(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 June 2012 (21.06.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/079110 A1

(51) International Patent Classification: *E21C 35/18* (2006.01)

(21) International Application Number: PCT/AU2011/001368

(22) International Filing Date: 27 October 2011 (27.10.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2010905501 16 December 2010 (16.12.2010) AU

(71) Applicant *(for all designated States except US)*: **NEWSOUTH INNOVATIONS PTY LIMITED** [AU/AU]; Rupert Myers Building, Gate 14, Barker Street UNSW, Sydney, New South Wales 2052 (AU).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **ZHANG, Liangchi** [AU/AU]; 14 Hermitage Road, West Ryde, New South Wales 2114 (AU).

(74) Agent: **GRIFFITH HACK**; Level 29, Northpoint, 100 Miller Street, North Sydney, New South Wales 2060 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: CUTTING TIP AND TOOL

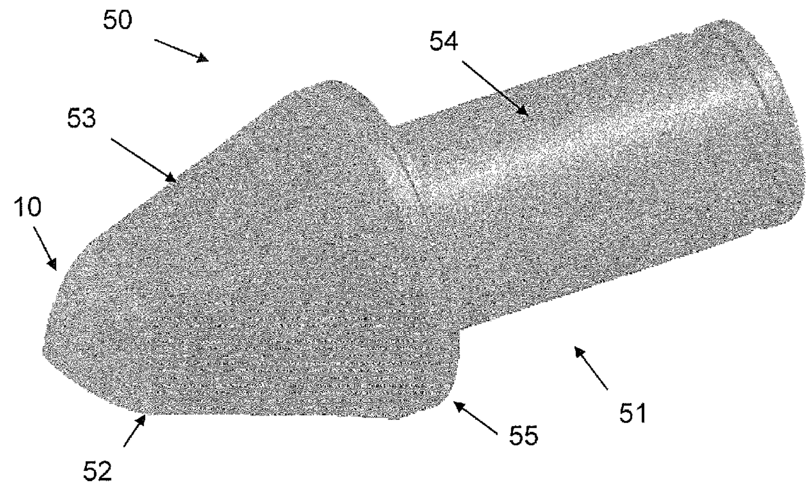

Fig. 1

(57) **Abstract**: A cutting tip (10) for a mechanical excavator comprises a tip body (11) having a tip axis, a generally pointed distal end (12), a proximal end (13) spaced from the distal end along the tip axis, and a circumferential wall (14) which is non-symmetrical about the tip axis which diverges outwardly from the distal end towards the proximal end. The non-symmetrical circumferential wall comprises a plurality of axially extending ridges (15) and intermediate faces (16) disposed between the ridges.

WO 2012/079110 A1

CUTTING TIP AND TOOL

Technical Field

A cutting tip and cutting tool (also referred to as a cutting pick) is disclosed, generally for use in excavation equipment and processes. The cutting tip and tool has been developed especially for mechanical excavators for use in the mining industry and will be described in that context. However, it is to be appreciated that the cutting tip and tool has broader applications and is not limited to that use.

Background Art

Mechanical excavators that incorporate cutting picks are extensively used in the removal of rock and coal in the mining industry. Such machinery includes roadheaders, continuous miners and longwall shearers. One of the most widely used cutting picks is the "point attack" pick (otherwise known as the conical pick). The tip of these picks, which actually engages in cutting, has a conical geometry and is made of hard material such as tungsten carbide. These picks are popular particularly as they have a relatively long service life.

Despite the popularity of the point attack picks, they are known to generate large amounts of dust due to the indentation action of the conical tip, which crushes a considerable volume of coal/rock at the point of impact. The excessive dust has been a major issue, particularly in underground coal mining due to the adverse health effects such as black lung (pneumoconiosis) which has been the biggest killer of underground workers. The usual practices to mitigate the problem of excessive dust, such as blowing large quantities of air at high speed, water spray and installation of dust scrubbers are expensive and only partially effective. In addition to the dust, the point attack pick is known to consume excessive energy and generate excessive noise (which can result in significant hearing loss to those working in the mine) and excess coal fines which are more difficult and hence more costly to process at the coal preparation plant.

The above references to the background art do not constitute an admission that such art forms a part of the common and/or general knowledge of a person of ordinary skill in the art. The above references are also not intended to limit the application of the cutting tip and tool as disclosed herein.

Summary of Disclosure

Disclosed herein is a cutting tip for a mechanical excavator. The cutting tip may generally find application in excavation equipment and processes.

The cutting tip comprises a tip body having a tip axis, a generally pointed distal end, a proximal end spaced from the distal end along the tip axis, and a circumferential wall which is non-symmetrical about the tip axis and which diverges outwardly from the distal end towards the proximal end. The non-symmetrical circumferential wall comprises a plurality of axially extending ridges and intermediate faces disposed between the ridges.

In one embodiment, a first one of the intermediate faces may be adapted, in use, to be presented in facing relation to a material surface (e.g. a rock face) and may have a different profile to that of a second face which may be disposed opposite the first face. In a particular form, the first face may have a substantially planar profile and the second face may have a substantially non-planar profile.

In one embodiment, the second face may have a longitudinally extending transitional portion located between the proximal and distal ends of the tip. The transitional portion may have a generally arcuate profile and may, for example, have a substantially concave or convex profile.

In one embodiment the second face may further comprise a distal portion immediately adjacent the distal end. The distal portion can meet with the transitional portion such that a surface profile of the distal portion defines a tangent line to the surface profile of the transitional portion at a point where the two portions meet.

In a particular embodiment, the transitional portion may be located between the distal portion and a proximal portion adjacent the proximal end. At least one of the distal and proximal portions may be substantially planar.

In one particular embodiment, the tip may be of polygonal shape and may have opposite side faces intermediate the first and second faces. For example, each one of the side faces may have a substantially concave or inwardly bowed profile.

In one embodiment the tip may have four faces. In another form the tip may have more than four faces.

