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(21) International Application Number: PCT/GB96/00752 (22) International Filing Date: 28 March 1996 (28.03.96) (30) Priority Data: 9506494.5 30 March 1995 (30.03.95) GB (71) Applicant (for all designated States except US): McPHERSON'S LIMITED [AU/AU]; 64 Geddes Street, Mulgrave, VIC 3170 (AU). (72) Inventor; and (75) Inventor/Applicant (for US only): UPTON, Albert, Bryan [GB/GB]; 37a Coldwell Lane, Sheffield S10 5TJ (GB). (74) Agents: HOUGHTON, David et al.; Hulse & Co., Eagle Star House, Carver Street, Sheffield S1 4FP (GB).		(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: KNIFE BLADES (57) Abstract The invention relates to knife blades and to a method of their production. Knife blades of the type with a hardened surface intended to enhance cutting performance, are known, such as, for example in EP 92908829.2, and EP 93303062.9. Such knife blades display considerably improved cutting characteristics in comparison with conventional blades and the object of the invention is to provide a knife blade exhibiting still further enhanced cutting characteristics. This objective is met by a knife blade comprising a cutting edge formed on a blank, one side of the edge being provided with a coating formed by a particulate material in a matrix, the matrix being softer than the particulate material, and the coating being such that a considerable number of the particulates project from the matrix in the vicinity of the cutting tip of the blade edge, to form the cutting tip.		

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KNIFE BLADES

This invention relates to knife blades and to a method of their production.

It has long been known that the surface hardness and wear resistant properties of metal objects can be enhanced
5 by the provision of a hard surface on the metal objects. Thus it is known to generate a carbide and/or nitride enriched or transformed surface, by an appropriate heat treatment, and also known to provide a hard surface coating such as by carburising or nitriding, chemical or physical
10 vapour deposition, electroplating, plasma arc spraying, and other processes.

When considering a knife blade, providing a hard surface particularly at the cutting edge, is difficult to put into practice by any of the techniques outlined above,
15 as a consequence of the very thin sections of blanks ordinarily employed in knife blade construction, and the acute angle to be found at the cutting tip. To take a finished enriched, or transformed hard surface layer, there is the inevitable depletion of carbon from the body of the
20 blade, leaving a blade of thin section with insufficient strength. With surface coatings with a finished blade the relatively small included angle formed at the cutting edge is such that there is an inevitable build-up of coating material at the actual cutting tip and which has a major
25 adverse effect on the sharpness of the blade.

Attempts have been made hitherto to apply a hardened surface to a knife blade such as by a diffusion heat

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treatment and by vapour deposition of carbides or nitrides. In one known form of construction there has been the treatment of a tapered blank followed by a single wetting or grinding to form a single edge ground or chisel cutting edge that puts the cutting edge in line with one side face of the blank. When subjected to recognised edge testing procedures, such knives have demonstrated no significant improvement in their cutting characteristics in comparison with untreated blades of the same configuration.

Improvements of considerable note have been achieved where a knife blade comprises a V-shaped cutting edge formed on a blank and such that the cutting tip lies substantially centrally of the width of the blank, one side face of the V-shaped cutting edge being provided with a coating of a material harder than the material of the blank, the actual cutting edge being formed wholly of the harder material. EP 92908829.2 discloses a method of forming a blade where a blank is first ground with one face of the V-shaped edge, the ground face is then provided with a hard coating, and the blank is then ground with the other face of the V-shaped edge. EP 93303062.9 improves on this by providing a hard coating having a columnar crystal structure that extends away from the surface of the blank and to the outer face of the coating.

The object of the present invention is to provide still further improvements in the cutting and edge retention characteristics.

According to the present invention, a knife blade

comprises a cutting edge formed on a blank, one side of the edge being provided with a coating formed by a particulate material in a matrix, the matrix being softer than the particulate material, and the coating being such that a considerable number of the particules project from the matrix in the vicinity of the cutting tip of the blade edge, to form the cutting tip.

