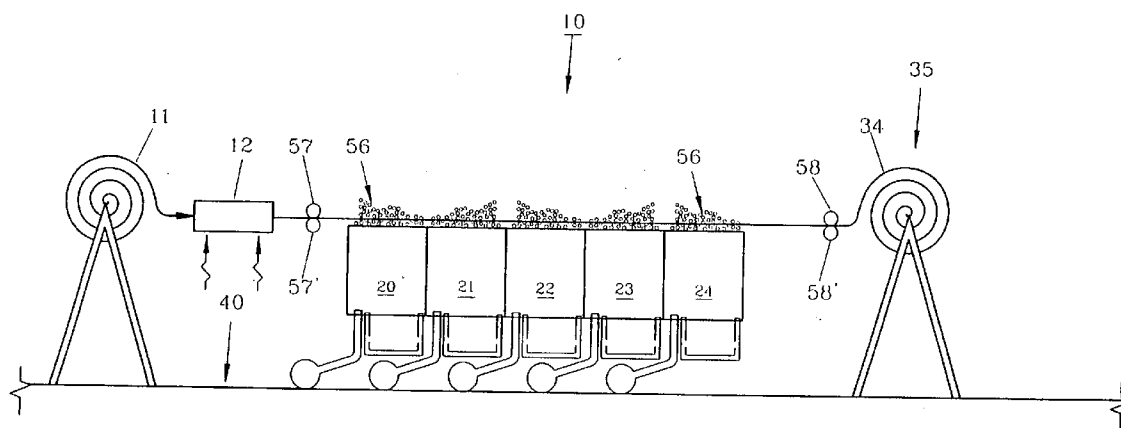




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(19) **United States**(12) **Patent Application Publication**
Tyl(10) **Pub. No.: US 2008/0011394 A1**(43) **Pub. Date: Jan. 17, 2008**(54) **THERMODYNAMIC METAL TREATING
APPARATUS AND METHOD****Publication Classification**(76) Inventor: **Thomas W. Tyl, Siler City, NC
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P.O. BOX 21927
GREENSBORO, NC 27420**(51) **Int. Cl.****C21D 9/52** (2006.01)**C21D 1/613** (2006.01)**C21D 1/74** (2006.01)(52) **U.S. Cl. 148/596; 148/633; 148/636; 266/252**(57) **ABSTRACT**

A thermodynamic metal treating apparatus and process describes utilizing a quenchant mixture of liquid and gas in a cell. Heated metal is passed over the heated quenchant mixture which contains a liquid and a gas such as air bubbled through the liquid at a desired rate. The process is particularly suited for improving the breaking, tensile strength and ductility of steel wire as is used in belted vehicle tires. A series of quenching cells allow for fast, uniform treatment of the metal wire.

