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(54) **PRECIPITATION HARDENABLE AUSTENITIC STEEL**

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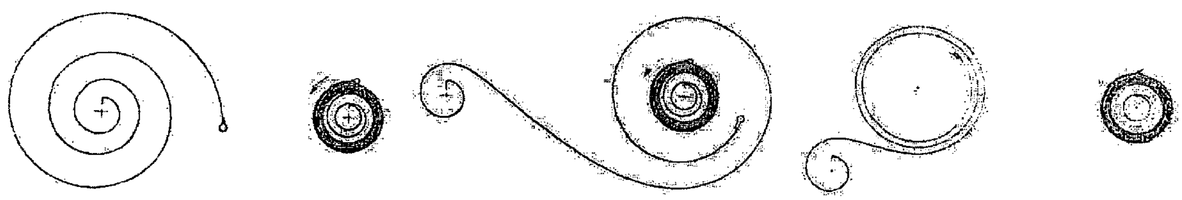
(57) **ABSTRACT**

The present invention relates to a stainless steel alloy, more precisely a highstrength stainless, precipitation hard-enable, austenitic, stainless alloy, containing a well adjusted amount of aluminium and a high silicon content and which has the following composition (in weight-%): C 0-0.07 Si 0.5-3.0 N 0-0.1 Cr 15.0-20.0 Ni 7.0-12.0 Al 0.25-1.5 Cu 0<Cu<4.0 Mn 0-3.0 Mo 0-2.0 Ti 0-1.0 and the balance Fe together with normally occuring impurities and additives and a product that is reduced by cold working, especially drawing, without intermediate heat treatment, the strength of which increases by final heat treatment at 300° C. to 500 ° C. by not less than 14%, that shows a M_{d30}-value of between −55 and −100, a loss of force that is smaller than 3.0% at 1 N during 24 h and which is very suitable for use in spring applications, such as springs of round wire and strip steel and in medical applications, such as surgical and dental instruments.



