

[54] APPARATUS FOR APPLYING SOLID LUBRICANT TO THE MATERIAL WORKING FACE OF A TOOL

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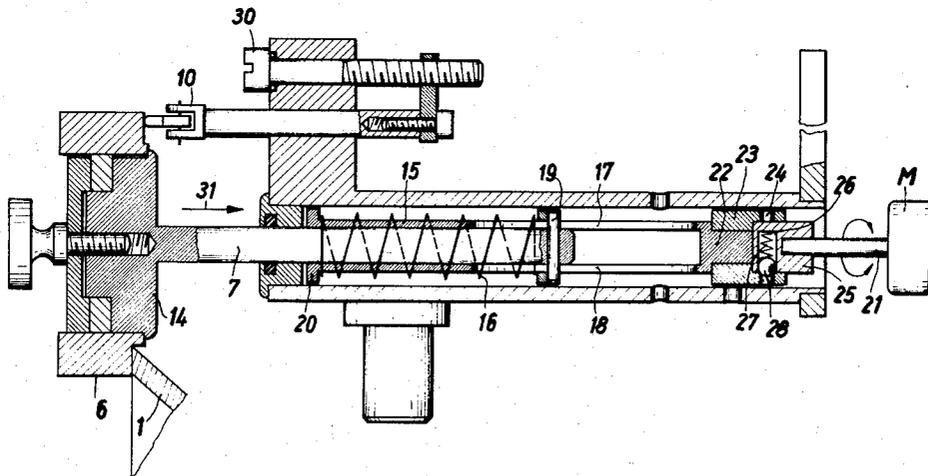
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[57] ABSTRACT

A rotary tool has a material-removing face and is rotated at a first speed about a first axis. A body of solid lubricant is located axially adjacent the material-removal face and is rotated about the second axis at a slower second speed. An advancing arrangement advances the rotated body of solid lubricant longitudinally of the first axis against the material-removal face of the tool.

19 Claims, 7 Drawing Figures



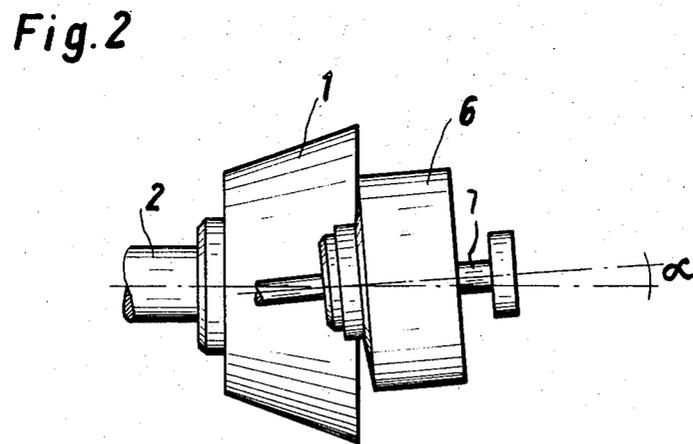
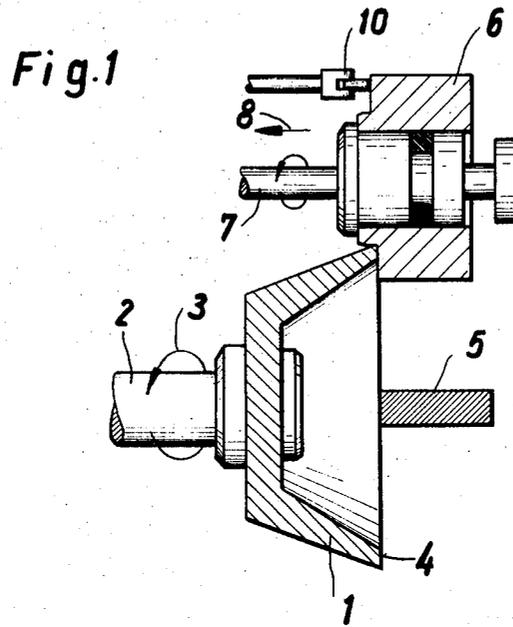