Preferably, the cutting edge of the knife blade is of generally V shape, and the coating of particulate material and matrix provided on one side only of the V-shaped edge. Thus, a first face of the edge may be ground and coated, and following that, the second face of the edge is ground. Equally, both of the first and second faces of the V-shaped edge can be ground, one side only of the V-shaped edge being provided with a coating, the uncoated side of the V-shaped edge being re-ground after coating has been applied. The generally V-shaped edge may be formed by plunge or flat grinding to both sides, edge grinding to both sides, hollowgrinding to both sides, or the edge may be formed by one grinding technique to one side and a different grinding technique to the other. The blade may be formed from a parallel blank and provided with a centre generally V-shaped cutting edge, or may be a taper or hollowground blade with a whetted generally V-shaped cutting edge.

Preferably, the coating provided to one side of the edge of the blade is a cemented carbide material such as, for example, tungsten carbide particles in a cobalt, or a cobalt/chrome matrix. It will be understood that other

carbides and other matrices can be employed.

Further preferably, the cemented carbide material may be sprayed on to one side of the edge of the blade by a high velocity oxy-fuel spray technique, or by a high pressure high velocity oxy-fuel spray technique. Other
5 cemented carbide deposition techniques can also be employed.

When the coating is a cemented carbide such as tungsten carbide, it is preferably composed of 5% to 20% of cobalt or cobalt/chrome and 80% to 95% of tungsten carbide,
10 the coating being applied in a manner that causes the presence of micropores to be distributed throughout the coating, preferably controlled to ensure that the summation of the micro-pores is less than 1% of the total volume of the coating.

15 To avoid the uneconomic employment of the coating of the invention, it is preferred to limit the coating to one side of a cutting edge. To achieve this, it is preferred to blank the blade and leave exposed the side of the edge to be coated. To maximise production, a blade can be employed to
20 mask a blade behind, a number of blades being loaded in an appropriate jig, with the front blade masked by a masking plate, to leave all of the edges of the blades exposed.

When the coating of the invention is provided by the high velocity oxy-fuel, or high pressure high velocity oxy-fuel,
25 spraying of cemented carbides, the blades should be set in relation to each other such that the blade sides are not in contact, to ensure that the sprayed material does not bond together adjacent blades. Preferably, the direction of

the spray is approximately at 90° to the side of the blade edge to be sprayed, but may be set at an acute angle to achieve a slightly greater width of spray coated face on each blade, by spraying a masked blade behind the tip of a
5 masking blade.

The blades may be so positioned in relation to the spray that a number of blades can be simultaneously sprayed, and in one operation provided with a required depth of sprayed material at the cutting edge. To further maximise
10 the production of sprayed blades, a number of jigs, each with a number of blades, can be assembled after the manner of a carousel, and the carousel rotated in front of a spray head. This causes the sequential spraying of blade edges and the progressive build-up of coating thickness until the
15 predetermined thickness of coating is provided.

By having a coating of a hard particulate material bound by a softer matrix, the result is that the cutting tip of the edge is effectively formed by the considerable number of projecting particles of hard material.

20 The thickness to be achieved is a function of the rate of spraying of the cemented carbide and the rate of rotation of the carousel, i.e. the higher the rotational speed of the carousel the greater is a spray rate required to produce a particular thickness of coating on the blade,
25 the final thickness of coating also being controlled by the number of revolutions of the carousel and hence the number of passes of a blade across the spray.

Desirably, the coating of the invention has a

thickness of between 8 and 60 micron, preferably is 25 to 45 micron, and still further preferably 25 to 30 micron. Desirably, the coating has a specific gravity of 12.6.

