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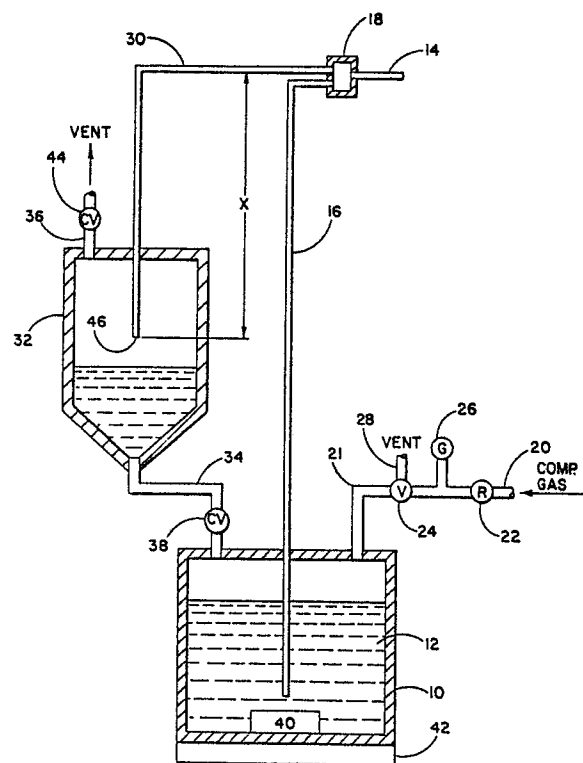
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57) A slurry dispensing apparatus for supplying slurry to a workpiece comprises a reservoir (10) for containing a supply of slurry, a first conduit (16) in fluid communication with the reservoir (10), and selectively operable pressure means (20,21,24,26,28) operable to force slurry from the reservoir into the first conduit (16). A needle or nozzle (14) supplies slurry to a workpiece. A bypass chamber (18) connects the first conduit (16) to the needle or nozzle to supply slurry under pressure from the first conduit (16) to the needle or nozzle (14), the bypass chamber (18) diverting excess slurry. A second conduit (30) is connected to the bypass chamber (18) for receiving the excess slurry from the first conduit (16). A chamber (32) is positioned at an elevation below the bypass chamber (18) and is connected to the second conduit (30) to receive the excess slurry. A delivery conduit (34,38) delivers slurry in the chamber (32) to the reservoir (10). The delivery conduit includes a normally closed first valve (38), so that, when slurry is forced from the reservoir (10) to the needle or nozzle (14), excess slurry is collected in the chamber (32) and, when the pressure means (20,21,24,26,28) is operated not to force slurry from the reservoir (10), the valve (34) is opened to permit slurry in the chamber (32) to return to the reservoir (10) and air is admitted to clean the apparatus.



## A SLURRY DISPENSING APPARATUS AND A METHOD OF DISPENSING SLURRY TO A WORKPIECE

This invention relates to slurry dispensing apparatus, e.g. for use in conjunction with polishing or lapping apparatus and methods of dispensing slurry to workpieces.

It is common in polishing or lapping apparatus to apply an abrasive slurry to a workpiece, which abrasive slurry is used in a polishing, lapping or finishing process. Most known slurry supply and dispensing apparatus employs a mechanism, such as a needle or nozzle, for dispensing the slurry onto a workpiece. Slurry is pumped to the needle or nozzle from a reservoir, and a control mechanism controls the pressure and flow of slurry. In some cases, apparatus may be employed to recover, clean and return used slurry to the reservoir, but in most cases used slurry is simply discarded.

One problem with known slurry supply and dispensing apparatus is that it is not altogether possible to clean and purge a discharge orifice of the needle or nozzle. When metering minute quantities of slurry, for example a few drops a minute, the relatively small discharge orifice of the needle or nozzle tends to clog. In the past, clogged needles or nozzles were simply removed and discarded, but this necessitated frequent shutdowns of the polishing or lapping apparatus to remove and replace the clogged needle or nozzle. The clogged condition of the needle or nozzle caused a cessation in the delivery of slurry to the workpiece. If the apparatus was not promptly shutdown for replacement of the clogged needle or nozzle, damage often occurred to the workpiece and to the polishing or lapping apparatus itself, necessitating costly repairs.

The present invention seeks to provide a slurry dispensing apparatus in which a discharge orifice of a needle or nozzle may be periodically cleaned without shutdown of the lapping or polishing apparatus of which it forms part.

