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(54) **A mill or other metal cutting tool.**

(57) A metal cutting tool is made by taking a plate of hard metal carbide, and crushing the plate to form a mosaic consisting of a plurality of irregularly sized and irregularly shaped platelettes. The platelettes, in the form of a mosaic, are secured to a support surface. The support surface may form a blade protruding radially from a body which forms a mill to cut casing in a well bore.

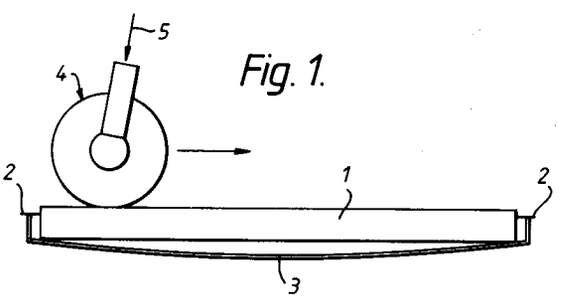

Fig. 1.

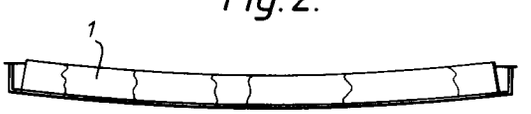

Fig. 2.

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The present invention relates to a mill or other metal cutting tool. The invention more particularly relates to a mill for use in milling metal casing in a well bore, such as a gas or oil well bore.

It is often necessary to utillse a mill to remove casing present in a well bore, such as an oil well bore, for example, if the casing is damaged in any way. It has been proposed to provide a mill for this purpose which consists of an elongate body adapted to be connected to the lower end of the drilling string, the body having a plurality of radially outwardly directed blades, the blades being dressed with a cutting material, such as a hard metal carbide. When the tool is lowered into a well bore at the bottom of the drilling string and is then rotated, the cutting material present on the blades scrapes across the top edge of casing to be removed, and cuts away the metal forming the casing.

The present invention relates to a method of making a metal cutting tool and also relates to a mill of general type described above.

According to one aspect of this invention there is provided a method of manufacturing a tool to cut metal, the method comprising the steps of taking at least one plate of a hard metal carbide, crushing the plate to form a mosaic consisting of a plurality of irregularly sized and irregularly shaped platelets, and securing those platelets, in the form of the mosaic, to a support surface.

Preferably the plate of hard metal carbide is mounted over a concave or convex surface and is rolled with a roller which exerts a pressure on the plate.

Conveniently, after the crushing step, the crushed plate is coated with a copper-based paste or other brazing material and is then subjected to a heating process.

Preferably the platelets formed by the plate are restrained in the form of the plate during the heating process.

Conveniently the heating process is carried out in a furnace.

The invention also relates to a mill to cut casing in a well bore, the mill comprising an elongate body, means at one end to attach the body to a drilling string and a plurality of cutter blades protruding substantially radially from the body, each cutter blade having a leading edge provided with an area carrying cutting material, the cutting material comprising a mosaic of irregular platelets formed by crushing a plate of hard metal carbide.

In one embodiment each blade has a positive angle of rake.

In another embodiment each cutting blade has a negative angle of rake.

Preferably each outer blade is substantially four times as thick as the cutting material applied to it.

Conveniently the cutting material is within the range ISO P 30 to P 50. The preferred material is tungsten carbide with 8 to 15% cobalt, with ISO P 50 or thereabouts. The cobalt provides a binder phase. Other materials that provide a binder phase are nickel and iron.

Advantageously the end of the elongate body opposed to the means for connecting the body to the drilling string is provided with a plurality of stabilizer blades.

Preferably the lower end of the body is provided with means to be connected to assemblies to be located beneath the mill.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a diagrammatic view of a process in which a plate of tungsten is crushed;

FIGURE 2 is a view of the essential components of Figure 1 after the tungsten plate has been crushed;

FIGURE 3 is a perspective view of a crushed plate of tungsten;

FIGURE 4 is a side view of a mill in accordance with the invention, with parts thereof cut away; and

FIGURE 5 is an enlarged view of the lower part of one of the cutter blades of Figure 5.