The invention is based on the recognition that with a particulate material and a matrix softer than the particulate material, micro-wear of the matrix takes place to expose the particulate material, to create by the considerable numbers of particles that are exposed at the cutting tip a cutting edge to a blade that is extremely sharp. The final grind to the uncoated side of the blade either to form the second face of the V-shaped edge, or to re-grind the second face of the V-shaped edge, is such as to generate a microscopically uneven or rough tip at the extremity of the sprayed material, such an uneven or rough initial tip being the primary cause of an extremely sharp initial cutting edge. As the knife is used, the micro-wear of the matrix exposes more and more particles, allows used particles to fall away and be replaced by fresh particles behind them in the matrix. This micro-fragmentation at the edge is assisted by imperceptible but actual wear of the uncoated side of the edge immediately behind the tip to help maintain matrix and particulate material forming the whole of the cutting tip of the blade. Of further assistance is the presence of micro-voids distributed throughout the matrix, the voids taking part in the micro-fragmentation that continuously occurs at the cutting tip as the blade is used.

The net effect is a blade that not so much has an

edge that retains its sharpness, but a blade edge that increases in sharpness by use.

Because conventional edge testing has failed to quantify the improvement provided by the invention, considerable efforts have been made to find a way of quantifying the performance of an edge, and allowing a proper comparison with another edge.

Theoretical consideration of the performance data of knives suggests an exponential relationship for the deterioration of the cutting edge with time. In order to test this theory the standard exponential equation given in Eqn (1) below was evaluated adopting the following rational.

$$K = A.e^{-\lambda t} \quad \text{Eqn 1}$$

where K, A and λ are constants and t is time

Plotting K versus t using an arbitrary value for λ gives a classic exponential curve.

By taking logarithms (In) Eqn 1 reduces to

$$\ln K = -\lambda t + \ln A \quad \text{Eqn 2}$$

A plot of $\ln K$ versus t gives rise to the linear plot with intercept $\ln A$ and negative slope λ .

In practice A and K are numerical values usually denoted by N_0 and N respectively.

All the knife blades showed deterioration in performance to varying extents. Thus to test this theory on the wear of various knife blades then the following values were defined:

N_0 = the number of strokes to cut the first block

N = the number of strokes to cut a block after 'n'

blocks have been cut

N_{test} = 30 being the end of practical testing as a
measure of cutting efficiency

N_{cum} = cumulative number of strokes

5 λ = wear constant

In other words the number of blocks 'n' which have been cut
is a function of the time, whilst the cumulative number of
strokes is proportional to the time taken for each test run.

To illustrate the application of the theory four
10 knives were considered

Knife A - a taper ground blade with a terminal
over-ground or whetted V at the cutting edge

Knife B - a knife made in accordance with GB(EP)
Patent No. 0220362, formed from a parallel blank with a
15 centre V-cutting edge, the cutting edge being plain to one
side and formed with serrations/scallops to the other side.

Knife C - a knife made in accordance with EP
93303062.9, formed from a parallel blank with a centre V
cutting edge, the cutting edge being plain to one side and
20 formed with serrates/scallops to the other side, the
serrated/scalloped side being coated with a material having
a columnar crystal structure.

Knife D - the knife as described in A above, one
face of the over-ground or whetted V being provided with a
25 coating in accordance with the invention.

In the accompanying drawings:

Figure 1 is a graphical representation of the cutting
performance of Knife A;

Figure 2 corresponds to Figure 1 but shows the cutting performance of Knife B;

Figure 3 corresponds to Figure 1 but shows the cutting performance of Knife C; and

5 Figure 4 corresponds to Figure 1 but shows the cutting performance of Knife D.

In each of Figures 1 to 4 the equation has been further modified such that

$$\ln N_{\text{test}}/N = -\lambda t \text{ or}$$

10 $\ln N/N_{\text{test}} = \lambda t$

and $\ln N/N_{\text{test}}$ (performance index) has been plotted against N_{cum} (cumulative number of strokes) resulting in a range of lines of varying negative slope.

15 Whilst there are deviations from strict linearity it is believed that taking into account experimental errors, the close approximation to linearity is sufficient to show that the exponential theory holds true.

20 Thus the performance of the blades can now be quantified in terms of the slope ' λ ' and a value derived for the effective 'half-life'. By 'half-life' is meant a comparative measure of the cumulative number of strokes taken by the blade to reach 50% N_{test} .

