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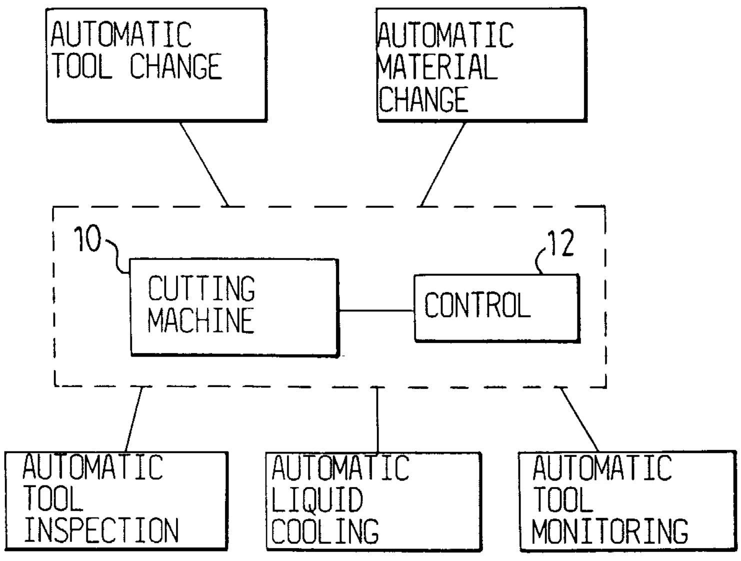
(54) **Title:** AN APPARATUS AND A METHOD FOR PRODUCING A DENTAL RESTORATION



(57) **Abstract:** The present invention relates to an apparatus and a method for machining blanks of high-strength material, such as ceramics, in dental applications by means of a cut-ting machine (10), such as a milling- or a grinding machine. The invention implies storing at least one set of data programs, wherein each set of data programs comprising instructions required for the machining of one of said blanks; machining of said blank in dependence of said set of data programs; changing cutting tools in de-pendence of said set of data programs; inspecting cutting tool quality prior to and/or after said change of cutting tools; monitoring vibrations of said machine (10) during said machining; cooling said cutting tool by means of liquid during said machining; and changing blanks in dependence of said set of data programs. With such an apparatus and method high-strength ceramics may effectively be produced in an automatic and cost-effective way.

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An apparatus and a method for producing a dental restoration

TECHNICAL FIELD OF THE INVENTION

The present invention relates to an apparatus for machining blanks of high-strength material, such as ceramics, in dental applications.

The invention also relates to a method for machining blanks of high-strength material, such as ceramics, in dental applications.

Finally, the invention relates to the use of such an apparatus or method for manufacturing of tooth restorations made from high-strength ceramic materials.

RELATED ART

CAD/CAM-based systems for the manufacturing of dental restorations are known in the art. In such systems data about the topology of a prepared tooth and possibly also the surrounding teeth are collected and stored in a computer. An operator interacts with the CAD-part of the system in order to create a computer model of the desired tooth restoration. This computer model is then transferred to the CAM-part of the system, where cutting tools, tool paths, speed of rotation, etc. are determined for the machining of the restoration out of a given blank. In the last step this information is sent to a CNC-machine, whereupon the machining may commence.

The development of such CAD/CAM-based systems aimed at the dental field has been on-going in several parallel projects since the beginning of the 1980:s. One pioneer in the field was Dr. Francois Duret who showed a system in public in 1985. This system became later commercially available under the name Sopha System (Sopha Biconcept Inc., Vienne, France). See references Duret, "Vers unit prothèse informatisée" Tonus Dentaire No 73, 1985 pp. 55-57; Duret et al: "CAD-CAM in dentistry", JADA, Vol. 117, November 1988, pp. 715-720; and Williams: "Dentistry and CAD/CAM: Another French Revolution", Journal of Dental Practice Administration, January/March 1987.