The dimensions of the cutting tip may vary depending on the application (e.g. the type and configuration of material being excavated, etc.) as well as the form of tool in which the tip is used. In one particular form, the transitional portion may have a radius of curvature in the range of 2mm to 8mm. Further, the distal portion may define a smaller angle with respect to the tip axis than the proximal portion. In one form, the angle defined between the distal portion and the tip axis may be in the range of 25 to 34 degrees. In one form, the angle defined between the proximal portion and the tip axis may be in the range of 35 to 45 degrees. In one form, an angle defined the first face and the tip axis can be greater than the angle defined between the tip axis and the distal portion of the second face. In a particular form, the angle defined between the first face and the tip axis may be in the range of 35 and 45 degrees.

In one embodiment the tip may comprise a coupling disposed at the proximal end of the tip body which may be arranged to mount the cutting tip into a cutting tool bit. In one arrangement the coupling may be in the form of a projection that extends from the proximal end and may be arranged to be received in a corresponding recess in the tool bit. In a particular form, the coupling may be in the form of a recess that is arranged to be received in a corresponding projection in the tool bit. The coupling may be formed of a material which has been subjected to a grinding hardening process to harden the material.

The tips may be made from a hard material including diamond, polycrystalline diamond (PCD), cubic born nitride (CBN) and polycrystalline cubic born nitride (PCBN). It will also be appreciated that the tips may be made of a more conventional hard material such as sintered tungsten carbide.

Also disclosed is a cutting tip for a mechanical excavator. The cutting tip comprises a tip body having a tip axis, a generally pointed distal end, a proximal end, and a circumferential wall which diverges outwardly from the distal end towards the proximal end along the tip axis. The circumferential wall comprises a plurality of axially extending ridges and intermediate faces disposed between the ridges. One of the faces has an arcuate transitional portion extending between a proximal and distal portion of the face. At least one of the proximal and distal portions has a generally planar profile.

Also disclosed is a cutting tip for a mechanical excavator. The cutting tip comprises a tip body, a generally pointed distal end, a proximal end, and a circumferential wall which diverges outwardly from the distal end towards the proximal end. The circumferential wall comprises a plurality of axially extending ridges and intermediate faces disposed between the ridges. A first one of the intermediate faces which, in use is adapted to be in facing relation to a surface of the material to be cut, has a substantially planar profile.

Also disclosed is a cutting tool comprising a bit body having a leading end, and a cutting tip, as described in accordance with the first aspect above, disposed at the leading end.

In a particular embodiment the cutting tip may be mounted to the bit body and may be formed from a harder material than the bit body. In one form the bit body may have an outer surface which has been mechanically hardened using a grind hardening process.

Also disclosed is a method of cutting a material using a cutting tool mounted on a rotating drum and comprising a tip on which is provided a longitudinally extending planar portion adjacent a distal end thereof, the method comprising presenting the cutting tool to a face of the material such that a substantial portion of the confronting face is in facing relation to the material face during cutting of the material under rotation of the drum.

In one embodiment the method may further comprise maintaining the facing relation for further rotations of the drum.

In one embodiment the tip used in the above method may be the cutting tip as disclosed above.

In one embodiment, where the material is granite, the tip may be presented at an angle of attack in the range of 60 to 65 degrees.

In one embodiment, where the material is sandstone, the tip may be presented at an angle of attack in the range of 50 to 60 degrees.

In one embodiment the tip may comprise a tip body, a generally pointed distal end, a proximal end spaced from the distal, and a circumferential wall which diverges outwardly from the distal end towards the proximal end. The circumferential wall may comprise a plurality of axially extending ridges and intermediate faces disposed between the ridges. The substantially planar portion may be provided on one of the intermediate faces.

In one embodiment the substantially planar portion may extend substantially across the length and width of the face.

Brief Description of the Drawings

It is convenient to hereinafter describe embodiments of the cutting tip and cutting tool with reference to the accompanying drawings. It is to be appreciated that the particularity of the drawings and the related description is to be understood as not superseding the generality of the preceding broad description of the cutting tip and cutting tool.

In the drawings:

Fig 1 is a schematic view of a cutting tool according to a first embodiment;

Fig 2 is a side view of the cutting tip of the tool of Fig 1;

Fig 3 is a top plan view of the tip of Fig 2;

Fig 4 is a front view of the tip of Fig. 2;

Fig 5 is a bottom plan view of the tip of Fig 2;

Fig 6a is a top view of a cutting tip according to a second embodiment;

Fig 6b is a side view of the cutting tip of Fig 6a;

Fig 7 is a schematic view of the position of the cutting tool of Fig 6 when impacting a material surface;

Fig 8a is a front view of the tool bit of Fig 1 without the tip; and

Fig 8b is a sectional view of Fig. 8a through A-A.

Detailed Description of Specific Embodiments

Fig 1 illustrates a cutting tool 50 (otherwise known as a cutting pick) for a mechanical excavator. The cutting tool 50 includes two main components, a cutting bit 51 and a hard insert otherwise known as a cutting tip 10 which is disposed at a forward end 52 of the cutting bit 51. As will be observed from the figures, the cutting tip 10 has a circumferential wall which is non-symmetrical about a central axis CL of the tip 10 and which provides significant advantages in relation to optimised cutting forces and radial crack generation and propagation, as will be described in more detail herein.

The non-symmetrical cutting tip 10 is securely mounted to the forward end 52 of the cutting bit 51 so that it can accommodate the significant forces impacted on the cutting pick in use. The cutting tip 10 may be bonded or braze welded onto the cutting bit 51 and may also include a projection or recess which is received in a complementary shaped recess or projection in the cutting bit 51. Other fastening or mounting arrangements including releasable mechanical fastening arrangements may also be used and are within the ambit of the disclosure.

With additional reference to Figs 8a and 8b, the cutting bit 51 includes an enlarged head portion 53 on which the cutting tip is mounted and a cylindrical shank 54 which extends rearwardly from a proximal end 55 of the bit head 53. The shank 54 is mounted into a pick holding device of the excavator in a manner that prevents axial and optionally rotational movement (i.e. so as to maintain the tip alignment during operation, as described in more detail herein) of the pick 50. In the illustrated example, the shank 54 is received in a socket of the pick holding device. A channel 56 defined in an outer wall of the shank 54 is arranged to slidingly receive a projecting portion provided on an inner wall of the socket, thereby preventing rotational movement of the cutting bit during operation. It will be understood that numerous other techniques for preventing rotational movement could equally be employed and the particular configuration described herein should not in any way be seen as limiting to the cutting tip and tool.

