

May 25, 1971

I. BEHAR

3,580,746

PROCESS FOR THE MODIFICATION OF THE MECHANICAL
CHARACTERISTICS OF CARBON STEEL WIRE

Filed Sept. 29, 1967

3 Sheets-Sheet 1

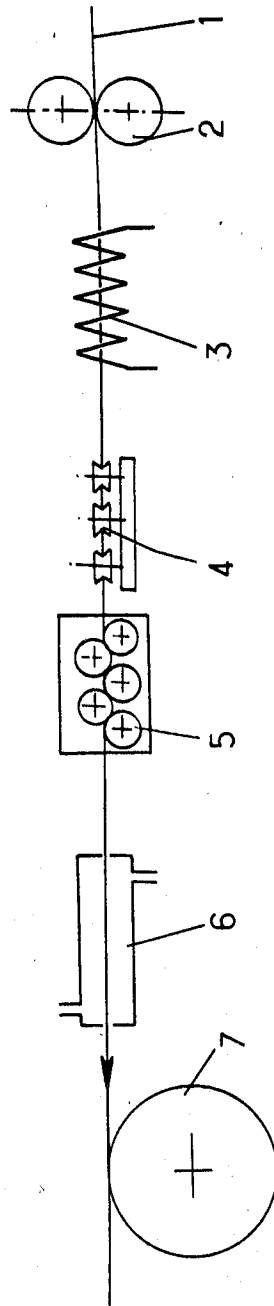


Fig. 1

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3 Sheets-Sheet 2

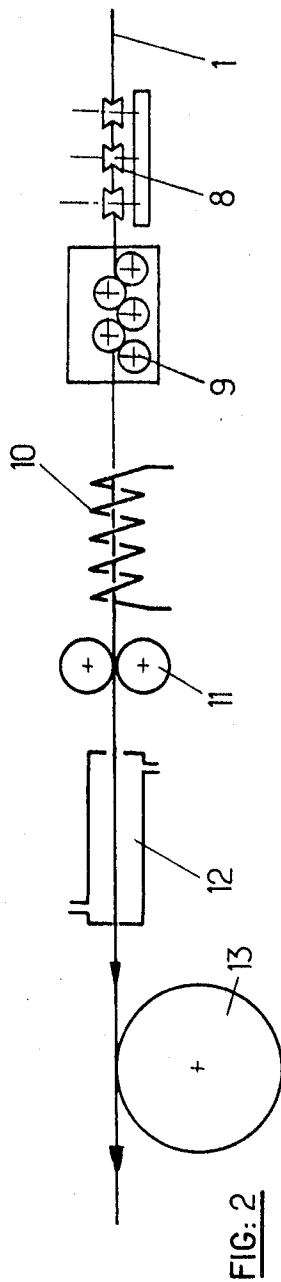


FIG. 2



FIG. 3d



FIG. 3c



FIG. 3b

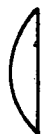


FIG. 3a



FIG. 3



FIG. 4c

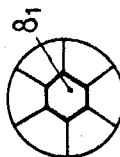


FIG. 4b



FIG. 4a

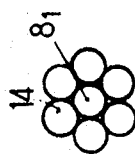


FIG. 4

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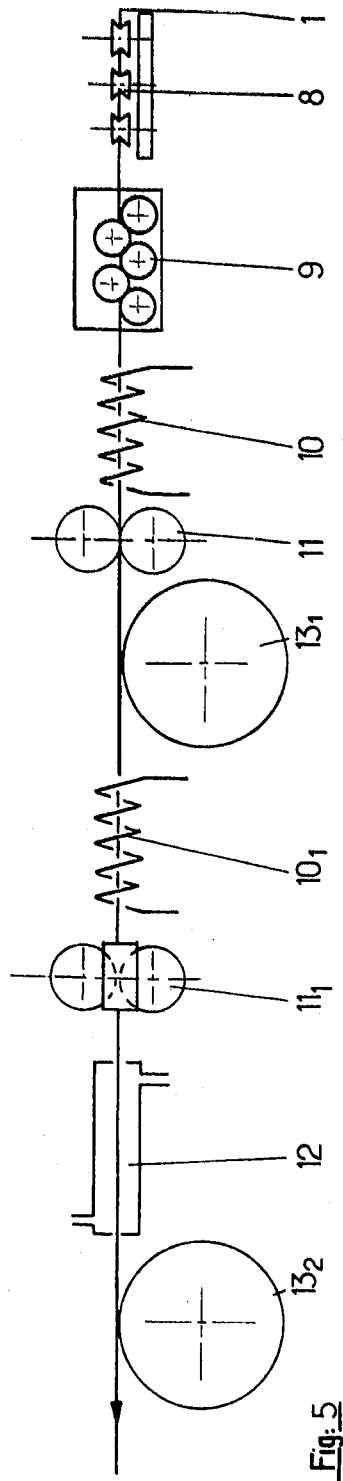
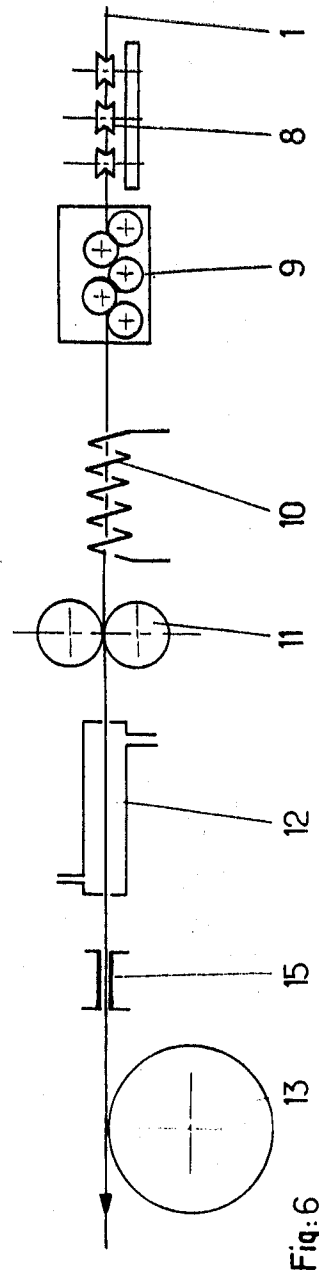
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3 Sheets-Sheet 3



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PROCESS FOR THE MODIFICATION OF THE
MECHANICAL CHARACTERISTICS OF CARBON
STEEL WIRE

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8 Claims

ABSTRACT OF THE DISCLOSURE

The invention deals with a process for the modification of the mechanical characteristics of carbon steel wire, consisting of the following first patenting, then cold deforming, and finally deforming said wire at a temperature above the ambient temperature but below the recrystallization temperature of the steel in said wire, by applying transverse force to said wire.

Carbon steel wire of high mechanical properties are usually used for the manufacture of springs and the reinforcing of prestressed concrete.

The most frequent compositions used for these purposes are as follows:

Carbon	0.60-0.90
Manganese	0.50-1.25
Silicon	0.10-0.40

The remainder is composed of iron and impurities usually present in industrial products.

Improved mechanical properties are usually obtained by a succession of the following operations:

Patenting by heating to 850°-950° and rapid cooling to 400-550°;

Cold drawing (the wire being drawn through several draw-plates (dies) which progressively reduce the section of the wire).

The patented and cold drawn wires are wound around a capstan and are thus presented in the form of a coil.

For the application of these wires to prestressed concrete and certain springs the following properties should be obtained:

- (a) a sufficient degree of straightness,
- (b) a high tensile strength,
- (c) a high elastic limit,
- (d) a high elongation value.

Existing drawn wires do not adapt themselves to these applications, because although they have a high tensile strength their elastic limit and elongation factor are too low, and they also present a curvature corresponding to the form of the wire drawing rollers.

The wires must therefore undergo a straightening treatment and the elastic limit and elongation factor must be increased.

There exist means of mechanical straightening which consist of subjecting the wire to alternate and gradually decreasing stresses.

