P/00/001
Section 29

662365

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PATENT REQUEST : STANDARD PATENT

I/We, being the person(s) identified below as the Applicant(s), request the grant of a Standard Patent to the person(s) identified below as the Nominated Person(s), for an invention described in the accompanying complete specification.

Applicant(s) and Nominated Person(s):	SANDVIK AB
Address:	S-811 81 SANDVIKEN SWEDEN
Invention Title:	CEMENTED CARBIDE BODY WITH INCREASED WEAR RESISTANCE
Name(s) of Actual Inventor(s):	E. TORBJORN HARTZELL; UDO K. FISCHER JAN AKERMAN
Address for Service:	GRIFFITH HACK & CO 509 ST KILDA ROAD MELBOURNE VIC 3004
Attorney Code:	HA

BASIC CONVENTION APPLICATION DETAILS

Application No:	**Country:**	**Application Date:**
9103344-9	SE	13 November 1991

Drawing number recommended to accompany the abstract: 2

DATED: 9 November 1992

SANDVIK AB

GRIFFITH HACK & CO.

[signature]

Patent Attorney for and
on behalf of the Applicant

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Regulation 3.1(2)

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NOTICE OF ENTITLEMENT

I/We SANDVIK AB

of S-811
81 SANDVIKEN
SWEDEN

being the applicant(s) in respect of an application for a patent for an invention entitled CEMENTED CARBIDE BODY WITH INCREASED WEAR RESISTANCE, state the following:

1. The nominated person(s) has/have, for the following reasons, gained entitlement from the actual inventor(s):

   THE NOMINATED PERSON IS THE ASSIGNEE OF THE INVENTORS.

2. The nominated person(s) has/have, for the following reasons, gained entitlement from the basic applicant(s) listed on the patent request:

   THE APPLICANT AND NOMINATED PERSON IS THE BASIC APPLICANT.

3. The basic application(s) listed on the request form is/are the first application(s) made in a Convention country in respect of the invention.

DATE: 9 November 1992

SANDVIK AB

GRIFFITH HACK & CO.

Patent Attorney for and on behalf of the applicant(s)

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CEMENTED CARBIDE BODY WITH INCREASED WEAR RESISTANCE

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(56) Prior Art Documents
AU 10917/92 C22C 29/08 E21B 10/46
US 4854405
US 2842342

(57) Claim

1. A cemented carbide button for rock drilling having a working surface and comprising a core and a surface zone surrounding the core whereby both the surface zone and the core contain WC and a binder phase based on at least one of cobalt, nickel or iron and in addition the core contains eta-phase characterised in that:

(i) the core extends to the top working surface of the button;

(ii) the core contains from 2% to 60% by volume of eta-phase;

(iii) the eta-phase has a grain size of 0.5-10 μm;

(iv) the width of the core is 10%-65% of the cross-section of the cemented carbide body; and

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(v) the concentration of the binder phase in the surface zone increases in a direction towards the core to at least 1.2 times the binder phase concentration of the eta-phase core.

7. Method of manufacturing a cemented carbide button having the features defined in any one of claims 1 to 6 comprising the steps of:

(i) milling and pressing a powder comprising WC with substoichiometric carbon content and a binder phase based on at least one of cobalt, nickel or iron to form a pressed button;

(ii) sintering the pressed button to form a sintered button; and

(iii) subjecting the sintered button to a partially carburising heat treatment.

8. Method of rock drilling with a cemented carbide button having the features defined in any one of claims 1 to 6, wherein the cemented carbide button is brought in connect with rock and the button moves relative to the rock whereby material is removed from the rock.

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COMPLETE SPECIFICATION

STANDARD PATENT

Applicant(s):

SANDVIK AB

Invention Title:

CEMENTED CARBIDE BODY WITH INCREASED WEAR RESISTANCE

The following statement is a full description of this invention, including the best method of performing it known to me/us:

Cemented carbide body with increased wear resistance

The present invention relates to cemented carbide buttons useful in tools for rock drilling, mineral cutting, oil drilling and in tools for concrete and asphalt milling.

