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(54) **A lapping system for automatic contouring**

(57) A system for providing a predefined curvature to the distal end of a transducer (5), in which a flat lapping plate (11) is rotated about an axis while the transducer distal end is disposed in a lapping engagement with the lapping plate (11). A rocker mechanism (26) imparts a rocking motion to the transducer about a pivotal axis. A control system (40) provides an output control signal which can vary the rocking rate, the extent of rocking motion, and the force applied in accordance with an input control signal obtained from the element being lapped or from other sensing devices.

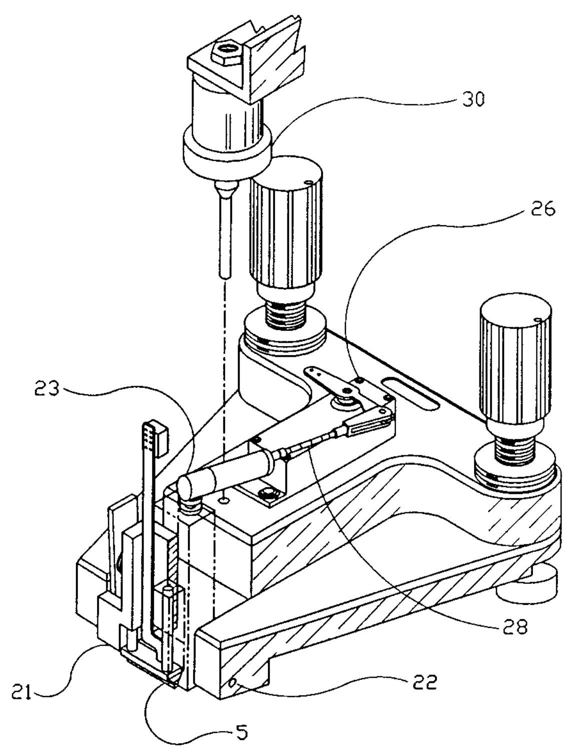

Fig 3

EP 0 687 525 A1

CROSS-REFERENCE TO COPENDING PATENT APPLICATION

Copending patent application Serial Number 08/103,669 filed August 10, 1993 in behalf of E. Valstyn et al., and assigned to the same assignee, discloses a read-write magnetic head assembly having a flux sensing or magnetoresistive (MR) read element and an inductive head, such as may be processed with the lapping apparatus disclosed in the present application.

FIELD OF THE INVENTION

This invention relates to a system for lapping a transducer element and in particular to a magnetic transducer that is useful for recording on and sensing data recorded on a magnetic medium.

DESCRIPTION OF PRIOR ART

The prior art discloses a number of different type systems for providing a curved contoured surface on a magnetic transducer adapted to read data from a nonrigid surface such as a magnetic tape.

In U.S. patent 4,914,868, Church et al disclose a lapping control system for a row of thin film MR type magnetic transducers that are mounted on a beam member capable of being deflected in a quadratic curvature when subjected to a force from a pressure transducer at the middle of the beam member. The resistance of each MR element is measured during lapping and a control signal is generated to control the pressure transducers. As the deflection of the beam member is changed, the angle between the row of transducers and the lapping plate is also changed. U.S. patent 4,912,883 to Chang et al. discloses a similar system.

The prior art also discloses various arrangements for grinding or lapping lens blanks which employ grinding wheels and lapping plates wherein the position of the blank is controlled relative to the abrading surface by various feedback arrangements.

The prior art does not disclose a system for providing a contoured curved surface on an overly narrow transducer in which the angular position of the transducer relative to the planar surface of the lapping plate is controlled with time, based on a feedback signal that is indicative of the amount of material remaining on the transducer element.

SUMMARY OF INVENTION

An object of this invention is to provide an improved system for providing a desired curvature on the surface engaging portion of a transducer.

Another object of the invention is to provide a system for providing a curvature to the medium engaging end of a magnetic transducer in which the transducer is rocked on an axis disposed parallel to a flat lapping plate.

A further object of the invention is to provide an automatic system for contouring the medium engaging end of a transducer by rocking the transducer about an axis parallel to a flat lapping plate in a direction perpendicular to the transducer element. The contouring is achieved under control of a feedback signal which is developed by means of the transducer or other sensing device and supplied to a servo system that controls the rate and extent of the rocking motion.

