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(71) Applicant: **Ideko, S. Coop**
20870 Elgoibar Guipuzcoa (ES)

(72) Inventors:
- **Alberdi Lorenzo, Raúl**
  20015 Donostia (Guipuzcoa) (ES)
- **Lizarralde Dorronsoro, Rafael**
  20560 Oñati (Guipuzcoa) (ES)

(74) Representative: **Cabinet Plasseraud**
52, rue de la Victoire
75440 Paris Cedex 09 (FR)

(54) Cooling-lubricating method for grinding

(57) The invention relates to a cooling-lubricating method for grinding, which consists of projecting the cutting fluid (2) and a supplementary fluid (4) at a very low temperature against the grinding wheel (1), such that both fluids (2 and 4) penetrate into the grinding wheel (1), the supplementary fluid (4) acting on the cutting fluid (2), modifying the properties of the latter, which cutting fluid, upon reaching the area of contact between the grinding wheel (1) and the workpiece (6) being ground, again recovers the original properties due to the temperature increase occurring in said area.

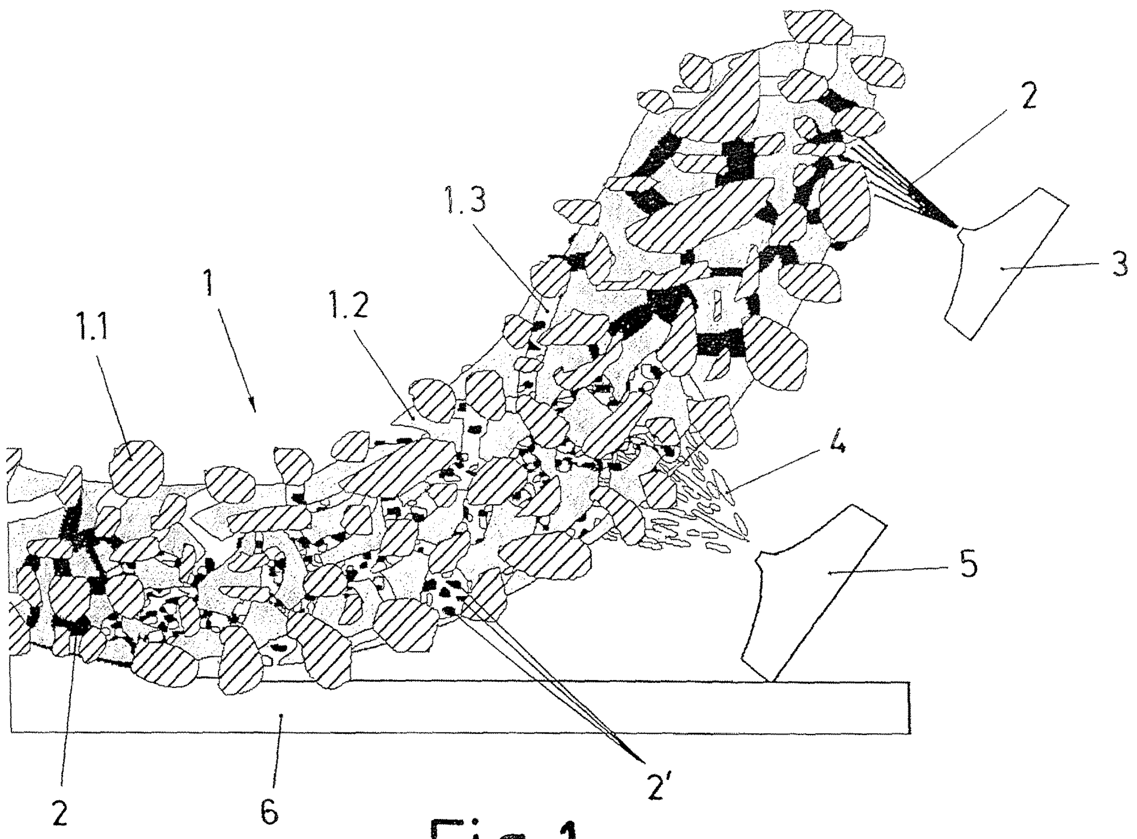

Fig.1

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Description

Field of the Art

[0001] The present invention relates to providing a liquid coolant in machining processes, proposing a method, by means of the combined projection of a cutting fluid and a supplementary fluid at a very low temperature, which allows advantageously improving the cooling-lubricating conditions in grinding processes.

State of the Art

[0002] In machining processes, cooling carries out several functions, including that of scaling down the generation of heat and that of reducing friction, absorbing and eliminating heat from the cutting area.

[0003] The liquid coolant commonly used in grinding has two functions: that of lubricating the area of contact between the grinding wheel and the workpiece, preventing heat from being generated in the process and the temperature from increasing, and that of cooling, removing heat, the generation of which could not be prevented when lubricating.

[0004] The aforementioned liquid coolants also have a function of carrying away the chips generated during the working process. These liquids are identified by means of the general name of cutting fluids. The most common cutting fluids are pure oils and water-oil mixtures, also referred to as cutting oils. Cutting oils are currently the most commonly used method although this trend may change with the growth of the use of organic oils.

[0005] The cutting oil improves the conditions of the area of contact, prolonging the life of the tools and reducing the friction force. It furthermore cools to prevent overheating of the workpieces to be machined and of the tools, removing the filings and chips.

[0006] The cutting fluid must be clean enough so that the process can be carried out and so that the machine does not deteriorate. To that end, special filtration equipment is used to achieve that the cutting oil is in the proper condition. The filtration equipment operates continuously during the working process and can be of many types: by decanting, paper filter, drum filter, cartridges, diatomaceous earth, magnetic filters, etc. This equipment is expensive and takes up a very high percentage of the surface area of the machine, ranging from 15% to 120% according to the applications and depending on the flow rate that must be filtered.

[0007] However, despite these filtrations, over time the properties of the cutting fluids are lost. In the specific case of cutting oils, in addition to losing their properties, a series of contaminants arise which further reduce the properties of such cutting oils. These contaminants notably include the external oils coming from leaks in the hydraulic and greasing circuits, lubricants, solid metal particles, microorganisms, cleaning cloth remains, environmental dust, etc.

[0008] This loss of properties at a given time requires considering the cutting oil being used to be depleted and must then be discarded.

[0009] However, the composition of cutting oils is based on products such as lubricants, defoamers, corrosion inhibitors, dyes, stabilizers, coolants, wetting agents, additives, emulsifiers, etc. All these products, in combination with the aforementioned external contaminating agents, make these cutting oils highly contaminating wastes for both the environment and the operators who handle them once they are depleted.

[0010] Depleted cutting oils are considered a hazardous waste by European and Spanish laws and must be eliminated through authorized waste service managers so that they can transport such waste to decontamination or elimination points.

[0011] To that end dry machining solutions or systems for reducing the consumption of these cutting fluids, known as MQL (Minimum Quantity Lubricant), have been studied.

[0012] The success of dry machining or machining with a small amount of cutting fluid depends on finding alternatives to the functions that these cutting fluids carry out.

[0013] With respect to machining processes with tools with a defined cutting edge, in works such as turning and milling, dry machining and MQL is possible due to the fact that they are cutting processes, the length of contact between the workpiece and the tool is very small, they are open and accessible operations and the removal of chips does not present tremendous difficulties. There are even cases in which dry milling certain materials at a high speed achieves better surface finishes than milling with cutting fluids in the same conditions.

[0014] In contrast, drilling, reaming and tapping present more drawbacks for being performed in dry conditions since they are not operations that are as accessible as the aforementioned operations and problems with the proper removal of chips and with heating arise.

[0015] The tests performed until now have been on a laboratory scale in order to better know the mechanisms acting in this type of machining. Due to these problems, no industrial application which performs dry drilling, reaming or tapping is known today. Nevertheless, R&D projects have been successfully developed for the application of MQL in these processes.

[0016] In grinding, there are very few solutions for an industrial application for performing dry grinding, not even for MQL applications so therefore the most highly contaminating process in manufacturing shops is usually grinding.

[0017] The existing applications are for pulling off very small pieces of material, with very small lengths of contact, similar to those in cutting processes.

[0018] In grinding, it is common for the length of contact between the grinding wheel and the workpiece to be in a larger order of magnitude than in cutting processes.

[0019] Furthermore, and unlike cutting processes, in which the cutting fluid enters from the exterior, without penetrating into the tool, in grinding the cutting fluid must penetrate into the grinding wheel, through the pores, in order to access the entire length of contact.

[0020] Traditional MQL systems used in cutting processes are not useful for abrasion processes in general, and specifically for grinding, since they are not designed for the cutting fluid, projected from the exterior, to penetrate into the grinding wheel, through the pores of the latter, but rather to reach a cutting edge from the exterior.

[0021] Despite the contamination involved with grinding, it continues to be an essential machining process due to the precisions, surface finishes and the stress states that are obtained and which are highly unlikely to be attained by other machining processes such as milling or turning. In fact, grinding is especially suitable for machining hard materials, such as steels for tools or ceramic materials.

[0022] In the search for improvements from the ecological point of view, there is a line of work which seeks to replace grinding with other equivalent processes, however based on what has previously been stated, this is only possible on very limited occasions. Therefore, there are two lines of R&D: one of them consists of replacing grinding with other less contaminating cutting processes; the other one consists of performing a more environmentally friendly grinding.

[0023] This search for environmental friendliness is especially focused on reducing the consumption of the cutting fluids. An example of actual consumption is a flow rate of 750 l/min for grinding a blade with a grinding wheel 200 mm wide.

[0024] It is therefore a priority of manufacturers of grinders to reduce or eliminate cooling-lubricating, provided that the features and the cost of the ground workpieces do not change or change very little. The reasons are environmental, as is obvious, but also economic: less surface area of the machines if the large filtration equipment is eliminated, lower cost of cooling-lubricating, and lower energy consumption due to the savings of power since pressure pumps are not necessary to move the fluid.

[0025] To achieve a more environmentally friendly grinding, the following solutions are known:

.- The manufacture of grinding wheels with radial insertions. This solution proposes an intermittent grinding method, in which solid lubricant pellets are placed on radial grooves previously made in the grinding wheel. The lubricating materials used are graphite and/or CaF_2. In addition to the complexity of the manufacture of the grinding wheels, this solution provides lubricating but not cooling and good surface finishes of the workpiece to be machined are not obtained due to scratches caused by the graphite insertions.

.- Patent document PCT W02004/087376 discloses a solution using only liquid nitrogen as coolant and lubricant. This solution involves considerable risks for operators and handlers because they have to handle a liquefied gas at a low temperature, since the liquid nitrogen is at temperatures of -196° C.

[0026] Tests have also been performed with grinding wheels in which embedded in the general body of the grinding wheel there are solid lubricants which liquefy when reaching the high temperatures of the area of contact between the grinding wheel and the workpiece to be ground. This solution is not satisfactory either because cooling is not obtained; furthermore the grinding wheels are very complex and expensive to make, and the obtained finishes are not satisfactory.

[0027] Tests have also been performed to apply MQL to grinding. These tests include particularly the investigations of Dr. Zhang of the University of Sidney. The tests performed by Dr. Zhang consist of using two nozzles for cooling the process. One nozzle projects an oil spray, which is referred to as an MQL spray system and an industrial vortex tube. The cooling is very scarce due to the limited cooling capacity of the air coming out of the vortex and therefore the obtained results are not satisfactory enough for obtaining an industrial application.

[0028] Another important work developed in this field was carried out by the University of Rio de Janeiro. In this case, a system combining an oil spray with compressed air is also used, but unlike Zhang's work, the air is at ambient temperature and the air is mixed with the oil in the nozzle.

<u>Object of the Invention</u>

[0029] The present invention proposes a new cooling-lubricating method for grinding, according to which the corresponding cutting fluid is still projected against the grinding wheel so that it can penetrate into gaps and pores defined between the abrasive grains and the corresponding binder forming the grinding wheel. Now, according to the invention, in addition to projecting the cutting fluid, a supplementary gaseous or liquid fluid at a very low temperature is also projected, carrying out the following basic functions:

.- Causing a change of properties of the cutting fluid, making it switch from liquid to solid state or increasing its viscosity and therefore its capacity to adhere to the grains inside the grinding wheel. This change occurs when the cutting fluid has already penetrated inside the grinding wheel, being housed in the aforementioned pores and gaps defined between the grains and the corresponding binder

.- It is the vehicle which allows carrying the cutting fluid, once it has penetrated into the gaps and pores defined between the grains of the grinding wheel and the binder and has solidified or adhered to the grains, providing opposition to the centrifugal force which tends to take the cutting fluid towards the periphery of the grinding wheel.

[0030] In traditional solutions, even though the cutting fluid penetrated inside the grinding wheel due to the pressure with which it was projected, the rotation of the latter at high revolutions tended to take it out towards the periphery due to the centrifugal force before reaching the area of contact with the workpiece to be ground. This was very negative, since it was most suitable for all of the projected cutting fluid to reach said area of contact which is where it must carry out its functions. This means that the cutting fluid must be sent very close to the area of contact between the grinding wheel and the workpiece, this distance between grinding wheel, workpiece and nozzle being a critical parameter of the design of the process.

[0031] Now, with the proposed solution, when the properties of the cutting fluid change, even though the same centrifugal force exists, a large percentage of said solidified fluid remains inside the pores and gaps and does not go out towards the periphery of the grinding wheel.

[0032] The cutting fluid thus reaches the entire length of contact and upon reaching this area, due to the temperature increase which occurs, again changes state, (absorbing heat and therefore cooling) and liquefies, whereby the centrifugal force tends to take it towards the periphery of the grinding wheel (performing the lubricating function), but precisely in the area of contact which is where it must carry out its function.

[0033] This assures that virtually all the projected cutting fluid reaches the area of contact, which allows economizing the amount of projected cutting fluid since there are virtually no losses.

.- Furthermore, the supplementary fluid at a very low temperature carries out cooling functions since it is at a very low temperature and even solidified.

[0034] The following advantages, among others, are thus achieved by means of the application of the proposed method:

.- A saving in the consumption of cutting fluid.
.- A saving in the energy consumption, since it is not necessary to use water under pressure and the use of the corresponding force pump is avoided.
.- Taking up less space as the large filtration equipment is avoided.
.- Better conditions in the cooling-lubricating.

[0035] All these improvements distinguish the method object of the present invention from the solutions known until now and give it its own identity.

Description of the Drawings

[0036]

Figure 1 shows a sectioned part of a grinding wheel (1) which is being cooled-lubricated, according to the method object of the present invention, showing how the cutting fluid (2) penetrates inside the grinding wheel (1), in the gaps (1.3) of the latter and changes its properties due to the effect of a supplementary fluid (4) at a very low temperature, to be carried to the area of contact; such that upon reaching this area of contact, the temperature increase makes it recover its initial state, thus acting in said area of contact as coolant and lubricant.

Figure 2 shows an installation operating according to the method object of the present invention according to a possible non-limiting practical embodiment.

Detailed Description of the Invention

[0037] The object of the present invention is a cooling-lubricating method for grinding. Figure 1 schematically depicts a sectioned part of a grinding wheel (1) which is traditionally formed by the corresponding abrasive grains (1.1) and a binder (1.2). Pores and gaps, identified with reference number (1.3) and hereinafter identified as gaps (1.3), are defined between the abrasive grains (1.1) and the binder (1.2).

[0038] At least one nozzle (3) projecting a cutting fluid (2) in liquid state against the grinding wheel (1) is arranged at the suitable point and with the corresponding inclination. The cutting fluid (2) penetrates into the gaps (1.3) of the grinding wheel (1) .

[0039] Arranged next to the nozzle (3) there is at least a second nozzle (5) projecting a supplementary gaseous or liquid fluid (4) at a very low temperature, hereinafter identified as supplementary fluid (4).

[0040] When the supplementary fluid (4) comes into contact with the cutting fluid (2), it causes a change in the properties of the latter, making it switch from liquid to solid state, or increasing its viscosity enough so that the cutting fluid (2), now depicted in Figure 1 by the granules (2'), adheres to the abrasive grains (1.1) and to the binder (1.2). This change occurs when the cutting fluid (2) has already penetrated inside the grinding wheel (1), being housed in the gaps (1.3).

[0041] This adhesion provides opposition to the centrifugal force which, due to the rotation of the grinding wheel (1) at a high speed, tends to take the cutting fluid (2) towards the outside of the grinding wheel (1).

[0042] The supplementary fluid (4) is thus the vehicle which allows carrying the cutting fluid (2) housed in the gaps (1.3) from the area of penetration into the grinding wheel (1) until reaching the area of contact.

[0043] Upon reaching the area of contact between the grinding wheel (1) and the workpiece to be ground (6), the temperature increase that occurs entails a new change in the properties of the cutting fluid (2) which recovers its initial liquid state; such that now the adherence between the cutting fluid (2) and the abrasive grains (1.1) and the binder (1.2) is lost, there being no opposition to the centrifugal force which tends to take the cutting fluid (2) towards the periphery of the grinding wheel (1), which allows it to reach the entire area of contact between the grinding wheel (1) and the workpiece to be ground (6).

[0044] The supplementary fluid (4) can be a gas or a liquid. Tests have been performed in practice using a gas, specifically carbon dioxide, also called carbonic acid gas and carbonic anhydride (CO_2), with positive results, but this cannot be understood in a limiting sense since virtually any gas or liquid that can reach the cryogenic temperatures necessary for changing the properties of the cutting fluid (2) can be used as supplementary fluid (4).

[0045] Figure 2 schematically depicts a possible practical embodiment according to which nozzle (3) is connected to a tank (7) containing the cutting fluid (2) and nozzle (5) is connected to a carboy (8) containing a supplementary gas (4).

[0046] The fact that there is more than one nozzle (3) and/or more than one nozzle (5) does not change the essential nature of the invention at all; nor does the fact that the most suitable distance is left between them, even the fact that the nozzles (3 and 5) are part of one and the same unit.

[0047] In addition and during the grinding process the diameter of the grinding wheel (1) decreases due to the wear, the incorporation of conventional solutions, such as for example the activation of CNC axes to achieve that the relative position between the grinding wheel (1) and the nozzles (3 and 5) is kept invariable, having been provided.

Claims

1. A cooling-lubricating method for grinding, of the type carrying out cooling-lubricating by means of the use of a cutting fluid (2) which is projected against the grinding wheel (1), penetrating inside the latter, **characterized in that** in addition to the cutting fluid (2), a supplementary fluid (4) at a very low temperature is also projected against the grinding wheel (1), such supplementary fluid also penetrating inside the grinding wheel (1) acting on the cutting fluid (2) once the latter has penetrated inside the grinding wheel (1) and has been housed in the internal gaps (1.3) of the latter, the supplementary fluid (4) thus modifying the properties of said cutting fluid (2); **in that** the cutting fluid (2) maintains its modified properties until reaching the area of contact between the grinding wheel (1) and the workpiece (6) to be ground; and **in that** upon reaching the area of contact between the grinding wheel (1) and the workpiece (6) to be ground, the temperature increase generated causes a new modification in the properties of the cutting fluid (2), thus recovering the properties it had when it initially penetrated inside the grinding wheel (1).

2. The cooling-lubricating method for grinding according to the previous claim, **characterized in that** when the cutting fluid (2) penetrates into the grinding wheel (1) and is housed in the internal gaps (1.3) of the latter, it is in liquid state and when it comes into contact with the supplementary fluid (4) at a low temperature it changes its properties, switching to a solid state or a state with enough viscosity so as to adhere to the grains (1.1) and to the binder (1.2) of the grinding wheel (1), providing opposition to the centrifugal force generated by the rotation of the grinding wheel (1) itself.

3. The cooling-lubricating method for grinding according to claims 1 and 2, **characterized in that** once the properties of the cutting fluid (2) have been modified by the action of the supplementary fluid (4), such cutting fluid remains inside the grinding wheel (1), rotating with it, to travel the distance between the point of its projection against the grinding wheel (1) and the start of the area of contact between the grinding wheel (1) and the workpiece (6) to be ground.

4. The cooling-lubricating method for grinding according to claims 1, 2 and 3, **characterized in that** upon reaching the area of contact between the grinding wheel (1) and the workpiece (6) to be ground, the temperature in the grinding wheel (1) increases until reaching a value which returns the initial properties to the cutting fluid (2), this cutting fluid (2) again switching to its liquid state to be taken, by the centrifugal force, towards the periphery of the grinding wheel (1) thus acting in the aforementioned area of contact between the grinding wheel (1) and the workpiece (6) to be ground.