In an embodiment an outer surface of the cutting bit 51 is subjected to a grind-hardening process. An example grind hardening process which may be suitable for use with the cutting bit is outlined in the following published paper authored by the present inventor, the contents of which are incorporated herein:

Zhang, L.C. (2007) ‘Grind-hardening of steel surfaces: a focused review’, *Int. J. Abrasive Technology*, Vol. 1, No. 1, pp.3–36.

Such a grind hardened outer surface may advantageously increase the hardness of the outer surface for better withstanding the rigours of cutting, particularly when cutting into hard rock such as granite and like materials. In the illustrated embodiment the outer surface has been treated such that the hardened layer extends 1.5mm into the outer surface, achieving a hardness of up to 700HV (with a 5kg load).

In use, a plurality of the picks 50 are typically mounted in respective pick holding devices which are mounted on a rotatable drum of the excavator. The picks 50 extend outwardly from the drum and, as the drum rotates, it is moved across the rock face in a cutting direction. In this way the picks impact the rock face at an angle (commonly referred to as the attack angle) and a typical orientation of the cutting pick when impacting the rock material is schematically disclosed in Fig 7. Before describing optimal pick orientations and attack angles in any detail, the particular pick geometry of the tip in accordance with a particular embodiment will first be described.

In this regard, and now with specific reference to Figs 2 to 5, the cutting tip 10 includes a tip body 11 having a pointed distal point end 12 and a broader proximal end 13. The pointed distal end 12 locates on the centre axis CL of the cutting tip 10 which coincides in use with the central axis of the cutting tool illustrated in Fig 1.

The cutting tip 10 further includes a profiled circumferential wall 14 that diverges outwardly from the distal end 12 to the proximal end 13. Unlike conical point attack picks, which induce a uniform stress profile in the material on impact by the cutting tip, the wall 14 of the cutting tip disclosed herein is specifically profiled to produce a non-uniform stress profile that facilitates radial cracking in the material to be cut on impact.

In the illustrated form as shown in Fig 3, the cutting tip wall 14 is profiled to incorporate a plurality of axially extending ridges 15 that extend from the proximal end to the distal end and a plurality of intermediate faces 16 which are located between these ridges (i.e. faces 16a, b and c). As illustrated in Figs 2 and 3, the proximal end 13 of the cutting tip 10 is generally square (with or without rounded corners) with the ridges 15 extending from the corners of the square end to the pointed distal end 12. As such, the cutting tip includes four ridges 15 and four mutually inclined intermediate faces 16.

As is evident from Figs 2 through 4, the faces 16 of the wall 14 do not all share the same profile, thus creating a non-symmetrical circumferential wall profile at the cutting tip end. It has been discovered by the present inventor that the particular profiling of the individual faces can significantly impact on both the cutting efficiency of the pick, as well as the stress intensity factor for the material (which persons skilled in the art will appreciate is a measure of how well cracks propagate in the surface of the material being cut).

With particular reference to Figs 2 through 5, the tip 10 comprises a first face 16a having a substantially planar profile and which is adapted to be presented in facing relation to a material surface (e.g. a rock face) for cutting. A second face 16b is disposed opposite the first face 16a and has a substantially non-planar profile. Such a non-symmetrical wall profile is designed specifically to encourage propagation of larger cracks in the surface of material being cut (i.e. leading to generation of bigger chips) than for conventional picks having a symmetrical outer wall profile. Furthermore the tip geometry as illustrated in Figs 2 to 5 is designed to crush less material than such conventional picks and accordingly results in lower energy consumption, less noise, less dust generation and less pick tip wear.

In more detail, the second face 16b comprises a generally planar distal portion 17 adjacent the distal end 12 of the tip 10 and a generally planar proximal portion 19 adjacent the proximal end 13. As is evident from Fig 2, the first portion 17 defines a smaller angle with respect to the central axis CL of the tip than the second portion 19. According to the embodiment described herein, the angle defined between the first portion 17 and the central tip axis CL is 30°, while the angle defined between the second portion 19 and the central tip axis CL is 38°. It will be understood, however, that the angles described above may vary and can range +/- 5°, depending on the application.

A transitional portion 21 extends between the distal and proximal portions 17, 19 and has a generally arcuate profile. In the illustrated form in Fig 2, the transitional portion 21 meets with the distal portion 17 such that a surface profile of the distal portion 17 defines a tangent line to the arcuate profile of the transitional portion 21 at the meeting point. Further, as shown in Fig 2, the portion 21 defines a generally smooth transitional curve between the portions 17, 19 and has a radius of curvature r_1 of 5mm (although it will be understood that this radius may be more or less than 5mm depending on the application). In alternative embodiments, the transitional portion may not have a smooth profile and instead have more of a stepped or discontinuous profile, for example, by being made up of a plurality of mutually inclined straight line sections. Furthermore, the length of both the proximal and distal portions should not be seen as being limited to that shown in the figures and can be of any particular length, depending only on the desired application.

In order to provide a sufficiently strong apex to the tip geometry, the planar first face 16a defines a larger angle with respect to the central tip axis CL than the first portion of the second face 16b. According to the illustrated embodiment, the angle is 38°, resulting in a pitch angle σ at the distal end of 68° (i.e. when presented to the rock face in the manner shown in Fig 7). However, the geometry of the cutting tip could be such that the pitch angle σ varies more widely than this range and typically can range between 50° and 90°.

A pair of side faces 16c are located intermediate the first and second faces 16a, 16d. Each of the side faces 16c has a substantially concave profile for reducing the amount of contact friction experienced by the cutting tip in use. Such a configuration may advantageously increase the working life of the tip without having any adverse affects on the tip's performance.