In accordance with this invention, the relative angle between a transducer and a lapping plate is continuously varied by mechanical means. The value of the relative angle is controlled by a control system. The control system typically includes a data processor or computer and actuators for controlling the relative angle and for sensing the throat height of the transducer while it is lapped. The control system provides an output signal that is applied to a servo motor actuator or other means for establishing the desired relative angle.

The flat plate lapping system of this invention creates a curved surface on the media engaging portion of a transducer. The system includes a means for mounting the transducer such that the surface to be contoured is held in contact with the flat lapping plate as the plate rotates past the surface being contoured. The means for mounting the transducer allows for vertical motion of the surface of the lapping plate such that the transducer may follow the plate surface while a continuous controlled force is applied to the transducer against the plate surface. The mounting means also allows for rotation of the transducer about a pivot axis which is parallel to the plane of the lapping plate. This rotation about the pivot axis is repeated in a rocking motion while the head is forced against the lapping plate. The exact contour is realized by controlling both the rotation rate of the rocking motion as a function of the relative angle to the plane of the lapping plate and also the total excursion of the rocking motion. In an implementation of the invention, the system further employs a sensing means, which includes the transducer or other sensing elements, to determine the amount of material that has been removed or that remains to be removed. The rotational rate of the rocking motion, the total excursion of this motion, as well as the force applied, are varied with time in response to a preprogrammed algorithm which uses the above mentioned sensing means as an input. The lapping operation then automatically is concluded when the correct amount of material has been removed and the desired contour has been achieved.

The system is very flexible for providing a wide range of contours with simple or complex curvatures.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the drawing in which:

Fig. 1 is a schematic block diagram of an automatic lapping system, made in accordance with the present invention;

Fig. 2 is an enlarged representation of a typical prior art magnetic transducer illustrating an MR read element and an inductive write element disposed adjacent to a magnetic tape, partly shown;

Fig. 3 is an oblique view of an embodiment of the transducer holder and pivoting mechanism.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The system shown in Fig. 1 comprises a flat plate lapping apparatus designated by reference character 10. The lapping apparatus includes a horizontal round flat lapping plate 11 which is mounted for rotation about a vertical axis by a shaft 12. As shown, the plate 11 is attached to the shaft 12 that is rotated by a motor 14. A motor control block 16 provides both electrical power and control signals to the motor 14.

The system also includes means 20 for mounting a magnetic transducer 5 above the plate 11 so that the media engaging end of the transducer is disposed adjacent to the plate. The mounting means 20 includes a holder 21 in which the transducer 5 is removably clamped. The holder 21 is attached to a reciprocating shaft 22. The transducer holder 21 has an end portion 23 disposed above the shaft 22, which is connected to a rocker mechanism 26. Operation of mechanism 26 imparts a rocking motion to the end portion 23 of the holder 21 by moving the connecting member 28 back and forth in a horizontal direction, thus applying a rocking motion to the transducer 5.

The extent of the rocking motion can be defined as an angle through which the plane of the transducer is rotated, measured from the vertical position where the transducer is normal to the lapping plate 11. The details of the rocking unit 26 are not shown in that the details per se are not necessary for explanation and understanding of the invention. Various arrangements known in the art can be employed in the system of Fig. 1 to cause the pivotably mounted end portion 23 of the holder 21 to experience a controllable rocking motion with the range of motion and velocity being the controlled parameters.

The system also includes an arrangement for varying the position of the holder 21 in a direction perpendicular to the plane of the lapping plate. The movement adjusts the vertical position relative to the plate 11 during the lapping operation. A fixed or adjustable force is applied to the transducer by force actuator 30 to bear it against the lapping plate. The pivot axis is allowed to float as material is lapped away. This also allows the transducer to follow the surface of the plate.

