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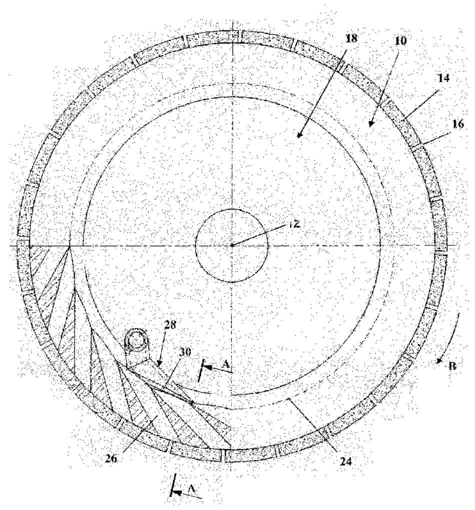

(57) Abstract: A rotary machining tool, comprising a rotatable hub (10) carrying a plurality of tool elements (14) around its outer periphery for machining a work-piece at a predetermined contact region of the tool; a plurality of passages (26) extending outwardly from an inner chamber (22) of the hub (10) at a non-orthogonal angle to the hub axis (12) so as to emerge at the outer periphery of the hub between respective pairs of adjacent tool elements (14); and a nozzle (28) disposed within the inner chamber (22) close!} adjacent to the rotary path of the inner ends of the hub passages (26) and adapted to supply fluid lubricant directed inside the hub passages (26) without interaction of the fluid with other part of the wheel hub surface and forcing it under procure into no more than two of the passages (26) at any time when the hub is rotated, such that the fluid lubricant is ejected between tool elements (14) substantially only at the predetermined contact region of the tool.

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DESCRIPTION

MACHINING TOOL HAVING AN IMPROVED INTERNAL FLUID DELIVERY SYSTEM

The present invention relates to a machining tool and, in particular, a tool having means for delivering a fluid to a contact zone with a work-piece. More particularly the present invention relates to grinding or milling tools.

It is common in the machine tool industry to use abrasive grinding wheels to shape and finish work-pieces, and to use milling wheels to cut workpieces. In almost all machine tool operations, the friction between the tool and work-piece generates tremendous amounts of heat energy which, if left uncontrolled, can lead to significant damage of the tool and the workpiece. Accordingly, tool life is shortened, and machine tool operations are less productive and more expensive. This problem is critical in high speed milling and especially in high speed grinding, which generate especially large quantities of heat.

It is therefore common in the industry to use a coolant, particularly a liquid coolant, to reduce the temperature in the region of the contact area between the tool and the workpiece. There are various fluid delivery methods that supply the coolant to the tool and seek to direct the fluid towards the grinding or cutting zone, where the tool engages the workpiece.

Whilst the fluid can be delivered to the grinding or cutting zone, it is often difficult to ensure that such fluid is delivered in sufficient quantities within the boundaries of the required area. This becomes more problematic during high material removal rate when the length and the depth of the cutting zone are large.

Known machining tools include those having a grinding wheel where fluid coolant is supplied to the periphery of the grinding wheel by way of a central channel. In some examples fluid is supplied under pressure through a hole in the spindle. In other systems fluid is supplied via a central hole in the wheel itself. Thereafter, fluid coolant is pumped out, due to centrifugal effect and/or due to the supply pressure, through the channels towards the periphery of the wheel. These known tools typically suffer from the disadvantage that fluid coolant exits the wheel around the whole periphery of the wheel, whereas the fluid coolant need only be supplied to the contact area between wheel and workpiece where material cutting occurs. Therefore most of the coolant is wasted. Furthermore, special spindle or other arrangements are required to ensure that the fluid coolant is delivered, so that the wheel is not compatible with other machines. Examples of such systems are found in: US6358133 B (Fig.12, 13); US5423717 A; US4333371 A; US3282263 A; GB726194 A.

Another known tool has a grinding wheel in which fluid is supplied from a nozzle into a chamber formed within the wheel using a flooding method. Fluid coolant is pumped out through channels in the wheel towards the periphery of the wheel. In these systems, the nozzle serving to dispense the fluid is pointed towards that region of the wheel chamber which is closest to the cutting area. However, due to the distant location of the nozzle as well as due to the design of the fluid inlet zone within the hub, the fluid is influenced by the wheel hub before it enters the wheel hub passages. As a result, the rotating hub accelerates the fluid along a circular path which causes the fluid to enter more than a chosen number of hub passages, and in many cases enters all the passages at the same time.

Therefore, fluid exits from the wheel periphery at a wider angle, often throughout the whole periphery of the wheel, instead of being localized within the boundaries of the cutting zone. Therefore, a significant part of the coolant fluid is wasted. In addition, because of the low fluid supply pressure and the nozzle and the chamber design, these systems are designed to utilise only a pumping action of the rotating wheel caused by the centrifugal effect. Furthermore, because of the fluid flow-rate through the wheel being entirely dependant on the centrifugal effect, it is not possible to utilise fluid pressure from the fluid supply system to increase the flow-rate through the cutting zone independently of the rotational speed of the wheel. Often in practice, in order to prevent thermal damage of the machined component while making deep cuts, a higher flow-rate is required than can be achieved by the centrifugal effect from the wheel. In addition, this type of tool cannot make use of non-liquid coolants, such as a gas. Examples of such systems are: US6358133 B (Fig.15, 16); EP1334790 A; GB210580 A; US5993297 A (Fig.8); JP59088260 A (Fig1)

Another type of tool (WO2004011194 A1) consists of a grinding wheel comprising an internal chamber which communicates with the external surface of the wheel via a plurality of channels disposed within the wheel. The coolant is supplied to the internal chamber of the wheel by one or more supply channels. Thereafter, fluid passes through the wheel channels to the wheel periphery. Fluid delivery channels are angled, providing a fluid jet which is directed in the same direction of the rotational direction of the grinding wheel. In this system liquid coolant is supplied at high pressure which produces a high velocity jet at the outlet of the supply channel. It is intended to supply fluid to the cutting zone by utilizing particular pipe (channel) depending on the location of the cutting zone around the wheel periphery. However, this design suffers from shortcomings which prevent the desired performance from being attained.

Particularly, the design features include:

a). distant location of the inlets of the wheel passages from each other within the internal wheel chamber,

b). different angular position of the fluid delivery passage and the wheel passages, which does not allow their alignment when the wheel is rotated,

c). distant location of the nozzle passage outlet end from the wheel passages inlet ends,

Accordingly, due to these design features, (similarly to previously described prior art), supplied fluid is influenced by the wheel hub before entering the wheel passages. Consequently fluid is spread along the rotary path of the chamber and enters multiple wheel passages, preventing localization of the fluid flow within the boundaries of the cutting zone.

Due to the same design features, utilization of high pressure fluid delivery, in order to force fluid directly into the wheel passages to increase the flowrate to the cutting zone independently of the rotational speed of the wheel, is not possible. Therefore, the fluid flow through the wheel passages is limited by the centrifugal pumping effect of the rotating wheel.

Furthermore, although the fluid stream is supplied at high pressure and high velocity, which is directed in the same direction as the wheel rotation, it serves only to minimize the resistance to the rotating wheel.

In addition, gases cannot be used with this system.

It is an object of the present invention to overcome or alleviate one or more of the problems associated with the prior art.

In accordance with the present invention, there is a rotary machining tool, comprising

a rotatable hub carrying a plurality of tool elements around its outer periphery for machining a work-piece at a predetermined contact region of the tool;

an internal chamber defined within the hub and having a radially inwardly facing annular surface;

a plurality of passages having inner ends which open through said annular surface of the internal chamber, the passages extending outwardly at an angle to the hub axis so as to emerge at the outer periphery of the hub between respective pairs of adjacent tool elements; and

a nozzle part disposed within said internal chamber and having a radially outer surface which is shaped to conform to said annular surface of the hub and is positioned adjacent to it, to direct fluid lubricant into no more than a predetermined number of said passages as well as enabling fluid pressurization into these passages at any time when the hub is rotated, such that the fluid lubricant is ejected between tool elements substantially only at a predetermined contact region of the tool in quantities larger than can be achieved by wheel centrifugal effect alone.