It will be observed from Fig 3, that the ridges 15 located between the second face 16b and the side faces 16c have a similarly sectioned profile to that of the second face 16b. That is, the ridges each have distal and proximal portions 15a, 15c of generally planar profile, and a generally arcuate transitional portion 15b which runs between planar portions 15a, 15c.

Whilst the tip geometry shown in Figs 2 to 5 has a generally concave second face profile, the second face profile may be other than concave and, in an alternative embodiment, may be either planar or at least partially outwardly contoured. An example of an outwardly contoured second face profile is shown in Figs 6a and 6b. As illustrated, the primary difference between the tip 60 of Fig 6 and the tip 10 of Fig 2 is that the second face 62 (and adjacent ridges 64) bows outwardly to define a generally convex profile. The present inventor has found that when cutting into particularly hard materials, such as granite and the like, the outwardly contoured second face profile may perform better than the concave profile (which is particularly suited for cutting softer materials such as sandstone and the like), in relation to the resultant cutting force experienced by the tip. As for the concave embodiment, the arcuate profile may only partially extend across the second face and may be bounded by proximal and distal end portions.

In both illustrated forms, the cutting tip 10, 60 includes a coupling 23 which extends outwardly and down from the proximal end 13 of the tip body 11 (see, for example, Figs 2 and 6a). In the illustrated forms, the coupling 23 is in the form of a stub shank which is cylindrical and which is arranged to locate within a corresponding recess in the leading end 52 of the tool bit body 51 (see Figs 8a and 8b). It is to be appreciated that the construction of the coupling can take other forms as will be appreciated by those skilled in the art.

With reference to Fig 7, the operation and optimal orientation of the pick 50 will now be described.

As previously mentioned, the present inventor has found that the orientation of the tip has a substantial effect on the performance of the pick. In particular, it has been discovered that the size of the crushed zone, and the amount of energy dissipated in forming the crushed zone (which persons skilled in the art will appreciate represents between 70 to 85 percent of the external work done by the pick in the cutting process), is at a minimum when the pick is presented to a free surface of the material such that the substantially planar first face 16a is in facing, or substantially facing, relation to the free surface. In contrast, when the pick is presented such that one of the axial ridges 15 is in facing relation to the free surface there is an increased amount of energy required in forming the crushed zone which clearly impacts on the pick's performance.

It will be understood that these findings apply for any pick having mutually inclined faces separated by axially extending ridges (e.g. such as the pyramidal shaped pick described in the published PCT Application No. PCT/AU2008/000969 by the same Applicant, the contents of which are incorporated herein by reference), where any one of the mutually inclined faces could be presented in facing relation to the free surface of the material for achieving optimal pick performance.

Furthermore, the optimal attack angle α for the afore-described pick embodiments (i.e. so as to keep the resultant force angle aligned with the direction of the shank) will vary depending on the material to be cut. For the pick geometry and planar surface aligned orientation described herein, it has been found that an attack angle of between 60 to 65° is optimal for cutting particularly hard material such as granite, while a slightly reduced attack angle of 50 to 60° is optimal for cutting softer material such as sandstone. Thus, for such materials the rake angle β, which is a function of the pitch angle σ and the attack angle α, will be positive (i.e. it does not extend beyond a line normal to the rock surface). However, persons skilled in the art will appreciate that the rake angle may not always be positive and in some circumstances (e.g. for cutting particular materials) may be negative in order to keep the resultant force angle aligned with the shank direction.

Whilst the tip geometry of the embodiments shown in Figs 1 to 6 has a generally square base, other tip geometries can be provided which have the advantageous cracking behaviour as discussed above. For example, the cutting tip may employ a tip geometry having a hexagonal, pentagonal or other polygonal shaped base resulting in more or less ridges than the four in the earlier embodiment.

Furthermore, the ridges may be arranged to follow the profiling of the intermediate regions. For example, ridges 15', 15" on either side of the face 16a can follow the profiling of face 16a, whereas ridges 15''', 15'''' on either side of the face

16b can follow the profiling of the face 16b. However, by varying the width and/or profile of the ridges along their length, the ridges may extend in a straight line, may be convex or concave or otherwise, irrespective of the configuration or profile of the intermediate faces (i.e. whether those regions are flat, concave, convex or a combination thereof). In this way there is provided more opportunity to optimise the cutting tip geometry in respect of its ability to enhance cracking, have effective cutting surfaces and good wear performance for a range of materials to be cut.

Whilst specific embodiments of a cutting tip and cutting tool have been described, it should be appreciated that the cutting tip and cutting tool may be embodied in many other forms.

In the claims which follow and in the preceding description, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the cutting tip and cutting tool.

CLAIMS

1. A cutting tip for a mechanical excavator comprising a tip body having a tip axis, a generally pointed distal end, a proximal end spaced from the distal end along the tip axis, and a circumferential wall which is non-symmetrical about the tip axis and which diverges outwardly from the distal end towards the proximal end, the non-symmetrical circumferential wall comprising a plurality of axially extending ridges and intermediate faces disposed between the ridges.

2. A cutting tip in accordance with claim 1, wherein a first one of the intermediate faces is adapted, in use, to be presented in facing relation to a surface of a material to be cut, and a second face is disposed opposite the first face, wherein the profile of the first face is different to the profile of the second face.

3. A cutting tip in accordance with claim 2, wherein the first face has a substantially planar profile and the second face has a substantially non-planar profile.

4. A cutting tip in accordance with claim 2 or claim 3, wherein the second face has a longitudinally extending transitional portion located between the proximal and distal ends of the tip, the transitional portion being generally arcuate.

5. A cutting tip in accordance with claim 5, the second face further comprises a distal portion immediately adjacent the distal end, the distal portion meeting with the transitional portion such that a surface profile of the distal portion defines a tangent line to the surface profile of the transitional portion at a point where the two portions meet.

6. A cutting tip in accordance with claim 4 or claim 5, wherein the transitional portion has a substantially concave or convex profile.

7. A cutting tip in accordance with any one of claims 4 to 6, wherein the transitional portion is located between the distal portion and a proximal portion adjacent the proximal end, at least one of the distal and

proximal portions having a substantially planar surface profile.