The practical methods generally used are as follows:

(a) The wire is passed through two rollers placed at 90° to each other, and is successively subjected to gradually decreasing angular deflections.

(b) The wire is passed through eccentric dies which form part of a rotating framework. The wire is thus simultaneously subjected to alternate bending forces on each of its generatrices, as well as to alternate torsional

forces, increasing progressively and then decreasing in the direction of movement of the wire.

The straightening resulting from these two known methods produces a straight wire with an improved elongation factor, but the disadvantages are that the tensile strength, and above all the elastic limit, which is already low after drawing, are decreased.

The mechanical properties may also be modified by cold rolling at ambient temperature and by hot rolling at a temperature high enough for the recrystallization of the steel during the process. The hot rolling is usually carried out at the AC3 point of steel, i.e. above the temperature at which the steel passes from the body centred cubic structure to a face centred cubic structure.

At ambient temperature, the steel possesses a low plasticity and for cold working numerous reducing stages are necessary; it is even necessary occasionally to interrupt the cold treatment in order to carry out a recrystallization process (heat treatment).

The hot rolling, being carried out at recrystallization temperature, allows much greater deformation than at ambient temperature, but results in a lower mechanical resistance.

The main purpose of the invention is to remedy these inconveniences. It deals with, in effect, a process for the modification of the mechanical properties of carbon steel wire, by means of mechanical straightening, modification of the section or the shape at a temperature above ambient and below the recrystallization temperature of steel. The wire is then cooled to the ambient temperature and wound on to a bobbin of sufficient diameter to avoid bending.

Other purposes and advantages of the invention are borne out by the following description and claims and the enclosed sketches of which:

FIG. 1 is a schematic view of an installation to carry out the process of straightening of carbon steel wire;

FIG. 2 is a schematic view of an installation to carry out the process of drawing carbon steel wire;

FIGS. 3, 3a, 3b, 3c, and 3d are views showing the wire sections obtained by one single rolling operation;

FIGS. 4, 4a, 4b, and 4c are views showing a strand or a group of parallel wires which are transformed by deformation of the group of wires.

FIG. 5 is a schematic view showing an alternative method of carrying out the process;

FIG. 6 is a schematic view showing the manufacture of a wire having a high plasticity;

The installation to carry out the process of rectification of carbon steel wires (FIG. 1) comprises, for example, a set of rollers-guide 2, through which is passed the wire to be straightened 1; the wire is led into a heating zone made up of, for example, an induction heating coil 3.

The wire which is at the desired temperature is straightened, mechanically by alternate bending, which is obtained by 2 sets of rollers 4 and 5 which are placed at 90° to each other; the wire passes through a cooler 6 and is then wound around a spool or bobbin of sufficient diameter to avoid bending.

The tables of comparison 1 and 2 indicate the advantages offered by the invention as compared to the normal processes.

TABLE 1

	Straightening at—	
	Ambient temperature plus annealing at 280° C.	280° C.
Yield point, kg./mm. ²	174	183
0.1% yield strength, kg./mm. ²	153	172
Extension based on a length of 500 mm., per cent	4.03	4.42

TABLE 2

	Straightening at—	
	Ambient temperature plus annealing at 280° C.	280° C.
Creep loss in 2 hours under load to 80% stress at the yield point, percent.....	0.039	0.010
Percent relaxation loss after 120 hours at an initial tension of 70% of the stress at the yield point, percent.....	4.6	1.5

In both cases the wire used had the following composition:

	Percent
Carbon	0.80
Manganese	0.70
Silicon	0.20
Sulphur and phosphorus	0.06
The remainder: iron and impurities.	

After patenting and cold drawing from 11 mm. to 7 mm. the following properties were obtained:

	Kg./mm. ²
Yield point	173
0.1% yield strength	112
Elongation at yield point for a length of 500 mm.: 2.5%.	

Following the usual procedure the wire is straightened at ambient temperature by alternate bending, then treated at 280° C., cooled and wound.

