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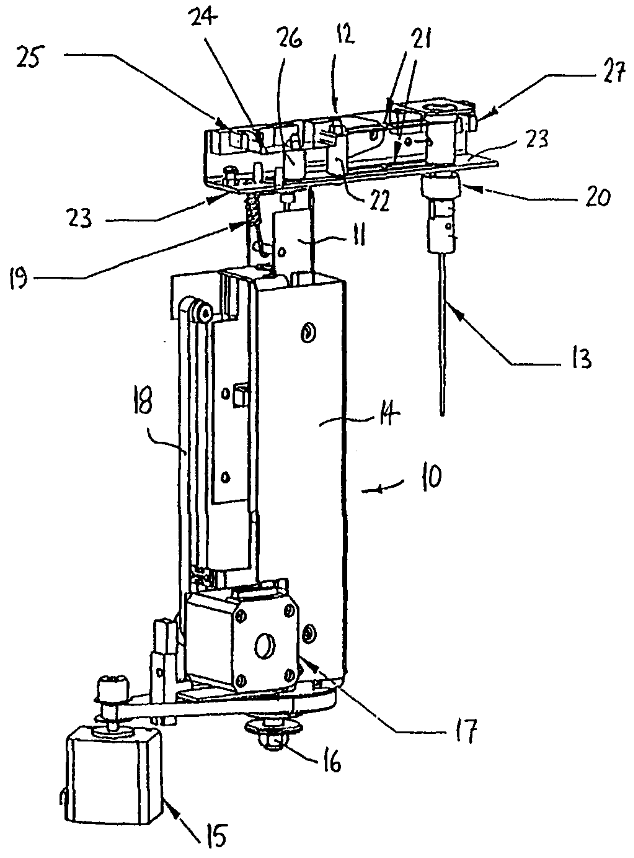
(54) Title: LABORATORY SAMPLING PROBE POSITIONING APPARATUS

(57) Abstract

A probe mounting and positioning mechanism in automated clinical laboratory testing instruments comprises a probe supporting arm (12) which is mounted, adjacent one end, on the top of a support column (11) and at the other end supports a probe (13). The column (11) is moveable up and down in a frame (14) which is itself mounted for pivotable movement whereby the probe arm and hence the probe may be positioned to obtain and dispense biomedical samples. The probe (13) is mounted on the arm (12) via a probe mount (20) for limited axial movement relative to the arm by means of parallel leaf springs. The arm (12) is mounted on the column (11) by a dislocating joint which is held together by a spring (19). Movement of the probe relative to the arm or dislocation of the joint during collisions of the probe or arm, are detected by respective optical sensors.



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TITLE: LABORATORY SAMPLING PROBE POSITIONING APPARATUS

This invention relates to sampling probes in automated clinical laboratory testing instruments and more particularly to a mechanism for accurate positioning of a sample probe in such an instrument.

These instruments typically perform a range of standard clinical tests on biomedical samples such as blood serum, plasma or urine and operate by combining accurately measured quantities of sample with accurately measured quantities of a chemical reagent and monitoring the reaction products using one or more possible detection techniques. Samples and reagents are typically presented in racks, carousels or trays of some description and may be accessed randomly by the probe that withdraws accurately metered quantities of fluid and transfers this to a reaction or measurement location.

Samples will be typically presented in test tubes or cups that may vary in size from approximately 2 to 15 mm in target diameter. Similarly, the access holes in the reagent containers may be 10 to 20 mm in diameter.

Such instruments are normally intended for very rapid sample test throughput and may achieve from 200 to 2000 tests performed in an hour. To achieve this, the sample probes are moved at very high speeds by robotic mechanisms that must achieve rapid and accurate positioning in both horizontal and vertical directions.

The requirements for such a positioning mechanism would include:

1. The ability to position the probe over a nominated target position to a tolerance of about ±0.25 mm or on occasion significantly better.

2. The ability to position the probe vertically to a target nominal height with a tolerance of ±0.2 mm or better.

3. The ability to move and stop rapidly without undue disturbance to the fluid being transported, such as loss of fluid through undue vibration.

