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GRINDING TOOLS FOR WORKING MATERIALS OF GREAT STRENGTH AND HARDNESS

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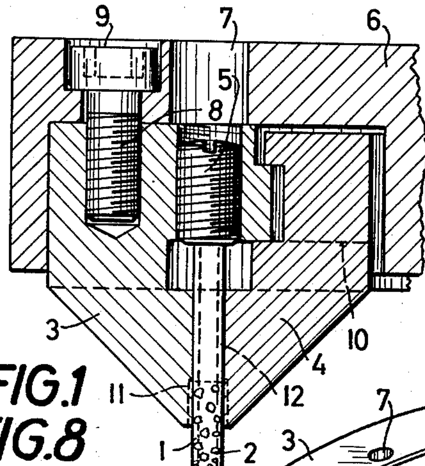


FIG.1

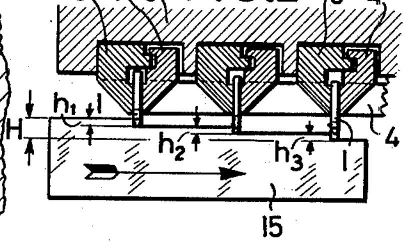


FIG.2

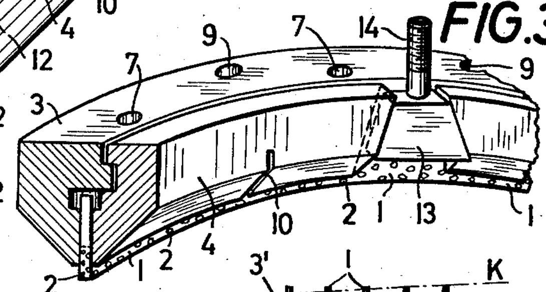
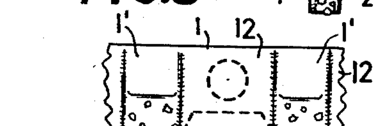


FIG.3

FIG.8



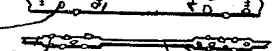


FIG.8'

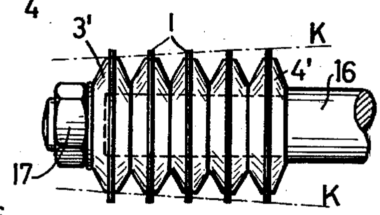


FIG.9

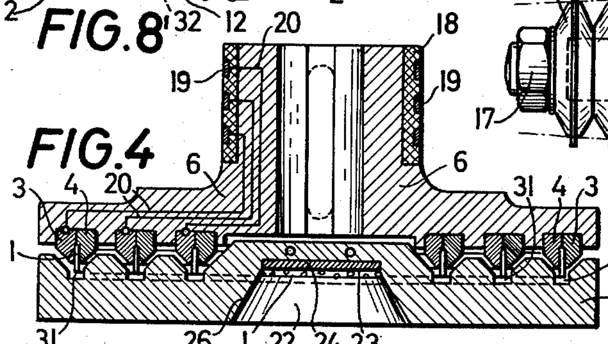


FIG.4

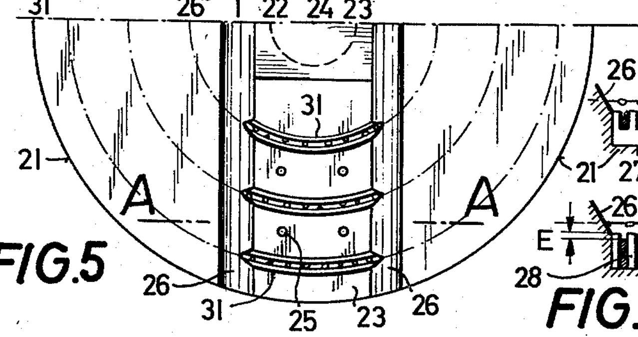


FIG.5

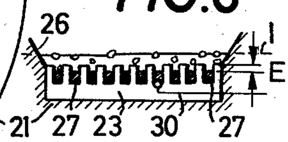


FIG.6

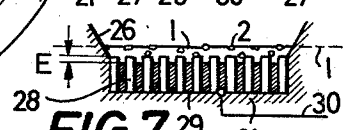


FIG.7

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GRINDING TOOLS FOR WORKING MATERIALS OF GREAT STRENGTH AND HARDNESS

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12 Claims. (Cl. 51—209)