Other CAD/CAM-based systems intended for the manufacture of crowns have been developed by Rekow ED, "Computer-aided design and manufacturing in dentistry. A review of the state of the art". Prosthet Dent 1987; 58: 512-516; and van der Zel JM, "Ceramic-fused-to metal restorations with a new CAD-CAM system", Quintessence Int 1993; 24:769-778.

The original CEREC system (Sirona AG, Bensheim, Germany), capable of creating ceramic inlays, onlays and veneers was constructed by Mörmann and Brandestini and has been on the market since the end of 1980:s. This system enable dentists to design and mill the ceramic restorations chairside at one appointment, see Mörmann WH, Brandestini M, "CEREC tutorial step by step", University of Zürich, Dental Institute 1988; and Mörmann WH, Brandestini M, "The CEREC reconstruction of inlays, onlays and veneers". Berlin: Quintessence 1989.

Another available system is the DCS system (DCS Dentalsysteme, Wilhelmshaven, Germany), which is aimed for dental laboratories. This system is mainly used for restorations (copings and coping bridges) in titanium.

Most of the dental restorations, such as crowns and bridges, are today based on a metal base veneered with porcelain. This type of restoration has existed for many years and is called PFM – Porcelain Fused Metal, and is advantageously manufactured in accordance with the methods disclosed in the above mentioned documents.

However, there is today a strong trend to replace these metal based restorations with fully ceramic restorations. The major driving forces are the outstanding aesthetics results that can be achieved with these types of restorations, and the biocompatibility of these materials. Traditional dental feldspar ceramics, i.e. porcelain, which has been used for a long time in dentistry, are not suitable in fully ceramic restorations, even though they may exhibit excellent aesthetic results. The reason is that materials in this group are too fragile, and can thus not be used except for as in veneers, where exclusively their hardness characteristics are employed.

In stead, industrial high-performance ceramics, such as dense-sintered high-purity alumina and yttria-stabilised zirconia, are required. These materials combine, in contrast to feldspar ceramics, good aesthetic results with outstanding mechanical properties. Yttria-stabilised zirconia, with a history of use in hip joints in surgical orthopaedics, has high fracture toughness, which makes it suitable for restorations or parts of restorations that are exposed to high masticatory loads. However, industrial high-performance ceramics are, in contrast to metals used in PFM-restorations, not easily manufactured in shapes that correspond to prepared teeth. Particularly, yttria-stabilised zirconia in sintered (or sintered and HIP:ed, i.e. High temperature Isostatic Pressing) form is very hard to shape. It is substantially their exceptional fracture toughness that make them difficult to machine in cutting machines, such as milling- and grinding machines.

The above mentioned CAD/CAM-based systems are not adapted for a cost-effective machining of these industrial high-performance ceramics, but requires extensive operator intervention during the whole machining process. Continuous surveillance of the machining process is for instance absolutely necessary, since the tools are quickly worn down, which will jeopardise tool function and machining results.

OBJECT OF THE INVENTION

The object of the present invention is to provide an apparatus and a method for automatic, unattended machining of high-strength material, such as ceramics, in dental applications in a cost effective way.

SUMMARY OF THE INVENTION

This object is achieved by means of an apparatus according to claim 1.

This object is also achieved by means of a method according to claim 5.

Finally, this object is achieved by means of an use according to claim 12.

By (i) storing at least one set of data programs, wherein each set of data programs comprising instructions required for the machining of one of said blanks; (ii) machining of said blank in dependence of said set of data programs; (iii) changing cutting tools in dependence of said set of data programs; (iv) inspecting cutting tool quality prior to and/or after said change of cutting tools; (v) monitoring vibrations of said machine during said machining; (vi) cooling said cutting tool by means of liquid during said machining; and (vii) changing blanks in dependence of said set of data programs, a reliable system for machining high-strength material, such as ceramics, is achieved.

