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CUTTING INSTRUMENTS

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ABSTRACT OF THE DISCLOSURE

Process for producing a cutting edge in a deposit on a metallic substrate, the deposit being a nickel-phosphorus or a cobalt-phosphorus alloy or a mixture thereof.

This invention is concerned with improvements in or relating to cutting instruments, that is instruments having one or more cutting edges, and is particularly concerned with razor blades.

In recent years the useful life of razor blades, that is the number of acceptable shaves that can be obtained from each blade, has been increased by the use of stainless steel as the blade material in place of high carbon steel that for many years previously was almost exclusively used as the blade material. This increase in the useful life of razor blades is wholly or largely due to the fact that stainless steel is more corrosion-resistant than high carbon steel. The suitability of a material for the manufacture of razor blades is not, of course, solely dependent on its corrosion-resistance and the most important factor in this respect is the ability of the material to retain the cutting edge formed during manufacture of the blade, which ability is believed to be related to the hardness of the material.

We have now found that razor blades having their cutting edges formed in hardened nickel-phosphorus and/or cobalt-phosphorus alloys have a corrosion-resistance which is at least as good as that of stainless steel and, due to the greater hardness of such alloys, may be expected to retain their sharpness better than stainless steel razor blades. While this discovery is particualrly applicable to razor blades, it is also applicable to cutting instruments in general.

According to the present invention we provide a process for the production of cutting instruments which comprises depositing on a metallic substrate adapted to form the body of the cutting instrument, a nickel-phosphorus or a cobalt-phosphorus alloy or a mixture of said alloys, said alloy(s) containing from 3 to 15% phosphorus and the deposition being effected on at least that part of the substrate which is adjacent an evenutal cutting edge of the instrument, hardening the deposit by heat treatment and forming a cutting edge wholly in the deposit. If desired, the cutting edge may be coated with a coating to improve its cutting effectiveness.

The form of the susbtrate will depend, of course, upon the type of cutting instrument to be produced and in the case of a razor blade, for example, will take the form of a steel strip having the appropriate dimensions, that is thickness and width, and configuration, that is having the appropriate slots and/or holes already formed in it. The part of the substrate immediately adjacent the eventual cutting edge should be so formed as to provide adequate support for the deposit in which the actual cutting edge will subsequently be formed. The cutting edge of razor blades is formed by grinding and honing and in order that such grinding and honing operations, when carried out on the nickel and/or cobalt deposit, should not penetrate through the latter to the underlying substrate, it is preferred that in the production of razor blades, the edges

of the strip should have a form similar to or approximating the form of the eventual cutting edge, that is a part or the whole of a sharpening operation should be carried out before nickel and/or cobalt deposition.

The substrate may be formed of any metal or alloy which meets the service requirements of the cutting instrument and which provides adequate adhesion for the nickel and/or cobalt deposit; ferrous metal substrates are suitable for most purposes. In the case of razor blades, the substrate may, for example, be formed of high or low plain carbon steels or stainless steel.

The maximum hardness of the nickel and/or cobalt deposit is developed by a heat treatment as will be described below and this hardness is not deleteriously affected by subsequent heating up to, say 400° C., which reheating may be carried out, for example, after the application of a polyfluorocarbon or other synthetic polymer coating to the nickel and/or cobalt.

The nickel-phosphorus and/or cobalt-phosphorus alloy deposit can be formed by electroless or electrolytic plating; the deposits formed by electroless plating normally contain from 6 to 12% phosphorus, while those formed by electrolytic plating may contain from 3 to 15% phosphorus. In each case, the phosphorus content depends on the bath composition and the latter can be adjusted to obtain the desired phosphorus content in the deposit. Of these two methods, electrolytic plating is in most cases to be preferred since it gives a faster rate of deposition.

The techniques of electroless plating are well understood and have been widely described (see, for example, A.S.T.M. Special Technical Publication 265, 1959, "Symposium on Electroless Nickel") and any of the bath compositions and plating conditions suitable for the plating of the chosen substrate with the chosen metal can be used to form the deposit. The plating bath essentially consists of an aqueous solution of a soluble nickel and/or cobalt salt, such as the chloride or sulphate, sodium hypophosphite to reduce the salt to the metal, a buffer, such as sodium acetate, and one or more brighteners, plating rate accelerators and inhibitors of random decomposition. Plating is normally carried out with the bath at an elevated temperature, for example from 90° C. up to the boiling point of the bath, and with continual supervision of the pH, which may be acidic or alkaline in the case of nickel deposition and should be alkaline for cobalt.

