

	No. 1	No. 2
Tensile strength (lbs.) p.s.i.	248,000	248,000
Elastic limit (Johnson's) p.s.i.	203,000	229,000
Elongation (percent in 10 in.)	3.4	3.1
Elongation (percent in 2 in.)	6.3	5.2
Reduction in area (percent)	53.0	54.8
Torsion (No. twists in 10 in.)	16.0	25.0
Hardness (Rockwell C)	47.0	48.0

Heat treatment of wire for drawing qualities

Using our method of heat treating we have given wire of Swedish steel of the analysis and gauge of the specimen first above referred to, a novel heat treatment which produced in said wire the characteristics desired for reduction by drawing.

In said novel treatment we heated the advancing wires between the contact troughs **10** and the quench pot **21** as hereinabove described until it attained a temperature of approximately 1475° F. as it entered the molten alloy of the quench pot which was maintained at a temperature of 500° F. When the temperature of the wires was reduced to the temperature of the quenching alloy they were withdrawn from the said alloy and advanced direct to the lead pot **53** which was maintained at a temperature of 850° F. Between the quench pot **21** and the lead pot **53** we re-heated the wires to a temperature of 850° F. as they entered the lead pot **53** by passing a suitable heating current through said wires which current was supplied thereto through the medium of the molten metals in said pots **21** and **53**. The wires were kept within the molten metal of the pot **53** about 18 seconds after which they were withdrawn and air cooled to atmospheric temperature.

Said wires after being heated as described showed a structure in which very fine constituents were homogeneously arranged, and developed the following physical qualities which will be recognized as excellent for reduction by drawing: tensile strength (p. s. i.) 170,000 lbs.; percentum of elongation in 2 inches, 11; percentum reduction in area 70; and Rockwell C 34–36.

It will be noted, that in using our apparatus for thus heat treating, the wires are not quenched in the oil bath **40**, but are by-passed and reheated at once by a current supplied through the molten metals of the quench pot **21** and the lead pot **53**.

Our novel method of heat treating and described apparatus may be used instead of the process known as patenting, which is the conventional treatment given steel wire to prepare it for reduction by drawing. This patenting is secured by heating the wires as already explained until above the critical temperature for the particular steel. The molten metal of the quench pot is maintained at about 950° F. and the wires after quenching are maintained at said temperature of 950° F. for a substantial period before air cooling.

Using our described apparatus as taught in our co-pending application No. 252,954 filed Jan. 26, 1939 we have heat treated half of a bundle of commercial steel wire by heating to 1650° F. by electrical resistance as the wire advanced from the contact troughs **10** to the lead pot **53**. The molten metal in said lead pot was maintained at

a temperature of 975° F. and the wire was kept therewithin until quenched to said temperature. From the contact troughs 10 the wire was advanced directly into the lead pot 53, through passages insulated for the conservation of heat. The wire was retained within the lead pot 53 which was maintained at 975° F. for about 18 seconds, and was then air cooled.

Said wire, so treated, presented a structure resembling that of wire patented by the conventional methods, but having a much finer grain, and had the following physical properties; elastic limit 84,000 lbs.; yield point 105,200; tensile strength, p. s. i., 158,000 lbs; percentum of elongation 11.5; percentum reduction, 62; and Rockwell C 26–28.

This wire patented by our described method was drawn down from 0.0915" to 0.0175" using the following practice: 0.0915" diameter in 6 drafts to 0.0315" diameter. The wire was then copper coated and drawn in 7 drafts through continuous machines to 0.0175" diameter. The physical properties of this wire after thus drawing were as follows: 1st end—tensile strength p. s. i. 354,000 lbs. and torsions in 8 inches 101–108; last end—tensile strength p. s. i. 350,000 lbs., and torsions in 8 inches 105–106.

Another half of the same bundle of wire was patented by conventional methods. In contrast with the similar wire which had been treated by our method, the physical properties of this wire were as follows: elastic limit 68,400 lbs.; yield point 89,100 lbs.; tensile strength p. s. i. 146,500 lbs.; percentum elongation 9; percentum reduction 29.2; and Rockwell C 31–34.

Other means and modes of applying the principle of our invention may be employed instead of those explained, change being made as regards the method and means herein disclosed, provided the step or steps stated by any of the following method claims or the equivalent thereof be employed, or provided that the means of any of the following apparatus claims or their equivalents be employed.

We, therefore, particularly point out and distinctly claim as our invention:

1. In a method of heat treating steel, in the form of wire and the like, the steps of advancing such material longitudinally at a uniform speed into and through a contact pot containing an electrically conductive liquid and into and through a quenching bath of molten metal in spaced relation therewith; controlling the temperature of the quenching bath within a desired range; maintaining the material in such quench bath until it attains the temperature thereof; and passing through the section of advancing material, defined between the surface of such quench bath and the surface of the liquid in such contact pot, a current of electricity such as will heat the advancing material progressively to a desired maximum temperature as it enters such quenching bath, such current being supplied thereto through the medium of the molten metal of such quench bath and through the liquid of such contact pot.

