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(54) Apparatus and method for blasting metallic surfaces.

(57) The method of treating the surfaces of aluminium alloy cylinder bores (2) or other objects by blasting the surfaces with extremely high pressure water jets (7) at pressures of at least 173 MPa (25,000 psi) for preparing the surfaces of such bores or other objects for subsequent treatments such as coating with wear-resistant materials (40).

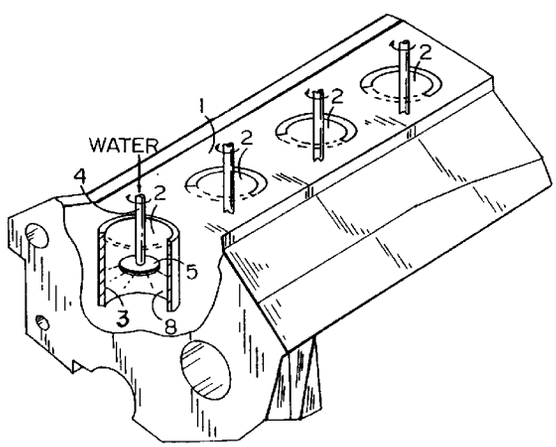

FIG. 1

EP 0 568 315 A1

This invention pertains to an apparatus and method for blasting the cylinder walls of aluminium engine blocks in preparation for the coating of the same with a wear-resistant coating material. It also broadly pertains to an apparatus and method for blasting other products for subsequent treatment.

In recent years, aluminium pistons and aluminium engine blocks have been used in automotive engines, but scuffing and wear due to the motion between the piston and the cylinder wall has created a problem. This problem and efforts made to solve it are described in US-A-5 080 056 which teaches a method of forming a scuff- and wear-resistant liner in a relatively low-silicon content aluminium alloy cast engine block. It discloses that engine block cast of a suitable low-silicon aluminium alloy, such as the aluminium 319 alloy, are easily cast into an engine block, and aluminium-bronze alloy compositions are applied by a thermal spray process onto the internal diameter of the cylinder bores of the aluminium casting. The patent discloses that before the thermal sprayed composition is applied to the cylinder bore it is thoroughly cleaned and degreased so as to be in suitable condition for the thermal sprayed coating to be adhered to the walls of the cylinder bore.

The owner of US-A-5 080 056 approached the present applicants requesting that an apparatus be developed for preparing the surface of the cylinder bore portion of the casting for application of the thermal sprayed coating material. The obvious method for preparing the surfaces was believed to be by dry or slurry blasting a grit such as small ground pieces of glass, aluminium oxide, silicon carbide, etc. that would roughen the surface of the cylindrical bore portion to which the coating could be more firmly attached and held. Use of blasting a grit creates the problem of ensuring that all of the grit is removed from the engine block in order to avoid the grit or abrasive contaminating parts of the engine. Further, the grit itself could probably lodge in crevices of the engine block or the cylinder bore surface itself. Thus, the use of grit or abrasives to roughen the surface requires subsequent cleaning of the entire area where the grit may be which is a time-consuming operation. Also, there is no assurance that all of the grit has been washed out completely. In fact, it is practically impossible to assure all the grit has been removed from the areas where it may be contained as a result of the blasting operation.

Another disadvantage of using grit or abrasive slurries is that the abrasive or grit can even contaminate the surface being treated and although in many instances the roughened surface is suitable to hold the coating, increased tenacity of the roughened surface is desired. In accordance with the preferred embodiments of our invention, these problems are eliminated in a more economical way than one skilled in the art would ever conceive.

According to one aspect of the present invention, apparatus for preparing the surfaces of the cylinder wall portions of an engine block for application of a wear-resistant coating comprises means for creating jets of water having pressures sufficiently high to clean and erode the surfaces of said cylinder wall portions to provide an irregular surface to increase the adhesive characteristics thereof; and means for directing said jets against said surfaces of said cylinder wall portions to clean and erode said surfaces to provide said irregular surfaces with increased adhesive characteristics.

According to another aspect of the present invention, a method of preparing the surfaces of cylindrical wall portions of an engine block for application of a wear-resistant coating comprises the steps of; creating jets of water having pressures sufficiently high to clean and erode the surfaces of said cylinder wall portions to provide an irregular surface to increase the adhesive characteristics thereof; and directing said jets against said surfaces of said cylinder wall portions to clean and erode said surfaces to provide said irregular surfaces with increased adhesive characteristics.

Thus, the surfaces are prepared using substantially pure water as the blasting media; by pure water is meant that there is no grit and essentially no other materials added to the water.

The pressures of the water jets preferably exceed 173 MPa and may be between 173 MPa and 414 MPa (25,000 and 60,000 pounds per square inch - psi) and preferably about 345 MPa (50,000 psi), particularly for the very best results in preparing aluminium 319 alloy for coating as described in US-A-5 080 056.

We have discovered that water jets will roughen the surface of the aluminium cylinder bore and clean them at the very same time. The water jets not only roughen the surface to increase the surface area to which the thermal sprayed composition can attach but, also, attack the pores of micro structure, that is the interstices of the metal, so as to form undercuts that provide superior adhesion for the coatings as compared to prior known methods. Thus, the processes of the invention clean the surface to eliminate leaving any pre-existing contaminated material on the surfaces, etch the surface to provide superior adhesion for the coating and leave no harmful residue of itself.

The invention may be carried into practice in various ways but two forms of apparatus and their method of operation, all in accordance with the present invention, will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a perspective cutaway, schematic view of a four cylinder aluminium cast engine block with the major part of the apparatus in the cylinders so as to illustrate the invention;

Fig. 2 is a perspective cutaway view of a cylinder

with the major part of the apparatus contained therein;

Fig. 3 is a perspective cutaway view of a cylinder illustrating the step of the coating being thermally sprayed on the inside surface of the cylinder, such surface having previously been prepared as illustrated in Figs. 2 and 3;

Figs. 4a, 4b and 4c illustrate the sequential condition of a metal surface treated in accordance with the invention and then coated; Fig. 4a showing the surface untreated; Fig. 4b showing the surface after being treated and Fig. 4c showing the coated surface;

Figs. 5 and 6 show another form of apparatus used for the treatment of a flat surface rather than a cylindrical surface; and

Fig. 7 shows an apparatus for moving either of the two rotating heads shown in Figs. 1, 2, 3 and 5.

Figs. 1 and 2 show a schematic representation of a cast aluminium engine 1 having four cylinder chambers 2, one of which is cutaway to disclose the cylinder walls 3. The engine block 1 is a casting of a suitable aluminium alloy such as the aluminium 319 alloy, which is well-known as an alloy that can be readily cast into complex configurations such as engine blocks. The aluminium 319 alloy is a low-silicon aluminium alloy having the composition and characteristics set forth in the Metals Handbook, 8th Edition, America Society of Metals. It not only contains by weight 90.2% aluminium, 6.3% silicone and 3.5% copper, but it is a malleable ductile metal having a surface hardness of Brinell 70-95. Although the 319 aluminium alloy is the only metal that we are familiar with as being easily cast into an engine block and which can be treated by our method and apparatus to produce the objects and advantages of our invention, it is believed that other malleable ductile metals can be treated by our method to produce the same objects and advantages. It is believed that the criteria necessary for our invention to properly treat the surface requires a metal that has a Brinell hardness of between about 50-100. These alloys include the zinc alloy AG40A which has a composition of 95.96% zinc, 4% aluminium and 0.04% magnesium and a Brinell hardness of 82; a copper-hardened rolled zinc having the composition of 99% zinc and 1% copper and a Brinell hardness of 60; a rolled zinc alloy having a composition of 98.99% zinc, 1% copper and 0.010% magnesium and a Brinell hardness of 80; a magnesium alloy AM100A having a composition of 89.9% magnesium, 10% aluminium and 0.1% manganese with a Brinell hardness of 52-69; a magnesium alloy AZ63A having a composition 90.8% magnesium, 6% aluminium, 3% zinc and 0.2% manganese with a Brinell hardness of 50-73; a magnesium alloy AZ92A having a composition of 88.9% magnesium, 9% aluminium, 2% zinc and 0.1% manganese and a Brinell hardness of 63-81; and the magnesium alloy AZ31B having a composition of 95.8% magnesium, 3% aluminium, 1% zinc and 0.2% manganese with a Brinell hardness of 49-73. The only composition that we have tested is the 319 aluminium alloy, although we believe the method and apparatus will properly treat the above-listed other alloys.

As briefly disclosed in Figs. 1 and 2, water is pumped at a high pressure through the rotating conduit 4 to the cylindrical head 5 which is rotating with the conduit 4. The head 5 has a plurality of orifices 6; a very small diameter preferably between .127 and .152 mm (.005 and .006 inch). The pressure of the water forced through the conduit 4 and out of the orifices 6 creates a number of water jets 7 that have a pressure at least as high as 173 MPa (twenty-five thousand pounds per square inch, 25,000 psi) and, as high as 414 MPa (60,000 psi), or higher. The preferred pressure of water jets 7 is about 345 MPa (fifty thousand pounds per square inch) 50,000 psi). As the conduit 4 and head rotates, they are moved upwardly and downwardly so that the water jets strike the surfaces 8 to be treated. In treating a 319 aluminium cylinder bore surface, we have found that the speed of rotation between 500-1500 rpm rotation with a traverse movement of the head at a rate of 127 mm (5.0 inches) per minute produces a satisfactory result if two passes are made; each pass being approximately 140 mm (5.5 inches). The ideal standoff distance, that is the distance from the edge of the head to the wall of the cylinder bore, was 12.7 to 25.4 mm (one-half to one inch). Obviously, variables in the standoff distance, the speed of rotation and the traverse rate will vary depending upon the metal being treated, the extent of the aggressive surface desired and the pressure of the water jets. Greater water jet pressures and/or increases in the time of treatment produce more aggressive surfaces.

After the surface 8 has been treated and prepared as described above, the surface 8 or portions thereof are coated by the method described in US-A-5 080 056. Briefly, aluminium-bronze alloy is supplied to the centre of the coating head in the form of a wire 16, which is provided on a spool. A commercially available thermal spray gun apparatus is employed to coat the cylinder. This is accomplished by using a high velocity oxy-fuel thermal spray method. A combustion mixture of propylene and oxygen (HVOF) flowing at a supersonic speed is introduced down the centre of the coating head 17 and ignited using an electric spark (not shown) of high voltage and low amperage inside the tip of the coating head 17. Once ignited, the flame is self-sufficient. The aluminium-bronze alloy is melted and blown as a spray by the high velocity gas of the head 17 and deposited on the interior surface 8 of the cylinder wall 3. The metal spray gun apparatus automatically rotates the coating head 17 about the wire 16 and directs the droplets 18 of the molten

wire material against the cylinder walls surface 8 by moving the head up and down the axis of the cylinder walls.

Fig. 7 shows a robot mechanism for producing the motions as described in relation to Figs. 1 and 2. In Fig. 7, reference numeral 4 designates the conduit 4 as shown in Figs. 1 and 2. It is rotated by a rotary lance drive mechanism 10. A motor 11 drives the lance 12 to which the conduit 4 and the cylinder head 5 are attached and rotatable therewith. The unit 10 includes a passageway member extending from one side to which a water conduit 13 is connected. A high pressure pump 14 of the type known as an ultra-high pressure water intensifier sold by Flow Systems International as Model 12XT is connected to the conduit 13 for supplying water under pressure to the rotating conduit 4 and cylinder head 5.

The unit 10 is secured to the bottom end of a mast assembly 20 which extends upwardly through the roof of compartment 21 and is adapted to be moved upwardly and downwardly as indicated by the arrows 22. This is accomplished by the mast being connected to a screw 23 which is rotated by a motor 24. The actuation of this mast in a vertical up and down direction is similar to that described in US-A-5 067 285.

Although when the lateral position of conduit 4 and the cylindrical head 5 is once established, it is not necessary to change such lateral position in the treatment of one cylinder, when one head 5 is to be utilized to treat different cylinders such as those shown in Figs. 1 and 7, it is desirable to move the entire unit 10 and mast 20 laterally from right to left as seen in Fig. 7. For that purpose, a carriage 30 is provided which is attached to a nut 31 which is mounted for movement on a screw 32. The screw 32 is actuated by a motor 33 so that turning of the screw 32 moves the nut 31 and the carriage 30. An example of this type of apparatus is described in US-A-5 067 285.

Figs. 4a, 4b and 4c illustrate the unusual result obtained by the present method and apparatus. Fig. 4a shows a surface such as a very small section of the surface 8 of one of the cylinders 2. It shows a relatively smooth surface which has been prepared as described in US-A-5 080 056. Fig. 4b shows the surface 8 after it has been treated by the described method and apparatus. It will be noted that the high pressure water jets have, in fact, eroded the surface. They have not cut into the surface as might occur with grit such as glass particles, but have actually eroded and formed undercut portions 9a, 9b and 9c. It is believed some metal structures have a porosity which is exposed by the erosion of the surface leaving a surface that is undercut. The addition of the undercuts in the surface advances the adhesive characteristics of the surface. Also, the erosion greatly increases the surface area. Therefore, the configuration of the irregular surface 8 after treatment by our method and apparatus provides for superior adhesion. This is illustrated by Fig. 4c which shows the coating 40 that is held to, and retained by, the increased surface area and particularly by the undercuts 9a, 9b, 9c and others not specifically designated.

Although the method and apparatus have been described in relation to the treatment of the cylindrical walls of an aluminium engine block by subjecting the walls to extremely high pressure water jets, it is also possible to utilise the method and apparatus for flat pieces or other forms of metal, particularly malleable ductile metal having surface hardnesses like that of the aluminium 319 alloy referred to above. Figs. 5 and 6 are schematics of apparatus for treating such surfaces.

Fig. 5 shows a tubular water conduit 104 connected to a cylindrical head 105. The head has a plurality of orifices 106 the same size as orifice 6 of Figs. 1 and 2. Orifices 106 are located on the bottom surface of the cylinder 105. Thus, the jets 107 are directed downwardly on the surface 108; the spacing between the bottom of the cylindrical head 105 is approximately 12.7 to 25.4 mm (one half to one inch). It should be understood that the speed of rotation of the conduit 104 and head 105, the pressure of the water jets 107 and the standoff distance, i.e., the distance between the bottom face of the head 105 and the surface 108, are preferably the same as that previously described with relation to Figs. 1 and 2, although such parameters can change depending upon many circumstances all as described above.

The conduit 104 and head 105 is moved by an apparatus such as that shown in Fig. 7. Thus, the conduit 104 would be attached to the lance 12 and in place of the engine block 1 the workpiece 100 would be substituted. All of the advantages enumerated above with relation to Figs. 1 and 2 would also be obtained on a flat or contoured piece such as the workpiece 100 of Figs. 5 and 6.

Claims

1. Apparatus for preparing the surfaces (8) of the cylinder wall portions (3) of an engine block for application of a wear-resistant coating comprising: means for creating jets (7) of water having pressures sufficiently high to clean and erode the surfaces (8) of said cylinder wall portions to provide an irregular surface to increase the adhesive characteristics thereof; and means (5,6) for directing said jets (7) against said surfaces (8) of said cylinder wall portions to clean and erode said surfaces to provide said irregular surfaces with increased adhesive characteristics.

2. Apparatus for preparing a metal surface for subsequent treatment comprising: means for creating jets of water having pressures at least as high

as 173 MPa (25,000 psi), and preferably between 173 MPa and 414 MPa, and means for directing said jets against a metallic surface to be prepared for coating.

3. Apparatus according to claim 1 or claim 2 in which the pressures of said jets are between 173 MPa and 414 Mpa (25,000 and 60,000 psi), preferably about 345 MPa (50,000 psi), so as to erode said surfaces and provide undercut portions thereof.

4. Apparatus according to any of claims 1 to 3 in which the means for directing the jets is a rotating member (5) rotatable about an axis and having means (6) for directing the jets in a direction substantially radially outwardly of said axis against the surfaces of said cylinder wall portions.

5. Apparatus according to any of claims 1 to 4 in which the means for creating said jets (7) include a high pressure pump forcing water through jet nozzles having substantially diameters between .127 and .152 mm (.005 and .006 inch).

6. A method of preparing the surfaces (8) of cylindrical wall portions of an engine block for application of a wear-resistant coating comprising the steps of; creating jets of water having pressures sufficiently high to clean and erode the surfaces of said cylinder wall portions to provide an irregular surface to increase the adhesive characteristics thereof; and directing said jets against said surfaces of said cylinder wall portions to clean and erode said surfaces to provide said irregular surfaces with increased adhesive characteristics.

7. A method according to claim 6 wherein said surfaces are eroded to provide undercuts (9a,9b,9c).

8. A method according to claim 6 or claim 7 in which the pressures of the jets created are between 173 MPa and 414 MPa (25,000 and 60,000 psi), preferably about 345 MPa.

9. A method according to any of claims 6 to 8 in which the surfaces of said wall portions are constructed of a malleable ductile light metal, preferably with a Brinell surface hardness of about between 50 and 100, more preferably a Brinell surface hardness of about between 70 and 95.