(21) Appl. No.: **11/487,044**(22) Filed: **Jul. 14, 2006**

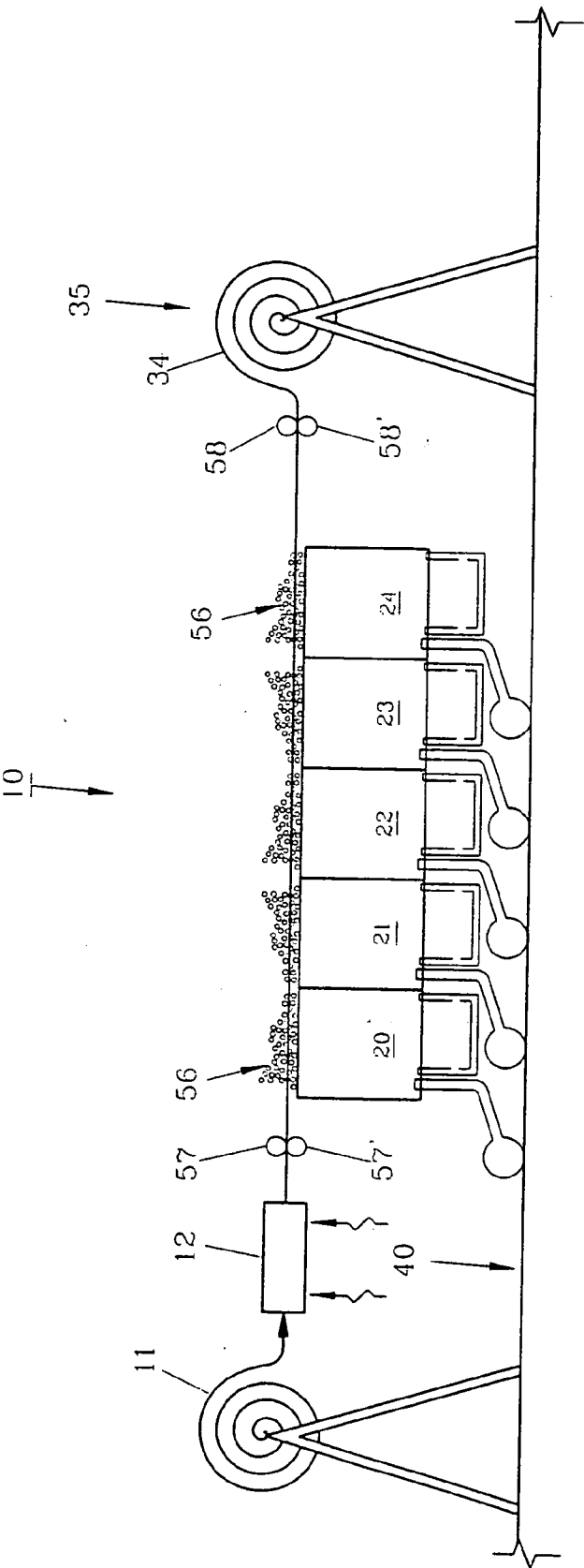


FIG. 1

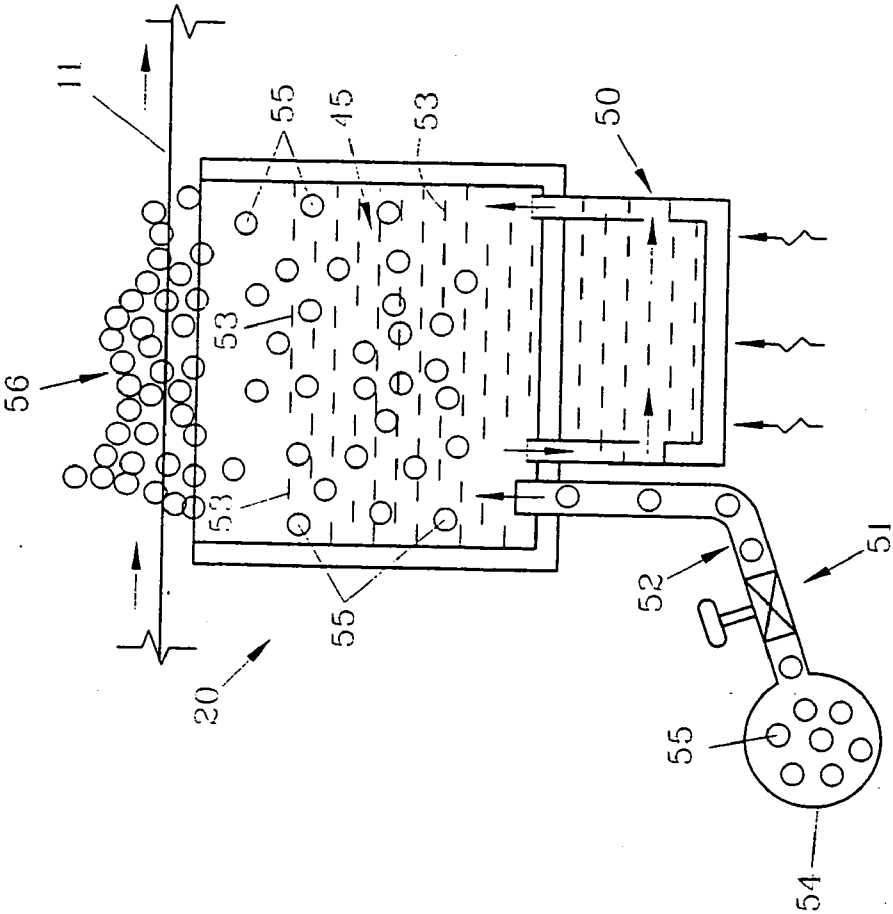