Bath compositions and plating conditions for obtaining the nickel-phosphorus and cobalt-phosphorus alloys by electrolytic deposition have also been described (see, for example, "Plating," January 1950, pages 36–42) and any of the bath compositions and plating conditions recommended for the substrate metal used in the present process can be employed. The plating bath essentially consists of an aqueous solution of a soluble nickel and/or cobalt salt, such as the chloride or sulphate, phosphoric acid and phosphorus acid. Plating is normally carried out with the bath at an elevated tempearture, for example, of from 70° to 80° C., and suitable current densities are, for example, from 20 to 40 amps./dm.^{2}.

Prior to effecting either electroless or electrolytic deposition, the substrate surface on which the deposit is to be formed should, of course, be thoroughly cleaned; suitable cleaning treatments are described in the examples which follow, but other treatments could equally well be used.

Whichever method of deposition is used, the coating thickness is preferably up to 0.005 inch. In the case of razor blades, after sharpening a continuous steel strip in the conventional manner, plating is carried out on the strip. Alternatively the strip may be separated into individual blades and the latter loaded into a magazine with spacers between adjacent blades and plating may be carried out with the blades and spacers tightly packed

ogether in the magazine. The spacers used in these two nethods should be formed of a material to which the leposit will not adhere.

After plating, the coated substrate is washed and dried nd then heated to increase the hardness and adhesion of the deposit. Hardening is obtained by heating to a temperature of from 320° to 500° C., maximum hardness being obtained by heating to from 350–425° C. for from 10 minutes to one half hour. Greater corrosion resistance nd adhesion is obtained by heating to higher temperatures, e.g. 720° C., but since these improvements are obtained to the detriment of the hardness, it is preferred not to heat to above 425° C. This heat treatment is preferably carried out under non-oxidizing conditions, i.e. under vacuum or in a non-oxidizing atmosphere, such as cracked ammonia.

The cutting edge is then formed in the nickel and/or cobalt deposit and conventional grinding and honing operations can be used for this purpose.

As an optional final step in the production of razor blades, a coating which improves the shaving effectiveness of the blade can be applied to the cutting edge. This coating may take the form of a partially cured polysiloxane coating, the expression "partially cured polysiloxane coating" being used herein to refer to the coatings described in Patent No. 2,937,967 a polyolefin coating, the expression "polyolefin coating" being used herein to refer to the coatings described in Patent No. 3,071,858, or a polyfluorocarbon coating, the expression "polyfluorocarbon coating" being used herein to refer to the coating described in Patent No. 3,071,856. The formation of these coatings and the advantages obtained by their use are fully described in the above patents.

In order that the invention may be more fully understood, the following examples in which all percentages are by weight, are given by way of illustration only:

EXAMPLE I

A sharpened and unlacquered high carbon steel strip as used in conventional razor blade production, i.e. of conventional width and thickness for razor blades and having the appropriate holes and slots formed therein, was subjected to the following cleaning operations:

(i) Degreasing in hot trichloroethylene liquid
(ii) Degreasing in trichloroethylene vapor
(iii) Cathodic cleaning in an aqueous alkali cleaner sold under the trademark "Diversey 808," the solids content of which consists of 85% trisodium phosphate, 10% sodium metasilicate and 5% wetting agent
(iv) Washing in cold water
(v) Dipping in 10% aqueous hydrochloric acid solution
(vi) Washing in cold water

The cleaned strip was then immersed in an aqueous electroless plating solution of the following composition:

	Gm./litre
Nickel chloride	30
Sodium hypophosphite	10
Sodium acetate	5
Sodium citrate	21.75
Sodium thiosulphate	0.006

The solution was maintained at a temperature of 90–95° C. and the strip was immersed for approximately five hours. During this period, sufficient of the following "make-up" solution was added at frequent intervals to replace nickel and hypophosphite ions that had been used up, the nickel content of the plating solution being controlled and kept approximately constant by such additions:

	Gm./litre
Nickel chloride	70
Sodium hypophosphite	175
Sodium acetate	5

At the end of this period, a deposit 0.002 inch thick was obtained. The plated strip was removed from the plating bath, rinsed in water and dried.

It was then heated for one half hour at 400° C. in a non-oxidizing atmosphere of cracked ammonia.

The strip was then divided into blades and the blades were sharpened as follows.

