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METHOD OF HEAT TREATING HIGH-CARBON CORROSION RESISTANT STEELS

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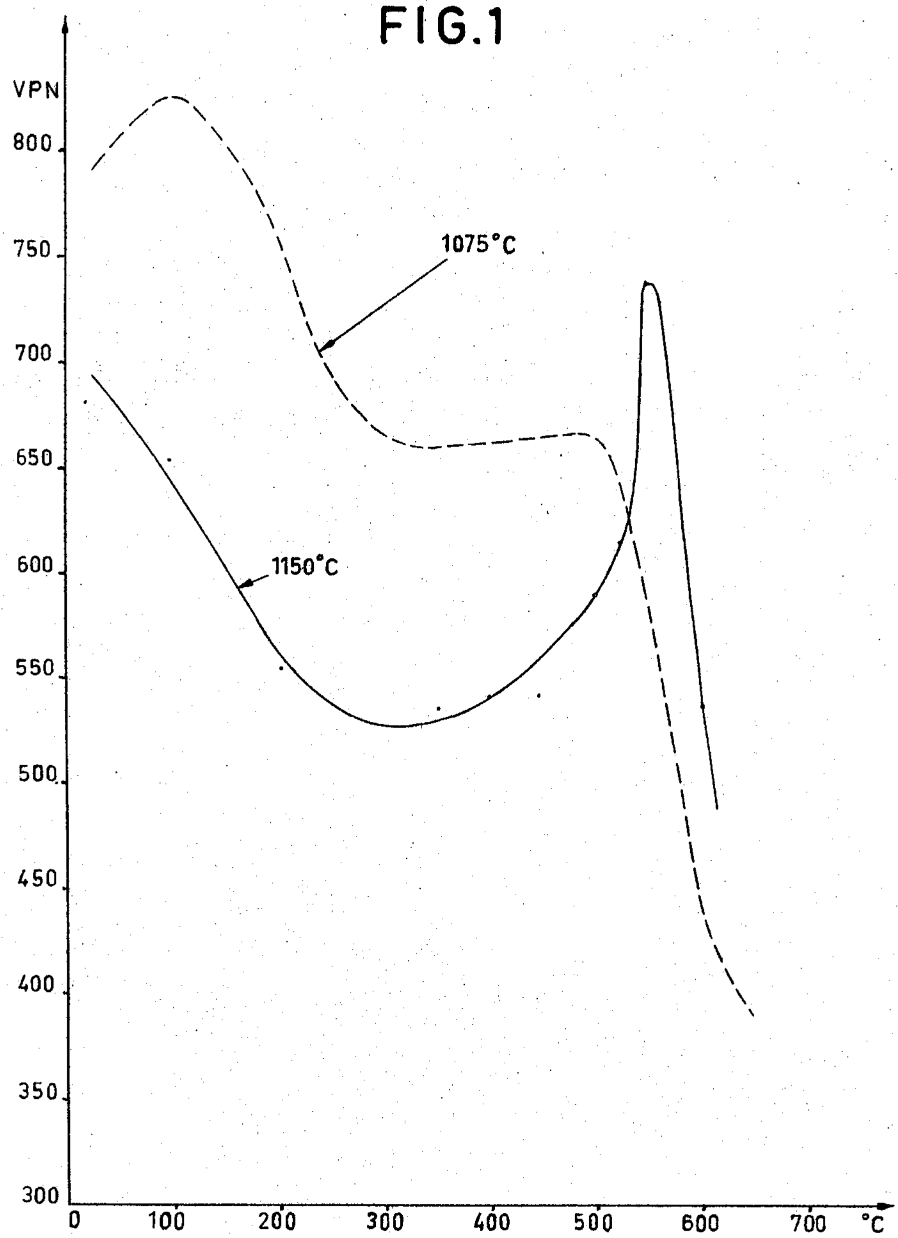
FIG. 1



INVENTORS
Ragnar Kihlberg
Erik Gunnar Edliden
BY
Pierce, Scheffler & Parker
attorneys

