

June 13, 1972

KEINOSUKE TAKEO ET AL

3,669,762

METHOD FOR HEAT-TREATING OF HOT ROLLED RODS

Filed Sept. 18, 1969

5 Sheets-Sheet 1

Fig. 1

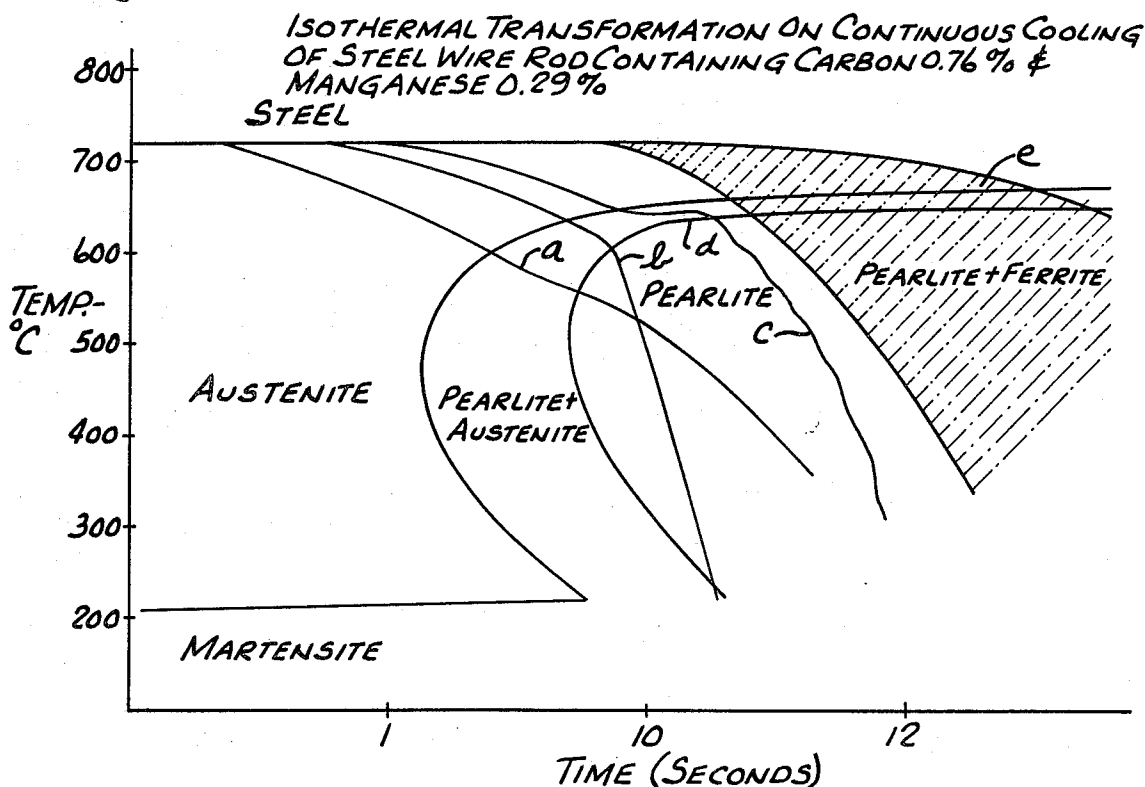
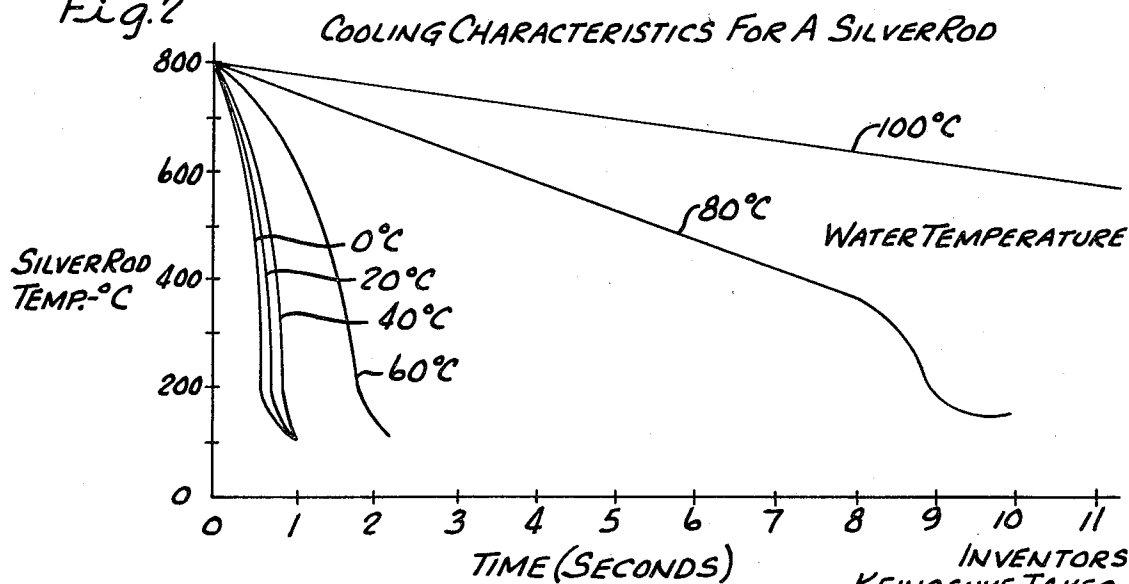


Fig. 2



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Fig. 6

WIRE ROD(1)