A) Simple wound spring

B) Resilient wound spring

C) Cross-curve wound spring

Figure 1

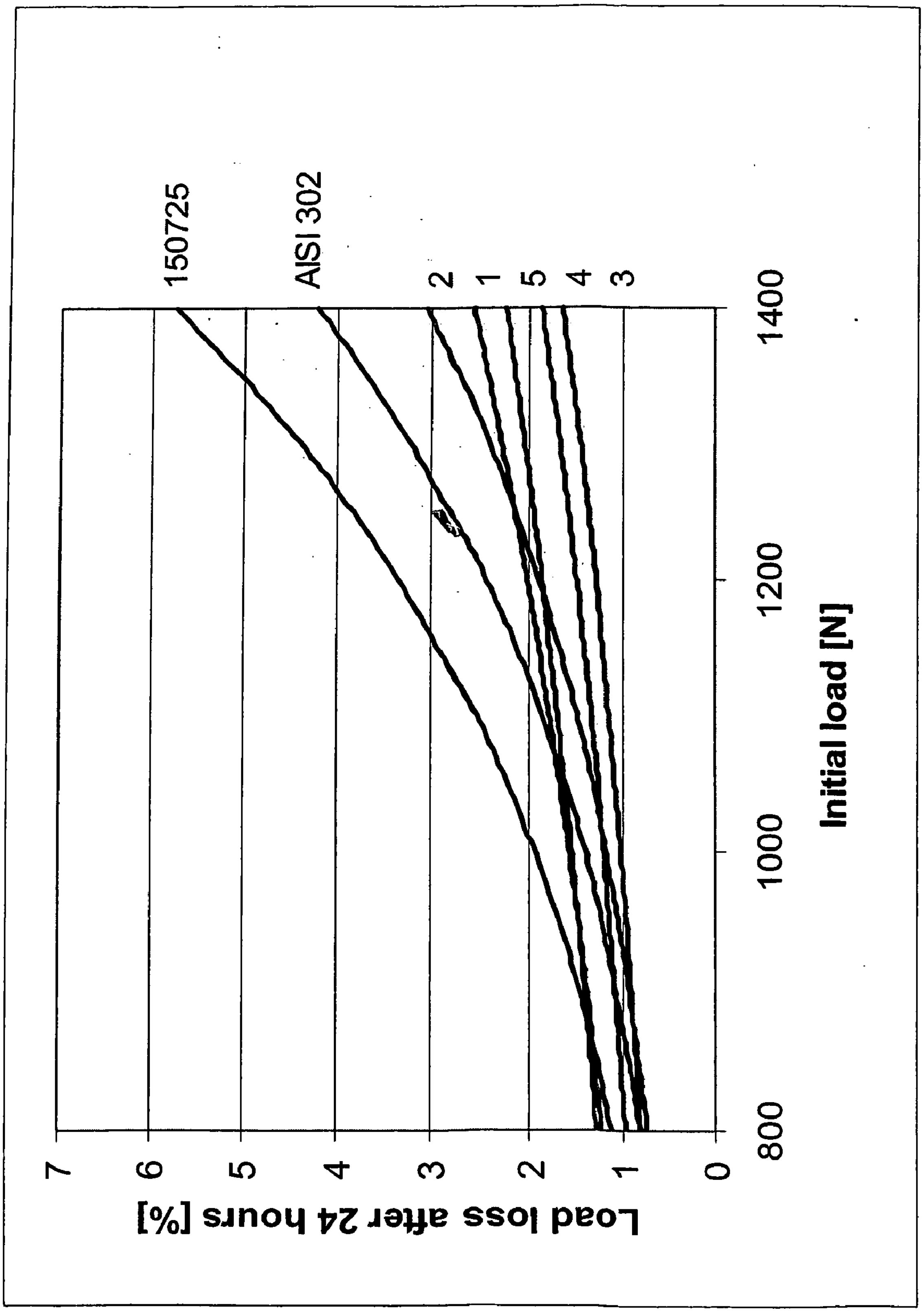

150725
AISI 302
2
1
5
4
3