According to one aspect of the present invention there is provided a slurry dispensing apparatus for supplying a slurry to a workpiece characterised by comprising: reservoir means for containing a supply of slurry; first conduit means in fluid communication with said reservoir means; selectively operable pressure means operable to force slurry from said reservoir means into said first conduit means; needle or nozzle means for supplying slurry to a workpiece; bypass means connecting said first conduit means to said needle or nozzle means to supply slurry under pressure from said first conduit means to said needle or nozzle means, said bypass means, in operation, diverting excess slurry; second conduit means connected to said bypass means for receiving said excess slurry from

said first conduit means; chamber means, in operation, positioned at an elevation below said bypass means and connected to said second conduit means to receive said excess slurry; and delivery means for delivery of slurry in said chamber means to said reservoir means, said delivery means including normally closed first valve means, so that, in operation, when slurry is forced from said reservoir means to said needle or nozzle means, excess slurry is collected in said chamber means and, when said pressure means is operated not to force slurry from said reservoir means, said first valve means is opened to permit slurry in said chamber means to return to the reservoir means and air is admitted to clean the apparatus.

Preferably said reservoir means is a sealed reservoir and said pressure means comprises a gaseous pressure source in fluid communication with said reservoir means, second valve means selectively connecting said reservoir means to said gaseous pressure source or to atmosphere, said first valve means comprising a check valve for permitting flow of slurry through said delivery means when the pressure in said reservoir means is not greater than in said chamber means.

In one embodiment said chamber means is a sealed chamber, check valve means being provided for venting said chamber means to atmosphere when the pressure within said chamber means exceeds atmospheric pressure.

Preferably said needle or nozzle means is, in operation, disposed at an elevation higher than said reservoir means.

According to another aspect of the present invention there is provided a method of dispensing slurry to a workpiece through an orifice of needle or nozzle means and periodically purging said orifice, characterised by comprising the steps of: supplying slurry under pressure to said orifice by transporting slurry to a bypass chamber with which said orifice is in fluid communication, and diverting excess slurry to a bypass conduit; and periodically reversing transport of slurry from said bypass chamber to create a sub-atmospheric pressure within said bypass chamber thereby drawing air into said bypass chamber through said orifice to purge the same.

A reservoir preferably supplies slurry to the bypass chamber, the slurry being transported to said bypass chamber by creating a pressure within said reservoir, and the reversing transport of slurry being accomplished by reducing the pressure in said reservoir to atmospheric pressure.

An intermediate chamber may receive excess slurry from said bypass conduit, excess slurry be-

ing returned from said intermediate chamber to said reservoir when the pressure in said reservoir is reduced to atmospheric pressure.

Thus purging and cleaning of the slurry dispensing apparatus may require only a few seconds as opposed to several minutes required to replace clogged needles or nozzles in the conventional apparatus, so that cleaning may be accomplished during polishing, lapping, etc. processes. Moreover, the needle or nozzle means can be cleaned more often than in conventional apparatus, lessening the likelihood of clogging. As a result, shutdowns are less frequent and costly repairs are less likely.

The invention is illustrated, merely by way of example, in the accompanying drawing which is a schematic diagram of a slurry dispensing apparatus according to the present invention.

Referring to the drawing, a reservoir 10 contains a slurry 12 to be applied through a needle or nozzle 14 to a workpiece (not shown). A supply conduit 16 supplies slurry to a bypass chamber 18 which, in turn, supplies slurry to the needle or nozzle 14. Slurry in the conduit 16 is ordinarily under pressure, it being preferred that the reservoir 10 is an enclosed reservoir pressurised by compressed gas introduced to a conduit 20 and applied to the reservoir 10 by way of a regulator 22 and a 3-way valve 24. Preferably, a gauge 26 is employed to measure the pressure in the conduit 20. The valve 24 provides communication between a conduit 21 connected to the interior of the reservoir 10 and either the conduit 20 or to atmosphere via a conduit 28.

Excess slurry not dispensed through the needle or nozzle 14 is bypassed through the chamber 18 through a conduit 30 to an intermediate chamber 32. The lower end of the chamber 32 feeds by gravity through a conduit 34 and a check valve 38 to the reservoir 10. Preferably, the reservoir 10 includes a magnet 40 and a magnetic actuator 42 to agitate the slurry, maintaining abrasive material in the slurry uniformly suspended in a liquid carrier or lubricant. The reservoir 10 is preferably at a lower elevational position than the intermediate chamber 32, which in turn is at a lower elevational position than the bypass chamber 18 and the needle or nozzle 14.