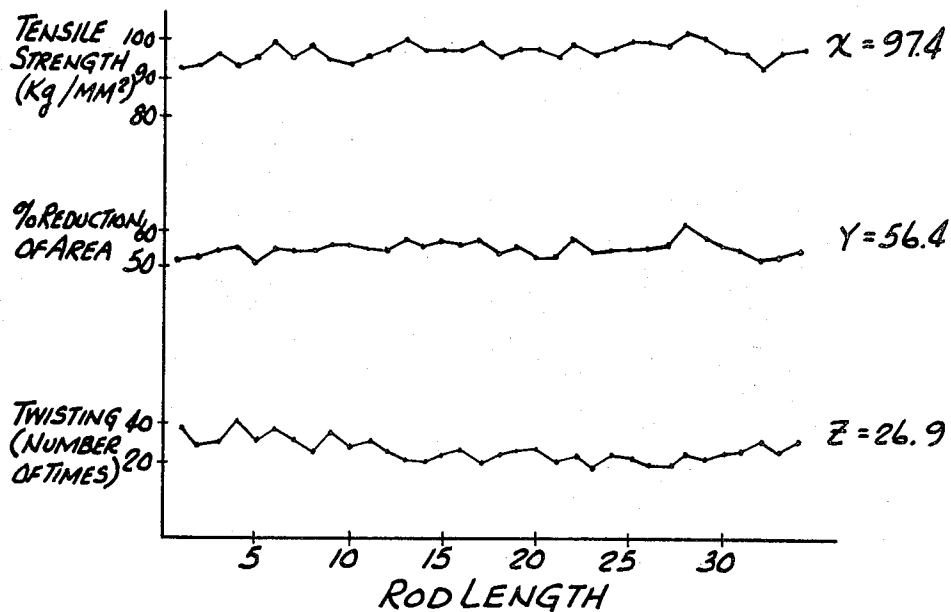
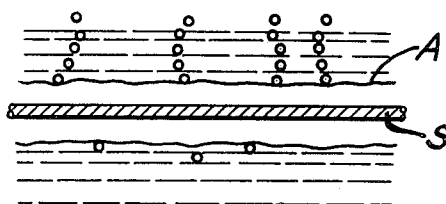


Fig. 3



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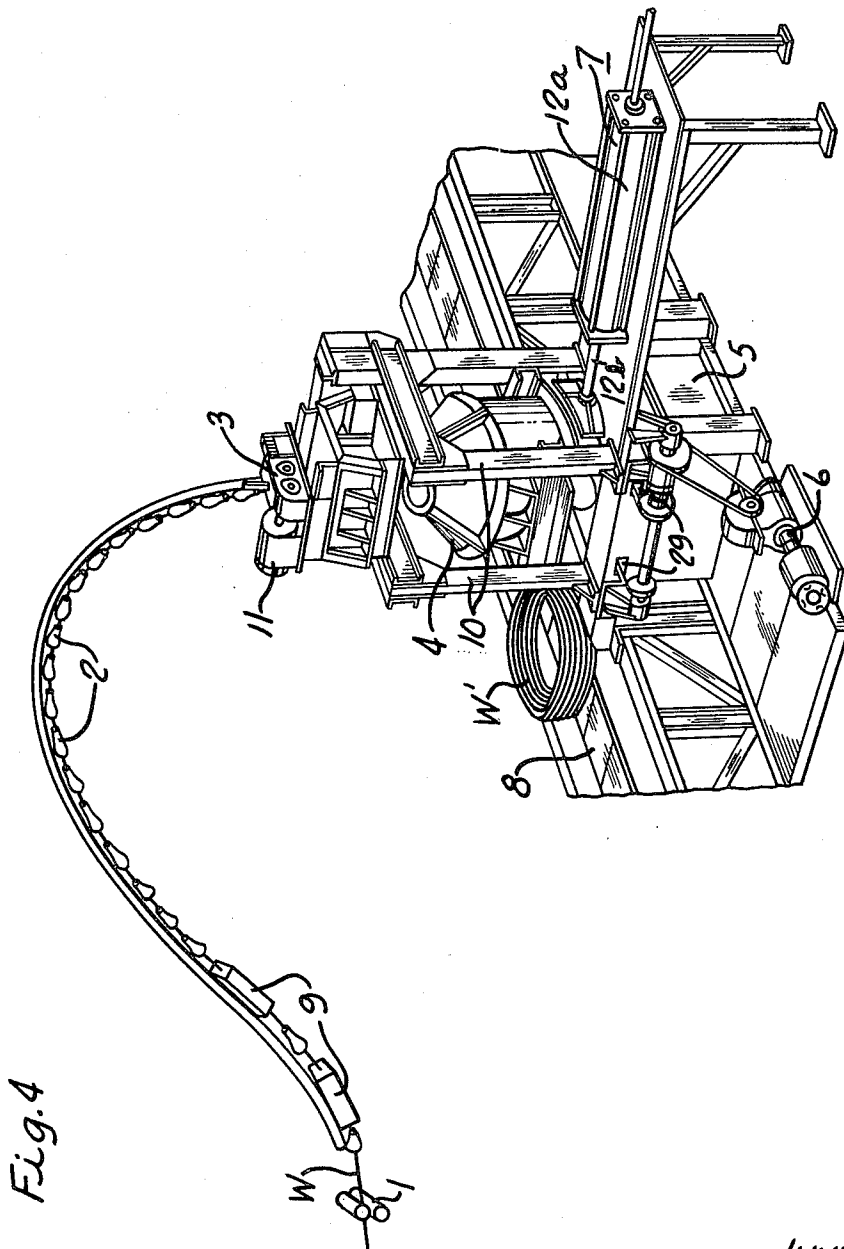
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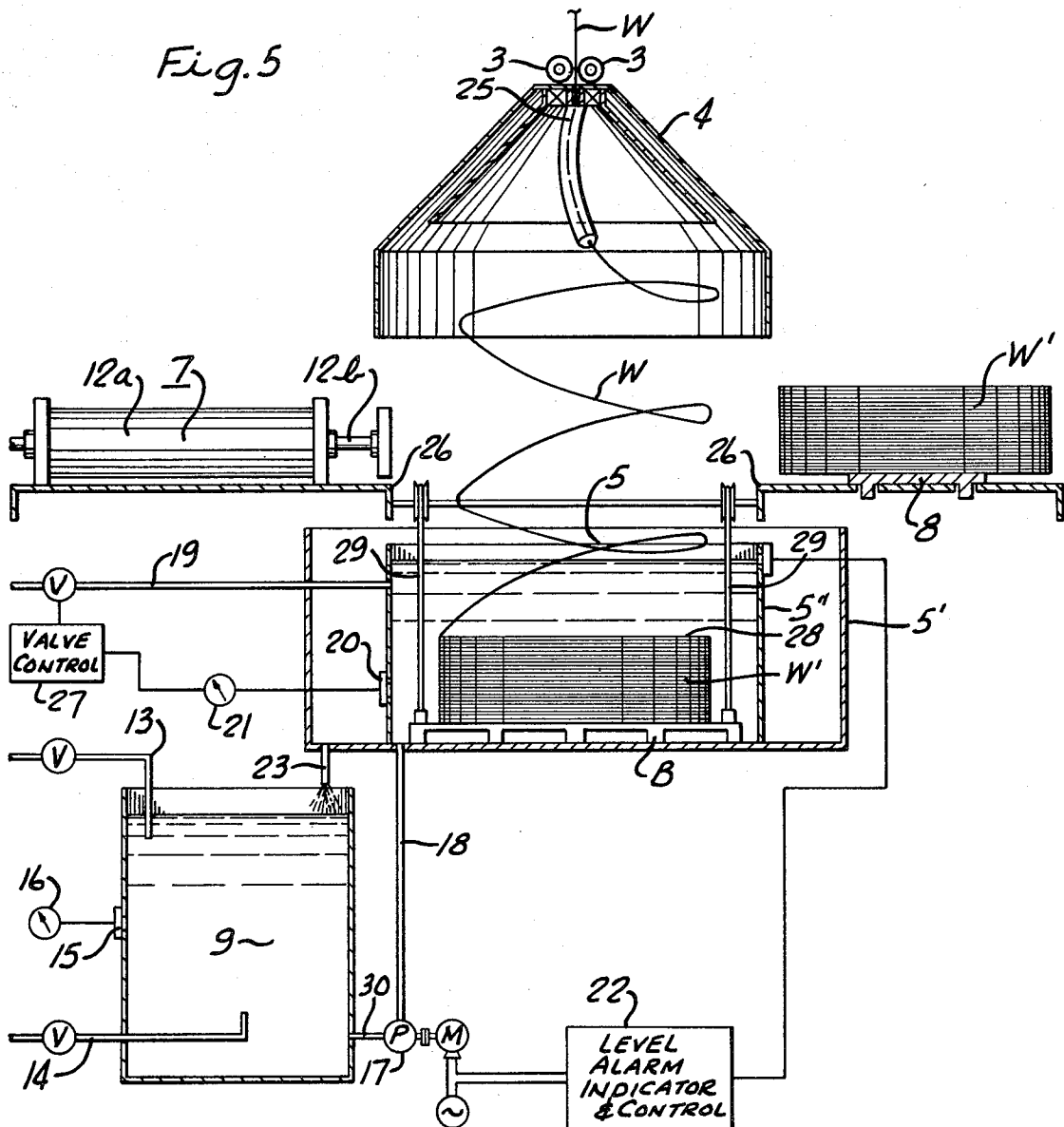
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Fig. 7