Moreover, a cutting machine may be in operation during, e.g. a whole shift, since all necessary software, tools and material blanks are already provided for, whereby a plurality of blanks can be machined without any operator intervention. This results in a cost-effective production, since the machining may be unattended.

Furthermore, when a tool is worn, i.e. the diamond plating is worn down, the friction between the tool and the blank increases, and thus heat is generated. This may cause cracks to arise in the material blank, whereby the material blank has to be rejected. By inspecting the tool quality less rejections of material blanks are achieved.

Furthermore, when a tool is worn, vibrations of the machine increase. By monitoring vibrations during machining, yet a way of inspecting tool quality is achieved.

Preferably, if said step of inspecting cutting tool quality prior to and/or after said change of cutting tools, detects a cutting tool not corresponding to pre-determined quality requirements, that cutting tool is rejected and not further used, instead a replacement cutting tool is employed in further machining, and a machining sequence already performed with the rejected cutting tool is repeated. Furthermore, security is also improved if a tool is inspected before it is used in a machining sequence, since an incorrect tool, e.g. corresponding to an other machining sequence, immediately is revealed, thus preventing accidents due to operator mistake.

Suitably, if said step of monitoring vibrations of said machine during said machining, detects levels of vibrations not corresponding to pre-determined acceptable levels, machining is interrupted and the actual cutting tool is rejected and not further used, instead a replacement cutting tool is employed in further machining, and a machining sequence already performed with the rejected cutting tool is repeated.

Hereby is achieved that tools used for machining always fall within pre-determined tolerance zones, which improves machining results and thus the final products.

Alternatively, if the unacceptable vibrations are temporary, e.g. caused by a non-uniform depth of engagement, which may happen if large amounts of material are cut simultaneously, there is no need of rejecting the tool. Instead, feed speed is temporarily lowered. However, if the unacceptable vibration levels remain, the tool is rejected. Hereby, an unnecessary rejection of a tool is avoided.

Advantageously, said step of inspecting cutting tool quality prior to and/or after said change of cutting tools comprises laser measurements of cutting tool diameter and/or cutting tool length. Hereby a reliable, simple and fast way of measuring tool quality is achieved.

Preferably, said step of cooling said cutting tool by means of liquid during said machining comprises ejection of a cooling liquid from at least one nozzle and immersion of said blank in a basin filled with cooling liquid. Hereby, an efficient cooling is achieved, which enhances tool life.

Suitably, said cutting machine is adapted for at least 4-axis machining, preferably 5-axis machining. Hereby is achieved that dental restorations with complicated three-dimensional shapes easily may be formed.

Advantageously, spindle speeds greater than 70 000 rpm, and preferably, diamond- and/or boron nitride-plated grinding tools are used during machining, and suitably, disc tools with diameter 10-30 mm are used for roughing, and several types of grinding pins with diameter 1,0-4,0 mm are used for semi-finishing and finishing. Hereby is achieved a machining, which is adapted to the material characteristics of ceramic materials, as well as the shape of dental restorations.

Preferably, blanks made from yttria stabilised zirconia are used for the dental restorations. Hereby is achieved dental restorations, completely made from yttria stabilised zirconia, having outstanding strength properties, being bio-compatible and exhibiting excellent aesthetic results.

DRAWING SUMMARY

A preferred embodiment of the present invention will now be described with references to the accompanying drawings, on which:

Fig. 1 is a principle view of the apparatus and the method according to the invention;

Fig. 2 is a schematic front view of a part of the inventive apparatus showing the principles of tool change;

Fig. 3 is a schematic side view of a part of the inventive apparatus showing the principles of material change;

Fig. 4a-b is schematic views of a part of the inventive apparatus showing the principles of tool inspection;

Fig. 5 is schematic side views of a part of the inventive apparatus showing the principles of liquid cooling;

Fig. 6 is a schematic front view of a part of the inventive apparatus showing the principles of tool monitoring during machining;