The coated blade was secured in a blade holder in a machine equipped with interlocking 800 grit honing wheels of 6 inch diameter. These wheels were set to cut a half angle of 11° on each side of the blade making a total included angle of 22° at the tip. The wheel speed was 3250 r.p.m. and the direction of rotation was such that the wheels cut from the base to the tip of the angle. By this means a sharp edge was formed in the Ni-P alloy, provided that the machine was correctly adjusted initially. Failure to do this resulted in the wheels cutting through the coating and exposing the substrate. For all honing operations, paraffin was found to be the most satisfactory coolant.

The wheels were then reset to cut half angles of 9° on each side of the blade (an included angle of 18°). The object of this was to produce a backing angle which was taken to within 0.001 inch of the blade tip.

Because of the free-cutting nature of the Ni-P alloy, grooves were left on the final facet which run towards the blade tip, giving rise to blade edge weakness. It was therefore necessary to give a final finishing operation to polish out the grooves. This was carried out as follows:

A pair of 3 inch diameter interlocking wheels were faced with chrome leather on the lands. The leather was then soaked with γ-polishing alumina in water and allowed to dry. By this means the leather became sufficiently impregnated with γ-alumina to act as a strop. The honed blade was passed several times between the revolving wheels, running at 3000 r.p.m. in the same direction as the honing wheels. This produced a finely polished edge free from grooves.

EXAMPLE II

A sharpened and unlacquered high carbon steel strip similar to that used in Example I was subjected to the following cleaning operations:

(i) Ultrasonic degreasing in cold perchloroethylene
(ii) Cathodic cleaning as in cleaning step (iii) of Example I
(iii) Washing in cold water
(iv) Dipping in 10% aqueous hydrochloric acid solution
(v) Washing in cold water

The cleaned strip was then immersed in an aqueous electrolytic plating solution of the following composition, being connected as the cathode:

	Gm./litre
Nickel sulphate	160
Nickel chloride	46
Phosphoric acid	50
Phosphorous acid	22

The plating solution was maintained at 70–80° C., the anodes were formed of nickel, the current density was 20–40 amps./dm.^{2} and in less than one hour a deposit 0.002 inch thick was obtained.

The coated strip was washed in water, dried, heat treated at 400° C. for one half hour, divided into blades and the blades were sharpened as described in Example I.

EXAMPLE III

A sharpened and unlacquered high carbon steel strip similar to that used in Example I was cleaned as described in Example II and electrolytically plated with Co-P alloy using an aqueous plating solution of the following composition:

	Gm./litre
Cobalt chloride	180
Phosphoric acid	50
Phosphoroues acid	40

The strip was connected as the cathode and cobalt anodes were used. The plating solution was maintained at 70° C., the current density was 30 amps./dm.^{2} and in less than an hour a deposit 0.002 inch thick was obtained.

The coated strip was washed with water, dried, heat treated at 400° C. for one half hour, divided into blades and the blades were sharpened as described in Example I.

Having thus disclosed my invention and described in detail an illustrative embodiment thereof, I claim as new and desire to secure by Letters Patent:

1. A process for the production of cutting instruments which comprises depositing on a metallic substrate adapted to form the body of the cutting instrument, an alloy selected from the class consisting of a nickel-phosphorus alloy, a cobalt-phosphorus alloy, and a mixture thereof, said alloy containing from 3 to 15% phosphorus and the deposition being effected on at least that part of the substrate which is adjacent an eventual cutting edge of the instrument, hardening the deposit by heat treatment and forming a cutting edge wholly in the deposit.

2. A process according to claim **1** in which the thickness of the alloy deposit is up to 0.005 inch.

3. A process according to claim **1** in which hardening of the deposit is effected by heating it to about 400° C. for from 10 to 30 minutes.

4. A process according to claim **1** in which hardening of the deposit is effected by heating it to from 350° to 425° C. for from 10 to 30 minutes.

5. A process for the production of razor blades which comprises depositing on at least one edge of a steel strip having the dimensions and configuration appropriate to the production of razor blades therefrom, an alloy selected from the class consisting of a nickel-phosphorus alloy, a cobalt-phosphorous alloy, and a mixture thereof, said alloy containing from 6 to 12% phosphorus, hardening the deposit by heat treatment, and forming a cutting edge wholly in the deposit.

6. A process according to claim **5**, in which the thickness of the alloy deposit is up to 0.005 inch.

7. A process according to claim **5** in which hardening of the deposit is effected by heating it to about 400° C. for from 10 to 30 minutes.

8. A process according to claim **5** in which hardening of the deposit is effected by heating it to from 350° to 425° C. for from 10 to 30 minutes.

9. A process according to claim **5**, in which the edge on which deposition is effected is at least partially sharpened prior to effecting the deposition.

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