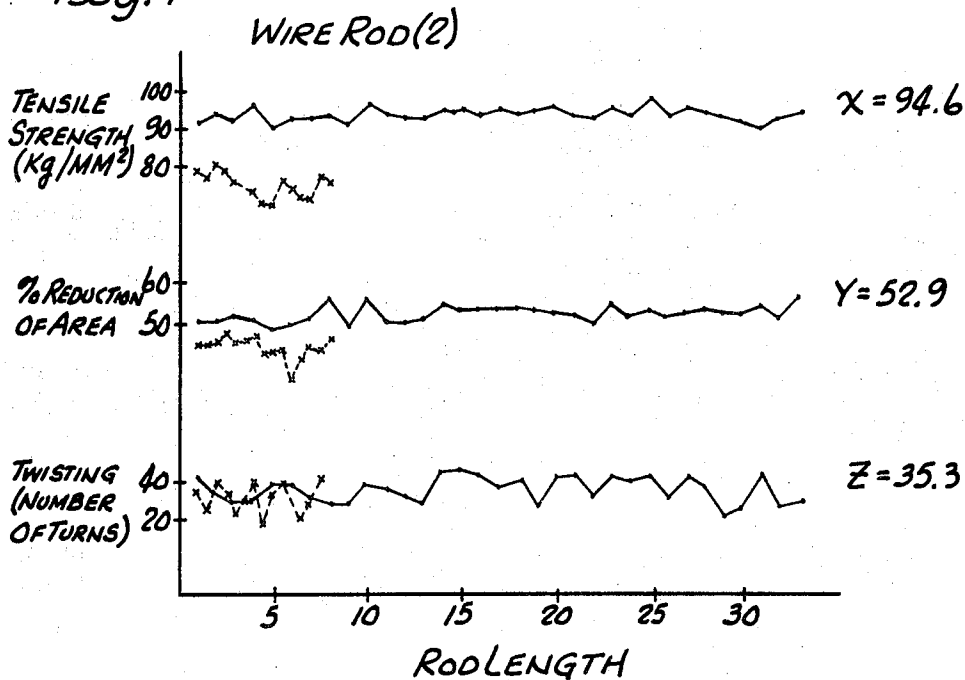
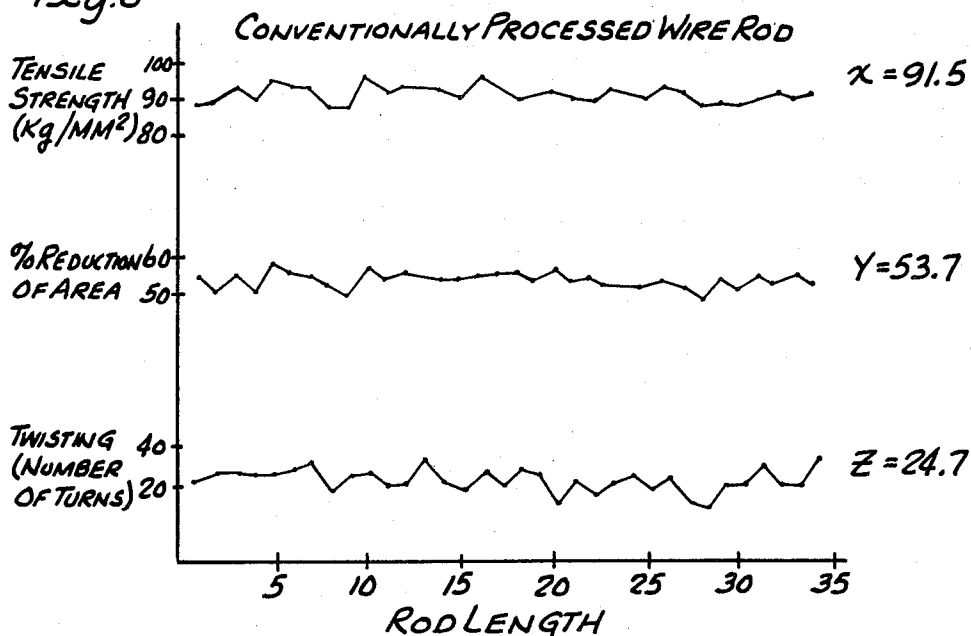


