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(54) **SUBJECTIVE OPTOMETRIC APPARATUS**

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(57) **ABSTRACT**

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A subjective optometric apparatus is provided, which enables the subject to undergo a vision test in a manner as if wearing a trial frame. The subjective optometric apparatus of the present invention includes: a subjective optometric unit which contains an Alvarez lens composed of a pair of optical elements and capable of continuous change in refraction characteristics through relative displacement of the pair of optical elements with respect to each of optical axes of optometric windows and which is equipped with a drive mechanism for driving the pair of optical elements; and a controller for controlling the subjective optometric unit, in which the subjective optometric unit is equipped with a left-eye examination unit, a right-eye examination unit, a support member which effects supporting so as to allow adjustment of a horizontal distance between the left-eye examination unit and the right-eye examination unit in order to adjust the distance between a pair of optometric windows according to an interpupillary distance of the subject, an attachment member provided on the support member and enabling the subjective optometric unit to be attached to the head of the subject, and a nose pad member provided on the support member and adapted to adjust a positional relationship of the subjective optometric unit with respect to the eyes of the subject.

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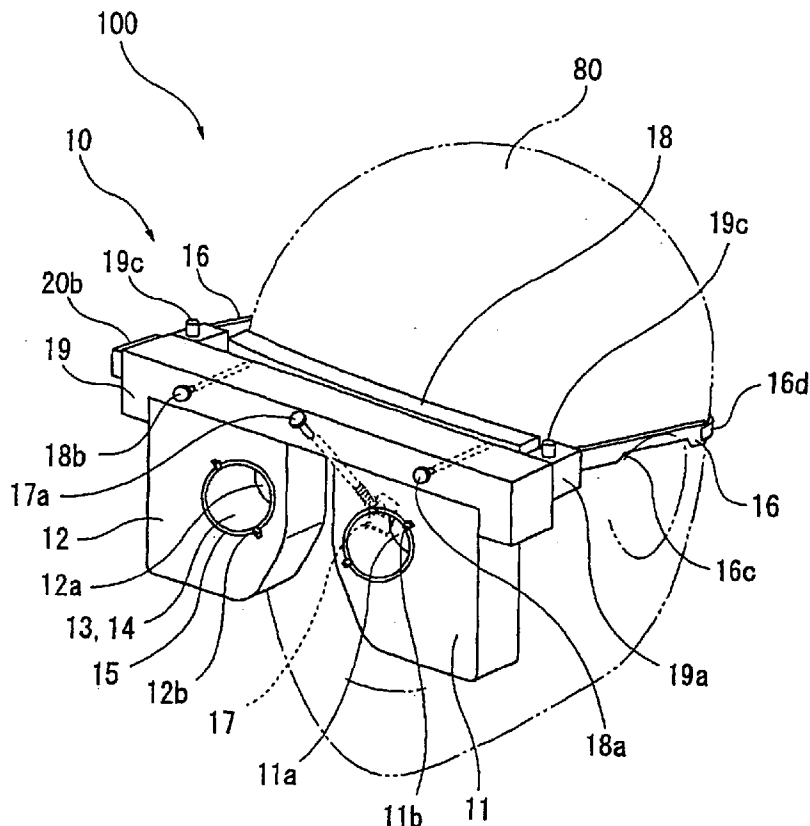