Preferably, the predetermined number is two only.

Preferably, the internal chamber is of part-circular or "V" section, the outlet of the nozzle being shaped so as to match the curvature or angled profile of said peripheral surface of the inner chamber.

The nozzle outlet channel is disposed at an angle to direct fluid into hub passages in the direction opposite to the rotation of the wheel.

Advantageously, the passages through the hub are of circular or rectangular section and extend at the same, non-orthogonal angle to the hub axis, whereby they emerge at the peripheral surface of the hub chamber with elongated, substantially elliptical or rectangular mouths, the mouth of the nozzle being shaped substantially to match.

The use of passages extending at a non-orthogonal angle to the hub axis, as opposed to being radial in the known system described hereinbefore, has the advantage of enabling the centrifugal pumping effect to be maximised.

The tool elements can comprise arcuate abrasive elements when the rotary tool is a grinding wheel and cutting elements when the rotary tool is a milling wheel.

Advantageously, the angular position of the nozzle within the hub chamber can be adjusted to enable the lubricating fluid to be supplied to different selected contact regions to the tool periphery.

Preferably, said radially outer surface of the nozzle part is positioned to initially contact said annular surface of the hub.

The initial contact between nozzle outer surface and hub inner surface is provided in order to allow grinding of excessive material from the nozzle outer surface by the hub outer surface thus achieving a minimal distance between these two surfaces which effectively approaches to zero.

Preferably, the radially outer surface of the nozzle part comprises a non-metallic material, more preferably graphite.

Preferably, said annular surface is defined by a metallic material.

Preferably, a seal is formed between the nozzle part and said annular surface of the internal chamber, enabling fluid to be delivered under pressure into said passages.

Preferably, said annular surface has, in axial section, a truncated "V" or part-circular shape, the nozzle part being complementarily shaped.

Neighboring passages converge to form a vertex at said annular surface.

Said vertex is oriented non-radially and pointed against the supplied fluid stream to minimize restriction of the fluid by the wheel hub and to urge fluid from the nozzle directly into the hub passages by avoiding interference of the fluid with other parts of the wheel hub surface.

Preferably, said passages have a rectangular or square cross section.

Preferably, the nozzle part defines an outlet passage oriented to be aligned with one of said passages extending outwardly from the hub axis when the two passages are juxtaposed.

Preferably, said radially outer surface of said nozzle part is arcuate in a radial plane and has substantially the same diameter of curvature as the annular surface of the hub.

Preferably, said abrasive elements (segments) have end surfaces which are non-orthogonal to a tangent to the wheel peripheral surface drawn at the point of intersection between the end surface of the abrasive element and the wheel peripheral surface.

Preferably, the nozzle-shoe is rotatable about the axis of the tool, being mounted upon a rotatable arm.

Preferably, the arm is rotatably mounted upon a base plate which is fixed to a machine by means of angle brackets allowing adjustment of the base plate along three different directions to allow the rotational axis of the arm to be aligned with the axis of the rotary tool.

Specific embodiments of the invention are described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a partially cut-away front elevation of a grinding wheel in accordance with one embodiment of the present invention;

Fig. 2 is a partially cut-away side elevation of the grinding wheel of Fig. 1;

Fig. 3 is a partial sectional view of a fluid delivery means;

Fig. 4 is a partial cut-away view of part of a milling tool in accordance with a second embodiment of the grinding wheel of Fig. 1;

Figs. 5, 6 and 7 are partial front elevations illustrating grinding wheels having abrasive sections of three different forms;

Fig. 8 is a partially cut-away front elevation of a grinding wheel in accordance with another embodiment of the present invention;

Fig. 9 is a partial cut-away side elevation of the grinding wheel of Fig. 8;

Fig. 10 is a partial cut-away side elevation of a grinding wheel similar to that of Fig. 8 but showing elliptical mouths at the inner peripheral surface of the wheel hub;

Fig. 11 is a partially sectional view of a fluid delivery means;

Fig. 12 is a front view of an arrangement for nozzle-shoe mounting which is rotatable around the wheel central axis; and

Fig. 13 is a side view of the Fig. 12 arrangement.

The grinding wheel of Figs. 1, 2 and 3 comprises a hub 10 mounted on a spindle (not shown) for rotation about a horizontal central axis 12 and having a plurality of arcuate abrasive sections 14 disposed around its periphery which are spaced apart circumferentially by gaps 16 forming respective radially extending channels disposed between adjacent arcuate abrasive sections 14. The grinding wheel hub 10 is formed on one side with a large circular recess 18. As best seen in Fig. 3, the recess 18 has an outer peripheral surface 24 which is of part-circular (or angular) transverse section whereby effectively to define an annular chamber 22 internally within the hub 10.

Extending between the peripheral surface 24 of the recesses 18/chamber 22 and the outer peripheral surface of the hub 10 is a plurality of passages/holes 26 which in this embodiment comprise straight bores of uniform circular section. The radially outermost end of each passage 26 communicates with a respective one of the radial gaps 16 between adjacent pairs of the arcuate abrasive sections 14.

As best seen in Fig. 1, in this embodiment the passages 26 are each disposed at the same (non-radial) angle relative to the hub axis 12 (and to tangents to the hub periphery) whereby the distances between the radially inner (inlet) ends of the passages 26 when they reach the surface of the internal chamber 18 has reduced substantially to zero as seen in Figs. 1 and 2.

Disposed within the hub recess 18 is a fluid dispensing nozzle part 28 having a nozzle outlet 30 facing, but spaced slightly inwardly of, the curved peripheral surface 24 of the recess 18. The outlet 30 is shaped so as to conform closely to the shape of the curved peripheral surface 24 of the hub recess 18 so that there is a substantially uniform radial spacing between the periphery of the nozzle outlet 30 and the adjacent portion of the peripheral surface 24 of the recess 18.

The nozzle part 28 itself lies in a plane perpendicular to the rotational axis of the grinding wheel 10 but has a connecting tube 32 at its inlet end which extends perpendicularly away from the wheel 10 for connection, in use, to a cooling fluid supply (not shown).

As shown in Figs. 1 and 3, the fluid delivery outlet 30 of the nozzle part 28 is positioned very close to the inlet ends of the passages 26. The distance between the nozzle edge and the peripheral surface 24 of the internal chamber 18 is reduced to the minimum practically possible, consistent with physical contact between the nozzle and the rotating hub being avoided.

This is achieved at initial set up of the nozzle by allowing the nozzle outer surface to touch the hub's inner surface and locking the nozzle in this position by means of special arrangements, which will be described below. Once the wheel starts rotating, the excessive material from the nozzle outer surface (which is in physical contact with the hub surface) will be removed by the hub outer surface due to frictional interaction of both of these materials, thus automatically achieving the minimal distance between these two surfaces which effectively approaches to zero.

The shape of the mouth of the nozzle part 28 conforms to that of the curved internal peripheral surface of the hub internal chamber 18.

The cross-sectional area of the nozzle is equal or substantially equal to the cross-sectional area of each of the passages 26.

When the hub 10 is rotated about the hub axis 12, the axis of the nozzle is arranged to coincide sequentially with the axis of each of the opposed passages 26 and also with its angular direction whereby there is momentary alignment between fluid ejected by the nozzle part 28 and each of the passages 26 in turn.

The passages 26 act as conduits between the nozzle part 28 and the gaps 16 between the arcuate abrasive sections 14 for delivering fluid coolant to the outer periphery of the grinding wheel 10.

Because of the angle at which the circular sectioned passages 26 emerge at the curved peripheral surface 24 of the recess 18, their shape at the interface with the surface 24 is generally elliptical. Thus, in order to overlap accurately with the passages 26, the nozzle outlet 30 is similarly elliptical in shape.

As will be best seen from Fig. 1, in this embodiment, the length of the elliptical nozzle outlet in the circumferential direction of the hub corresponds substantially to the length of the elliptical inlets of the passages 26 whereby at any one time the nozzle is supplying fluid, in this embodiment, to a maximum of two passages 26 depending on the instantaneous overlap of the nozzle therewith. Thus, cooling fluid is restricted to a correspondingly short circumferential length of the grinding wheel.