8. A cutting tip in accordance with claim 7, wherein both the distal and proximal portions have a substantially planar surface profile.

9. A cutting tip in accordance with claim 7 or 8, wherein the distal portion defines a smaller angle with respect to the tip axis than the proximal portion.

10. A cutting tip in accordance with claim 9, wherein the angle defined between the distal portion and the tip axis is in the range of 25 to 34 degrees.

11. A cutting tip in accordance with claim 9 or 10, wherein the angle defined between the proximal portion and the tip axis is in the range of 35 to 45 degrees.

12. A cutting tip in accordance with any one of claims 5 to 11, wherein an angle defined the first face and the tip axis is greater than the angle defined between the tip axis and the distal portion of the second face.

13. A cutting tip in accordance with claim 12, wherein the angle defined between the first face and the tip axis is in the range of 35 and 45 degrees.

14. A cutting tip in accordance with any one of claims 4 to 13, wherein the tip is of polygonal shape having opposite side faces intermediate the first and second faces.

15. A cutting tip in accordance with claim 14, wherein at least one of the side faces has a substantially concave profile.

16. A cutting tip according to any one of the preceding claims, further comprising a coupling disposed at the proximal end of the tip body and being arranged to mount the cutting tip into a cutting tool bit.

17. A cutting tip according to claim 16, wherein the coupling is in

the form of a projection that extends from the proximal end and is arranged to be received in a corresponding recess in the tool bit.

18. A cutting tip according to claim 17, wherein the coupling is in the form of a recess that is arranged to be received in a corresponding projection in the tool bit.

19. A cutting tip according to any one of claims 16 to 18, wherein the coupling is formed of a material which has been subjected to a grinding hardening process to strengthen the material.

20. A cutting tip according to any one of the preceding claims, wherein the tip is formed from one of the following hard materials: diamond, polycrystalline diamond (PCD), cubic born nitride (CBN) and polycrystalline cubic born nitride (PCBN).

21. A cutting tool comprising a bit body having a leading end, and a cutting tip according to any one of claims 1 to 20 disposed at the leading end.

22. A cutting tool according to claim 21, wherein the cutting tip is mounted to the bit body and is formed from a harder material than the bit body.

23. A cutting tool according to claim 22, wherein the bit body has a grind hardened outer surface.

24. A cutting tip for a mechanical excavator comprising a tip body having a tip axis, a generally pointed distal end, a proximal end, and a circumferential wall which diverges outwardly from the distal end towards the proximal end along the tip axis, the circumferential wall comprising a plurality of axially extending ridges and intermediate faces disposed between the ridges, wherein one of the faces has an arcuate transitional portion extending between a proximal and distal portion of the face, at least one of the proximal and distal portions having a generally planar profile.

25. A cutting tip for a mechanical excavator comprising a tip body, a generally pointed distal end, a proximal end, and a circumferential wall which diverges outwardly from the distal end towards the proximal end, the

circumferential wall comprising a plurality of axially extending ridges and intermediate faces disposed between the ridges, wherein a first one of the intermediate faces which, in use, is adapted to be in facing relation to a face of the material to be cut has a substantially planar profile.

26. A method of cutting a material using a cutting tool mounted on a rotating drum and comprising a tip on which is provided a substantially planar confronting face adjacent a distal end thereof, the method comprising presenting the cutting tool to a face of the material such that a substantial portion of the confronting face is in facing relation to the rock face during cutting of the material during rotation of the drum.

27. A method of cutting in accordance with claim 26, further comprising maintaining the facing relation for further rotations of the drum.

28. A method of cutting in accordance with claims 26 or 27, wherein the tip is the tip in accordance with any one of claims 1 to 20, 24 or 25.

29. A method of cutting in accordance with claim 27, wherein where the material is granite, the tip is presented at an angle of attack in the range of 60 to 65 degrees.

30. A method of cutting in accordance with claim 27, wherein where the material is sandstone, the tip is presented at an angle of attack in the range of 50 to 60 degrees.