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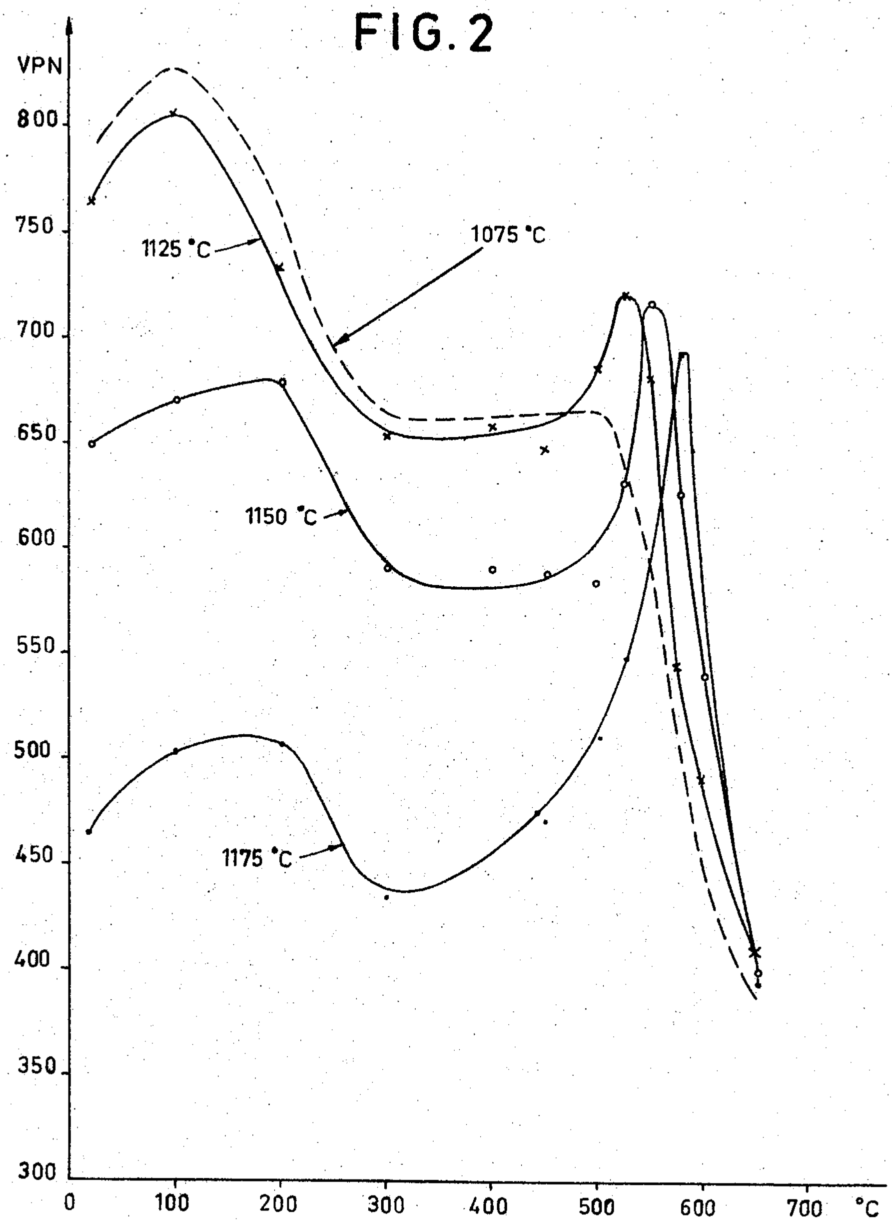
FIG. 2



INVENTORS
Ragnar Kihlberg
Erik Gunnar Edliden
BY
Pierce Scheffler & Parker
attorneys

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METHOD OF HEAT TREATING HIGH-CARBON CORROSION RESISTANT STEELS

Ragnar Kihlberg and Erik Gunnar Edliden, Munkfors, Sweden, assignors to Uddeholms Aktiebolag, Uddeholms, Sweden, a Swedish joint-stock company, and Wilkinson Sword Limited, London, England, a British joint-stock company

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1 Claim. (Cl. 148—125)

This invention relates to a method of heat treating high-carbon corrosion resistant steels adapted for manufacturing fine cutting tools and instruments, for example razor blades, intended for cutting relatively soft materials (thus, not for metal working), said method comprising the steps of first heating the steel to a temperature above its top temperature (the lowest temperature to which the steel must be heated for obtaining maximum hardness after cooling to room temperature) whereafter the steel is cooled to room temperature or possibly a lower temperature and, finally, heated again.