As shown in Figs. 1 and 2, the abrasive sections 14 are adhered to the wheel hub 10 around its periphery. As shown in Fig. 5, the abrasive sections 14 can have two central grooves 34, preferably of semi-cylindrical shape, at its two opposed ends whereby each adjacent pair of abrasive sections 14 form outlet channels of cylindrical shape midway, in this case, along the gaps 16.

Fig. 6 shows an embodiment where the gaps are arranged at an angle to the hub axis 12, but parallel to each other. Fig. 7 shows a similar arrangement but where only every other gap 16 is mutually parallel.

Fig. 4 shows how exactly the same practical effect can be achieved to form a milling wheel 10 if the arcuate abrasive sections 14 are replaced by metal segments 14a carrying cutting plates 40.

The cutting plates 40 are located closely adjacent to the outlets of the passages 26, whereby to guide the fluid flow from the passages 26 onto their surface and onto the work-piece during a milling operation.

In use, fluid coolant is delivered by a pump (not shown) from the supply tank to the nozzle part 28 by way of a conduit. The hub 18 is caused to rotate by a drive motor (not shown) in the direction B indicated in Fig. 1.

By means of the pump action fluid is forced into the wheel passages at high pressure and high velocity, which enables supply of greater flowrate to the cutting zone than can be achieved by centrifugal effect of the rotating wheel alone. In addition to this the centrifugal effect acting on the fluid due to the rotation of the hub urges the fluid coolant to flow outwardly towards the periphery of the hub. The coolant flows by way of a maximum of two passages 26 (in this embodiment) which are sequentially aligned therewith at any given time, the nozzle being positioned within the hub 10 so that the coolant fluid flow is directed specifically to the desired contact region between the wheel 10 and work-piece (not shown).

In other embodiments, the nozzle length could be greater so as to overlap with an arrangement of three or more passages 26 at any given time. However, the preferred arrangement is that shown in the drawings where the nozzle can communicate with a maximum of two passages 26.

In still further embodiments, and depending upon the particular requirements, two nozzles can be employed for the delivery of two types of fluid (liquid or gas)

The actual position at which the nozzle part 28 is disposed within the hub chamber 18 can be selected by rotating the nozzle part 28 around the chamber 18 to a new fixed position, thus enabling fluid to be supplied at any required location around the external surface of the grinding wheel where a working zone is located.

The grinding wheel of Figs. 8-11 is in many respects similar to that of Figs. 1-4. It comprises a hub 101 mounted on a spindle (not shown) for rotation about a horizontal central axis 102 and having a plurality of arcuate abrasive sections 103 disposed around its periphery which are spaced apart circumferentially by gaps 104 forming respective channels disposed between adjacent arcuate abrasive sections 103. The grinding wheel hub 101 is formed on one side with a large circular recess 105. As best seen in Fig. 11 the recess 105 has a peripheral surface 106 which is of angular (or part circular in Fig. 3) transverse section whereby effectively to define an annular chamber 107 within the hub 101.

Associated with each gap/channel 104 is a respective reservoir 109 formed as a recess in the wheel's peripheral surface.

Extending between the peripheral surface 106 of the recess 105/chamber 107 and the outer peripheral surface of the hub 101 is a plurality of passages/holes 108 which in this embodiment comprise straight bores of uniform rectangular (or circular in Fig. 3) section. The radially outermost end of each passage 108 communicates with a respective reservoir 109 and a respective one of the gaps 4 between adjacent pairs of the arcuate abrasive sections 103.

Disposed within the hub recess 105 is a fluid dispensing nozzle-shoe 110 which is initially in physical contact with the wheel hub surface 106. Similarly to the earlier embodiment, the minimal radial distance (almost approaching to zero) between the nozzle-shoe 110 and the hub surface 106 is formed automatically as a result of their frictional interaction which causes wear of the nozzle outer surface at a depth necessary to only avoid further physical contact between these surfaces. Accordingly the entire nozzle-shoe outer surface is also automatically shaped to conform to the shape of the adjacent inner peripheral surface 106 in both axial and radial planes. In the radial plane, as seen in Fig. 8, the nozzle-shoe 110 has an arcuate shape which is elongated along the circumferential path of the surface 106 to cover the inlets of at least two of the passages 108. The radii of the arcuate outer surface of the nozzle-shoe 110 and the adjacent inner peripheral surface 106 of the wheel are preferably the same. As in the earlier embodiment, when the hub 101 is rotated about the hub axis 102, the nozzle-shoe outlet channel (indicated in phantom at 112) is arranged to coincide sequentially with each of the opposed passages 108, whereby there is momentary alignment between nozzle-shoe outlet channel axis 113 and the hub passage axis 114, so that the stream of fluid lubricant produced from the nozzle-shoe outlet channel 112 is in direct communication with the workpiece surface (not shown) through the straight line via hub passages 108.

Preferably the mouth of the outlet channel 112 of the nozzle-shoe 110 is shaped to be smaller or to match the width of the mouths of the hub passages 108 emerging from the inner peripheral surface 106, the nozzle-shoe preferably providing fluid flow into inlets of no more than two hub passage at a time, so that the outward fluid flow from the wheel periphery is attained simultaneously from the outlet ends of only the same two hub passages.

The distances between inner mouths of neighbouring hub passages 108 on the inner peripheral surface 106 of the hub chamber 107 are diminished preferably to zero, to form a knife edge 191, therefore minimising the fluid restriction by the wheel hub and providing smooth fluid flow into said hub inner passages.

Advantageously, fluid flow is injected from the nozzle-shoe outlet channel 112 into the hub inner passages 108 at high velocity by pressurising the fluid and thence increasing the flow-rate through the predetermined number of hub passages 108 beyond the flow-rate that can be achieved by only centrifugal effect of the rotating wheel.

As seen from Fig. 1, abrasive segments 103 from one or from both ends are shaped to form a non-orthogonal angle φ relative to the tangent 115 drawn through the point of intersection 116 between the surface of the abrasive segment end and the wheel peripheral surface. Respective pairs of the abrasive segments form a fluid passage 104 being disposed at the angle φ so as to assist fluid flow outwardly from the grinding wheel during the rotation at high speed.

In some embodiments, the circumferential extent of the mouth of the outlet channel 112 of the nozzle-shoe 110 is smaller than or equal to the extent of the mouths of the hub passages 108 where they emerge from the inner peripheral surface 106, so that the nozzle-shoe supplies fluid to no more than two of the passages 108 at any given moment.

Viewed in the axial plane (Fig. 11) the nozzle-shoe has a radially outer portion formed as a truncated, outwardly convergent "V" shape. The inner peripheral surface 106 of the wheel has a complementary shape, so that together these parts form at least a partial seal against egress of fluid. Continuous friction in this region may lead to undesirable wear of the nozzle outer surface material (graphite). In the present embodiment the nozzle-shoe 110 is made from two materials, the main body being preferably metallic material more preferably steel, whereas the outlet end 111 is a non-metallic material, preferably graphite, thus allowing frictional interaction with the material of the rotating wheel hub 101, being preferably steel.

In the present invention the fluid is supplied directly from the nozzle channel 112 into the hub passages 108 rather than via the wheel internal chamber 107. This is different from the prior art devices discussed above. This design feature avoids interaction of the supplied fluid with other parts of the wheel hub surface which would otherwise accelerate and spread the supplied fluid along its rotary path, allowing the fluid to enter more hub passages, than necessary for localization of the fluid within the boundaries of the cutting zone. The alignment of the nozzle channel 112 with the hub passage 108 as well as their close location (almost approaching to zero) permits the fluid to be forced at high velocity into the hub passages, thus achieving greater flowrate through the predetermined number of passages than could be achieved by centrifugal effect of the rotating wheel alone.