Fig. 1

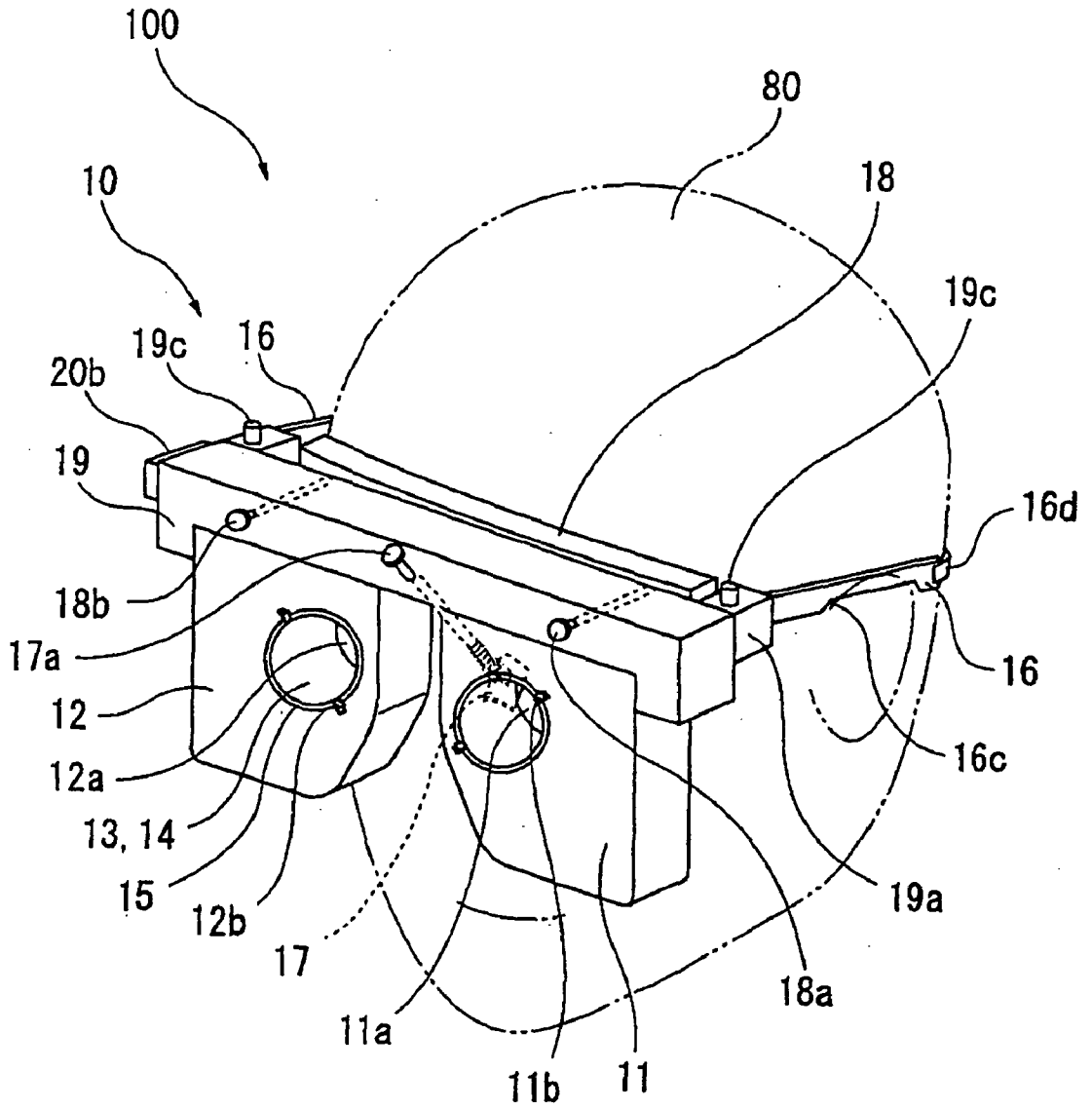


FIG. 2

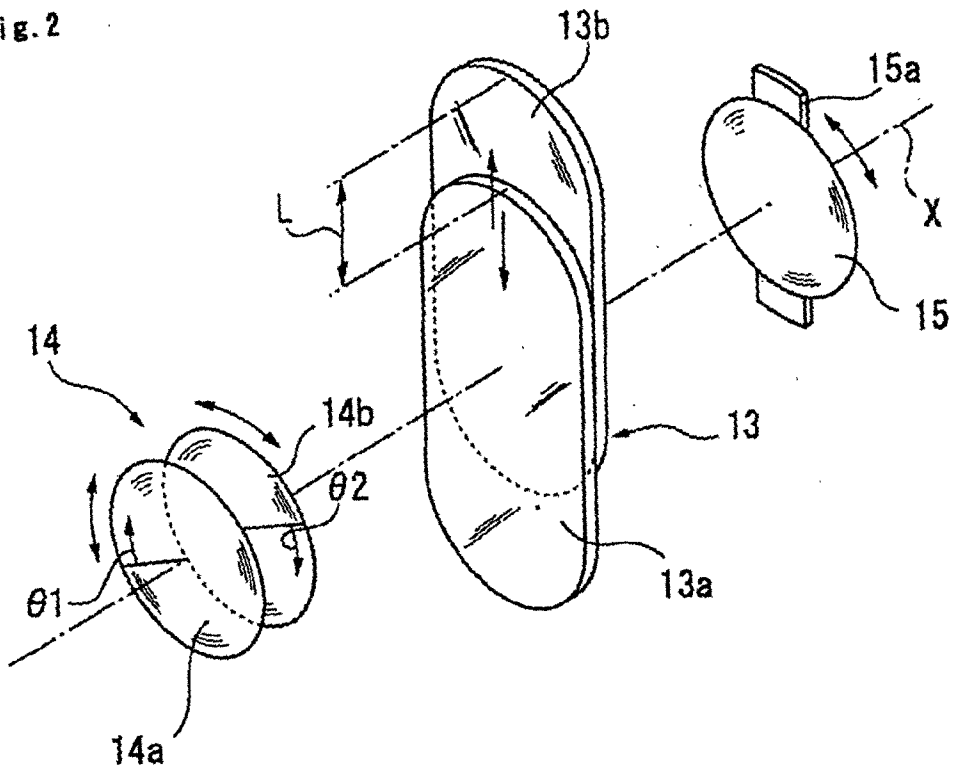


FIG. 3

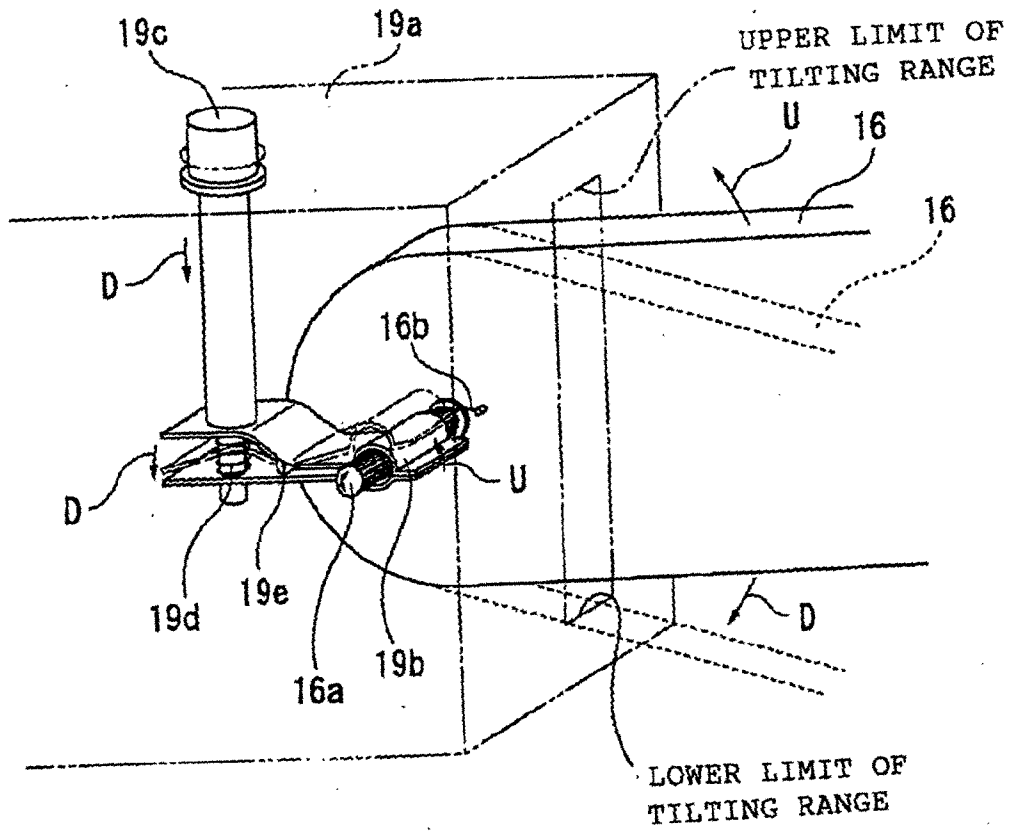


Fig. 4(A)

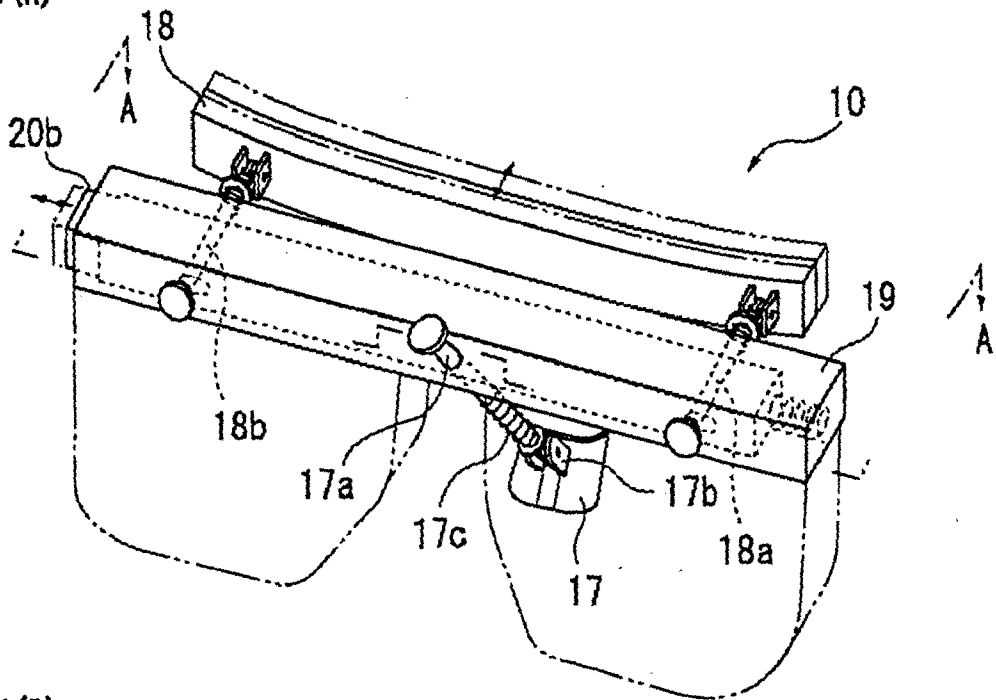


Fig. 4(B)

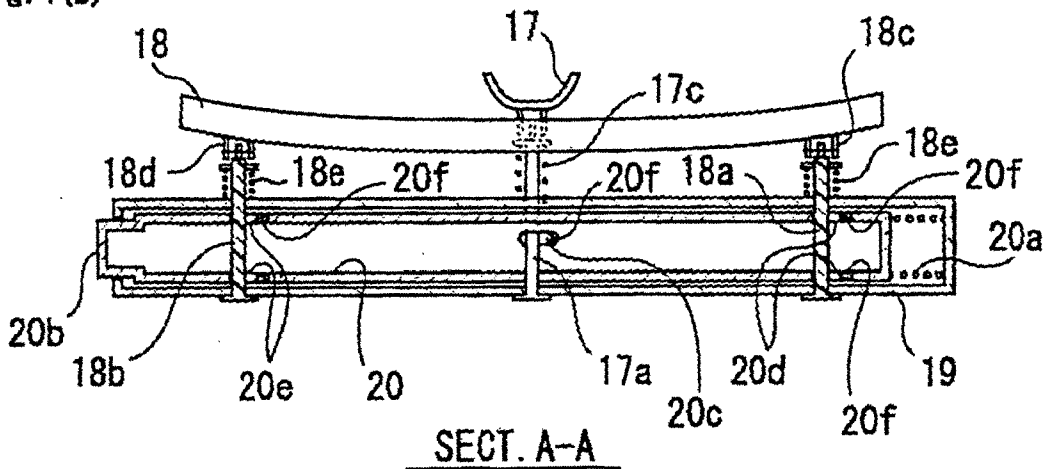


Fig. 4(C)

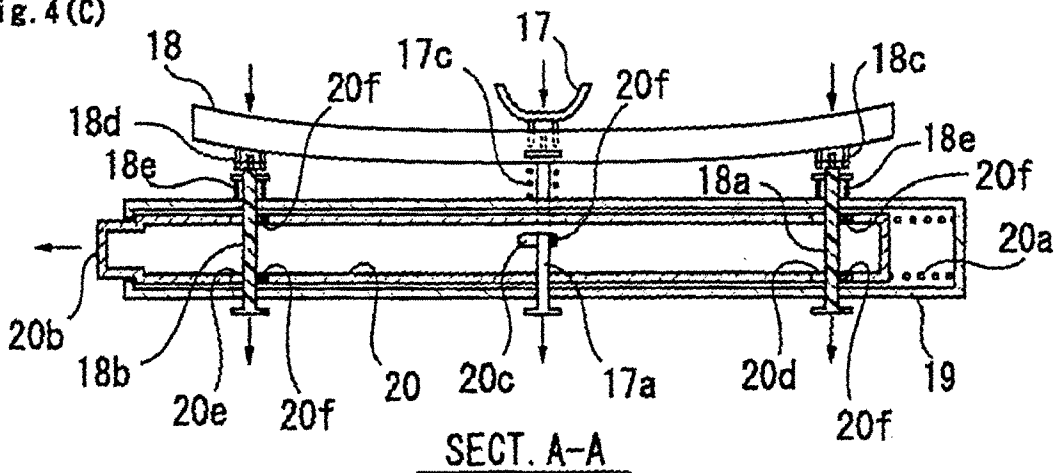


Fig. 5

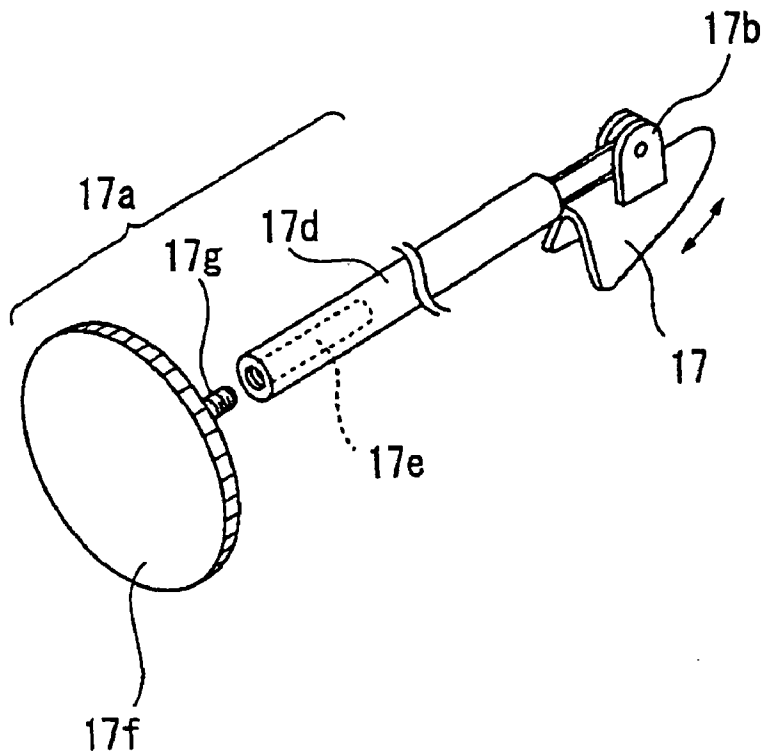


Fig. 7

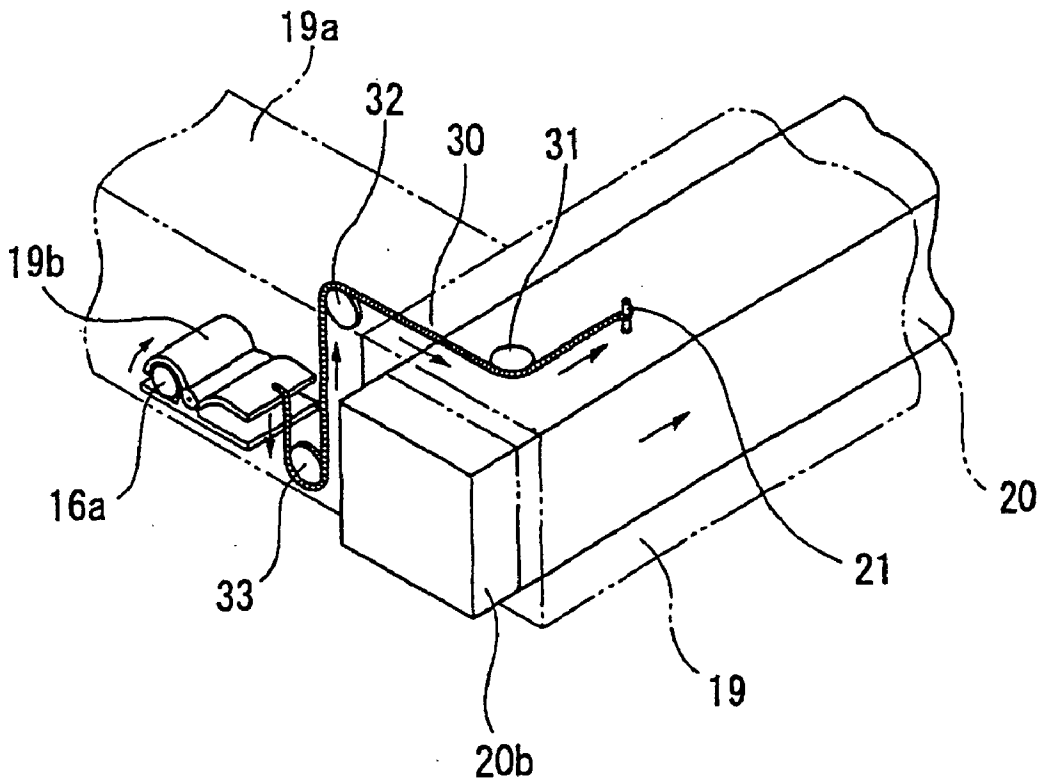


Fig. 6 (A)

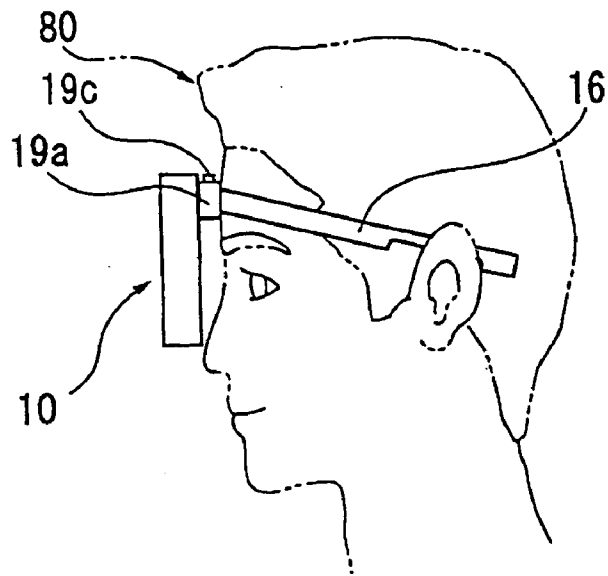


Fig. 6 (B)

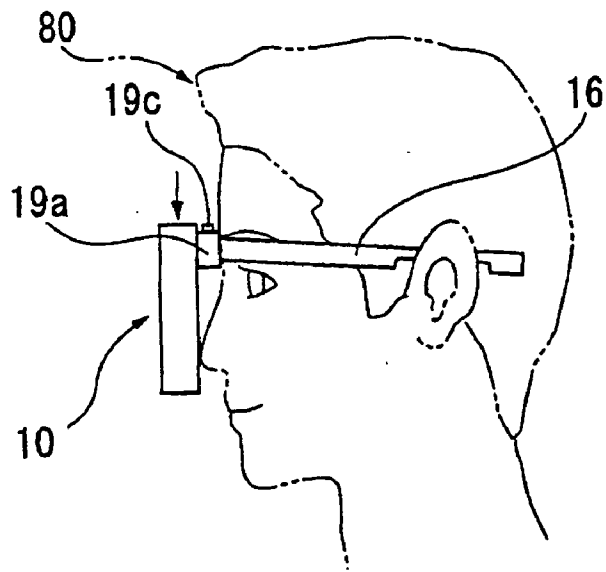


Fig. 6 (C)

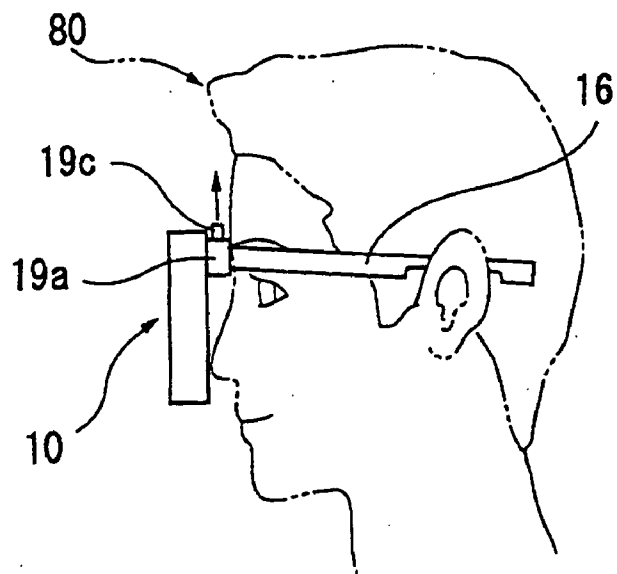


Fig. 8

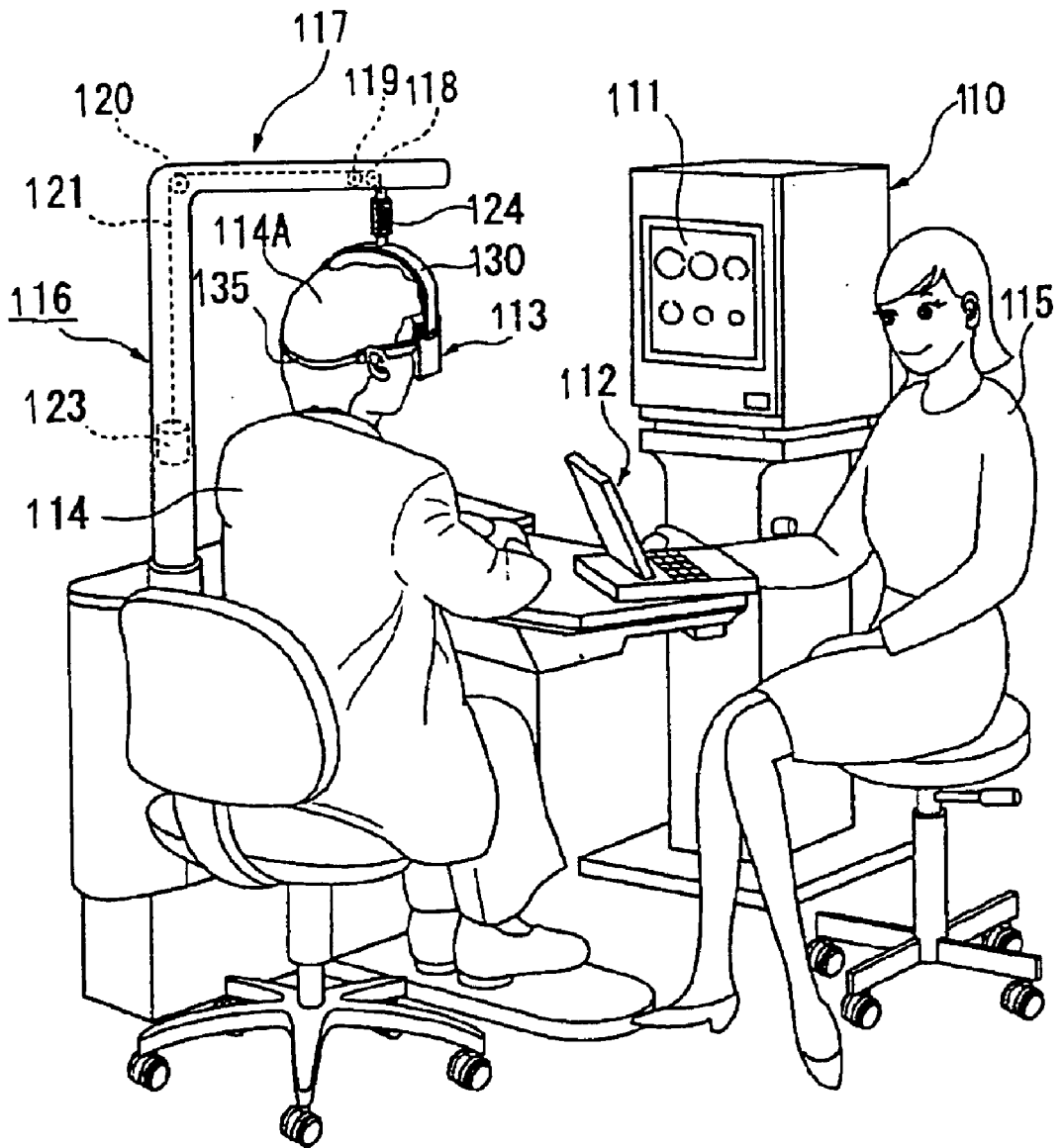


Fig. 9