Fig. 3

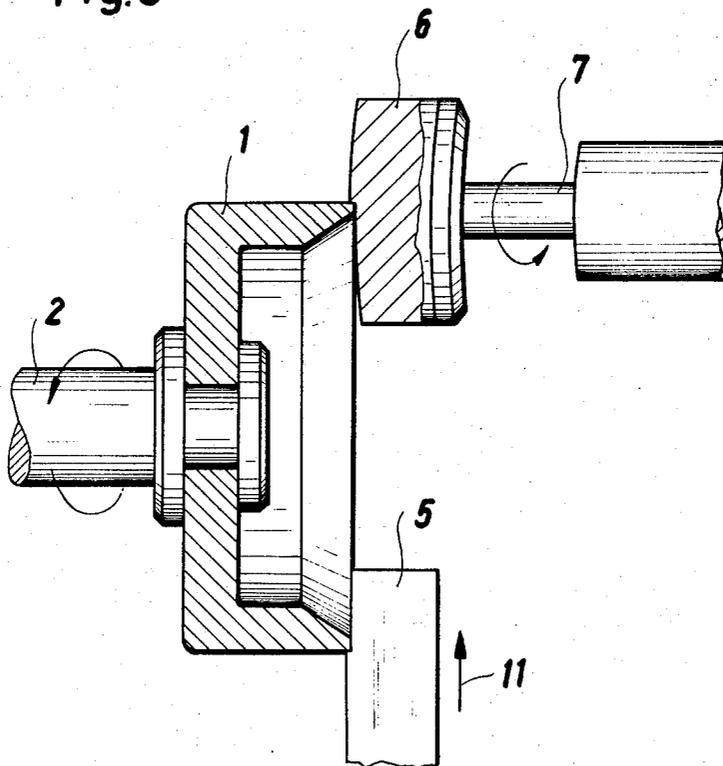


Fig. 4

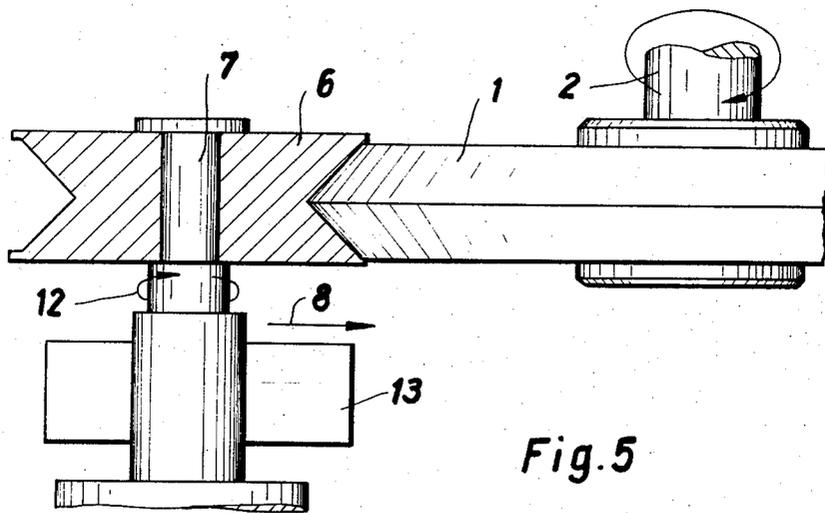
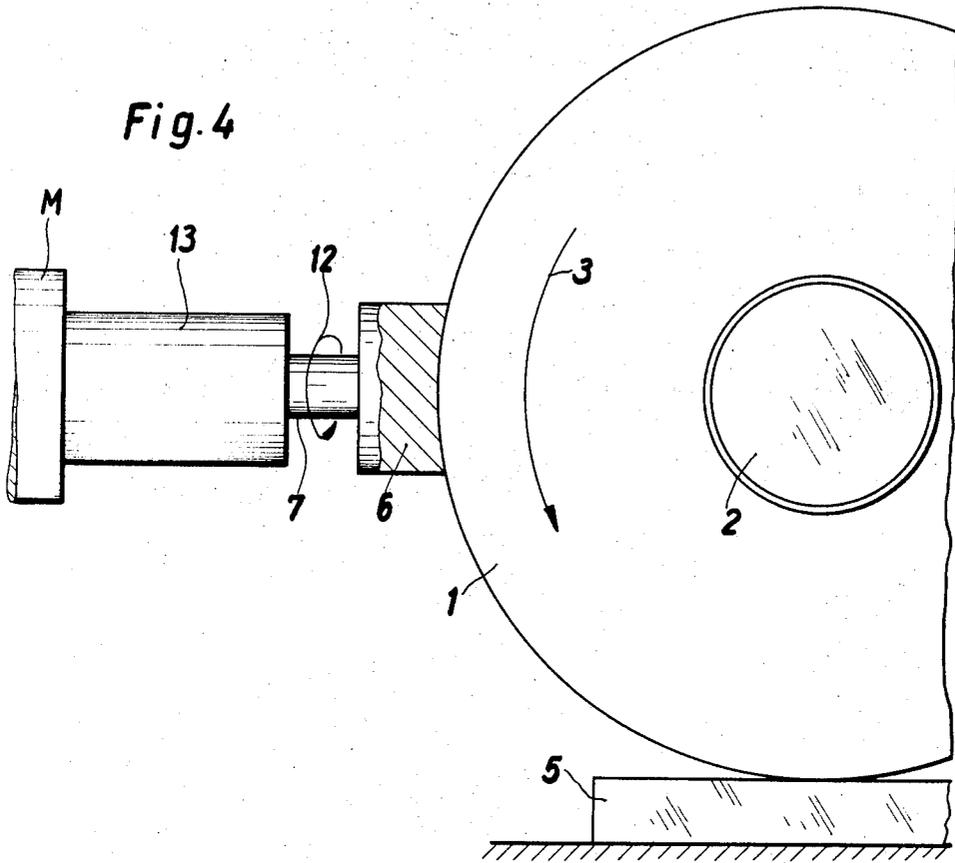