It is desirable in some cases to be able to change the region in which fluid emerges from the wheel, e.g. to match changes in the position of the workpiece. To achieve this, the position of the nozzle-shoe 110 about the axis 102 is adjustable by virtue of a mounting arrangement seen in Figs. 12 and 13. The nozzle-shoe 110 is carried upon a radial arm 117 which in this embodiment is rotatable through an angular range about the axis 102. The arm 117 is mounted on a flange 119 which is itself mounted for rotation about axis 102 by virtue of a shallow integral lip received in a bore 126 of a fixed base plate 122. Bolts 124 pass through arcuate slots 123 in the flange 119 and serve to lock the assembly in a required angular position. The bolts are threadedly received in bores 127 of the base plate, and there are multiple sets of these bores so that the bolts can be re-sited to extend the range of angles through which the assembly can be adjusted. The base plate 122 is mounted upon right angle brackets 125 through bolts 131 received in slots 128 in the base plate 122 and in slots 129 in the right angle brackets, the former being perpendicular to the latter so that the base plate position can be adjusted both horizontally and vertically.

The right angle brackets 125 are themselves mounted to the associated machine through a plurality of slots 130 extending in the direction parallel to the wheel hub axis. The slots 128, 129 and 130 provide for 3D movement of the arrangement to align the flange's axis with the wheel's central axis 102.

The nozzle-shoe 110 is carried by the arm 117. Hence the nozzle-shoe 110 can be rotated through 360 degrees. Bolts 118 serve to lock the nozzle-shoe in place.

In the above described arrangements, fluid is delivered directly from the part forming a nozzle to the passages such as 26 through which the fluid is delivered to the service of the tool. In contrast to many prior art devices, in the present arrangement little if any fluid escapes into the internal space of the hub. As a result, fluid delivery is effectively concentrated in the desired angular region. Several features contribute to this direct delivery of fluid to the passages 26. The conformity of the shape of the nozzle part or nozzle shoe to the shape of the internal circumferential surface of the hub is one such feature. The small spacing between the nozzle parts and the hub surface is another and as explained above a suitable spacing can be achieved simply by initially placing the two parts in contact and allowing one to wear. The alignment of the passages in the nozzle part with the passages 26 also assists in providing the required direct fluid delivery. Finally the very close spacing of the mouths of the passages 26, forming the knife edged vertices such as 191 is believed to assist in guiding/pumping the fluid into the passages. It should be understood that a workable system need not necessarily incorporate all of these features.

CLAIMS

1. A rotary machining tool, comprising

a rotatable hub carrying a plurality of tool elements around its outer periphery for machining a work-piece at a predetermined contact region of the tool;

an internal chamber defined within the hub and having a radially inwardly facing annular surface;

a plurality of passages having inner ends which open through said annular surface of the internal chamber, the passages extending outwardly at an angle to the hub axis so as to emerge at the outer periphery of the hub between respective pairs of adjacent tool elements; and

a nozzle part disposed within said internal chamber and having a radially outer surface which is shaped to conform to said annular surface of the hub and is positioned adjacent to it, to direct fluid lubricant into no more than a predetermined number of said passages at any time when the hub is rotated, such that the fluid lubricant is ejected between tool elements substantially only at a predetermined contact region of the tool.

2 A rotary tool as claimed in claim 1, wherein said nozzle part and said annular surface of said hub are separated by a gap created by wear of one or both in use.

3. A rotary tool as claimed in claim 1, wherein the predetermined number is two.

4. A rotary tool as claimed in claim 1, 2 or 3, wherein said annular surface of the internal chamber is of part-circular or "V" section, the outlet of the nozzle

being shaped so as to match the curvature or angled profile of said peripheral surface of the inner chamber.

5. A rotary tool as claimed in claim 4, wherein the passages through the hub are of circular or rectangular section and extend at the same, non-orthogonal angle to the hub axis, whereby they emerge at the peripheral surface of the hub chamber with circumferentially elongate mouths, the mouth of the nozzle being shaped substantially to match.

6. A rotary tool as claimed in any of claims 1 to 5, wherein the internal chamber of the hub is formed by a recess on one side of the hub.

7. A rotary tool as claimed in any of claims 1 to 6, wherein said tool elements comprise arcuate abrasive elements when the rotary tool is a grinding wheel and cutting elements when the rotary tool is a milling wheel.

8. A rotary tool as claimed in any of claims 1 to 7, wherein the angular position of the nozzle within the hub chamber is adjustable to enable the lubricating fluid to be supplied to different selected contact regions at the tool periphery.

9. A rotary tool as claimed in any of claims 1 to 8, wherein there are two or more nozzles for supplying different fluid lubricants, which can be liquids and/or gases, into the hub passages and thence to the predetermined cutting zone at the tool periphery.

10. A rotary tool as claimed in any preceding claim, in which said radially outer surface of the nozzle part is positioned to initially contact said annular surface of the hub.

11. A rotary tool as claimed in claim 10 in which the radially outer surface of the nozzle part comprises a non-metallic material.

12. A rotary tool as claimed in claim 11 in which said annular surface is defined by a metallic material.

13. A rotary tool as claimed in any preceding claim in which a seal is formed between the nozzle part and said annular surface of the internal chamber, enabling fluid to be delivered under pressure into said passages.

14. A rotary machining tool as claimed in any preceding claim in which said annular surface has, in axial section, a truncated "V" or part-circular shape, the nozzle part being shaped to match.

15. A rotary tool as claimed in any preceding claim in which neighbouring passages converge to form a vertex at said annular surface.

16. A rotary tool as claimed in claim 15 in which said vertex is oriented non-radially and pointed against the supplied fluid stream to urge fluid from the nozzle directly inside the hub passages.

17 A rotary tool as claimed in claim 16, wherein the direction of the fluid stream is opposite to the direction of the wheel rotation.

18. A rotary tool as claimed in claim 15 or claim 16 in which said passages have a rectangular or square cross section.

19. A rotary tool as claimed in any preceding claim in which the nozzle part defines an outlet passage oriented to be aligned with one of said passages extending outwardly from the hub axis when the two passages are juxtaposed.

20. A rotary tool as claimed in any preceding claim in which said radially outer surface of said nozzle part is arcuate in a radial plane and has substantially the same diameter of curvature as the annular surface of the hub.

21. A rotary tool as claimed in any preceding claim in which abrasive elements (segments) have end surfaces which are non-orthogonal to a tangent to the wheel peripheral surface drawn at the point of intersection between the end surface of the abrasive element and the wheel peripheral surface.

22. A rotary tool as claimed in claim 21, wherein the angle of inclination of said abrasive end surfaces is substantially equal to the angle of inclination of the wheel passages.

23. A rotary tool as claimed in any preceding claim in which the nozzle-shoe is rotatable about the axis of the tool, being mounted upon a rotatable arm.

24. A rotary tool as claimed in claim 23 wherein the arm is rotatably mounted upon a base plate which is fixed to a machine by means of angle brackets allowing adjustment of the base plate along three different directions to allow the rotational axis of the arm to be aligned with the axis of the rotary tool.

25. A rotary tool as claimed in claim 5 in which the passages are of constant transverse area along their length.

26. A rotary tool as claimed in claim 11 in which the outer surface of the nozzle part comprises graphite.

27. A rotary machining tool substantially as hereinbefore described, with reference to and as illustrated in the accompanying drawings.