In EP-A-182759 cemented carbide buttons are disclosed with a core with finely and evenly distributed eta-phase embedded in the normal alpha + beta - phase structure, and a surrounding surface zone with only alpha + beta - phase. (Alpha = tungsten carbide, beta = binder-phase, e.g., cobalt and eta = M_6C, $M_{12}C$ and other carbides, e.g., Co_3W_3C). An additional condition is that in the inner part of the surface zone situated close to the core the cobalt-content is higher than the nominal content of cobalt and that the cobalt-content in the outermost part of the surface zone is lower than the nominal and increases in the direction towards the core up to a maximum usually at the eta-phase core.

Cemented carbide buttons according to the mentioned patent application have given increased performance for all cemented carbide grades normally used in rock drilling.

When drilling with buttons according to the above mentioned patent the cobalt-poor surface layer is successively worn away. The cobalt-rich intermediate layer, when exposed, is worn more rapidly than the surrounding areas and a crater is formed, fig 1.3. As a result, the risk for spalling is increased and at the same time the drilling rate is decreased. At continued wear the eta-phase core is exposed and the button then assumes a more rounded cap shape, fig 1.5. The wearing through of the cobalt-rich intermediate zone is particularly critical in rotary crushing drilling with chisel shaped or conical buttons which are not reground. In order to avoid too deep a crater in the button the thickness of the etaphase-free surface zone is kept to a minimum. The risk is then that the cobalt-poor surface zone peels off and expose the cobalt-rich part with a resulting rapid wear. The button thereby quickly loses several mm in protrusion height. The protrusion and shape of the button influence the drilling properties, in particular the penetration rate.

According to the invention it has now turned out that buttons where the etaphase core extends out to the very top working surface of the button give longer life and increased drilling rate, particularly in rotary crushing drilling, percussive drilling in soft rocks and in mineral cutting. The etaphase core is not crushed due to that it is protected by the surface zone free of etaphase, whose outer part is under compressive stress.

The invention is described with reference to the following figures in which a - etaphase core, b - cobalt-rich zone and c - cobalt-poor zone.

Fig 1 shows a button made according to known technique, in which:.

1.1 Unworn button.

1.2 Wear only in the cobalt-poor etaphase free surface zone.

1.3 Wear through the cobalt-rich intermediate zone.

1.4 Continued wear - the button has changed shape.

1.5 The etaphase core clearly exposed.

Fig 2 shows buttons according to the invention in various embodiments, namely:

2.1 Conical button, symmetrical etaphase core.

2.2 Spherical button, asymmetrical etaphase core.

2.3 Chisel-shaped button, symmetrical eta-phase core.

The eta-phase core contains at least 2 % by volume, preferably at least 5 % by volume of eta-phase but at the most 60 % by volume, preferably at the most 35 % by volume. The eta-phase shall be finegrained with a grain size of 0.5 - 10 µm, preferably 1 - 5 µm, and be evenly distributed in the matrix of the normal WC-Co-structure. The width of the eta phase core shall be 10 - 95 %, preferably 25 - 75 % of the cross section of the cemented carbide body. The etaphase core extends to the very top (working) surface of the button. Normally, the position of the core is symmetrical, but for certain locations of the button in a drill, e.g., as peripheral button, the core may suitably be in an asymmetrical position in the button.

The binder phase content in the zone free of eta-phase increases in the direction towards the eta-phase core up to a maximum usually at the eta phase core of at least 1.2 times, preferably at least 1.4 times, compared to the binder phase content in the centre of the eta phase core.

In addition, the top surface of the button may have a thin surface layer 10-100 µm thick free of etaphase.

The invention can particularly be used in grades with 10-25 % by weight cobalt for rotary crushing drilling, but also in grades with 5-10 % by weight cobalt for percussive drilling in softer rocks and in grades with 6-13 % by weight cobalt for mineral tools. The WC-grain size can vary from 1.0 µm up to 10 µm preferably 2-8 µm.