DETAILED DESCRIPTION

Fig.1 is a principle diagram of the apparatus and the method according to the present invention. Reference numeral 10 indicates a cutting machine, such as a milling- or a grinding machine. This machine is of a conventional type for machining material blanks into desirably shaped dental restorations and is well known in the art, and is adapted for at least 4-axis machining, preferably 5-axis machining, where three axes contribute to the orthogonally arranged slide axes, and the other two axes to rotation about two of these axes. The machining is controlled by means of pre-recorded instructions/data programs. These pre-recorded instructions/data programs are created in a not shown computer being provided with CAD/CAM-software. The CAD-part designs a computer model corresponding to the desirably shaped dental restoration, and the CAM-part determines cutting tools, tool paths, speed of rotation, etc., i.e. all necessary parameters needed for the manufacturing of the dental restoration in accordance with the created computer model, type of blank, and chosen material.

Connected to the cutting machine is a control unit 12, which has a not shown user interface, such as a monitor and a keyboard. The control unit comprises general control programs for the automation and control of the cutting machine, and the pre-recorded instructions/data programs, which preferably are sent to the control unit 12 via a not shown internal network, e.g. from the CAD/CAM-computer. An operator may interact with the machining via the user interface, e.g. start new machining sessions, achieve instructions when the pre-recorded instructions/data programs are downloaded, so as to take certain steps, such as controlling tools, material blanks etc.. The pre-recorded instructions/data programs are preferably a plurality of sets of data programs, where each set comprises necessary data instructions to accomplish machining of one blank into a complete dental restoration.

Furthermore, fig. 1 depicts a plurality of functions, which when a cost-effective and high-qualitative machining of high-performance ceramics is to be achieved, are required. These functions are described with reference to figs. 2-6.

Fig. 2 depicts the principles of tool change. Cutting tools 14 required for the machining are arranged and hold by a tool magazine 16 in the form of a revolving magazine 16, which can rotate about an axis x. The spindle of the cutting machine for clamping the cutting tool during machining is denoted 18. Between the tool magazine 16 and the spindle 18 is a tool changing device 20 arranged, which can rotate about an axis z, as well as move along this axis.

Accordingly, when cutting tools 14 are to be changed, (i.e. in dependence of the pre-recorded instructions/data programs) the magazine 16 is rotated to a tool changing position and a tool cup 22 is let down. The tool changing device 20 is rotated, and an arm 24 grips the tool present in the spindle 18 and the new tool in the tool cup 22. The tools are unfastened from the magazine and the spindle, respectively, when the tool changing device is downward travelled along the z-axis. When the tool changing device is rotated 180 ° the tools shift place, and after an upward travel the new tool is placed in the spindle and the changed tool in the tool cup 22. By yet a 180 °-rotation the tool changing device 20 returns to its original position.

Fig. 3 depicts the principles of material change, which are similar to those as for tool change. Material blanks 30 required for the machining of a plurality of dental restorations are arranged and hold by a material magazine 32 in the form of a revolving magazine 32, which can rotate about an axis y, as well as travel along the machine axes x, y, z,. A chuck of the cutting machine for clamping the material blank 32 during machining is denoted 34.

Accordingly, when a material blank 30 is to be changed, (i.e. in dependence of the pre-recorded instructions/data programs), e.g. upon completion of a machining, the material magazine 32 is first positioned, i.e. by means of x, y, z-travelling, in a material change position. That is, when a centre line 36 of a slot 38 of the material magazine 32 gets in line with the chuck 34. The tool magazine is rotated about the y-axis, until the slot containing the desired material blank gets in the material change position. The material blanks 30 are changed when the material magazine 32 is travelled in the direction as indicated by arrow A until the chuck clamps the blank. Thereafter the material magazine is returned to its original position.