Load loss after 24 hours [%]
0
1
2
3
4
5
6
7
800
1000
1200
1400
Initial load [N]

Figure 2

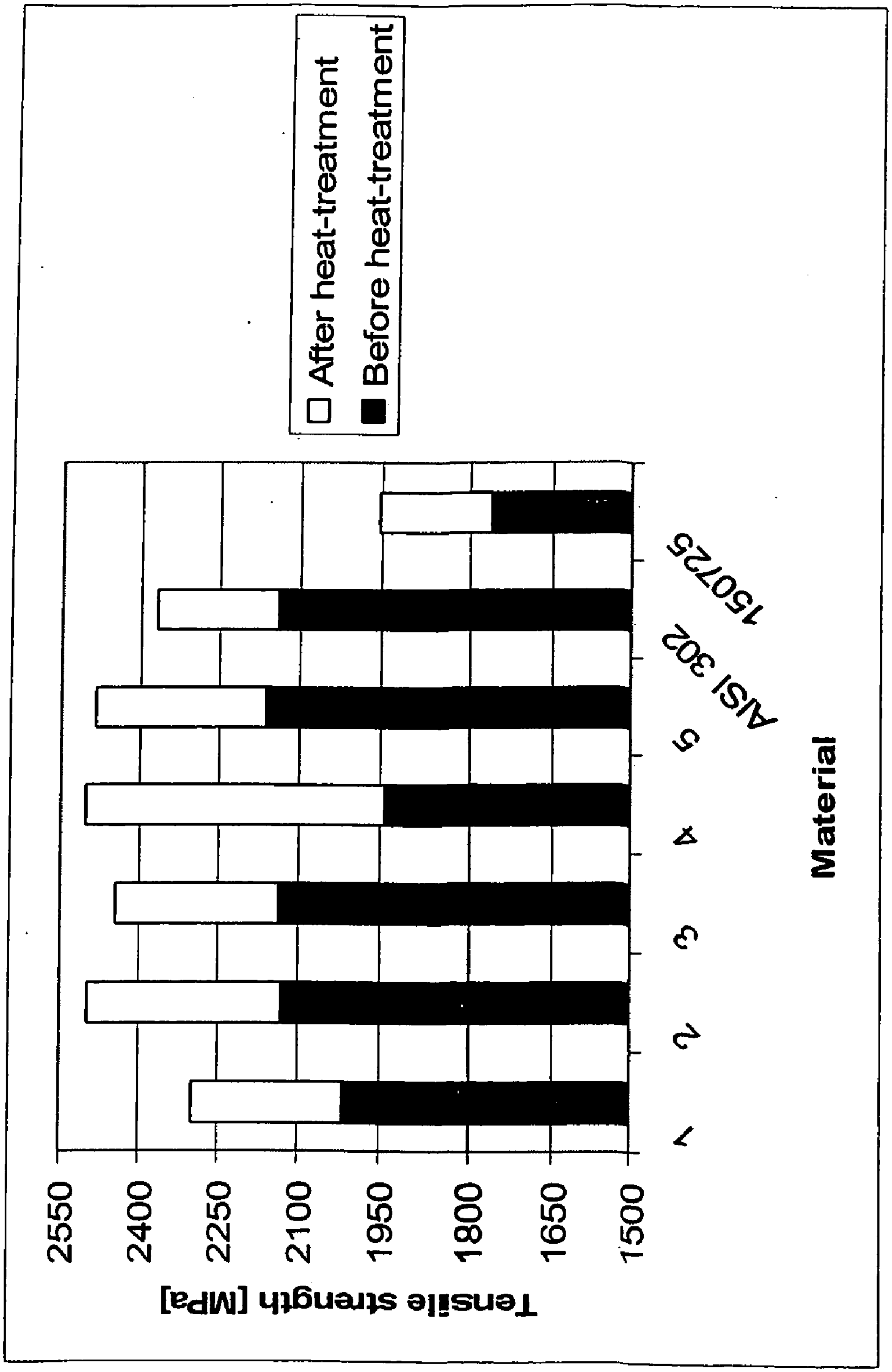
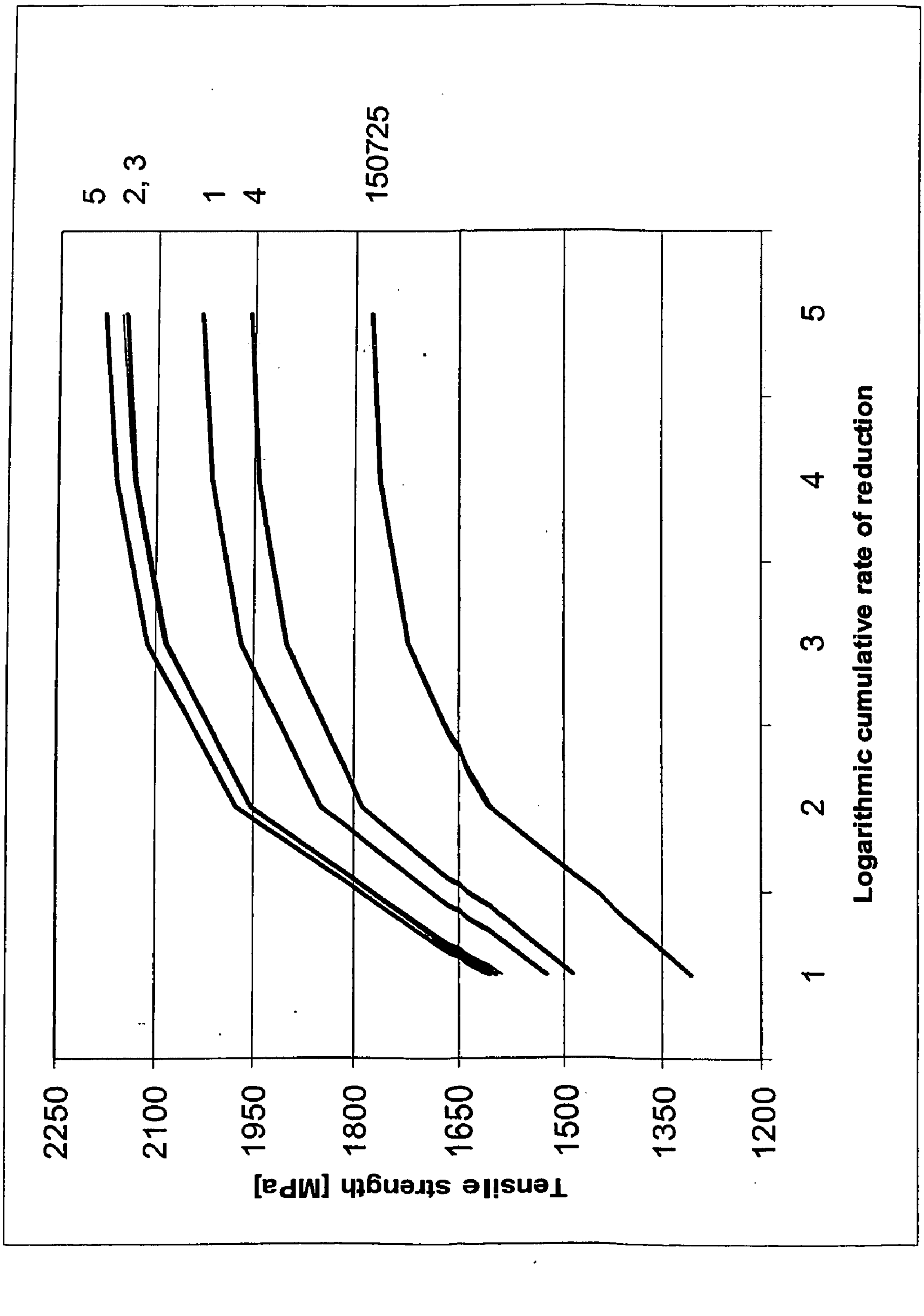