FIG. 2

FIG. 3

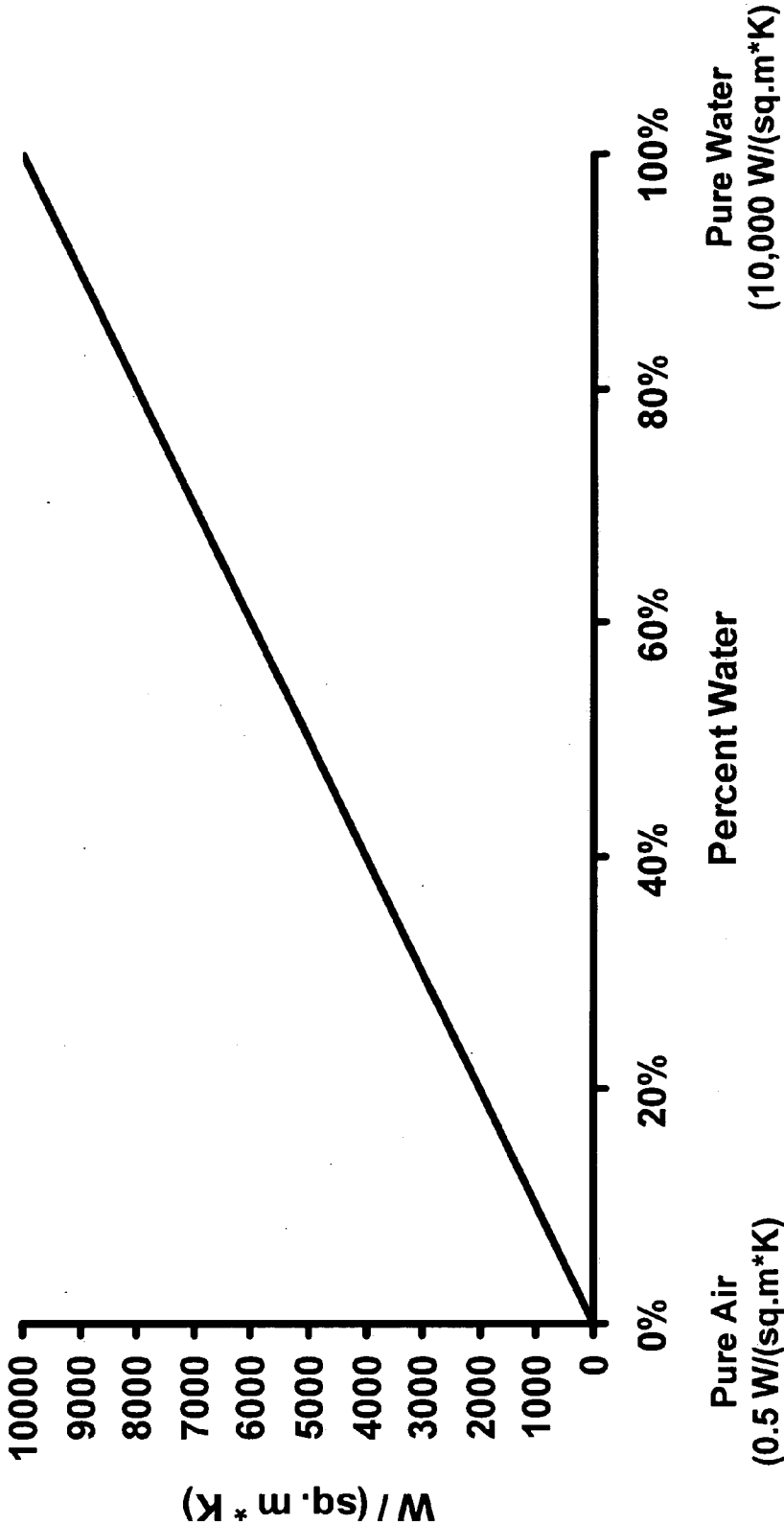


FIG. 4

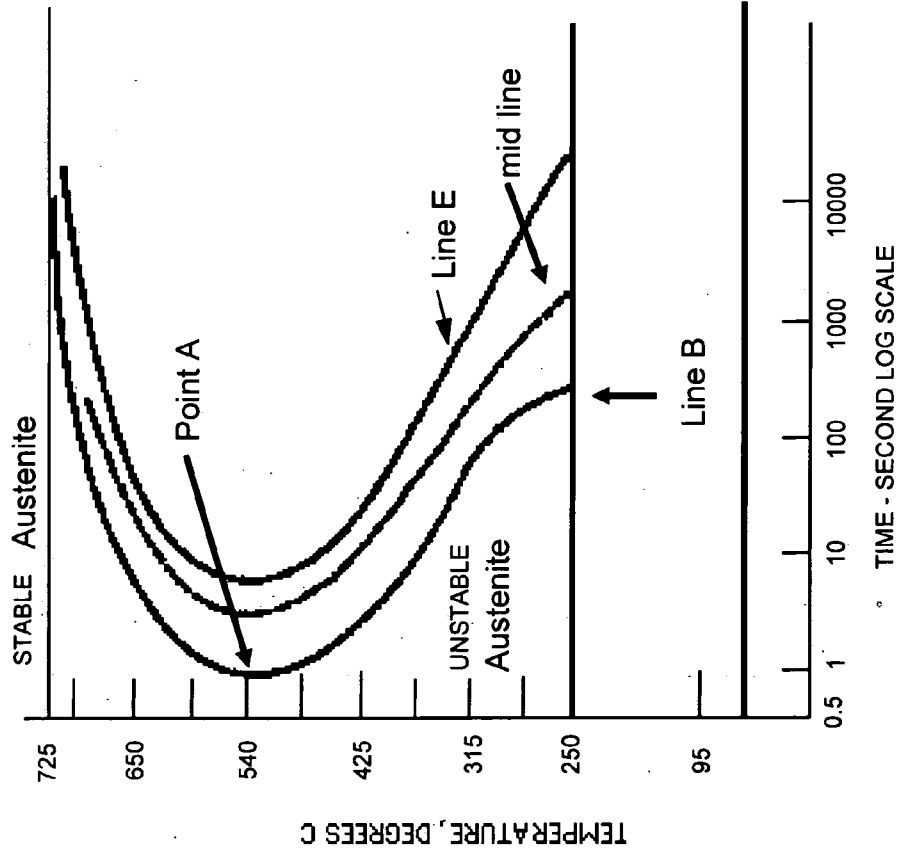


FIG. 5

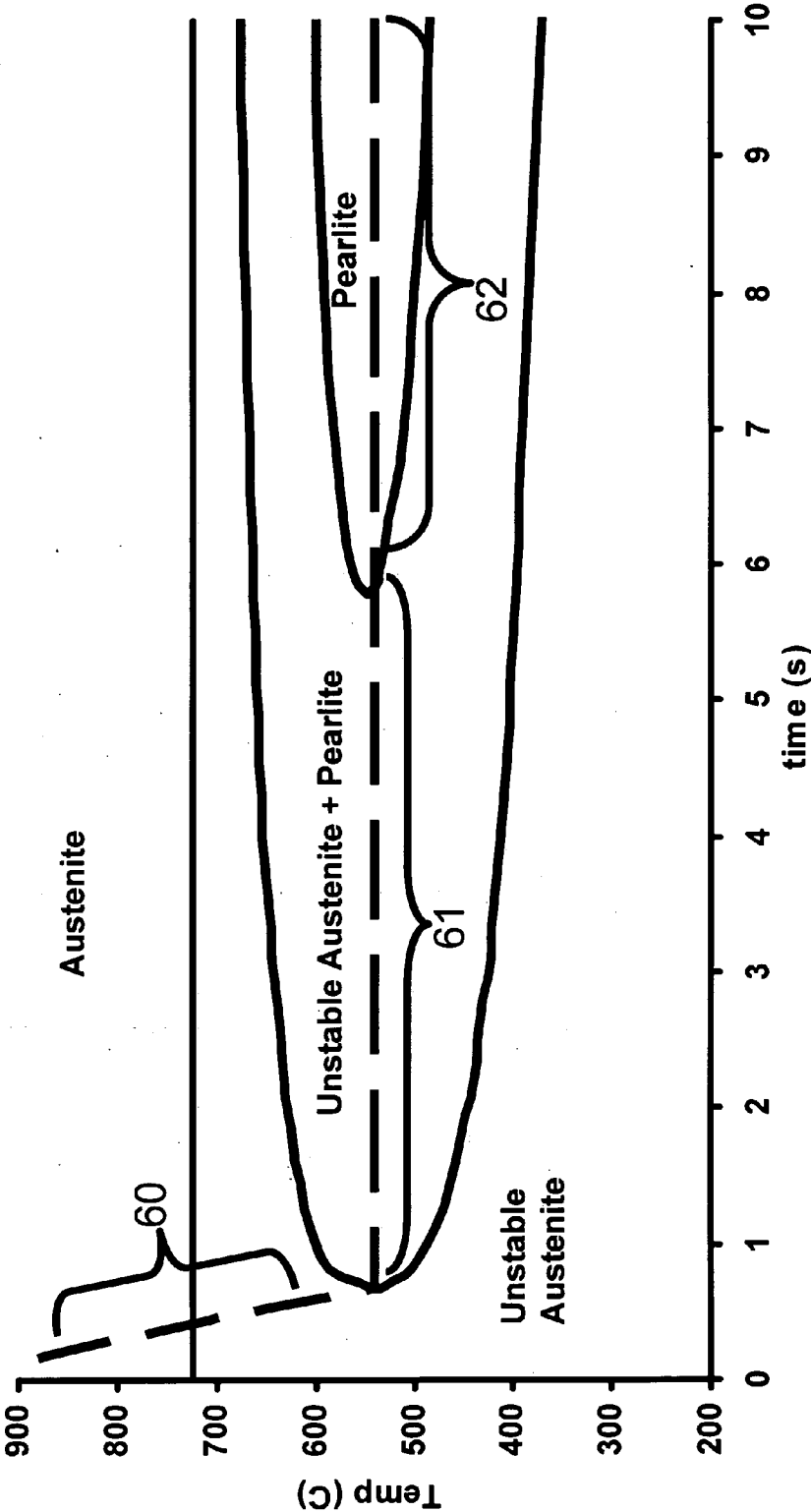