Fig. 4 depicts the principles of tool inspection. Prior to and/or after every tool change the tool quality of the cutting tools 14, i.e. tool diameter and tool length, are inspected. This is performed automatically by moving the tool to a tool inspecting device 39, which is in the form of a laser diode 40 and a receiver 42. When the tool has been lowered between the diode and the receiver the tool inspection can start. Light emitted by the laser diode 40 is received by the receiver 42. By reading the position of the machine slides, i.e. x, y, z-positions, when the receiver 42 gives a signal the tool diameter may be determined if the direction of motion is as indicated by arrow A, or the tool length if the direction of motion is as indicated by arrow B.

Consequently, a tool 14 is inspected before it is used in a machining sequence, where a machining sequence is the pre-determined tool path the tool follows, so as to cut material from the blank. The tool 14 is also inspected after it has been used in a machining sequence. By such inspections, the intended machining is always achieved, while machining by means of tools not complying with pre-determined quality requirements never is performed.

Fig. 5a-b shows the principles of cooling by means of liquid, where fig. 5a depicts roughing and fig. 5b depicts finishing of the material blank 30. The spindle of the machine is indicated with 18, tools for roughing and finishing 14a and 14b, respectively, material blank 30, upper nozzles 54 and lower nozzles 56. With reference to fig. 5a a disc tool 14a is used in the spindle 18 for machining of the blank 30. Cooling is provided by means of the upper nozzles 54 arranged around the spindle as well as from beneath by the lower, movable nozzles 56. When semi-finishing or finishing is to be accomplished the blank is pivoted 90° around the x-axis, as is shown in fig. 5b. When pivoted, the material blank is immersed in a basin 58 filled with cooling liquid. By means of the upper nozzles 54 the basin is continuously filled with cooling liquid during machining. Immersion of blank provides for a very effective cooling. However, this type of cooling is more easily performed when the tool diameter of the tools are small, since the splashing is less intensive in comparison when bigger tools are used. Therefore, when semi-finishing and finishing of the blanks, this type of cooling is mainly employed, while when roughing, nozzles are employed.

Fig. 6 shows the principles of tool monitoring. A sensor 60, such as an accelerometer is attached to the spindle 18 and is connected to computer means 62. When the tool 14 is machining the material blank 30 vibrations arise, which may be detected. By analysing how the vibrations is changed when the tool 14 is exhibited to tool wear, it is possible to determine when the tool should be rejected, so as to avoid damages to the material blank. During machining, if the vibrations increases to levels not corresponding to pre-determined acceptable levels, the machining is immediately interrupted, so as to avoid damages. The actual cutting tool is also rejected and not further used, instead a replacement cutting tool is employed in further machining. A machining sequence already performed with the rejected cutting tool is repeated.

With reference to fig. 1 again, the interaction of the above mentioned functions during machining of a dental restoration will shortly be explained. After downloading sets of data programs comprising the instructions for the machining of at least one material blank 30 into a complete dental restoration, the machining may commence. During machining required tool changes, tool inspections, tool monitoring, liquid cooling and material change are performed automatically in dependence of the data programs controlling each machining sequence. When a first machining is completed, the first finished-machined tooth restoration is removed, and the machining of a second blank may commence. These machining cycles may continue without any operator intervention as long as material blanks are present in the material magazine.

CLAIMS

1. An apparatus for machining blanks of high-strength material, such as ceramics in dental applications comprising:
   - a cutting machine (10), such as a milling- or a grinding machine;
   - means (12) for storage of at least one set of data programs, wherein each set of data programs comprises instructions required for the machining of one of said blanks;
   - magazine means (16) for holding a plurality of cutting tools (14) intended for the machining;
   - means (20) for changing said cutting tools in dependence of said set of data programs;
   - means (39) for inspection of cutting tool quality prior to and/or after said change of cutting tools (14);
   - means (60) for monitoring vibrations of said machine during said machining;
   - means (54, 56, 58) for liquid cooling of cutting tools (14) during said machining;
   - magazine means (32) for holding a plurality of blanks (30); and
   - means (32) for changing said blanks in dependence of said set of data programs.