The following are the derived values of the above knives tested:

	Approximate Value of λ	Approximate N_{cum} (50% N_{test})
Knife A	0.038	17
Knife B	0.0014	700
Knife C	0.00042	4500
5 Knife D	0.000015	No perceived deterioration

It is believed that knife C exhibits the highest sharpness factor and edge retention characteristics of knives known in the prior art. Its approximate N_{cum} at 4500 compared to 700 for knife B which is, in fact, the same knife but with a
10 columnar crystal coating to one side of its generally V-shaped edge, is an adequate demonstration of the notable reduction in edge deterioration exhibited by knife C in comparison with knife B.

Knife D of the present invention is an immeasurable
15 improvement over knife C, and knife D simply cannot be compared with same, but uncoated, knife A.

CLAIMS

1. A knife blade comprising a cutting edge formed on a blank, one side of the edge being provided with a coating formed by a particulate material in a matrix, the matrix being softer than the particulate material, and the coating being such that a considerable number of the particulates project from the matrix in the vicinity of the cutting tip of the blade edge, to form the cutting tip.

2. A knife blade as in Claim 1, wherein the cutting edge of the knife blade is of generally V-shape and the coating of particulate material and matrix is to one side only of the edge.

3. A knife blade as in Claim 1 or Claim 2, wherein the coating is applied to a first formed face of a V-shaped cutting edge and the second face of the V-shaped cutting edge subsequently ground.

4. A knife blade as in Claim 1 or Claim 2, wherein both faces of a V-shaped cutting edge are formed and the coating applied to one face, the other face being re-ground subsequent to the application of the coating.

5. A knife blade as in any of Claims 1 to 4, wherein one or both sides of the V-shaped cutting edge are plunge or flat ground.

6. A knife blade as in any of Claims 1 to 4, wherein one or both sides of the V-shaped cutting edge are edge ground, hollow ground, or formed by one grinding technique to one side and a different grinding technique to the other.

7. A knife blade as in any of Claims 1 to 6, wherein

the coating to one side of the edge of the blade is a cemented carbide material.

8. A knife blade as in Claim 7, wherein the coating is composed of carbide particles in a cobalt or in a chrome/cobalt matrix.

9. A knife blade as in Claim 7 or Claim 8, wherein the coating comprises 5% to 20% of cobalt or chrome/cobalt and 80% to 95% of carbide particles.

10. A knife blade as in any one of Claims 1 to 9, wherein the coating is a sprayed coating formed by a plasma, a high velocity oxy-fuel or a high pressure high velocity oxy-fuel spray technique.

11. A knife blade as in any one of Claims 1 to 10, wherein the coating has micropores distributed throughout the coating.

12. A knife blade as in Claim 11, wherein the micropores are controlled to ensure that their summation is less than 1% of the total volume of the coating.

13. A knife blade as in Claims 1 to 12, wherein the coating has a thickness of between 8 and 60 micron, preferably 25 to 45 micron, and still further preferably, 25 to 30 micron.

14. A knife blade as in Claims 1 to 13, wherein the coating has a specific gravity of 12.6.

15. A knife blade as in Claims 1 to 14, wherein the grinding or re-grinding of the uncoated face of the V-shaped edge is such as to generate a microscopically uneven or rough tip at the extremity of the coating.

16. A method of producing a knife blade as in any of Claims 1 to 15, wherein to limit the coating to one side of a cutting edge, the blade is blanked to leave exposed the side of the edge to be coated.

17. A method as in Claim 16, wherein a blade is employed to mask a blade behind, a number of blades being loaded in an appropriate jig with the front plate masked by a masking plate to leave all of the edges of the blades exposed.

