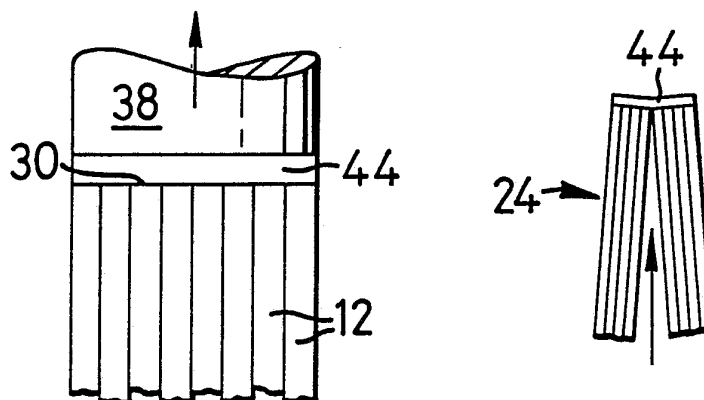




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : B23K 20/12, C23C 26/00	A1	(11) International Publication Number: WO 90/02015 (43) International Publication Date: 8 March 1990 (08.03.90)
(21) International Application Number: PCT/GB89/00983 (22) International Filing Date: 23 August 1989 (23.08.89) (30) Priority data: 8820448.2 30 August 1988 (30.08.88) GB (71) Applicant (for all designated States except US): FRICTEC LIMITED [GB/GB]; Portsmouth Enterprise Centre, Quarmaine Road, Portsmouth PO3 5QT (GB). (72) Inventor; and (75) Inventor/Applicant (for US only) : BEDFORD, Gerald, Montgomery [GB/GB]; 2 Brandon Road, Southsea, Hampshire PO5 2LY (GB). (74) Agents: BERESFORD, Keith, Dennis, Lewis et al.; Beresford & Co., 2-5 Warwick Court, High Holborn, London WC1R 5DJ (GB).		(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US. Published <i>With international search report.</i>

(54) Title: FORMING HARD FACINGS ON MATERIALS**(57) Abstract**

A sheet, blade or lamina of metal (12) of thickness 0.1 - 1 mm e.g., for forming a disposable knife blade has adhered along one edge a friction surfacing material (16) of extent 0.1 - 4 mm, said friction surfacing material extending from and lying in the major plane of the sheet, blade or lamina. The blade may be inexpensively produced by a method which comprises mechanically depositing by means of rotatory friction surfacing a layer (44) of relatively hard material along the substrate edge, in which (a) a stack of sheets or blades (12) is clamped together to form the substrate, (b) the friction surfacing material (44) is deposited along an edge of the stack, and (c) the resulting surfaced stack is split into individual sheets (12) each having one edge a generally coplanar layer (16) of adhered friction coating material.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MR	Mauritania
BE	Belgium	GA	Gabon	MW	Malawi
BF	Burkina Fasso	GB	United Kingdom	NL	Netherlands
BG	Bulgaria	HU	Hungary	NO	Norway
BJ	Benin	IT	Italy	RO	Romania
BR	Brazil	JP	Japan	SD	Sudan
CA	Canada	KP	Democratic People's Republic of Korea	SE	Sweden
CF	Central African Republic	KR	Republic of Korea	SN	Senegal
CG	Congo	LI	Liechtenstein	SU	Soviet Union
CH	Switzerland	LK	Sri Lanka	TD	Chad
CM	Cameroon	LU	Luxembourg	TG	Togo
DE	Germany, Federal Republic of	MC	Monaco	US	United States of America
DK	Denmark				

FORMING HARD FACINGS ON MATERIALS

This invention relates to the formation of hard facings along edges of materials by friction surfacing.

British Patent Specification No. 572 789 (Hans Klopstock) describes a method for joining metals, in which a rotating rod or bar of weld metal is fed into contact with the metal part or parts to be treated, with such continuity of pressure and at such speed of relative movement with respect thereto, that the frictional heat generated causes the end of the rod or bar and the metal to attain welding temperature. The result is that the metal of the rod or bar becomes deposited on the metal under treatment, so as to form a local enlargement or to join two juxtaposed metal parts together, or to fill in blowholes or the like.