Fig. 8



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U.S. Cl. 148—18

9 Claims

ABSTRACT OF THE DISCLOSURE

Heat treatment of hot rolled wire rod to provide a microstructure of improved ductility and cold working properties to permit the rod to be drawn without further heat treatment by immersing the wire rod, while the hot rolled rod is at a temperature level above the temperature at which allotropic transformation of the austenite commences, into a heated water bath of sufficient temperature level to permit the generation of a steam envelope and film uniformly around and on the surface of the rod to control the rate of cooling of the wire rod. A surface activating agent may be added to the water bath to control the stability and period of maintenance of the steam film on the surface of the wire rod. The heated wire rod to be treated is continuously fed by a coiler down into a container within which the water bath is disposed, the coiler causing the wire rod to form into a concentric coiled bundle.

BACKGROUND OF THE INVENTION

This invention relates to a method of heat treating of wire rod and apparatus used in performing the method.

It is well known in the prior art to produce rods, such as steel rods, from an ingot or billet wherein the billet is heated in a furnace to a suitable temperature for hot rolling into rods of selected diameter. The rods thus produced are then immediately heat treated by either separate operation or a combined operation with the hot rolling operation, which operation is generally referred to as "patenting." Well known conventional patenting processes are air and lead patenting. However, temperature control has been a major obstacle in obtaining the desirable metallurgical structure in hot rolled rods in preparation for subsequent cold working.

Since the steel rods when formed by hot rolling are not suitable for cold drawing by means of dies or rolls, the patenting process is employed to produce a metallurgical structure in the wire that is suitable for cold drawing, that is, reduce and eliminate the formation of detrimental constituents such as martensite and lamellar pearlite. The patenting process improves the workability of the rod by increasing its strength and thereby permitting consecutive drawing operations to be performed on a single rod.

The most important aspect of the patenting process is temperature control. After the rod has been heated to a sufficiently high temperature, the rod must then be cooled as rapidly as possible to a lower tempering temperature where it may be held for several seconds to permit formation of the desired metallurgical structure. The cooling rate of the rod must be carefully controlled, and its rate of cooling should be uniform. If the cooling rate maintained is too slow, after coiling the rolled rod, the desired metallurgical structure in the rod will not be fully obtained. By the same token, if the rod is cooled too fast, metallurgical structures will be formed in the rod which impair its ability to be cold-worked or drawn.

In the patent of Lewis 2,994,328, issued Aug. 1, 1961, it has been proposed to continuously pass a high carbon steel rod through a series of water cooling stands to cool

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the rod immediately after it has been hot rolled. The patenting treatment was achieved by detecting the water cooled wire temperature at the coiling end of the rod and adjusting the flow of water volume to each of the water cooling stands in accordance with temperature deviations from the selected temperature level desired to be maintained during the cooling process. In this manner, an attempt is made to maintain a uniform desired temperature throughout the length of the hot rolled rod by varying the rate of water flow at the first cooling stand depending on the magnitude of temperature differential at the coiling end of the rod. However, in order to obtain any degree of uniform temperature throughout the rod, it is necessary to use a number of water cooling stands and the distance between the hot roll stands and the final rod coiler must be increased to increase and bring about the desired coiling speed, producing unfavorable results, particularly a decrease in the desired rate of cooling the hot rolled rod, which permits the formation of coarse pearlite restricting the ability to be easily cold worked.

The most recent trend in patenting processes is the depositing of rolled steel on a moving conveyor in the form of flat overlapping non-concentric rings and a cooling gas is applied to the moving non-concentric rings for the full width of the conveyor. The amount of gas applied is controlled in a manner in order to obtain the desired rate of cooling during metallurgical constituent transformation. An example of this process is McLean et al. 3,231,432, issued Jan. 25, 1966. The prime disadvantage of this type of patenting process is that the cooling rate does vary along the length of the rod particularly at the point of cross over of the adjacent non-concentric rings which may cause changes in the metallurgical properties of the rod at these points effecting the cold working properties of the rod. By the same token, the controlling of the rate of cooling by means of a forced gas medium is much more difficult than in the case of a liquid cooling medium.