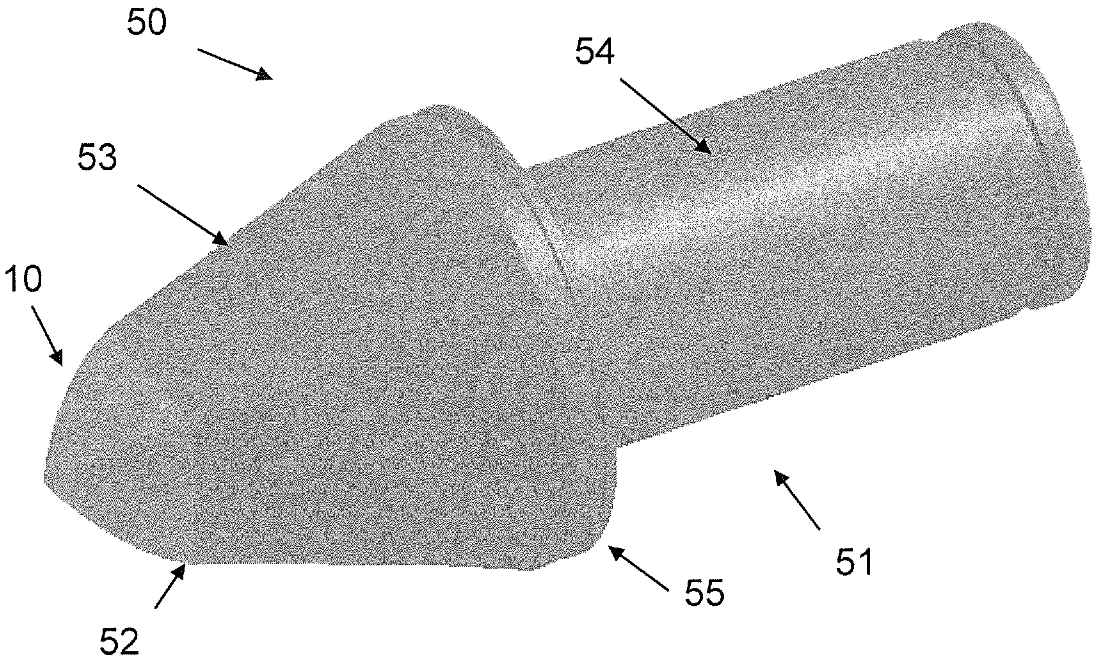

Fig. 1

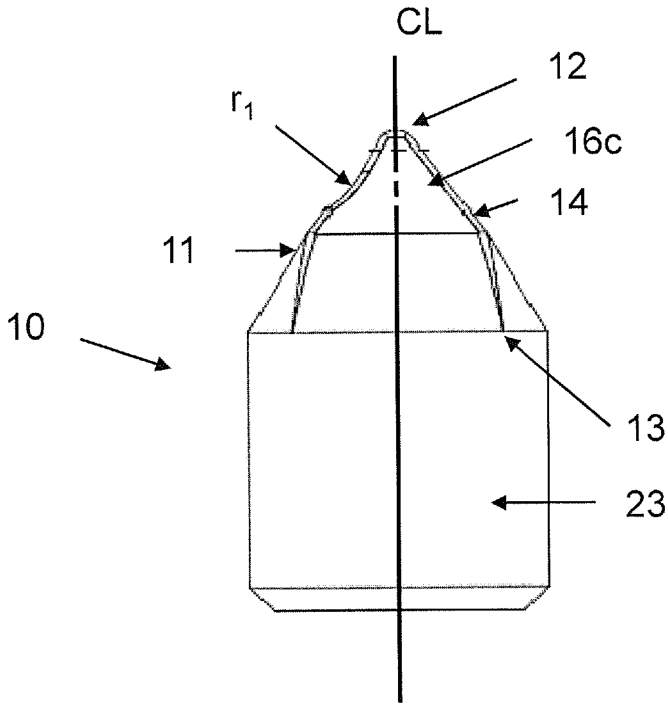

Fig. 2

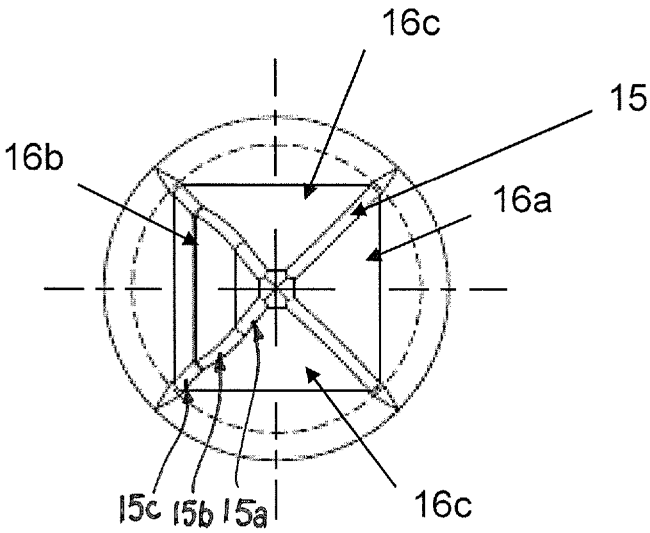

Fig. 3

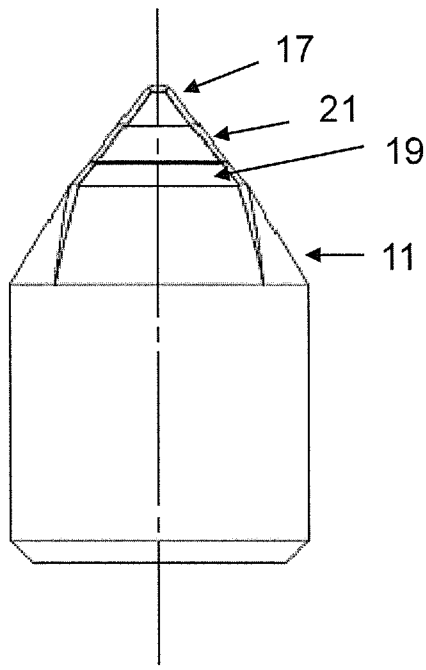

Fig. 4

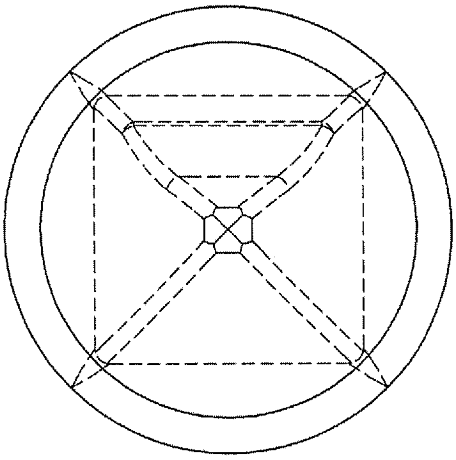

Fig. 5

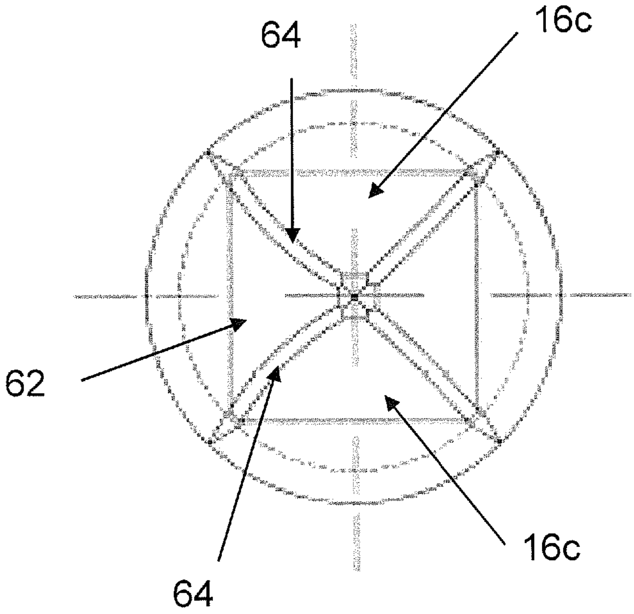

Fig. 6a

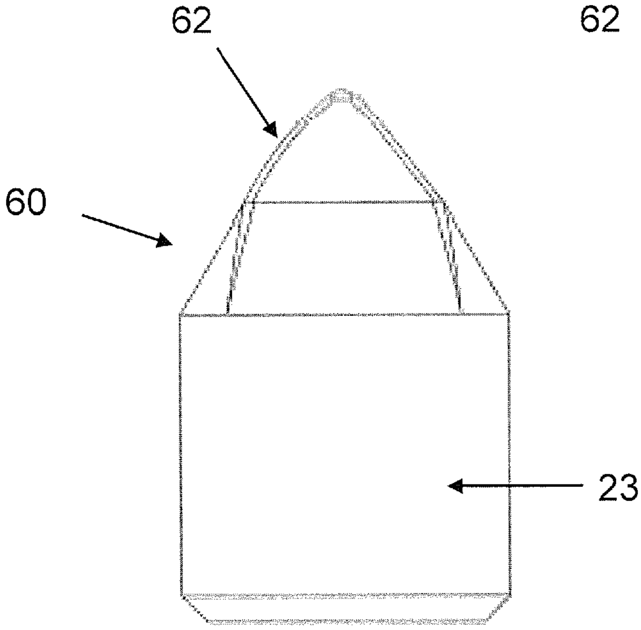