Methods of friction surfacing materials are described in Patent Specifications GB-A-1 018 412 and US-A-3 537 172 (both to Voznesensky et al), and WO-A-87/04957. The last-mentioned specification describes the formation of a hard facing, preferably of a high speed tool steel or a Stellite, along the edge of a substrate through mechanical deposition by rotatory friction surfacing. The combination of high temperatures, below the melting points of coating material and substrate, with high rates of strain gives rise to a very fine coating microstructure, resulting in an edge or valve facing or seat which exhibits unexpectedly good mechanical properties and service life. The coating is formed in a recessed edge of the substrate, on a major face thereof, and gives rise to coatings the thickness of which is more than 0.2 mm and typically 0.2 to 2.0 mm, which is thick enough for the coating to be

subsequently machined flat prior to being given a sharp edge.

This invention is concerned with the production of hardened edges on plates, which term is to be understood in this description and the accompanying claims to include sheets, strips, laminae or generally any plate-like piece, not necessarily flat but being capable of being nested with other similar pieces to form a stack. The plates may be of carbon or stainless steel or other metal. They may typically be laminae intended for scalpel or knife blades or the like. The plates may be upwards of 0.5 mm thick.

For use as disposable knife blades in particular, an inexpensive method of forming the strengthened edge is needed.

This invention provides a method for applying a hard facing along an edge of a substrate which comprises mechanically depositing, by means of rotatory friction surfacing treatment, an applied layer of a relatively hard coating material along the substrate edge, wherein the method includes the steps of (A) clamping together a stack of plates to form the substrate, (B) depositing the said hard material by rotatory friction surfacing along an edge of the stack, and (C) splitting the resulting treated stack into individual plates, each having bonded along one of its edges a generally coplanar applied layer of the said hard material.

The invention also provides a metal plate (as defined above) at least 0.5 mm thick, having bonded along one edge, by the method of the invention, an applied layer of a relatively hard material about 0.2 to 2.0 mm thick and extending from and lying in the major plane of the plate.

After a stack of plates has been assembled, it is desirable to ensure that its upper and lower end surfaces are flat, smooth and directed at right angles to the major surfaces. For friction surfacing, the
5 stack is preferably held between thermally conductive jaws of a clamping device such as a vice, and is supported on a block which also fits between the jaws of the clamping device, and which rests on a slide or bed of the latter. If the upper ends of the plates are
10 not clean, the mechtrode material, transferred from the end of the rotating sacrificial mechtrode used in the friction surfacing process, may become poorly bonded to the substrate metal. If they are not level, then: (a) the coating of mechtrode material will be uneven as
15 between different plates, or between different regions of the individual plates; (b) substrate material of plates that are higher than the adjacent plates may become rolled over on to the adjacent plates, and (c) inadequately supported plates may be unable to
20 withstand the pressures needed for mechtrode deposition, and may become bent. To avoid these difficulties, it is desirable to machine the upper and lower surfaces of the assembled stack, e.g. by milling or grinding, so that they are clean, true and level
25 before the friction surfacing operation is undertaken. The surfaces of the supporting block must also be true and level so that there is no gap between any of the individual plates and the adjacent surface of the supporting block.

30 During friction surfacing (step (B)), the stack of plates is held wholly within the bite of the jaws of the vice or other clamping means in which it is retained. In the absence of adequate clamping forces on the stack, the mechtrode can push the individual
35 plates apart. The individual plates, especially if

- they are thin blades, cannot otherwise withstand the forming pressure of the mechtrode, which would then penetrate the stack. By positioning the stack wholly within the bite of the jaws, the clamping force is effective at the upper and lower edges of the stack, and separation of the plate during the friction surfacing process can be avoided. It has been found that the upper edge of the stack can be located about 5 to 10 mm below the upper edge of the clamping jaws.
- 10 Where the substrate plates are of steel, there is a risk that the edges of the individual plates immediately underlying the deposited mechtrode material may become diffusion-bonded together during step (B) as a side effect of the heat generated by friction
- 15 surfacing and the clamping forces on the substrate pack. This diffusion bonding creates a weld between the plates which makes subsequent separation into individual plates in step (C) more difficult or time consuming. A preferred remedy is to form a weld-
- 20 inhibiting coating on the major faces of each plate, at least adjacent to the edges to be friction surfaced, when preparing the plates before stacking them together for clamping. Such a weld-inhibiting coating may conveniently be of iron oxide formed by oxidation. The
- 25 metal of each plate in the stack is thus separated from that of its neighbours by layers of iron oxide which inhibit diffusion bonding.