SUMMARY OF THE INVENTION

The principal object of this invention is the method of heat treating hot rolled wire rod to improve its ductility and cold workability without further heat treatment by immersion of the wire rod, immediately after being hot rolled and at sufficiently high patenting temperature above the temperature at which allotropic transformation of the austenite commences, into a water bath which is at a temperature level to permit the generation and formation of a vapor or steam envelope and film around and on the surface of the wire rod, as the rod is deposited into the bath. The thermal conductivity of the film or envelope being extremely low, it is possible to control and therefore reduce the rate of cooling of the wire rod in order that the desired metallurgical structure may be obtained suitable for wire rod drawing. Also the method comprising this invention eliminates coarse scale formation resulting in substantial scale loss.

The controlled rate of cooling obtained through the development of the steam film on the surface of the wire rod not only provides for improved finer grain structure of ferrite and fine pearlite without formation of undesirable quantities of bainite or martensite, but also eliminates the step of the conventional air patenting process of reheating of the rolled rods encouraging undesirable crystal growth.

Another object of this invention is the provision of surface activating agent in the warm water bath to increase the stability and maintenance of the steam film on the surface of the wire rod and thereby further decrease the rate of cooling of the wire rod.

Another object of this invention is the provision of a coiler to receive the hot rolled wire rod and progressively position the wire rod in a concentric coiled manner in a bath container positioned directly beneath the coiler, the bath container provided with a warm liquid patenting medium which may consist of a water bath containing a surface activating agent. Elevator means may be provided in the bath container which, upon operation, elevates the coiled wire rod bundle to the top level of the container where it is transferred to an adjacent conveyor through operation of fluid motor means.

Other objects and advantages appear in the following description and claims.

The accompanying drawings show, for the purpose of exemplification without limiting the invention or the claims thereto, certain practical embodiments illustrating the principles of this invention wherein:

FIG. 1 illustrates a series of continuous cooling transformation curves of high carbon steel containing 0.76% of carbon and 0.29% of manganese subjected to a lead bath patenting (curve *a*), a warm water patenting according to this invention (curve *b*), a conventional air patenting (curve *c*) and the normal cooling after coiling (curve *d*).

FIG. 2 shows a relation between time and temperature change of a silver rod which is heated and immersed into warm water baths having mutually different temperatures.

FIG. 3 shows a condition or behavior of the coolant near the surface of the heated steel wire.

FIG. 4 is a perspective view of the patenting apparatus comprising this invention.

FIG. 5 shows a diagrammatic view of the essential portion of the apparatus of FIG. 4.

FIG. 6 graphically illustrates the tensile strengths, reductions of area and twisting properties of steel rods subjected to the warm water patenting method of this invention.

FIG. 7 graphically illustrates tensile strengths, reductions of area and twisting properties of steel rods subjected to the warm water patenting method of this invention as compared to the same properties of an unpatented rod.

FIG. 8 is the same type of graphic illustration of FIG. 6, but for a steel rod subjected to a direct conventional patenting process.

The improved method of patenting herein has been achieved after many years' empirical study and investigation as to the physical behavior of heated rods or wires in the water bath, and the change of mechanical and metallurgical properties and structures caused to the rods by such treatments. The term "rod" includes the following types of steel wires: a hard steel wire rod containing carbon, 0.25 to 0.85% weight, silicon 0.15 to 0.35% weight and manganese, 0.30 to 0.90% weight; a piano wire rod containing carbon 0.60 to 0.95% weight, silicon, 0.12 to 0.32% weight and manganese 0.30 to 0.90% weight.

In FIG. 1 showing the isothermal transformation diagram of the steel containing 0.76% weight carbon and 0.29% weight manganese, a central pearlite-austenite zone is a zone of transformation wherein a part of the austenite indicated at the left in FIG. 1 in the austenite zone is converted into pearlite according to the passage of time and decreasing of the temperature of the steel. The curves *a*, *b*, *c*, and *d* and the zone *e* shows the progress of the transformation for rods respectively subjected to a 500° C. lead bath patenting process, a warm water bath patenting process according to the present invention, and an air patenting process and the normal cooling process after coiling.

Cooling the rod after coiling produces a variation throughout the rod bundle in its cooling rate, that is, the cooling rate is not uniform, which scatters the pearlitic structures throughout the metallurgical structure as indicated in the hatched zone *e*. The rod inside of the bundle has the microstructure containing remarkable ferrite precipitation.

The wire subjected to the lead bath patenting process as shown by the curve *a* is observed to have a partial ferrite precipitation and its outer surface having proper fine pearlitic structure. The wire subjected to the air patenting, curve *c*, is ascertained to have the intermediate microstructure between that of wire of curve *a* and that of zone *e*. As a matter of course in the past, the wire stock for such items as wire rope, wheel spokes or springs is preferably subjected to a lead bath patenting process. Experimental works show that the cooling rate in the lead bath patenting treatment is about 20° C./sec.

The graph of FIG. 2 shows the cooling characteristics for a silver rod, as reported in Transaction of Japan Institute of Metals (Nippon Kinzoku Gakkaishi), vol. 16, (1952) p. 107, wherein the silver rod having a diameter of 10 mm. is heated to 800° C. and immersed into water at the respective water temperatures of 100° C., 80° C., 60° C., 40° C., 20° C. and 0° C. In the case where the silver rod is dipped into the boiling water at 100° C., the temperature of the silver rod lowers from 800° C. to 700° C. in 5 seconds, and therefore the cooling rate is calculated 20° C./sec. By reducing the water temperature to 80° C., 60° C., or less, the cooling rate is, of course, greatly increased. The same is true with respect to a steel rod or wire. The present patenting treatment or process makes use of this relation between the water bath temperature and the resulting cooling rate of wire to improve metallurgical structure of the rod for drawing.