FIG. 6

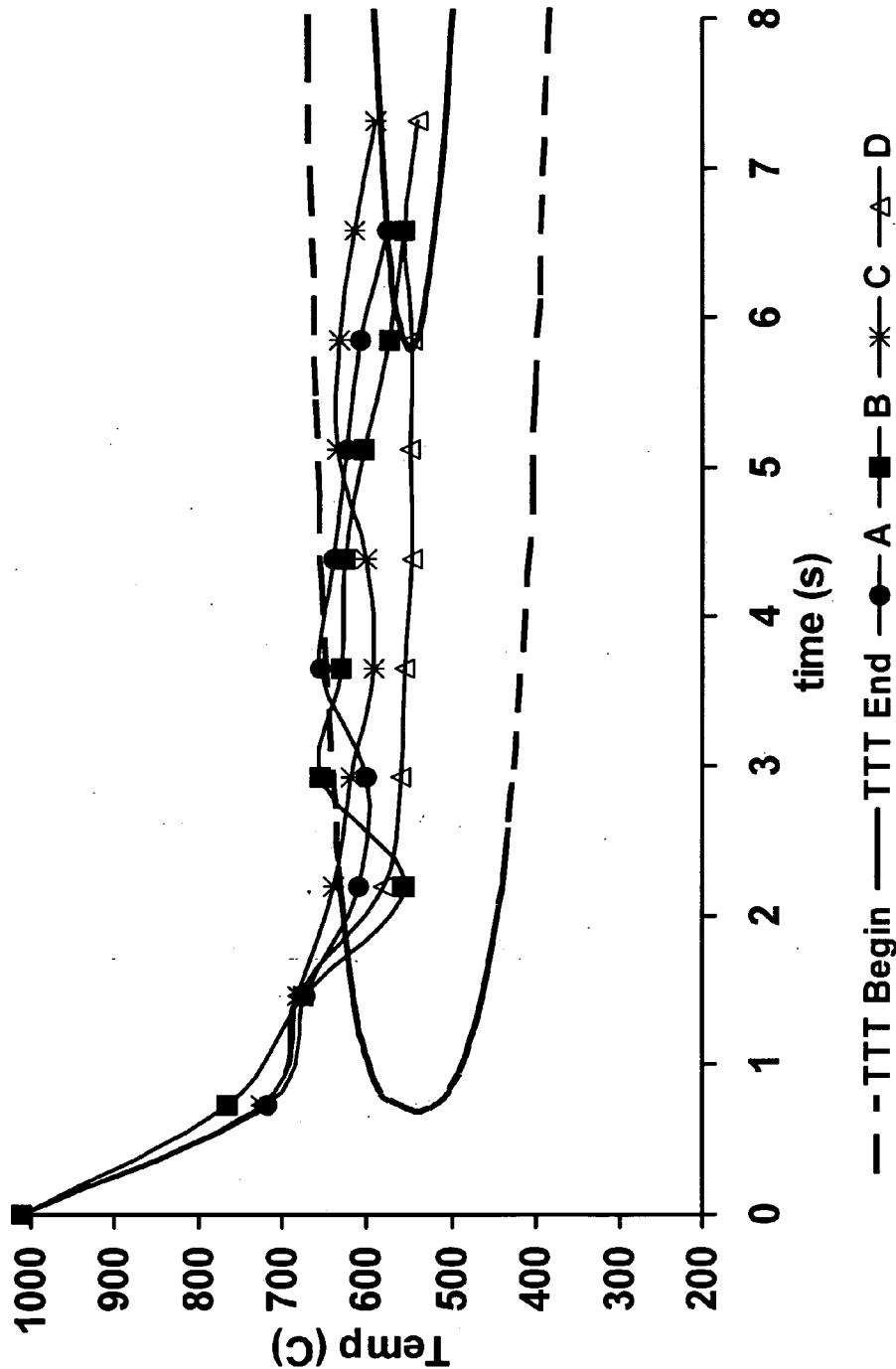


FIG. 7

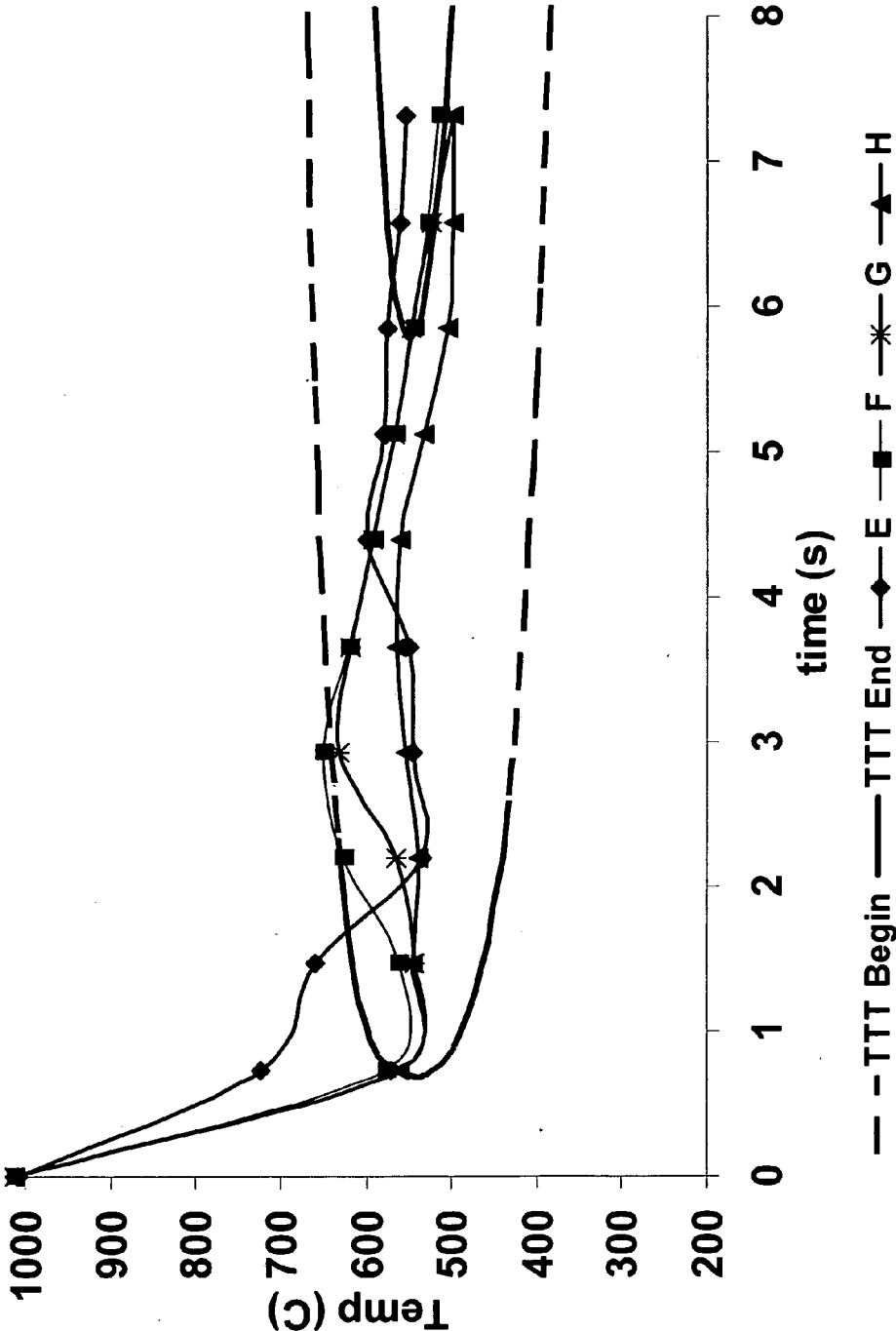
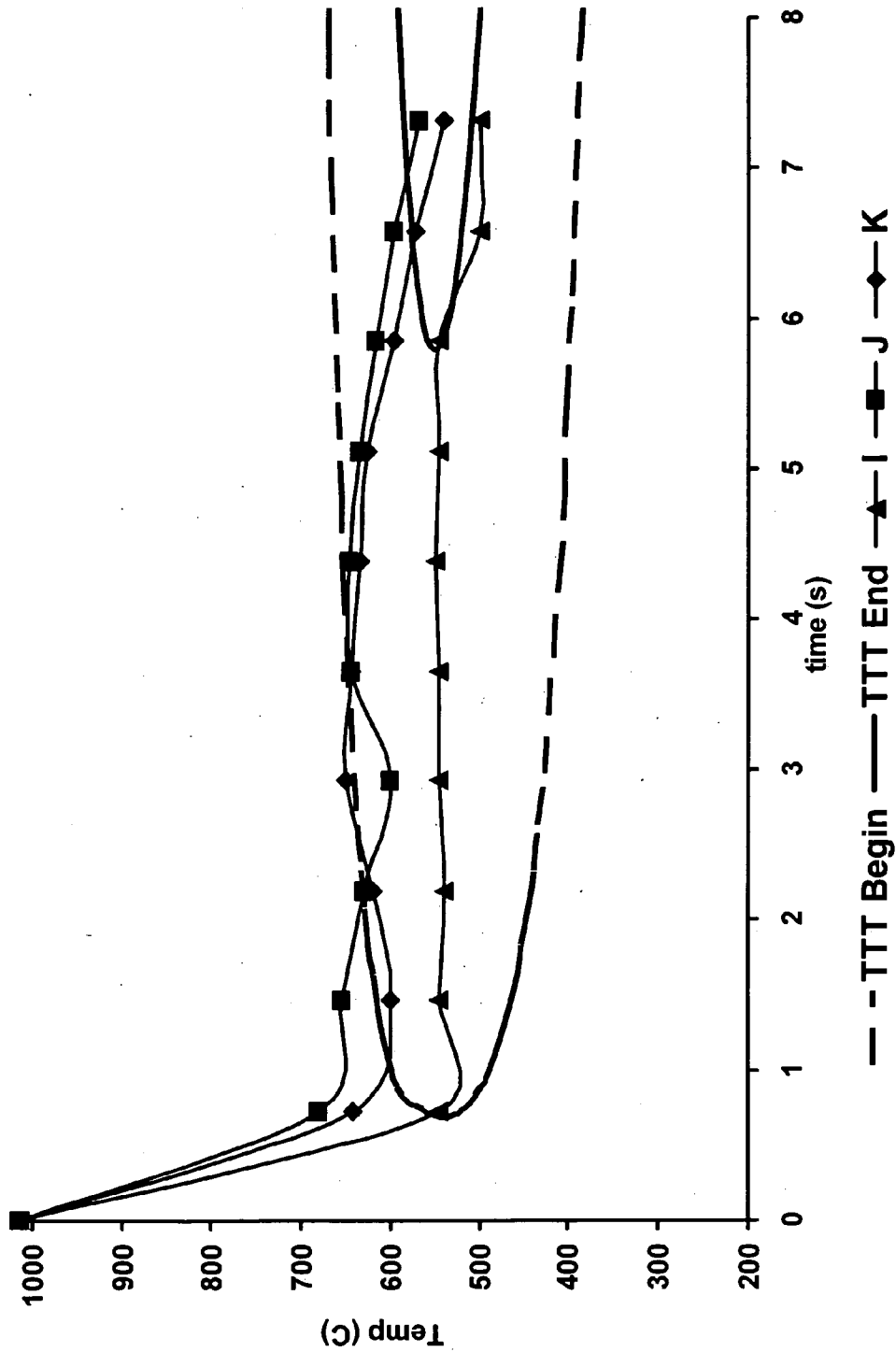