In step (C), splitting of the stack into individual plates involves breaking the applied layer along the

30 interface between each plate and the next, so that on each plate, the sides of the hardfacing layer are substantially coplanar with the major surfaces of the plate.

Particularly if either the substrate or the hard layer material is one which is capable of brittle fracture, the stack is preferably cooled, immediately prior to the splitting operation, down to a temperature such as 5 to assist easy and clean splitting, the splitting itself then being carried out while the stack is still at this reduced temperature. This temperature is preferably below the ductile/brittle transition temperature, if any, of the substrate and/or applied 10 layer material. This is because, if there are some traces of diffusion bonding (despite the presence of an oxide layer as described above), the combined effect of the low temperature and the natural notch between the plates induces brittle fracture of the diffusion bond 15 between the plates, while in any case it induces brittle fracture of the applied layer in the planes of the interfaces between plates. This ensures a clean break in either case, with no trace of ductile tearing.

Such cooling is for example carried out by immersing 20 the stack in liquid nitrogen for an appropriate period such as 20 minutes. It is of advantage where the substrates are of, for example, steel other than stainless steel, and/or the applied layer is of T1 high speed steel.

25 In order to produce a mechtrode coating of the desired thickness, it is necessary to select an appropriate combination of mechtrode load, mechtrode rotational speed, and table speed (i.e. relative linear velocity between the mechtrode and the pack). This will depend 30 on the diameter of the mechtrode and the materials of the mechtrode and substrate plates. The particular conditions needed will thus vary depending on the materials being used. For a given pressure applied by the mechtrode, too fast a table speed will not give the 35 intended coating thickness, whereas too slow a coating

speed will give a coating which is too thick and of irregular profile. Too fast a rotational speed can lead to a coating thinner than intended, whereas too slow a rotational speed can give rise to a damaged
5 coating. Deposition of T1 high speed tool steel on mild steel at a rotational speed of 1000 rev/min corresponds to an optimum table speed of 4 mm/s; a table speed of 2 mm/s is too slow and gives a thick but irregular deposit of mechtrode material; while a table
10 speed of more than about 5 to 6 mm/s leads to a regular, but too thin, deposit of mechtrode material. The corresponding figures for 440C martensitic stainless steel on 316 stainless steel are 1000 rev/min and about 3 mm/s, while those for Stellite on 316
15 stainless steel are 820 rev/min and about 2.5 mm/s.

The thickness of the coating of mechtrode material produced on the substrate will be selected depending on the intended use of the plate, on the intended machining operations to which it would be subjected,
20 and on the thickness of the substrate, but the coating produced will typically have a thickness of about 0.2 to 2.0 mm, and preferably about 1.0 mm. It is preferred that the coating be formed in a single pass of the mechtrode over the substrate, though multiple
25 mechtrode passes, building up more than one layer of mechtrode material on the substrate, are not excluded. The depth or thickness of the layer of mechtrode material produced can depend on the diameter of the mechtrode and the material of which it is made. Thus a
30 10 mm mechtrode may typically produce a coating in the range 0.2 to 1 mm thick, whereas a 25 mm diameter mechtrode may produce a coating in the range of 0.5 to 2.0 mm thick.