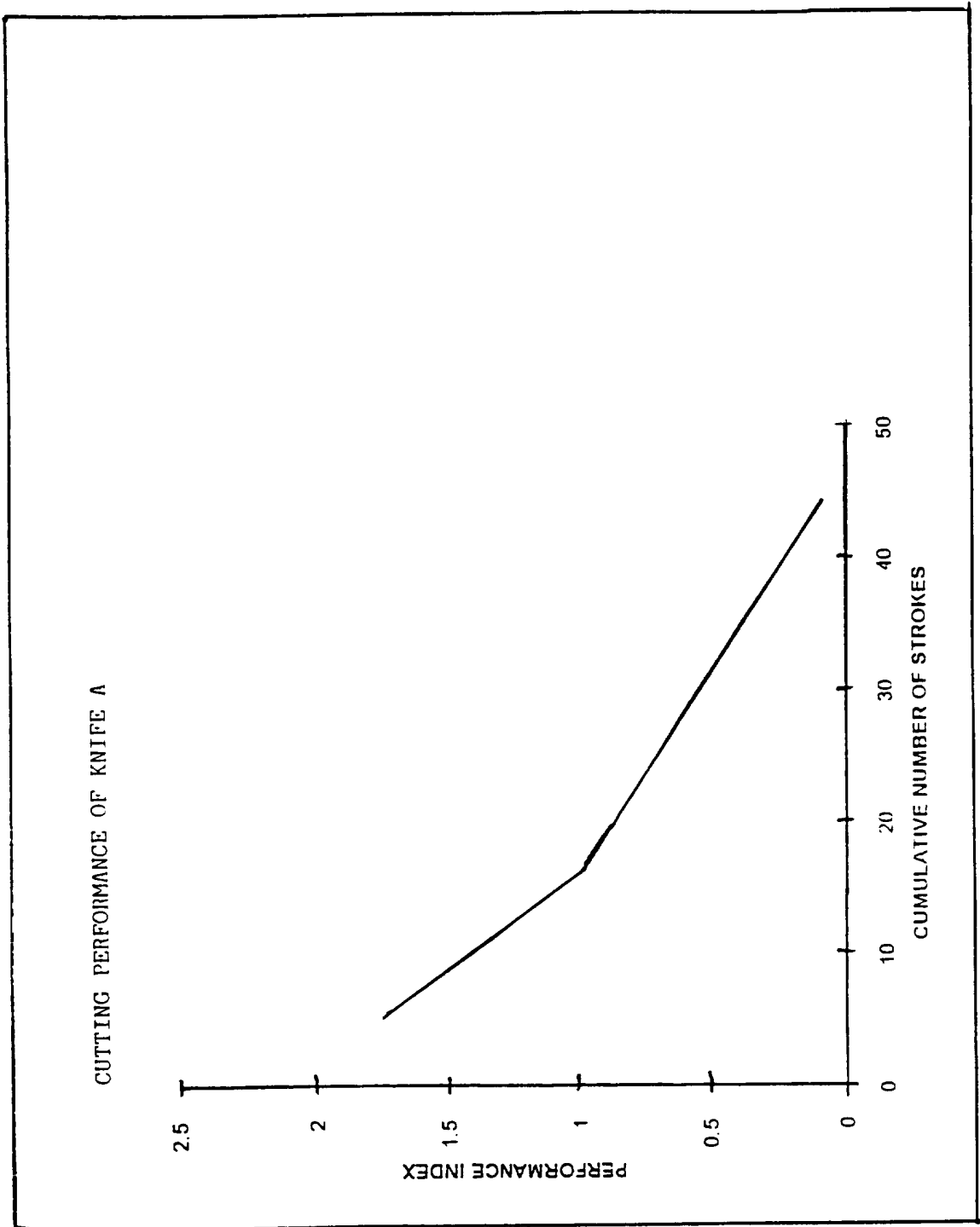
18. A method as in Claim 16 or 17, wherein the direction of spray is at approximately 90° , or more, to the side of the blade.

19. A method as in any of Claims 16 to 18, wherein a required depth of coating is provided in one operation.

20. A method as in any of Claims 16 to 19, wherein a number of coats are applied successively to build up a coating of a required thickness.