FIG. 8



THERMODYNAMIC METAL TREATING APPARATUS AND METHOD

FIELD OF THE INVENTION

[0001] The invention herein pertains to treating metal to improve its structural characteristics and particularly pertains to treatment of metal strands or wires to alter the tensile strength and ductility.

DESCRIPTION OF THE PRIOR ART AND OBJECTIVES OF THE INVENTION

[0002] Some conventional wire treating systems utilize air bubbled through a liquid quenching oil at or near room temperature, for example in the manufacture of springs, such as coil and leaf springs.

[0003] Heat transfer rates due to convection are governed by Newton's Law of Cooling:

$$Q/A = h(T_w - T_m); h = \frac{Q \setminus A}{(T_w - T_m)}$$

[0004] 1. Where (1) Q/A is the rate of heat transferred (Q) to the surrounding media per unit surface area (A) of the wire,

[0005] 2. T_w is the temperature of the wire,

[0006] 3. T_m is the temperature of the media, and

[0007] 4. h is the convective heat transfer coefficient.

[0008] Drawn wires for industrial purposes are usually made from carbon steel ranging from 0.35 to 1.10%, carbon and may also contain alloying elements such as chromium (Cr) boron (B), silicon (Si) or combinations of these elements. Before drawing the material is usually subjected to a heat treatment known as annealing.

[0009] The heat treatment consists of passing the wire through a furnace or other heat source to heat the wire to about 930° C. to 1020° C. This high temperature treatment produces a uniform face centered cubic austenite phase with a regulated grain size to help determine the product's subsequent ductility. Subsequent cooling in air or more commonly in molten lead or fluidized sand produces a phase transformation from face centered cubic austenite to body centered cubic ferrite and orthorhombic cementite arranged in alternating plates, jointly called pearlite. This transformation is rapid since the sections treated are relatively small (generally less than 3.5 mm). The resulting structure consists of very fine pearlite preferably with no grain boundary ferrite or cementite. The fineness of the pearlite depends on the product chemistry and the temperature to which the product is reduced after austenitizing. As annealed, fine pearlite wire is able to be drawn to reductions of area up to and sometimes exceeding 97%, resulting in very high drawn filament strengths. The final drawn filament strength provides exceptional fatigue resistance due to the very fine pearlite size, superior surface quality and the alignment of cementite plates in the drawn direction.

[0010] Heat processing metal objects by a fluidized bed is known where the temperature of a solid medium, such as sand suspended in a gas is used to regulate the rate of heat transfer. The rate of heat transferred to the surrounding media per unit surface area of the wire is determined by the temperature of the media since the convective heat transfer coefficient is constant for the media chosen.

[0011] Heat processing metal objects by means of a liquid lead bath or media is also known where the temperature of the liquid lead is used to regulate the rate of heat transfer. The rate of heat transferred to the surrounding media per unit surface area of the wire is determined by the temperature of the media.

[0012] Heat processing metal objects by means of air is also known where the temperature and velocity of the air is used to regulate the rate of heat transfer.

[0013] Once the physical characteristics of fluidized sand or molten lead baths are set, the flexibility of the heat treating process becomes limited. When processing strand products of different chemistries, like SAE 1070 and SAE 1090 steels requiring different quenching temperatures, it is not possible to accommodate both since only a single temperature can be maintained in any one quenching zone or bath.

[0014] Metal alloys such as steel alloys are produced with many different characteristics for use in different industries for different purposes. In recent years a large demand has developed for steel strands or wires for use in industrial applications such as vehicle tires, bridge strands, prestressed strands, galvanized drawn wire, music wire, saw wire and other products to improve their durability and strength. For vehicle use, such tires are generally referred to as steel belted radials which are realized as stronger and last much longer than conventional, non-belted tires.

[0015] Various companies manufacture tire wire cord for use by tire manufacturers which are generally supplied on spools and designate standard alloys of SAE 1070, 1080, 1090, and non-standard alloys designated 1090Cr, 1090B, 1090CrB and 1080SiCr with a breaking load commiserate with the type of steel used and the total amount of area reduction during final drawing.