2. Apparatus according to claim 1, wherein said means (39) for inspection of cutting tool quality prior to and/or after said change of cutting tools comprises means (40, 42) for laser measurements of cutting tool diameter and/or cutting tool length.

3. Apparatus according to claim 1 or 2, wherein said means for liquid cooling of cutting tools during said machining comprises at least one nozzle (54, 56) for ejection of cooling liquid.

4. Apparatus according to any of claims 1-3, wherein said means for liquid cooling of cutting tools during said machining comprises a basin (56) filled with cooling liquid for immersion of said blank (30) during said machining.

5. A method for machining blanks (30) of high-strength material, such as ceramics in dental applications by means of a cutting machine (10), such as a milling- or a grinding machine, comprising the steps of:
   - storing at least one set of data programs, wherein each set of data programs comprising instructions required for the machining of one of said blanks (30);
   - machining of said blank (30) in dependence of said set of data programs;
   - changing cutting tools (14) in dependence of said set of data programs;
   - inspecting cutting tool quality prior to and/or after said change of cutting tools (14);
   - monitoring vibrations of said machine (10) during said machining;
   - cooling said cutting tool (14) by means of liquid during said machining; and
   - changing blanks (30) in dependence of said set of data programs.

6. Method according to claim 5, wherein, if said step of inspecting cutting tool quality prior to and/or after said change of cutting tools (14), detects a cutting tool not corresponding to pre-determined quality requirements, that cutting tool is rejected and not further used, instead a replacement cutting tool is employed in further machining, and a machining sequence already performed with the rejected cutting tool is repeated.

7. Method according to claim 5 or 6, wherein, if said step of monitoring vibrations of said machine (10) during said machining, detects levels of vibrations not corresponding to pre-determined acceptable levels, feed speed is temporarily lowered.

8. Method according to any of claims -7, wherein, if said step of monitoring vibrations of said machine (10) during said machining, detects levels of vibrations not corresponding to pre-determined acceptable levels, machining is interrupted and the actual cutting tool is rejected and not further used, instead a replacement cutting tool is employed in further machining, and a machining sequence already performed with the rejected cutting tool is repeated.

9. Method according to any of claims 5-8, wherein said step of inspecting cutting tool quality prior to and/or after said change of cutting tools comprises laser measurements of cutting tool diameter and/or cutting tool length.

10. Method according to any of claims 5-9, wherein said step of cooling said cutting tool by means of liquid during said machining comprising ejection of a cooling liquid from at least one nozzle (54, 56).

11. Method according to any of claims 5-10, wherein said step of cooling said cutting tool by means of liquid during said machining comprising immersion of said blank in a basin (58) filled with cooling liquid.

12. Use of an apparatus or a method in accordance with any of claims 1-11 for manufacturing of tooth restorations made from high-strength ceramic materials.

13. Use according to claim 12, further comprising the step of using:
- cutting machines (10) adapted for at least 4-axis machining, preferably 5-axis machining.

14. Use according to claim 12 or 13, further comprising the step of using:
- spindle speeds greater than 70 000 rpm during machining.

15. Use according to any of claims 12-14, further comprising the step of using:
    - diamond- and/or boron nitride-plated grinding tools (14).

16. Use according to any of claims 11-15, further comprising the step of using:
    - disc tools (14a) with diameter 10-30 mm for roughing, and several types of grinding pins (14b) with diameter 1,0-4,0 mm for semi-finishing and finishing, of said blank (30).

17. Use according to any of claims 12-16, further comprising the step of using:
    - blanks (30) made from yttria stabilised zirconia.