Preferably, the intermediate chamber 32 is opened to atmosphere through a conduit 36. Optionally, a check valve 44 may be placed in the conduit 36 to open only when the pressure in the chamber 32 exceeds atmospheric pressure. Typically, the needle or nozzle 14 is interchangeable for different applications.

In operation of the illustrated slurry dispensing apparatus, gas or air under pressure is admitted through the conduit 20 and the valve 24 to pressurise the enclosed chamber of the reservoir 10 to

a suitable pressure, such as 140 - 560 g/cm<sup>2</sup> (2 - 8 psig). Slurry is forced upwardly through the conduit 16 to the bypass chamber 18 and through the needle or nozzle 14 to the workpiece. The pressure in the bypass chamber 18 created by the back pressure within the conduit 30, causes a small amount of slurry to flow through a discharge orifice of the needle or nozzle 14. With relatively small conduits 16,30, a relatively high volume of slurry can pass through the bypass chamber 18 from the conduit 16 to the conduit 30 for small amounts of slurry metered through the needle or nozzle 14. For example, several millilitres of slurry can pass from the conduit 16 to the conduit 30 for each drop of slurry metered through the needle or nozzle 14. Thus, slurry transport velocities may be high to maintain the abrasive in suspension and yield a uniform mixture of slurry discharged through the needle or nozzle 14. Excess slurry is bypassed through the chamber 18 and the conduit 30 to the intermediate chamber 32, which is at a lower elevation than the bypass chamber 18. The check valve 38 prevents slurry in the intermediate chamber 32 from returning to the reservoir 10 through the conduit 34 because the check valve 38 is closed by virtue of the pressure within the reservoir 10.

When it is desired to purge the apparatus, the valve 24 is moved to a second position to vent the interior of the reservoir 10 through the conduits 21,28 to atmosphere. This reduces the pressure within the reservoir 10, removing the pressure from the slurry in the conduit 16. The column of slurry in the conduit 30 between the upper outlet in the bypass chamber 18 and the lower outlet 46, designated by X in the drawing, supports a reduced, sub-atmospheric pressure within the bypass chamber 18 as the slurry in the conduit 16 drains by gravity to the reservoir 10. As a result, air is drawn through the needle or nozzle 14 into the bypass chamber 18 thereby to clean the needle or nozzle and purge it of slurry and any foreign material. Also, some of the slurry in the conduit 30 will be drawn into the bypass chamber 18, due to the reduced pressure therein. Hence, the flow of slurry in the apparatus is reversed, and the pressure in the bypass chamber is reduced to a slight vacuum (pressure below atmospheric pressure) for cleaning and purging purposes. At the same time, the check valve 38 is opened due to the weight of the slurry in the intermediate chamber 32 and the presence of atmospheric pressure in the reservoir 10. This permits the slurry in the intermediate chamber 32 to return to the reservoir 10. It is preferred that the conduits 16,30 are relatively small, for example, 3.2 mm (one-eighth inch) O.D. (outside diameter), to support a capillary column of slurry to create the desired reduced pressure during cleaning and purging cycles. The conduits 34,36,20,21,28 are

relatively large, for example, 6.4 mm (one-quarter inch) O.D. to permit quick ventilation and pressure changes and rapid draining of slurry from the intermediate chamber 32 to the reservoir 10.

In practice, the needle or nozzle 14 should be at the highest gravitational elevation of the apparatus thereby aiding in the backflow or flushing of the apparatus. Also, it is advantageous that the conduit 16 is connected below the conduit 30 to the bypass chamber 18 to aid in supporting the desired flows and pressures.

In practice, the cleaning or purging of the apparatus requires only a few seconds and can be accomplished without interrupting a lapping or polishing operation. The purging can be set to be automatically accomplished at regular intervals, such as every minute or two, by an electronic timer (not shown) operating the valve 24.

Optionally, the vent conduit 36 which vents the intermediate chamber 32 to atmosphere includes the check valve 44 which closes as the slurry in the intermediate chamber 32 drains into the reservoir 10. The inclusion of the check valve 44 offers the additional advantage that all air employed to purge the system must be admitted through the needle or nozzle 14, thereby assuring full cleaning. However, due to the very small opening of the orifice of the needle or nozzle, a considerably longer time would be required to drain slurry from the intermediate chamber 32 to the reservoir 10. In practice, it has been found more advantageous to omit the valve 44 and constantly to vent the intermediate chamber 32 to atmosphere and to operate a cleaning and purging cycle for a few seconds each minute or two. The cleaning and purging cycle can be accomplished without interrupting the lapping or polishing operation, and the slurry in the conduit 30 provides an adequate vacuum to purge the orifice of the needle or nozzle.