The properties obtained after straightening and annealing are noted in Table 1; after straightening at ambient temperature, the wire has the following properties:

	Kg./mm. ²
Yield point	172
0.1% yield strength	108
Elongation at yield point for a length of 500 mm.: 3.2%.	

In accordance with the process described in the invention, the wire is heated to 280° C. and straightened by alternate bending at this same temperature, then cooled and wound at ambient temperature, as shown on the accompanying drawing.

It may be noticed in the quoted example that the straightening at ambient temperature decreases the yield point and yield strength which are afterwards restored by the final annealing; the yield point after mechanical straightening at ambient temperature and annealing at 280° C. therefore closely resembles the yield point of the wire after drawing.

By contrast, in the process described by the invention the straightening at the annealing temperature not only prevents the reduction of the yield point of the wire, but actually increases it; also, the elastic limit of the wire is higher, which is a valuable property when the wire is used in springs and reinforcements of pre-stressed concrete.

The wires produced following the process of this invention also possess improved properties of creepage and stress relief.

When a spring is maintained under constant load it has a tendency to extend through the effect of creepage and the spring is considered more satisfactory when the extension produced by a constant effort is held to a minimum.

However, in the case of pre-stressed concrete reinforcements which are maintained at a constant length or in the case of springs which are subject to constant deformation it is established that the initial tension of the reinforcements or of the spring diminish progressively with time under the effect of stress relief.

The steels which are used for the compression of cement or in the form of springs are considered much better

when the stress relieving takes place during a shorter period.

Table 2, which contains the values of creepage and of stress relief for a steel straightened at ambient temperature and annealed following a conventional process, and for the same steel straightened following the new process which is the subject of this invention, at a temperature, above ambient and less than the temperature of recrystallization, shows the important differences in resulting properties.

It is noted that the process of the invention reduces the stress relieving and the creepage in considerable proportions thus allowing a substantial economy of steel.

The process applied carbon steel wires consists, as is represented by FIG. 2, in straightening the wire 1 by leading it through the sets of rollers placed at 90° to each other 8 and 9 and/or passing it through the guides.

Having completed the straightening, the wire is heated, for example, by means of an induction heating coil 4 which brings the wire temperature to about 300° C.

The wire is then compressed in one single passage at this temperature between a set of rollers 11.

The flat wire thus obtained (FIG. 3b) is cooled to ambient temperature during its passage through the cooler 12 and is then wound on to a special spool or reel 7.

The above process was applied using principally a wire of 8 mm. having a carbon content of 0.60%, manganese of 0.65%, sulphur and phosphorus of 0.06%. The remainder was comprised of iron and the impurities usually found in commercial steels. This wire was patented (to 900° C. and rapid cooling to 500° C.) then descaled, dephosphated and drawn on a conventional drawing machine in several passes from 8 mm. to 5 mm.

The wire which was treated following the above process had the following characteristics:

Width—9 mm.
Thickness—1.9 mm.
Tensile strength—150 kg./mm. ²
Elastic limit—134 kg./mm. ²
Elongation—5.3%

It is obvious that the process, dealt with by this invention, allows a considerable economy in the manufacture of such formed wires.

A flat wire produced by the said process presents improved characteristics of elongation, resistance to creepage, stress relief and tensile strength. These advantages may be seen from the following table:

	Drawing and cold rolling, percent	Cold drawing followed by 300° C. rolling, percent
Elongation of 500 mm. length.....	3	5.3
Creep loss after 2 hours tension at 80% yield point.....	0.05	0.008
Percent relaxation loss after tension for 120 hours at 70% of the yield point.....	5.3	1.2

A low creep loss is advantageous for applications where springs are subjected to a constant load, because as a result of this, the plastic deformation will be less and consequently the life of the spring will be increased.

The low relaxation losses in wires produced by this process offer advantages in applications where springs are subjected to a constant load as well as the application of wires for concrete under compression (steels for pre-stressed concrete).

In these two cases the wires under load lose their initial tension less rapidly than if they were manufactured according to the other described process.