Fig. 5

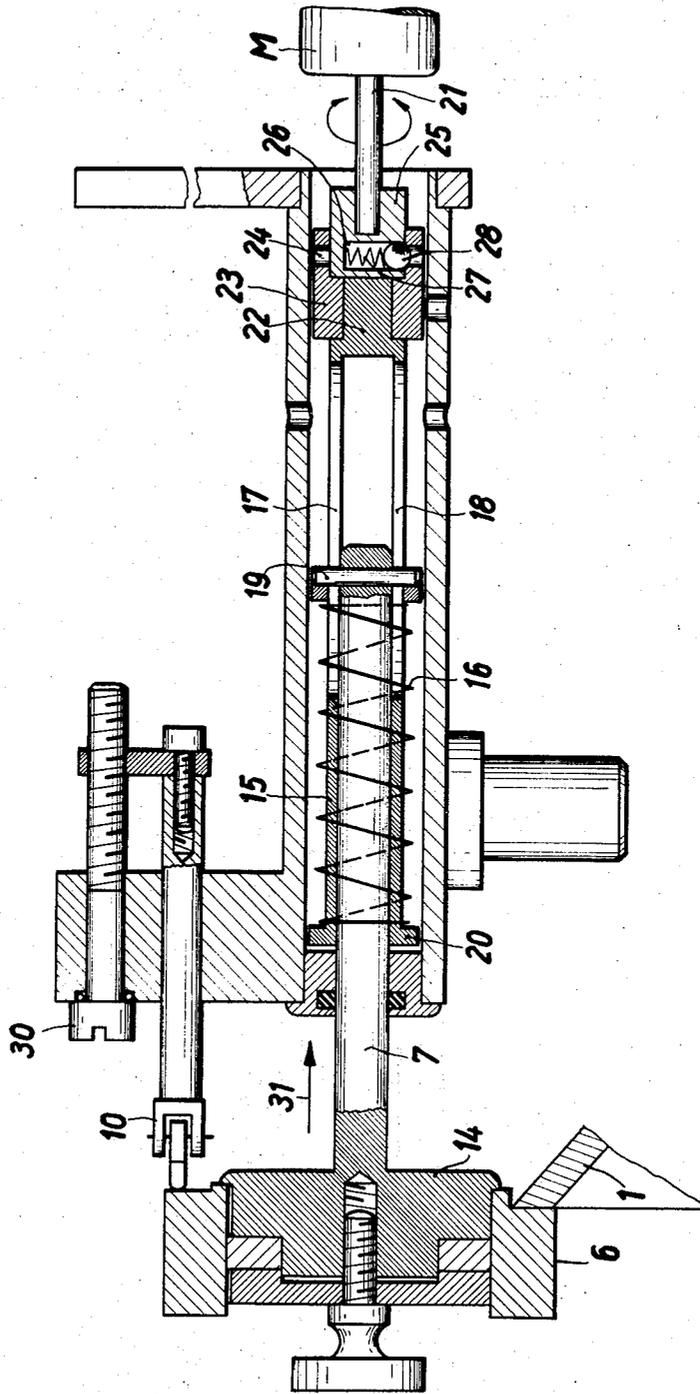
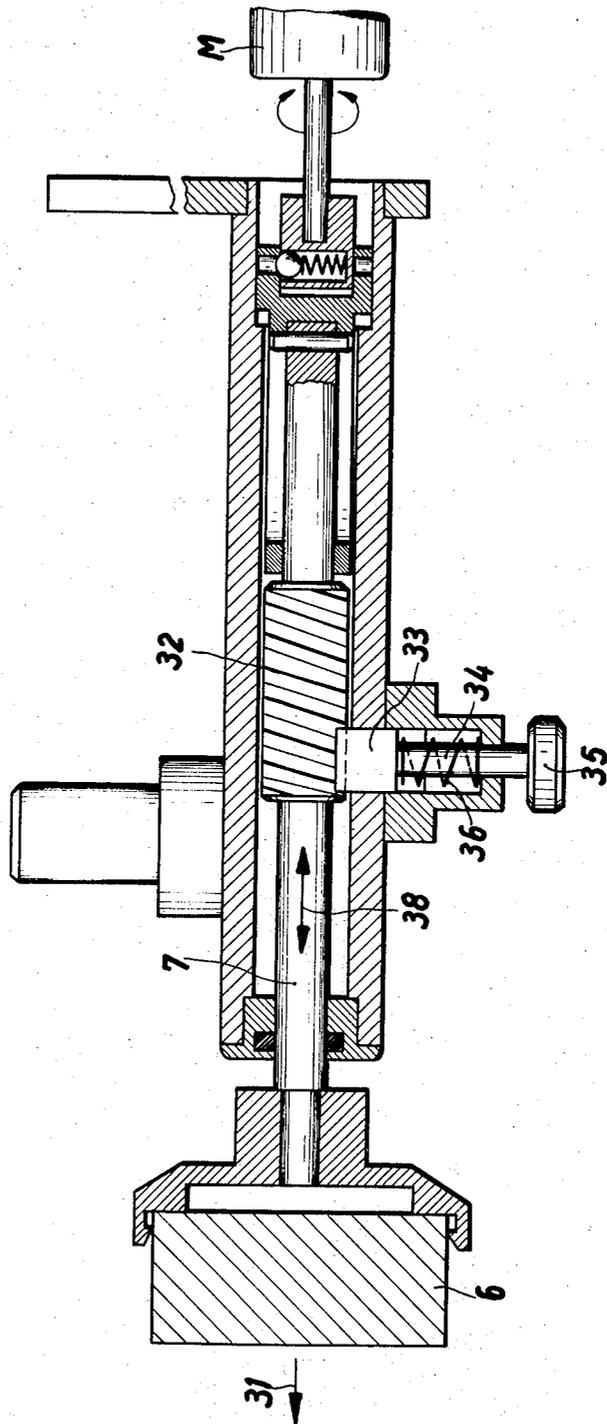


Fig. 6



APPARATUS FOR APPLYING SOLID LUBRICANT TO THE MATERIAL WORKING FACE OF A TOOL

BACKGROUND OF THE INVENTION

The present invention relates generally to an apparatus for removing material from a workpiece, and more particularly to such an apparatus which includes an arrangement for the dry lubrication of the material-removal tool of the apparatus.

It is already known to provide in such arrangements, which utilize a dry or solid lubricant in a rigid or very slightly plastic consistency. The lubricant is brought into contact with the material-removal face of the tool, and as a response of relative movement between the rotating tool and the body of solid lubricant some of the lubricant is rubbed off onto the material-removal face of the tool and will temporarily adhere to this face. This purpose is, of course, the same as in the use of liquid lubricants, namely to reduce the frictional forces and the frictional heat which develop between the material-removal tool and the workpiece upon which the tool acts. This results in a decrease of the forces which act upon the tool and a higher material-removal rate can be obtained.