The depth of the applied layer of mechtrode material
35 may be increased, by up to about 40% if necessary, by

so mounting the substrate plates in the clamping means that there is a "quasi recess", i.e. a void with side walls defined by the clamping means, such as to enable the edges of the mechtrode layer to be supported as it is built up. This quasi recess may conveniently comprise the space above the upper edge being treated, when located below the upper edge of the clamping jaws as mentioned above. However, the final coating thickness on the stack immediately prior to splitting in step (C) is limited by the practicality of the splitting operation itself. Thus, for a given combination of materials, the maximum final coating thickness is related to the thickness of each substrate plate. In general, the limiting plate thickness, for a given final coating thickness, is governed by the bending moment required for breaking the coating to split the plates away from each other without significant bending of the plates.

Accordingly, to facilitate splitting and to produce the required final coating thickness, the applied layer is preferably ground before the stack is split (and before the abovementioned cooling step if this is undertaken). This grinding step is discussed in another connection below: at this stage it should be noted that the thinner the substrate plates, the more material may need to be removed from the hard layer by grinding.

The transverse width of the applied layer will be similar to the diameter of the mechtrode employed. Mechtrodes of diameter up to 50 mm can be employed in a single pass, wider coatings requiring multiple passes on spaced parallel tracks. The width of this applied layer of mechtrode material will, of course, govern the thickness of the stack and hence the number of plates that can be treated on a single occasion.

In at least the case of high speed tool steel mechtrodes, a heat treatment step is desirable after the mechtrode material has been deposited on to the stack of plates, in order to develop secondary
5 hardening characteristics. Heating in a furnace at about 570°C for two cycles of one hour each, is usually sufficient. This heat treatment may take place either before or after step (C).

The significant feature of the process is that two
10 different kinds of hard facing alloys can be used for the mechtrode material. Thus when high speed tool steels and martensitic stainless steels are used, allotropic transformation to relatively soft austenite takes place at high temperatures. The austenite is
15 quenched to hard martensite as a result of the process. In contrast, alloys of the Stellite type undergo no allotropic change and simply experience high temperature softening to enable coating to take place. A feature of the friction surfacing (coating) process
20 is that the coating parameters are selected so as to generate the intended heat flow characteristics. In particular, the jaws of the vice or other clamping means used to hold the plates of the stack together are conductive, and provide a flow path for heat away from
25 the stack. This heat removal, together with the relative movement of the mechtrode and the stack, sets up heat flow characteristics which enable the relatively hard mechtrode material to be deposited on the relatively soft metal of the substrate. Parameters
30 are optimised with a view to sufficient heat being generated to enable the friction interface to rise from a level in contact with the substrate to a level along the mechtrode and spaced a small distance from the substrate.

A significant metallurgical advantage is that the mechtrode alloy is hot worked during coating, so that the resulting fine structure has attendant good properties. The microstructure of the applied hard layer is a very fine array of carbide particles in a matrix of (in the case of a high speed transformable tool steel) very fine martensite. On subsequent tempering, the latter is enhanced by secondary hardening. The size distribution of the carbides in the matrix is such that there are relatively few carbides above 2 microns in size. The carbides are very uniformly distributed through the matrix, while the fineness of the microstructure gives good edge retention properties when a cutting edge is subsequently ground on the individual plates. High speed tool steels normally have a much coarser microstructure, with large carbide particles in a banded form and a coarse martensitic matrix. By contrast, when the method described herein is used, because the austenite which is present at the equilibrium condition of the mechtrode during coating is hot worked at very high strain rates, it has an extremely fine microstructure, so that, on the rapid cooling which immediately follows, it is transformed to an equally fine martensitic structure. In cobalt-based alloys the resulting microstructure is uniform, with a highly uniform array of angular complex carbides in a solid solution matrix of cobalt/chromium.

After the plates have been coated with mechtrode material in step (B), the exposed surface of the applied layer of the latter may, as already mentioned, have to be ground to the required thickness of the applied layer. Such grinding is however desirable for another reason. Without a ground surface, the developing cracks in the mechtrode material tend to

follow the surface irregularities of the deposited material, and become particularly irregular at the end of the deposit. This irregularity in cracking leads to certain difficulties, namely that (a) few of the
5 separated plates have a perfect coating of mechtrode material, (b) portions of the mechtrode material may be chipped off easily from the substrate metal, and (c) satisfactory splitting of the stack into the individual plates is difficult even with cooling. However, if the
10 mechtrode material is ground smooth and flat, it has been found that splitting becomes much easier, because cracks propagate linearly along the divisions between adjacent plates. After the deposited mechtrode material has been ground until its surface is smooth,
15 true and flat, the stack of plates is, as already discussed, preferably cooled below the ductile/brittle transition temperature of the substrate and/or mechtrode materials as applicable, in order not only to embrittle the materials, but also to assist crack
20 propagation therein.