4. Provide the capability to position the probe over a number of pre-defined stations, which may be sample cups, reagent containers, reaction vessels, cuvettes, washing stations and the like.

5. The ability to move between specified positions or sampling stations in under typically 0.5 seconds.

In addition, it would be normal that the mechanism provide:

6. A means of sensing the fluid surface and stopping the probe tip at or just below the surface.

7. A means of sensing an obstruction below the probes such that when the probe contacts an unexpected obstacle, such as the bottom of an empty test tube, downward motion may be halted to protect the probe.

In general it has not been usual to provide the mechanisms with protection against collisions in other directions.

There are a number of shortcomings with existing technologies in this area, including the following:

1. These mechanisms are typically very expensive to produce as they often involve precision engineering to achieve the positioning tolerances required.

2. Typically they are quite heavy as a result of item 1 and require significant forces, (motor sizes) to move at the required speed.

3. Also as a result of 1 and 2, a collision with an unexpected obstruction while travelling at high speed results in physical damage to the mechanism, or at best misalignment such that positioning accuracy no longer achieves the required tolerances.

4. They are typically not robust against wear, dirt etc. that may impact their ability to maintain performance in the longer term.

5. They require lengthy precision factory alignment before use, and this alignment may be difficult to reproduce in the field when service is required.

6. Sensing collisions with obstructions under the probe ("crash detection") involves the movement of a significant mass, typically involving the probe, its support arm or structure and an attached sensing mechanism. At the speeds involved this imparts a significant impact load to the probe tip and may cause damage over time.

Accordingly, it is an object of this invention to provide an improved mounting and positioning mechanism that overcomes one or more of the aforementioned shortcomings of the existing mechanisms.

Therefore the invention provides a probe mounting and positioning mechanism in automated clinical laboratory testing instruments, said mechanism including a probe supporting arm, a probe mounted on one end of said arm for limited longitudinal movement relative to said arm and a sensor for detecting occurrence of said longitudinal movement.

Another form of the invention provides a probe mounting and positioning mechanism in automated clinical laboratory testing instruments, said mechanism including a probe supporting arm extending substantially horizontally from the top of a support column, said arm being connected to said column by a dislocating joint whereby collision forces on the arm, or on a probe extending from said arm, cause dislocation of the joint and said joint including means to facilitate ready relocation and consequent alignment of the joint.

In order that the invention may be more readily understood, a particular embodiment will now be described with reference to the accompanying drawings wherein;

FIG. 1 is a perspective view of a probe mounting and positioning mechanism according to the invention,

FIG. 2 is a view similar to FIG. 1 but from the opposite side,

FIG 3 is a perspective view on an enlarged scale of part of a probe mounting and positioning mechanism according to a second embodiment of the invention and,

FIG 4 is a perspective view from the opposite side of part of the mechanism shown in FIG 3.

Referring now to Figures 1 and 2, the mounting and positioning mechanism 10 consists essentially of a support column 11, a probe supporting arm 12 and a probe 13. The support column 11 is mounted vertically within a frame 14 which is separately mounted for rotation on a main machine frame (not shown) whereby actuation of stepper motor 15 causes the frame 14, and hence the support column 11 to pivot about longitudinal rotation axis 16. Vertical movement of the support column 11 within the frame 14 is controlled by further stepper motor 17 via belt drive 18.

The probe supporting arm 12 is mounted at one end of the arm onto the top of the support column 11 by a dislocating joint which is displaced if a collision force occurs on the arm 12. The two parts, that is, the supporting arm 12 and support column 11 each have a flat surface where the two parts mate and although it is not clearly evident in Figures 1 and 2 the flat surface of the supporting arm 12 has three hemispherical protrusions two of which are located in corresponding recesses in the flat surface at the top of column 11. The third protrusion is the head of an adjustable screw which bears on the flat surface at the top of the column 11.The shape and location of the recesses (not shown) is such that the supporting arm 12 is positively and accurately located relative to the column 11 and a retaining spring 19 holds the two parts together. Should a collision force occur on the arm 12 or the probe 13, the hemispherical protrusions are cammed out of the recesses and the joint dislocates thereby avoiding any damage to the mechanism.