As shown in FIG. 3, hot steel rod *S* is wrapped by steam film *A* as soon as it is immersed into the boiling water bath. Therefore, it will be noted that the heat transfer from the steel rod *S* is transmitted to the coolant exclusively through the steam film *A*. As the thermal conductivity of the steam film *A* is extremely low, the cooling rate of the hot steel rod *S* according to this invention is much reduced as compared with the cooling rate without the utilization of a steam film to such extent as to be equal to that cooling rate where a room temperature water bath is maintained.

Therefore, the essential point of the heat treating method of this invention is to generate the steam film uniformly on the wire surface and to keep and maintain this film state for some period of time until sorbite or pearlite transformation has been completed, and more particularly, to control the temperature and composition of water bath and the surface condition of the rod or wire, these three factors influencing the property of the steam film. If the water bath temperature is elevated, the steam film becomes thicker in extent, reducing the cooling velocity of the rod.

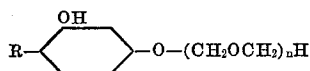
When the warm water coolant contains a surface activating agent, the stability and maintenance of a vapor or steam film is further increased. Such surface activating agents which can be used include a cationic activating agent such as alkyl sulfonates, alkylarylsulfonates, alkali salts of higher aliphatic acids, alkyl sulfates, Formalin-condensated naphthalene sulfonates, and alkyl naphthalene sulfonates, or an anionic activating agent such as quaternary ammonium salts, and fatty acid amine salts, or a non-ionic activating agent such as polyoxyethylene alkyl ethers, polyoxyethylene alkyl phenol ethers, polyoxyethylene alkyl esters, polyvalent alcohols, and fatty acids. The surface activating agent is selected by taking into consideration such factors as industrial uses over a long period of time, deterioration in use, occurrence of muddiness, any poisonous character, presence of a bad odor, corrosiveness, foaming characteristic, lowering of surface tension of the bath, permeability, moistness, its cost, etc. In view of these considerations, polyoxyethylenes are preferable as a surface activating agent. The amount of surface activating agent to be added is desirably 0.1 to 2%, by weight, based upon the use of warm water for cooling. Particularly the amount of 0.2 to 0.5%, by weight, of surface activating

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agent is effective in operation of the patenting process. For example, a warm water bath containing 0.5%, by weight, of sodium alkyl naphthalene sulfonate is longer by 30 to 50% in the duration time of film boiling and maintenance thereof than utilizing a bath of pure water. The vapor film grows and is maintained thicker and the cooling velocity of wire rod is thus delayed.

In carrying out the patenting process of this invention, a rod was hot rolled and had a temperature immediately before immersion of 860° C. The temperature of water bath containing a surface activating agent at the time of immersion of the rod was between 50° C. to 80° C.

The water for industrial use was used as the basic warm water bath and polyoxyethylenes of the form of



was added as the surface activating agent.

The results are summarized in Table 1, wherein there is shown how the surface activating agent works with respect to various different wire rods and water temperatures. For plant production in patenting wire rods, the activating agent is added in such amounts as to produce the desired cooling trend or conditions.

TABLE 1

Ex. No.	Size (mm., dia.)	Composition (wt. percent)		Active agent (wt. percent)	Water temp. (° C.)	Film boiling time (sec.)
		C	Mn			
1-----	5.5	0.62	0.47	0.5	55-60	21-26
2-----	6.3	0.65	0.71	0.1	54-58	8-15
3-----	7.0	0.84	0.53	0.1	49-62	6-18
4-----	10.0	0.83	0.67	2.0	60-70	18-23
5-----	10.0	0.83	0.67	0.5	64-70	18-24
6-----	11.0	0.82	0.49	0.1	54-70	15-22
7-----	11.0	0.79	0.42	0.1	53-79	13-29
8-----	13.0	0.62	0.70	0.1	60-75	18-28
9-----	13.0	0.64	0.48	0.1	62-73	25-28

A wire rod of 6.3 mm. diameter was investigated to determine in what manner the film boiling time of wire rod surface was changed upon addition of a surface activating agent.

TABLE 2

	Change of film boiling time in seconds				
Water temperature, ° C.-----	95	80	70	60	52
Use of industrial water-----	50	24	18	8	2
Added with 0.1% of activating agent-----	70	38	29	27	15

As can be seen from these results, the stability of vapor film on the wire rod surface is increased with addition of the surface activating agent in the range of temperature in which, in case of using industrial water, the vapor film is normally unstable, and the boiling time of the film tends to increase with the concentration of activating agent.

On the other hand, where peeling scale is attached to the wire surface because of prior hot roll processing, there is produced a nucleus of bubble formations upon contact with the steam film, and therefore the steam film is broken in extremely short period of time after the wire rod has been introduced into the bath producing a larger cooling velocity to the wire and causing a martensite transformation, which is undesirable.

The wire immediately after finish rolling, however, has smooth and flat surface possessing an extremely thin and compact scale layer and can be subjected to the warm water patenting process until completion of the pearlite

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transformation because of the maintenance of a stable steam film around the wire.

Of course, a wire exposed to air for some period can be treated as well by the warm water patenting process of this invention.

A wire coil wound in a warm water bath after being subjected to the patenting treatment according to this patenting method is kept at high temperature during a shorter period of time as compared with the conventional wire coiling wound in air, so that the amounts of the scale formed on the wire surface are reduced down to half of that formed by the conventional coiling method.