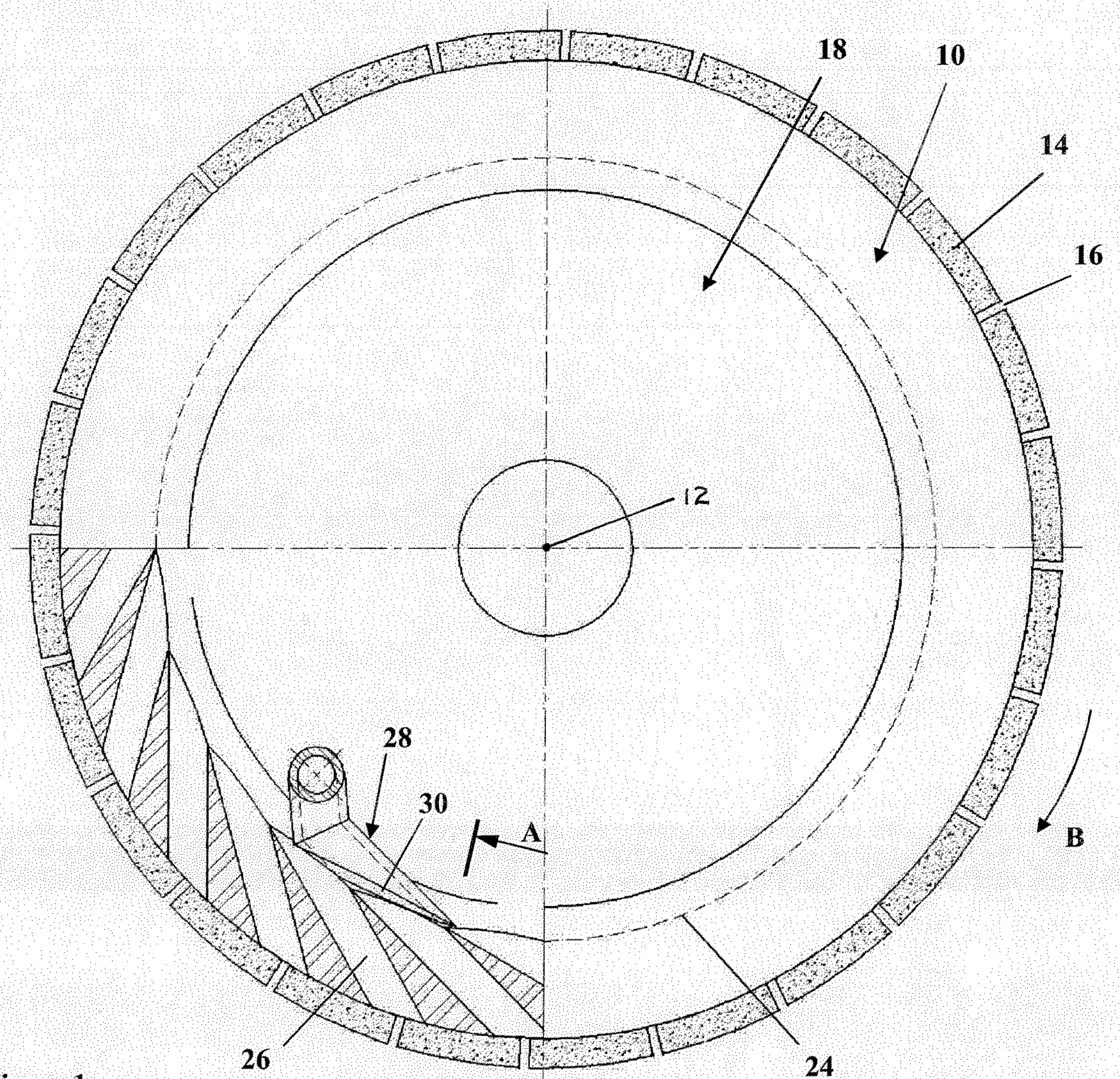


Figure 1

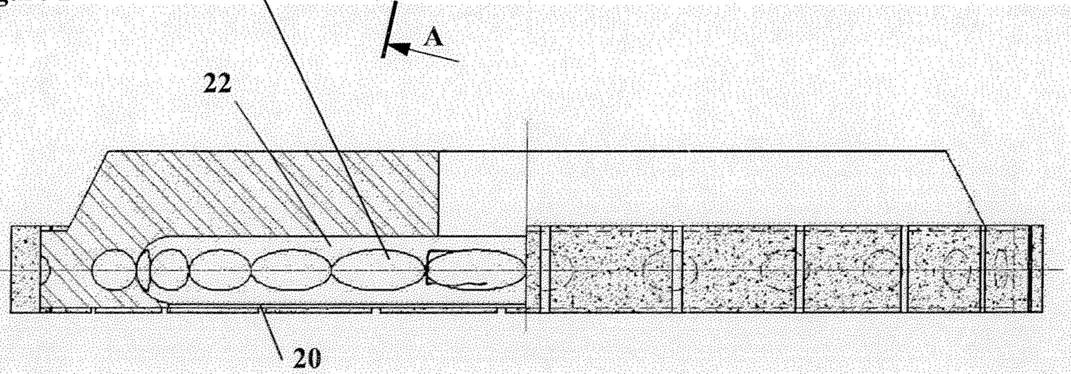


Figure 2

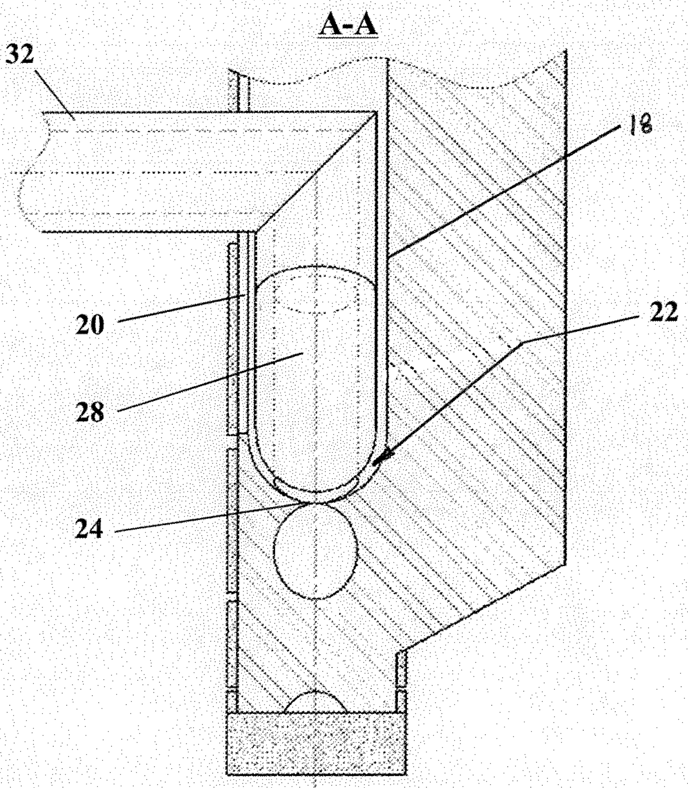
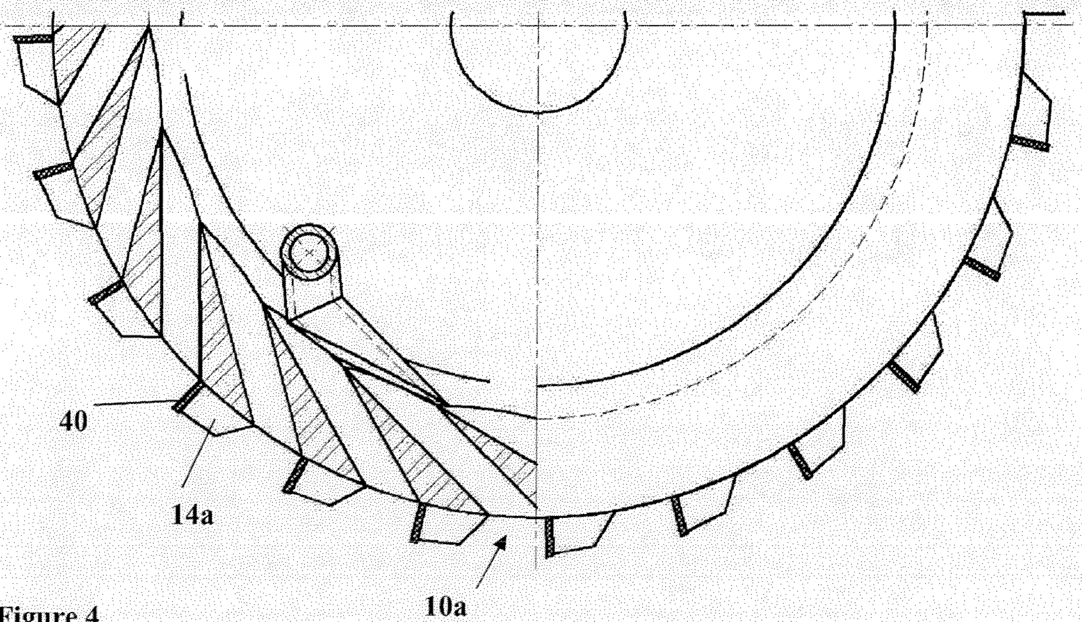