The probe 13 is mounted at the other end of the arm 12 in a manner allowing a small vertical movement of the probe 13 relative to the supporting arm 12. The mounting arrangement of the probe 13 comprises a probe mount 20 which is connected to the arm 12 via parallel leaf springs 21. The leaf springs 21 are connected to post 22 which is mounted on a lower flange 23 of the arm 12. The springs 21 are spaced apart and essentially form a parallelogram mount that maintains the vertical alignment of the probe while allowing several millimetres of vertical movement to absorb any shock during a collision. In other words, the probe mount 20 is able to move vertically up and down a short distance on the springs 21 whilst maintaining vertical alignment. The springs 21 work against each other to produce a net downward force on the probe 13. This force is well controlled and almost constant over the distance of travel of the probe mount and allows a simple and quick assembly without spring adjustments to achieve a working force within a specified range, typically 40-60 grams.

Although it is not clearly evident in figures 1 and 2, the upper leaf spring 21 extends beyond the probe mount 20 and has a downwardly extending tab at its end. The tab (not shown) breaks the beam of a first optical sensor 27 which detects when there is any vertical movement of the probe 13. In this way a collision between the probe 13 and an unexpected obstacle, such as the bottom of an empty test tube, is detected. In this manner downward movement of the probe may be halted to protect the probe.

In a similar manner, the opposite end of the upper leaf spring is extended to provide a collision sensor flag 24 for a second optical sensor 25 that is positioned so that any movement of the arm 12 from its mount, that is, any dislocation of the joint, will be detected due to the upwardly turned end of the upper leaf spring either moving into or out of alignment with a beam of the second sensor 25. This movement of the collision sensor flag 24 occurs due to its mounting on post 26 which, through an aperture in the arm 12, is mounted on the top of column 11.

Figures 3 and 4 show a further embodiment of the invention which in principle of operation is the same as the embodiment shown in Figures 1 and 2. The larger scale of the drawings enables this second embodiment to be seen more clearly and those parts which are the same or similar to parts in the first embodiment have the same reference numerals.

As is evident in Figure 3, the probe mount 20 is arranged at the distal end of the leaf springs and the tab for breaking the beam of first optical sensor 27 is an upstanding tab 28 located on the lower leaf spring 21 between its fixed mounting point (bolt 29) and its distal end 30. A printed circuit board 31 with circuit components is attached to the probe mount 20 between the leaf springs and moves up and down with movement of the probe mount 20. The first optical sensor 27 is mounted on the underside of the circuit board 31.

A post 32 is fixed to the top of support column 11 and bears on the underside of a cantilevered extension portion 33 of upper leaf spring 21. The upper leaf spring 21 is fixed to the probe supporting arm 12 by means of bolts 34 and 35. It will be evident that any dislocation of the joint between arm 12 and column 11 will cause the arm to be raised relative to the column whereby the post 32 will move away from the underside of the extension portion 33 of spring 21. This causes tab 36 at the end of the extension portion 33 to move down and into the beam of second optical sensor 25 whereby the beam is broken and the dislocation of the joint is sensed. The second optical sensor 25 is mounted on the arm 12.

Referring now to Figure 4, the joint between the column 11 and probe support arm 12 is shown more clearly. A plate 37 on the top of column 11 has an elongate hole 38 and a further hole (not evident in the drawings) which is a circular hole. The circular hole is in line with the longitudinal axis of the hole 38. A protrusion 39 on a plate 40 forming part of the arm 12 is accommodated in the hole 38 when the joint is properly located and the protrusion 39 is prevented from transverse movement (relative to the longitudinal axis of the hole) in the hole. A similar protrusion (not evident in the drawings) is located in the circular hole and thus between the two protrusions and two holes the arm 12 and column 11 are positively located relative to each other. The purpose of the elongate hole 38 is to allow for manufacturing tolerances. A further similar protrusion (also not shown) on the underside of plate 40 is the head of a screw and bears on the top surface of plate 37. This further protrusion is adjustable to allow levelling of the arm 12 relative to the column 11. In other words the arm 12 is effectively supported at three points (the three protrusions) on the plate 37. Spring 19 holds the joint together except when collision forces overcome the force of the spring.