Such considerations are applicable not only to grinding wheels or similar instrumentalities, but also for other rotating material-removal tools such as circular saws and milling tools whose material-removal faces or edges may be of hard metal, steel, abrasive particles and the like.

The solid lubricant bodies known from the prior art, whose composition incidentally depends upon the particular circumstances involved, that is upon the material of the rotary tool to be lubricated and upon the type of workpiece on which the tool acts, are of rod-like configuration. They are rather difficult to handle and heretofore no equipment has become known which would make it possible to economically use them in such a manner as to provide for the precise metering of the transfer of lubricant from the body to the rotary tool. As a result, the teachings of the prior art with respect to the use of solid lubricants for lubricating rotary material-removing tools, has not found more than token acceptance in the industry. In part this is also due to the fact that in many instances the dimensions of such rod-shaped bodies of solid lubricant must be very large and bulky. This is true if the body of lubricant is made large enough so that it is not used up after a short period of time and must then be replaced, but can last in operation for a reasonable period of time without having to be replaced. In such circumstances the dimensions of the rod-shaped solid lubricant bodies are so cumbersome as to make their employment very difficult. Attempts to make the rod-shaped bodies last longer by making their diameters larger, rather than their length, have also not been successful because if they are made wider than the often narrow material-removal face of the rotary material-removal tool, and even wearing-away and utilization of the lubricant of the solid-lubricant body can be assured only if then the body has imparted to it a transverse reciprocatory movement. This, however, requires separate devices for producing such movement and controlling it, and is, therefore, expensive.

Yet, the use of such solid-lubricant bodies inherently promises advantages over the use of liquid lubricants,

except that such advantages heretofore could not be obtained in view of the disadvantages outlined above.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to overcome the aforementioned disadvantages of the prior art.

More particularly it is an object of the present invention to provide, in an apparatus for removing material from a workpiece, an arrangement which overcomes the disadvantages of the prior art.

A still more particularly object of the invention is to provide such an arrangement in which a body of solid lubricant can be employed for lubricating purposes, and in which the frequently rather expensive solid lubricant it can be precisely needed onto the tool.

Another object of the invention is to provide such an arrangement permitting the utilization of a body of solid lubricant of relatively large volume without, however, having to resort to imparting to the body reciprocatory or other movements to assure even wearing-away of the body.

In pursuance of these objects, and of others which will become apparent hereafter, one feature of the invention resides, in an apparatus for removing material from a workpiece, in a combination which, briefly stated, comprises a rotary tool having a material-removing face, and first rotating means for rotating this tool about a first axis and at a first speed. A body of solid lubricant is located axially adjacent the material-removing face of the tool and second rotating means is provided for rotating the body about a second axis and at a slower second speed. Advancing means effects advancement of the first axis against rotary body of solid lubricant longitudinally of the first axis against the material-removing face of the tool.

With this construction, and particularly if a gear drive motor is utilized for driving the body of solid lubricant, it is possible to precisely control the speed and amount at which solid lubricant is transferred to the rotary tool, and such speed can be varied in steps or continuously.

The drive of the body of solid lubricant can be effected intermittently, that is if it can be interrupted if and when the drive is not required. For instance, interruption can be programmed to take place automatically during times during which the rotary tool is not in engagement with a workpiece. This avoids an unnecessary development of dust and an unnecessary wearing-away of the lubricant, increasing the economy of utilization of solid lubricants substantially. This is especially important if the lubricant substance or substances of a body of solid lubricant are constituted on one of the more expensive types of materials, such as hexagonal boron nitride or molybdenum disulfide.

The invention makes possible, as already pointed out earlier, the use of solid lubricant bodies of relatively large volume. The reason for this is that in an arrangement according to the present invention the solid lubricant body can be configured as a disk or as an annulus of relatively large diameter. This means that the amount of lubricant available in a central body is rather large, so that when such body has been first put in use it can last for a significant period of time, making it unnecessary to interrupt any operation of the rotary tool for the frequent replacement of the body of solid lubricant.

cant. Moreover, such bodies of solid lubricant can be used for lubricating even rotary tools having a narrow material-removal face, achieving an even wearing-away of the lubricant without having to effect transverse movement of the body of solid lubricant relative to the material-removal face.