In one embodiment of the invention, the transducer 5 includes a signal generating arrangement which provides an indication of the amount of material that has been lapped or that remains at any given time in the lapping process. As is known in the prior art, the resistance of a magnetoresistive element is measured and an electrical control signal is produced which gives an accurate indication of the amount of material that remains to be removed. In the case of an inductive transducer, the inductance may be measured to determine the electronic throat height. As shown in Fig. 1, line 31 extending from transducer 5 to the control system 40 enables a control signal to be generated, corresponding to the amount of material to be removed before the lapping operation is terminated.

It should be understood that prior to any lapping, the end of the transducer 5 is basically a rectangular block, having the long sides perpendicular to the rocking direction. Initially, the block is placed in lapping contact relationship with the plate 11 as the plate is rotated. The rocking mechanism is then energized to impart a rocking motion to the end of the transducer in contact with the plate. In theory the amount of material being removed per unit of time is a function of the area in contact with the lapping plate and the linear speed of the plate relative to that area and the force applied. The control system 40 is pre-calibrated to adjust the rocking angle at a rate determined by the angle and by the signal fed back from the transducer 5. The algorithm may be changed with the progression of time or the amount of material remaining to be removed so that the proper contour is achieved when the throat height is correct.

The control system 40 is provided with means to manually control parameters such as the speed of rotation of the lapping plate 11, the initial throw of the rocker mechanism 26, which determines the angle of rocking through which the plane of the thin transducer element is rotated, and the initial rate at which the rocker mechanism operates. These initial values may then be modified from the control signals supplied from the transducer and/or the passage of time.

Fig. 2 is an enlarged view of the transducer in contact with a section of magnetic tape, illustrating how the contoured section of the tape engaging end of the transducer conforms to an engaging medium.

The novel lapping system employs a predetermined pattern of varied angular positions while the lapping plate is rotated. In this way, the desired contour and throat height of the transducer are produced. The control system 40 preferably includes a signal processor that has a programmed unit, which receives the data relating to the amount of remaining material to be removed.

Claims

1. A system for providing a predefined curvature to the distal end portion of a transducer (5) comprising:

lapping means including a flat lapping surface (11) having an axis of rotation disposed normal to said lapping surface during a transducer lapping operation;

means for positioning said transducer relative to said surface with said transducer disposed with said distal end portion in lapping engagement with said surface; and

means (26) for rocking said transducer (5) about a pivotal axis to form a desired curvature to said distal end of said transducer (5).

2. A system as in Claim 1, in which said positioning means includes

a transducer holder (21);

a shaft (22) or pivot bearing means for mounting said holder (21) for pivotal movement;

means (20) for mounting said shaft (22) coaxially with said pivotal axis; and

means for adjusting the position of said holder (21) as said transducer (5) is lapped such that the transducer (5) follows the lapping surface (11) as said surface rotates and as said transducer (5) is moved in a rocking motion.

3. A system as in Claim 1 or 2 in which said rocking means includes a reciprocating member connected to said holder (21) remote from said transducer (5) for pivoting said holder (21);

means for varying the position of said reciprocating member to change the angle of said transducer as it is being lapped.

4. A system as in anyone of Claims 1 to 3, in which a control system (40) is coupled electrically to said transducer (5) or a sensing means for receiving an input signal representative of the position of said transducer (15), and for providing an output control signal responsive to said input signal, said output control signal corresponding to the desired and time varying position.

5. A system as in Claim 4, in which said control system (40) is connected for supplying said output control signal to said rocking means (26).

6. A system as in Claim 4 or 5, in which said control system (40) comprises signal processing means including data storage means for converting said input signal from said transducer (5) or sensing device to said output control signal.

7. A system as in Claim 6, in which said signal processing means comprises a programmed digital processing unit, and means for entering data to said processing unit related to said curvature of said transducer (5) prior to the start of said lapping operation, said data being used during said lapping operation to convert said input signal to said output signal.