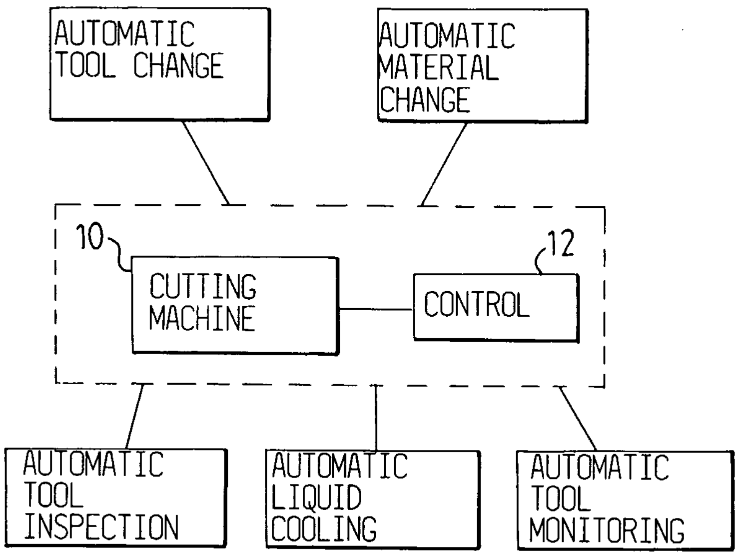

FIG.1

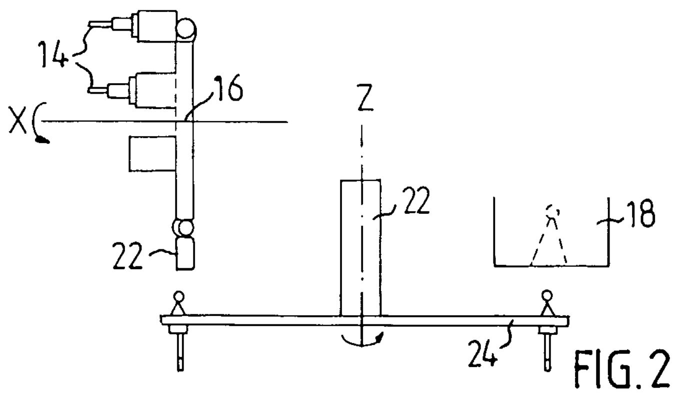

FIG.2

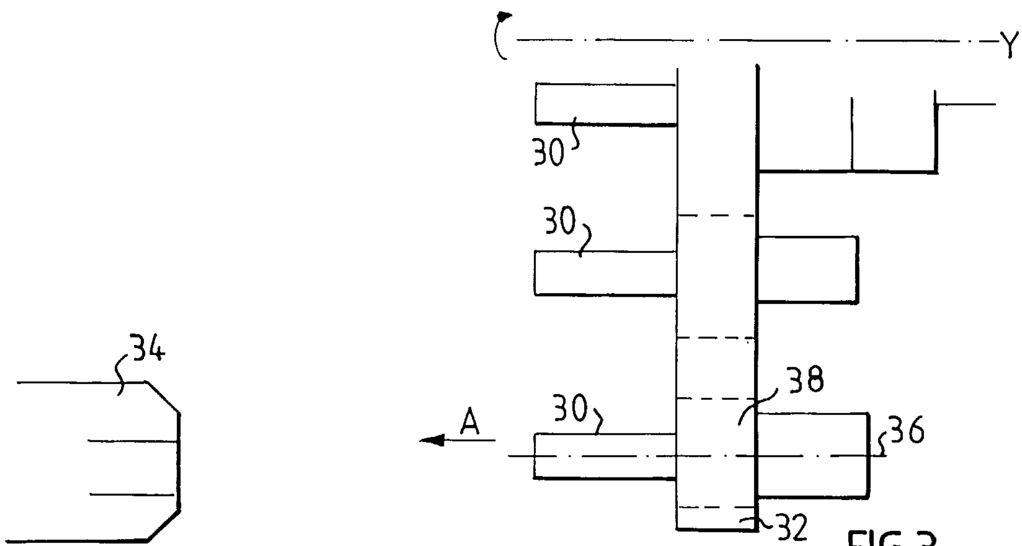

FIG.3

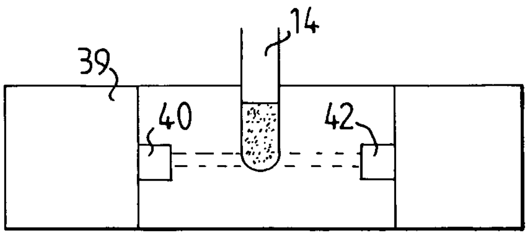

FIG. 4a

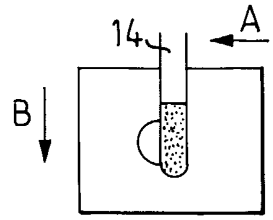

FIG. 4b

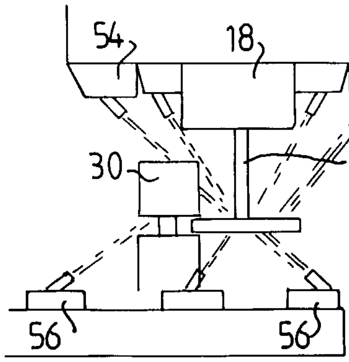

FIG. 5a

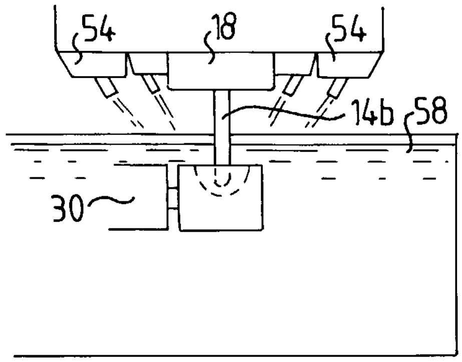

FIG. 5b

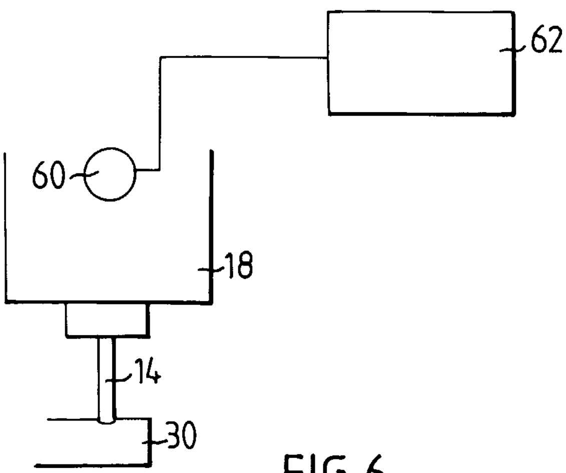

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00543

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A61C 13/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A61C

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

SE,DK,FI,NO classes as above

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9913796 A1 (DENTRONIC AB), 25 March 1999 (25.03.99) --	1-17
A	WO 9947065 A1 (EIDGENÖSSISCHE TECHNISCHE HOCHSCHULE ZÜRICH NICHTMETALLISCHE WERKSTOFFE), 23 Sept 1999 (23.09.99) -- --------	1-17

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1 July 2002	03-07-2002
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INTERNATIONAL SEARCH REPORT
Information on patent family members

10/06/02

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9913796 A1	25/03/99	AU 9195398 A	05/04/99
		EP 1018974 A	19/07/00
		SE 509208 C	14/12/98
		SE 9703353 A	14/12/98
WO 9947065 A1	23/09/99	AU 3244199 A	11/10/99
		BR 9908852 A	21/11/00
		CA 2322761 A	23/09/99
		CN 1293552 T	02/05/01
		EP 0943295 A	22/09/99
		EP 0943296 A	22/09/99
		EP 1067880 A	17/01/01
		JP 2002506674 T	05/03/02
		NO 20004574 A	13/09/00