The practical procedure for the continuous production of the patented rod requires uniform and homogeneous heat treatment eliminating the deviation of the cooling velocity between the center zone and the peripheral zone of the coil dipped and placed in the water bath. For that purpose, the coiled wire is gradually dipped into the warm water bath or the wire is gradually coiled into the latter, and the resulting wire, as coil, is formed in a bundle on the bottom base plate of the water bath container. When desired coiled bundle is formed, the bundle is removed from the water bath container.

FIG. 4 shows the apparatus used for performing the method comprising this invention.

A path for conveying the wire rod W from finishing rolls 1 to a pinch roller 3 is formed by a series of guide pipe segments 2 and a plurality of water cooling means inserted therebetween as indicated at 9. The pinch rollers 3 provided at the top of a frame work 10 are driven by a motor 11. An Edenborne type coiler 4 is provided beneath the pinch rollers 3 and the coiler 4 is connected to an outlet of the pinch roller 3 by a wire guiding pipe 25. A warm water bath container 5 is provided beneath the coiler 4. A wire coil conveyor 8 is provided at the same level indicated at 26 as the top of the water bath container 5. A coil transfer means 7 is provided adjacent to the top of the container 5 at the opposite side of the conveyor 8, and may comprise a hydraulic cylinder 12a and piston 12b to transfer a coiled bundle of wire W' across the upper plane of the water bath 5 onto the conveyor 8. Elevator means in the form of a vertically moveable seat plate B shown in FIG. 5 is provided in the water bath container 5 and can be lifted or elevated to the container top level 26 by a motor driving means 6 shown in FIG. 4, which level is the same level as conveyor 8.

As shown in FIG. 5, the warm water overflow from an inner shell 5'' of the water bath 5 enters a space between the latter and an outer shell 5' of the container and is fed back to a water supply tank 9 from the bottom outlet 23 from the container 5. A warm water feeding pipe 13 and a steam injecting pipe 14 are inserted into the tank 9. A temperature indicator 16 is provided to be connected to the temperature indicator 15 on the tank 9. A pump 17 provided near the lower part of the tank 9 is connected to pipe 30 of the tank 9 to supply heated water through pipe 18 to the interior of the inner shell 5'' of the container 5.

A temperature detector 20 is attached to the inner shell 5'' of the water bath container 5 and a temperature indicator 21 is connected to detector 20.

The water supply tank 9 is first filled with water through the water feeding pipe 13 and then hot steam is injected from the steam injector pipe 14 into the water mass in tank 9 to elevate the water temperature to the desired temperature level. The resultant warm water will be fed into the warm water bath through pipe 18 by pump 17 into the container 5.

The temperature of the water supply bath 9 is detected by the temperature indicator 16 to keep or maintain the desired temperature level for feeding into the warm water bath container 5.

If the level of the warm water bath in the inner shell 5'' of the container 5 descends below a predetermined

level, a level alarm indicator 22 actuates the pump 17 to replenish the warm water in the container 5. If the temperature of the water bath in the inner shell 5" elevates above the predetermined value, the temperature indicator 21 directs the operation of the control valve 27 to feed cool water from the feeding pipe 19 into the warm water bath 5. If necessary, a cooler for the warm water can be attached to the inner shell 5" to control the temperature of the warm water bath.

The wire W proceeding from the finishing rolls 1 and having the temperature of 700–1200° C. is passed through the guide pipe segments 2 and the water cooling means 9 to the pinch roller 3, as shown in the FIGS. 4 and 5.

If desired, the temperature of the wire rod can be reduced or merely fed and guided to the pinch rollers 3 having a temperature of 600° C. to 1100° C., where it is then fed into the Edenborne type coiler 4. The r.p.m. of the pinch roller 3 and that of the coiler 4 are synchronized with the rolling velocity of the finishing stand rolls 1 in such a manner as not to apply too much tension to or produce excessive slack on the wire rod W. The wire rod W is fed into the coiler 4 and is gradually wound into the coiled bundle W' while being dipped or immersed slowly into the warm water bath container 5 provided directly beneath the coiler 4.

The automatic control of the water temperature and water level in the warm water bath container 5 as particularly described above is not an essential point of this invention, so that it will be conducted using the conventional means not shown herein.

After finishing the patenting treatment of the coil in the water bath, a wire holder 28 on a seat plate B is lifted by the driving means 6 by means of the cables 29 to the conveyor 8 level 26, and the bundled wire W' is thrust on the conveyor 8 by a horizontal motion of the piston plunger 12b and the transfer means 7.

The following examples illustrate the improved workability of wire rod treated in accordance with the method of this invention.

Using the apparatus of FIGS. 4 and 5, 2 lots of steel wires containing a carbon content of 0.59% weight and manganese 0.47% weight (JIS SWRH-4A), having 5.5 mm. diameter (the rod weight being 180 kg.), heated to a temperature of 800° C. were dipped into

- (1) a warm water bath at 83° C., and
- (2) a warm water bath at 90° C., respectively,

to achieve the patenting treatment according to this invention.

Tests were conducted for (a) wire rod treated according to the example above and a warm water bath number 2, (b) an as-rolled wire rod, and (c) commercially processed patented wire rod to determine the ultimate drawing limit and the ratio of cross-sectional area reductions. The test results are shown in Table 3.

TABLE 3

Wire patenting	Properties	
	Ultimate drawing limit, mm., dia.	Ratio of area reduction, percent
As rolled wire rod.....	5.5-2.6	78
Wire rod patented according to this invention..	5.5-1.1	96
Commercially processed patented wire rod.....	5.5-1.1	96

It is apparent from the Table 3 that the wire patented according to this invention has excellent cold workability characteristics.