[0016] After prolonged use it is not uncommon for some of the wires in steel belted tires to wear, fatigue and break. Tire manufacturers and suppliers have sought to improve the quality of steel belted tires by changing their manufacturing techniques and testing other, more expensive steel compounds, wire diameters and the like with varying results.

[0017] Thus, in order to improve the quality of steel belted tires and reduce or at least not greatly add to the manufacturers' costs the present invention was conceived and one of its objectives is to provide a steel wire for use in tire manufacturing which has been treated to improve its tensile strength and ductility characteristics.

[0018] It is another objective of the present invention to provide a steel wire produced by a process described herein for the manufacture of steel belted radial tires.

[0019] It is another objective of the present invention to provide apparatus and a steel wire treating process which can be readily adapted by current wire suppliers without excessive costs and expenditures for new equipment.

[0020] It is another objective of the present invention to provide a method of treating metal using a liquid to vary the heat transfer coefficient of the treatment mixture by varying the gas volume in the quenchant mixture.

[0021] It is still another objective of the present invention to provide a thermodynamic metal treating process employing treatment baths or cells at temperatures of approximately 100° C. which produces vapors or foam thereabove for the treating process.

[0022] Various other objectives and advantages of the present invention will become apparent to those skilled in the art as a more detailed description is set forth below.

SUMMARY OF THE INVENTION

[0023] The aforesaid and other objectives are realized by providing an improved strand metal product and treatment method. Particularly, the process as herein described improves the tensile strength and ductility of conventional steel wire as used in belted vehicle tires although the process can also be adapted for other products and uses. The process includes, in one example, the steps of heating a conventional wire such as a 2 mm diameter 1090 steel wire to a range of 930-1050° C. by first passing the wire through an oven. Upon exiting the oven the elevated temperature wire is then directed at a speed of approximately 7 meters/min. to quenching apparatus having, for example, different air and water quenchant mixtures in a plurality of consecutive baths or cells. Each cell mixture has an elevated temperature of approximately 100° C., consistent to a production liquid bath without outside cooling. Each cell also has a different volume of air continuously distributed through the liquid in the mixture. The first cell mixture forms a vapor or foam which cools and treats the metal wire above the cell. The wire is then passed above subsequent cells, likewise cooling and treating the wire. Once the quenching or treating process has been completed at the last cell the wire is dried through evaporation and wound into a spool of suitable size for delivery to a subsequent drawing operation. The wire can be further processed as is conventional by drawing to smaller diameters.

[0024] In a second example, the first step consists of heating a conventional wire such as a 1.2 mm diameter 1070 steel wire to a range of 930-1020° C. by first passing the wire through an oven. Upon exiting the oven the elevated temperature wire is then directed at a speed of approximately 12.5 meters/min. to quenching apparatus having, for example, different air and water quenchant mixtures in a plurality of consecutive baths or cells. Each cell mixture has an elevated temperature of approximately 100° C. to form a vapor or foam above the cell. The first cell cools and treats the metal wire with 100 percent liquid. The wire is then passed to subsequent cells each having different volumes of air continuously distributed through the liquid in the mixture in the range of 0 to 100 percent. The wire is passed slightly above the cell for treatment with the vapor and foam mixtures. Once the quenching or treating process has been completed in the last cell the wire is dried by evaporation and wound into a spool of suitable size for delivery to a subsequent drawing operation and is further processed conventionally by drawing to smaller diameters.

[0025] While only two (2) single wire type treatments are described, as would be understood multiple wires could be processed simultaneously using commercial apparatus. The velocity of the wire moving through the process is dependent on the wire size, wire chemistry, the equipment selected and the results desired. Likewise, the percentage volume of air in the quenchant in each cell may vary from 0 to 100% for optimum vapor or foam production and wire treatment. The results are also dependent upon wire diameter, speed and wire chemistry. Also, the liquid used as a quenchant may

be water or commercial proprietary liquids with usual foaming compounds added as required.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. 1 demonstrates a schematic representation of the apparatus used in the thermodynamic metal treating process;

[0027] FIG. 2 shows an enlarged view of one of the apparatus cells as seen in FIG. 1;

[0028] FIG. 3 illustrates a graph of convection coefficient of air/water volume percentages of quenchant mixtures;

[0029] FIG. 4 depicts a typical TTT curve for SAE 1080 steel;

[0030] FIG. 5 pictures another TTT curve for eutectoid steel;

[0031] FIG. 6 demonstrates a first TTT curve for SAE 1070 steel;

[0032] FIG. 7 shows a second TTT curve for SAE 1070 steel; and

[0033] FIG. 8 illustrates a third TTT curve for SAE 1070 steel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS AND OPERATION OF THE INVENTION

[0034] For a better understanding of the invention and its operation, turning now to the drawings, FIG. 1 demonstrates preferred treating apparatus 10 in schematic representation. As seen, treating apparatus 10 comprises standard oven 12, preferably a Thermcraft 6' long, 1600° C. tube furnace manufactured by Thermcraft, Inc. of Winston Salem, N.C. 27177-2037. To measure wire 11 exiting oven 12 a pyrometer (700-1400° C.) from Pyrometer Instrument Company of Windsor, N.J., 08561-0479 with five (5) consecutive cells 20, 21, 22, 23 and 24, each including heat source 50 having a conventional electric immersion heater (rated at 240V, 4.5 kw, 3 phase), and air regulator 51 (seen in FIG. 2 in greater detail) Air regulator 51 is preferably a Dwyer Air Flow meter rated 0-50 L/min from Dwyer Instruments, Inc. of Michigan City, Ind. In the preferred treatment method a coil of wire 11, conventional steel wire designated 1090 having a nominal diameter of 2.0 mm, or alternatively 1070 (not seen) having a nominal diameter of 1.2 mm is mounted above floor 40 as in a typical industrial treatment operation. Wire 11 is fed through oven 12 for heating purposes, preferably to about 930-1020° C. Heated wire 11 is then directed by front roller guides 57, 57' slightly above first cell 20, where quenchant mixture 45 (FIG. 2) is displaced over the top of first cell 20 by introduction of gas 55 to liquid 53 resulting in vapor or foam 56 which completely covers wire 11. Wire 11 continuously travels through vapors across the top of cells 20-24 and dries by evaporation through the air to form created wire 34 which passes through rear roller guides 58, 58' and is wound onto reel 35 at the terminal end of treating apparatus 10. While only five cells 20-24 are shown herein, more or less cells could be used depending on the particular manufacturer's circumstances and treatment operation. Each cell 20-24 includes a thermometer such as a Raytex 500-1100° C. close focus fiber optical type from Raytex Equipment Company, Houston, Tex. In addition, only one wire 11 is shown but typically bundles of wires having 5-90 wires per

bundle would be processed simultaneously during normal production. Other metal strand materials could likewise be treated.