The plates are then split apart endwise, starting from the centre of the stack. As far as possible, each subdivision of the stack is split in the middle, i.e. in half, until individual plates are obtained. The use of
25 this symmetrical ordered sequence of dividing the stack is desirable because the coatings of the mechtrode material on the different plates support one another, and a symmetrical division sequence promotes a more even hard facing coating on each plate.

30 During the surfacing process (step (B)), the mechtrode is first lowered on to one end of the exposed upper surface of the stack, and is then moved along it to deposit the coating before being lifted clear of the stack. There is therefore an end portion of the upper
35 surface with which the mechtrode is, at least

momentarily, in stationary contact (in the sense that the axis of rotation of the mechtrode is stationary). This has been observed to result in undesirable deformations in the region of the upper ends of the
5 plates in the stack, such that it is difficult or impossible to split the plates from each other in these end regions so as to produce a usable product.

Accordingly, to avoid the consequences of these end effects the end portions are preferably cut away from
10 the stack before the latter is split (and before it is cooled as described above, if that step is undertaken). If the stack is heat treated prior to being split, the end portions are preferably, though not necessarily, removed before heat treatment takes place.

15 In order to obtain fully symmetrical splitting as described above, the number of plates in the stack at the commencement of step (C), i.e. after removal of the end portions, is an even number.

An embodiment of the invention will now be briefly
20 described, by way of example only, with reference to the annexed diagrammatic drawings, in which:-

Figure 1 is an end view of a knife blade which is the product of a process according to the invention;

Figure 2 is an end-wise cross-section through a stack
25 of plates clamped ready for the application of a hard facing layer, taken on the line II-II in Figure 3;

Figure 3 is a plan view on Figure 2;

Figure 4 is an enlarged scrap view corresponding to part of Figure 2 and showing the stack at the end of
30 the friction surfacing operation;

Figure 5 shows a stack early in the splitting operation;

Figure 6 shows the top end of two adjacent plates during splitting;

- 5 Figure 7 is an end view of an individual plate split from the stack; and

Figure 8 is a view similar to Figure 3 but showing an alternative way of stacking the plates in a clamping device; and

- 10 Figure 9 is a scrap view as seen from one side of Figure 2, but showing a modification.

Figure 1, not to scale, shows a disposable knife blade 10 comprising a mild steel laminar 12, 1.0 mm thick, with its sharpened cutting edge 14 tipped with a layer
15 16 of T1 high speed steel. This blade is made as follows.

Eight mild steel plates 12, 1.0 mm thick, are oxidised to form a weld inhibiting coating, and are then stacked as shown in Figures 2 and 3 with their top and bottom
20 edges substantially level, and clamped in a vice 20 having thermally conducting jaws 22 between which the stack, 24, is securely clamped with the jaws in contact with the entire area of the exposed end surfaces of the stack. All of the plates rest on a support block 26,
25 having its top and bottom edges ground parallel. The block 26 is supported on the bed 28 of the vice.

The top edge 30 and the bottom edge 32 of the stack are milled flat, so as to be parallel with each other and truly perpendicular with the faces of the stack in
30 contact with the jaws 22. Once the stack, with its top and bottom edges milled, is clamped between the jaws

and firmly seated on the block 26, it is ready for the friction surfacing operation. In this condition, the top edge 34 of the jaws lies a suitable small distance above the top edge 30 of the stack.

5 A cylindrical mechtrode 38, only the leading end of which is shown, rotating about its own vertical axis at 1000 rev/min, is lowered vertically on to the end portion 40 of the stack and into contact with the top surface 30, and is then moved once along the latter as
10 indicated by the arrow in Figure 3, at a speed of 4 mm/s. When it reaches the other end portion 42 of the stack, the mechtrode is raised clear of the stack. During its pass over the surface 30, the mechtrode deposits, by friction surfacing, a layer 44 of the high
15 speed tool steel over the surface 30. The plates 12 are now joined together by the applied layer 44 of the hard facing high speed tool steel material.