Tensile strength, reduction of area, and number of twisting (100 d.) were tested as to the wire rod patented according to the water bath treatment number 1, the wire rod patented according to the water bath treatment number 2, and the commercially processed patented wire rod. These test results are plotted in FIGS. 6, 7, and 8, respectively, and summarized in Table 4.

TABLE 4

Wire patenting	C, percent	Mn, percent	Properties					
			Tensile strength, kg./mm.		Reduct. of area, percent		Twist counts	
			X	Y	X	Y	X	Y
As rolled wire rod.....	0.59	0.47	74	3.0	44	3.0	20	
Patented wire rod 1 of this invention.....	0.59	0.47	97	1.6	56	1.9	27	
Patented wire rod 2 of this invention.....	0.59	0.47	95	1.6	53	2.1	35	
Air patented wire rod.....	0.59	0.47	90	1.5	50	2.3	16	
Lead bath patented wire rod.....	0.59	0.47	110	1.7	49	2.4	12	
Commercially process patented wire rod.....	0.60	0.49	92	1.7	54	3.1	25	

It is apparent from the Table 4 that the wire patented according to this invention has excellent mechanical properties except for the slightly low tensile strength as compared with the wires treated by prior patenting processes. To keep the maximum temperature change of the warm water bath in a narrow range of within 3 to 4° C. is not difficult, and therefore the uniformity of the continuously treated wire rod product is attainable. It is a usual practice and custom to always hold the water bath temperature at the boiling point to maintain the constant treating condition and attain uniformity in the mechanical properties of mass produced wire rod products. More than 5° C. of mean temperature difference affects the properties of the resultant wire rod product. Therefore, it is preferable to increase the capacity of the warm water bath and hold the constant water bath temperature, and thus produce uniform mechanical characteristics in wire rod products.

While a wire rod treating method comprising a step of hot rolling and thereafter following by the consecutive step of direct warm water patenting has been particularly described in connection with the above examples, it will be understood to those skilled in the art that this method and apparatus for executing the method are also applicable to the wire rod that is hot rolled and air cooled or drawn without departing from the spirit and scope of this invention by heating these wires to the quenching temperature without rough or coarse scale formation.

We claim:

1. The method of heat treating hot rolled wire rods containing a carbon content of 0.25 percent or more to provide a microstructure of improved ductility and cold working properties permitting the wire rod to be subsequently cold drawn without further heat treatment, said heat treating commencing as the wire rod travels from the rolls to the wire rod coiling apparatus, comprising the steps of

maintaining the wire rod immediately after hot rolling at a temperature level above the temperature at which allotropic transformation of the austenite commences, immersing the wire rod as maintained at said temperature level into a hot water bath, controlling the rate of cooling of the rod to substantially complete allotropic transformation of the austenite thereby avoiding the development of coarse pearlite in such quantities as to interfere materially with said properties through the maintaining of the vapor envelop cooling stage around the surfaces of the wire rod for a period of time by selecting and maintaining a constant temperature level in said bath within a temperature range of 70° C. to 100° C., and thereafter removing the wire rod from said bath.

2. The method of heat treating hot rolled wire rod of claim 1 characterized by adding a surface activating agent to the heated water bath to improve the stability and period of maintenance of the vapor envelop cooling stage around and on the surface of the wire rod.

3. The method of heat treating hot rolled wire rod of claim 2 characterized in that the surface activating agent is a cationic activating agent selected from the group consisting of alkyl sulfonates, alkylarylsulfonates, alkali salts

of higher aliphatic acids, alkyl sulfate, Formalin-condensated naphthalene sulfonates, and alkyl naphthalene sulfonates.

4. The method of heat treating hot rolled wire rod of claim 2 characterized in that the surface activating agent is an anionic activating agent selected from the group consisting of quaternary ammonium salts and fatty acid amine salts.

5. The method of heat treating hot rolled wire rod of claim 2 characterized in that the surface activating agent is a non-ionic activating agent selected from the group consisting of polyoxyethylene alkyl ethers, polyoxyethylene alkyl esters, polyvalent alcohols and fatty acids.

6. The method of heat treating hot rolled wire rod of claim 1 characterized by adding a surface activating agent in the form of polyoxyethylene in amount of 0.1% to 2%, by weight, to the heated water bath to improve the stability and period of maintenance of the vapor envelop cooling stage around and on the surface of the wire rod.

7. The method of heat treating hot rolled wire rods of claim 2 characterized by the step of maintaining of the vapor envelop cooling stage around the surfaces of the wire rod for a period of time by selecting and maintaining a constant temperature level of said bath in excess of 45° C.

8. The method of heat treating hot rolled wire rods containing a carbon content of 0.25 percent or more to provide a microstructure of improved ductility and cold working properties permitting the wire rod to be subsequently cold drawn without further heat treatment, said heat treating commencing as the wire rod travels from the finishing rolls to the wire rod coiling apparatus, comprising the steps of

maintaining the wire rod immediately after hot rolling at a temperature level above the temperature at which allotropic transformation of the austenite commences, continuously coiling the heated wire rod into a container containing a hot water bath thereby continuously immersing said rod therein as coiled, controlling the rate of cooling of said wire rod as im-

mersed in said batch by selecting and maintaining a constant temperature level in said bath within the temperature range of 70° C. to 100° C. and controlling the flow of hot water into said container and cooler water flowing therefrom to maintain the maximum temperature difference of said bath at any one time to less than 5° C. from said selected temperature level, thereby prolonging the vapor envelop cooling stage around and on the surfaces of the wire rod for a sufficient time duration to substantially complete allotropic transformation of the austenite thereby avoiding the development of coarse pearlite in such quantities as to interfere materially with said properties and

thereafter removing the coiled wire rod from said container and from said bath.

9. The method of heat treating hot rolled wire rods of claim 8 characterized by continuously maintaining the temperature level of the hot water bath substantially at its boiling point.

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