The drive of the body of solid lubricant can be effected via a small gear motor, and generally speaking a small electro motor will be sufficient. However, it is possible to use pneumatic or hydraulic drives, or to provide a mechanical transmission of motor power from the drive there employed for rotating the rotary tool itself.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary diagrammatic sectional illustration of one embodiment of the invention;

FIG. 2 is a top-plan view of FIG. 1;

FIG. 3 is a view similar to FIG. 1 but illustrating a further embodiment of the invention on an enlarged scale;

FIG. 4 is a partly sectioned front-elevational view of another embodiment of the invention;

FIG. 5 is a partly sectioned top view illustrating a further embodiment of the invention;

FIG. 6 is a sectioned view illustrating still another embodiment; and

FIG. 7 is a view similar to FIG. 6 illustrating yet a further embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Discussing firstly the embodiment illustrated in FIGS. 1 and 2, which the basic concept of the present invention will become obvious, it is pointed out that here reference numeral 1 identifies a substantially cup-shaped rotary material-removing tool. This tool is not novel per se and tools of this type are used in apparatus for removing material from a workpiece. The tool 1 is mounted on the driven shaft 2, which for purposes of the present discussion will be considered the rotating or drive means for the tool 1. Evidently, the shaft 2 must itself be rotated which can be accomplished in any known manner requiring no detailed discussion. The shaft 2 is rotated in the direction of the curved arrow 3 and the annular material-removal face 4 at the right-hand axial end (in FIG. 1 and FIG. 2) of the tool 1 is brought into engagement with the workpiece 5 from which material is to be removed. The workpiece 5 is usually advanced into contact with the face 4, but this also is of no consequence for the purposes of the present invention.

In accordance with the invention there is, however, provided a body 6 of solid lubricant, here of annular configuration. The body 6 is mounted on a shaft 7 which for purposes of the present discussion is also to be considered the rotating means for rotating the body 6 of the solid lubricant. The shaft 7 rotates in the direction of the curved arrow associated with it, and is addi-

tionally during such rotation advanced in the direction of the arrow 8 (see FIG. 1) so as to contact the face 4. Thus, there is constant engagement between the body 6 of solid lubricant and the face 4. The body 6 may be at least in part of molybdenum disulfide, hexagonal boron nitride or graphitic material, or combinations of these materials.

The means for effecting the advancement in the direction of the arrow 8 will be discussed later, but it should be understood that they may for instance be of the type designated with reference numeral 13 in FIG. 4.

In the illustrated embodiment of FIGS. 1 and 2 the longitudinal axis of the shafts 2 and 7 are inclined with reference to one another, forming an angle of divergence α which is shown in FIG. 2. This angle is small and the inclination has been found to be advantageous if the removing of material from the workpiece 5 takes place while the workpiece is moved to and fro with reference to the tool 1, because in this type of material removing operation there is a relatively high transmission of forces to the face 4 which must therefore be well and predominantly lubricated. This is possible when the axes are inclined relative to one another at the angle α as illustrated.

Located above the shaft 7 (as seen with reference to FIG. 1) and engaging the reverse side of the lubricant body 6, that is the axial side which faces in the direction of advancement indicated by the arrow 8, is a contact arm 10 having the illustrated roller and engaging the adjacent axial end of the lubricant body 6. The location where the arm 10 or the roller thereof engages the body 6 is located behind the general plane of the contact face 4, that is to the left of that general plane, with the term "behind" referring to the fact that the location is beyond the general plane as the material-removal face 4 as seen in the direction of the arrow 8. This assures a removal of lubricant from the solid lubricant body 6 in spiral streaks.

In the embodiment of FIGS. 1 and 2 it is assumed that the tool 1 may be rotated at approximately 4000 rpm. In such a case the rotation of the body 6 can be effected at only approximately 12 rotations per hour. Quite evidently, there is a very significant speed differential between the tool 1 and the body 6, and by appropriately selecting the pressure with which the body 6 engages the face 4, due to the advancement of the body 6 in the direction of the arrow 8, a uniform and precisely determinable transmission of lubricant to the face 4 can be obtained. In this connection it is also necessary to keep in mind the differential size relationships of the lubricant body 6 on the one hand, which may have an outer diameter of approximately 60 millimeters and an inner diameter of approximately 40 millimeters in the embodiment of FIGS. 1 and 2, and of the tool 1 on the other hand which may and does have a substantially larger diameter. In an embodiment such as illustrated in FIGS. 1 and 2, with the above-assumed size and speed relationships, it will take more than 3 hours before the lubricant body 6 is completely used up, assuming that an appropriate lubricant is chosen. This means that for such a period of time the apparatus can operate without interruption, that is without having to stop the operation and replace the used-up lubricant body with a new one.