According to the invention, metallic or non-metallic bands uniformly studded or set with diamond particles, in some cases in zones or section, and clamped concentrically in annular slots provided in a carrier disk, so that they only project slightly therefrom and only the diamond grains bonded in a narrow edge of the bands come into contact with the material to be ground, the height adjustment of the individual bands on the carrier disk being effected in such a manner that as a workpiece is fed past the carrier disk rotating at a high speed, the removal of the material takes place in stages or steps. Ground, split or even small faceted diamonds can be used as studding material for the bands. If their size allowed their "hard" direction to be determined in an economical manner by means of an X-ray goniometer, orientation setting in the band, which in this case is preferably made of band steel, is advisable. In addition to the already known processes for the production of thin diamond tools, such as saws, the embedding can also be effected between foils which are electrically heated in a protective gas atmosphere and at the same time pressed or rolled together. However, it is also advisable to keep the diamond studded zones of the grinding band narrow and to separate the sections by thin band sections with apertures, holes and the like so that, when the band is bent, the unbroken embedding of the diamond particles obtained by press welding, is not impaired. This could be ensured if the setting with diamond particles is carried out only on bands which are already formed into a circular ring of suitable diameter.

Irrespectively of the binding material selected, the diamond grinding wheels on the market are very expensive both to purchase and in use. They have mostly several layers of closely arranged diamond crystals or grains which are only exposed when the layers become abraded so that additional sharp edges of the diamond crystals become effective. It is evident that for bonding the expensive diamond crystals, materials and bonding processes are chosen which ensure that the crystals will be held for as long a period as possible.

Experiments have shown that under similar working conditions, depending upon the carrier material and the stressing, the specific diamond consumption determined by weighing, can, when grinding hard metals with the same degree of hardness, vary in the proportion of 1:4, and the volumetrically determined grinding wheel consumption in a proportion of 1:12. It has likewise been found that, owing to the residual particles, unavoidable for every diamond grain size, wheels with coarse grain show a lower specific diamond consumption than wheels with fine grain. The rough depth of the ground workpiece surface is naturally greater with coarse grained disks or wheels if no attempt is made to obtain a corresponding compensation by increasing the peripheral speed of the grinding wheel. However, there are limits to the extent to which the peripheral speed of the wheels on the market can be increased, particularly in view of the fact closely arranged grinding grains on the cutting face are

getting unduly hot. It has been discovered that the temperatures at the face of the wheel, when grinding hard metals having a medium degree of hardness, already exceeds 100° C. Changes in the original geometrical shape of the diamond grinding wheel make expensive dressing necessary in order to true-up a grinding surface which has become cambered or conical.

The grinding tools according to the invention present the following advantages over the diamond grinding wheels already on the market:

The carrier disk equipped with ring-shaped clamping devices can be used repeatedly, it allows the use of higher numbers of revolutions and grinding speeds, irrespectively of the firmness of the usual bonds. The flexible grinding bands can be produced easily and cheaply in any desired lengths. They require only small quantities of diamond crystals for setting and allow the oriented fixing of the individual diamond grains or crystals. Like the blades of a cutter spindle on a wood planing machine for example, the bands can be easily inserted in the carrier disk, set and readjusted, and completely or partly exchanged in the case of wear or damage.

Height adjustment of the individual bands formed into a circular ring, can be varied so that a stepped removal of material can be effected as the workpiece is fed past the tool. The size of the embedded crystals can differ in the individual bands; it can be so selected that the outermost grinding band rough grinds while the grinding band nearest the centre of rotation of the grinding tool finish grinds.

Even the kind of hard material used in the individual bands can be varied. Depending upon the material to be worked, all the non-metallic and metallic grinding and hard materials known in the grinding industry, including for example tungsten carbide, can be used.

As the shape of the carrier disk allows the individual grinding bands and their ring-shaped clamping arrangement to be fitted so that they are insulated from each other, a removal of material by mechanical grinding can be combined with a removal of material by electro-erosion (electrolytic erosion, spark erosion, electric arc erosion), the clamping device of the grinding bands, in the case of non-metallic bands, serving as electrodes. The current is fed to the mutually insulated grinding bands or their clamping devices over contact pieces, collecting rings or contact disks dipping in mercury baths.