10. A method according to any of claims 6 to 9 in which the metal is an aluminium alloy.

11. A method according to any of claims 6 to 10 in which the step of applying said coating is by thermal spraying.

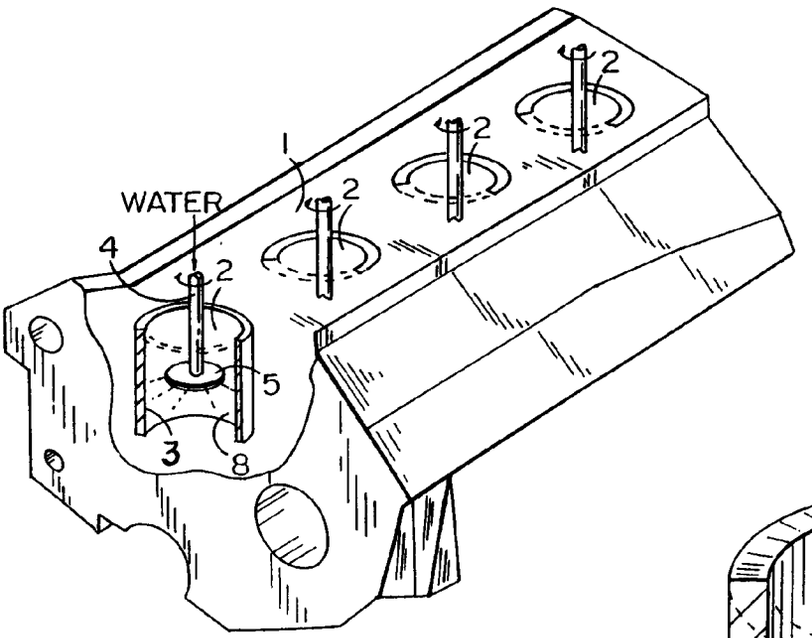

FIG. 1

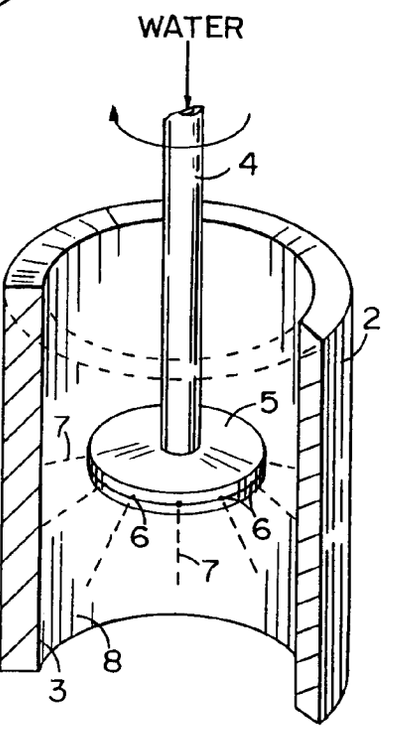

FIG. 2

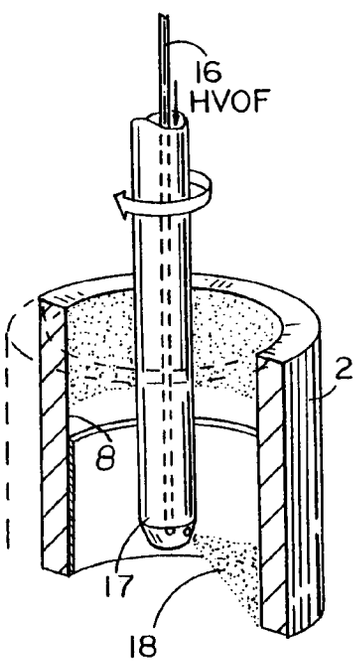

FIG. 3

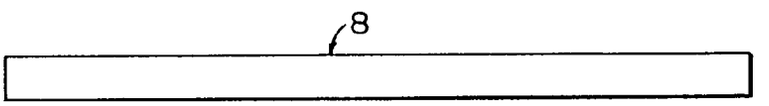

FIG. 4A

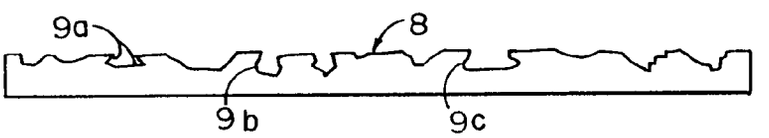

FIG. 4B

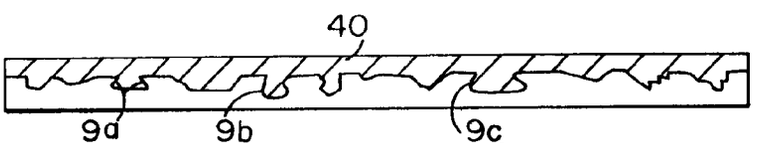

FIG. 4C

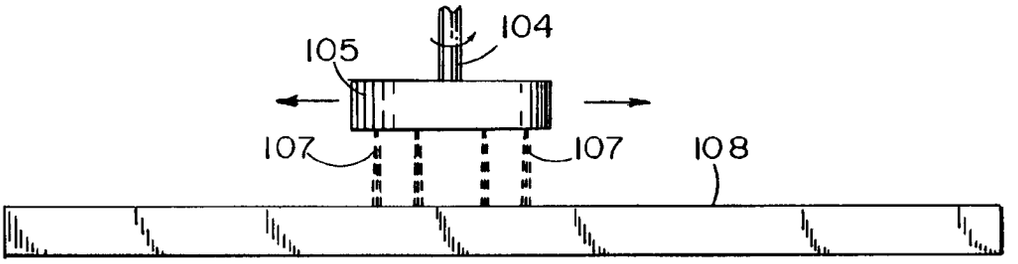

FIG. 5

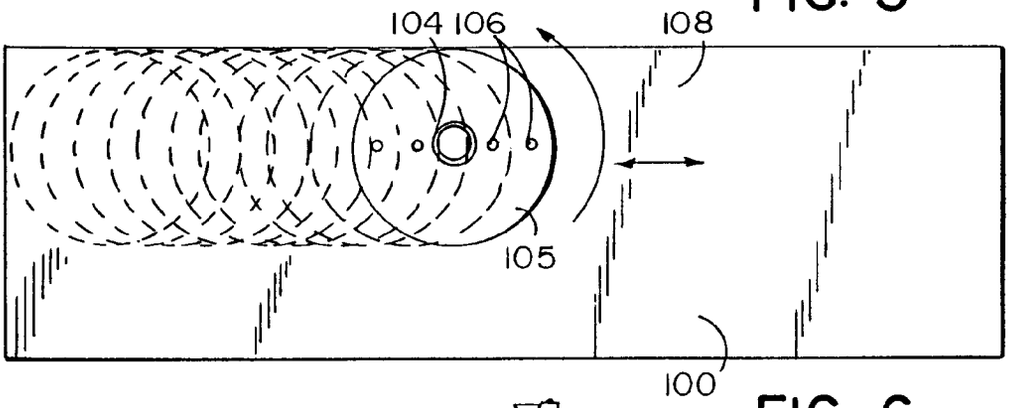

FIG. 6

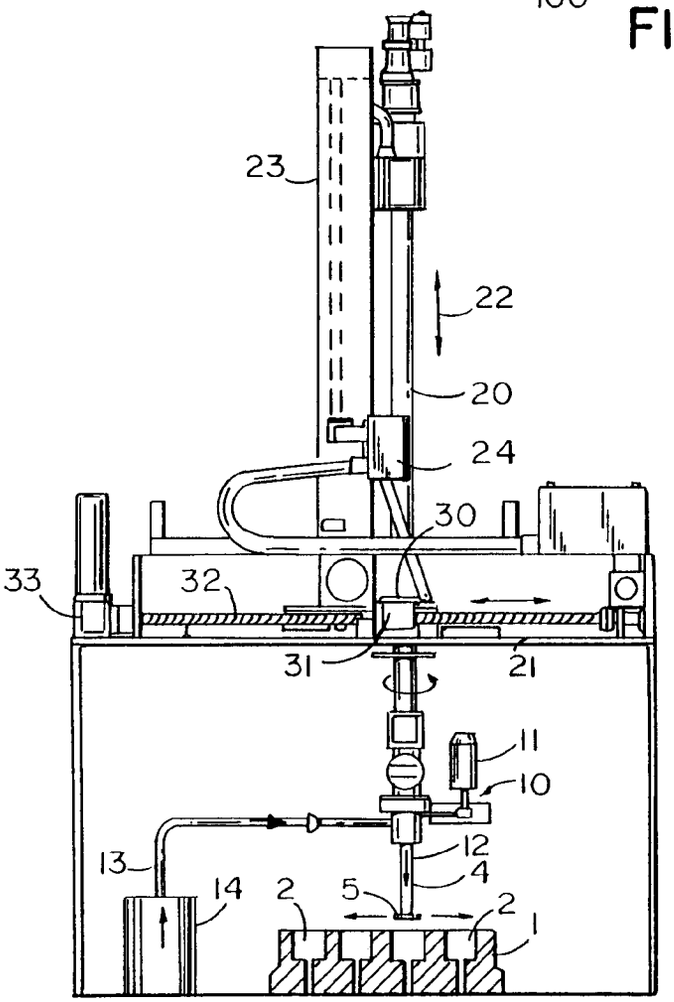

FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 3275

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,Y	US-A-5 080 056 (KRAMER ET AL.) * the whole document *	1-11	C23C4/02
D,Y	US-A-5 067 285 (HILBRANDS) * the whole document *	1-11	
Y	CH-A-677 897 (EDI MARK) * column 2, line 13 - line 25; claims *	1-11	
A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 428 (M-762)11 November 1988 & JP-A-63 162 160 (SUMITOMO METAL IND LTD) * abstract *	1-11	
A	DATABASE WPIL Section Ch, Week 8648, 15 October 1986 Derwent Publications Ltd., London, GB; Class M13, AN 86-314327 & JP-A-61 231 155 (YOSHIKAWA KOGYO KK) * abstract *	1-11	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C23C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09 AUGUST 1993	KAUMANN E.K-H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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