Figure 3



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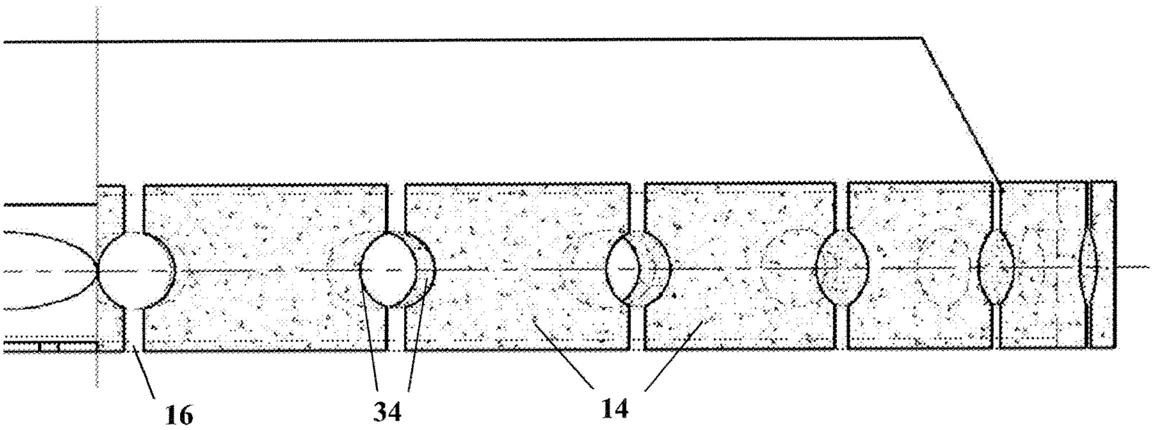

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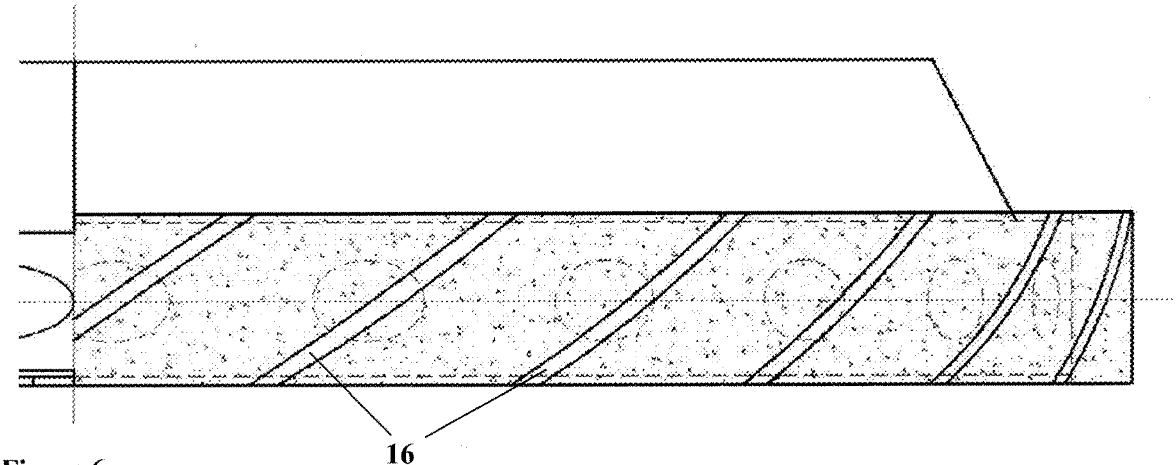

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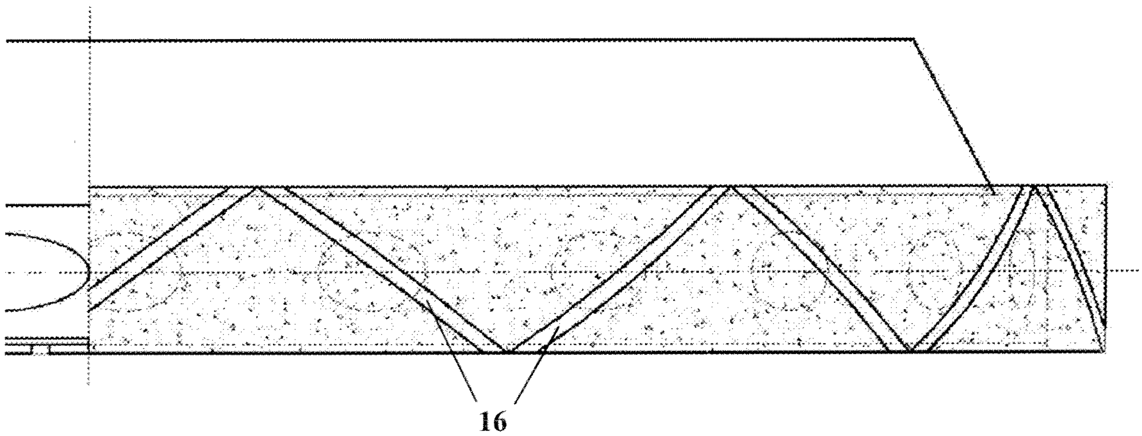

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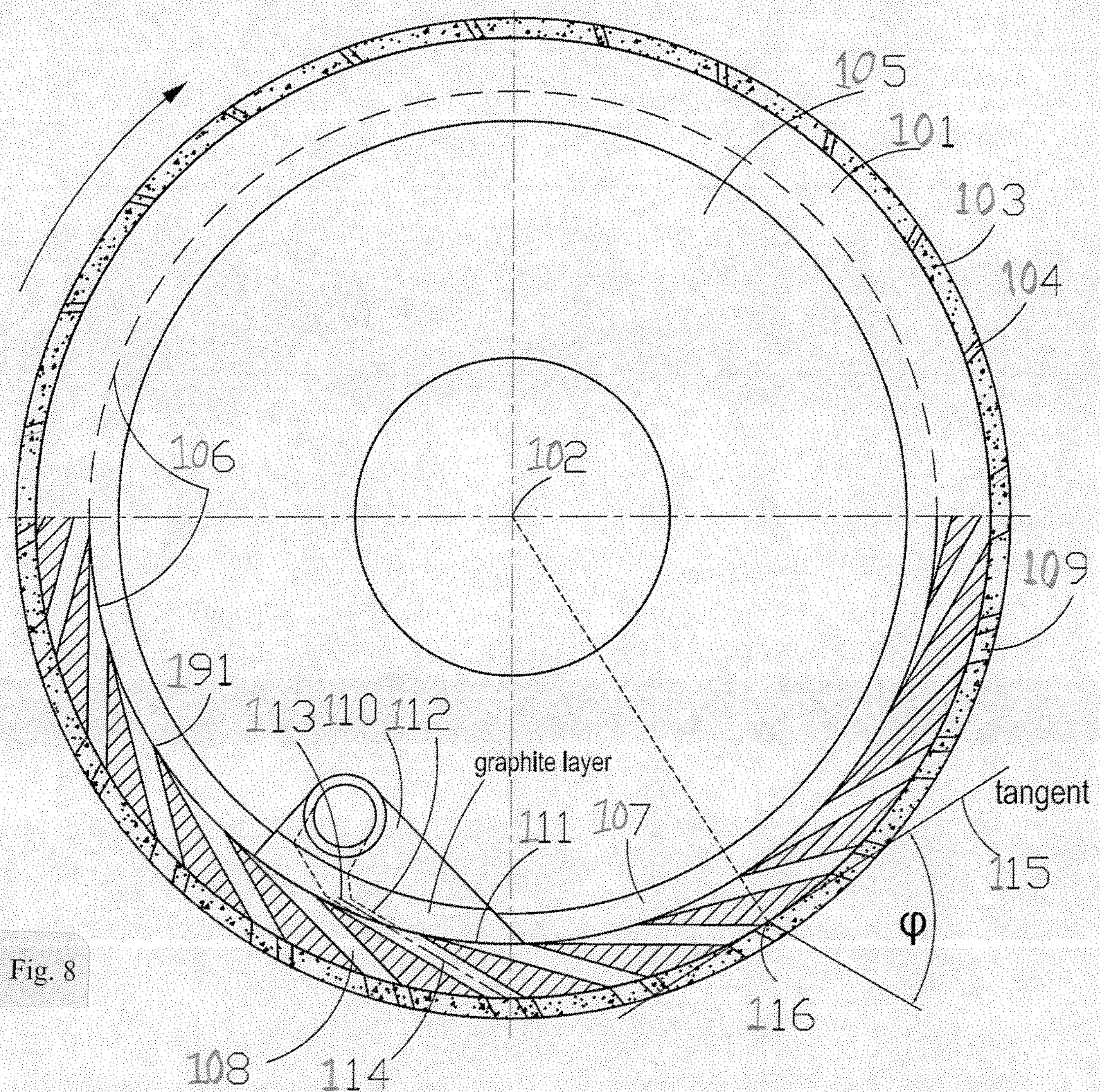
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Fig. 8