In the embodiment of FIG. 3 which is particularly well suited for applications in which recesses are to be

formed by the material-removal tool in the workpiece 5, it is advantageous if the lubricant body 6 with its shaft 7 does not extend entirely in parallelism with the shaft 2 of the tool 1. In other words, here also the rear or right-hand axial end of the lubricant body 6 will be inclined somewhat with reference to the shaft 2, but in this embodiment it will be found outwardly of the plane of the Figure by a small amount. This assures that the major portion of lubricant which is wrapped off the body 6 will become deposited at the outer annular edge of the material-removal face of the tool 1, but is the edge which is subjected to particular stresses in this type of material removal where the workpiece 5 is advanced relative to the material-removal face of the tool 1 in the direction of the arrow 11.

Coming to the embodiment in FIG. 4 it will be seen that here again like reference numerals designate like components as in the preceding embodiments. Reference numeral 1 identifies a material-removal tool which, however, is here illustrated as a disk rotating in the direction of the arrow 3. Adjacent the periphery of the disk which periphery here has the material-removing face, there is again located a body 6 of solid lubricant. It is mounted on the shaft 7 which rotates in direction of the arrow 12. Reference character M designates diagrammatically a drive motor for the shaft 12 and reference numeral 13 identifies an advancing device which is capable of advancing the shaft 7 and the body 6 axially of itself, that is into engagement with the material-removing face of the tool 1. The device 13 may be provided with a threaded guidance arrangement which will be described subsequently and which provides the desired advancement towards the tool 1.

In FIG. 5 we have illustrated an embodiment in which the body 6 of solid lubricant is again advanced in the direction of the arrow 8 towards the circumferential edge face of the tool 1, in direction normal to the elongation of the shaft 2 and with the shaft 7 extending in parallelism with the shaft 2. This arrangement is particularly suitable for lubricating disk-shaped tools having a profiled circumferential edge face as shown in FIG. 5.

FIGS. 6 and 7 finally, illustrate two embodiments which are exemplary of arrangements for advancing the body 6 into engagement with the material-removing face of the tool.

Discussing firstly FIG. 6 it will be seen that the body 6 is mounted on the shaft 7 as before. The mounting is effected via an intermediary, via the carrier 14 which may be of one piece with or separate from the shaft 7, and the latter case being suitably situated thereto. A tube 15 is provided into which the shaft 7 extends and in which the shaft 7 is axially displaceable (in telescope fashion) against the biasing action of a helical spring 16. The rear-end portion (the end portion remote from the body 6) is provided with two grooves 17 and 18 for which a transverse pin 19 extends, which also passes through an appropriate passage provided in the turning end portion of the shaft 7. The helical spring 19 surrounds the shaft 7 in part and engages with one of its ends the end portions of the pin 19 which extend outwardly beyond the shaft, whereas the other end of the spring abuts a collar 20 at the front or left-end of the tube 15.

In order to protect the motor M which is again diagrammatically illustrated, there is provided a slip cou-

pling between it (or rather the shaft 21 of the motor) and the body 6. This is in form of a sleeve 23 which is connected with an end portion 22 of the tube 15 and is provided with radial bores or passages 24. A member 25 is accommodated in the sleeve 23, being fixedly connected with the output shaft 21 of the motor M, and being provided with a bore 26 in which there is located a spherical member 28 which is being urged outwardly of the bore by the pressure of a spring 27. Normally, that is when a small torque is to be transmitted, the spherical element 28 extends in part into a bore 24, thus coupling the elements 15 and 21 for joint rotation. However, if a torque is exceeded whose magnitude is defined by the resistance of the spring 27 to axial compression, then the circle element 28 will be inwardly displaced out of the bore 24 and the shaft 7 will be uncoupled from the shaft 21.