[0035] In schematic FIG. 2, cell 20 is seen enlarged as removed from apparatus 10. Heat source 50 is in communication with cell 20 to heat and re-circulate quenchant mixture 45 contained in cell 20. Cell 20 includes a liquid circulation pump (not seen) such as a Bell & Gossett NBF-220 110° C., 15PASI, 115V, 2 watt (P83033 model) recirculating pump. Standard air speed regulator 51 is in communication with gas supply 54 having an ACSI digital pressure meter (part No: 1200-0030,602056) rated at .XXPSI, a 0-200 PSF air gauge at Ashcroft.com (Ashcroft, Inc.) and a speedaire 2Z767D, 200PSI 125° F. air regulator (as sold at Grainger.com) containing gas 55 and supply line 52 also in communication with cell 20 to provide gas 55 to liquid 53 thereby forming quenchant mixture 45. As would be understood, schematic FIG. 2 does not fully demonstrate mechanical, electrical or other components as used herein. Heat source 50 and air regulator 51 are conventional in the trade and can vary in size, shape and efficiency depending on their particular requirements.

[0036] Heat source 50 recirculates quenchant mixture 45 within cell 20 while maintaining its temperature at approximately 100° C. In a typical installation, liquid 53 shown would consist of preferably typical conventional RAQ-TWT quenching solution sold by Richards Apex, Inc. of Philadelphia, Pa. RAQ-TWT is a proprietary formula containing: polyalkylene glycol—45.5%; polyethylene glycol ester—12%; a proprietary metal working fluid additive—12%, a

volume percentage to change the forced convective heat transfer coefficient as shown schematically in FIG. 3 where pure air is estimated to be 0.5 W/(sq.m*K) and pure water is estimated to be 10,000 W/(sq.m*K). The forced convective heat transfer coefficient varies linearly with combinations of air and water as shown in FIG. 3.

[0038] FIG. 4 shows a typical Time, Temperature, Transformation (TTT) curve for SAE 1080 steel. The optimal structure developed by the heat treating process for industrial drawing is obtained by cooling 1080 steel wire from the austenization temperature (930-1020° C.) to 540° C. very rapidly (about 1 second) on the left of FIG. 4 at point A on line B and holding the 1080 steel wire at 540° C. until both the midline and line E are crossed (about 6 seconds).

[0039] FIG. 5 shows a schematic of eutectoid steel (iron/carbon steel with 0.8 to 0.83 carbon) TTT curve indicating where three different forced convective heat transfer coefficients are required to produce the proper microstructure, forced convective heat transfer coefficient 60 to reduce the wire temperature from about 930-1020° C. to 540° C., forced convective heat transfer coefficient 61 to hold the wire at temperature during the exothermic reaction from austenite to pearlite and forced convective heat transfer coefficient 62 to cool the wire to a safe operating temperature.

[0040] Examples for the thermodynamic wire transformation process for SAE 1090 steel are provided in Table 1 below.

TABLE 1

experimental data for 1090 steel, nominal 2.0 mm diameter													
Example	Flow Rate liters per minute					Percent Air					Diameter (mm)	Breaking Load (N)	Tensile Strength (Mpa)
	Cell 20	Cell 21	Cell 22	Cell 23	Cell 24	Cell 20	Cell 21	Cell 22	Cell 23	Cell 24			
1	25	15	5	5	0	18%	11%	4%	4%	0%	1.9609	3600	1192
2	20	10	10	5	0	14%	7%	7%	4%	0%	1.9607	3599	1192
3	35	10	5	5	0	25%	7%	4%	4%	0%	1.9641	3712	1225
4	35	10	10	5	5	25%	7%	7%	4%	4%	1.9622	3735	1235
5	40	10	10	5	0	28%	7%	7%	4%	0%	1.9624	3920	1296
6	35	30	0	0	0	25%	21%	0%	0%	0%	1.9625	3947	1305
7	40	25	5	0	0	28%	18%	4%	0%	0%	1.9613	3946	1306
8	35	25	10	5	0	25%	18%	7%	4%	0%	1.9611	3951	1308
9	30	30	5	5	0	21%	21%	4%	4%	0%	1.9613	3955	1309
10	40	20	5	5	5	28%	14%	4%	40%	4%	1.9637	3989	1317
11	35	25	10	5	0	25%	18%	7%	4%	0%	1.9622	3995	1321
12	35	30	5	5	5	25%	21%	4%	4%	4%	1.9622	3998	1322
13	40	25	5	5	5	28%	18%	4%	4%	4%	1.9620	4003	1324
14	35	25	10	10	0	25%	18%	7%	7%	0%	1.9630	4022	1329
15	40	35	5	5	0	28%	25%	4%	4%	0%	1.9631	4035	1333
16	35	35	10	5	0	25%	25%	7%	4%	0%	1.9621	4055	1341
17	30	30	10	10	5	21%	21%	7%	7%	4%	1.9614	4085	1352
18	40	30	10	5	5	28%	21%	7%	4%	4%	1.9637	4128	1363
19	35	30	10	10	5	25%	21%	7%	7%	4%	1.9624	4162	1376
20	40	30	10	10	5	28%	21%	7%	7%	4%	1.9611	4171	1381

defoamer—0.5%, and water—30%, with a typical pH of 3-9%. This quenchant solution is diluted to 10% by volume with water prior to use. Other commercial quenching liquids or water could also be used.

[0037] Gas 55 contained within gas supply 54 is preferably air but other gases may be used to form quenchant mixture 45. Mixture 45 can be varied by the air flow rate and

[0041] As seen in Table 1, conventional 2 mm SAE 1090 steel wire was processed using a plurality of cells 20-24, containing liquid 53, preferably quenchant RAQ-TWT as described above, diluted to 11 concentration in water by volume. By bubbling gas 55 (preferably air) through liquid 53 at various rates in individual cells 20-24 the breaking loads and tensile strength of wire 11 can be altered.

[0042] In Example 1 seen in Table 1, the preferred method utilizes a nominal 2 mm diameter wire (1090 steel) treated with a resulting breaking load of 3600 Newtons (N) and a tensile strength of 1192 Megapascals (MPa). Example 6 shows the method with the same 2 mm wire being treated only in cells 20 and 21 and having an increased breaking load of 3947 N with a tensile strength of 1305 MPa. In Example 20, the method employs cells 20, 21, 22, 23 and 24, all utilized with various flow rates and air volumes with the breaking load increasing to 4171 N and a tensile strength increasing to 1381 MPa. All examples shown herein were run at a constant wire speed of 7 meters per minute.

[0043] Thus, by increasing the volume or percentage of gas 55 in quenchant mixture 45, improved breaking loads and tensile strengths of 1090 wire can be realized by the described methods.