Fig. 6b

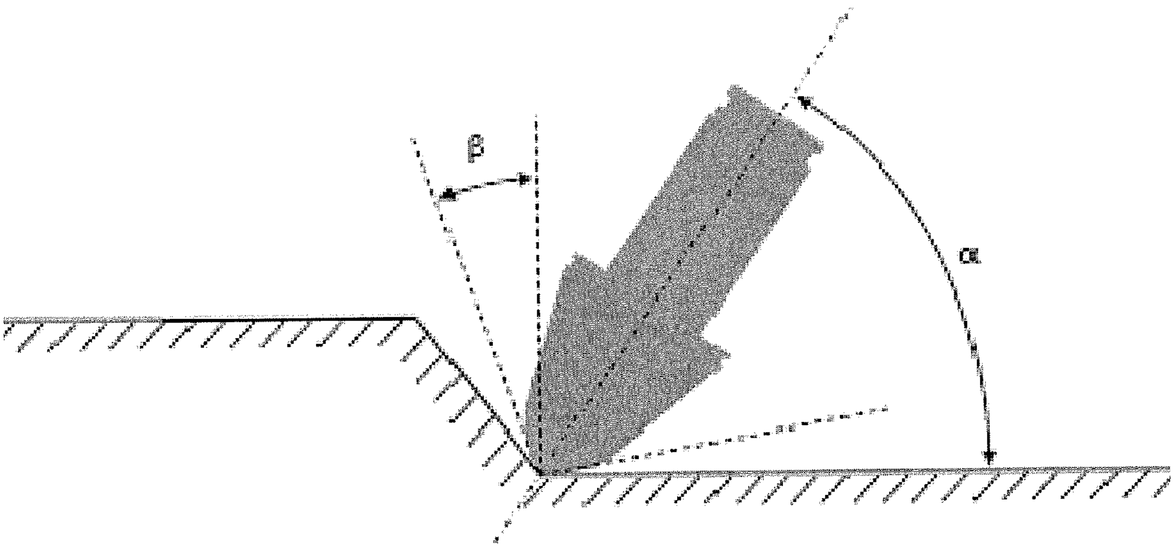

Fig. 7

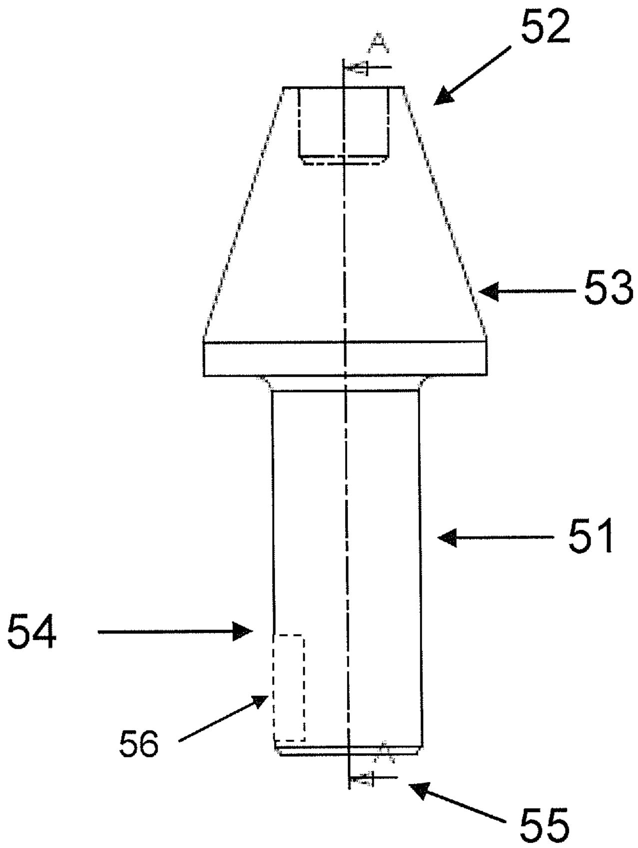

Fig. 8a

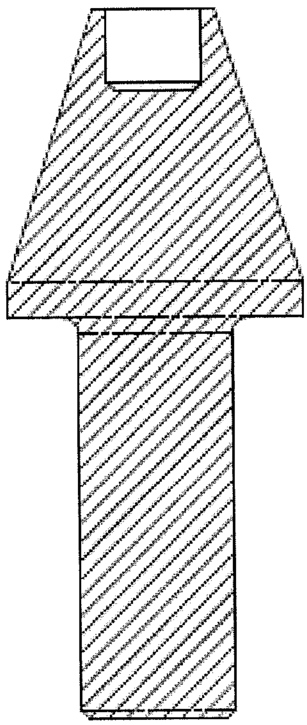

Fig. 8b

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU2011/001368

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. *E21C 35/18* (2006.01)