After heat-treatment
Before heat-treatment
Tensile strength [MPa]
2550
2400
2250
2100
1950
1800
1650
1500
1
2
3
4
5
AISI 302
150725
Material

Figure 3



Tensile strength [MPa]
2250
2100
1950
1800
1650
1500
1350
1200
Logarithmic cumulative rate of reduction
1
2
3
4
5
5
2, 3
1
4
150725

Figure 4

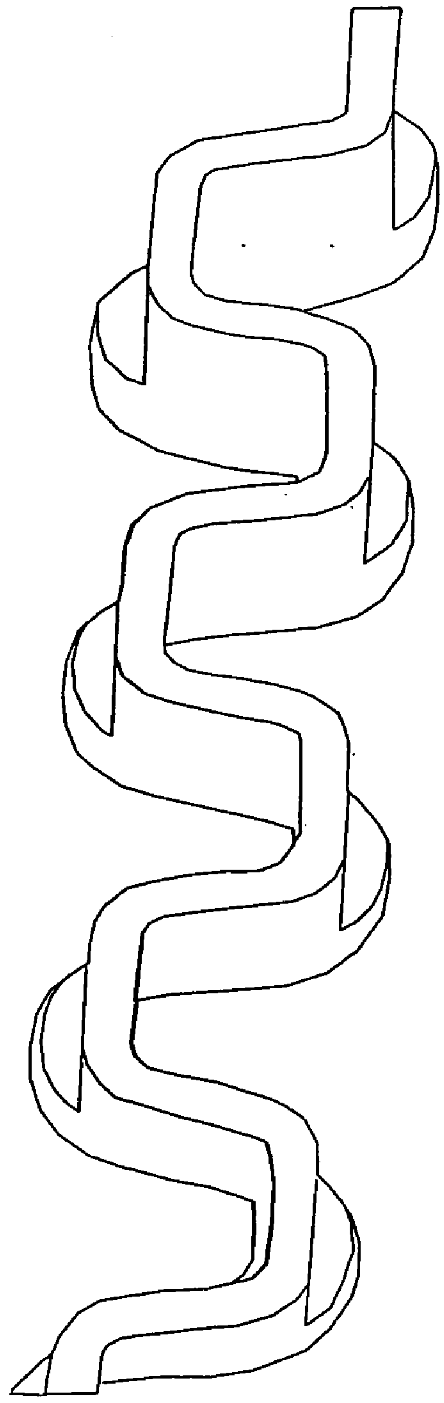


Figure 5

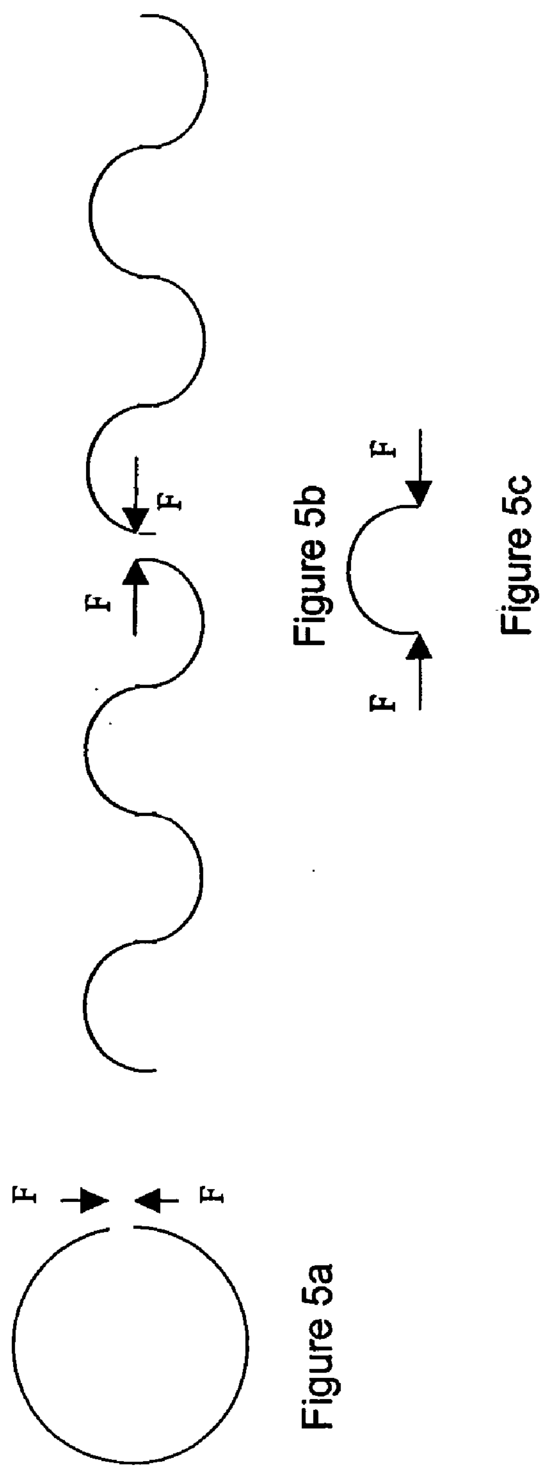
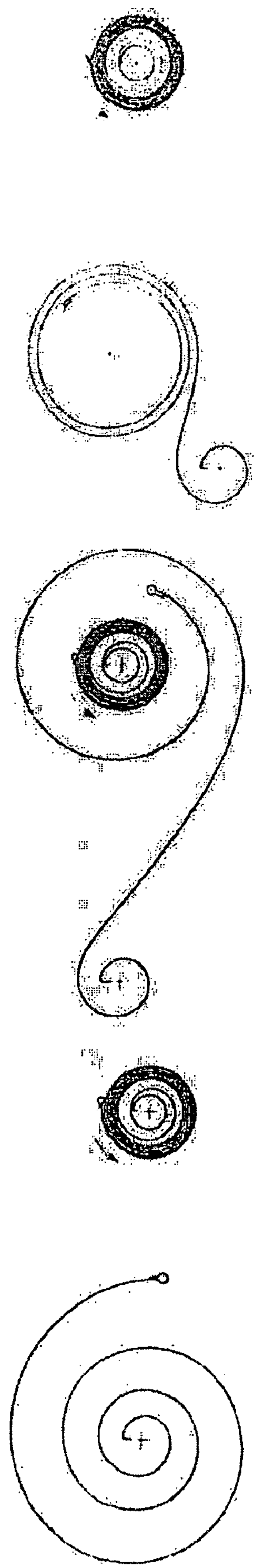


Figure 5a

Figure 5b

Figure 5c

Figure 6



A) Simple wound spring

B) Resilient wound spring

C) Cross-curve wound spring

PRECIPITATION HARDENABLE AUSTENITIC STEEL

TECHNICAL AREA OF THE INVENTION

[0001] The present invention relates to an austenitic stainless steel alloy, more precisely a high-strength precipitation hardenable austenitic stainless steel alloy containing a well balanced aluminium content and a high silicon content, a product which is reduced by cold working, especially drawing, without intermediate heat treatment, the strength of which increases through final heat treatment at 300° C. to 500° C. by not less than 14%, which shows a M_{d30}-value of between −55 and −100, a loss of force that is lower than 3.0% at 1400 N during 24 hours and which is very suitable for use in spring applications, such as springs of round wire and strip steel and in medical applications, such as surgical and dental instruments.

BACKGROUND OF THE INVENTION

[0002] On the market for stainless spring steel, the cold-Worked austenitic stainless springsteels of type AISI 302 assume a dominating position. This is based on a combination of relatively good corrosion resistance and a possibility to cold-work the material to a considerable strength, which is a prerequisite for a good spring material. Based on the cold-worked state, the mechanical properties may be increased additionally by means of a simple heat treatment. Steel of the type AISI 631 is alloyed with aluminium in order to additionally enhance the increase of strength at heat treatment. During cold-working, a transformation takes place from the annealed structure's principal constituent of austenite to deformation martensite, which is harder than the phase from which it is formed. This quick deformation hardening simultaneously decreases the ductility of the material, and for that reason soft annealing has to be executed at one or several steps in the production chain. This makes the production process more expensive, as well as increases the risk of introducing surface defects in the material. For steel of the type AISI 631, the addition of aluminium entails that the material tends to form ferrite in the structure during solidification after casting. The resulting austenite-ferritic structure and relatively low alloy content entails a quick deformation-hardening, which means that only moderate reductions are possible in order to avoid formation of cracks during the production process. Alternatively, steels of the type AISI 304 and AISI 316 are used as spring steels. These steels are higher alloyed and have a lower carbon content than steels of the type AISI 302 and AISI 631. This entails that a higher rate of reduction can be allowed in this type of steel. The disadvantage of these steels is that the resulting product properties that are essential for a good spring function frequently are worse than for steels of AISI 302 and AISI 631. One example of such a property is the resistance to relaxation, which describes the ability of a spring to retain spring strength over time.

[0003] U.S. Pat. No. 6,106,639 describes a Cr—Ni—Cu steel, which can be reduced strongly between the annealings. In the exemplification it is indicated that a strength of 1856 MPa at a reduction of ϵ=3,41 (5,5 to 1 mm). This is compared with a specified strength according to the standard of 2050 MPa. According to U.S. Pat. No. 6,106,639, a heat treatment has to be performed to allow the alloy to attain strength values according to this standard. The alloy according to U.S. Pat. No. 6,106,639 contains copper as strength increasing element at heat treatment.

[0004] In U.S. Pat. No. 6,048,416, a Cr—Ni—Cu-steel intended for enhancement of vehicle tyres in the form of high-strength steel wire is described. In order to attain the desired properties, the alloy according to U.S. Pat. No. 6,048,416, must composition-wise be within a stability interval expressed by a so-called JM value (JM=551-462×(C %+N %)−9.2×Si %−20×Mn %−13.7×Cr %−29×(Ni %+Cu %)−18.5×Mo %), which should be greater than −55 but less than −30. In the alloy according to the invention, the cumulative logarithmic ($\epsilon=2*\ln(S_0/S_f)$) rate of reduction is limited to 4 as a maximum. This corresponds to a maximal area reduction at wire drawing of 98%. Besides copper, the alloy according to U.S. Pat. No. 6,048,416 contains no precipitation-hardening element.

SUMMARY OF THE INVENTION

[0005] Therefore, it is an object of the present invention to provide a high strength, precipitation hardenable, austenitic stainless steel alloy containing a well-balanced amount of aluminium and a high silicon content, a product, which is reduced by cold-working, especially drawing, without an intermediate heat treatment, the strength of which increases by final heat treatment at 300° C. to 500° C. with not less than 14%, which shows shows a Md30-value of between −55 and −100, a loss of force that is lower than 3.0% at 1400 N during 24 hours and which is very suitable for use in spring applications, such as springs of round wire and strip steel and medical applications, such as surgical and dental instruments.

[0006] According to the present invention, these objects are attained by a high-strength, precipitation hardenable, austenitic stainless steel alloy, which contains (in weight-%):

C	more than 0 to 0.07
Si	0.5–3.0
N	>0–0.1
Cr	15.0–20.0
Ni	7.0–12.0
Al	0.25–1.5
Cu	0 ≦ Cu ≦ 4.0
Mn	>0–3.0
Mo	>0–2.0
Ti	>0–1.0

[0007] Balance Fe and normally occurring impurities and additives.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIG. 1** shows the loss of force of the springs after 24 hours of materials according to the invention compared with AISI 302 and charge no. 150725.

[0009] **FIG. 2** shows the ultimate tensile strength of materials according to the invention compared with AISI 302* (* —with intermediate heat treatment) and charge no. 150725.

[0010] **FIG. 3** shows the ultimate tensile strength as a logarithmic function of the cumulative reduction rate of materials according to the invention compared with charge no. 150725.

[0011] **FIG. 4** shows schematically a segment of a possible embodiment of an expanding ring in a side view.

[0012] **FIG. 5** shows in **FIG. 5***a* the ring seen from above. The ends are pressed against each other by the force F, in **FIG. 5***b* the ring is shown seen from the side, the ends being pressed against each other by the force F and in **FIG. 5***c* a part of the expanding ring is shown that constitutes a flat spring element and how this is influenced by the force F.

[0013] **FIG. 6** shows different embodiments for strip springs.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The importance of the alloying elements for the present alloy is as follows:

[0015] Carbon (C) has a high propensity to combine with chromium which means that chromium carbides is precipitated in the crystal grain boundaries, whereby the surrounding the bulk is depleted of chromium. Thus, at high carbon contents the corrosion properties of the material deteriorate, problems also arise with embrittlement that foremost causes problem when the wire is shaped to springs. Therefore, the carbon content should be held at as low a level as possible, being more than 0.0 weight-% , but maximum 0.07 weight-% , preferably 0.05 weight-% , most preferably maximum 0.035 weight-%.

[0016] Silicon (Si) has a ferrite-stabilising effect, which entails that too a high silicon content produces a two-phase structure. Therefore, the silicon content should not exceed 3.0 weight-% . However, silicon is also favourable in that it contributes to a greater increase of strength at heat treatment of the cold-worked product. Therefore, the silicon content should not be lower than 0,5 weight-% and should be in the range of 0.5 to 3.0 weight-% , preferably. between 0.5 and 2.5 weight-% , most preferably 0.5 to 1.5 weight-%.

[0017] Nitrogen (N) is an alloying element that together with aluminium forms non-disirable brittle slags in the form of aluminium nitrides. Further, nitrogen increases the deformation-hardening at cold-working, which is a disadvantage in the present invention. Therefore, it is of highest importance that the nitrogen content is held on as low a level as possible, maximum 0.1 weight-% , preferably 0.05 weight-%.

[0018] Chromium (Cr) is a very important alloying element what concerns the corrosion resistance of the material. This is due to the ability of chromium to form a passive layer of Cr_2O_3 on the surface of the steel. In order for that passive layer to form, it is required that the chromium content exceeds approximately 12.0 weight-% , in addition, the corrosion resistance increases with added chromium content. Another advantage of chromium is that the austenitic structure of the material is stabilized against transition to martensite at cold-working. However, chromium is ferrite-stabilising, and therefore the content should not be too high. Therefore, in the alloy according to the present invention the chromium content should not be lower than 15.0 weight-% and not be higher than 20.0 weight-% , preferably be in the range of 16.0 to 19.0 weight-%.

[0019] Nickel (Ni) is an alloying element that in a sufficient amount guarantees that the material gets an austenitic structure at room temperature. Furthermore, the ductility is improved with an increased nickel content. However, nickel is an expensive alloying element and high contents entail a slow deformation-hardening, which in its turn entails difficulties to attain a sufficient strength. Therefore, the nickel content should be within the range of 7.0 till2.0 weight-% , preferably between 8.0 till I.0 weight-% , most preferably within the range of 9.0 to 10.0 weight-%.