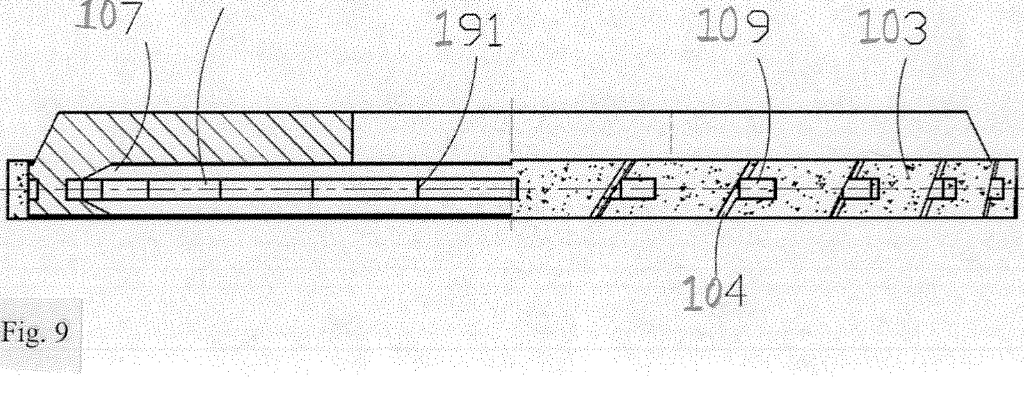
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Fig. 9

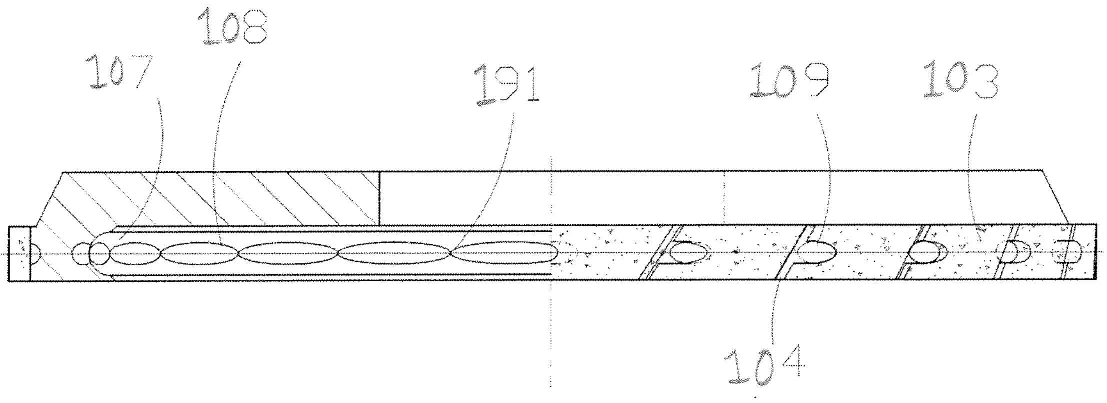
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Fig. 10

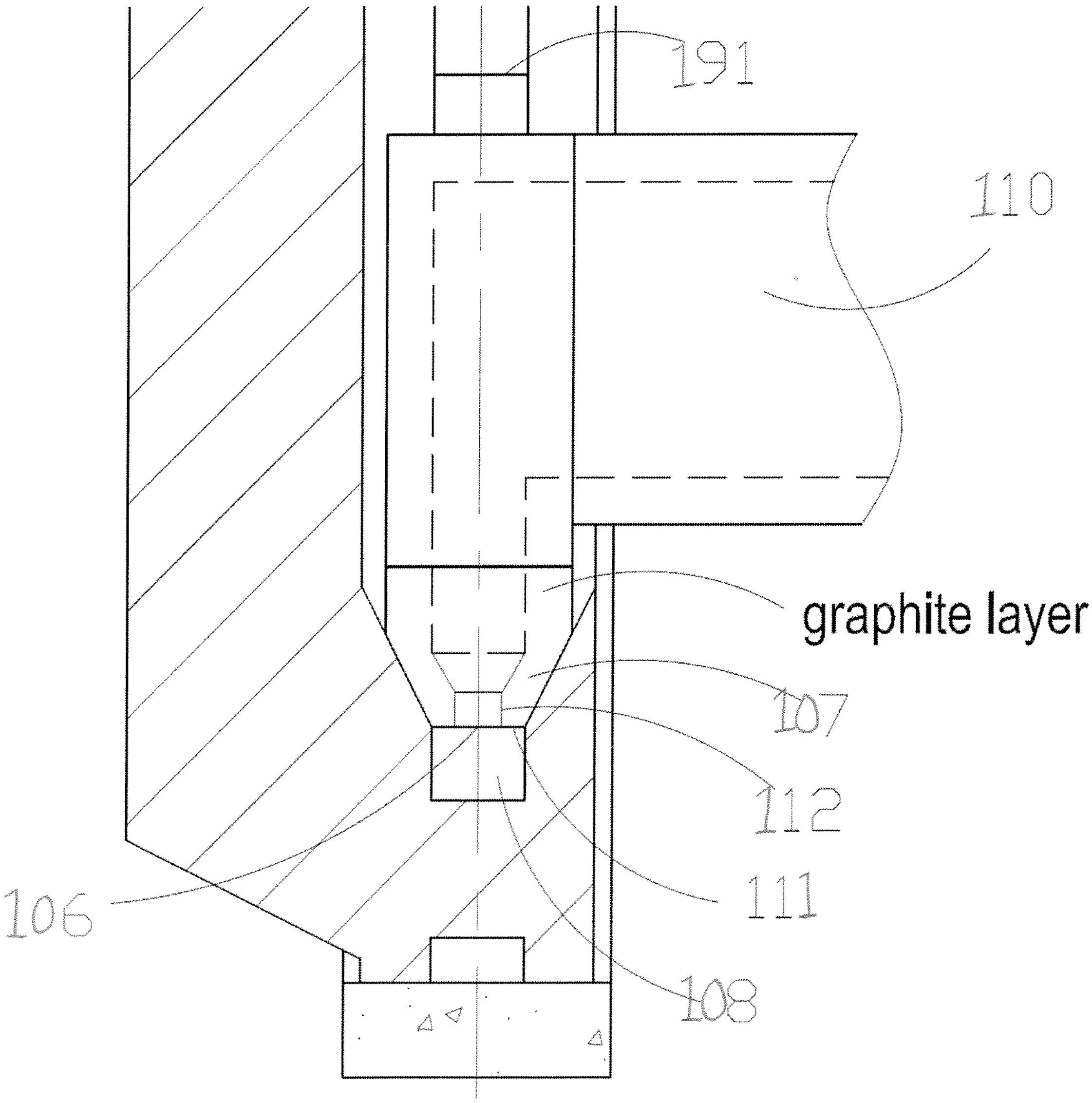
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Fig. 11