Referring initially to Figure 1 of the accompanying drawings initially a plate of a hard metal carbide material, such as cutting-grade tungsten carbide, is produced, the plate having a size typically of 5.3 cm x 3.5 cm. The plate ideally is cutting-grade tungsten carbide within the ISO range of P 30 to P 50 with a preferred value of approximately P 40. The preferred material is tungsten carbide with 8 to 15% cobalt, iron or nickel with ISO P 50 or thereabouts. The cobalt, iron or nickel acts as a binder phase. The tungsten plate is initially sintered and may be initially treated by rumbling and/or by cleaning with acid. The tungsten plate is retained, by means of rubber pads 2 having an appropriate cut-out defined therein, above a hard steel base 3 which presents a concave upper face of a size equivalent to the size of the plate 1. The plate may be restrained above the concave surface 3 by other means, such as laterally acting clamps or the like.

The plate is then crushed by passing over the upper surface of the plate a roller 4 to which is applied a significant downward pressure, as indicated by the arrow 5. Preferably the roller has a width which is equal to the width of the plate 1. The effect is that the plate 1 is crushed, and cracks to form random sized and random shaped platelets, which form a mosaic. The plate 1 is then of a

convex form, as illustrated in Figure 2.

The plate is then inverted above a mould or a form, so that the plate 1 falls onto the mould or form. The mould or form has a recess dimensioned to receive the plate, so that the plate is retained as an integral unit, even though the plate 1 still has its initial generally rectangular outer shape, but is separated, by cracks into the random sized and spaced platelets. The plate 1 is then coated in a copper-based paste or other conventional brazing material, and the plate is then inserted into a furnace where the temperature of the plate is elevated in a reducing atmosphere, which may be termed an endothermic atmosphere. The purpose of the reducing atmosphere is to prevent oxidation of the carbide and the copper-based paste. The carbide and the copper-based paste are thus elevated to a high temperature where a "wetting" or "tinning" process is effected.

The atmosphere may be another type of gas or a vacuum within the furnace.

The furnace can be an ordinary furnace, or an induction furnace, or alternatively the temperature may be raised using torches or even using resistance heating.

In modified examples of the invention the "wetting" or "tinning" process described above may be effected in different ways, such as by dip brazing, salt bath brazing, electric blanket brazing, radiant heat brazing or exothermic brazing, as may be felt to be appropriate.

The individual elements of the plate 1 are then, in the form of the mosaic equivalent to the original plate, transferred to and brazed to a cutting blade 6 which forms part of a mill. The cutting blade 6 is formed of steel, and the plate 1 is brazed to the leading face of the cutting blade 6. The cutting blade 6 may typically be four times as thick as the plate 1. A plurality of the plates 1 may be brazed to the blade 6. Any suitable brazing technique may be used.

Referring now to Figure 4, a mill incorporating plates of cutting material, such as the plate 1 produced by the process as described above, is illustrated. The mill comprises an elongate member 10 having axial bore 11 therethrough. The upper end of the elongate member is provided with a threaded pin 12 of a conventional design to enable the member to be secured to the lower end of a drill string intended for use "down hole" on an oil well or a gas well. In an alternative embodiment the pin 12 may be replaced by a conventional box.

The lower end of the elongate body 10 is provided with four radially outwardly extending elongate stabilizer blades 13 of conventional form. The stabilizer blades are each inclined to the vertical axis, (but may in alternative embodiments be vertical) and project radially outwardly from the body 10 by a short distance. The stabilizer blades may each carry an outer coating 14 of an appropriate material, to give the blades wear resisting properties.

The lower end of the body 10 may be provided with a conventional box or pin to be connected to assemblies which are to be located beneath the mill.

Attached to the main body 10 at a position between the stabilizer blades 13 and the threaded pin 12 are four radially outwardly directed cutter blades 6. Each cutter blade is inclined slightly to the vertical. The blades may be inclined to present a negative rake, or to present a positive rake. In an alternative embodiment the blades may be vertical.

Each cutter blade presents a substantially horizontal lower surface 15. The tool is intended, in use, to rotate in a clockwise sense when viewed from above and the leading face of each blade is provided with an area 16 to which is secured a plurality of plates 1 fabricated as described above.

As can be seen from Figure 5 a plurality of plates 1, each comprising individual random sized and random shaped platelets are be secured to the leading face of the blade 6.