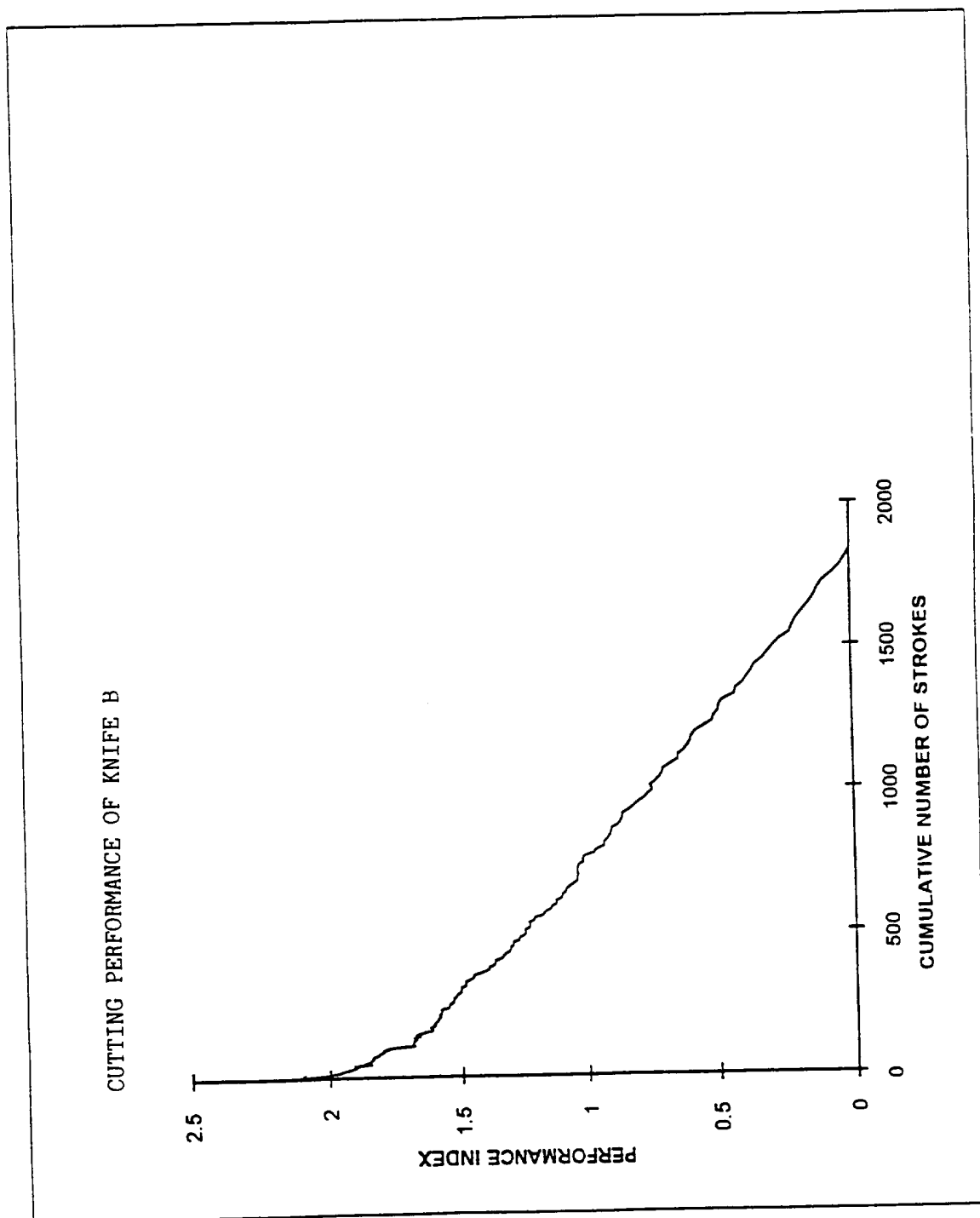
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FIG 1