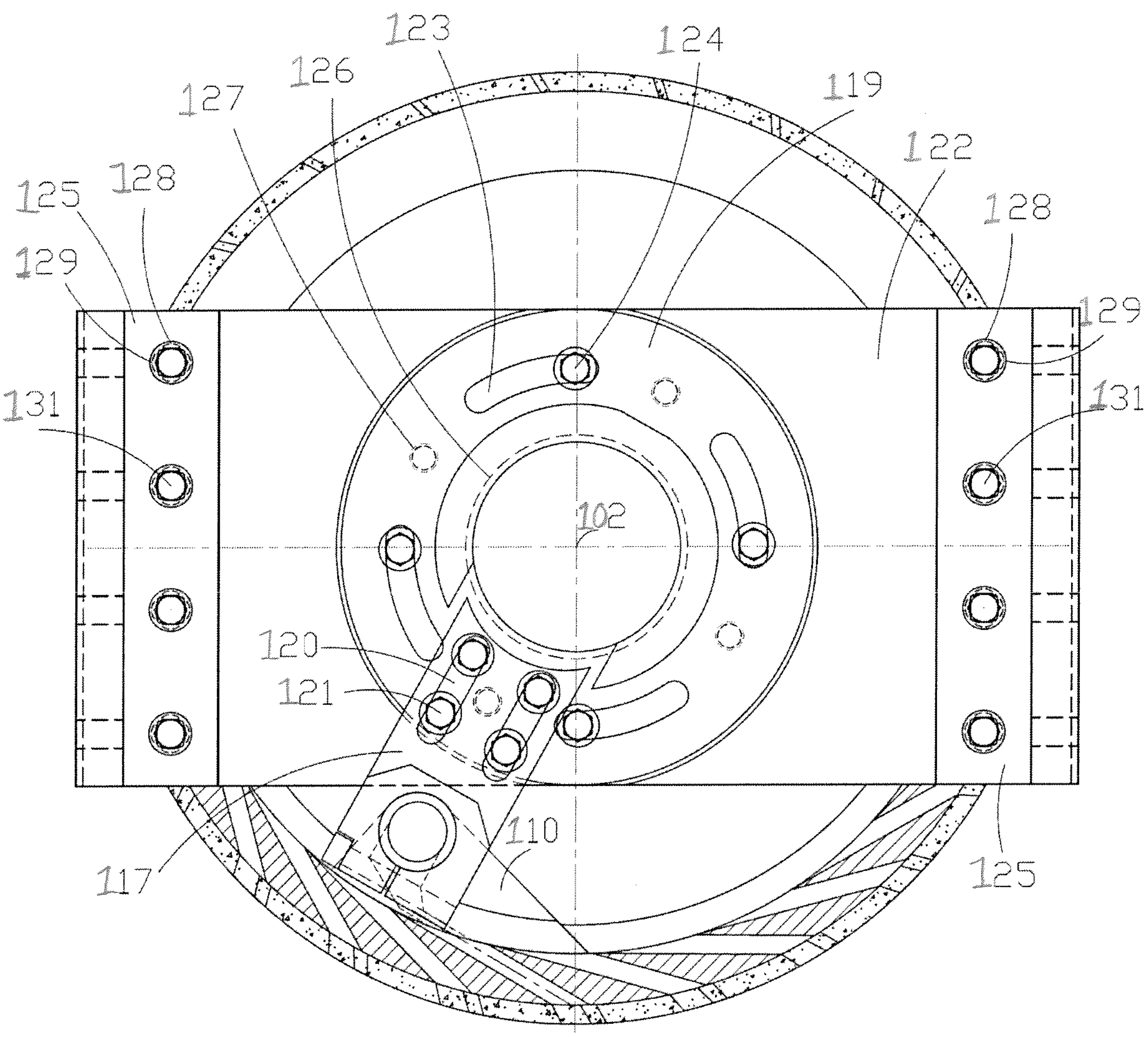
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Fig. 12

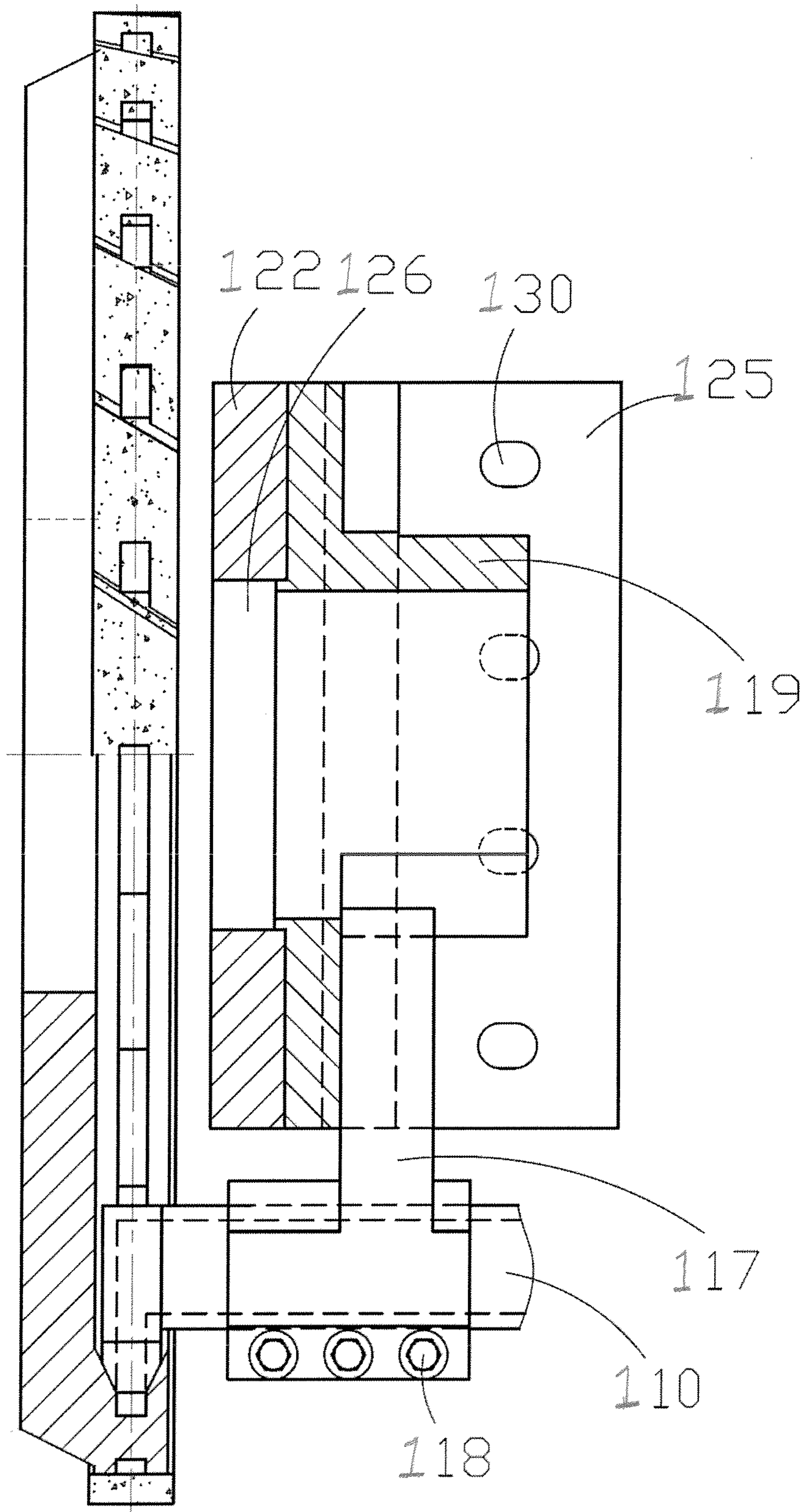

Fig. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2007/050245

A. CLASSIFICATION OF SUBJECT MATTER
INV. B24D5/10 B24D7/10 B23C5/08 B23C5/28 B23Q1/00
B23Q11/10

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)
B24D B24B B23C B23Q

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 483 561 A1 (EATON CORP [US] DANA CORP [US]) 6 May 1992 (1992-05-06) column 5, line 20 - column 6, line 3; figures 3,5	1,6,7
A	DE 34 15 498 A1 (WERKZEUGMASCH OKT VEB [DD]) 29 November 1984 (1984-11-29) abstract; figures	1
A	WO 02/058886 A1 (MAKINO INC [US]) 1 August 2002 (2002-08-01) page 10, lines 9-12; figure 1	1
A	WO 94/09937 A (GLEASON WORKS [US]) 11 May 1994 (1994-05-11) abstract; figures	1
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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
15 August 2007	23/08/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Garella, Mario

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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 4 351 486 A (SCHMOELLER KARL-HEINZ ET AL) 28 September 1982 (1982-09-28) column 6, lines 10-27 -----	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2007/050245

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