In use of the mill, the body 10 is connected to the lower end of a drilling string by means of the threaded pin 12 and is lowered down-hole. The stabilizer blades 13 are inserted into a casing which is to be cut away, the casing being dimensioned so that the cutter blades 6 will rest on the top of the casing, with the casing being aligned with the area 16 of each blade 6 which is covered with the crushed plates 1. The mill is then rotated in the clockwise direction (as viewed from above). The carbide material effectively cuts or scrapes away the material forming the casing. Hydraulic fluid or "mud" may be pumped down the central bore 11 of the tool and will then flow upwardly, past the outside of the tool carrying with it the swarf or metal chippings generated as the tool operates.

Whilst the invention has been described with reference to one particular embodiment, it is to be appreciated that modifications may be effected without departing from the scope of the invention. For example, the slab of tungsten carbide may be crushed on a convex surface rather than a concave surface or may be crushed on an irregular rough surface. The tungsten plate may be produced by crushing before or after sintering.

The plates 1 may be brazed to the blade 6 by any appropriate method.

The number of blades 6 on the mill, and the spacing between the blades can be selected appropriately. Thus there may be more than four blades, or less than four blades.

Whilst the invention has been described with

reference to a specific form of mill, it is to be appreciated that the crushed tungsten plate as described with reference to Figures 1 to 3 may be applied to blades, arms, knives for cutting elements on other forms of tool.

Claims

1. A method of manufacturing a tool to cut metal, the method comprising the steps of taking at least one plate of a hard metal carbide, crushing the plate to form a mosaic consisting of a plurality of irregularly sized and irregularly shaped platelets, and securing those platelets, in the form of the mosaic, to a support surface.

2. A method according to Claim 1 wherein the plate of hard metal carbide is mounted over a concave or convex surface, and is rolled with a roller which exerts a pressure on the plate.

3. A method according to Claim 1 or 2 wherein, after the crushing step, the crushed plate is coated with a copper-based paste or other brazing material and is then subjected to a heating process.

4. A method according to Claim 3 wherein the platelets formed by the plate are restrained in the form of the plate during the heating process.

5. A method according to Claim 3 or 4 wherein the heating process is carried out in a furnace.

6. A mill to cut casing in a well bore, the mill comprising an elongate body, means at one end to attach the body to a drilling string and a plurality of cutter blades protruding substantially radially from the body, each cutter blade having a leading edge provided with an area carrying cutting material, the cutting material comprising a mosaic of irregular platelets formed by crushing a plate of hard metal carbide.

7. A mill according to Claim 6 wherein each blade has a positive angle of rake.

8. A mill according to Claim 6 wherein each cutting blade has a negative angle of rake.

9. A mill according to any one of Claims 6 to 8 wherein each cutter blade is substantially four times as thick as the cutting material applied to it.

10. A mill according to any one of Claims 6 to 9 wherein the cutting material is within the range ISO P 30 to P 50.

11. A mill according to any one of Claims 6 to 9 wherein the cutting material is tungsten carbide with 8 to 15% binder phase material.

12. A mill according to Claim 11 wherein the binder phase material is nickel, cobalt or iron and the material has ISO P 50 or thereabouts.

13. A mill according to any one of Claims 6 to 12 wherein the end of the elongate body opposed to the means for connecting the body to the drilling string is provided with a plurality of stabilizer blades.

14. A mill according to any one of Claims 6 to 13 wherein the lower end of the body is provided with means to be connected to assemblies to be located beneath the mill.

15. A method of manufacturing a tool to cut metal substantially as herein described with reference to the accompanying drawings.

16. A mill substantially as herein described with reference to and as shown in the accompanying drawings.

17. Any novel feature or combination of features disclosed herein.

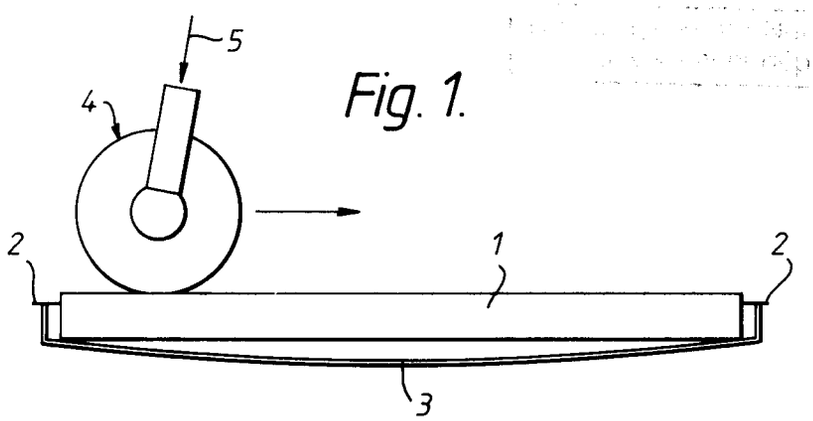


Fig. 1.