The above description covers the items essential to the probe mounting and positioning mechanism of the invention. Those features not specifically described will be readily apparent to persons skilled in the art and do not constitute part of the invention.

It should be apparent from the description above, that the mounting and positioning mechanism of the present invention addresses a number of the shortcomings described above in relation to existing mechanisms. The present invention incorporates a number of design features which provide advantages over the prior art. For example, the feature of vertical "crashed detection" provides sensing through movement of the probe itself and its immediate mounting support, rather than relying on transmission of the motion through the probe arm support and other massive interconnections to a sensing device. The unique mounting arrangement maintains extremely stringent positioning accuracy while dramatically reducing the impact load during a crash.

Where traditionally the probe body would be mounted rigidly to a supporting arm and structure, all of which must move in the case of a collision, the present invention employs two parallel leaf springs to support the probe independently of the main arm structure. The probe mount is supported against lateral movement to prevent distortion of the springs in case of a sideways collision. As a consequence, the present invention incorporates reduced fabrication complexity, a set up free assembly approach, reducing assembly time and costs and reduced costs of materials. Furthermore, the mechanism of the present invention is extremely robust against degradation of performance through wear, dirt etc and provides improved lifespan for the probe due to decreased crash severity.

In addition, the unique dislocating joint which has been incorporated into the probe support arm, connecting the arm to its mounting column, provides 6 degrees of freedom for protection of the mechanism against damage through collisions with the probe and its supporting arm while moving in any direction. The new mechanism can collide with an obstruction during any motion, or be struck from any direction, without permanent physical damage or misalignment requiring service intervention. Therefore, the joint mechanism also provides protection from collision in any direction, automatic sensing of collision thus enable error reporting and simple assembly procedure. The mechanism is resettable to a tolerance of ± 0.1 mm in ten seconds without the use of tools and again involves extremely low cost materials which do not suffer from wear. The design may be manufactured completely from sheet metal fabrication and requires no casting or precision finishing, which is common on similar prior art mechanisms.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A probe mounting and positioning mechanism in automated clinical laboratory testing instruments, said mechanism including a probe supporting arm, a probe mounted on one end of said arm for limited longitudinal movement relative to said arm and a sensor for detecting occurrence of said longitudinal movement.

2. A mechanism according to Claim 1 wherein said probe is held in a probe mount that is mounted on said arm in a manner facilitating said limited longitudinal movement of the probe, said probe mount being supported on said arm by parallel leaf springs forming opposite sides of a parallelogram mount, wherein respective first ends of said springs are fixed to said arm and respective other ends of said springs are connected to said probe mount.

3. A mechanism according to Claim 2 wherein said arm extends substantially horizontally and said longitudinal movement is in a vertical direction, said parallelogram mount maintaining vertical alignment of said probe over a short vertical movement of the probe, said springs being tensioned to work against each other and produce a net downward force on the probe mount which is substantially constant over the distance of travel of the probe relative to the arm.

4. A mechanism according to Claim 2 or 3 wherein one of said springs provides both a vertical travel stop and an indicator flag for said sensor, said stop and flag comprising an upstanding tab on said spring, said sensor being an optical sensor that senses said tab moving into or out of alignment with a beam of said sensor.

5. A mechanism according to Claim 2, 3 or 4 wherein said probe mount is supported against lateral movement to prevent distortion of the springs in the event of a sideways collision of the probe.

6. A mechanism according to any one of the preceding claims wherein the other end of said arm is supported at the top of a support column by means of a dislocating joint whereby collision forces on the probe or the supporting arm cause dislocation of the joint, and said joint including means to facilitate ready relocation and consequent alignment of the joint.