The upper surface of the applied layer 44 is now ground to the required thickness, and for control of cracking
20 as discussed above. The stack may be removed from the vice before or after this grinding operation. The end portions 40 and 42 are cut off, and the stack is heat treated at 570°C in two cycles of one hour each; the heating is followed by immersion in liquid nitrogen for
25 20 minutes.

While the stack is still at substantially the low temperature of the liquid nitrogen, it is split, starting from the bottom, using a tool not shown, so as
to split the stack in half as indicated by the arrow in
30 Figure 5. Each block of four plates 12 is then split in half, and finally the resulting four blocks of two plates are split in half to give individual plates 12, each with a flat topped tip 16 (Figure 7). Figure 6 shows a splitting operation between two of the plates

at the instant where brittle fracture of the layer 44 is taking place in a plane substantially coincident with the interface 46 between the two plates 12.

Finally, the cutting edge shown in Figure 1 is formed on the plate shown in Figure 7, to give the finished blade.

In Figures 2 to 4, the plates 12 are stacked with their ends abutting against the jaws 22. Figure 8 shows an alternative arrangement in which a stack of plates is clamped in the vice with the interfaces between the plates parallel to the clamping faces of the jaws instead of perpendicular thereto. This arrangement may well be preferable in the manufacture of small tools, where it is acceptable for the hard faced edge of each tool to be of a length no greater than the diameter of the mechtrode, the profile of which is indicated in phantom in Figure 8. As before, it moves along the top edge of the stack from adjacent one jaw to adjacent the other.

In Figure 9, the top edge 30 of the stack 24 is shown mounted a few millimetres below the level of the top edge 34 of the jaws 22, to define a "quasi recess" 36, which may be desirable under certain circumstances as discussed more fully earlier herein.

CLAIMS

1. A method of applying a hard facing along an edge of a substrate which comprises mechanically depositing, by means of rotatory friction surfacing treatment, an applied layer of relatively hard coating material along
5 the substrate edge, wherein the method includes the steps of (A) clamping together a stack of plates to form the substrate, (B) depositing the said hard materials by rotatory friction surfacing along an edge of the stack, and (C) splitting the resulting treated
10 stack in individual plates, each having bonded along one of its edges a generally coplanar applied layer of the said hard material.
2. A method according to Claim 1, including the further step of levelling the said edge of the stack by
15 machining material therefrom before depositing the layer of hard material.
3. A method according to Claim 1 or Claim 2, including the further step of grinding the applied layer of hard material to a smooth finish before the stack is split
20 into individual plates.
4. A method according to any one of the preceding Claims, wherein the plates are of ferrous material and are oxidised before assembly into the stack, so as to inhibit subsequent diffusion-bonding of the plates to
25 each other adjacent to the applied layer.
5. A method according to any one of the preceding Claims, wherein the stack is heat treated after step (B) but before step (C).
6. A method according to any one of Claims 1 to 4,
30 wherein the individual plates are heat treated after step (C) has taken place.

7. A method according to any one of the preceding Claims, including the further step, where either the substrate or applied layer is of a material exhibiting a ductile/brittle transition, of cooling the treated stack immediately before splitting it in step (C) to a temperature below the ductile/brittle transition temperature of the substrate material, or below that of the said hard coating material, or below both transition temperatures, splitting then being carried out while the stack is still at this low temperature.

8. A method according to Claim 7, wherein the stack is cooled by immersing it in liquid nitrogen.

9. A method according to any one of the preceding Claims, wherein the stack is split, in step (C), into individual plates by separation from the edge opposite to the applied layer, towards the latter.

10. A method according to any one of the preceding Claims, wherein the stack is formed from at least three plates.

11. A method according to Claim 10 when dependent on Claim 9, wherein the stack is split by successive operations each producing portions of the stack containing as nearly as possible equal numbers of plates still joined at the applied layer, until individual plates are obtained.