Several embodiments of the invention are illustrated by way of example in the accompanying drawing, in which:

Fig. 1 shows on an enlarged scale a cross-section of a clamping device composed of two rings with a grinding band set with diamond crystals clamped therein;

Fig. 2 is a cross-section through three clamping devices each composed of two rings, with grinding bands clamped at different heights therein to enable the workpiece to be worked in steps;

Fig. 3 is a perspective part view of a clamping device composed of two rings in which the grinding band set with diamond crystals is clamped by forces exerted on the inner ring by a wedge;

Fig. 4 is a cross-section of a grinding tool according to the invention with three grinding bands clamped in a clamping device fitted in a carrier disk, a front plate, and collecting rings which serve for feeding the current in the case of supplementary electro-erosive material removal;

Fig. 5 shows the front plate according to Fig. 4 in top plan view;

Figs. 6 and 7 show on a larger scale a section on line A—A of Fig. 5 through a modified form of construction for the workpiece support on the front plate which serves for supplementary electro-erosive material removal;

Fig. 8 shows in part a plan view of a flexible grinding band with diamond crystals set in sections thereof,

Fig. 8' shows in part an elevational view of the construction of Fig. 8, and

Fig. 9 shows a grinding tool assembly composed of clamping disks with peripheral tapering and diamond studded grinding rings inserted therein.

In Fig. 1 the grinding band is designated by **1**, the diamond crystals by **2** and the two steel rings of the clamping device by **3** and **4**. In order to prevent the divided inner ring **4** from falling out while the grinding band is being clamped in position, the outer ring **3** has a rib which engages in a groove in the inner ring **4**. The outer ring **3** is connected with the carrier disk **6** by a screw **8** the head of which is accommodated in a sunk hole **9**. The grinding band adjusting bolts **5** are also fitted in the outer ring **3** and can be manipulated through bores **7** in the carrier disk **6**. As the diamond crystals **2**, owing to their size, project, for example, beyond the side walls of the grinding band **1**, in the surface of which they are embedded or can be held as a coating by thin layers applied on this surface, it is advisable to provide the steel rings **3** and **4** with recesses **11** in the region of the bonded diamonds.

As shown in Figs. 2 and 4, several clamping devices composed of steel rings **3** and **4** can be inserted in the carrier disk **6**. The resilient inner ring **4** first lies loosely in a recess in the carrier disk and, as shown in the perspective view of Fig. 3, can then be increased in diameter by a wedge **13** which can be shifted in longitudinal direction by a pin **14** provided with a screw thread, so that the grinding band **1** located between the rings **3** and **4** can be clamped as in a chuck. A slight additional resiliency is imparted to the inner ring by the incisions **10** for the purpose of compensating for variations in the thickness in the grinding band. In the case of rings of relatively large diameter, several wedge-shaped members **13** are employed. It is evident that the clamping of the inner ring relatively to the outer ring **3** may also be effected by other means, for example, by radially arranged screws or the like. It is advisable to harden the clamping rings **3** and **4** and to roughen the surfaces coming into contact with the grinding bands.

The height adjustment of the grinding bands **1** forming a circular ring after the insertion of the clamping device may be effected by the stud bolt **5** shown in Fig. **1**, so that the removal of the material from the workpiece **15** takes place in steps or stages as shown in Fig. 2. If the workpiece **15** is moved in the direction of the arrow a step h_1 in height is first ground off, while the two grinding bands located further inwards will cut to a depth h_2 and h_3 respectively. The whole of the material removed corresponds to the measurement H. By suitably selecting the size of gain of the diamonds the grinding band on the outer side can rough grind and that on the inner side finish grind. The grinding bands **1** and also their clamping rings **3** and **4** may be electrically insulated in the carrier disk **6** shown in Fig. 4. Furthermore the carrier disk **6** may be made from non-conducting material. A connection can be established between the clamping rings **3** and **4** and the collecting rings **19** carried by the sleeves **18**, by means of the leads **20**.

As it is possible to arrange on the end face of one and the same tool **6** several concentrically interengaging diamond studded grinding bands **1** forming circular rings and having separate current feeds, the material removed by mechanical grinding can be combined with a material removal by electro-erosion (electrolytic erosion, spark erosion or electric arc erosion). The metallic grinding bands **1** then serve as electrodes. The current feed is effected by contact pieces, collecting rings or contact disks dipping in mercury baths.

A suitable guide is provided for bringing the diamond crystals of the grinding bands fitted together in circular rings and moving with a high circumferential speed, into contact with the workpiece to be ground. The rotating grinding tool **6** including the clamping devices **3** and **4** and the grinding bands **1** are covered by a front plate **21** which does not participate in the rotary motion and is provided with channels **31**. A groove **22** with inclined side walls **26** is worked in the front plate **21**. The depth of this groove **22** is such that the channels **31** in which the grinding bands **1** run without touching the front plate, are cut in such a manner that, as can be seen from Figs. 4 and 5, the front edge of the grinding bands **1** projects through the bottom of the groove.

The bottom of the groove is formed by a plate **23** which is made from wear-resisting metallic or non-metallic hard material. A coolant, an electrolyte, an insulating liquid or the like may be fed through bores **24** and **25**. It is not necessary for the groove to extend across the entire width of the front plate **21**.