The cobalt-portion in the eta-phase can completely or partly be replaced by one of the metals iron or nickel i.e. the etaphase itself can contain one or more of the iron group metals in combination.

Up to 15 % by weight of tungsten in the alfaphase can be replaced by one or more of the metallic carbide former Ti, Zr, Hf, V, Nb, Ta, Cr and Mo.

Cemented carbide bodies according to the invention are manufactured according to powder metallurgical methods: milling, pressing and sintering. By starting from a powder with substoichiometric composition with respect to carbon an etaphase containing cemented carbide is obtained during the sintering. This is after the sintering given a carburizing heat treatment. The top surface of the button is protected from carburisation by a thin layer of, e.g., Al_2O_3.

The invention also relates to a method of rock drilling at which a cemented carbide button having an etaphase core is brought in contact with rock and the button moves relative to the rock, whereby material is removed from the rock. According to the invention the etaphase core is already from the beginning of the drilling in contact with the rock.

Example 1

Buttons with a conical top were pressed using a WC-10 wt% cobalt powder with 0.2 % by weight substoichiometric carbon-content (5.3 % by weight carbon instead of 5.5 % by weight). These were sintered at 1450°C under standard conditions. After sintering the diameter of the buttons was 14 mm. The top surface of the buttons was covered by a CVD-layer of Al_2O_3. The buttons were then heat treated in a furnace containing CO/H_2 atmosphere at 1400°C for 4 hours.

The buttons manufactured in this way comprised a 4 mm wide surface zone free of eta-phase and a core with a diameter of 6 mm containing finely dispersed eta-phase. The core extended to the top surface of the button, (fig. 2.1). The cobalt-content at the surface of the cylindrical part was measured to be 5 % by weight and just outside the eta-phase-core 16 % by weight.

Example 2

Buttons with a chisel-shaped top were pressed using a WC-15 wt% cobalt powder with a 0.4 % by weight substoichiometric carbon-content (4.8 % carbon instead of 5.2 %). The buttons were sintered at 1410°C under standard conditions. After sintering the diameter of the buttons was 12 mm. The buttons were covered by a thin layer of graphite-slurry except from the top surface which was coated with a thin layer of Al_2O_3-slurry. The buttons were then heat treated in a furnace containing H_2 atmosphere at 1400°C for 2 hours.

The buttons manufactured in this way comprised a 3 mm wide surface zone free of eta-phase and a core with a diameter of 6 mm containing finely dispersed eta-phase. The core extended to the top surface of the button, (fig. 2.3). The cobalt-content at the surface of the cylindrical part of the button was measured to be 7 % and just outside the eta-phase-core 25 %.

Example 3

Drilling in an open pit mine with roller bits.
Machine: Bucyrus Erie 45R. Feeding pressure was 30 ton and rotation 60-85 rpm. Holes with a depth of 20 m were drilled.

Bit: 9 7/8" CS 3.
Rock: Biotite gneiss-mica slate.

Variant 1. Buttons according to Example 1.

Variant 2. Buttons according to EP-A-182759 with an average cobalt-content of 10%.

Result:

Variant	Life length m	Index	Rate of penetration m/h	Index
1	1210	106	18	139
2	1145	100	13	100

The bit according to the invention has reached longer life but above all higher penetration rate.

Example 4

In raise boring, rolls equipped with cemented carbide buttons are used. The buttons have a chisel shaped top and the rolls are scrapped when the buttons are worn flat.

On a raise-head (diameter 2.5 m) a roll with cemented carbide buttons (diameter 22 mm) according to the invention was tested. A test-roll with standard buttons was placed diametrically to the former roll.

Rig : Robbins 71R.
Drilled shaft : 155 m.
Rate of penetration : 0.9 m/h

Variant 1. Buttons according to the invention with a diameter of 22 mm and a surface zone free of eta-phase of 5 mm. The cobalt-content close to the outer surface of the button was 8 % and in the cobalt-rich part of the surface zone it was 22 %. The nominal cobalt-content was 15 %.

Variant 2. Standard buttons with a cobalt-content of 15 %.