[0020] Aluminium (Al) is a central alloying element in the present invention. Aluminium is added as a precipitation hardening element in order to increase the strength, which in turn influences the relaxation resistance. During precipitation-hardening at 350-500° C. of the cold-worked wire, precipitations in the form of β-NiAL are formed, which improves the mechanical properties unlike materials known until now. This effect is of highest importance when the wire is to be used as springs, the relaxation resistance of which has to meet very high requirements. A disadvantage of aluminium is that it is ferrite-stabilizing, for what reason the aluminium content should be limited to maximum 1.5 weight-%. However, in the light of the above-mentioned, the aluminium content should be at least 0.25 weight-% and preferably be in the range of 0.41.0 weight-%.

[0021] Copper (Cu) is an alloying element that has two important properties. Firstly, copper is an austenite-stabilizing element and secondly copper decreases the deformation-hardening of the material and entails improved ductility. Since the material has to withstand extreme reductions without intermediate annealings, the copper content has to be as high as possible. However, with an increasing copper content, the risk of unwanted precipitations increases, which decreases the ductility of the material. Therefore, the copper content should be in the range of $0 \leqq Cu \leqq 4.0$ weight-% , preferably between 2.0 to 3.5 weight-% , most preferably between 2.4 to 3.0 weight-%.

[0022] Manganese (Mn) has similar effect as nickel, both with regard to forming austenite at setting as well as stabilizing the same against transformation into martensite at cold-working. However, manganese increases the deformation-hardening, which nickel does not. This results in a faster deformation-hardening and diminishes the greatest possible reduction rate between the annealings.

[0023] Therefore, the manganese content should be more than 0.0 weight-% , but being limited to maximum 3.0 weight-% , preferably to maximum 1.0 weight-%.

[0024] Molybdenum (Mo) is a ferrite-stabilizing element that has a strongly favourable effect on the corrosion resistance in chloride environments. Established PRE (Pitting Resistance Equivalent) formulas allocate molybdenum a factor of ≈3 in comparison with the effect of chromium. However, a high molybdenum content stabilises the ferrite phase in the steel. Further, there is an increased risk of precipitation of intermetallic phases, such as sigma phase. Therefore, the molybdenum content should be more than 0.0 weight-% , but limited upwards to 2.0 weight-%.

[0025] Titanium (Ti) is, like aluminium, a precipitation-hardening element that is added in order to increase the strength, which in turn influences the relaxation resistance. Furthermore, titanium together with silicon gives a strong heat treatment effect already at low contents of titanium. However, titanium is strongly ferrite-stabilizing, for what reason the content should not be too high. Therefore, the titanium content should be more than 0.0 weight-% , but being limited up to 1.0 weight-% , preferably maximum 0.75 weight-%.

[0026] Description of the Test Procedure

[0027] The test materials were produced by melting in a high frequency furnace. Subsequently, all test ingots were fully ground before they were forged. Forging was performed on the ingot to 103×103 mm length in stock. The heating temperature was in the range between 1240° C. and 1260° C. The holding time at full temperature was 1 h. At the subsequent blank treatment, the blanks were fully ground and ultrasonically tested.

[0028] The wire rod in the dimension range of Ø5.50 mm-Ø5.60 mm was produced by warming the blanks to 1200° C.-1240° C., whereupon they were rolled to final dimension and then cooled by water quenching. The hot-rolled wires were then cold-worked by drawing in a conventional drawing machine.

[0029] The chemical composition, in weight-% , of the alloys in the test program and reference materials are given in Table 1.

TABLE 1

Chemical composition (in weight-%)

	1	2	3	4	5	6	7	AISI 302	150725
C	0.023	0.021	0.023	0.027	0.033	0.024	0.019	≦0.12	0.011
Si	0.96	1.46	1.37	0.59	0.96	1.45	0.88	≦2.0	0.51
N	0.021	0.020	0.019	0.018	0.020	0.022	0.034	≦0.1	0.012
Cr	16.45	16.35	16.42	16.46	16.73	16.74	17.40	≧16.0 ≦19.0	17.44
Ni	9.68	9.61	9.73	9.82	9.02	9.38	9.32	≧6.0 ≦9.5	9.48
Al	0.42	0.93	0.81	0.83	0.44	0.96	0.71	—	<0.003
Cu	2.99	2.97	2.98	3.00	2.48	3.04	2.95	—	3.02
Mn	0.68	0.93	0.73	0.70	0.93	0.95	0.86	≦2.0	0.66
Mo	<0.01	<0.01	<0.01	<0.01	<0.01	0.17	0.07	≦0.80	0.16

[0030] The strength of the alloys in cold-worked state and after heat treatment at uniaxial tensile testing is seen in Table 2, where the ultimate tensile strength corresponds to the maximum value of the load in the elongation-load diagram. All alloys have been reduced to a logarithmic cumulative degree of reduction of ϵ=3.95 (corresponding to an area reduction of 98%) without intermediate annealing. AISI 302 could not be cold-worked to ϵ=3.95 without crack formation, because of which an annealing operation had to be carried out before drawing to finished dimension. However, all alloys have the same wire diameter.

[0031] The heat treatment was accomplished with the same purpose as for spring steel of the type AISI 302, when an increase of the mechanical properties is obtained. Thereby, several important spring properties, such as, for example, the relaxation resistance, are influenced but in a stronger way than known hitherto.

TABLE 2

Ultimate tensile strength before and after heat treatment.

Charge no.	Ultimate tensile strength after cold working [MPa]	Ultimate tensile strength after heat treatment [MPa]	Heat treatment effect [%]
1	2014	2298*	14.1
2	2132	2496*	17.1
3	2136	2442*	14.3
4	1942	2502*	28.8
5	2162	2482**	14.8
AISI 302	2140	2370*	10.7
150725	1760	1953*	11.0

*Heat treatment time = 1.5 h, Heat treatment temperature = 350° C.
**Heat treatment time = 1.0 h, Heat treatment temperature = 480° C.