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)

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 practicable, search terms used)
WPI & EPODOC – IPC & EC: B21C 35/18 & Keywords (tip, head, tooth, teeth, bit, ridge, face, edge, crest, surface, plane, axis, longitudinal, rotational, unsymmetrical, irregular, uneven, unbalanced, flat, planar, square, sharp, smooth, arc, rounded, curved and like terms)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1112446 A (TUNGSTEN CARBIDE DEVELOPMENT LIMITED) 8 May 1968 Page 2 lines 76-116, Figs. 3 & 4	1, 2, 16-23, 25-30
X	US 2010/0263939 A1 (HALL et al.) 21 October 2010 Paragraphs [0075], [0083], [0084], Figs. 11 & 19-21	1, 2, 16, 20-22, 25
X	WO 2009/003233 A1 (THE UNIVERSITY OF SYDNEY) 8 January 2009 Abstract, page 3 line 37 to page 4 line 3, page 7 lines 18-35	25-30
X	US 6196636 B1 (MILLS et al.) 6 March 2001 See Figs.	25

[X] Further documents are listed in the continuation of Box C   [X] See patent family annex

* 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 application or patent 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 when the document is taken alone

"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

Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2012	16/01/2012

Name and mailing address of the ISA/AU
AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustralia.gov.au
Facsimile No. +61 2 6283 7999

Authorized officer
RHYS MUNZEL
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No : +61 3 9935 9623

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6019434 A (EMMERICH) 1 February 2000 See Figs.	
A	US 5417475 A (GRAHAM et al.) 23 May 1995 See Figs.	
A	US 5551760 A (SOLLAMI) 3 September 1996 See Figs.	
A	US 2004/0065484 A1 (MCALVAIN) 8 April 2004 See Figs.	

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box 1

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box 1
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-24 relate to a cutting tip for a mechanical excavator comprising a tip body having a tip axis, the tip body comprising a circumferential wall that is asymmetrical about the tip axis and further comprises axially extending ridges and intermediate faces between the ridges. The asymmetry of the circumferential wall is specific to this group of claims.

- Claims 25-30 relate to a cutting tip for a mechanical excavator comprising a tip body having a substantially planar confronting surface adapted to be in facing relation to a face of the material to be cut. The substantially planar confronting surface is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions is a cutting tip body comprising a face. However it is considered that this feature is generic in this particular art.

Therefore in this light this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied.

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
GB	1112446	NONE					
US	2010263939	CN	101480914	CN	101523014	DE	102009003951
		EP	2049769	US	2006196698	US	7223049
		US	7320505	US	2008036278	US	2008036279
		US	7338135	US	7347292	US	7353893
		US	2008099249	US	2008036273	US	7384105
		US	2008035381	US	7387345	US	2006198703
		US	7387464	US	2006198697	US	7387465
		US	2008036271	US	7390066	US	2006198702
		US	7396085	US	7396086	US	7401863
		US	2008036275	US	7410221	US	2008036272
		US	7413256	US	2008036281	US	7413258
		US	2006198699	US	7413375	US	2008036274
		US	7419224	US	2008036282	US	7445294
		US	2008036283	US	7464993	US	2008100124
		US	7469756	US	2008036276	US	7469971
		US	2006198701	US	7473052	US	2008036270
		US	7475948	US	2007092336	US	7544011
		US	2007098496	US	7549821	US	2007290547
		US	7568770	US	2008099251	US	7588102
		US	2006204331	US	7591607	US	2008035386
		US	7600823	US	2008309146	US	7635168
		US	2008036280	US	7637574	US	2006198698
		US	7641418	US	2008106139	US	7648210
		US	2008315667	US	7661765	US	2008099250
		US	7665552	US	2008164073	US	7669674
		US	2008169698	US	7669938	US	2008284236
		US	7676968	US	2008283256	US	7681338
		US	2007290544	US	7686536	US	2008282584
		US	7690138	US	2008185468	US	7712693
		US	2008210798	US	7717365	US	2008036277
		US	7722127	US	2008063476	US	7740414

		US	2008309147	US	7744164	US	2008309148
		US	7832809	US	2010011628	US	7854078
		US	2008120163	US	7862126	US	2008197692
		US	7871133	US	2008035388	US	7886851
		US	2009146489	US	7946656	US	2008264697
		US	7946657	US	2010107455	US	7950170
		US	2007290545	US	7950746	US	2008164072
		US	7963617	US	2009200855	US	7992944
		US	2008036269	US	7992945	US	2008211290
		US	7997661	US	2008164748	US	8007050
		US	2008067859	US	8007051	US	2010065338
		US	8028774	US	2008197691	US	8029068
		US	2008246329	US	8033615	US	2008309149
		US	8033616	US	2009066149	US	8038223
		US	2008238181	US	8061784	US	2008035380
		US	2008035383	US	2008035387	US	2008035389
		US	2008048484	US	2008088172	US	2008115977
		US	2008115978	US	2008129104	US	2008172627
		US	2008187452	US	2008258536	US	2008314647
		US	2009000828	US	2009051211	US	2009058174
		US	2009133938	US	2009160238	US	2009182473
		US	2009200857	US	2009263308	US	2009267403
		US	2009273225	US	2009294182	US	2010054875
		US	2010059288	US	2010059289	US	2010065332
		US	2010065339	US	2010071964	US	2010089648
		US	2010237135	US	2010244545	US	2011042150
		US	2011180324	US	2011180325	US	2011240366
		US	2011240369	US	2011240377	US	2011240378
		US	2011247882	US	2011254348	US	2011254349
		US	2011254350	US	2011266861	US	2011291461
		WO	2006093856	WO	2008105915	WO	2009006612
		ZA	200900926				
WO	2009003233	AU	2008271918	CA	2699539	CN	101790621
		EA	201070081	EP	2167790	ZA	201000772
US	6196636	NONE					
US	6019434	EP	0908601	JP	11173051		
US	5417475	ZA	9408307				

US	5551760	US	5484191
US	2004065484	NONE	

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX