(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 753 120 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
22.07.2009 Bulletin 2009/30

(21) Application number: **05741265.2**

(22) Date of filing: **20.05.2005**

(51) Int Cl.:
H01L 41/09 *(2006.01)*

(86) International application number:
PCT/JP2005/009229

(87) International publication number:
WO 2005/114825 (01.12.2005 Gazette 2005/48)

(54) METHOD AND DEVICE FOR PRECISELY RESISTING AND MOVING HIGH LOAD

VERFAHREN UND EINRICHTUNG ZUM PRÄZISEN WIDERSTEHEN UND BEWEGEN HOHER LASTEN

PROCEDE ET DISPOSITIF POUR OPPOSER UNE RESISTANCE A UNE CHARGE ELEVEE ET POUR LA DEPLACER AVEC PRECISION

(84) Designated Contracting States:
CH DE FR GB LI

(30) Priority: **20.05.2004 JP 2004150134**

(43) Date of publication of application:
14.02.2007 Bulletin 2007/07

(60) Divisional application:
07003909.4 / 1 793 432

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Printed by Jouve, 75001 PARIS (FR)

EP 1 753 120 B1

Description

Technical Field

[0001] The present invention relates to a precise and high load resistance moving device, and more particularly, relates to a precise and high load resistance moving method and device suitable for a precise moving mechanism using a wedge and a piezoelectric element and a fine moving mechanism for a microscope.

Background Art

[0002] Fig. 1 is a known positioning device of a stage as an impact driving mechanism by a rapid deformation of a piezoelectric element.

[0003] In the drawing, reference numeral 101 denotes a floor surface of a fixed part, reference numeral 102 denotes a wall surface of the fixed part, reference numeral 103 denotes a wedge-shaped moving body, reference numeral 104 denotes a piezoelectric element which is fixed to a side surface of the moving body 103, reference numeral 105 denotes an impact element which is fixed to a tip part of the piezoelectric element 104, reference numeral 106 denotes a stage which moves in a vertical direction by a movement of the wedge-shaped moving body 103, and reference numeral 107 denotes a guide of the moving body 103 by a spring. Although it is not shown in the drawing, to the piezoelectric element 104, a pulse voltage source which generates a rapid deformation of the piezoelectric element 104 is connected (see non-patent document 1 below).

[0004] Moreover, as the mechanism for moving a moving body by a rapid deformation of a shear piezoelectric element, the following mechanism is disclosed (see non-patent document 2).

[0005] Fig. 2 is a schematic view of such known mechanisms for moving the moving body by the rapid deformation of the shear piezoelectric element.

[0006] As illustrated in the drawing, conventionally, a piezoelectric element 202 which deforms in a shear direction is sandwiched between a main body 201 and a leg 203, and voltage of saw-tooth wave is applied to the piezoelectric element 202 to generate a movement.

> Non-patent document 1: Tseng KuoHao, Shibuya Toshikatsu, Higuchi Toshiro, "Development of a Precise Position Adjuster Utilizing Piezo Actuator for Heavy Load" Proceedings of JSPE annual spring meeting 2002, pp112.
> Non-patent document 2: Ph. Niedermann, R.Emch, and P.Descouts, Rev.Sci.Instrum., 59, 368,(1988).

Disclosure of Invention

[0007] However, in the above-described known impact driving mechanism, impulse force is applied to the side surface of the moving body 103, and driving force which actually contributes to the movement of the moving body 103 is weak. Accordingly, while strong impulse force is required for the movement, the moving speed is slow and it is difficult to precisely adjust the moving body.

[0008] Moreover, in the above-described known mechanism for moving the moving body by the rapid deformation of the shearing piezoelectric element, the moving body is directly moved in the vertical direction by the rapid deformation of the shear piezoelectric element 202. However, there are disadvantages, for example, that a selection width of pressure to the sliding surface is narrow, the moving speed is slow, the load resistance is low, displacement after the positioning by the application of the force in the vertical direction, and it is not possible to maintain stable movement at several to ten nanometers.

[0009] JP-A-2003-134859 describes a piezoelectric actuator which comprises a piezoelectric element and a mass body which are configured to move first and second moving bodies.

[0010] In view of the above, embodiments of the present invention seek to provide a precise and high load resistance moving method and device in which a moving body can be precisely moved in a perpendicular direction, even when force is applied in a vertically downward direction, by using a piezoelectric element which generates a shear deformation, or, by combining the piezoelectric element which generates the shearing deformation and a piezoelectric element which generates a vertical deformation. Further, embodiments of the present invention seek to provide a precise and high load resistance moving method and device in which a moving body can be precisely moved in a perpendicular direction even when force is applied in a vertically downward direction, and positioning in xy directions or positioning of three degrees of freedom in xyz directions is possible, by arranging or layering a plurality of piezoelectric elements which generate shearing deformations so that their shear directions differ.

[0011] According to one aspect of the present invention, there is provided a precise and high load resistance moving method according to claim 1 defined hereinafter.

[0012] According to another aspect of the present invention, there is provided a precise and high load resistance moving device as defined in claim 8 hereinafter.

Brief Description of the Drawings

[0013]

> Fig. 1 illustrates a known positioning device of a stage as an impact driving mechanism by a rapid deformation of a piezoelectric element.
> Fig. 2 is a schematic view of a known mechanism for moving a moving body by a rapid deformation of a shearing piezoelectric element.
> Fig. 3 is a schematic view of a precise and high load resistance moving device illustrating a first embodiment of the present invention.

Fig. 4 is a schematic view illustrating operation of the precise and high load resistance moving device illustrating the first embodiment of the present invention.

Fig. 5 is a schematic view illustrating an example of drive pulses of the precise and high load resistance moving device illustrating the first embodiment of the present invention.

Fig. 6 is a schematic view illustrating another example of drive pulses of the precise and high load resistance moving device illustrating the first embodiment of the present invention.

Fig. 7 is a schematic view of a precise and high load resistance moving device illustrating a second embodiment of the present invention.

Fig. 8 is a schematic view of a precise and high load resistance moving device illustrating a third embodiment of the present invention.

Fig. 9 is a schematic view of a precise and high load resistance moving device illustrating a fourth embodiment of the present invention.

Fig. 10 is a schematic view illustrating operation of the precise and high load resistance moving device illustrating the fourth embodiment of the present invention.

Fig. 11 is a schematic view illustrating an example of drive pulses of the precise and high load resistance moving device illustrating the fourth embodiment of the present invention.

Fig. 12 is a schematic view of a precise and high load resistance moving device illustrating a fifth embodiment of the present invention.

Fig. 13 is a schematic view of the precise and high load resistance moving device illustrating a modification of the fifth embodiment of the present invention.

Fig. 14 is a schematic view of a precise and high load resistance moving device illustrating a sixth embodiment of the present invention.

Fig. 15 is a view illustrating waveforms applied to a layered piezoelectric element (see Fig. 9) in an ultrasonic motor mode of a precise and high load resistance moving device of the present invention.

Fig. 16 is a view illustrating behavior of a moving element by the precise and high load resistance moving device illustrated in Fig. 14.

Fig. 17 is a view illustrating a modification of a guide of the precise and high load resistance moving device according to an embodiment of the present invention.

Fig. 18 is a schematic view of a precise and high load resistance moving device provided with a sliding surface of an embodiment of the present invention.

Fig. 19 is a schematic view of a precise and high load resistance moving device (1) of an embodiment of the present invention which has a vertical positioning mechanism in which a positional potential is not changed as a whole.

Fig. 20 is a schematic view of a precise and high load resistance moving device (2) of an embodiment of the present invention which has a vertical positioning mechanism in which a positional potential is not changed as a whole.

Fig. 21 is a schematic view of a precise and high load resistance moving device (3) of an embodiment of the present invention which has a vertical positioning mechanism and a positional potential is not changed as a whole in which a moving element has a movement positioning function in xyz three axes.

Fig. 22 is a schematic view of a precise and high load resistance moving device (4) of an embodiment of the present invention which has a vertical positioning mechanism in which a positional potential is not changed as a whole and a moving element has a movement positioning function in xyz three axes.

Fig. 23 is a schematic view of a precise and high load resistance moving device of an embodiment of the present invention which positions a moving element in xyz directions using a base, two wedges, and four piezoelectric elements.

Fig. 24 is a view (1) in which displacements of a moving element of a precise and high load resistance moving device of an embodiment of the present invention in a vertical direction is measured.

Fig. 25 is a view (2) in which displacement of a moving element of a precise and high load resistance moving device of an embodiment of the present invention in a vertical direction is measured.

Fig. 26 is a view (3) in which displacements of a moving element of a precise and high load resistance moving device of an embodiment of the present invention in a vertical direction is measured.

Fig. 27 is a view (4) in which displacements of a moving element of a precise and high load resistance moving device of an embodiment of the present invention in a vertical direction is measured.

Fig. 28 is a view (5) in which displacements of a moving element of a precise and high load resistance moving device of an embodiment of the present invention in a vertical direction is measured.

Fig. 29 is a view (6) in which displacements of a moving element of a precise and high load resistance moving device of an embodiment of the present invention in a vertical direction is measured.

Fig. 30 is a view (7) in which displacements of a moving element of a precise and high load resistance moving device of an embodiment of the present invention in a vertical direction is measured.

[0014] By combining a piezoelectric element which generates a shear deformation, or a layered piezoelectric element in which a piezoelectric element which generates a shear deformation and a piezoelectric element which generates a vertical deformation are combined, with a wedge-shaped moving element, it is possible to move even when pressure is applied to a large sliding surface. In addition, by adjusting each phase of the piezoelectric element which displaces in vertical and horizontal directions, a high-speed moving mechanism as a bidirectional ultrasonic motor can be realized.

[0015] Especially, when the piezoelectric element which generates the vertical deformation is bonded to the piezoelectric element which generates the shear deformation, and both piezoelectric elements are driven simultaneously, or with a certain phase difference, a high load resistance and robustness against a state of the surface can be obtained.

[0016] Moreover, by using a plurality of the piezoelectric elements which generate the shear deformations and varying shearing directions of the shearing deformation piezoelectric elements, a moving mechanism movable in two axes or three axes directions can be realized. Embodiments

[0017] Hereinafter, embodiments of the present invention will be described in detail.

[0018] Fig. 3 is a schematic view of a precise and high load resistance moving device illustrating a first embodiment of the present invention.

[0019] In the drawing, reference numeral 1 denotes a floor surface of a fixed part, reference numeral 2 denotes a wall surface of the fixed part, reference numeral 3 denotes a wedge-shaped moving element, reference numeral 4 denotes a piezoelectric element which is fixed to a bottom surface of the wedge-shaped moving element 3 and generates a shear deformation, reference numeral 5 denotes a moving body which is driven by the wedge-shaped moving element 3 and moves in a perpendicular direction, and on an upper surface of the moving body 5, a sample 6, for example, is placed. Reference numeral 7 denotes a guide (bearing) which holds the moving body 5 with a spring, and reference numeral 8 denotes a drive pulse source for generating a rapid deformation to the piezoelectric element 4 which generates a shear deformation.

[0020] If the piezoelectric element 4 which generates the shear deformation is rapidly deformed by a pulse from the drive pulse source 8, the wedge-shaped moving element 3 finely moves in a horizontal direction (here, leftward direction). Then, the wedge-shaped moving element 3 is struck to the moving body 5, and the moving body 5 moves upward (or alternately, by extracting, the moving body 5 can be moved downward), and thus, a fine movement positioning of the moving body 5. in the vertical direction can be performed.

[0021] Fig. 4 is a schematic view illustrating operation of the precise and high load resistance moving device illustrating the first embodiment of the present invention, and Fig. 5 is a schematic view illustrating an example of the drive pulse.

[0022] First, the wedge-shaped moving element 3 is located at a position illustrated in Fig. 4(a), and to the bottom surface of the wedge-shaped moving element 3, the piezoelectric element 4 which generates the shear deformation is fixed.

[0023] Then, to the piezoelectric element 4 which generates the shear deformation, when saw-shaped drive pulses 9 and 9' illustrated in Fig. 5 are applied from the drive pulse source 8, the piezoelectric element 4 rapidly deforms in the leftward direction as illustrated in Fig. 4 (b). That is, as illustrated in Fig. 4(c), the piezoelectric element 4 moves leftward by Δd, and the wedge-shaped moving element 3 is struck under the moving body 5 from the right-hand side, and thus, the moving body 5 is lifted up vertically upward by Δh and positioned.

[0024] In this embodiment, the example in which the saw-shaped pulses illustrated in Fig. 5 are applied as the drive pulses is described. Alternatively, as illustrated in Fig. 6, drive pulses 10 and 10' which have a mountain shape (an inclination becomes sharp as it comes to a top and the summit is not flat) with the upward tops and downward tops can be applied.

[0025] Fig. 7 is a schematic view of a precise and high load resistance moving device illustrating a second embodiment of the present invention.

[0026] In this embodiment, further, a piezoelectric element 11 which generates a shear deformation (here, in the leftward direction) is also fixed to the upper surface of the wedge-shaped moving element 3, and the piezoelectric element 11 is driven to be synchronized with the piezoelectric element 4 which generates the shearing deformation (the leftward direction). Thus, the wedge-shaped moving element 3 is struck to or extracted from the moving body 5 to perform a very fine movement positioning of the moving body 5 in the perpendicular direction.

[0027] Moreover, in Fig. 7, the piezoelectric element 11 can be a piezoelectric element which generates a shear deformation in a depth direction of the page surface. In this case, by rapidly deforming and driving the piezoelectric element 4, the wedge-shaped moving element is moved on the base. And by striking or extracting the wedge-shaped moving element to/from a moving body which is movable in the vertical direction against the base and in the depth direction against the page surface, a fine movement positioning of the moving body in the vertical direction is performed, and by rapidly deforming and driving the piezoelectric element 11, it is possible to perform a fine movement positioning of the moving body, which is movable in the vertical direction and in the depth direction of the page surface, in the depth direction of the page surface.

[0028] Further, in Fig. 7, the piezoelectric element 11 can be a layered piezoelectric element in which a piezoelectric element which generates a shear deformation in an inclined surface direction and a piezoelectric element which generates a shear deformation in the depth direction of the page surface are bonded. By rapidly deforming and driving the piezoelectric element 4 on the bottom surface of the wedge-shaped moving element and the element which generates the shear deformation in the inclined surface direction out of the layered piezoelectric element 11, the wedge-shaped moving element is moved on the base. And by striking or extracting the wedge-shaped moving element to/from the moving body, which is movable in the vertical direction against the base and in the depth direction against the page surface, a fine movement positioning of the moving body in the vertical direction is performed. And by rapidly deforming and driving the element which shear-deforms in the depth direction of the page surface out of the layered piezoelectric element 11 arranged on the upper inclined surface, it is also possible to perform a very fine movement positioning of the moving body in the depth direction of the page surface.

[0029] Fig. 8 is a schematic view of a precise and high load resistance moving device illustrating a third embodiment of the present invention.

[0030] In this embodiment, in addition to the second embodiment, a piezoelectric element 12 which generates a shear deformation (here, in a vertical direction) is fixed to a part where the moving body 5 and the wall surface 2 of the fixed part contact, and the piezoelectric element 12 is driven to be synchronized with the piezoelectric elements 4 and 11 which generate the shear deformations. Thus, with a friction coefficient of the surfaces in which the moving body 5 and the wall surface 2 of the fixed part contact being reduced, the wedge-shaped moving element 3 is struck to or extracted from the moving body 5 to perform a fine movement positioning of the moving body 5 in the vertical direction.

[0031] Fig. 9 is a schematic view of a precise and high load resistance moving device illustrating a fourth embodiment of the present invention.

[0032] In the drawing, reference numeral 21 denotes a floor surface of a fixed part, reference numeral 22 denotes a wall surface of the fixed part, reference numeral 23 denotes a wedge-shaped moving element, reference numeral 24 denotes a layered piezoelectric element which is fixed to a bottom surface of the wedge-shaped moving element 23 and in which a piezoelectric element 24A which generates a shear deformation (here, in a leftward direction) and a piezoelectric element 24B which generates a vertical deformation (extension) are bonded, and reference numeral 25 denotes a moving body which is driven by the wedge-shaped moving element 23 and moves in a vertical direction, and a sample 26, for example, is placed on an upper surface of the moving body 25. Reference numeral 27 denotes a guide (bearing) which holds the moving body 25 by a spring against the wall surface 22 of the fixed part, and reference numeral 30 denotes a drive pulse source for driving the layered piezoelectric element 24.

[0033] When the layered piezoelectric element 24 in which the piezoelectric element 24A which generates the shear deformation and the piezoelectric element 24B which generates the vertical deformation are bonded is rapidly deformed by a pulse from the drive pulse source 30, the wedge-shaped moving element 23 finely moves in a horizontal direction and a perpendicular direction. Then, the wedge-shaped moving element 23 is struck to or extracted from the moving body 25 to perform a very fine movement positioning of the moving body 25 in the perpendicular direction.

[0034] Fig. 10 is a schematic view illustrating operation of the precise and high load resistance moving device illustrating the fourth embodiment of the present invention, and Fig. 11 is a schematic view illustrating an example of drive pulses of the precise and high load resistance moving device.

[0035] First, the wedge-shaped moving element 23 is located at a position illustrated in Fig. 10(a). To the bottom surface of the wedge-shaped moving element 23, the layered piezoelectric element 24 in which the piezoelectric element 24A which generates the shear deformation (here, in the leftward direction) and the piezoelectric element 24B which generates the vertical deformation (extension) are bonded is fixed.

[0036] Then, when a drive pulse illustrated in Fig. 11 (a) is applied to piezoelectric element 24A which generates the shear deformation and a drive pulse illustrated in Fig. 11(b) is applied to the piezoelectric element 24B which generates the vertical deformation, as illustrated in Fig. 10(b), first, the piezoelectric element 24A which generates the shear deformation deforms in the leftward direction, and the wedge-shaped moving element 23 moves to the left in response to the deformation. Then, the piezoelectric element 24B which generates the vertical deformation extends to lift up the moving body 25.

[0037] That is, as illustrated in Fig. 10(c), the piezoelectric element 24A which generates the shear deformation moves in the leftward by Δd, while the wedge-shaped moving element 23 is struck from the right side of the moving body 25, and then the piezoelectric element 24B which generates the vertical deformation extends to lift up the moving body 25. Thus, the moving body 25 is lifted up vertically upward by Δh and positioned.

[0038] With respect to the drive pulse, the drive pulse of the mountain shape illustrated in Fig. 6 can be used.

[0039] As described above, by performing the shear deformation and vertical deformation rapidly and with an appropriate time difference, a rapid resistant force is generated in the diagonal and downward direction like hops of a rabbit, for instance. Thus, even if a high surface pressure acts on the sliding surface, a displacement in a desired direction can be achieved. In this embodiment, higher load resistance is achieved. Further, with the introduction of the element which generates the vertical deformation, it is possible to increase the limit where movement does not occur anymore.

[0040] Further, in Fig. 9, to the part where the moving body 25 and the wall surface 22 of the fixed part contact, in place of the bearing, a layered piezoelectric element (not shown) in which a piezoelectric element which generates a shear deformation and a piezoelectric element which generates a vertical deformation are bonded is fixed, and driven to be synchronized with the piezoelectric element 24. Thus, with a friction coefficient of the surfaces in which the moving body 25 and the wall surface 22 of the fixed part contact being reduced, the wedge-shaped moving element 23 is struck to or extracted from the moving body 25 to perform a fine movement positioning of the moving body 25 in the perpendicular direction.

[0041] Fig. 12 is a schematic view of a precise and high load resistance moving device illustrating a fifth embodiment of the present invention.

[0042] In this embodiment, in addition to the fourth embodiment, to an upper surface of the wedge-shaped moving element 23, a layered piezoelectric element 28 in which a piezoelectric element 28A which generates a shear deformation (here, in the leftward direction) and a piezoelectric element 28B which generates a vertical deformation (extension) are bonded is fixed, and driven to be synchronized with the layered piezoelectric element 24. Thus, the wedge-shaped moving element 23 is struck to or extracted from the moving body 25 to perform a very fine movement positioning of the moving body 25 in the perpendicular direction.

[0043] Fig. 13 is a schematic view of the precise and high load resistance moving device illustrating a modification of the fifth embodiment of the present invention.

[0044] In this embodiment, in addition to the fourth embodiment, to the upper surface of the wedge-shaped moving element 23, the layered piezoelectric element 28 in which the piezoelectric element 28A which generates the shear deformation (here, in the leftward direction) and a piezoelectric element 28C which generates a shear deformation in a depth direction of the page surface are bonded is fixed, and driven to be synchronized with the layered piezoelectric element 24. Thus, the wedge-shaped moving element 23 is struck to or extracted from the moving body 25 to perform a fine movement positioning of the moving body 25 in the perpendicular direction. Further, by performing a rapid deformation drive of the piezoelectric element 28C, with the vertical surface (the floor surface 21 of the fixed part) and the lower side of the moving body 25 as guiding surfaces, it is possible to perform a fine movement positioning in the page surface direction.

[0045] Fig. 14 is a schematic view of a precise and high load resistance moving device illustrating a sixth embodiment of the present invention.

[0046] In this embodiment, in addition to the fifth embodiment, to a part where the moving body 25 and the wall surface 22 of the fixed part contact, a layered piezoelectric element 29 in which a piezoelectric element 29A which generates a shear deformation (here, in an upward direction) and a piezoelectric element 29B which generates a vertical deformation are bonded is fixed, and driven to be synchronized with the layered piezoelectric elements 24 and 28. Thus, the wedge-shaped moving element 23 is struck to or extracted from the moving body 25 to perform a fine movement positioning of the moving body 25 in the perpendicular direction.

[0047] Fig. 15 is a view illustrating waveforms applied to the layered piezoelectric element (see Fig. 9) in an ultrasonic motor mode of a precise and high load resistance moving device of the present invention, and Fig. 16 is a view illustrating micro displacement of a sliding surface of the piezoelectric element side by the precise and high load resistance moving device viewed from a side of a horizontal surface. In this case, macroscopically, the moving element provided with the piezoelectric element moves rightward.

[0048] On the floor surface 21 of the fixed part, the piezoelectric element 24A which generates the shear deformation (here, in the leftward direction) and the piezoelectric element 24B which generates the vertical deformation (extension) are bonded, and a sinusoidal wave such as a wave illustrated in Fig. 15(a) is applied to the piezoelectric element 24A which generates the shear deformation and a sinusoidal wave such as a wave illustrated in Fig. 15(b) is applied to the piezoelectric element 24B which generates the vertical deformation. Thus, as illustrated in Fig. 16, the sliding surface circulates or elliptically circulates clockwise viewed from a direction the drawing is viewed, and drives the wedge-shaped moving element 23. In place of the above-described sinusoidal waves, a cosine wave can be applied.

[0049] As described above, by using a periodic waveform generated from a signal generator, in view of the sinusoidal waves, a rectangular wave, and the pulse property of the moving mechanism, and applying the waveform to a piezoelectric element which generates a vertical deformation or a shear deformation simultaneously or with a phase difference, a high-speed displacement in the ultrasonic motor mode is enabled By finding a phase difference which is good in movement efficiency and performing a change of a polarity of a lateral deformation to the vertical deformation or a 180° shift of the phase, it is possible to perform an efficient displacement in another direction.

[0050] Moreover, to the above-described embodiments, modifications can be applied as follows:

(1) In place of the guides 7 and 27 which hold the above-described precise and high load resistance moving device by springs, a magnetic body can be used as the wall surface of the fixed part, and by arranging a magnet to the wall surface side of the fixed part of the moving body, the moving body can be attached to the fixed part. The attachment means of the magnet to the fixed part of the moving body can be applied to all the other embodiments (see Figs. 3, 4, 7, 8, 9, 10, 12, 13, 14, 18).

Fig. 17 is a view illustrating a modification of the guide of the precise and high load resistance moving device.

In the drawing, reference numeral 31 denotes a floor surface of a fixed part, reference numeral 32 denotes a wall surface of the fixed part formed of a magnetic body, reference numeral 33 denotes wedge-shaped moving element, reference numeral 34 denotes a piezoelectric element which generates a shear deformation (here, in a leftward direction) and fixed to a bottom surface of the wedge-shaped moving element 33, reference numeral 35 denotes a moving body which is driven by the wedge-shaped moving element 33 and moves in a perpendicular direction, and a sample 36, for example, is placed on an upper surface of the moving body 35. Reference numeral 37 denotes a magnet which is fixed to the moving body 35 so as to come in contact with the wall surface 32 of the fixed part formed of the magnetic body.

(2) In place of the above-described guide of the magnet, although it is not shown, a guide mechanism by a ball bearing can be used.

(3) Not by the above-described layered piezoelectric element which is directly in contact with the floor surface of the fixed part, but by providing another sliding surface to the layered piezoelectric element, the layered piezoelectric element can contact the floor surface.

[0051] Fig. 18 is a schematic view of a precise and high load resistance moving device provided with the sliding surface.

[0052] Here, it is structured that the sliding surface 29 fixed to the bottom surface of the layered piezoelectric element 24 contacts the floor surface 21 of the fixed part.

[0053] With such a structure, a stable contact state can be maintained.

[0054] Next, Fig. 19 is a schematic view of a precise and high load resistance moving device (1) of an embodiment of the present invention which has a vertical positioning mechanism in which a positional potential is not changed as a whole.

[0055] In the drawing, reference numeral 40 denotes a precise high load resistance moving device having a vertical positioning mechanism, reference numeral 41 denotes a base, reference numeral 42 denotes a first fixed part (base), reference numeral 42A denotes a side wall of the first fixed part (base), reference numeral 43 denotes a second fixed part (base), reference numeral 43A denotes a side wall of the second fixed part (base), reference numeral 44 denotes a wedge which has a triangular shape in a cross section, reference numeral 45 denotes a first piezoelectric element formed of a piezoelectric element which generates a shear deformation and which is fixed to a bottom surface of the wedge 44 which has the triangular shape in the cross section, reference numeral 46 denotes a second piezoelectric element which is fixed to an inclined surface of a left side of the wedge 44 which has the triangular shape in the cross section and formed of a layered piezoelectric element in which a piezoelectric element 46A which generates a shearing deformation and a piezoelectric element 46B which generates a vertical deformation are bonded, reference numeral 47 denotes a third piezoelectric element which is fixed to the inclined surface of a right side of the wedge 44 which has the triangular shape in the cross section and formed of a layered piezoelectric element in which a piezoelectric element 47A generates a shear deformation and a piezoelectric element 47B which generates a vertical deformation are bonded, reference numeral 48 denotes a first moving body, and reference numeral 49 denotes a second moving body.

[0056] With such a structure, in a vertical positioning mechanism including the first moving body 48 and the second moving body 49, by simultaneously driving the first moving body 48 and the second moving body 49, a wedge-shaped moving mechanism in which positional potential is not changed as a whole can be provided. The mechanism has an advantage that no difference in an upward and downward moving property arise, and possess high reliability. A spring for pressing the sliding surface and a magnet for obtaining pressing force are not necessary and it is possible to resist a heavy load with the wedge. Further, displacement to a vertical load is hardly generated. With the drive of the second piezoelectric element 46 and the third piezoelectric element 47, the first moving body 48 and the second moving body 49 can be displaced in the vertical direction.

[0057] Fig. 20 is a schematic view of a precise and high load resistance moving device (2) of an embodiment of the present invention which has a vertical positioning mechanism in which a positional potential is not changed as a whole.

[0058] Here, the precise and high load resistance moving device 40 which has the vertical positioning mechanism illustrated in the above-described Fig. 19 is placed on a first base 51 through a fourth piezoelectric element 52 which is fixed to a bottom surface of a second base 41' and formed of a piezoelectric element which generates a shear deformation.

[0059] Also in this embodiment, in the vertical positioning mechanism including the first moving body 48 and the second moving body 49, the wedge-shaped moving mechanism in which positional potential is not changed as a whole can be provided. The mechanism has the advantage that no difference in the upward and downward property arise, and possess high reliability. The spring for pressing the sliding surface and the magnet for obtaining pressing force are not necessary and it is possible to resist the heavy load with the wedge. Further, displacement to the vertical load is hardly generated. The first moving body 48 and the second moving body 49 can be displaced not only in the vertical direction, but, with a drive of the fourth piezoelectric element 52 formed of the piezoelectric element which generates the shear deformation, can be displaced in the lateral direction.

[0060] Moreover, as a modification of the positioning mechanism described in Figs. 19 and 20, in a case in which the shear deformation piezoelectric elements 46A and 47A, or the vertical deformation piezoelectric elements 46B and 47B are excluded, a similar displacement can be obtained.

[0061] Fig. 21 is a schematic view of a precise and high load resistance moving device (3) of an embodiment of the present invention which has a vertical positioning mechanism in which a positional potential is not changed as a whole in which a moving element has a movement positioning function in xyz three axes, and Fig. 22 is a schematic view of a precise and high load resistance moving device (4) of an embodiment of the present invention which has a vertical positioning mechanism in which a positional potential is not changed as a whole in which a moving element has a movement positioning function in xyz three axes.

[0062] Here, in the precise and high load resistance moving device 40 which has the vertical positioning mechanism illustrated in Fig. 19 or 20, of piezoelectric elements 46C and 47C which generate shear deformations in a depth direction of the page surface are arranged, and displacement positioning of the moving bodies 48 and 49 in the depth direction of the page surface can be performed.

[0063] In Fig. 21, the reference numeral 40 denotes the precise and high load resistance moving device which has the vertical positioning mechanism, the reference numeral 41 denotes the base, the reference numeral 42 denotes the first fixed part (base), the reference numeral 42A denotes the side wall of the first fixed part (base), the reference numeral 43 denotes the second fixed part (base), the reference numeral 43A denotes the side wall of the second fixed part (base), the reference numeral 44 denotes the wedge which has the triangular shape in the cross section, the reference numeral 45 denotes the first piezoelectric element formed of the piezoelectric element which generates the shearing deformation and which is fixed to the bottom surface of the wedge 44 which has the triangular shape in the cross section, the reference numeral 46 denotes the second piezoelectric element which is fixed to the inclined surface of the left side of the wedge 44 which has the triangular shape in the cross section and formed of the layered piezoelectric element in which the piezoelectric element 46A which generates the shear deformation and a piezoelectric element 46C which generates a shear deformation in the depth direction of the page surface are bonded, the reference numeral 47 denotes the third piezoelectric element which is fixed to the inclined surface of the right side of the wedge 44 which has the triangular shape in the cross section and formed of the layered piezoelectric element in which the piezoelectric element 47A which generates the shear deformation and a piezoelectric element 47C which generates a shear deformation in the depth direction of the page surface are bonded, the reference numeral 48 denotes the first moving body, and the reference numeral 49 denotes the second moving body.

[0064] With such a structure, in the vertical positioning mechanism including the first moving body 48 and the second moving body 49, simultaneously driving the first moving body 48 and the second moving body 49, the wedge-shaped moving mechanism in which positional potential is not changed as a whole can be provided. The mechanism has the advantage that no difference in the upward and downward moving property arise, and possess high reliability. The spring for pressing the sliding surface and the magnet for obtaining pressing force are not necessary and it is possible to resist a heavy load with the wedge. Further, displacement to the vertical load is hardly generated. With a drive of the piezoelectric element 46A and the piezoelectric element 47A, the first moving body 48 and the second moving body 49 can be displaced in the vertical direction. Moreover, with a rapid deformation drive of the piezoelectric element 46C, a fine movement positioning of the moving body 48 in the page surface direction can be performed, and with a rapid deformation drive of the piezoelectric element 47C, a fine movement positioning of the moving body 49 in the depth direction of the page surface direction can be performed. That is, with the vertical positioning mechanism in which the positional potential is not changed as a whole, the movement positioning in the xyz three axes directions can be performed.

[0065] Further, in Fig. 22, the precise and high load resistance moving device 40 which has the vertical positioning mechanism illustrated in the above-described Fig. 21 is placed on the first base 51 through the fourth piezoelectric element 52 which is fixed to the bottom surface of the second base 41' and formed of the piezoelectric element which generates the shear deformation.

[0066] Also in this embodiment, in the vertical positioning mechanism including the first moving body 48 and the second moving body 49, the wedge-shaped moving mechanism in which positional potential is not changed as a whole can be provided. The mechanism has the advantage that no difference in the upward and downward moving property arise, and possess high reliability. The spring for pressing the sliding surface and the magnet for obtaining pressing force are not necessary and it is possible to resist the heavy load with the wedge. Further, displacement to the vertical load is hardly generated. The first moving body 48 and the second moving body 49 can be displaced not only in the vertical direction and in the normal line of the page surface, but in the lateral direction, with the drive of the fourth piezoelectric element 52 formed of the piezoelectric element which generates the shear deformation.

[0067] Moreover, as a modification of the positioning mechanism described in Figs. 21 and 22, in a case in which the shear deformation piezoelectric elements 46A and 47A are excluded, a similar displacement in xyz three axes can be obtained.

[0068] Fig. 23 is a schematic view of a precise and high load resistance moving device of the present invention which positions a moving body in xyz directions using a base, two wedges, and four piezoelectric elements.

[0069] In the drawing, reference numeral 61 denotes a base, reference numeral 62 denotes a first wedge which is arranged at a left side on the base 61 and has a horizontal bottom surface and an inclined surface of which the inside is lower. To the bottom surface of the first wedge 62, a first piezoelectric element 63 formed of a piezoelectric element which generates a shear deformation is fixed, and on the inclined upper surface, a second piezoelectric element 64 formed of a layered piezoelectric element in which a piezoelectric element 64A which generates a shear deformation and a piezoelectric element 64C which generates a shear deformation in a depth direction of the page surface are bonded is fixed. Further, reference numeral 65 denotes a second wedge which is arranged at a right side on the base 61 and has a horizontal bottom surface and an inclined surface of which the inside is lower as an upper surface. To the bottom surface of the second wedge 65, a third piezoelectric element 66 formed of a piezoelectric element which generates a shearing deformation is fixed, and on the inclined upper surface, a fourth piezoelectric element 67 formed of a layered piezoelectric element in which a piezoelectric element 67A which generates a shear deformation and a piezoelectric element 67C which generates a shear deformation in the depth direction of the page surface are bonded is fixed. Reference numeral 68 denotes a moving body which is arranged so as to be bridged by the first wedge 62 and the second wedge 65.

[0070] As described above, this embodiment is the precise and high load resistance moving device which has the base 61 and the two wedges 62 and 65, and positions the moving body 68 in the xyz directions. The first wedge 62 and the second wedge 65 can move laterally by the drive of the first piezoelectric element 63 and the third piezoelectric element 66, and moreover, in response to the movement of the first wedge 62 and the second wedge 65, and by the drive of the second piezoelectric element 64 and the fourth piezoelectric element 67, the moving body 68 can move in the vertical direction. Further, by the shear deformation drive of the piezoelectric elements 64C and 67C, the moving body 68 can be moved and positioned in the depth direction of the page surface. That is, it is possible to perform the movement positioning in the xyz three axes as a whole.

[0071] As a modification of the positioning mechanism described in Fig. 23, in a case in which the shear deformation piezoelectric elements 64A and 67A are excluded, a deformation of a similar degree of freedom can be obtained.

[0072] Further, as another modification of the positioning mechanism described in Fig. 23, in a case in which the piezoelectric elements 63 and 66 are replaced with layered piezoelectric elements in which a shear deformation piezoelectric element and a vertical deformation piezoelectric element are bonded, a deformation of a similar degree of freedom can be obtained.

[0073] Figs. 24 to 28 are views (1) to (5) in which, using the device described in Fig. 23, displacements of the moving body 68 in the vertical direction which is generated by the displacement of the wedges 62 and 65 in the lateral direction are measured. Fig. 24 illustrates a decreasing tendency. When rapid deformation is driven with a sawtooth voltage (A) of 300 Vpp at 50 steps per second, and vertical displacements are expressed at 100 nm / div (B), a displacement of 20 nm per step was obtained. Accordingly, it is understood that a very high linearity can be obtained. Fig. 25 also illustrates a decreasing tendency. When rapid deformation is driven at 50 steps per second with a sawtooth voltage (A) of 300 Vpp, and vertical displacements are expressed at 1 μm / div (B), a displacement of 20 nm per step was obtained. Fig. 26 illustrates an increasing tendency at the vertical displacement scale of the same drive condition as in Fig. 25, and a displacement of 20 nm per step was obtained. Figs. 25 and 26, in both directions of vertically upward and downward, illustrates that stable fine movements are possible. Fig. 27 illustrates a decreasing tendency measured by increasing sensitivity of a displacement sensor. When rapid deformation is driven at 1 step per second with the sawtooth voltage (A) of 300 Vpp, and vertical displacements are expressed at 200 nm / div (B), a displacement of 17 nm per step was obtained. Fig. 28 illustrates an increasing tendency at the same drive condition as in Fig. 27. When vertical displacements are expressed at 50 nm / div (B), a displacement of 5 nm per step was obtained. Figs. 27 and 28 illustrate that a displacement of upward or downward is definitely generated per step.

[0074] Figs. 29 and 30 are views (6 and 7) in which, using the device described in Fig. 7, displacements of the moving body 5 in a vertical direction which is generated by extracting or striking the wedge-shaped moving element 3 are measured. In a case in which driven at a sawtooth voltage (A) of 200 Vpp, and vertical displacements are expressed at 2.5 nm / div (B), it is illustrated that vertical movement positioning is possible and a fine movement on the order of nanometers is possible. In Figs. 29 and 30, fine vibration of the vertical displacements of Bs is noise.

[0075] As clearly understood from the above drawings, it is confirmed that the upward and downward displacement positioning can be possible, the displacement on the order ranging from 1 nm to 10 nm per step can be realized, the high linear displacement to the rapid deformation signal of a certain frequency can be obtained, and the definite stepping operation in each step can be obtained. Further, as a feature of the wedge, it is confirmed that even if a load on the order of kilograms in vertically downward direction is given, no displacement is generated.

[0076] In embodiments of the present invention, as compared to known moving mechanisms using a piezoelectric element, a larger surface pressure to a sliding surface can be selected, and a larger load can be moved. Moreover, by generating an elliptical vibration using the piezoelectric element which generates a shear deformation and the piezoelectric element which generates a vertical deformation, that is, by applying a sinusoidal wave or a rectangular wave having different phases to each piezoelectric element, a high-speed displacement as an ultrasonic motor capable of bidirectional high-speed movement is also possible. Further, by using the wedge-shaped moving element, it is possible to realize higher load resistance and finer positioning due to the deceleration effect of movement. Further, with the wedge-shaped moving element, even if a large downward force is given, there are advantages that a displacement is accurately generated and the positioned point can be retained. Further, with the combination of the wedge-shaped moving element and the piezoelectric element, the xyz moving mechanism can be realized.

[0077] Further, as well as having the high-rigidity, and the high-character frequency, the compact structure can be realized.

[0078] As described above, in embodiments of the present invention, the device capable of positioning a load on the order of kilograms in the vertical direction using the fine piezoelectric element can be provided and the resolution is on the order of nanometers.

[0079] The piezoelectric element can be fixed to either opposite surface. Moreover, in place of the layered piezoelectric element, each layer which composes the layered piezoelectric element can be fixed to each opposite surface.

Industrial Applicability

[0080] The precise and high load resistance moving method and device using the wedge-shaped moving element and the piezoelectric element according to embodiments of the present invention are applicable for a precise moving mechanism and a moving mechanism of a sample in a microscope.

Claims

1. A precise and high load resistance moving method comprising:

(a) fixing a piezoelectric element (4) which generates a shear deformation, to a bottom surface of a wedge-shaped moving element (3) placed on a base (1), and
(b) rapidly deforming the piezoelectric element (4) by driving the piezoelectric element (3) with drive pulses to move the wedge-shaped moving element (3) along a first axis in which the wedge-shaped moving element (3) drives into or away from a moving body (5) to move the moving body (5) along a second axis in an upward or downward direction relative to the base (1), to perform fine movement positioning of the moving body (5).

2. A precise and high load resistance moving method according to claim 1, wherein the piezoelectric element (4) is a layered piezoelectric element (24) in which a piezoelectric element (24A) which generates a shear deformation is bonded to a piezoelectric element (24B) which generates a vertical deformation.

3. A precise and high load resistance moving method according to claim 1, wherein the method further comprises ;

fixing a second piezoelectric element (11) which generates a shear deformation along an upper inclined surface of the wedge-shaped moving element (3).

4. A precise and high load resistance moving method according to claim 3, wherein the second piezoelectric element (11) generates a shear deformation in a direction along a third axis which is perpendicular to the first and second axes, and the moving body (5) is movable in a vertical direction relative to the base (1) along the first axis and in a direction along the third axis, and the method further comprises:

(c) performing a fine movement positioning of the moving body (5) by rapidly deforming the second piezoelectric element to move the moving body (5) in a direction along the third axis.

5. A precise and high load resistance moving method according to claim 1, wherein the piezoelectric element (4) is a layered piezoelectric element (24) in which a piezoelectric element (24A) which generates a shear deformation is bonded to a piezoelectric element (24B) which generates a vertical deformation, and the method further comprises:

fixing a layered piezoelectric element (28) to an upper inclined surface of the wedge-shaped moving element (23), the layered piezoelectric element (28) comprising a piezoelectric element (28A) which generates a shear deformation along an inclined surface which is bonded to a piezoelectric element (28C) which generates a shear deformation in a direction along a third axis which is perpendicular to the first and second axes, and:
moving the wedge-shaped moving element (23) on the base (1) by rapidly deforming the piezoelectric element (28A) which generates the shear deformation along the inclined surface out of the layered piezoelectric element (24) fixed to the bottom surface of the wedge-shaped moving element (23) and the layered piezoelectric element (28) fixed to the upper inclined surface, so that the wedge-shaped moving element (23) moves to drive the moving body (5) vertically along the first axis in the upward or downward direction relative to the base (1), to perform fine movement positioning of the moving body (5), and, by rapidly deforming the piezoelectric element (28C) which generates the shear deformation in the direction along the third axis relative to the layered piezoelectric element (28) fixed

to the upper inclined surface, to also perform fine movement positioning of the moving body (5) in a direction along the third axis.

6. A precise and high load resistance moving method according to claim 1, wherein the wedge-shaped moving element is a first wedge-shaped moving element (62) arranged at a left side on the base (61), the first wedge-shaped moving element (62) having a horizontal bottom surface and an inclined surface of which the inside is lower on an upper surface, the bottom surface being fixed to a first piezoelectric element (63) formed of a piezoelectric element which generates a shear deformation, a second piezoelectric element (64) which generates a shear deformation in a direction along a third axis which is perpendicular to the first and second axes being fixed to the inclined surface, and a second wedge-shaped moving element (65) arranged at a right side on the base (61), the second wedge-shaped moving element (65) having a horizontal bottom surface and an inclined surface of which the inside is lower on an upper surface, the bottom surface of the second wedge-shaped moving element (65) being fixed to a third piezoelectric element (66) formed of a piezoelectric element which generates a shear deformation, a fourth piezoelectric element (67) which generates a shear deformation in a direction along the third axis being fixed to the inclined surface of the second wedge-shaped moving element (67), the moving body (68) being arranged to bridge the first wedge-shaped moving element (62) and the second wedge-shaped moving element (65), by rapidly forming the first and third piezoelectric elements (63,66), the first and second wedge-shaped moving elements (62,65) are moved on the base (61), to perform fine movement positioning of the moving body (68) vertically movable along the first axis in upward and downward directions and in directions along the third axis, and by rapidly deforming the second and fourth piezoelectric elements (64,67), a fine movement positioning of the moving body (68) in a direction along the third axis is also performed.

7. A precise and high load resistance moving method according to claim 6, wherein the second piezoelectric element (64) is formed of a layered piezoelectric element in which a piezoelectric element (64A) which generates a shear deformation in an inclined surface direction is bonded to a piezoelectric element (64C) which generates a shear deformation in a direction along the third axis and the fourth piezoelectric element (67) is formed of a layered piezoelectric element in which a piezoelectric element (67A) which generates a shear deformation in the inclined surface direction which is bonded to a piezoelectric element (67C) which generates a shear deformation in a direction along the third axis.

8. A precise and high load resistance moving device comprising:

(a) a wedge-shaped moving element (3) arranged on a base (1) of a fixed body (2) and movable in a horizontal direction along a first direction,
(b) a pulse source (8) for rapid deformation drive of a piezoelectric element (4), and
(c) a moving body (5) vertically movable along a second axis in an upward or downward direction relative to the base (1),

characterised in that a bottom surface of the wedge-shaped moving element (5) is fixed to the piezoelectric element (4), the piezoelectric element (4) being configured to generate a shear deformation, when driven with drive pulses from the pulse source (8), to move the wedge-shaped moving element (3) along the first axis in the horizontal direction so that the wedge-shaped moving element (3) drives the moving body (5) to move the moving body (5) along the second axis in the upward or downward direction relative to the base (1).

9. A precise and high load resistance moving device according to claim 8, wherein the piezoelectric element (4) is a layered piezoelectric element (24) in which a piezoelectric element (24A) which generates a shear deformation is bonded to a piezoelectric element (24B) which generates a vertical deformation.

10. A precise and high load resistance moving device according to claim 8, wherein, further, a second piezoelectric element (11) is fixed on an upper surface of the wedge-shaped moving element (3).

11. A precise and high load resistance moving device according to claim 10, wherein the second piezoelectric element is a layered piezoelectric element (28).

12. A precise and high load resistance moving device according to claim 10, wherein the second piezoelectric element (11) is a piezoelectric element which shears in a direction along a third axis which is perpendicular to the first and second axes.

13. A precise and high load resistance moving device according to claim 11, wherein the second layered piezoelectric element (28) is formed of layers of a piezoelectric element (28A) which shears in an inclined surface direction and a piezoelectric element (28C) which shears in a direction along a third axis which is perpendicular to the first and second axes.

14. A precise and high load resistance moving device according to claim 11, wherein the second layered piezoelectric element (28) is formed of layers of a piezoelectric element (28A) which shears in an inclined surface direction and a piezoelectric element (28B) which extends and contracts in a normal direction of the inclined surface.

15. A precise and high load resistance moving device according to claim 8, wherein, further, a third piezoelectric element (37) is fixed to a surface of the moving body (35) which contacts a wall surface side of the fixed body (32).

16. A precise and high load resistance moving device according to claim 9, wherein, further, a third layered piezoelectric element (29) is fixed to a surface of the moving body (25) which contacts a wall surface side of the fixed body (22).

17. A precise and high load resistance moving device according to claim 8, wherein
the wedge-shaped moving element is a first wedge-shaped moving element (62) which is arranged at a left side on the base (61) and the first wedge-shaped element (62) has a horizontal bottom surface and an inclined surface of which the inside is lower on an upper surface, and the piezoelectric element fixed (63) to the bottom surface of the first wedge-shaped moving element is a first piezoelectric element, a second piezoelectric element (64) which generates a shear deformation in a direction along a third axis which is perpendicular to the first and second axes being fixed to the inclined surface,
a second viredge-shaped moving element (65) being arranged at a right side on the base (61) and having a horizontal bottom surface and an inclined surface of which the inside is lower on an upper surface, and to the bottom surface, a third piezoelectric element (66) made of a piezoelectric element which generates a shear deformation is fixed, and to the inclined surface, a fourth piezoelectric element (67) which generates a shear deformation in a direction along the third axis is fixed, wherein

(c) the device further comprises means in which a moving body (68) is arranged to bridge the first wedge-shaped moving element (62) and the second wedge-shaped moving element (65), by rapidly deforming the piezoelectric elements, the first and second wedge-shaped moving elements (62,65) are moved on the base (61), and a fine movement positioning in a direction along the third axis and the vertical direction of the moving body (68) movable in the vertical direction and in the direction along the third axis is performed so that a total of potential energy of the two moving bodies (62,65) in the vertical direction is not changed, and means which are configured to rapidly deform the piezoelectric elements (64,67) which generate the shear deformations in a direction along the third axis to perform a fine movement positioning of the moving body (68) in the direction along the third axis.

18. A precise and high load resistance moving device according to claim 17, wherein the second piezoelectric element (64) is formed of a layered piezoelectric element in which a piezoelectric element (64A) which generates a shear deformation in an inclined surface direction is bonded to a piezoelectric element (64C) which generates a shear deformation in a direction along the third axis, and the fourth piezoelectric element (67) is formed of a layered piezoelectric element in which a piezoelectric element (67A) which generates a shear deformation in an inclined surface direction is bonded to a piezoelectric element (67C) which generates a shear deformation in a direction along the third axis.

19. A precise and high load resistance moving device according to claim 17, wherein the first piezoelectric element (63) is a layered piezoelectric element formed of a piezoelectric element which generates a shear deformation and a piezoelectric element which generates a vertical deformation, and the third piezoelectric element (66) is a layered piezoelectric element formed of a piezoelectric element which generates a shear deformation and a piezoelectric element which generates a vertical deformation.

20. A precise and high load resistance moving device according to claim 17, wherein the second piezoelectric element (64) is a piezoelectric element in which a piezoelectric element which generates a shear deformation in an inclined surface direction is bonded to a piezoelectric element which generates a vertical deformation, and the fourth piezoelectric element (67) is a piezoelectric element in which a piezoelectric element which generates a shear deformation in an inclined surface direction is bonded to a piezoelectric element which generates a vertical deformation.

Patentansprüche

1. Verfahren zum Widerstehen und präzisen Bewegen einer hohen Last, das umfasst:

(a) Anbringen eines piezoelektrischen Elements (4), das eine Scherverformung erzeugt, an einer unteren Fläche eines auf einer Basis (1) platzierten keilförmigen sich bewegenden Elements (3) und
(b) schnelles Verformen des piezoelektrischen Elements (4) durch Antreiben des piezoelektrischen Elements (3) mit Antriebsimpulsen, um

das keilförmige sich bewegende Element (3) entlang einer ersten Achse zu bewegen, auf der das keilförmige sich bewegende Element (3) in einen oder weg von einem sich bewegenden Körper (5) fährt, um den sich bewegenden Körper (5) entlang einer zweiten Achse in einer Aufwärts- oder Abwärtsrichtung relativ zur Basis (1) zu bewegen, um eine Einstellung des sich bewegenden Körpers (5) durch kleinste Bewegungen durchzuführen.

2. Verfahren zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 1, wobei das piezoelektrische Element (4) ein geschichtetes piezoelektrisches Element (24) ist, in dem ein piezoelektrisches Element (24A), das eine Scherverformung erzeugt, an ein piezoelektrisches Element (24B) gebondet ist, das eine vertikale Verformung erzeugt.

3. Verfahren zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 1, wobei das Verfahren ferner umfasst:

Anbringen eines zweiten piezoelektrischen Elements (11), das eine Scherverformung entlang einer oberen geneigten Fläche des keilförmigen sich bewegenden Elements (3) erzeugt.

4. Verfahren zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 3, wobei das zweite piezoelektrische Element (11) eine Scherverformung in einer Richtung entlang einer dritten Achse erzeugt, die senkrecht zur ersten und zweiten Achse ist, und der sich bewegende Körper (5) in einer vertikalen Richtung relativ zur Basis (1) entlang der ersten Achse und in einer Richtung entlang der dritten Achse bewegbar ist und das Verfahren ferner umfasst:

(c) Durchführen einer Einstellung des sich bewegenden Körpers (5) durch kleinste Bewegungen durch schnelles Verformen des zweiten piezoelektrischen Elements, um den sich bewegenden Körper (5) in einer Richtung entlang der dritten Achse zu bewegen.

5. Verfahren zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 1, wobei das piezoelektrische Element (4) ein geschichtetes piezoelektrisches Element (24) ist, in dem ein piezoelektrisches Element (24A), das eine Scherverformung erzeugt, an ein piezoelektrisches Element (24B) gebondet ist, das eine vertikale Verformung erzeugt, und das Verfahren ferner umfasst:

Anbringen eines geschichteten piezoelektrischen Elements (28) an einer oberen geneigten Fläche des keilförmigen sich bewegenden Elements (23), wobei das geschichtete piezoelektrische Element (28) ein piezoelektrisches Element (28A) umfasst, das eine Scherverformung entlang einer geneigten Fläche erzeugt, das an ein piezoelektrisches Element (28C) gebondet ist, das eine Scherverformung in einer Richtung entlang einer dritten Achse erzeugt, die senkrecht zur ersten und zweiten Achse ist, und:

Bewegen des keilförmigen sich bewegenden Elements (23) auf der Basis (1) durch schnelles Verformen des piezoelektrischen Elements (28A), das die Scherverformung entlang der geneigten Fläche erzeugt, aus dem an der unteren Fläche des keilförmigen sich bewegenden Elements (23) angebrachten geschichteten piezoelektrischen Element (24) und dem an der oberen geneigten Fläche angebrachten geschichteten piezoelektrischen Element (28), so dass das keilförmige sich bewegende Element (23) sich bewegt, um den sich bewegenden Körper (5) vertikal entlang der ersten Achse in der Aufwärts- oder Abwärtsrichtung relativ zur Basis (1) anzutreiben, um eine Einstellung des sich bewegenden Körpers (5) durch kleinste Bewegungen durchzuführen, und um durch schnelles Verformen des piezoelektrischen Elements (28C), das die Scherverformung in der Richtung entlang der dritten Achse relativ zum an der oberen geneigten Fläche angebrachten geschichteten piezoelektrischen Element (28) erzeugt, ebenfalls eine Einstellung des sich bewegenden Körpers (5) durch kleinste Bewegungen in einer Richtung entlang der dritten Achse durchzuführen.

6. Verfahren zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 1, wobei das keilförmige sich bewegende Element ein erstes keilförmiges sich bewegendes Element (62) ist, das an einer linken Seite auf der Basis (61) angeordnet ist, wobei das erste keilförmige sich bewegende Element (62) eine horizontale untere Fläche und eine geneigte Fläche aufweist, wovon die Innenseite auf einer oberen Fläche niedriger ist, wobei die untere Fläche an einem ersten piezoelektrischen Element (63) angebracht ist, das aus einem piezoelektrischen Element gebildet ist, das eine Scherverformung erzeugt, ein zweites piezoelektrisches Element (64), das eine Scherverformung in einer Richtung entlang einer dritten Achse erzeugt, die senkrecht zur ersten und zweiten Achse ist, an der geneigten Fläche angebracht ist, und ein zweites keilförmiges sich bewegendes Element (65), das an einer rechten Seite auf der Basis (61) angeordnet ist, wobei das zweite keilförmige sich bewegende Element (65) eine horizontale untere Fläche und eine geneigte Fläche aufweist, wovon die Innenseite auf einer oberen Fläche niedriger ist, wobei die untere

Fläche des zweiten keilförmigen sich bewegenden Elements (65) an einem dritten piezoelektrischen Element (66) angebracht ist, das aus einem piezoelektrischen Element gebildet wird, das eine Scherverformung erzeugt, wobei ein viertes piezoelektrisches Element (67), das eine Scherverformung in einer Richtung entlang der dritten Achse erzeugt, an der geneigten Fläche des zweiten keilförmigen sich bewegenden Elements (67) angebracht ist, wobei der sich bewegende Körper (68) angeordnet ist, um sich über das erste keilförmige sich bewegende Element (62) und das zweite keilförmige sich bewegende Element (65) zu erstrecken, durch schnelles Verformen des ersten und dritten piezoelektrische Elements (63, 66) das erste und zweite keilförmige sich bewegende Element (62, 65) auf der Basis (61) bewegt werden, um eine Einstellung des sich bewegenden Körpers (68) durch kleinste Bewegungen durchzuführen, der entlang der ersten Achse in einer Aufwärts- und Abwärtsrichtung und in Richtungen entlang der dritten Achse vertikal bewegbar ist, und durch schnelles Verformen des zweiten und vierten piezoelektrischen Elements (64, 67) eine Einstellung des sich bewegenden Körpers (68) durch kleinste Bewegungen in einer Richtung entlang der dritten Achse ebenfalls durchgeführt wird.

7. Verfahren zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 6, wobei das zweite piezoelektrische Element (64) aus einem geschichteten piezoelektrischen Element gebildet wird, in dem ein piezoelektrisches Element (64A), das eine Scherverformung in der Richtung einer geneigten Fläche erzeugt, an ein piezoelektrisches Element (64C) gebondet ist, das eine Scherverformung in einer Richtung entlang der dritten Achse erzeugt, und das vierte piezoelektrische Element (67) aus einem geschichteten piezoelektrischen Element gebildet wird, in dem ein piezoelektrisches Element (67A), das eine Scherverformung in der Richtung der geneigten Fläche erzeugt, das an ein piezoelektrisches Element (67C) gebondet ist, das eine Scherverformung in einer Richtung entlang der dritten Achse erzeugt.

8. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last, die umfasst:

(a) ein keilförmiges sich bewegendes Element (3), das auf einer Basis (1) eines feststehenden Körpers (2) angeordnet und in einer horizontalen Richtung entlang einer ersten Richtung bewegbar ist,
(b) eine Impulsquelle (8) zum schnellen Verformungsantrieb eines piezoelektrischen Elements (4) und
(c) einen sich bewegenden Körper (5), der entlang einer zweiten Achse in einer Aufwärts- oder Abwärtsrichtung relativ zur Basis (1) vertikal bewegbar ist,

dadurch gekennzeichnet, dass eine untere Fläche des keilförmigen sich bewegenden Elements (5) an dem piezoelektrischen Element (4) angebracht ist, wobei das piezoelektrische Element (4) ausgebildet ist, um eine Scherverformung zu erzeugen, wenn es mit Antriebsimpulsen von der Impulsquelle (8) her angetrieben wird, um das keilförmige sich bewegende Element (3) entlang der ersten Achse in der horizontalen Richtung zu bewegen, so dass das keilförmige sich bewegende Element (3) den sich bewegenden Körper (5) antreibt, um den sich bewegenden Körper (5) entlang der zweiten Achse in der Aufwärts- oder Abwärtsrichtung relativ zur Basis (1) zu bewegen.

9. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 8, wobei das piezoelektrische Element (4) ein geschichtetes piezoelektrisches Element (24) ist, in dem ein piezoelektrisches Element (24A), das eine Scherverformung erzeugt, an ein piezoelektrisches Element (24B) gebondet ist, das eine vertikale Verformung erzeugt.

10. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 8, wobei ferner ein zweites piezoelektrisches Element (11) an einer oberen Fläche des keilförmigen sich bewegenden Elements (3) angebracht ist.

11. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 10, wobei das zweite piezoelektrische Element ein geschichtetes piezoelektrisches Element (28) ist.

12. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 10, wobei das zweite piezoelektrische Element (11) ein piezoelektrisches Element ist, das in einer Richtung entlang einer dritten Achse schert, die zur ersten und zweiten Achse senkrecht ist.

13. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 11, wobei das zweite geschichtete piezoelektrische Element (28) aus Schichten eines piezoelektrischen Elements (28A) gebildet wird, das in der Richtung einer geneigten Fläche schert, und eines piezoelektrischen Elements (28C), das in einer Richtung entlang einer dritten Achse schert, die zur ersten und zweiten Achse senkrecht ist.

14. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 11, wobei das zweite geschichtete piezoelektrische Element

(28) aus Schichten eines piezoelektrischen Elements (28A) gebildet wird, das in der Richtung einer geneigten Fläche schert, und eines piezoelektrischen Elements (28B), das sich in einer normalen Richtung der geneigten Fläche ausdehnt und zusammenzieht.

15. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 8, wobei ferner ein drittes piezoelektrisches Element (37) an einer Fläche des sich bewegenden Körpers (35) angebracht ist, der eine Wandflächenseite des feststehenden Körpers (32) berührt.

16. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 9, wobei ferner ein drittes geschichtetes piezoelektrisches Element (29) an einer Fläche des sich bewegenden Körpers (25) angebracht ist, der eine Wandflächenseite des feststehenden Körpers (22) berührt.

17. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 8, wobei
das keilförmige sich bewegende Element ein erstes keilförmiges sich bewegendes Element (62) ist, das an einer linken Seite auf der Basis (61) angeordnet ist, und das erste keilförmige Element (62) eine horizontale untere Fläche und eine geneigte Fläche aufweist, wovon die Innenseite auf einer oberen Fläche niedriger ist, und das an der unteren Fläche des ersten keilförmigen sich bewegenden Elements angebrachte piezoelektrische Element (63) ein erstes piezoelektrisches Element ist, wobei ein zweites piezoelektrisches Element (64), das eine Scherverformung in einer Richtung entlang einer dritten Achse erzeugt, die zur ersten und zweiten Achse senkrecht ist, an der geneigten Fläche angebracht ist,
ein zweites keilförmiges sich bewegendes Element (65) an einer rechten Seite auf der Basis (61) angeordnet ist und eine horizontale untere Fläche und eine geneigte Fläche aufweist, wovon die Innenseite auf einer oberen Fläche niedriger ist, und an der unteren Fläche ein drittes piezoelektrisches Element (66), das aus einem piezoelektrischen Element hergestellt ist, das eine Scherverformung erzeugt, angebracht ist und an der geneigten Fläche ein viertes piezoelektrisches Element (67), das eine Scherverformung in einer Richtung entlang der dritten Achse erzeugt, angebracht ist, wobei

(c) die Vorrichtung ferner Mittel umfasst, in denen ein sich bewegender Körper (68) angeordnet ist, um sich über das erste keilförmige sich bewegende Element (62) und das zweite keilförmige sich bewegende Element (65) zu erstrecken, durch schnelles Verformen der piezoelektrischen Elemente das erste und zweite keilförmige sich bewegende Element (62, 65) auf der Basis (61) bewegt werden und eine Einstellung durch kleinste Bewegungen in einer Richtung entlang der dritten Achse und der vertikalen Richtung des sich bewegenden Körpers (68) durchgeführt wird, der in der vertikalen Richtung und in der Richtung entlang der dritten Achse bewegbar ist, so dass eine Gesamtheit potenzieller Energie der zwei sich bewegenden Körper (62, 65) in der vertikalen Richtung nicht geändert wird, und Mittel, die ausgebildet sind, um die piezoelektrischen Elemente (64, 67) schnell zu verformen, die die Scherverformungen in einer Richtung entlang der dritten Achse erzeugen, um eine Einstellung des sich bewegenden Körpers (68) in der Richtung entlang der dritten Achse durch kleinste Bewegungen durchzuführen.

18. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 17, wobei das zweite piezoelektrische Element (64) aus einem geschichteten piezoelektrischen Element gebildet wird, in dem ein piezoelektrisches Element (64A), das eine Scherverformung in der Richtung einer geneigten Fläche erzeugt, an ein piezoelektrisches Element (64C) gebondet ist, das eine Scherverformung in einer Richtung entlang der dritten Achse erzeugt, und das vierte piezoelektrische Element (67) aus einem geschichteten piezoelektrischen Element gebildet wird, in dem ein piezoelektrisches Element (67A), das eine Scherverformung in der Richtung einer geneigten Fläche erzeugt, an ein piezoelektrisches Element (67C) gebondet ist, das eine Scherverformung in einer Richtung entlang der dritten Achse erzeugt.

19. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 17, wobei das erste piezoelektrische Element (63) ein geschichtetes piezoelektrisches Element ist, das aus einem piezoelektrischen Element gebildet wird, das eine Scherverformung erzeugt, und einem piezoelektrischen Element, das eine vertikale Verformung erzeugt, und das dritte piezoelektrische Element (66) ein geschichtetes piezoelektrisches Element ist, das aus einem piezoelektrischen Element gebildet wird, das eine Scherverformung erzeugt, und einem piezoelektrischen Element, das eine vertikale Verformung erzeugt.

20. Vorrichtung zum Widerstehen und präzisen Bewegen einer hohen Last gemäß Anspruch 17, wobei das zweite piezoelektrische Element (64) ein piezoelektrisches Element ist, in dem ein piezoelektrisches Element, das eine Scherverformung in der Richtung einer geneigten Fläche erzeugt, an ein piezoelektrisches Element gebondet ist, das eine vertikale Verformung erzeugt, und das vierte piezoelektrische Element (67) ein piezoelektrisches Element ist, in dem ein piezoelektrisches Element, das eine Scherverformung in der Richtung einer geneigten Fläche erzeugt, an ein piezoelektrisches Element gebondet ist, das eine vertikale Verformung erzeugt.

Revendications

1. Un procédé de déplacement précis et résistant à une charge élevée comportant les étapes visant à :

(a) fixer un élément piézoélectrique (4) qui génère une déformation par cisaillement, à une surface de dessous d'un élément mobile en forme de coin (3) placé sur une base (1), et
(b) déformer rapidement l'élément piézoélectrique (4) en entraînant l'élément piézoélectrique (4) avec des impulsions d'entraînement pour déplacer l'élément mobile en forme de coin (3) le long d'un premier axe dans lequel l'élément mobile en forme de coin (3) est entraîné dans ou à l'écart d'un corps mobile (5) pour déplacer le corps mobile (5) le long d'un deuxième axe dans une direction vers le haut ou vers le bas relativement à la base (1), afin de réaliser un réglage fin du positionnement du corps mobile (5).

2. Un procédé de déplacement précis et résistant à une charge élevée selon la revendication 1, où l'élément piézoélectrique (4) est un élément piézoélectrique en couches (24) dans lequel un élément piézoélectrique (24A) qui génère une déformation par cisaillement est lié à un élément piézoélectrique (24B) qui génère une déformation verticale.

3. Un procédé de déplacement précis et résistant à une charge élevée selon la revendication 1, où le procédé comporte de plus l'étape visant à :

fixer un deuxième élément piézoélectrique (11) qui génère une déformation par cisaillement le long d'une surface inclinée supérieure de l'élément mobile en forme de coin (3).

4. Un procédé de déplacement précis et résistant à une charge élevée selon la revendication 3, où le deuxième élément piézoélectrique (11) génère une déformation par cisaillement dans une direction le long d'un troisième axe qui est perpendiculaire aux premier et deuxième axes, et le corps mobile (5) peut être déplacé dans une direction verticale relativement à la base (1) le long du premier axe et dans une direction le long du troisième axe, et le procédé comporte de plus l'étape visant à:

(c) réaliser un réglage fin du positionnement du corps mobile (5) en déformant rapidement le deuxième élément piézoélectrique pour déplacer le corps mobile (5) dans une direction le long du troisième axe.

5. Un procédé de déplacement précis et résistant à une charge élevée selon la revendication 1, où l'élément piézoélectrique (4) est un élément piézoélectrique en couches (24) dans lequel un élément piézoélectrique (24A) qui génère une déformation par cisaillement est lié à un élément piézoélectrique (24B) qui génère une déformation verticale, et le procédé comporte de plus les étapes visant à :

fixer un élément piézoélectrique en couches (28) à une surface inclinée supérieure de l'élément mobile en forme de coin (23), l'élément piézoélectrique en couches (28) comportant un élément piézoélectrique (28A) qui génère une déformation par cisaillement le long d'une surface inclinée qui est liée à un élément piézoélectrique (28C) qui génère une déformation par cisaillement dans une direction le long d'un troisième axe qui est perpendiculaire aux premier et deuxième axes, et :
déplacer l'élément mobile en forme de coin (23) sur la base (1) en déformant rapidement l'élément piézoélectrique (28A) qui génère la déformation par cisaillement le long de la surface inclinée à partir de l'élément piézoélectrique en couches (24) fixé à la surface de dessous de l'élément mobile en forme de coin (23) et de l'élément piézoélectrique en couches (28) fixé à la surface inclinée supérieure, de sorte que l'élément mobile en forme de coin (23) se déplace pour entraîner le corps mobile (5) verticalement le long du premier axe dans la direction vers le haut ou vers le bas relativement à la base (1), pour réaliser un réglage fin du positionnement du corps mobile (5), et, en déformant rapidement l'élément piézoélectrique (28C) qui génère la déformation par cisaillement dans la direction le long du troisième axe relativement à l'élément piézoélectrique en couches (28) fixé à la surface inclinée supérieure, pour réaliser également un réglage fin du positionnement du corps mobile (5) dans une direction le long du troisième axe.

6. Un procédé de déplacement précis et résistant à une charge élevée selon la revendication 1, où l'élément mobile en forme de coin est un premier élément mobile en forme de coin (62) agencé d'un côté gauche sur la base (61), le premier élément mobile en forme de coin (62) ayant une surface de dessous horizontale et une surface inclinée dont l'intérieur est plus bas sur une surface supérieure, la surface de dessous étant fixée à un premier élément piézoélectrique (63) formé d'un élément piézoélectrique qui génère une déformation par cisaillement, un deuxième élément piézoélectrique (64) qui génère une déformation par cisaillement dans une direction le long d'un troisième axe qui est perpendiculaire aux premier et deuxième axes étant fixé à la surface inclinée, et un deuxième élément mobile en forme de coin (65) agencé d'un côté droit sur la base (61), le deuxième élément mobile en forme de coin (65) ayant une surface de dessous horizontale et une surface inclinée dont l'intérieur est plus bas sur une surface supérieure, la surface de dessous du deuxième élément mobile en forme de coin (65) étant fixée à un troisième élément piézoélectrique (66) formé d'un élément piézoélectrique qui génère une déformation par cisaillement, un quatrième élément piézoélectrique (67) qui génère une déformation par cisaillement dans une direction le long du troisième axe étant fixé à la surface inclinée du deuxième élément mobile en forme de coin (67), le corps mobile (68) étant agencé pour relier le premier élément mobile en forme de coin (62) et le deuxième élément mobile en forme de coin (65), en déformant rapidement les premier et troisième éléments piézoélectriques (63, 66), les premier et deuxième éléments mobiles en forme de coin (62, 65) sont déplacés sur la base (61), afin de réaliser un réglage fin du positionnement du corps mobile (68) pouvant être déplacé verticalement le long du premier axe dans des directions vers le haut et vers le bas et dans des directions le long du troisième axe, et en déformant rapidement les deuxième et quatrième éléments piézoélectriques (64, 67), un réglage fin du positionnement du corps mobile (68) dans une direction le long du troisième axe est également réalisé.

7. Un procédé de déplacement précis et résistant à une charge élevée selon la revendication 6, où le deuxième élément piézoélectrique (64) est formé d'un élément piézoélectrique en couches dans lequel un élément piézoélectrique (64A) qui génère une déformation par cisaillement dans une direction de surface inclinée est lié à un élément piézoélectrique (64C) qui génère une déformation par cisaillement dans une direction le long du troisième axe et le quatrième élément piézoélectrique (67) est formé d'un élément piézoélectrique en couches dans lequel un élément piézoélectrique[1] (67A) qui génère une déformation par cisaillement dans la direction de surface inclinée qui est liée à un élément piézoélectrique (67C) qui génère une déformation par cisaillement dans une direction le long du troisième axe.

[1] À l'instar de la version originale anglaise, ce sujet est sans verbe.

8. Un dispositif de déplacement précis et résistant à une charge élevée comportant :

(a) un élément mobile en forme de coin (3) agencé sur une base (1) d'un corps fixe (2) et pouvant être déplacé dans une direction horizontale le long d'une première direction,

(b) une source d'impulsions (8) pour un entraînement à déformation rapide d'un élément piézoélectrique (4), et

(c) un corps mobile (5) pouvant être déplacé verticalement le long d'un deuxième axe dans une direction vers le haut ou vers le bas relativement à la base (1),

caractérisé en ce qu'une surface de dessous de l'élément mobile en forme de coin (5) est fixée à l'élément piézoélectrique (4), l'élément piézoélectrique (4) étant configuré pour générer une déformation par cisaillement, lorsqu'entraîné par des impulsions d'entraînement de la source d'impulsions (8), pour déplacer l'élément mobile en forme de coin (3) le long du premier axe dans la direction horizontale de sorte que l'élément mobile en forme de coin (3) entraîne le corps mobile (5) afin de déplacer le corps mobile (5) le long du deuxième axe dans la direction vers le haut ou vers le bas relativement à la base (1).

9. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 8, où l'élément piézoélectrique (4) est un élément piézoélectrique en couches (24) dans lequel un élément piézoélectrique (24A) qui génère une déformation par cisaillement est lié à un élément piézoélectrique (24B) qui génère une déformation verticale.

10. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 8, où, de plus, un deuxième élément piézoélectrique (11) est fixé sur une surface supérieure de l'élément mobile en forme de coin (3).

11. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 10, où le deuxième élément piézoélectrique est un élément piézoélectrique en couches (28).

12. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 10, où le deuxième élément piézoélectrique (11) est un élément piézoélectrique qui cisaille dans une direction le long d'un troisième axe qui est perpendiculaire aux premier et deuxième axes.

13. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 11, où le deuxième élément piézoélectrique en couches (28) est formé de couches d'un élément piézoélectrique (28A) qui cisaille dans une direction de surface inclinée et d'un élément piézoélectrique (28C) qui cisaille dans une direction le long d'un troisième axe qui est perpendiculaire aux premier et deuxième axes.

14. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 11, où le deuxième élément piézoélectrique en couches (28) est formé de couches d'un élément piézoélectrique (28A) qui cisaille dans une direction de surface inclinée et d'un élément piézoélectrique (28B) qui s'étend et se contracte dans une direction normale de la surface inclinée.

15. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 8, où, de plus, un troisième élément piézoélectrique (37) est fixé à une surface du corps mobile (35) qui est en contact avec un côté de surface de paroi du corps fixe (32).

16. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 9, où, de plus, un troisième élément piézoélectrique en couches (29) est fixé à une surface du corps mobile (25) qui est en contact avec un côté de surface de paroi du corps fixe (22).

17. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 8, où
l'élément mobile en forme de coin est un premier élément mobile en forme de coin (62) qui est agencé d'un côté gauche sur la base (61) et le premier élément en forme de coin (62) a une surface de dessous horizontale et une surface inclinée dont l'intérieur est plus bas sur une surface supérieure, et l'élément piézoélectrique fixé (63) à la surface de dessous du premier élément mobile en forme de coin est un premier élément piézoélectrique, un deuxième élément piézoélectrique (64) qui génère une déformation par cisaillement dans une direction le long d'un troisième axe qui est perpendiculaire aux premier et deuxième axes étant fixé à la surface inclinée,
un deuxième élément mobile en forme de coin (65) étant agencé d'un côté droit sur la base (61) et ayant une surface de dessous horizontale et une surface inclinée dont l'intérieur est plus bas sur une surface supérieure, et à la surface de dessous, un troisième élément piézoélectrique (66) fait d'un élément piézoélectrique qui génère une déformation par cisaillement est fixé, et à la surface inclinée, un quatrième élément piézoélectrique (67) qui génère une déformation par cisaillement dans une direction le long du troisième axe est fixé, où

(c) le dispositif comporte de plus des moyens par lesquels un corps mobile (68) est agencé pour relier le premier élément mobile en forme de coin (62) et le deuxième élément mobile en forme de coin (65), en déformant rapidement les éléments piézoélectriques, les premier et deuxième éléments mobiles en forme de coin (62, 65) sont déplacés sur la base (61), et un réglage fin du positionnement dans une direction le long du troisième axe et de la direction verticale du corps mobile (68) pouvant être déplacé dans la direction verticale et dans la direction le long du troisième axe est réalisé de sorte qu'un total d'énergie potentielle des deux corps mobiles (62, 65) dans la direction verticale ne soit pas changé, et des moyens qui sont configurés pour déformer rapidement les éléments piézoélectriques (64, 67) qui génèrent les déformations par cisaillement dans une direction le long du troisième axe pour réaliser un réglage fin du positionnement du corps mobile (68) dans la direction le long du troisième axe.

18. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 17, où le deuxième élément piézoélectrique (64) est formé d'un élément piézoélectrique en couches dans lequel un élément piézoélectrique (64A) qui génère une déformation par cisaillement dans une direction de surface inclinée est lié à un élément piézoélectrique (64C) qui génère une déformation par cisaillement dans une direction le long du troisième axe, et le quatrième élément piézoélectrique (67) est formé d'un élément piézoélectrique en couches dans lequel un élément piézoélectrique (67A) qui génère une déformation par cisaillement dans une direction de surface inclinée est lié à un élément piézoélectrique (67C) qui génère une déformation par cisaillement dans une direction le long du troisième axe.

19. Un dispositif mobile précis et résistant à une charge élevée selon la revendication 17, où le premier élément piézoélectrique (63) est un élément piézoélectrique en couches formé d'un élément piézoélectrique qui génère une déformation par cisaillement et d'un élément piézoélectrique qui génère une déformation verticale, et le troisième élément piézoélectrique (66) est un élément piézoélectrique en couches formé d'un élément piézoélectrique qui génère une déformation par cisaillement et d'un élément piézoélectrique qui génère une déformation verticale.

20. Un dispositif de déplacement précis et résistant à une charge élevée selon la revendication 17, où le deuxième élément piézoélectrique (64) est un élément piézoélectrique dans lequel un élément piézoélectrique qui génère une déformation par cisaillement dans une direction de surface inclinée est lié à un élément piézoélectrique qui génère une déformation verticale, et le quatrième élément piézoélectrique (67) est un élément piézoélectrique dans lequel un élément piézoélectrique qui génère une déformation par cisaillement dans une direction de surface inclinée est lié à un élément piézoélectrique qui génère une déformation verticale.

FIG. 1

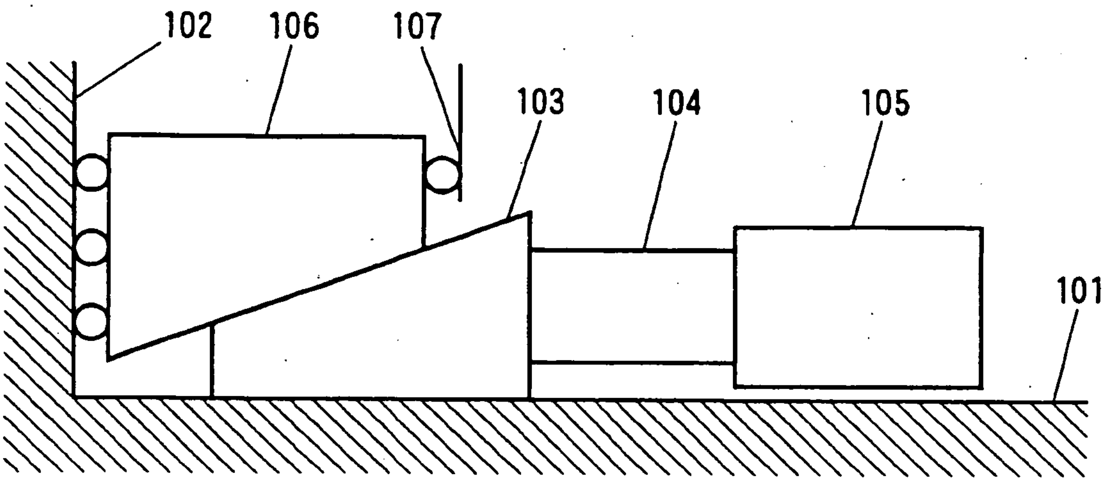


FIG. 2

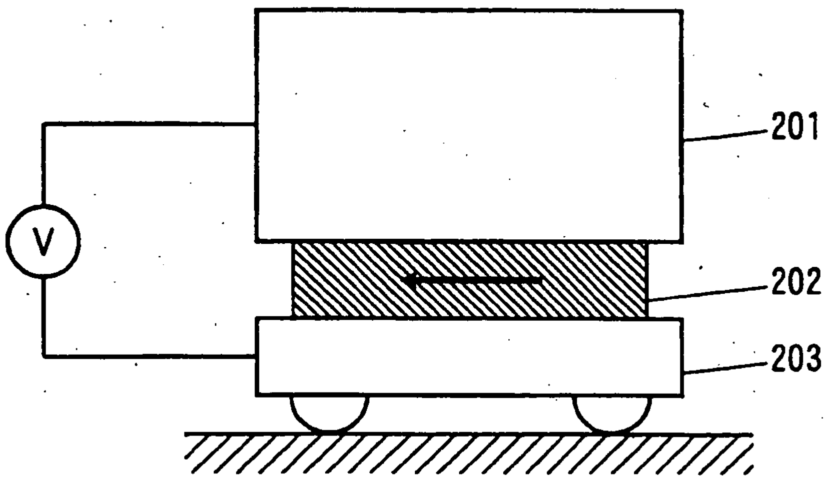


FIG. 3

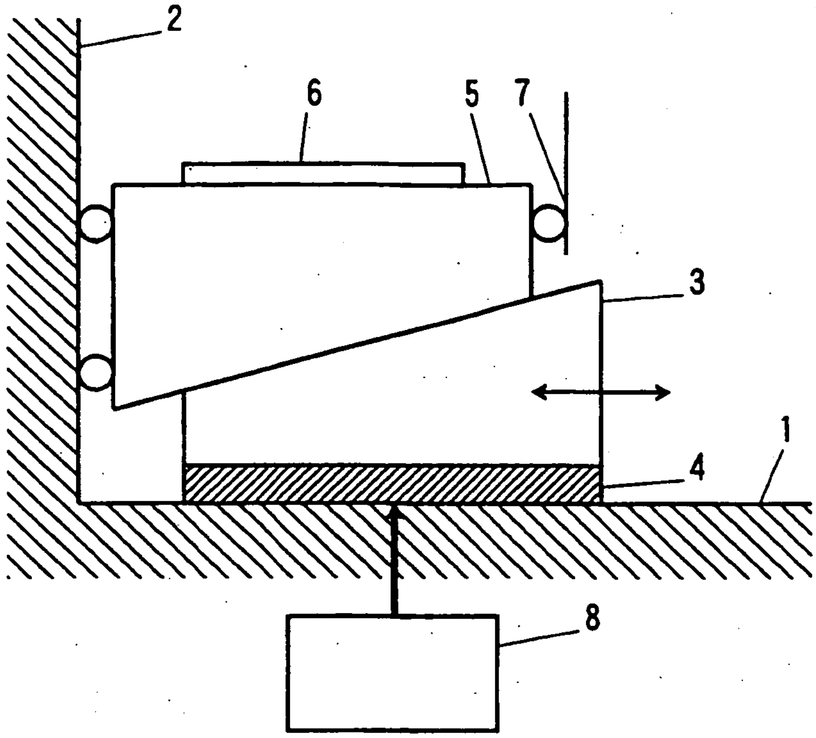


FIG. 4

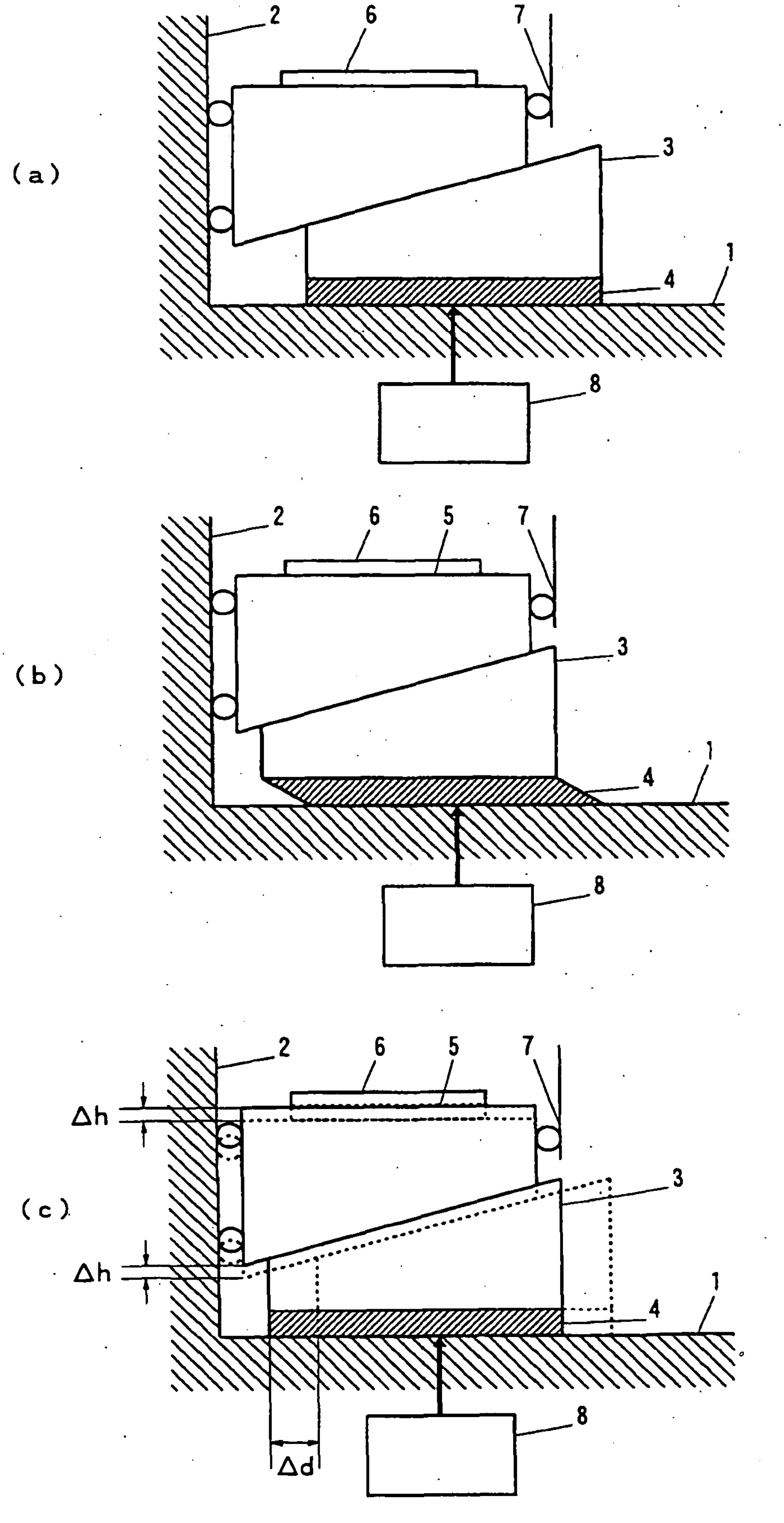


FIG. 5

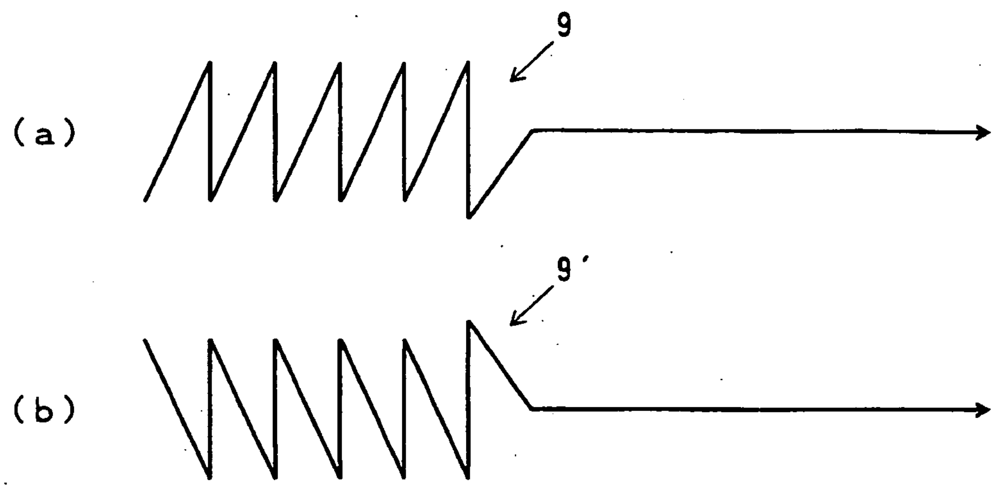


FIG. 6

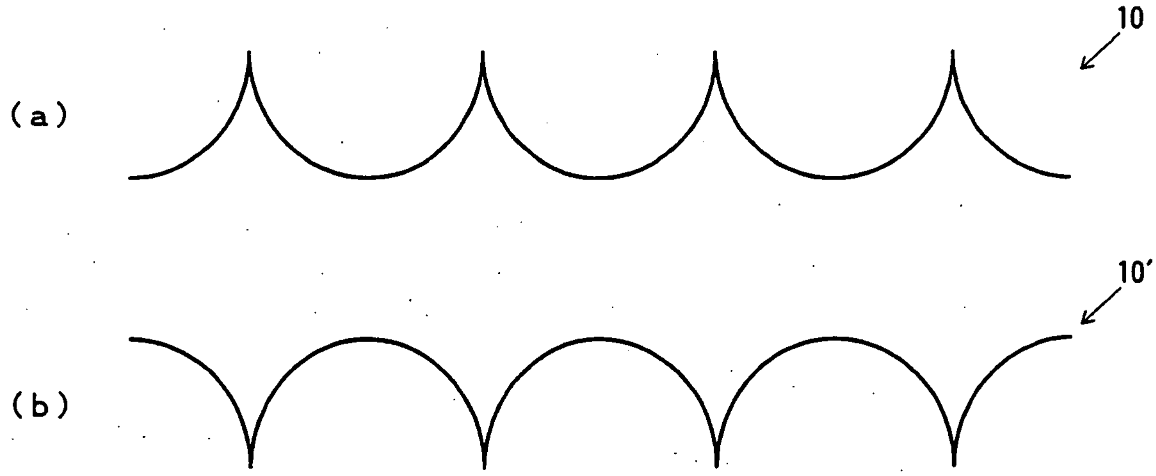


FIG. 7

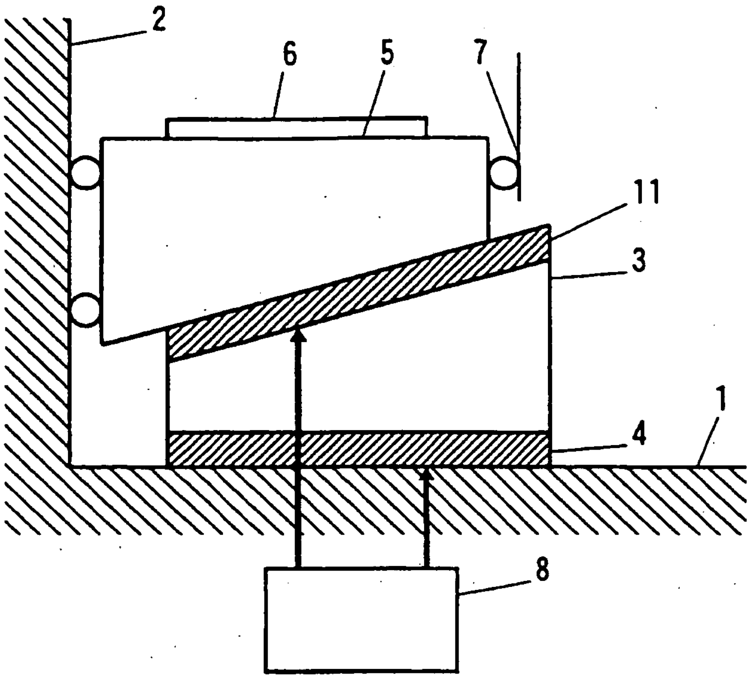


FIG. 8

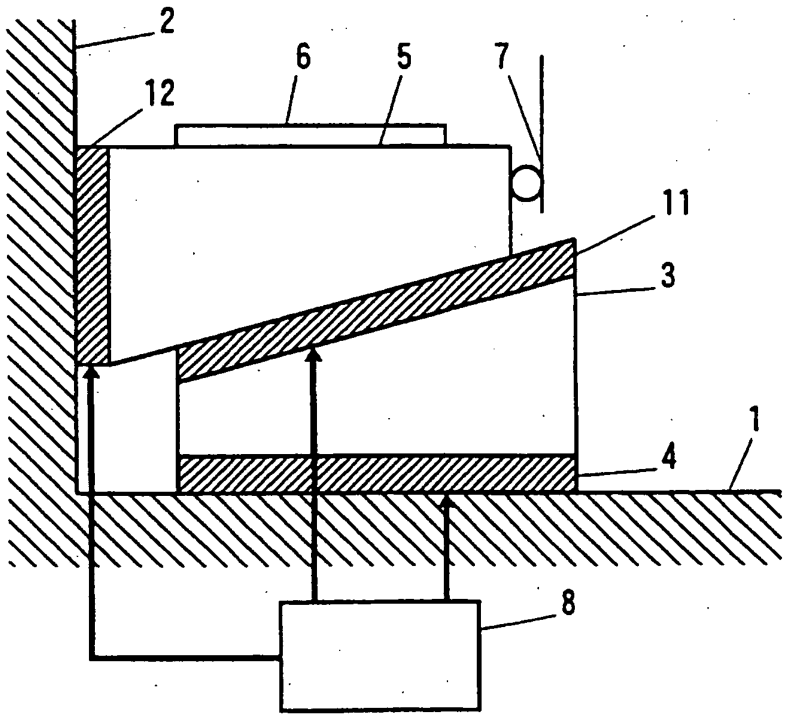


FIG. 9

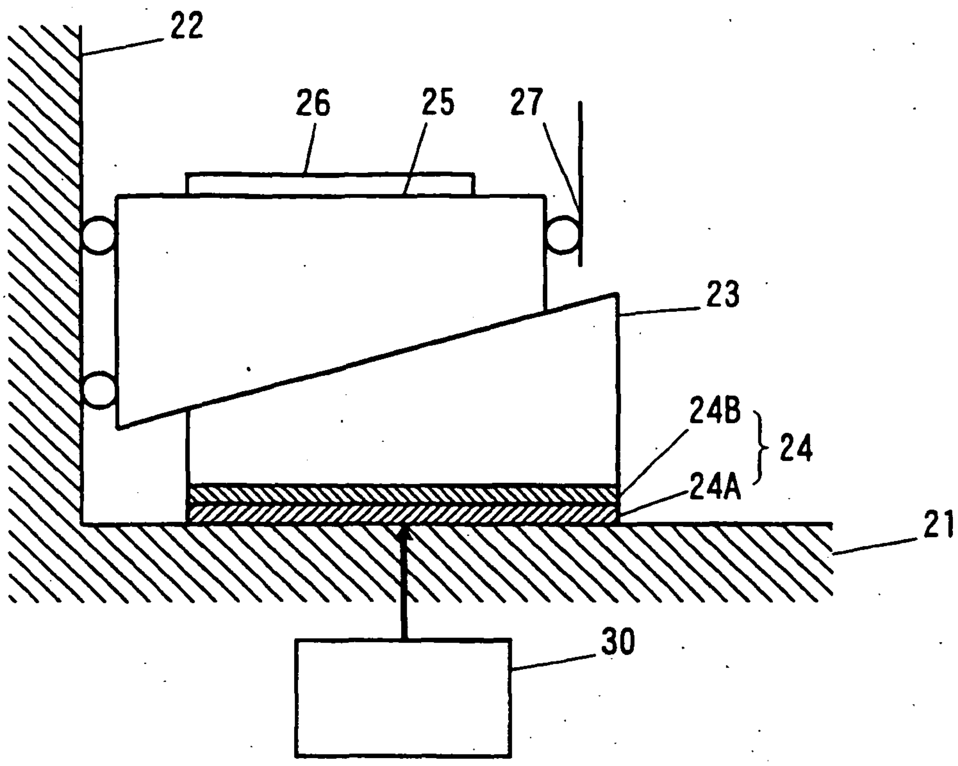


FIG. 10

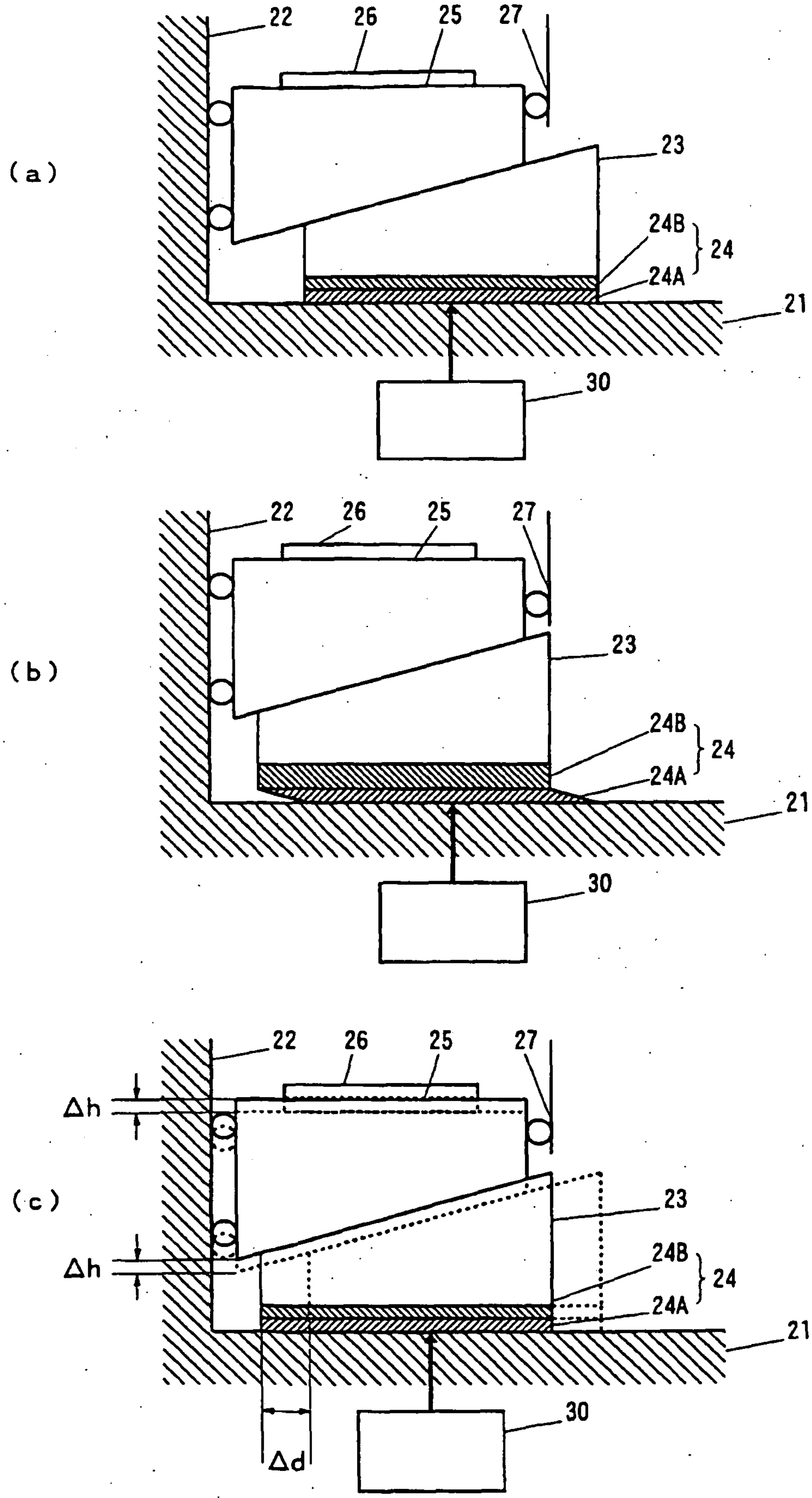

(a)
22
26
25
27
23
24B
24
24A
21
30
(b)
22
26
25
27
23
24B
24
24A
21
30
(c)
Δh
22
26
25
27
23
Δh
24B
24
24A
21
30
Δd

FIG. 11

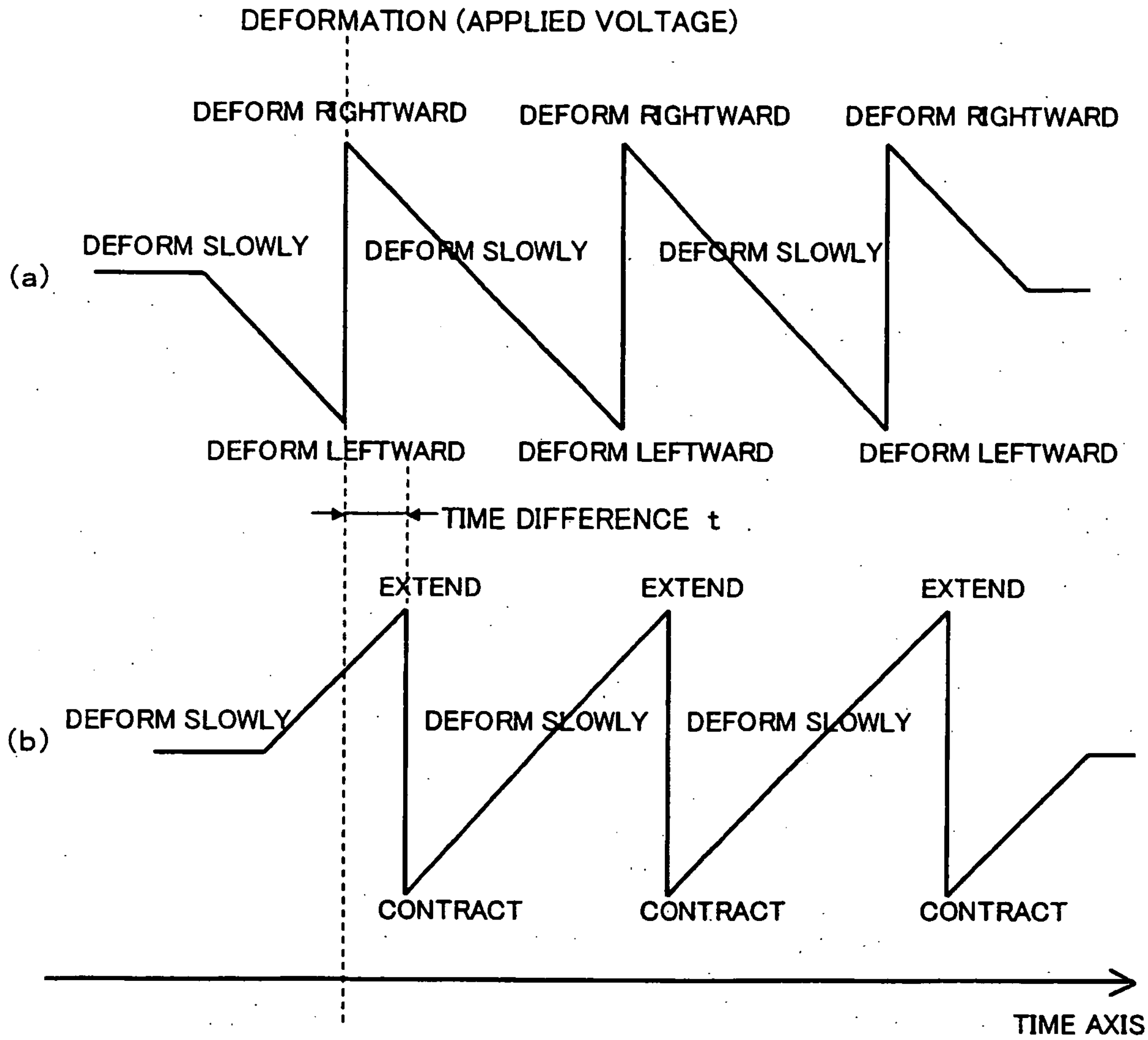

DEFORMATION (APPLIED VOLTAGE)
DEFORM RIGHTWARD
DEFORM RIGHTWARD
DEFORM RIGHTWARD
(a)
DEFORM SLOWLY
DEFORM SLOWLY
DEFORM SLOWLY
DEFORM LEFTWARD
DEFORM LEFTWARD
DEFORM LEFTWARD
TIME DIFFERENCE t
EXTEND
EXTEND
EXTEND
(b)
DEFORM SLOWLY
DEFORM SLOWLY
DEFORM SLOWLY
CONTRACT
CONTRACT
CONTRACT
TIME AXIS

FIG. 12

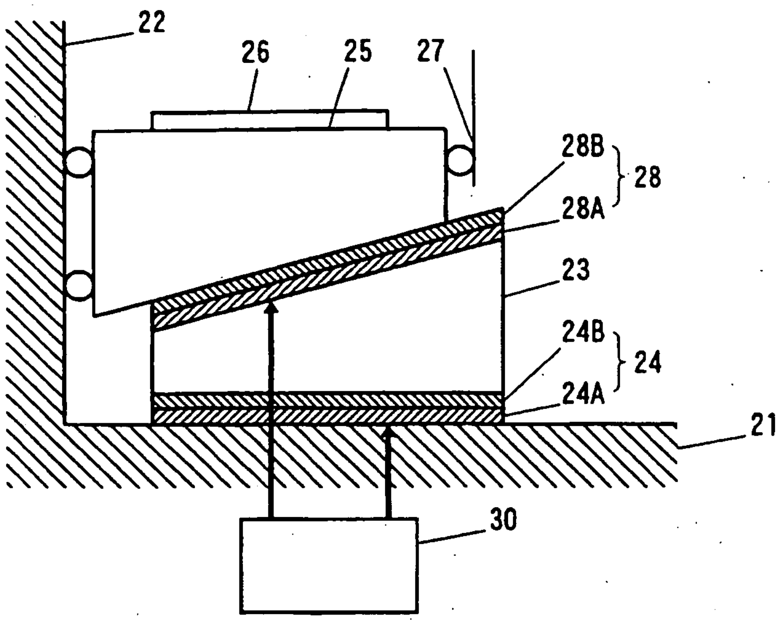

22
26
25
27
28B
28
28A
23
24B
24
24A
21
30

FIG. 13

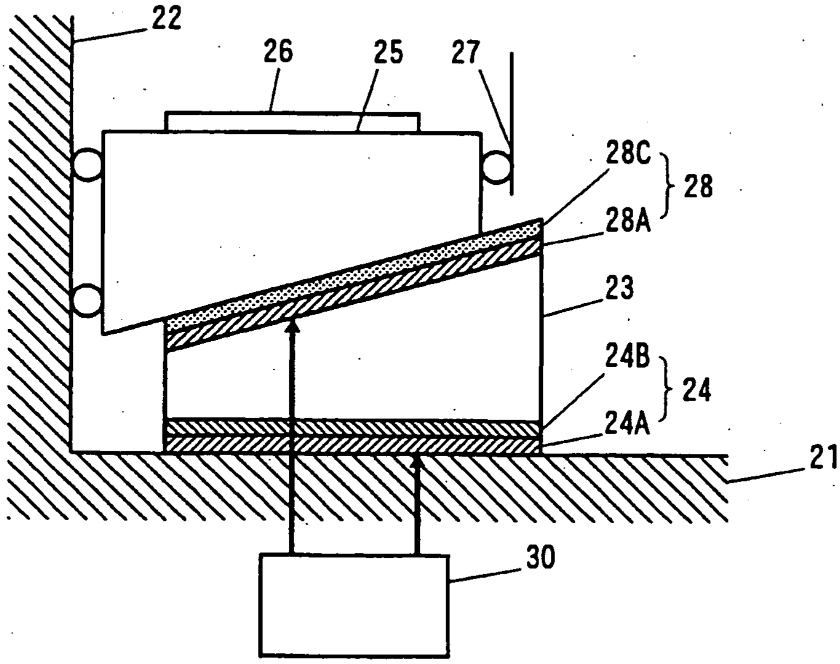

22
26
25
27
28C
28
28A
23
24B
24
24A
21
30

FIG. 14

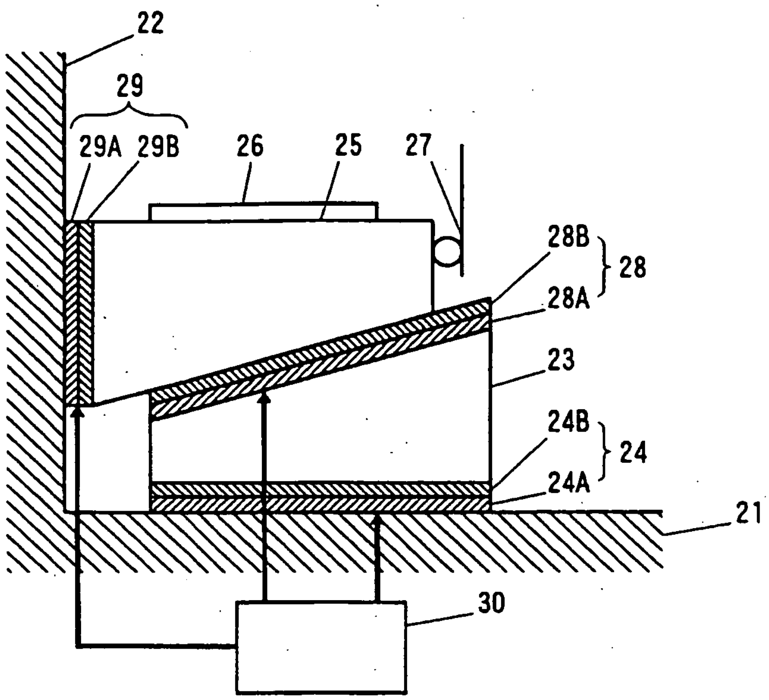

22
29
29A
29B
26
25
27
28B
28
28A
23
24B
24
24A
21
30

FIG. 15

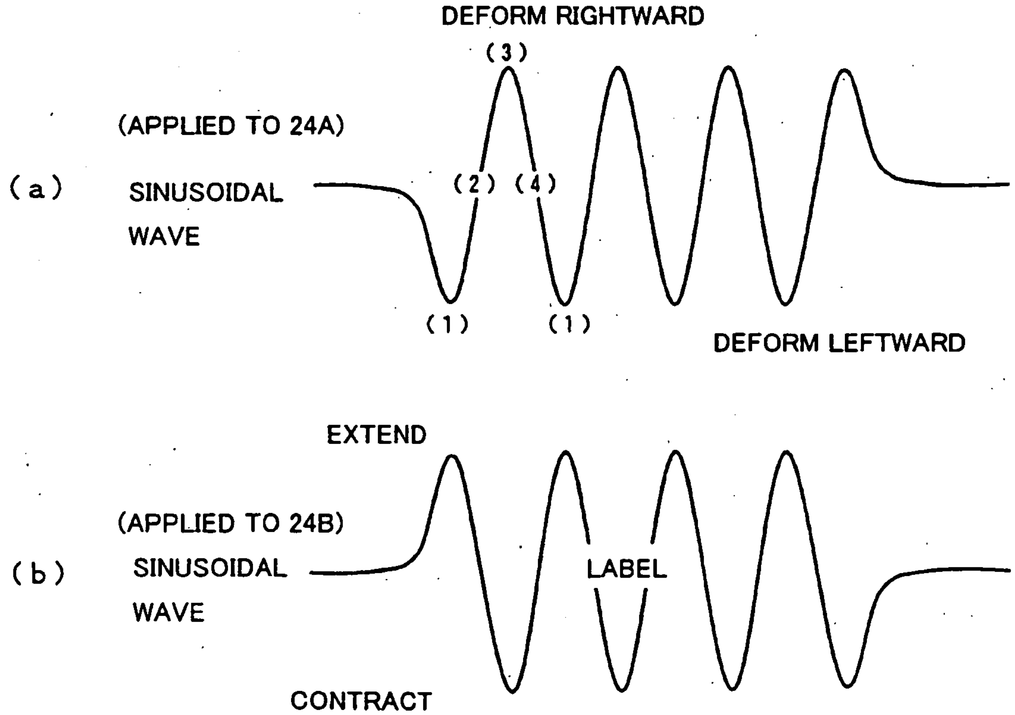

DEFORM RIGHTWARD
(3)
(APPLIED TO 24A)
(a)
SINUSOIDAL
WAVE
(2)
(4)
(1)
(1)
DEFORM LEFTWARD
EXTEND
(APPLIED TO 24B)
(b)
SINUSOIDAL
WAVE
LABEL
CONTRACT

FIG. 16

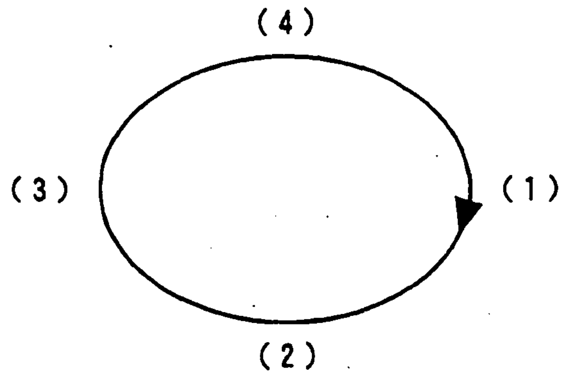


FIG. 17

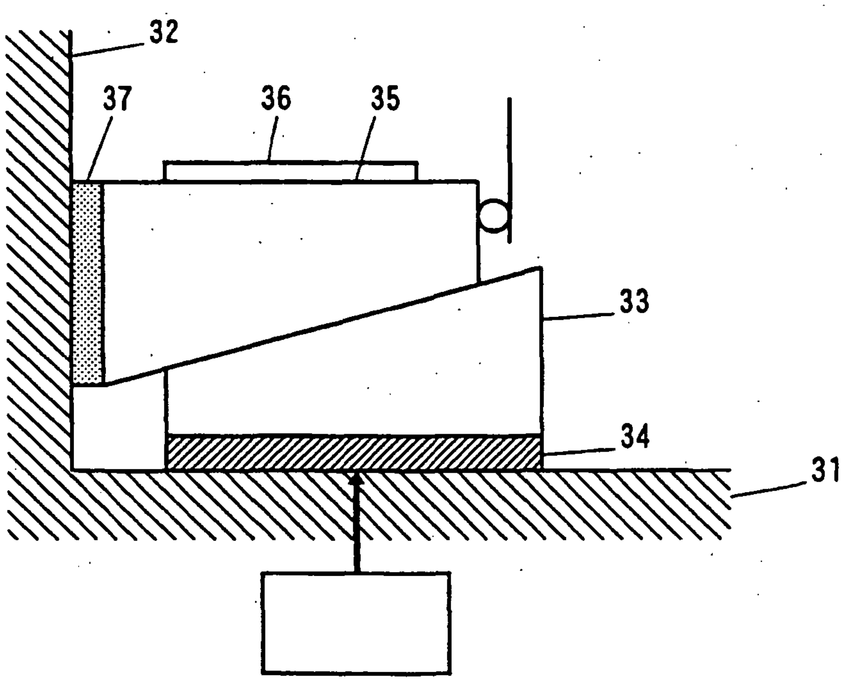


FIG. 18

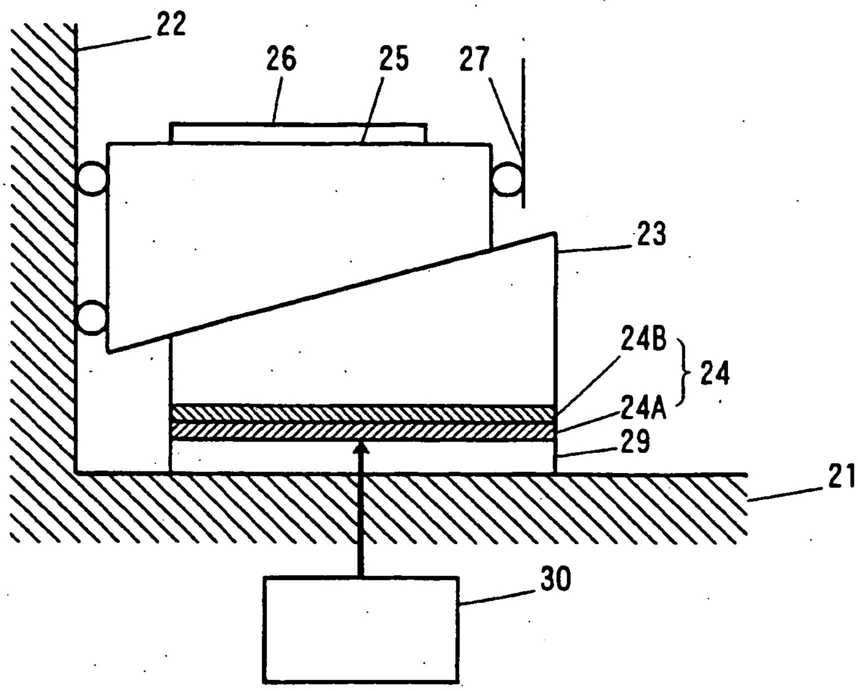

22
26
25
27
23
24B
24
24A
29
21
30

FIG. 19

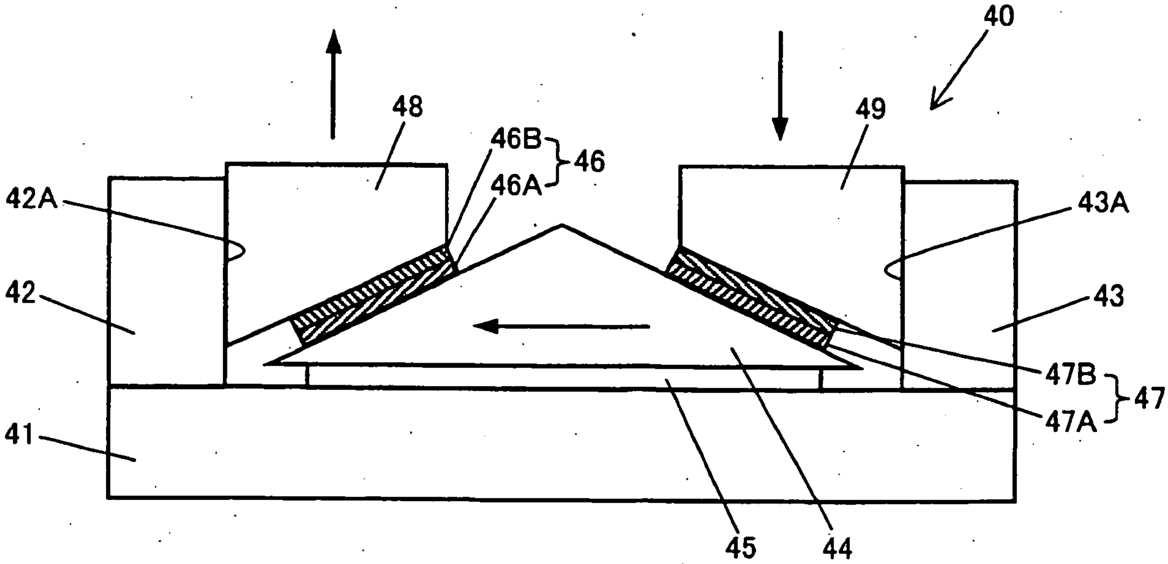

40
48
49
46B
46
46A
42A
43A
42
43
47B
47
47A
41
45
44

FIG. 20

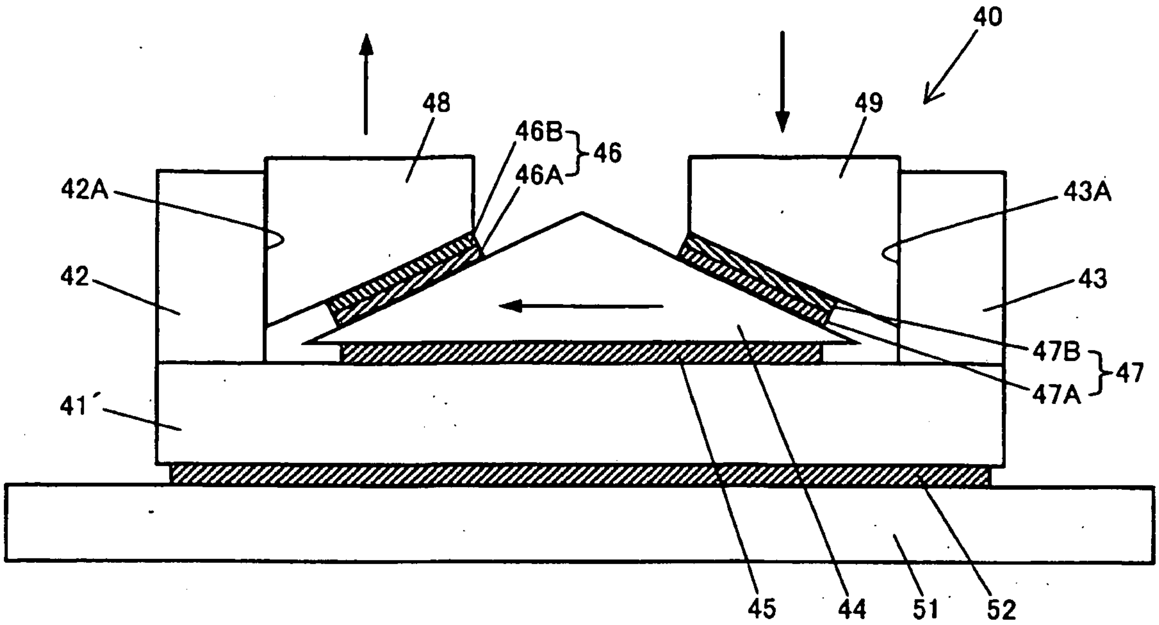

40
48
49
46B
46A
46
42A
43A
42
43
47B
47A
47
41´
45
44
51
52

FIG. 21

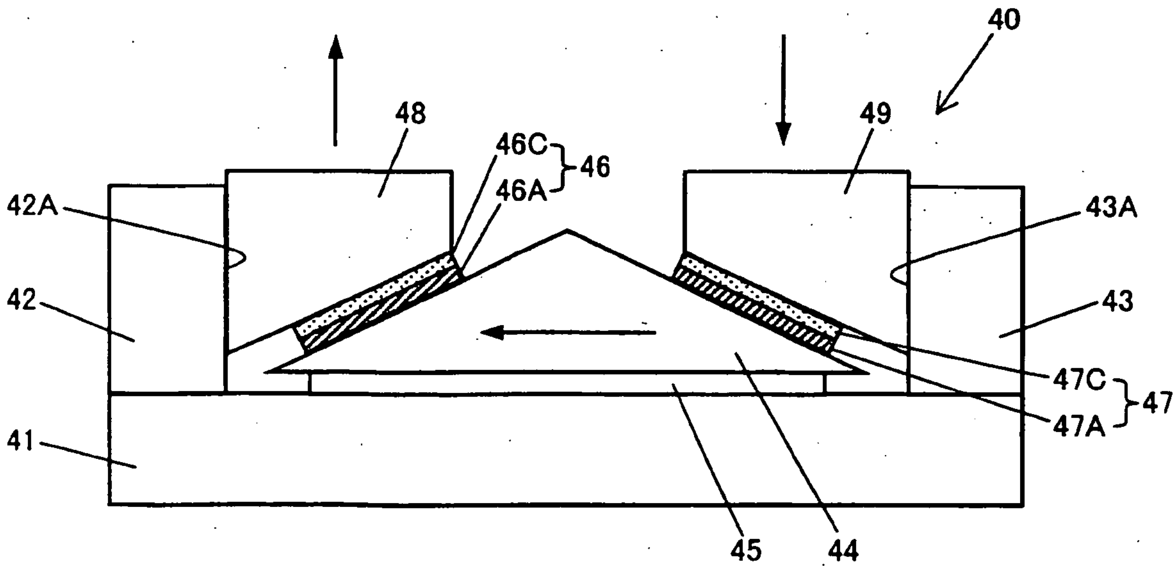

40
48
49
46C
46A
46
42A
43A
42
43
47C
47A
47
41
45
44

FIG. 22

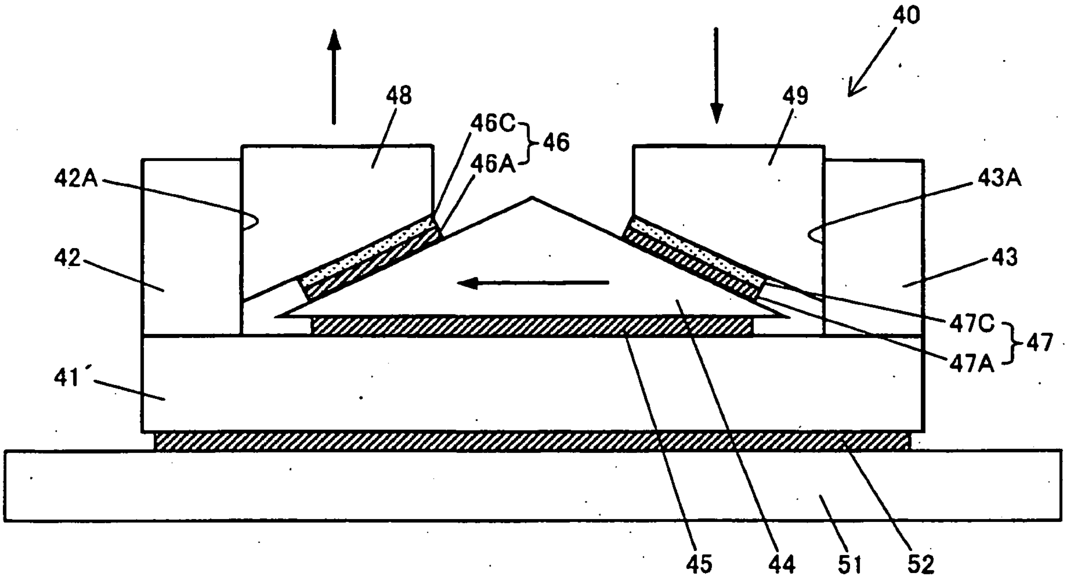

40
48
49
46C
46A
46
42A
43A
42
43
47C
47A
47
41'
45
44
51
52

FIG. 23

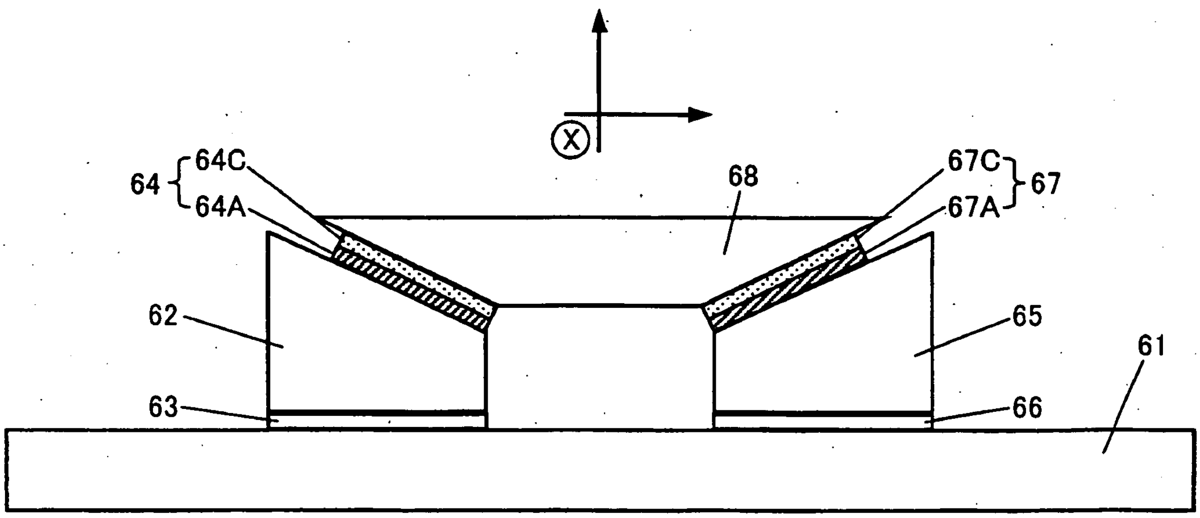

64
64C
64A
68
67C
67A
67
62
65
61
63
66

FIG. 24

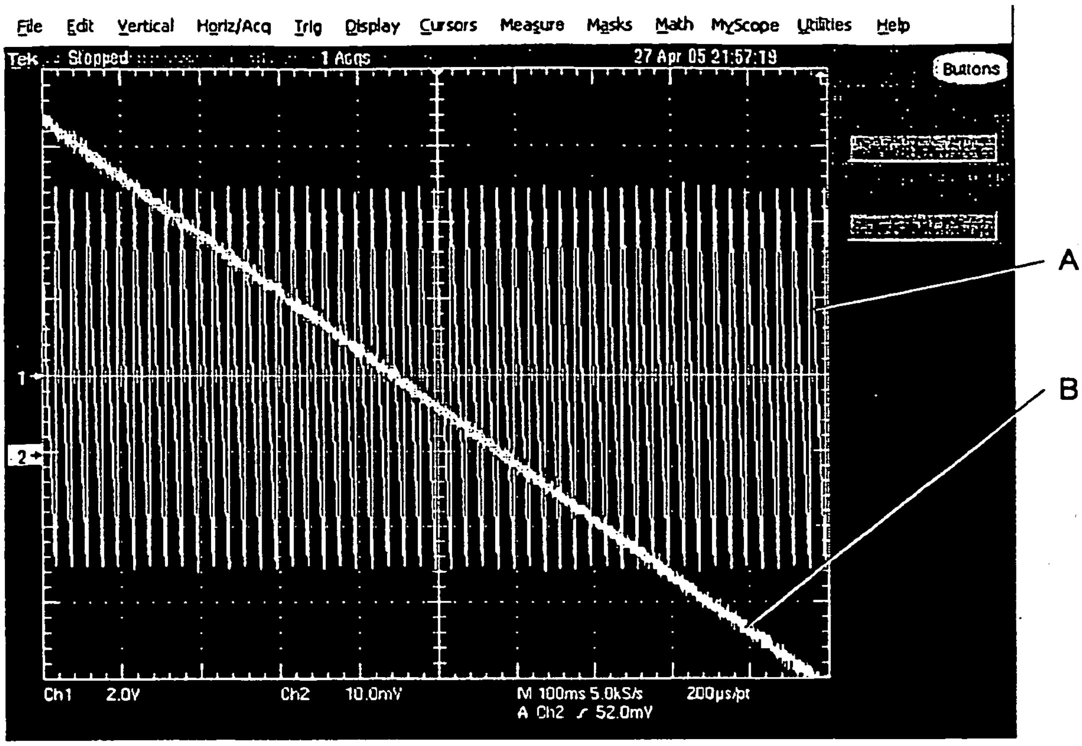

File Edit Vertical Horiz/Acq Trig Display Cursors Measure Masks Math MyScope Utilities Help
Tek Stopped 1 Acqs 27 Apr 05 21:57:19
Buttons
A
B
1
2
Ch1 2.0V Ch2 10.0mV M 100ms 5.0kS/s 200µs/pt
A Ch2 ⌐ 52.0mV

FIG. 25

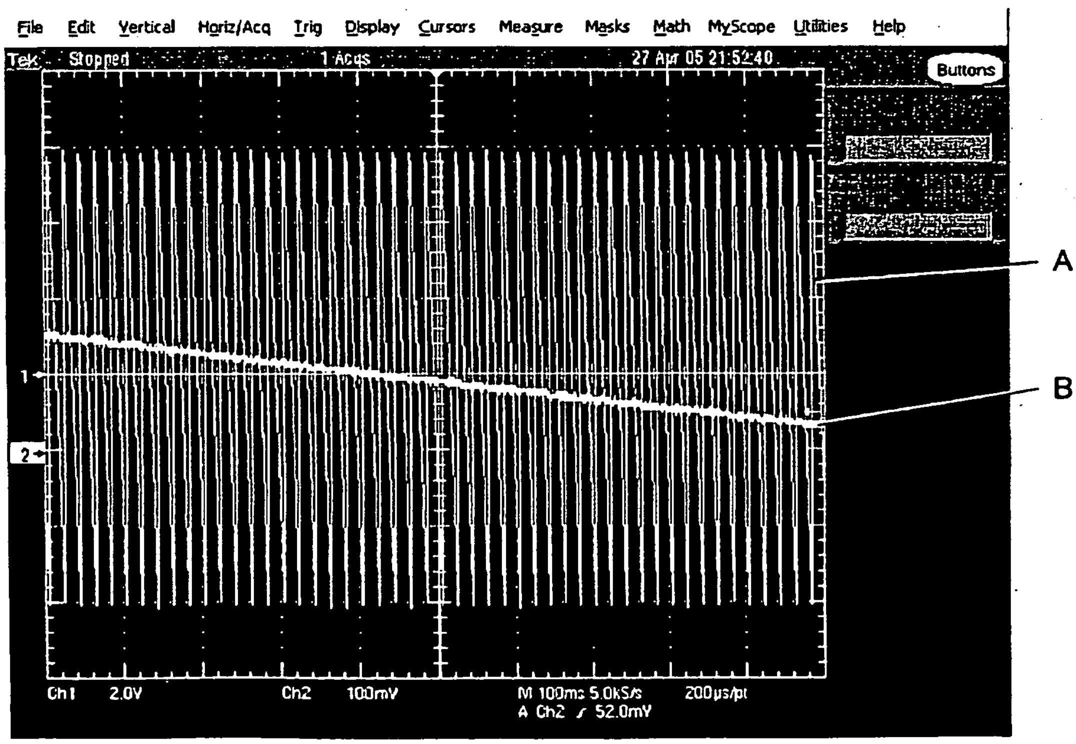

File Edit Vertical Horiz/Acq Trig Display Cursors Measure Masks Math MyScope Utilities Help
Tek Stopped 1 Acqs 27 Apr 05 21:52:40
Buttons
A
B
1
2
Ch1 2.0V Ch2 100mV M 100ms 5.0kS/s 200µs/pt
A Ch2 ⌐ 52.0mV

FIG. 26

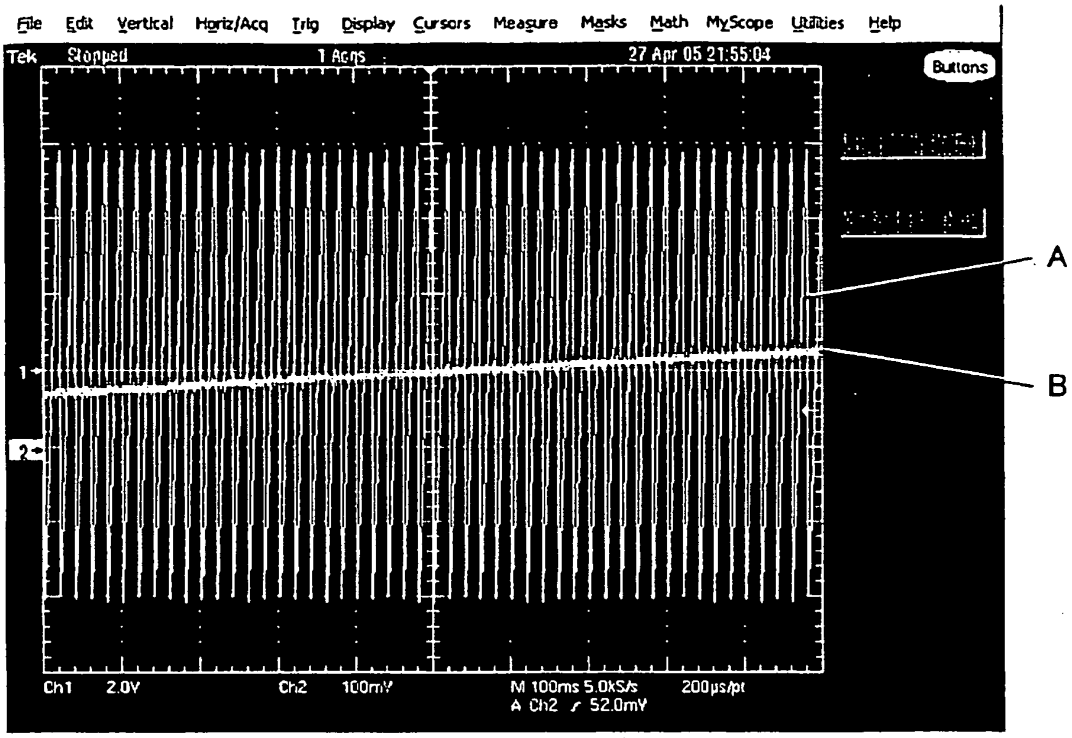

File Edit Vertical Horiz/Acq Trig Display Cursors Measure Masks Math MyScope Utilities Help
Tek Stopped 1 Acqs 27 Apr 05 21:55:04
Buttons
A
B
Ch1 2.0V Ch2 100mV M 100ms 5.0kS/s 200μs/pt
A Ch2 ⟋ 52.0mV

FIG. 27

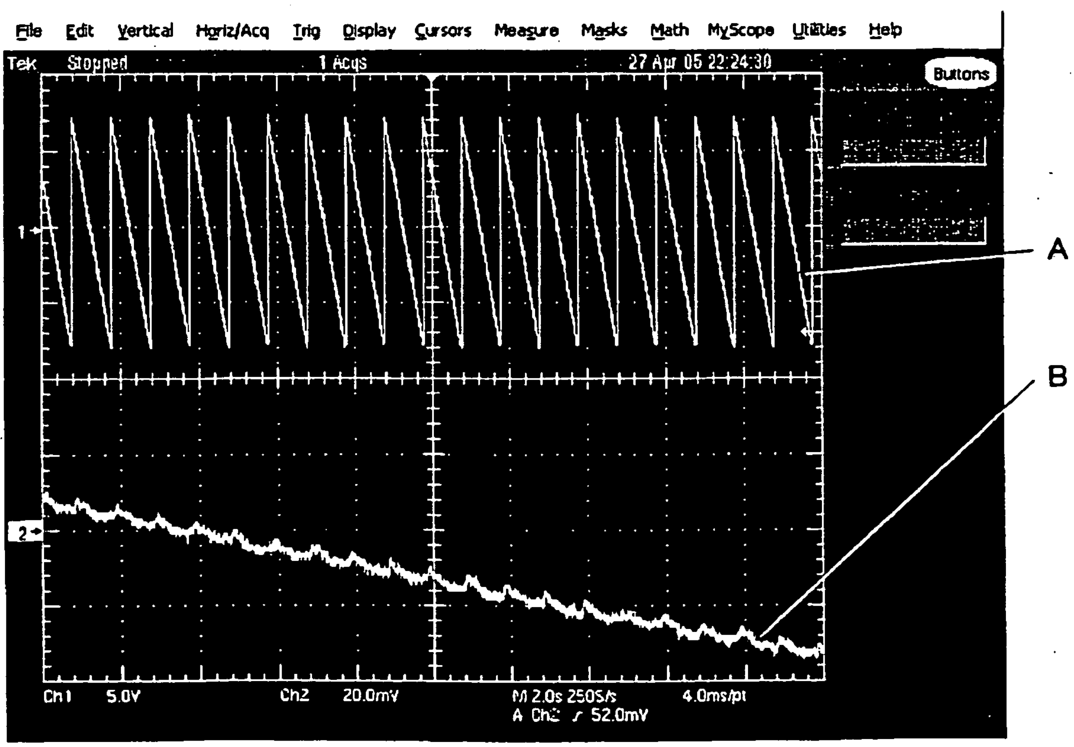

File Edit Vertical Horiz/Acq Trig Display Cursors Measure Masks Math MyScope Utilities Help
Tek Stopped 1 Acqs 27 Apr 05 22:24:30
Buttons
A
B
Ch1 5.0V Ch2 20.0mV M 2.0s 250S/s 4.0ms/pt
A Ch2 ⟋ 52.0mV

FIG. 28

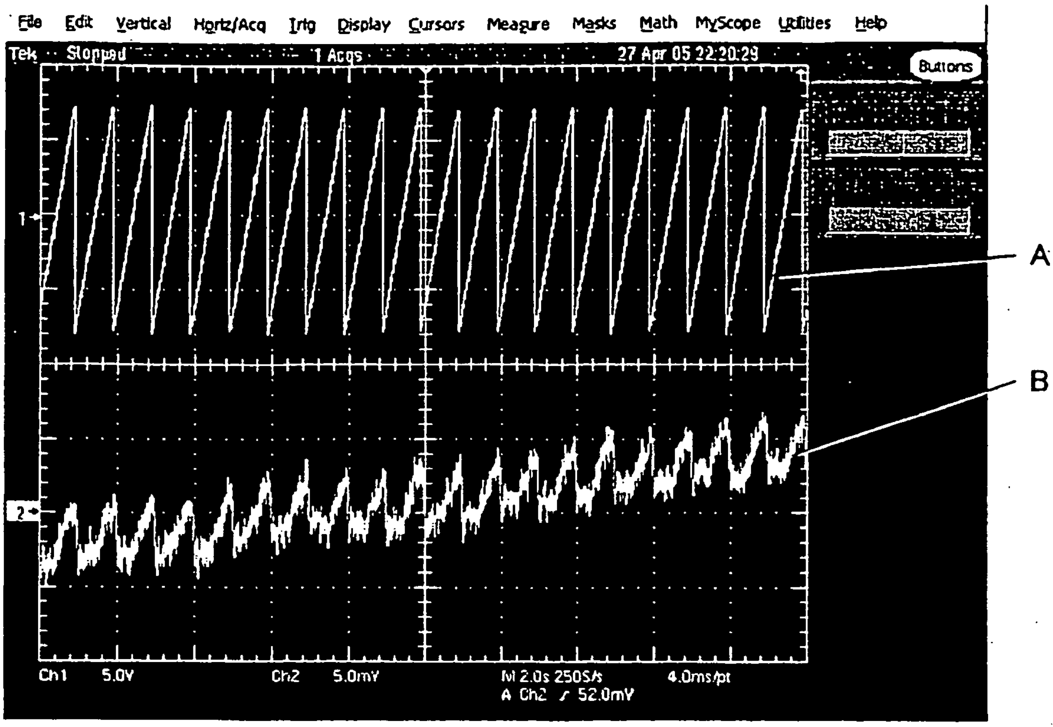

File Edit Vertical Horiz/Acq Trig Display Cursors Measure Masks Math MyScope Utilities Help
Tek Stopped 1 Acqs 27 Apr 05 22:20:29
Buttons
Ch1 5.0V Ch2 5.0mV M 2.0s 250S/s 4.0ms/pt
A Ch2 ⁄ 52.0mV
A
B

FIG. 29

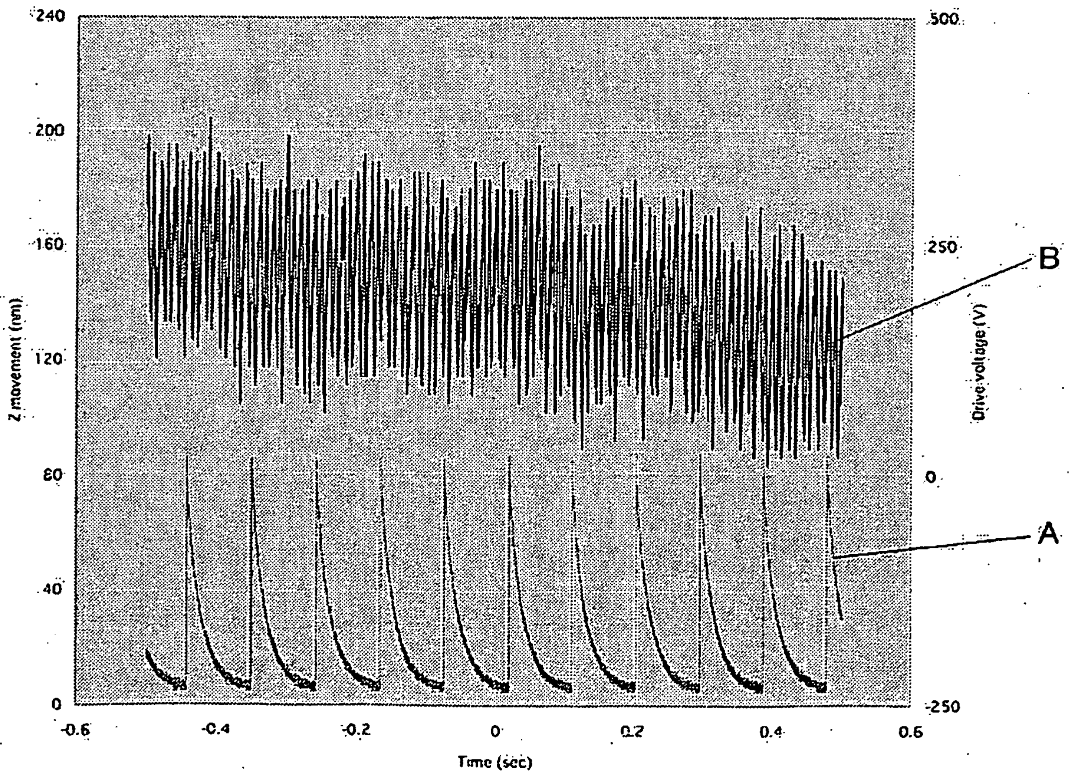
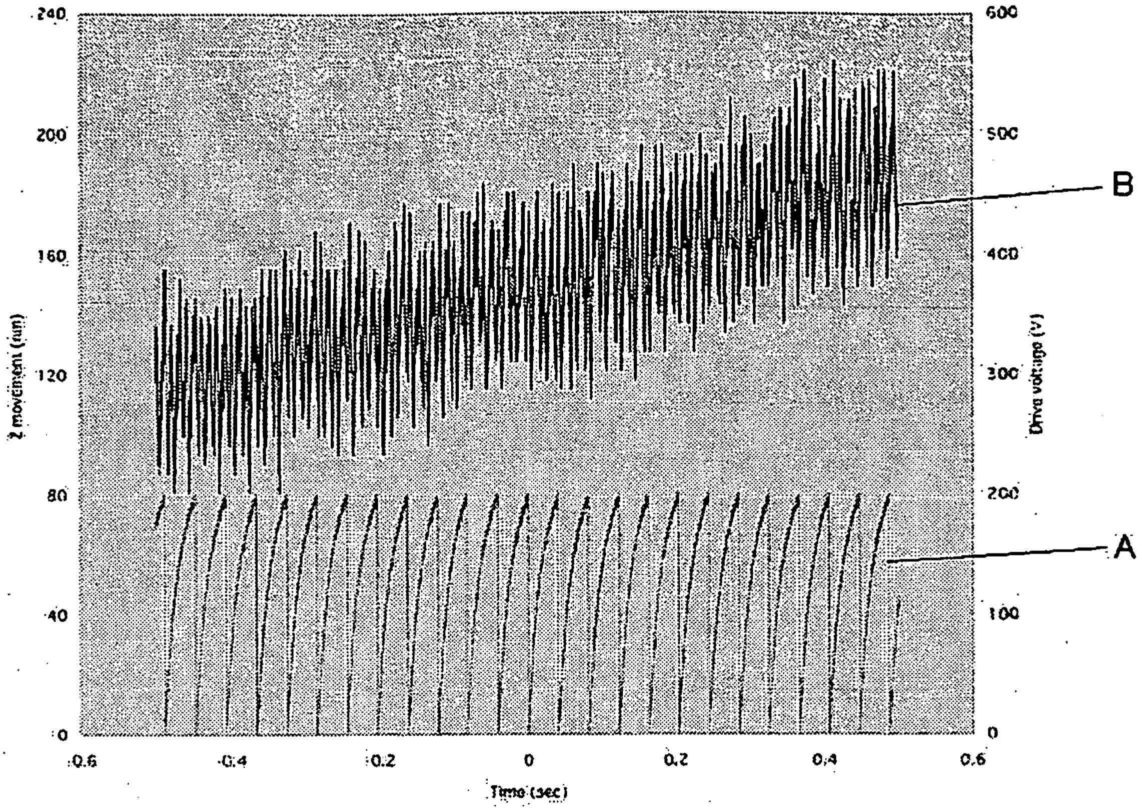

Z movement (nm)
Drive voltage (V)
Time (sec)
240
200
160
120
80
40
0
500
250
0
-250
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
A
B

FIG. 30


240
200
160
120
80
40
0
Z movement (nm)
600
500
400
300
200
100
0
Drive voltage (V)
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Time (sec)
B
A

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003134859 A **[0009]**

Non-patent literature cited in the description

- **Tseng KuoHao ; Shibuya Toshikatsu ; Higuchi Toshiro.** Development of a Precise Position Adjuster Utilizing Piezo Actuator for Heavy Load. *Proceedings of JSPE annual spring meeting,* 2002, 112 **[0006]**
- **Ph. Niedermann ; R.Emch ; P.Descouts.** *Rev.Sci.Instrum.,* 1988, vol. 59, 368 **[0006]**