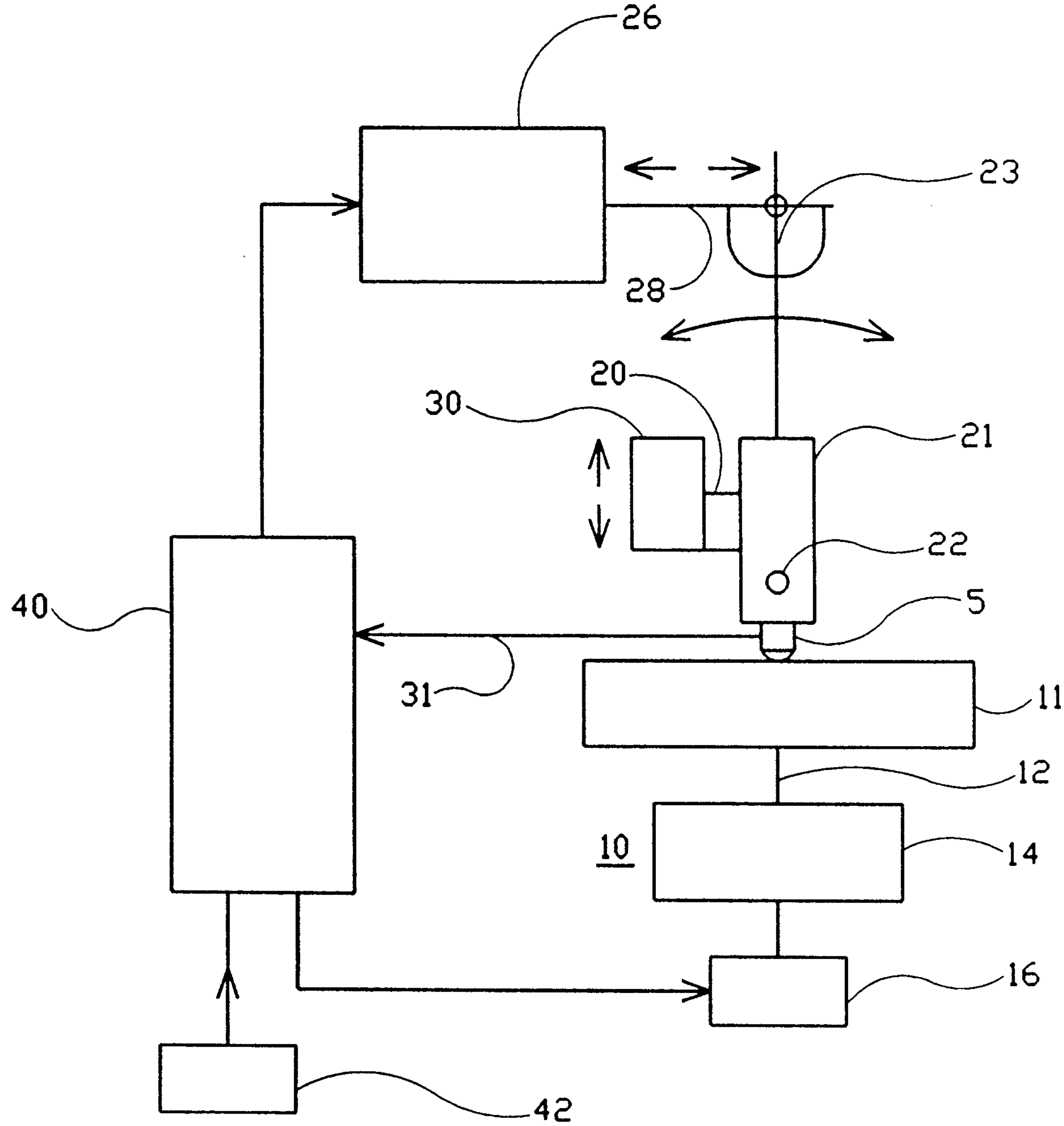

Fig 1

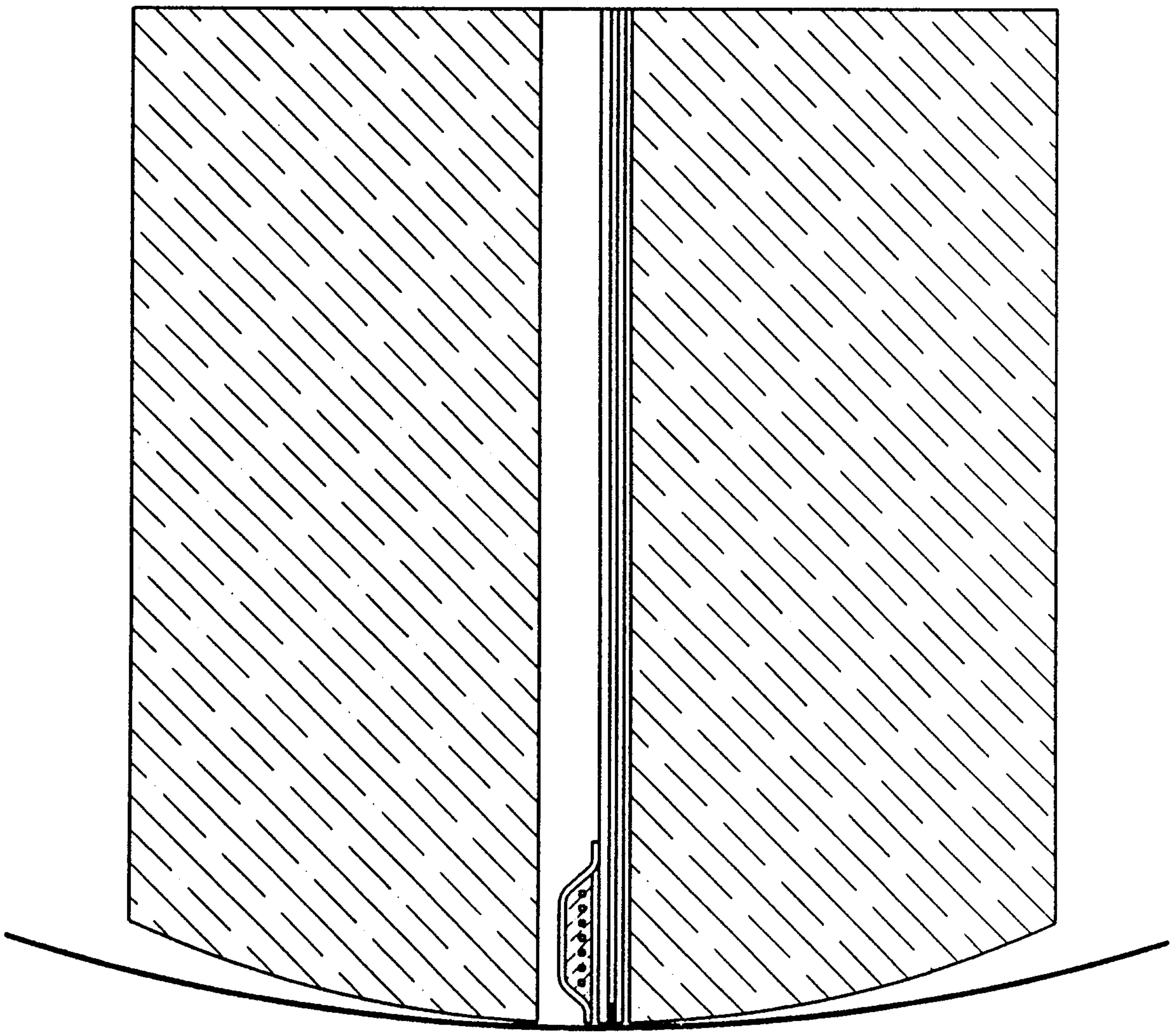

Fig 2

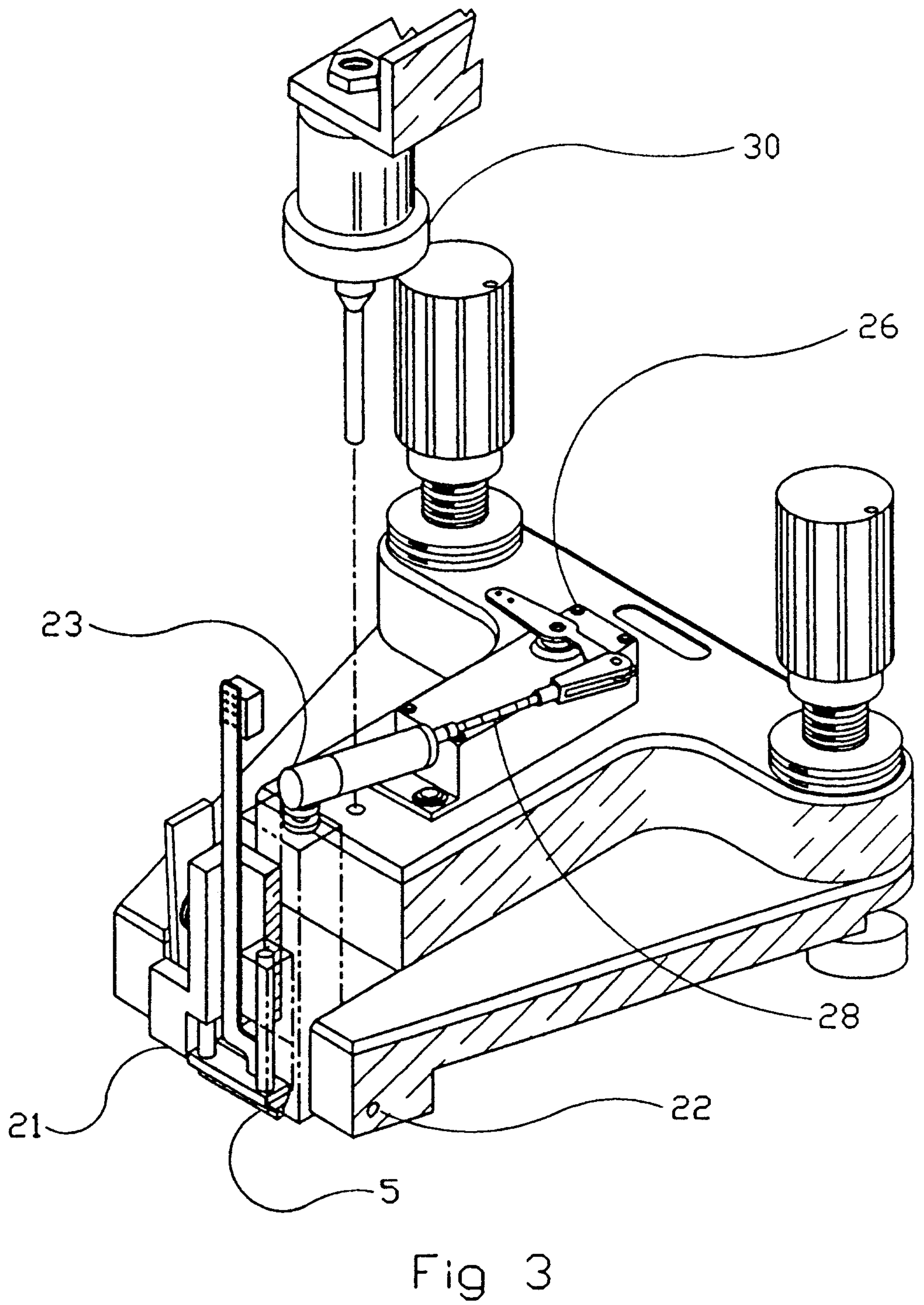

Fig 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 10 8941

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.6)
X	US-A-4 536 992 (D. HENNENFENT) * column 8, line 9 - line 34; figure 1 * ---	1-3	B24B37/04
P,X	WO-A-94 29077 (BYELOCORP SCIENTIFIC) * page 13, line 1 - line 13; figure 2 * ---	1	
A	EP-A-0 504 887 (READ-RITE CORP.) * abstract * ---	4-7	
A	DE-B-27 28 915 (W. SEIBERT) ---		
A	US-A-4 660 330 (O. FUCHS) ---		
A	WO-A-88 08357 (CH. SMITH) ---		
A	DD-A-232 664 (VEB RATHENOWER OPTISCHE WERKE) ---		
D,A	US-A-4 912 883 (M. CHANG) ---		
A D,A	EP-A-0 361 778 (IBM) & US-A-4 912 883 -----		TECHNICAL FIELDS SEARCHED (Int.Cl.6) B24B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	20 September 1995	Korth, C-F

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
P : intermediate document

T : theory or principle underlying the invention
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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