As shown in Fig. 6, the bottom of the groove in the front plate **21** may also consist of an electricity non-conducting hard material plate **23** in which a relatively large number of grooves are worked for the purpose of accommodating the metallic interconnected ribs **27** from which a lead **30** extends to a source of electric current. According to Fig. 7 the bottom of the groove in the front plate **21** is formed by separate layers of an electricity conducting material **21** and a wear-resisting, non-conducting material **28**. The metal plates **29** are in this case also connected to a source of current by the lead **30**.

The constructions of the bottom of the groove in the front plate **21** shown both in Fig. 6 and Fig. 7 enable the material removal by mechanical grinding by means of the grinding bands **1** to be combined with a material removal by electrolytic erosion. The metallic ribs **27** and **29** of Figs. 6 and 7 then serve as cathode and the workpiece to be worked as anode, thus constituting an electrolytic cell. The gap E shown in Figs. 6 and 7 must be so adjusted that no electric arcs can form.

The most important part of the grinding tool according to the invention is the diamond set grinding band **1** illustrated in Fig. 8. The band may be of non-metallic or metallic material. The setting with diamond crystals **2** is effected by known processes of manufacture and by bedding the diamond crystals between weldable foils which are heated in a protective gas atmosphere and subsequently pressed or rolled together.

To prevent the unbroken embedding of the diamond crystals attained by the press welding, from being impaired during the shaping of the grinding band into the form of a circular ring, it is recommended that the zones **11** (Fig. 8) permeated by the diamond crystals **2** be kept as narrow as possible and that the intervening sections **12** be produced by a thinner band thickness. The sections **12** may also be perforated as indicated in the drawing and provided with recesses **32**. Such tooth-gap shaped recesses **32** also ensure a good conducting off of the grinding dust. When employing the spark erosion process they also cause a repeated breaking of the current circuit. When clamping the grinding bands constructed as shown in Fig. 8, only the surfaces **15** of the band would bear against the clamping rings **3** and **4**. When manufacturing the bands the surfaces **15** can be ground over to prevent differences in thickness.

For special purposes, the grinding bands can also be replaced by thin walled diamond bonded grinding rings which, as shown in Fig. 9, are each clamped between conical shaped disks **3'** and **4'**. These clamping disks **3'** and **4'** are fitted together in sets to form a grinding tool and secured on the reduced shank of a bolt **16** by the nut **17**. Such a tool is used for grinding out bores or like. The disks can also be assembled in such a manner that the periphery of the individual grinding rings bears against the wall of a cone (K). It is likewise possible to electrically insulate the clamping disks and their collecting rings from each other for the purpose of using the electro-erosion process.

I claim:

1. A grinding apparatus comprising a narrow flexible grinding band in which abrasive particles are embedded, a carrier disc, a pair of concentrically arranged rings mounted on said carrier disc forming a clamping device, said grinding band being clamped curvilinearly in said clamping device with said band projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said band come into contact with the material to be ground, a stationary front plate covering said carrier disc having an annular groove therein, said plate having a groove extending radially for receiving and guiding the material to be ground, the cutting edge of said grinding band projecting slightly into said annular groove so that the material to be ground when fed along the bottom of said radial groove comes into contact with said grinding band.

2. A grinding apparatus comprising a plurality of narrow flexible grinding bands having abrasive particles imbedded therein, a carrier disc, a plurality of pairs of concentrically arranged rings mounted on said carrier disc forming clamping devices, said grinding bands being clamped circularly in said clamping devices with said bands projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said bands come into contact with the material to be ground, a stationary front plate covering said carrier disc having annular grooves therein, said plate having a radial groove for receiving and guiding the material to be ground, and the cutting edges of said grinding bands projecting slightly into said annular grooves so that when said material to be ground is fed along the bottom of said radial groove it will come into contact with said grinding bands.

3. A grinding apparatus comprising a plurality of narrow flexible grinding bands having abrasive particles imbedded therein, a carrier disc, a plurality of pairs of concentrically arranged rings mounted on said carrier disc forming clamping devices, said grinding bands being clamped circularly in said clamping devices with said bands projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said bands come into contact with the material to be ground, said rings of said clamping device being mutually electrically insulated on said carrier disc, collecting rings on said carrier disc, said grinding bands being connected by leads to said collecting rings and insulated contact discs mounted on the hub of the grinding apparatus so that said grinding bands may serve as electrodes for the removal of material by electro-erosion combined with mechanical grinding.