In the manner already discussed with respect to FIGS. 1 and 2, there is provided a contact arm 10 engaging the body 6. A screw 30 or similar means is provided which permits axial displacement and adjustment of the contact arm 10, in order to permit the position of the latter to be adjusted so that it will engage the body 6 behind and to one side of the general plane of the contact face of the tool, in order to assure that the removal of solid lubricant from the body 6 will take place in spiral tracks. During this removal, which is governed by the relative speed of the body 6 and the tool 1, there will be a constant displacement of the body 6 under the influence of the pressure of spring 16, in the direction of the arrow 31 and towards and of course in contact with the material-removing surface of the tool 1.

The embodiment in FIG. 7, finally, shows an arrangement capable of affording the same operations as in FIG. 6, but being structurally somewhat different. Here, the body 6 is again identified with the same reference numeral as before, but is of disk-shaped configuration, being required to advance in direction of the arrow 31 against the contact face of the non-illustrated tool. In this embodiment the arm 10 has been omitted.

A spindle 32 is provided on the shaft 7, having threads which mesh with the threads of a threaded body 33 which in turn is connected towards a pull rod 34 having a knob or handle 35. When a pull is exerted upon the knob 35 in outward direction, that is downwardly in FIG. 7, the member 33 can be displaced against the pressure of the helical spring 36 in direction transversely to the longitudinal axis of the shaft 7. In so doing it becomes disengaged from the spindle 32, permitting a partial displacement of the shaft 7 in the direction of the double-headed arrow 38, depending upon which direction is required, with such displacement being effected manually. When the desired position has been set for the shaft 7, the pull upon the knob 35 is released and the member 33 is returned into engagement with the spindle 32 by the spring 36. If now the diagrammatically illustrated motor M is energized, a continuous slow advancement of the shaft 7 and thereby the body 6 takes place in the direction of the arrow 31, as a result of the engagement of the screw threads of the elements 32 and 33. The sliding coupling illustrated in FIG. 7 has not been given reference numerals because it is identical in all respects with that which has been described with reference to FIG. 6.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in an apparatus for removing material from a workpiece, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In an apparatus for removing material from a workpiece, a combination comprising first rotating means rotatable about a first axis and at a first speed; a rotary tool rotatable by said first rotating means about said first axis and having a material-removing face extending transversely to said first axis; a body of solid lubricant adjacent said material-removing face and adapted to wear away in response to contact with said face; second rotating means for rotating said body of solid lubricant about a second axis and at a slower second speed; and urging means for urging the rotating body of solid lubricant longitudinally of said first axis against said material-removing face of said tool.

2. A combination as defined in claim 1, wherein said second axis extends in parallelism with said first axis.

3. A combination as defined in claim 1, wherein said second axis is slightly inclined with reference to said first axis.

4. A combination as defined in claim 1, wherein said second axis extends transversely to said first axis.

5. A combination as defined in claim 1, wherein said second axis extends normal to said first axis.

6. A combination as defined in claim 1, wherein said second axis is slightly inclined with reference to a plane

intersecting said first axis in direction normal thereto.

7. A combination as defined in claim 1, wherein said body is of disk-shaped configuration.

8. A combination as defined in claim 1, wherein said body is of annular configuration.

9. A combination as defined in claim 1; and further comprising drive means for effecting intermittent rotation of said body.

10. A combination as defined in claim 1, said second rotating means comprising a motor and a gear drive associated with said motor.

11. A combination as defined in claim 1, said body having two axial ends; and further comprising a contact arm engaging one of said ends of said body.

12. A combination as defined in claim 11, said material-removing face having a general plane; and wherein said contact arm engages said one end of said body at a side of said general plane which is spaced from said material-removing face in the direction of advancement of said body.

13. A combination as defined in claim 1, said urging means comprising biasing means maintaining said body in biased contact with said material-removing face.

14. A combination as defined in claim 13, wherein said biasing means comprises a biasing spring.

15. A combination as defined in claim 1, said second rotating means comprising a motion-transmitting drive train; and further comprising clutch means interposed in said drive train.

16. A combination as defined in claim 1, said second rotating means comprising a drive shaft, and threaded guide means for said drive shaft.

17. A combination as defined in claim 1, wherein said body is at least in part composed of graphitic material.

18. A combination as defined in claim 1, wherein said body is at least in part composed of molybdenum disulfide.

19. A combination as defined in claim 1, wherein said body is at least in part composed of hexagonal boron nitride.

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