7. A probe mounting and positioning mechanism in automated clinical laboratory testing instruments, said mechanism including a probe supporting arm extending substantially horizontally from the top of a support column, said arm being connected to said column by a dislocating joint whereby collision forces on the arm, or on a probe extending from said arm, cause dislocation of the joint, and said joint including means to facilitate ready relocation and consequent alignment of the joint.

8. A mechanism as defined in Claim 6 or 7 wherein said joint includes flat mating surfaces on said arm and said column, respectively, one said flat surface having protrusions which locate in spaced recesses in the other said surface to positively locate the arm relative to the column thereby providing said means to facilitate ready relocation and alignment of the joint.

9. A mechanism as defined in Claim 8 including a spring for maintaining location of said joint in normal circumstances.

10. A mechanism as defined in Claim 8 or 9 wherein said protrusions comprises two protrusions located in respective said recesses and an adjustable protrusion that bears on the other said surface.

11. A mechanism as defined in Claim 10 wherein one said recess is circular whereby the protrusion located therein is restrained against movement in any direction and the other said recess is elongated with its longitudinal axis extending in a direction preventing rotational movement of one plate relative to the other whilst allowing for manufacturing tolerances.

12. A mechanism according to Claim 11 wherein a further optical sensor is provided to sense said dislocation of said joint.

13. A mechanism according to Claim 12 wherein said further optical sensor comprises a beam, and a tab on an extended portion of said upper spring moves into or out of alignment with said beam when dislocation of said joint occurs, said extended portion being supported on a post at the top of said support column, which post normally supports said extended portion but allows said extended portion to drop when said dislocation occurs.

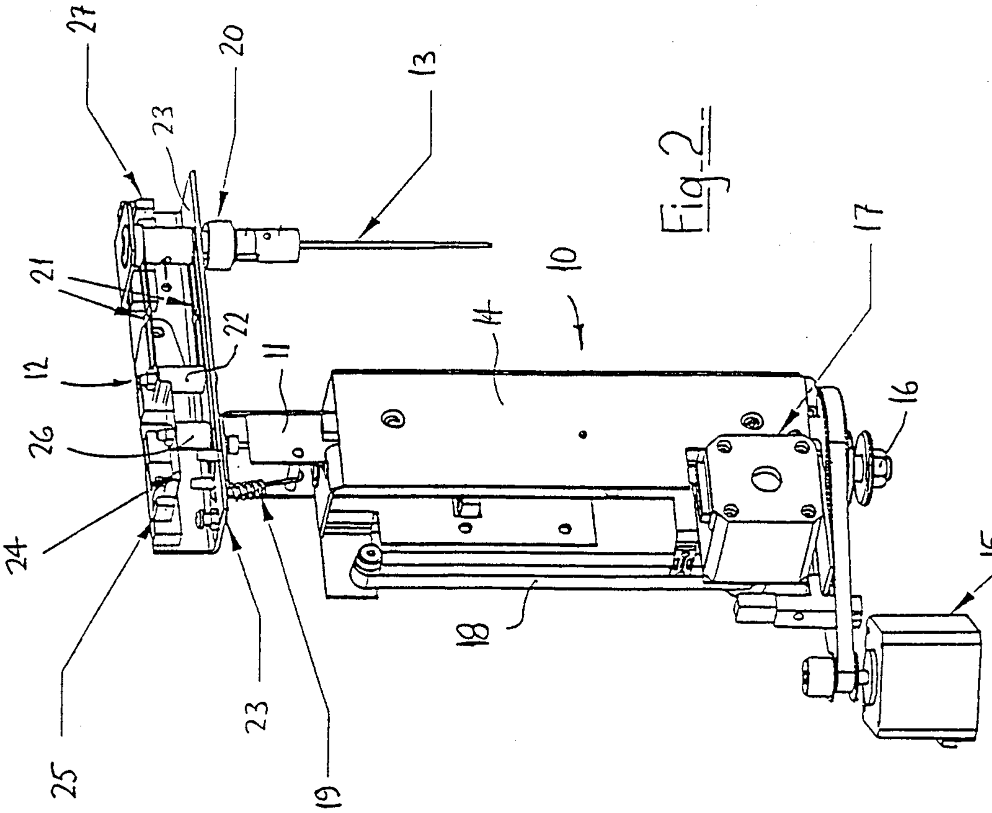
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Fig 2

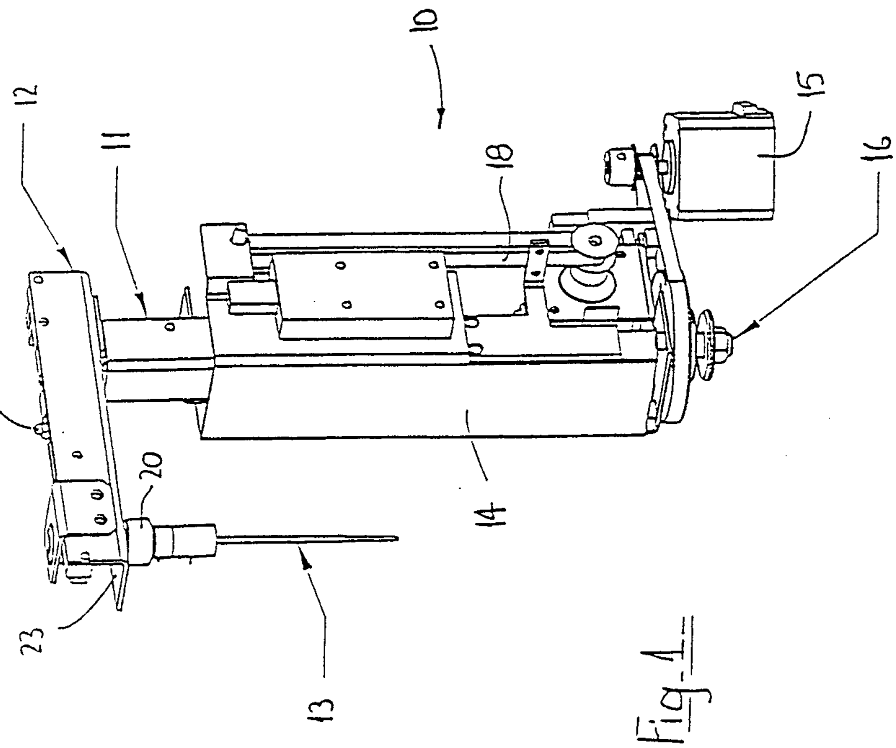
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Fig 1

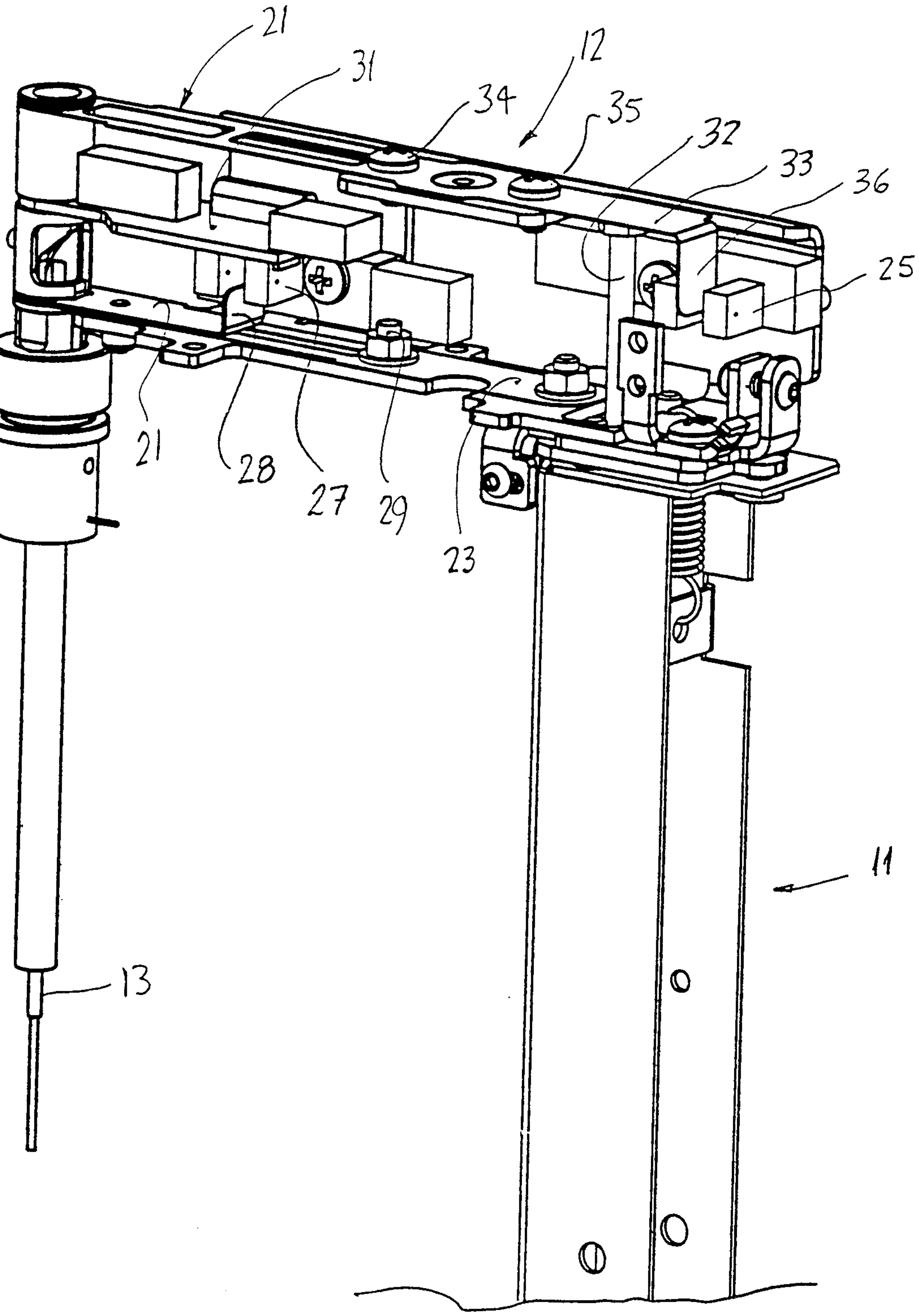

Fig. 3

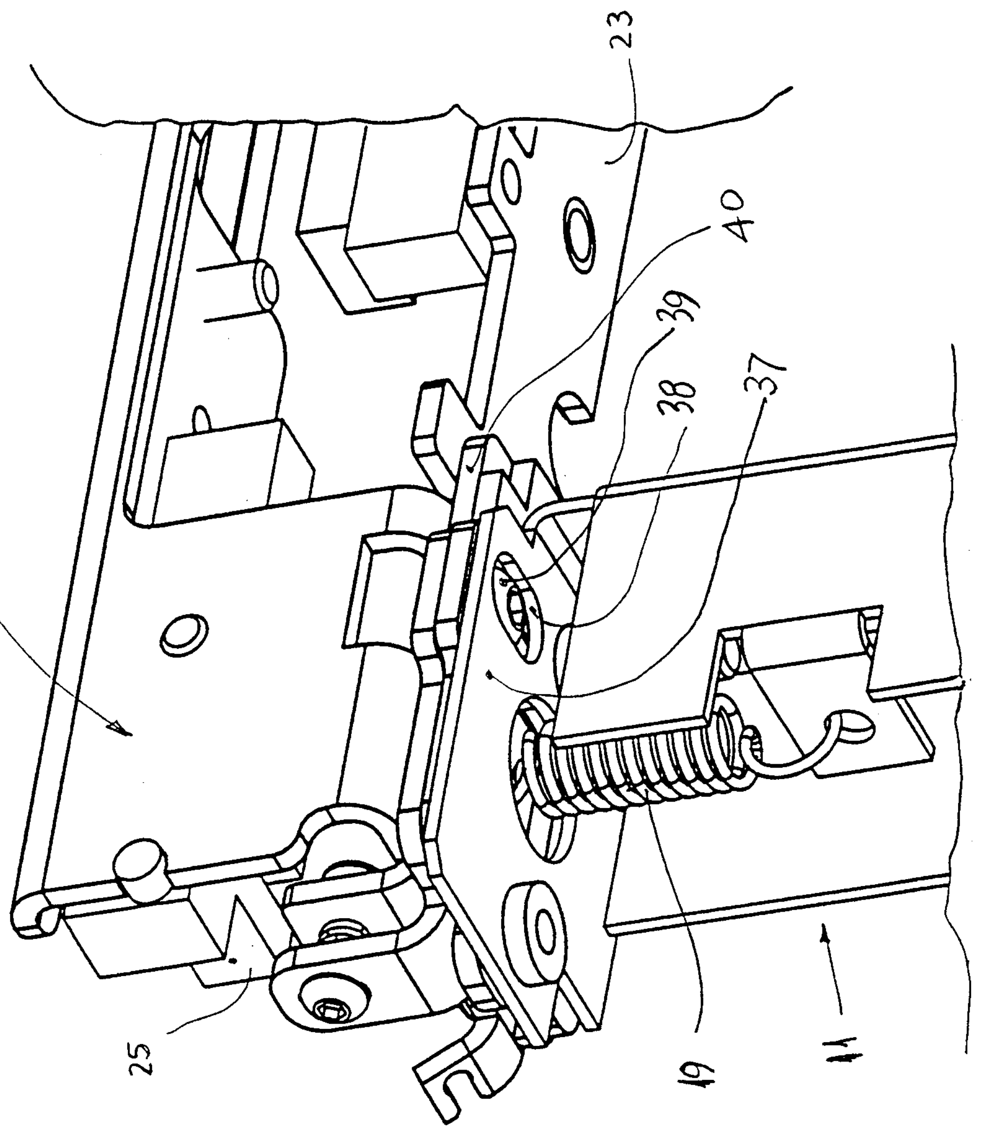

Fig 4.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00521

A.	**CLASSIFICATION OF SUBJECT MATTER**
Int Cl[6]:	G01N 1/14, 1/10, 35/10, B25J 13/08, 19/02, F16D 3/02

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)
B25J 9/-, 13/08, 19/-, F16D 3/02, G01N 1/-, 35/-, G05D 3/-

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT, JAPIO (SENS:, DETECT:, STOP:, COLLISION#, CRASH:, HALT:, DISLOCAT:, POSITION:, MOTION:, MOUNT:, LOCAT:, SPRING#, PROB:)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 4915574 A (PARK et al) 10 April 1990	
X	See Abstract, columns 3 and 4	1
Y	See column 5	6,7
	US 5240679 A (STETTLER) 31 August 1993	
Y	See abstract	6,7
	Patent Abstracts of Japan,	
P,X	JP 10-246690 A (SHIMADZU CORP) 14 September 1998	1

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 July 1999	23 JUL 1999

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00521

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4580941 A (INABA et al) 8 April 1986 See abstract and column 3	1-13
A	DD 276647 A (ZENTRALES FORSCHUNGSINSTITUT DES VERKEHRSWESENS) 7 March 1990 See abstract	1-13
A	DD 252512 A (VEB ELEKTROPROJEKT UND ANLAGENBAU BERLIN) 23 December 1987 See abstract	1-13
A	US 5204598 A (TORII et al) 20 April 1993 See abstract	1-13

Box 1 Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Claim 1 relates to a probe mounting and positioning mechanism that includes a probe supporting arm and a probe, on the end of the arm, for limited movement relative to the arm with a sensor to detect longitudinal movement of the probe.
Claim 7 relates to a probe mounting and positioning mechanism that includes a dislocating joint for a probe arm with means to relocate and align the joint if a collision occurs on the arm.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU 99/00521

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	5240679	CA	2046813	EP	478905	JP	4290942
US	4580941	EP	88559	JP	58155193		
US	5204598	EP	474881	JP	3281194	WO	9114544

END OF ANNEX