4. A grinding apparatus comprising a narrow flexible grinding band in which abrasive particles are embedded, a carrier disc, a pair of concentrically arranged rings mounted on said carrier disc forming a clamping device, said grinding band being clamped curvilinearly in said clamping device with said band projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said band come into contact with the material to be ground, a stationary front plate covering said carrier disc having an annular groove therein, said plate having a groove extending radially for receiving and guiding the material to be ground, the cutting edge of said grinding band projecting slightly into said annular groove so that the material to be ground when fed along the bottom of said radial groove comes into contact with said grinding band, and said plate comprising separate layers of electrical conducting material and electrical non-conducting material.

5. A grinding apparatus comprising a narrow flexible grinding band in which abrasive particles are embedded, a carrier disc, a pair of concentrically arranged rings mounted on said carrier disc forming a clamping device, said grinding band being clamped curvilinearly in said clamping device with said band projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said band come into contact with the material to be ground, a stationary front plate covering said carrier disc having an annular groove therein, said plate having a groove extending radially for receiving and guiding the material to be ground, the cutting edge of said grinding band projecting slightly into said annular groove so that the material to be ground when fed along the bottom of said radial groove comes into contact with said grinding band and said plate having metal strips so that the ground material may be removed mechanically and by electrolytical erosion.

6. A grinding apparatus comprising a narrow flexible grinding band in which abrasive particles are embedded, a carrier disc, a pair of concentrically arranged rings mounted on said carrier disc forming a clamping device, said grinding band being clamped curvilinearly in said clamping device with said band projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said band come into contact with the material to be ground, a stationary front plate covering said carrier disc having an annular groove therein, said plate having a groove extending radially for receiving and guiding the material to be ground, the cutting edge of said grinding band projecting slightly into said annular groove so that the material to be ground when fed along the bottom of said radial groove comes into contact with said grinding band and said annular groove is lined with a wear resisting material.

7. A grinding apparatus comprising a narrow flexible grinding band in which abrasive particles are embedded, a carrier disc, a pair of concentrically arranged rings mounted on said carrier disc forming a clamping device, said grinding band being clamped curvilinearly in said clamping device with said band projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said band come into contact with the material to be ground, a stationary front plate covering said carrier disc having an annular groove therein, said plate having a groove extending radially for receiving and guiding the material to be ground, the cutting edge of said grinding band projecting slightly into said annular groove so that the material to be ground when fed along the bottom of said radial groove comes into contact with said grinding band and said carrier disc being coupled with an oscillation generator.

8. A grinding apparatus comprising a narrow flexible grinding band in which abrasive particles are embedded, a carrier disc, a pair of concentrically arranged rings mounted on said carrier disc forming a clamping device, said grinding band being clamped curvilinearly in said clamping device with said band projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said band come into contact with the material to be ground, a stationary front plate covering said carrier disc having an annular groove therein, said plate having a groove extending radially for receiving and guiding the material to be ground, the cutting edge of said grinding band projecting slightly into said annular groove so that the material to be ground when fed along the bottom of said radial groove comes into contact with said grinding band and said band having incorporated therein disintegrated abrasives and diamond crystals.

9. A grinding apparatus comprising a plurality of narrow flexible grinding bands having abrasive particles imbedded therein, a carrier disc, a plurality of pairs of concentrically arranged rings mounted on said carrier disc forming clamping devices, said grinding bands being clamped circularly in said clamping devices with said bands projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said bands come into contact with the material to be ground, a stationary front plate covering said carrier disc having annular grooves therein, said plate having a radial groove for

receiving and guiding the material to be ground, and the cutting edges of said grinding bands projecting slightly into said annular grooves so that when said material to be ground is fed along the bottom of said radial groove it will come into contact with said grinding bands and said grinding bands differing from one another with respect to their setting grit.

10. A grinding apparatus comprising a narrow flexible grinding band in which abrasive particles are embedded, a carrier disc, a pair of concentrically arranged rings mounted on said carrier disc forming a clamping device, said grinding band being clamped curvilinearly in said clamping device with said band projecting slightly therefrom so that said abrasive particles bonded in a narrow edge of said band come into contact with the material to be ground and said grinding band having on the side directed towards the material to be ground spaced incisions.

11. A narrow flexible grinding band having abrasive particles embedded therein for use in a grinding apparatus using a face of a disc for the grinding action wherein said band is bent curvilinearly and only a narrow edge is exposed for carrying out the grinding action and said band is provided with perforations to increase the flexibility.

12. A narrow flexible grinding band having abrasive particles embedded therein for use in a grinding apparatus using a face of a disc for the grinding action wherein said band is bent curvilinearly and only a narrow edge is exposed for carrying out the grinding action and said abrasive particles are arranged in rows and said band is constructed thinner between said rows in order to increase the flexibility thereof.

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