The invention relates to a method of heat treating the steel and further to steel, cutting tools, such as razor blades and blanks (hardened but not ground blades) and to steel strips for such cutting tools treated (manufactured) according to the invention.

The invention is particularly adapted for use in the mass production of razor blades and other similar cutting tools having sharp edges (but not for metal cutting tools). The invention has as one of its objects to obtain for high-carbon corrosion resistant steels substantial hardness and to maintain this hardness even in the cutting tool after its manufacture.

The term "hardness" is to be understood to be the property of the material which is determined by a hardness measuring instrument according to the Vickers method and expressed by the relation between the impression load and the impression area.

In a method previously known through Swedish Patent No. 126,577 the steel is heated to a temperature which is from 20° to 50° C. higher than the top temperature and reheated to a temperature above 30° C. but not exceeding 200° C.

Steel of this type was originally hardened from temperatures of about 1025° C. When higher temperatures were used, the amounts of retained austenite obtained were so large that the hardness was reduced. By applying sub-zero treatment (Molinder hardening) the hardening temperature could be increased to 1075–1090° C. whereby more carbides were dissolved. The increased amount of retained austenite was transformed by said sub-zero treatment to martensite whereby a higher hardness of the hardened steel could be obtained. At the present time, the hardening is carried out from a relatively high temperature and is followed by sub-zero treatment and tempering at low temperature. Hereby a hardness of about 800 H_v is obtained.

It was found, however, that this hardness of the hardened strip was not maintained, for example, in the razor blade after its manufacture. This is partly due to the fact that modern razor blade production includes in many cases processes wherein the razor blade is heated to relatively high temperatures which result in a substantial decrease in hardness of the entire blade. As a further and main reason is to be mentioned that grinding results in

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such a local heating of the outermost edge that said edge is tempered to a relatively low hardness. As the outermost portion of the edge constitutes the active portion of the razor blade, the advantage gained by the higher starting of the hardened strip, thus, is lost.

The invention is substantially characterized in that the steel is heated to such a high temperature, preferably from 50° to 150° C. higher than its top temperature, that during the cooling relatively large amounts of austenite are retained, and that the steel is reheated to a temperature between 400 and 700° C. whereby a significant increase in hardness is obtained.

The hardness obtained in this way is both higher than the hardness of the untempered steel and, above all, considerably higher than the hardness of steel of the same analysis hardened in a conventional manner (by normal hardening or sub-zero treatment) which was tempered to the same temperature.

It is probable, but not proved that the reheating (tempering) of the hardened steel which brings about a significant increase in hardness, depends on a precipitation of alloying elements in the austenite phase. The alloying content in the austenite phase is thereby reduced, so that during the subsequent cooling the austenite can easily be transformed to martensite. In order to be able to utilize this effect, it is important to carry out the heating to such a high temperature that more carbides are dissolved than by normal hardening, whereby, during the cooling relatively large amounts of austenite are retained.

The high-carbon corrosion resistant steel to be treated according to the invention contains

0.8 to 1.4%, preferably 0.9 to 1.1% carbon
11 to 16%, preferably 12.5 to 14.5% chromium

and possibly impurities and/or additions of sulphur, phosphorus, manganese, silicon, vanadium, molybdenum, tungsten, antimony, nitrogen, cobalt, nickel, aluminum and titanium in an amount smaller than 5%, preferably smaller than 2,5%.

The steel is preferably heated to a temperature between 1100 and 1250° C., preferably between 1125° and 1175° C.

According to the preferred embodiment of the invention the cooling comprises the steps of quenching, preferably in oil or between cooling plates, possibly followed by a sub-zero treatment, preferably in Dry Ice, to a temperature between −50° C. and −80° C., the reheating being carried out to a temperature between 450° and 650° C., preferably between 500° and 600° C.

The invention is described below by way of examples, reference being had to the accompanying drawings wherein:

FIGS. 1 and 2 show the hardness as a function of the tempering temperature for steel hardened at high temperature.

Example 1

A steel having the analysis	Approximate percent
C	1
Si	0.2
Mn	1
Cr	14

in the form of a strip with a thickness of 0.90 mm. is annealed and austenitized at a temperature of 1150° C. in a tube-type furnace. The total heating time was 10 minutes. The cooling was carried out by quenching in oil followed by sub-zero treatment in Dry Ice at about −70° C.

The tempering was carried out at different temperatures in a convection furnace for 30 minutes.

The result obtained is shown in FIG. 1. As appears therefrom it is posible to obtain a hardness of about 740 V.P.N. by an austenitizing temperature of 1150° C. with subsequent cooling and tempering at 550° C.

Example 2

Punched razor blades having a thickness of 0.10 mm. and the analysis

	Approximate percent
C	1
Si	0.2
Mn	1
Cr	13.5

were austenitized at 1125° C., 1150° C. and 1175° C. in a tube-type furnace. The total heating time was 3 minutes. The cooling comprised quenching between cooling plates and subzero treatment in Dry Ice at about −70° C. The tempering was carried out at different temperatures in a convection furnace for 30 minutes.

The results are shown in FIG. 2. Even an austenitizing temperature as low as 1125° C. appears to be sufficient for rendering possible a precipitation which increases the hardness to 725 V.P.N. Under these trial conditions the tempering temperature 525° C. resulted in maximum hardness. The austenitizing temperature 1150° C. produced a hardness of 720 V.P.N. at the tempering temperature 550° C. The austenitizing temperature 1175° C. resulted in 690 V.P.N. at a tempering temperature of about 575° C.

In FIGS. 1 and 2 certain differences between the curves can be observed, which is due to the difference in the austenitizing time which results in different amounts of being dissolved at the same temperature, and to some extent also to the difference in the thickness of the material.

Example 3

For obtaining a measure of the brittleness of the material after different treating methods, ready-punched blades from the same strip as in Example 2 were treated in a way as appears from Table 1. In all experiments the tempering time was 30 minutes. After the austenitization cooling was carried out by quenching and sub-zero treatment to −70° C. The blades were broken in a jaw vice and the jaw distance at fracture was read. The indicated values represent the mean values of 5 to 10 measurements. The blades had the punching burrs during the breaking operation on their concave side.

The Test Nos. 1, 2 and 3 as well as the test in untempered state were not carried out according to the invention, but are only included for comparison.

Example 4

For finding out how the hardness changes as a result of repeated heating a so-called double tempering was carried out. Two razor blades were austenitized at 1125° C. for 3 minutes, quenched between cooling plates, subjected to sub-zero treatment in Dry Ice at −70° C. and tempered at 525° C. for 30 minutes. After the hardness test the two blades were tempered again, this time at 400° C. for 30 minutes. The results are shown in Table 2.

TABLE 2

Razor blade no.	After the first tempering hardness V.P.N.	After the second tempering hardness V.P.N.
1	721	722
2	707	716

The above tests have proved (a) that steel treated according to the invention maintains its high hardness at tempering temperatures at which steel hardened in a normal way had already become substantially softer (see FIG. 1), (b) that the increase in hardness probably does not substantially depend on the new formation of martensite from retained austenite during the cooling after the first tempering, but probably on some sort of precipitation hardening.

What we claim is:

A method of heat treating a high-carbon corrosive resistant steel intended for manufacturing cutting instruments adapted for cutting relatively soft material, said steel containing from 0.8 to 1.4% carbon, from 11 to 16% of chromium and less than 5% of the elements sulfur, phosphorus, manganese, silicon, vanadium, molybdenum, tungsten, antimony, nitrogen, cobalt, nickel, aluminum and titanium, the remainder being substantially all iron, comprising the steps of first heating the steel to a temperature of from 1100 to 1250° C., for at least about 3 minutes, quenching the heated steel to a temperature of from −50 to −80° C. and then reheating the steel to a temperature of from 450 to 650° C. for at least about 30 minutes.

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TABLE 1

Test No.	Austenitizing temp., ° C.	Not tempered	Tempered 300° C.	Tempered 500° C.	Tempered 525° C.	Tempered 550° C.	Tempered 575° C.	Hardness, V.P.N.
1	1,075	13,8						802
2	1,075		4,3					663
3	1,075			4,6				675
4	1,125	18,8						763
5	1,125				7,1			720
6	1,150	15,5						648
7	1,150					7,8		727
8	1,175	13,6						473
9	1,175						8,3	693

DAVID L. RECK, *Primary Examiner.*

HYLAND BIZOT, *Examiner.*

C. N. LOVELL, *Assistant Examiner.*