The process is equally applicable when the section required has a complex form with concave and convex sections. The wire, having been already heated to between 100° C. and the crystallization temperature, passes through grooved rolling cylinders which contain convex

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and concave zones, corresponding to the section required on the finished wire.

In FIGS. 3, 3a, 3b, 3c, and 3d are shown non-limiting examples of sections obtainable by a single rolling passage. In the production method shown in FIG. 4, a strand or a group of parallel wires 14, consisting of separate wires is transformed by one pass of the roller into triangular (FIG. 4a), round (FIG. 4b), or oval (FIG. 3c) sections.

In the method shown by FIG. 5, the wire is subjected to two passes of the roller at a temperature above ambient and below crystallization temperature; the wire 1 passes successively through the straightening rollers or guides 8 and 9 and is then brought up to temperature by means of a self induction heating coil 10. The wire is subjected to a preliminary transformation by the cylinders 11 and is then wound onto a capstan 13. Following this, it is led into the induction heating zone 10, before another transformation process by means of a set of 4 drawing dies 11. Finally it is cooled 12 and wound on to a special spool before being stored.

In the process of manufacture shown by FIG. 6, the wire is subject to drawing or deformation of section at a temperature above ambient and below that of recrystallization followed by drawing or deformation of section at ambient temperature. The wire 1, already having been treated, is brought into the induction heating zone 10 and is subjected to deformation between the rollers 11, at a temperature between 100° C. and that of recrystallization.

The wire is then cooled by a cooler 12 and is cold drawn by means of a die 15 before being wound onto a spool or bobbin 13.

The type of process is particularly suited to the manufacture of a wire having a high modulus of elasticity. The elastic limit of the wire is lowered by means of a passage through the drawing dies 15 at ambient temperature.

Another variant of the process is to obtain the final section by drawing the wire at a temperature between 100° C. and that of recrystallization. Then the elastic limit is reduced by submitting the wire to alternate bending efforts at ambient temperature, by passing it through a straightener.

The invention, of course, is not limited to the examples of manufacture described above and by the accompanying drawings, but may also embody other ways and means of manufacture without exceeding the limits of the specification; for example, the scope of the invention is not exceeded if the cylinders of the rolling mills are replaced by any other arrangement for modifying the form or section of the wire, regardless of the section so obtained, providing that the wire is previously heated to a temperature between 100° C. and that of recrystallization and then undergoes deformation in this temperature zone.

Similarly, it is possible to combine several methods of

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deforming the wire, each method being carried out while the temperature of the wire is between 100° C. and the temperature of recrystallization of steel.

It is equally possible to combine methods of deformation carried out while the temperature of the wire is between 100° C. and the recrystallization temperature with deformation produced at ambient temperature; the latter deformation is carried out between 100° C. and recrystallization temperature when a higher elastic limit is required, and at ambient temperature for a wire with a high modulus of elasticity.

Finally the induction heating coils may be replaced by any other known type of heating such as: The Joule effect, gas burners, molten metals etc.

What we claim is:

1. Method of making an elongated medium or high-carbon steel product having a high ultimate tensile strength, a high elongation at rupture, and a high elastic limit, which method comprises the steps of patenting an elongated hot-rolled product, subjecting said product to cold mechanical deformation, heating said product to a temperature in excess of the ambient temperature and below the temperature of recrystallization of the steel therein, and then subjecting said steel product at said last mentioned temperature to permanent deformation by applying force thereto in directions transverse to the longitudinal axis of said elongated product.

2. Method as claimed in claim 1 in which said elongated product is a steel wire.

3. Method as claimed in claim 1 in which said elongated product is a bundle of steel wires.

4. Method as claimed in claim 1 in which said cold deformation is produced by drawing said elongated product.

5. Method as claimed in claim 1 in which said cold deformation is produced by cold rolling.

6. Method as claimed in claim 1 in which said elongated product is straightened during said last-mentioned step, by flexing it in opposite directions.

7. Method as claimed in claim 1 in which said product is permanently deformed at said last-mentioned temperature by rolling it.

8. Method as claimed in claim 1 in which said last mentioned step is carried out at from 100° to 500° C.

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