Variant 3. Buttons according to EP-A-182759 with an average cobalt-content of 20 %. The thickness of the eta-phase free surface zone was 4 mm.

Result:

The remaining button-protrusion for variant 1 was 6 mm and for variant 2 was 3.5 mm. The buttons according to variant 2 had in addition a more rounded top. The surface zone free of eta-phase of the buttons according to variant 3 was spalled in an early stage and the remaining button-protrusion was 3 mm.

Example 5

Test with oil drill bits on an "on shore rig".

The bits were tested in an area with abrasive formations containing sandstone and limestone.

Bit dimension : 7 7/8".

Type of buttons : Chisel shaped.

Variant 1. In row 1 buttons according to the invention with a nominal cobalt-content of 8%. In the other rows buttons according to EP-A-182759 with a nominal cobalt-content of 15 %.

Variant 2. In row 1 buttons according to EP-A-182759 with a nominal cobalt-content of 8%. In the other rows buttons according to EP-A-182759 with a nominal cobalt-content of 15%.

Variant 3. Standard buttons with a cobalt-content of 8% in row 1 and 15% in the other rows.

Result:

Variant	Number	Drilled meters	Index	Rate of penetration m/h	Index
1	3	485	178	8.3	184
2	3	389	143	6.4	142
3	5	273	100	4.5	100

The distinctly better result of variant 1 is a consequence of the increased wear resistance thus leading to a maintained chisel shaped top of the buttons in row 1.

Example 6

Trenching in tarmac road for laying gas pipe line.

Machine: Rivard 120. 12 ton band tractor with one trenching wheel, diameter 2 m, equipped with totally 80 cutting tools.

Wheel width : 0.25 m.
Rotation speed of the tool: 10 m/s.
Trench depth : 1 m.

Tool positioning: The standard- and the test variants were placed in such a way that a fair judgement of properties could be made.

Type of button: Diameter 18 mm with a conical top and a length of 30 mm, brazed into standard tools.

Variant 1. Cemented carbide according to the invention. A nominal cobalt-content of 11%, the same zone distribution as in variant 2 but the eta-phase reached the top surface of the button.

Variant 2. Cemented carbide according to EP-A-182759. Nominal cobalt-content 11%, the surface zone free of eta phase was 5 mm in which the cobalt-poor part was 3 mm and the cobalt-rich part was 2 mm.

Variant 3. Standard cemented carbide with 11% cobalt and the WC-grain size 4 µm.

About 100 m^3 road was cut, the asphalt was 0.1 m thick, the intermediate layer containing bricks, sand and limestones was 0.3 m thick and the ground below contained sand, pebbles and some parts of limestone.

Result:

Variant	Height wear mm	Index	Failures	Number of tools
1	4.2	250	0	20
2	5.4	182	3	20
3	9	100	4	40

Example 7

Drifting in a limestone mine with drill bits, diameter 55 mm, equipped with buttons, diameter 11 mm.

Drilling machine : COP 1038 HB.
Feeding pressure : 60 bar.
Rotation pressure : 60 bar.
Hole depth : 4.4 m.

Variant 1. Buttons according to the invention. Nominal cobalt-content 6%. The diameter of the eta-phase core was 6 mm and the core reached the top surface of the button. The button had a conical top.

Variant 2. Buttons according to EP-A-182759 with the same size of the eta-phase core as in variant 1. Nominal cobalt-content 6% and a conical top.

Variant 3. Standard buttons with 6% cobalt and a spherical top.

Result:

Variant	Life length m	Index	Rate of penetration m/min	Index
1	1685	131	2.3	153
2	1320	116	1.9	127
3	1142	100	1.5	100

THE CLAIMS DEFINING THE INVENTIONS ARE AS FOLLOWS:

1. A cemented carbide button for rock drilling having a working surface and comprising a core and a surface zone surrounding the core whereby both the surface zone and the core contain WC and a binder phase based on at least one of cobalt, nickel or iron and in addition the core contains eta-phase characterised in that:

(i) the core extends to the top working surface of the button;

(ii) the core contains from 2% to 60% by volume of eta-phase;

(iii) the eta-phase has a grain size of 0.5-10 μm;

(iv) the width of the core is 10%-65% of the cross-section of the cemented carbide body; and

(v) the concentration of the binder phase in the surface zone increases in a direction towards the core to at least 1.2 times the binder phase concentration of the eta-phase core.