[0032] For evaluation of the relaxation resistance, springs of the type cylindric helical springs not having lined-up turns were produced. The test results are seen in Table 3.

TABLE 3

Spring dimensions	
Wire diameter (D_t)	0.762 mm
Inner diameter of the springs	6.84 mm
Average diameter (D_m) of the springs	7.6 mm
Pitch	1.52 mm
Number of turns (N_v)	50.5

[0033] The spring force (F) and the total spring suspension (f_t) were determined at room temperature by means of a force versus load curve. Subsequently, the spring constant (C) and shear modulus (G) were calculated by means of equation 1 and 2.

$$C=(F*N_v)/f_t \quad \text{Equation 1.}$$

$$G=(8*F*N_v*D_M^3)/(ft*D_t^4) \quad \text{Equation 2.}$$

[0034] The relaxation test was accomplished by loading blued springs with a constant load. The load was read each minute under the first five minutes and then the number of read-outs was cut down. Each test was stopped after twenty-four hours. Springs from the respective charge were loaded initially on four different levels. The relaxation was calculated by means of equation 3 and the results are summarised in **FIG. 1**.

$$R=((F_1-F_2)/F_1)*100 \quad \text{Equation 3.}$$

[0035] where

[0036] R=Relaxation

[0037] F_1=Initial load

[0038] F_2=Load at a given time

[0039] In **FIG. 1** it is seen that the alloy having a very low aluminium content, i.e. charge no 150725 relaxes considerably stronger than the alloys in the test program, which all have aluminium as an active alloying element. Furthermore, all alloys in the test program have an equivalent or better relaxation resistance than AISI 302.

[0040] M_{d30}/Nohara shows the temperature where at a rate of cold reduction of 30% , 50% of the austenite in the steel is transformed to transformation-martensite. A higher value for the temperature indicates, that the structure is more stable (more disposed to form martensite) and leeds to a higher rate of cold-deformation in the steel.

[0041] The M_{d30}-value according to Nohara is caculated by the formula:

$$M_{d30}\text{/Nohara}=551-462\times(c+N)-9,2\times\text{Si}-8,1\times\text{Mn}-13,7\times\text{Cr}-20\times(\text{Ni+Cu})-8,5\times\text{Mo}-68\times\text{Nb}-1,42\times(\text{ASTM grain size }-8).$$

[0042] Table 4 shows the results for the test charges 1 to 7. It has surprisingly shown that a steel with the composition according to the present invention attains the best heat treatment effect at M_{d30}-valus of between −55 and −100 and the highest increase in ultimate tensile strength after solely cold working without intermediate heat treatment.

TABLE 4

	M_{d30}/Nohara	
Charge nr.	Ni-ekvivalent	M_{d30}/Nohara [° C.]
1	23.60	−76.5
2	23.65	−77.7
3	23.64	−80.5
4	23.50	−78.2
5	23.19	−52.6
6	23.79	−80.8
7	23.99	−82.8

[0043] Description of Preferred Embodiments

[0044] In the following, some embodiments of the invention are described. These are intended to illustrate the invention, but not limit it.

[0045] The steel according to the present invention is subjected to a strong cold deformation. It can be shaped to different cross-section geometries, for example, oval wire, profiles of different cross-sections, for example, rectangular, triangular or more complicated embodiments and geometries. Round wire may even be flat-rolled.

EXAMPLE 1

Springs of Round Wire

[0046] As been described above, springs of wire made from the alloy according to invention are wound. These springs have good spring properties in the form of relaxation, i.e. the retention of spring force under a long period and are advantageously used in typical spring applications, such as, for instance, springs in locking applications, i.e. mechanical parts in the locking device, springs in aerosol containers, pens, especially ball point pens, pump springs, springs in industrial looms, springs in the vehicle industry, electronics, computers and fine mechanics.

EXAMPLE 2

Springs of Strip Steel

[0047] For plane torsion springs, the torque is a decisive quantity. The torque can be expressed as

$$M=\frac{E*I*2*\pi*(n-n_0)}{L}$$

[0048] where:

[0049] M=the torque of the spring

[0050] I=moment of bending inertia ($b*t^3/12$)

[0051] B=spring strip width

[0052] T=spring strip thickness

[0053] L=extended spring length

[0054] no=number of turns at free spring (unmounted)

[0055] n=number of working turns

[0056] In order to increase the torque at a given spring geometry, a so-called reverse winding may be accomplished. At a so-called "resilient" winding, the spring is preformed by being wound in a direction opposite the working direction. Then a heat treatment of the spring takes place, after which it is wound-in in the opposite direction in the spring housing. At so-called "cross curve" winding, the strip is formed on a tack, after which heat treatment takes place. Then the spring is wound in the opposite direction into the spring housing. By means of this procedure, a lower and sometimes even a negative value of no can be obtained in comparison with a singly wound spring, see **FIG. 6**. Due to the very good increase of strength at heat treatment, the alloy according to the present invention is very suitable for use as torsion springs, where high torque and good relaxation resistance is required.

EXAMPLE 3

Expander Wire

[0057] An expander is a bit of wire, which is corrugated and shaped to a flat spring connected in series. This spring is used, for instance, in order to regulate the pressure of the oil scraper rings against the cylinder wall in an internal combustion engine. A typical expander for car motors is seen as the corrugated wire between two piston rings. A possible embodiment of such a corrugated ring is shown schematically in **FIG. 4**.

[0058] A drawback of motor-driven vehicles today is the great energy consumption that is necessary in order to give the vehicle the desired performance thereof. The easiest ways to achieve a reduced energy consumption is, among other things, to diminish the internal friction of the drive and to reduce the total mass of the vehicle. The piston core accounts for more than half of the friction of a motor. Therefore, it is a continuous aim to improve the material and precision of the rings, pistons and cylinder walls with the purpose of reducing tare weights and bearing pressure. The expander is the spring that regulates the pressure of the oil scraper rings against the cylinder wall and thereby also oil consumption and part of the internal friction of a motor. The load of the expander wire consists of the force F, as shown in **FIGS. 5***a* to **5***c*.

[**0059**] For a flat spring, where the load is applied at an angle of 90° to the maximally loaded back, the following relation applies:

σ_{max}	Allowed maximum load in the back of the spring
F	the loading force which is determined by the length of the expander wire in relation to the piston diameter
T	Thickness of the wire
B	Width of the wire
E	Modulus of elasticity of the wire material
s	Suspension travel, how much the expander is deformed
R	The bending radius in each spring element

[**0060**]

$$\sigma_{max} = \frac{6FR}{BT^2} \quad (1)$$

$$s = \frac{42R^3F}{EBT^3} \quad (2)$$

the combination of (1) and (2) gives:

$$B = \frac{42R^3F}{EsT^3} = \frac{6FR}{\sigma_{max}T^2} \Rightarrow T = \frac{7R^2\sigma_{max}}{Es} \quad (3)$$

[**0061**] Expression (3) shows that the wire thickness that is required for a given property depends on the design of the expander. If the allowed tension of the material is increased, a smaller bending radius can be allowed, which is of great interest since rings of smaller types can be manufactured. The possibility of being able to manufacture smaller rings becomes more and more important since the demand for small motors increases as the environmental requirements are raised.

[**0062**] Another way to see the benefit of a higher strength in the expanding ring is by making an energy consideration according to the reasoning below.

A	Elastic energy
K	Material-use constant
E	Modulus of elasticity
V	Effective volume of the spring (how much of the material of the spring that is working)
σ	Applied tension

[**0063**]

$$A = VK\frac{\sigma^2}{E} \quad (4)$$

[**0064**] Expression (4) shows that a certain elastic energy for given modulus of elasticity is a function of the specific volume, material use and allowed maximum tension. An increased maximal allowed tension increases as a rule the material-use constant, which in combination gives a major impact on the required specific volume. Thus, it is possible to diminish the material volume increased allowed tension for retained level of elastic energy.

[**0065**] To form an expanding ring to the complex form thereof is only possible with soft materials. The workability is the primary reason for stainless steel being used at all. For the function of the expander, however, the tensile yield limit and ultimate tensile strength are at least as important as in all spring applications. This has earlier been a state of contradiction difficult to manage. By using the steel according to invention, the material may be formed in a relatively soft state so as to later be heat treated in the finished form, whereupon the desired spring properties are obtained by precipitation hardening.

EXAMPLE 4

Flat Wire

[**0066**] This embodiment according to the present invention is used especially in applications that make great demands on the relaxation properties of the steel, since it should resist a force without being preformed. This makes the steel especially suitable for use as, e.g., wire for windscreen wipers, where a good punchability of the starting material should be combined with a good relaxation resistance of the finished product.

EXAMPLE 5

Round and Flat Wire as Well as Strip Steel for Medical Applications

[**0067**] Wire, manufactured from the alloy according to invention may even be used in medical applications, for instance, in the form of dental instruments as files, such as root canal files, nerve extractor and the like, as well as surgical needles. Flat-rolled wire of the steel according to invention may advantageously be used for the production of dental and surgical instruments.

[**0068**] All these applications have in common that they have complicated geometries, which are produced by grinding, bending, and/or torsion advantageously before the last heat treatment and which then get a strong increase of the mechanical properties, i.e. a high breaking strength in combination with a good ductility.

1. Product, manufactured from a high-strength austenitic stainless alloy, in that it is precipitation hardenable and has the following composition (in weight-%):

C more than 0 to 0.07

Si 0.5-3.0

N>0-0.1

Cr15.0-20.0

Ni 7.0-12.0

Al 0.25-1.5

Cu0sus4.0

Mn>0-3.0

Mo>0-2.0

Ti>0-1.0

and the balance Fe together with normally occurring impurities and additives, said alloy reducible by cold-working, without an intermediate heat treatment, and it's strength is increased by a final heat treatment at 300° C. to 500° C. with at least 14%.

2. A product manufactured of a high-strength steel austenitic stainless precipitation hardenable alloy of claim 1, wherein the nickel at-a content of is between 8.0 and 11.0 weight-%.

3. A product manufactured of a high-strength steel austenitic stainless precipitation hardenable alloy of claim 1, wherein the nickel content is between 9.0 and 10.0 weight-%.

4. A product manufactured of a high-strength steel austenitic stainless precipitation hardenable alloy of claim 1, wherein the chromium content is between 16.0 and 19.0 weight-%.

5. A product manufacture of a high-strength steel austenitic stainless precipitation hardenable alloy of claim 1, wherein the aluminium content is 0.4-1.0 weight-%.

6. A Product manufactured of a high-strength steel austenitic stainless precipitation hardenable alloy of claim 1, wherein the silicon content is 0.5 to 2.5 weight-%.

7. A product manufactured of a high-strength steel austenitic stainless precipitation hardenable alloy claim 1, wherein silicon content is 0.5 to 1.5 weight-%.

8. A product of claim 1, which has loss of force which is smaller than 3.0% at 1400 N during 24 h.

9. A product of claim 1 in the form of wire, profiles and/or strip.

10. A product of claim 1 in the form of springs of round wire and strip steel.

11. A product claim 1 in the form of surgical and dental instruments.

12. (canceled)

13. (canceled)

14. (canceled)

15. (canceled)

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