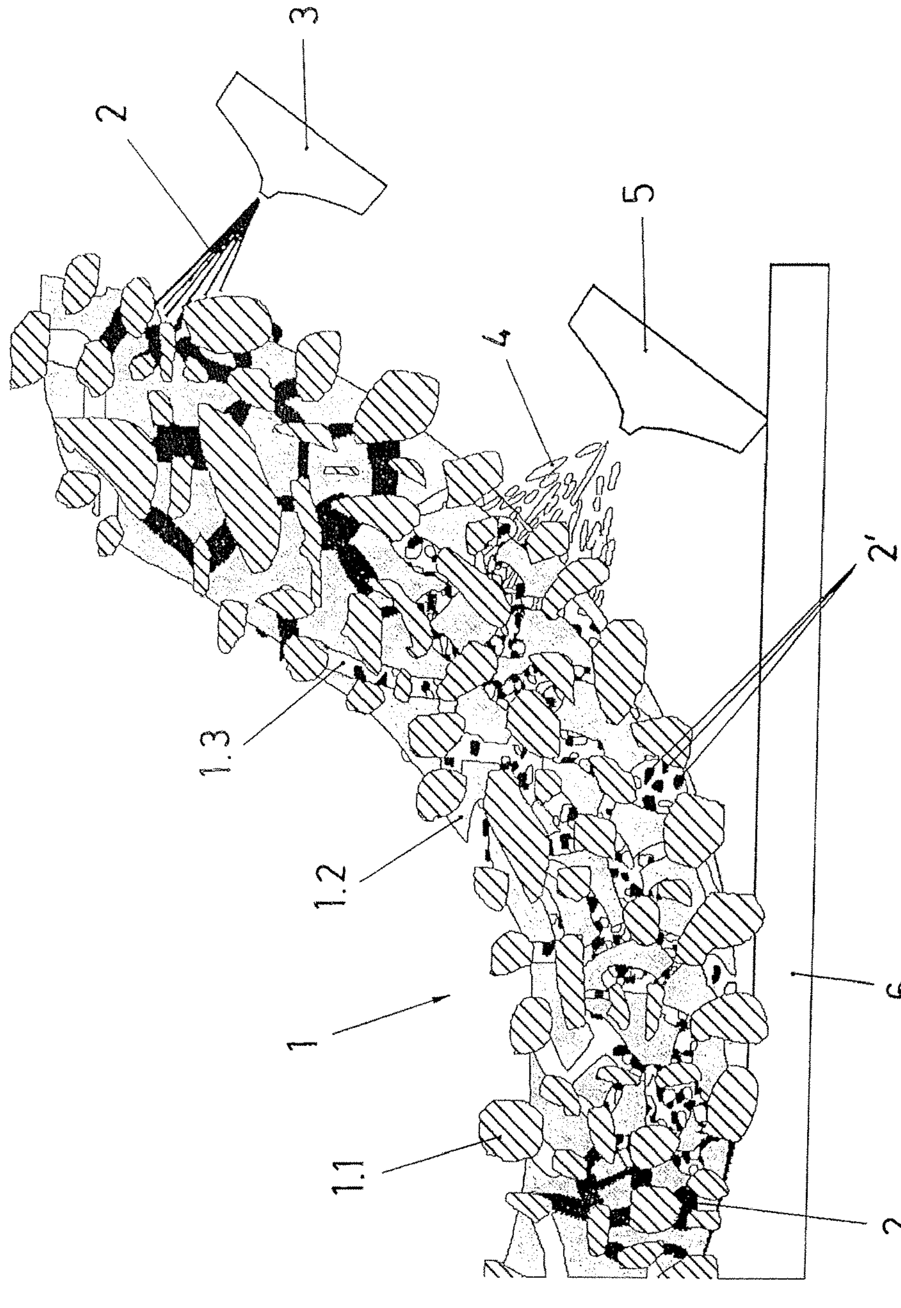

Fig.1

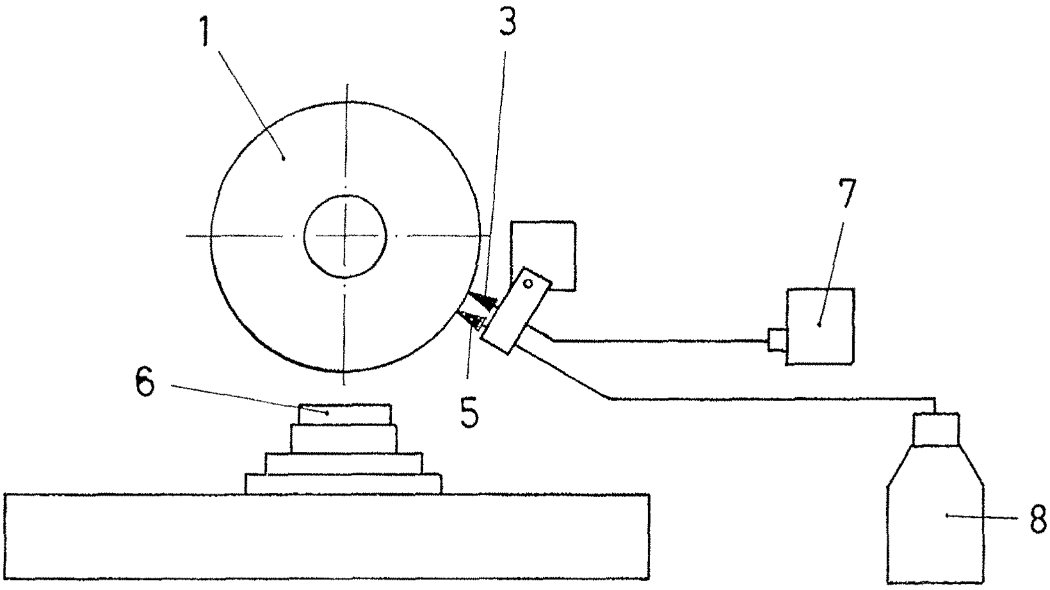

Fig. 2

EUROPEAN SEARCH REPORT

Application Number
EP 09 17 3983

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 6 083 084 A (YOKOGAWA KAZUHIKO [JP] ET AL) 4 July 2000 (2000-07-04) * column 14, line 40 - column 15, line 54; figures 4,6 * -----	1-4	INV. B24B55/02
A	US 2 914 892 A (EUGENE FOUQUET) 1 December 1959 (1959-12-01) * figure 1 * -----	1-4	
A	US 6 123 270 A (HARA MITSUGU [JP]) 26 September 2000 (2000-09-26) * the whole document * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

B24B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	3 May 2010	Koller, Stefan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 17 3983

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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