## Claims

1. A slurry dispensing apparatus for supplying a slurry to a workpiece characterised by comprising: reservoir means (10) for containing a supply of slurry; first conduit means (16) in fluid communication with said reservoir means (10); selectively operable pressure means (20,21,24,26,28) operable to force slurry from said reservoir means into said first conduit means (16); needle or nozzle means (14) for supplying slurry to a workpiece; bypass means (18) connecting said first conduit means (16) to said needle or nozzle means to supply slurry under pressure from said first conduit means (16) to said needle or nozzle means, said bypass means (18), in operation, diverting excess slurry; second conduit means (30) connected to said by-

pass means (18) for receiving said excess slurry from said first conduit means (16); chamber means (32), in operation, positioned at an elevation below said bypass means (18) and connected to said second conduit means (30) to receive said excess slurry; and delivery means (34,38) for delivery of slurry in said chamber means (32) to said reservoir means (10), said delivery means including normally closed first valve means (38), so that, in operation, when slurry is forced from said reservoir means (10) to said needle or nozzle means (14), excess slurry is collected in said chamber means (32) and, when said pressure means (20,21,24,26,28) is operated not to force slurry from said reservoir means (10), said first valve means (34) is opened to permit slurry in said chamber means (32) to return to the reservoir means (10) and air is admitted to clean the apparatus.

2. Apparatus as claimed in claim 1 characterised in that said reservoir means (10) is a sealed reservoir and said pressure means (20,21,22,24,26,28) comprises a gaseous pressure source in fluid communication with said reservoir means (10), second valve means (24) selectively connecting said reservoir means to said gaseous pressure source or to atmosphere, said first valve means (38) comprising a check valve for permitting flow of slurry through said delivery means (34,38) when the pressure in said reservoir means (10) is not greater than in said chamber means (32).

3. Apparatus as claimed in claim 1 or 2 characterised in that said chamber means (32) is a sealed chamber, check valve means (44) being provided for venting said chamber means to atmosphere when the pressure within said chamber means exceeds atmospheric pressure.

4. Apparatus as claimed in any preceding claim characterised in that said needle or nozzle means (14) is, in operation, disposed at an elevation higher than said reservoir means (10).

5. A method of dispensing slurry to a workpiece through an orifice of needle or nozzle means (14) and periodically purging said orifice, characterised by comprising the steps of: supplying slurry under pressure to said orifice by transporting slurry to a bypass chamber (18) with which said orifice is in fluid communication, and diverting excess slurry to a bypass conduit (30); and periodically reversing transport of slurry from said bypass chamber (18) to create a sub-atmospheric pressure within said bypass chamber thereby drawing air into said bypass chamber through said orifice to purge the same.

6. A method as claimed in claim 5 characterised in that a reservoir (10) supplies slurry to the bypass chamber (18), the slurry being transported to said bypass chamber by creating a pressure

within said reservoir, and the reversing transport of slurry being accomplished by reducing the pressure in said reservoir to atmospheric pressure.

7. A method as claimed in claim 6 characterised in that an intermediate chamber (32) receives excess slurry from said bypass conduit (18), excess slurry being returned from said intermediate chamber (32) to said reservoir (10) when the pressure in said reservoir is reduced to atmospheric pressure.