2. Cemented carbide button according to claim 1 characterised in that the core is asymmetrically located in the button.

3. Cemented carbide button according any one of claims 1 or 2 characterised in that the core contains from 5% to 35 % by volume of eta-phase.

4. Cemented carbide button according to any one of claims 1 to 3 characterised in that the eta-phase has a grain size of 1-5 μm and is evenly distributed in the

matrix.

5. Cemented carbide button according to any one of claims 1 to 4 characterised in that the width of the core is 25% to 75% of the cross-section of the cemented carbide body.

6. Cemented carbide button according to any one of claims 1 to 5 characterised in that the concentration of binder phase in the surface zone increases in the direction towards the core to at least 1.4 times the binder phase content in the eta-phase core.

7. Method of manufacturing a cemented carbide button having the features defined in any one of claims 1 to 6 comprising the steps of:

(i) milling and pressing a powder comprising WC with substoichiometric carbon content and a binder phase based on at least one of cobalt, nickel or iron to form a pressed button;

(ii) sintering the pressed button to form a sintered button; and

(iii) subjecting the sintered button to a partially carburising heat treatment.

8. Method of rock drilling with a cemented carbide button having the features defined in any one of claims 1 to 6, wherein the cemented carbide button is brought in connect with rock and the button moves relative to the rock whereby material is removed from the rock.

9. A cemented carbide button for rock drilling substantially as herein described with reference to any one or more of the accompanying drawings.

10. A method of manufacturing a cemented carbide button substantially as herein described with reference to any one or more of the accompanying drawings.

DATED THIS 29TH DAY OF JUNE 1995

SANDVIC AB

By its Patent Attorneys:

GRIFFITH HACK & CO

Fellows Institute of Patent

Attorneys of Australia

ABSTRACT

According to the invention there is now provided a cemented carbide button for rock drilling comprising a core and a surface zone surrounding the core whereby both the surface zone and the core contains WC (alpha-phase) and a binder phase based on at least one of cobalt, nickel or iron and that the core in addition contains eta-phase. The invention is characterized in that the eta phase core extends to the very top working surface of the button and as result longer life and higher drilling rate are obtained particularly for rotary crushing drilling, cutting drilling and percussive drilling in soft rocks.

Fig. 2

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Fig. 1

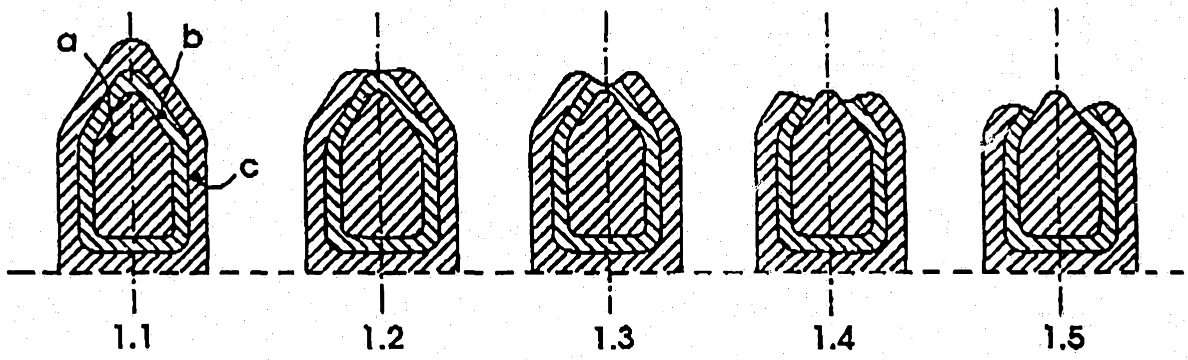

Fig. 2