2. In a method of heat treating steel, in the form of wire and the like, the steps of advancing such material longitudinally at a uniform speed into and through a contact pot containing molten metal and into and through a quenching bath of molten metal in spaced relation therewith; controlling the temperature of the quenching bath within a desired range; maintaining the material in such quench bath until it attains the temperature thereof; and passing through the section of advancing material, defined between the surface of such quench bath and the surface of the molten metal in such contact pot, a current of electricity such as will heat the advancing material progressively to a desired maximum temperature as it enters such quenching bath, such current being supplied thereto through the medium of the molten metal of such quench bath and through the molten metal of such contact pot.

3. In a method of heat treating steel, in the form of wire and the like, wherein an advancing wire is heated to austenitic condition by its resistance to the passage of an electric current and quenched in a bath of molten metal to a temperature below that of pearlite formation and above that of rapid martensite formation, the step of drawing the wire from the molten metal quench directly into an oil bath, through a portion of such oil bath in overlaying relation with a portion of such metal bath, whereby a secondary quench at a slower rate is secured.

4. A method of heat treating steel, in the form of wire and the like, comprising the steps of advancing the material longitudinally at uniform speed into and through a quenching bath of molten metal; controlling the temperature of the quenching bath to a temperature below the range of temperature at which pearlite will form rapidly in the steel when colling from an austenitic condition and above the temperature at which there will be rapid formation of martensite, which temperature of quenching bath when treating commercial steels of the usual analysis will be in the neighborhood of 425° F.; maintaining the material in such quench bath until it attains the temperature thereof; concurrently passing through the advancing material, defined between such quenching bath and a contacting electrode in spaced relation therewith, such a current of electricity as will heat the material progressively to a maximum temperature, as it enters such bath, which is in excess of the critical temperature of the steel, whereby it becomes substantially wholly austenitic; and further quenching by drawing from such bath of molten metal directly into and through an oil bath a portion of which overflows such bath of molten metal, whereby a secondary quench is secured wholly within such oil bath, without exposure to atmosphere.

5. Apparatus for the continuous heat treatment of wire and the like advanced therethrough, comprising a quench pot of molten metal; means operative to maintain the molten metal in said quench pot within a desired range of temperature; a contact pot of molten metal in spaced relation with said quench pot; means operative to apply a film of oil to the surface of such wire before it enters said contact pot; means operative to maintain a desired electrical potential between the metal in said pots; and means in each of said pots operative to hold a wire beneath the surface of the molten metal while such wire is drawn successively through said pots.

6. In apparatus as described, in combination, a quench bath of molten metal, and a quench bath of oil, said oil bath overlaying, and being supported by, a section of the surface of said molten metal bath, whereby a wire under treatment, drawn from said bath of molten metal will be further quenched in said oil bath before contacting atmosphere.

7. In apparatus as described, in combination,

a quench bath of molten metal, a quench bath of oil, and means operative to flow the oil from said oil bath onto said molten metal, whereby a wire drawn from said molten metal is kept within oil until it enters the said oil bath.

8. Apparatus for the continuous heat treatment of wire and the like advanced therethrough, comprising a contact pot of molten metal; a quench pot of molten metal; sinkers in each pot operative to hold below the surface of the molten metal, and guide, a wire drawn therethrough for treatment; a source of electro-motive force electrically connected in series in a circuit between the molten metal of said pots; an electrical condenser electrically connected in series in a second circuit between the molten metal of said pots; means adapted to maintain the molten metal in said quench pot at a desired temperature, whereby a treated wire is partially quenched; a bath of quenching oil; and means operative to maintain said bath of quenching oil with a substantial portion of the oil overflowed onto the molten metal of said quench pot, whereby wire under treatment drawn from the said molten metal directly into and through said oil, is further quenched in said oil before contacting the atmosphere.

9. Apparatus for the continuous heat treatment of wire and the like advanced therethrough, comprising a quench pot of molten metal; means operative to maintain the molten metal of said pot within a desired range of temperature; means operative to heat by its electrical resistance a wire, advanced at a uniform speed into, and through, said quench pot, to a desired maximum temperature which is attained as it enters the molten metal of said pot; means adapted to maintain such wire beneath the molten metal of said pot until it has attained substantially the temperature thereof; a bath of quenching oil; and means operative to maintain a substantial portion of the oil of said bath overflowed onto the molten metal of said quench pot, whereby wire under treatment drawn from said molten metal directly into and through said oil is further quenched in said oil before contacting the atmosphere.

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