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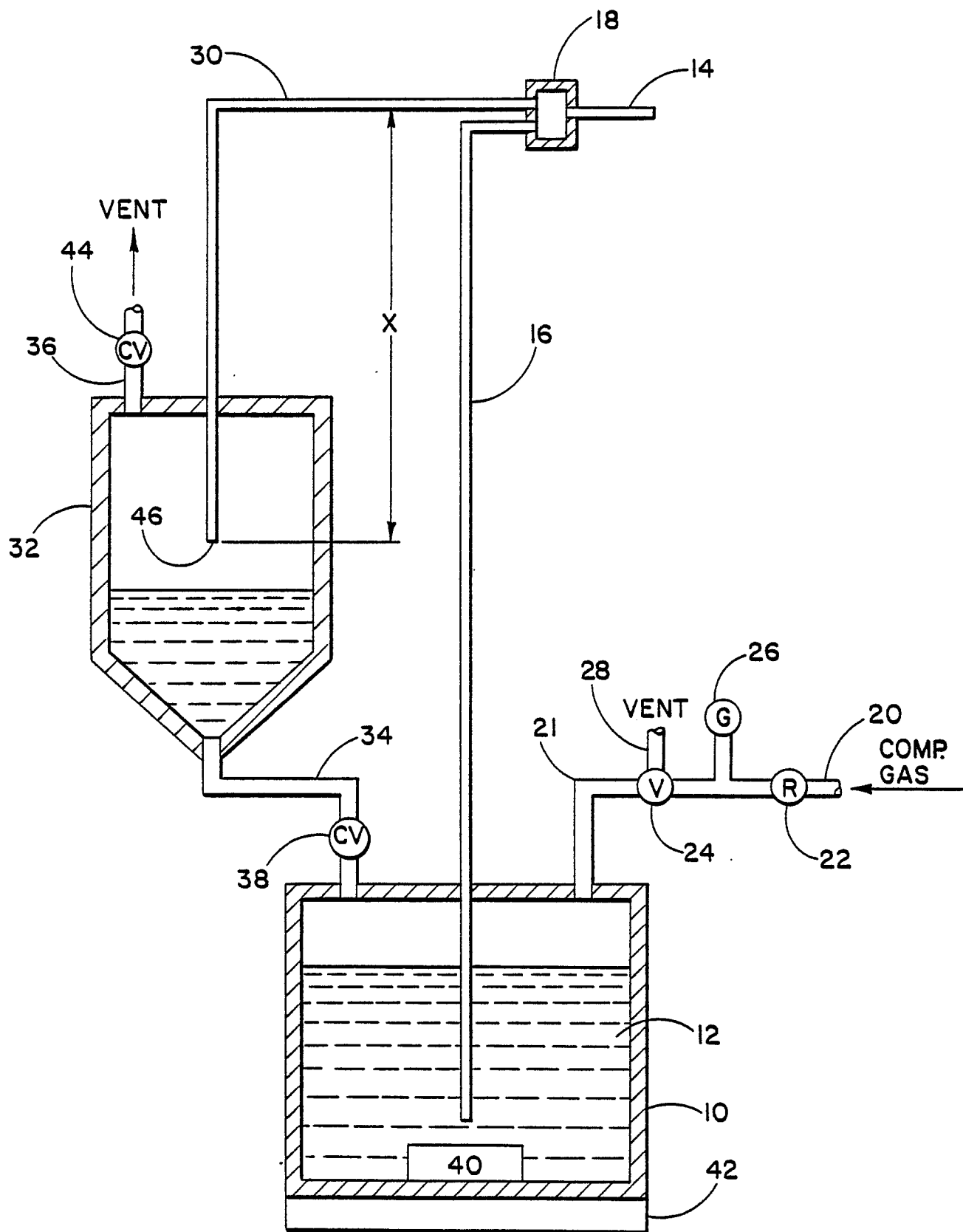
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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                         |                                                                                                                                                                                                                                                                                       |                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| Category                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages           | Relevant to claim                                                                                                                                                                                                                                                                     | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
| A                                                                                                                                                                                                                                                      | US-A-3 559 351 (RICHTER)<br>* column 2, line 25; column 3, line 5;<br>figure 1 *<br>--- | 1                                                                                                                                                                                                                                                                                     | B 24 C 1/08<br>B 05 B 15/02                   |
| A                                                                                                                                                                                                                                                      | FR-A-2 555 469 (BERTHOUD)<br>* claim 1; figures 1,3 *<br>---                            | 1,5                                                                                                                                                                                                                                                                                   |                                               |
| A                                                                                                                                                                                                                                                      | US-A-3 019 522 (BLUTH et al.)<br>* column 4, lines 10-50; figure 1 *<br>-----           | 1                                                                                                                                                                                                                                                                                     |                                               |
|                                                                                                                                                                                                                                                        |                                                                                         |                                                                                                                                                                                                                                                                                       | TECHNICAL FIELDS<br>SEARCHED (Int. Cl.4)      |
|                                                                                                                                                                                                                                                        |                                                                                         |                                                                                                                                                                                                                                                                                       | B 24 C<br>B 05 B                              |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                         |                                                                                                                                                                                                                                                                                       |                                               |
| Place of search<br>BERLIN                                                                                                                                                                                                                              |                                                                                         | Date of completion of the search<br>15-05-1988.                                                                                                                                                                                                                                       | Examiner<br>BERNAS Y.N.E.                     |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                         | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>-----<br>& : member of the same patent family, corresponding document |                                               |