[0044] Examples for the thermodynamic wire transformation process for SAE 1070 steel are provided in Table 2 below while FIGS. 6, 7 and 8 illustrate corresponding TTT curves.

having an increased breaking load of 1276 N with a tensile strength of 1168 MPa. In Example G, the method employs a Pipe Spray, a method of full liquid immersion where the hot wire is guided through a pipe filled with liquid, at 3 g/m in cell 20 with the breaking load increasing to 1315 N and a tensile strength increasing to 1197 MPa. In Example I, the method of full liquid immersion employs a pipe spray at 3 g/m (cell 20) and varying flows in cells 21-24 with the breaking load increasing to 1407 N and a tensile strength increasing to 1234 MPa. All examples shown herein were run at a constant wire speed of 12.5 meters per minute.

[0051] Thus, as illustrated by increasing the volume or percentage of gas 55 in quenching mixture 45 to various rates improved breaking loads and tensile strengths of the 1070 wire can be realized by the described methods.

[0052] The illustrations and examples provided herein are for explanatory purposes and are not intended to limit the scope of the appended claims. Other strand materials and metal shapes and sizes could also be accommodated by

TABLE 2

<u>experimental data for 1070 steel, nominal 1.2 mm diameter</u>													
Exam-	Air Flow Rate, liters per minute					Percent Air					Diameter	Breaking	Tensile
ple	Cell 20	Cell 21	Cell 22	Cell 23	Cell 24	Cell 20	Cell 21	Cell 22	Cell 23	Cell 24	(mm)	Load (N)	(Mpa)
A	Round Spray	0	0	0	0	20%	100%	100%	100%	100%	1.196	1289	1148
B	Flat Spray	15	0	0	0	5%	11%	100%	100%	100%	1.182	1541	1404
C	Flat Spray	0	0	0	0	5%	100%	100%	100%	100%	1.192	1266	1135
D	Flat Spray	0	2	0	0	5%	0%	FOAM	0%	0%	1.179	1276	1168
E	Flat Spray	2	0	0	0	5%	FOAM	100%	100%	100%	1.191	1352	1214
F	Pipe Spray 2.55 g/m	0	0	0	0	0%	100%	100%	100%	100%	1.197	1287	1143
G	Pipe Spray 3 g/m	0	0	0	0	0%	100%	100%	100%	100%	1.183	1315	1197
H	Pipe Spray 2.55 g/m	20	0	50	0	0%	14%	100%	35%	100%	1.183	1267	1153
I	Pipe Spray 3 g/m	20	0	50	50	0%	14%	100%	35%	35%	1.205	1407	1234
J	Pipe Spray 1.5 g/m	0	0	0	0	0%	100%	100%	100%	100%	1.200	1250	1105
K	Pipe Spray 1.5 g/m	0	0	0	0	0%	100%	100%	100%	100%	1.210	1161	1010

[0045] As seen in Table 2, conventional 1.2 mm SAE 1070 steel wire was processed in a plurality of cells 20-24, containing liquid 53 preferably quenchant RAQ-TWT as described above diluted to 10% concentration in water by volume with gas 55 combining therewith to form quenchant mixture 45.

[0046] In Example A, cell 20 was modified to apply a 3/8 inch round spray perpendicular to the wire.

[0047] In Examples B-E, cell 20 was modified to apply a 6 inch flat spray parallel (1/8 inch thick) to the wire.

[0048] In Examples F-K, cell 20 was modified to apply a pipe spray in the range of 1.5-3 g/m while the wire was encased in a 3/8 inch thick, 4 inch long pipe at various flow rates.

[0049] By bubbling gas 55 (preferably air) through liquid 53 at various rates in individual cells 21-24 the breaking loads and tensile strength of wire 11 can be treated with vapors 56.

[0050] In Example A, as seen in Table 2, the preferred method utilizes a round spray and nominal 1.2 mm diameter wire (1070 steel) treated with a resulting breaking load of 1289 Newtons (N) and a tensile strength of 1148 Megapascals (MPa). Example D shows the flat spray method with the same 1.2 mm wire being treated only in cell 20 and 22 and

obvious changes to the apparatus and processing steps, depending on the requirements of the user.

I claim:

1. A method of treating metal comprising the steps of:
 - a) heating the metal;
 - b) subjecting the heated metal to a quenchant comprising a liquid and a gas mixture;
 - c) controlling the liquid/gas mixture; and
 - d) removing the treated metal from the quenchant.

2. The method of claim 1 wherein heating the metal comprises the step of passing the metal through an oven.

3. The method of claim 1 wherein heating the metal comprises the step of heating the metal to at least 930° C.

4. The method of claim 1 wherein the step of heating the metal comprises the step of heating a steel wire of 2 mm diameter.

5. The method of claim 1 wherein the step of heating the metal comprises the step of heating a steel wire of 1.2 mm diameter.

6. The method of claim 4 wherein the wire diameter is between 0.90 mm and 3.5 mm.

7. The method of claim 1 wherein the step of heating the metal comprises heating a carbon steel product with a carbon content of at least 0.350 percent by weight.

8. The method of claim 1 wherein the step of heating the metal comprises the step of heating a carbon steel product containing chromium, boron and silicon.

9. The method of claim 1 wherein subjecting the heated metal to a quenchant comprises the step of subjecting the heated metal to a plurality of cells containing liquid and gas mixtures.

10. The method of claim 1 wherein subjecting the heated metal to a quenchant comprises the step of subjecting the heated metal to an aqueous liquid at about 100° C.

11. The method of claim 1 wherein subjecting the heated metal to a quenchant comprises the step of subjecting the metal to a mixture having at least 4% air by volume.

12. The method of claim 1 wherein subjecting the heated metal to a quenchant comprises the step of subjecting the metal to a mixture having at least 0-25% air by volume.

13. The method of claim 1 wherein subjecting the heated metal to a quenchant comprises the step of subjecting the metal to a mixture having air by volume in the range of 4-25%.

14. The method of claim 1 wherein controlling the liquid/gas mixture comprises the step of controlling the flow rate of the gas through the liquid.

15. Apparatus for treating metal comprising: a cell, a heater, said heater communicating with said cell, said heater for maintaining the temperature of a liquid contained within

said cell, a gas supply, said gas supply in communication with said cell for supplying gas to said cell.

16. The apparatus of claim 15 further comprising a guide, said guide proximate said cell to direct the metal to said cell.

17. The apparatus of claim 15 further comprising a liquid, said liquid contained within said cell.

18. The apparatus of claim 17 wherein said liquid comprises water.

19. The apparatus of claim 15 further comprising a gas, said gas directed from said gas supply into said cell.

20. The apparatus of claim 19 wherein said gas comprises air.

21. The apparatus of claim 15 further comprising a gas regulator, said gas regulator in communication with said gas supply.

22. A treated metal having an improved tensile strength formed by the process of:

- a) heating a metal to a selected temperature;
- b) guiding the heated metal into a liquid and gas mixture to treat the metal; and
- c) removing the treated metal from the liquid and gas mixture.

23. The metal formed as in claim 22 wherein heating the metal comprises the step of heating the metal to about 930° C.-1050° C.

* * * * *