12. A method according to any one of the preceding Claims, including the further step of removing, prior to step (C), end portions of the stack on which, during step (B), a rotatory mechtrode has been stationary.

13. A method according to Claim 12 when dependent on Claim 11, wherein the number of plates in the stack at the commencement of step (C) is an even number.

14. A method according to any one of the preceding Claims, wherein the plates are stacked in step (A) with the substrate edge to be treated lying below a plane containing the upper edge of a pair of clamping jaws
5 whereby the stack is clamped, so as to define a quasi recess over the said edge.

15. A method according to any one of the preceding Claims, wherein the hard coating material provides metal carbides in a matrix based on metal selected from
10 the group consisting of iron, cobalt and nickel.

16. A method according to Claim 15, in which the hard coating material is high speed transformable tool steel and wherein, in step (B), this material is applied to the stack without melting at an austenitising
15 temperature at high rates of strain, in such a way as to form a fine microstructure, with carbides of about 2 microns particle size or below and substantially uniformly distributed in a very fine martensitic matrix, the resulting applied layer being subsequently
20 tempered to achieve secondary hardening.

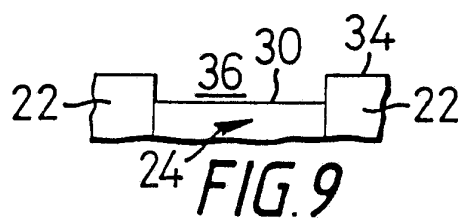
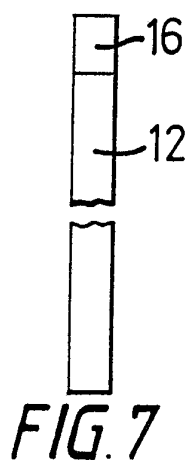
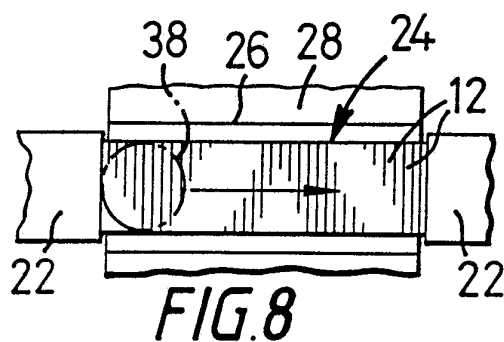
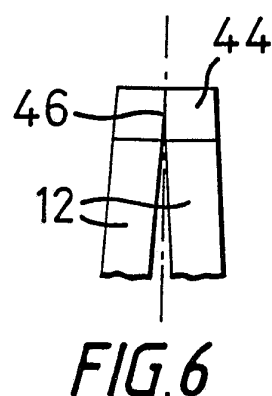
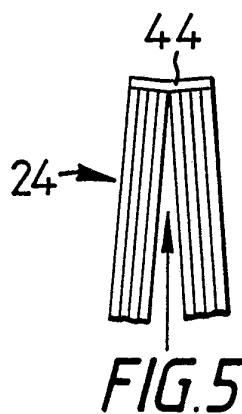
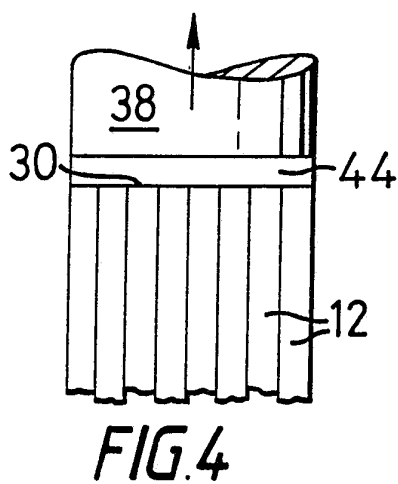
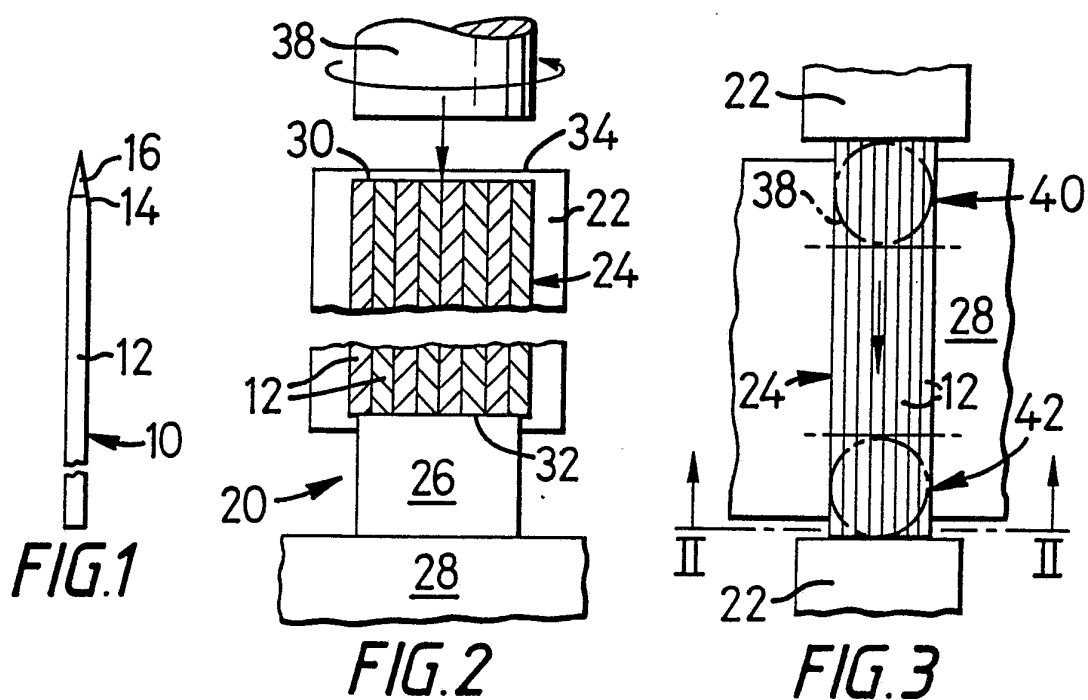
17. A method according to Claim 16, wherein after the hard layer has been applied, the substrate is maintained at a cryogenic temperature for a predetermined period and subsequently tempered.

25 18. A method according to any one of the preceding Claims, wherein the substrate plates are of mild or carbon steel.

19. A method according to any one of Claims 1 to 15, wherein the substrate plates are of a stainless steel
30 and the hard coating material is a cobalt/chromium/tungsten/carbon alloy.

20. A method according to any one of the preceding Claims, comprising the further step of forming into a cutting edge that edge of a plate separated from the stack which has the applied layer of hard material thereon.
21. A metal plate at least 0.5 mm thick, having bonded along one edge, by a method according to any one of the preceding Claims, an applied layer of a relatively hard material about 0.2 to 2.0 mm thick and extending from and lying in the major plane of the plate.
22. A method of applying a hard facing along an edge of a substrate, performed substantially as described with reference to Figures 2 to 7 of the drawings of this application.
23. A method of making a cutting blade, performed substantially as described with reference to the drawings of this application.

1/1



INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 89/00983

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC Int.Cl. 5 B23K20/12 ; C23C26/00		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	B23K ; C23C	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	FR,A,2469241 (GOETZE AG) 22 May 1981 see page 6, lines 1 - 29 ---	1, 3, 22, 23
A	WO,A,8704957 (FRICTION TECHNOLOGY LIMITED) 27 August 1987 see page 6, lines 6 - 18 see page 7, line 23 - page 8, line 31 (cited in the application) ---	1, 4-8, 18, 19-23
¹⁰ Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
17 NOVEMBER 1989	06. 12. 89	
International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorized Officer ARAN D.D. 	

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.

PCT/GB 89/00983

SA 30696

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

17/11/89

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR-A-2469241	22-05-81	None	
WO-A-8704957	27-08-87	EP-A- 0293387	07-12-88
		GB-A- 2210572	14-06-89