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Fig 2



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Fig. 3

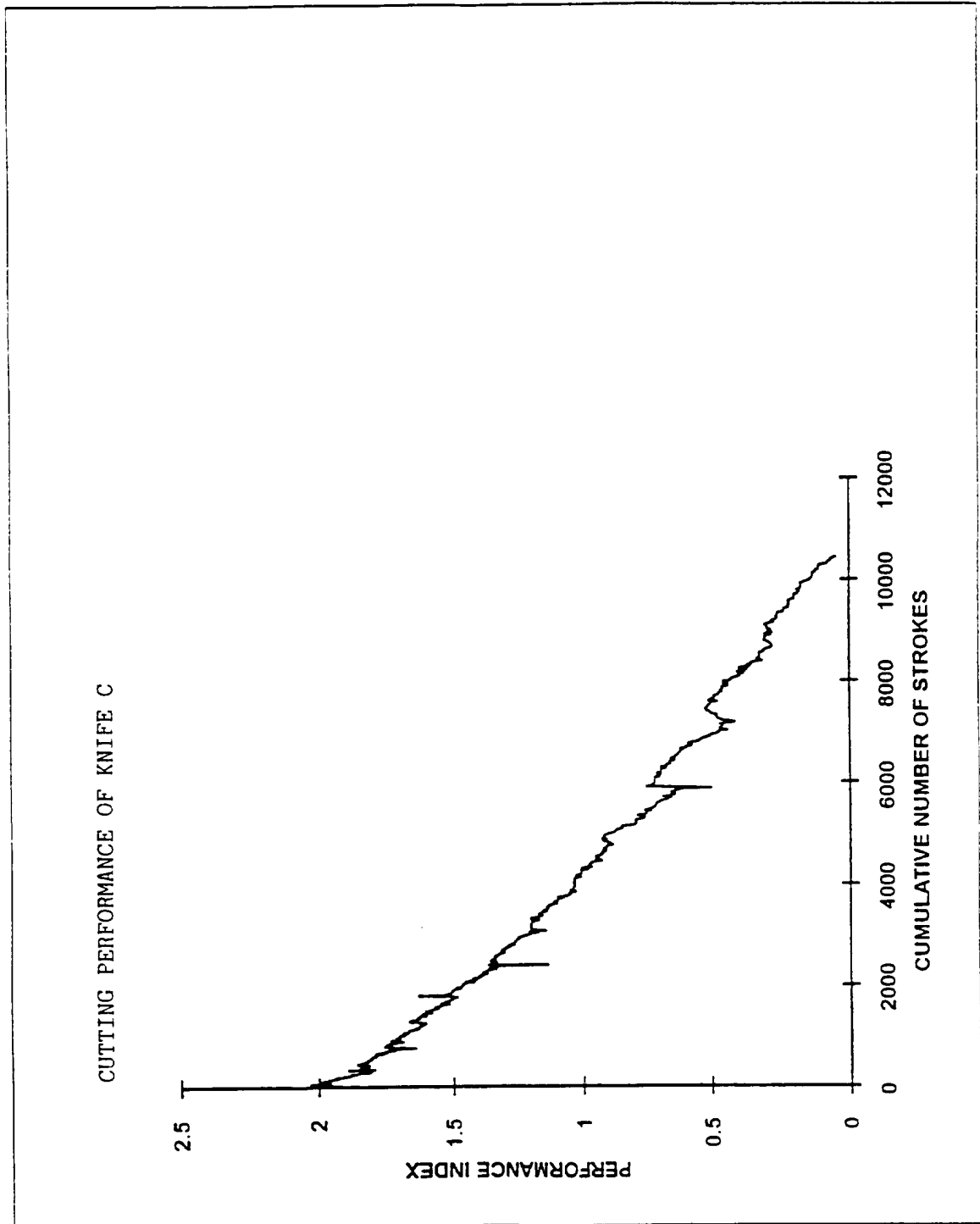
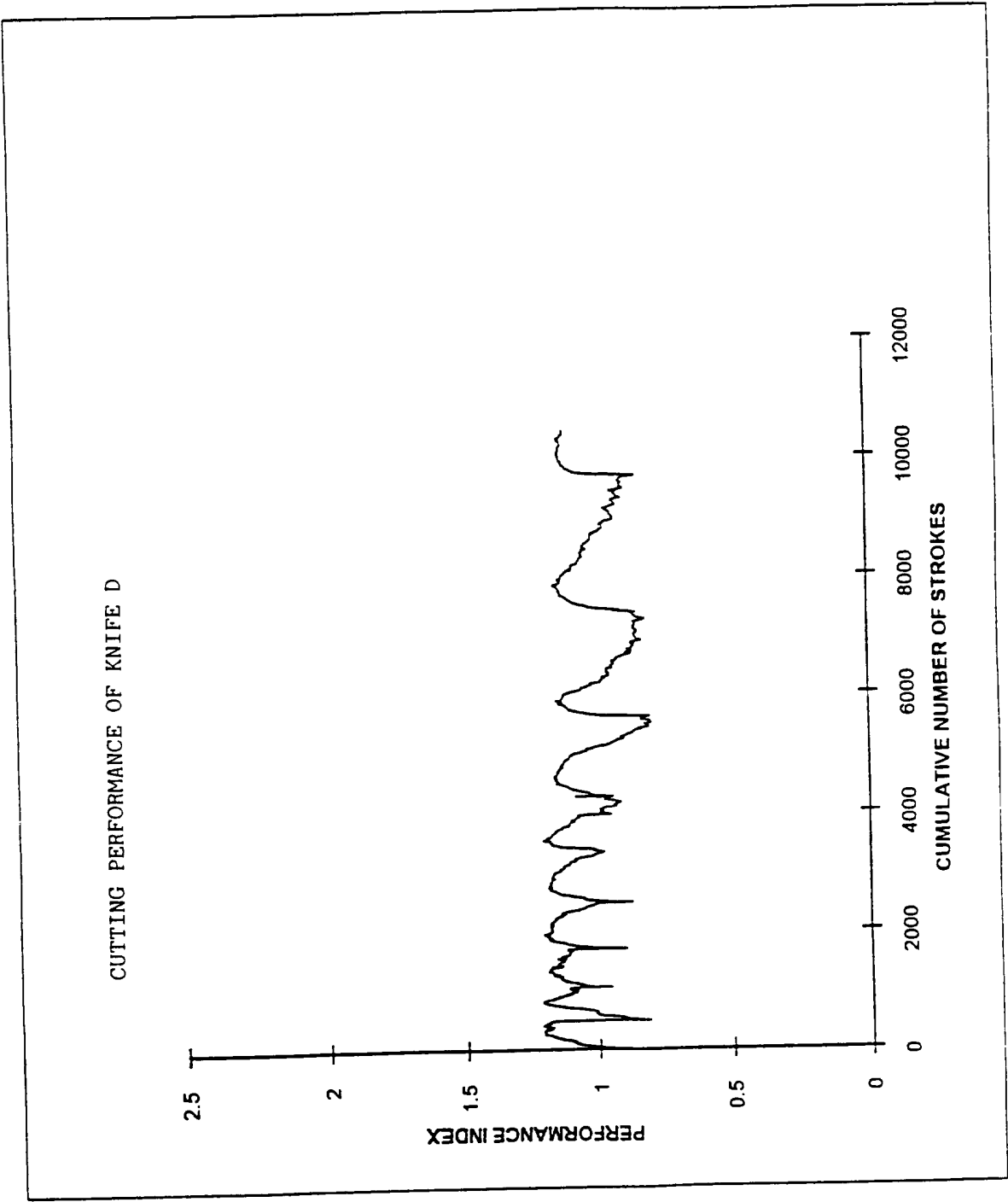


FIG 4



INTERNATIONAL SEARCH REPORT

International Application No
PC1/GB 96/00752

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B26B9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B26B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 567 300 (MCPHERSON'S LTD) 27 October 1993 cited in the application see the whole document ---	1-10, 15-20
A	EP,A,0 628 379 (SCHÄFER H) 14 December 1994 see the whole document ---	1-4
A	US,A,5 256 496 (KLUCZYNSKI M L) 26 October 1993 ---	
A	DE,A,24 29 814 (BAUER K) 2 January 1976 ---	
A	DE,A,25 12 001 (ROTEL-HOLDING AG) 23 October 1975 -----	

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☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 96/00752

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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