Fig. 2.

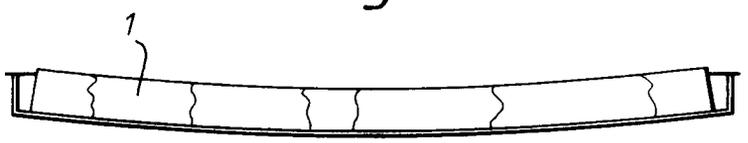
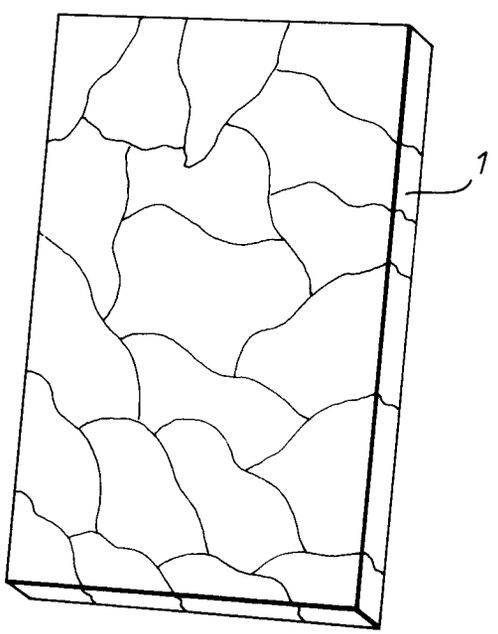


Fig. 3.



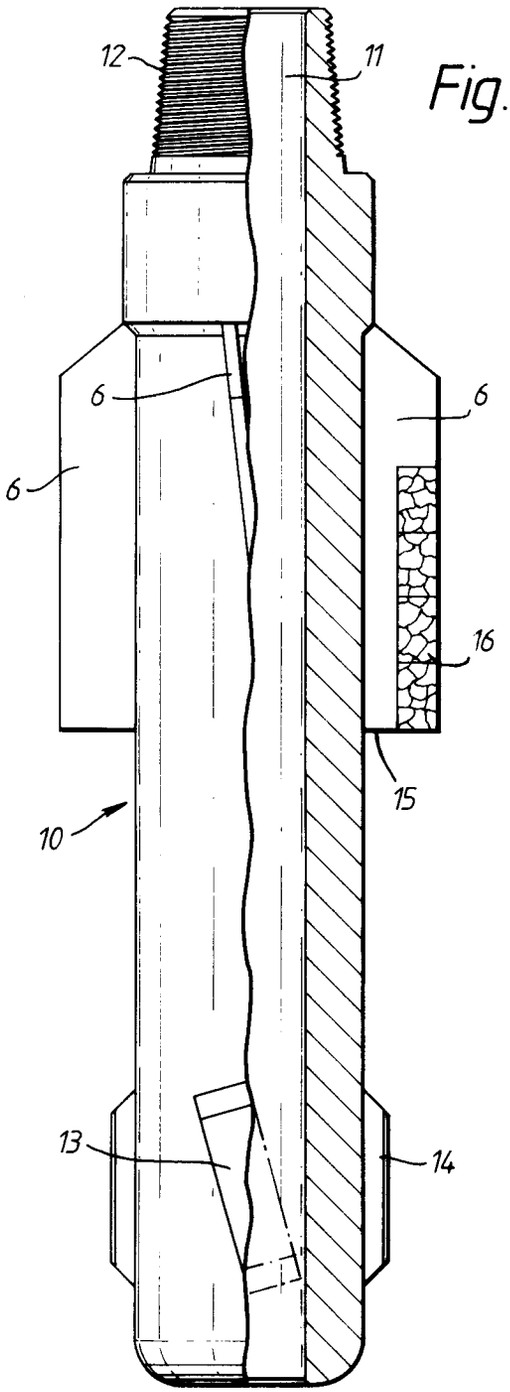


Fig. 4.

Fig. 5.