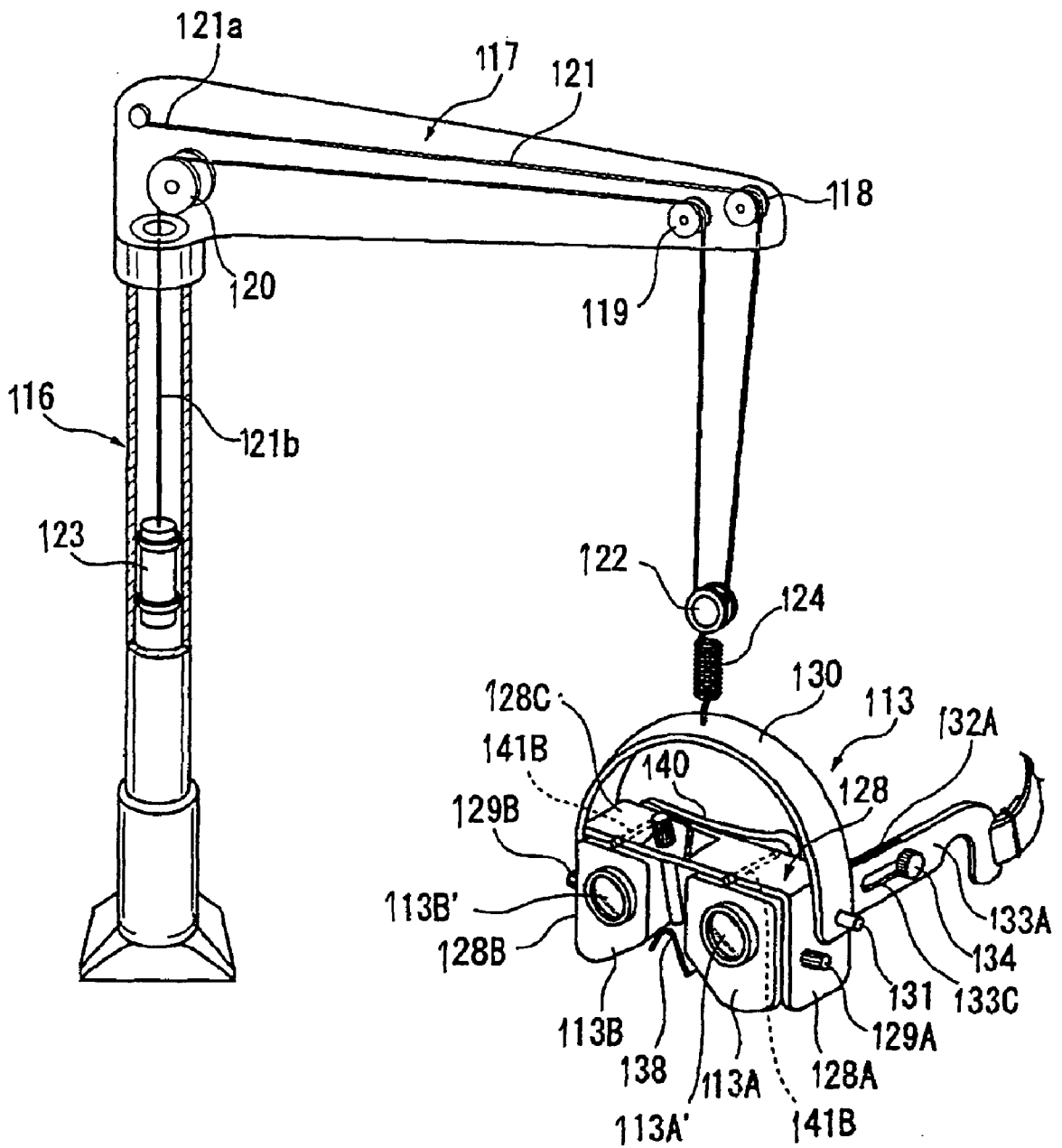


Fig. 10

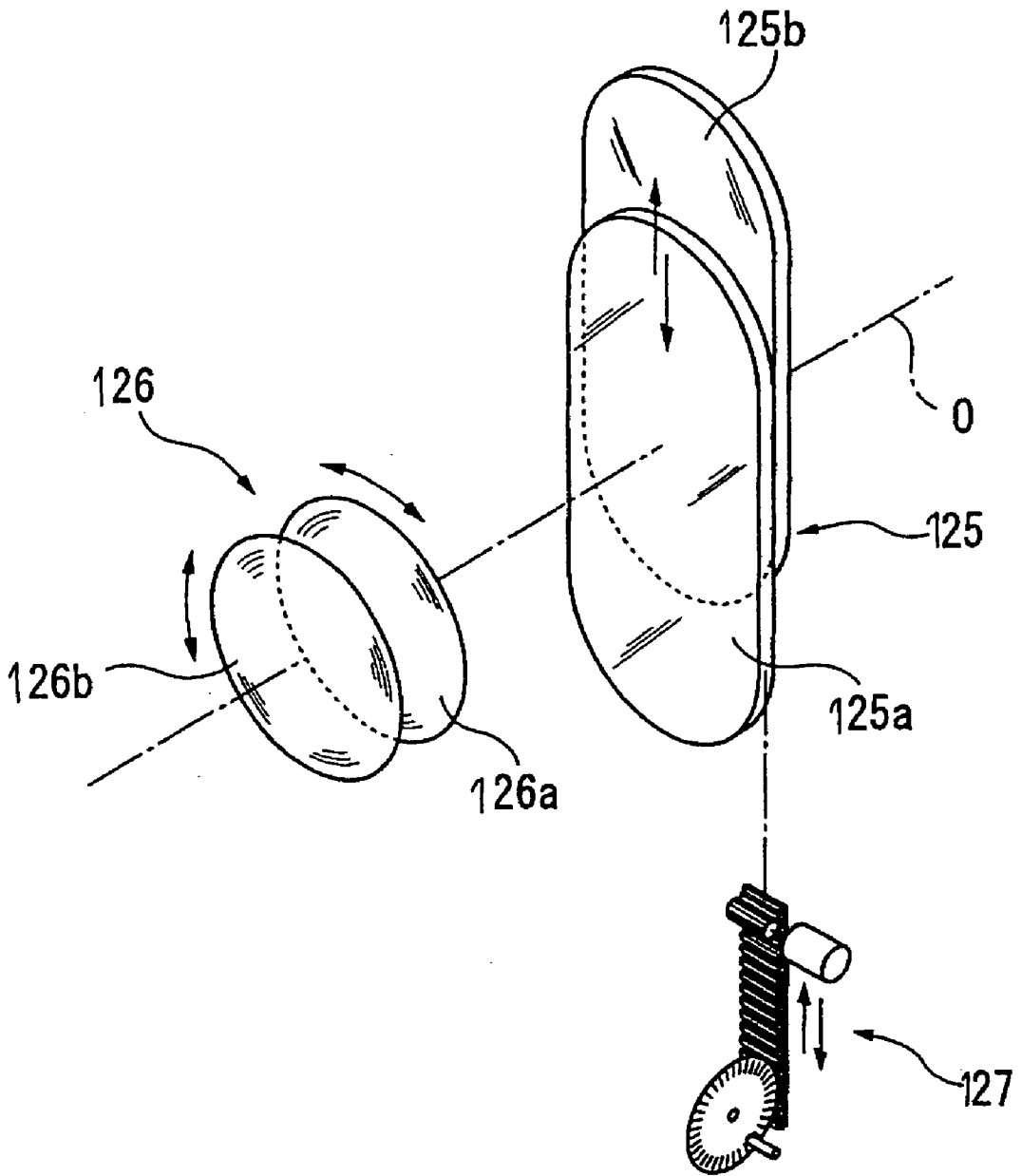


Fig. 11

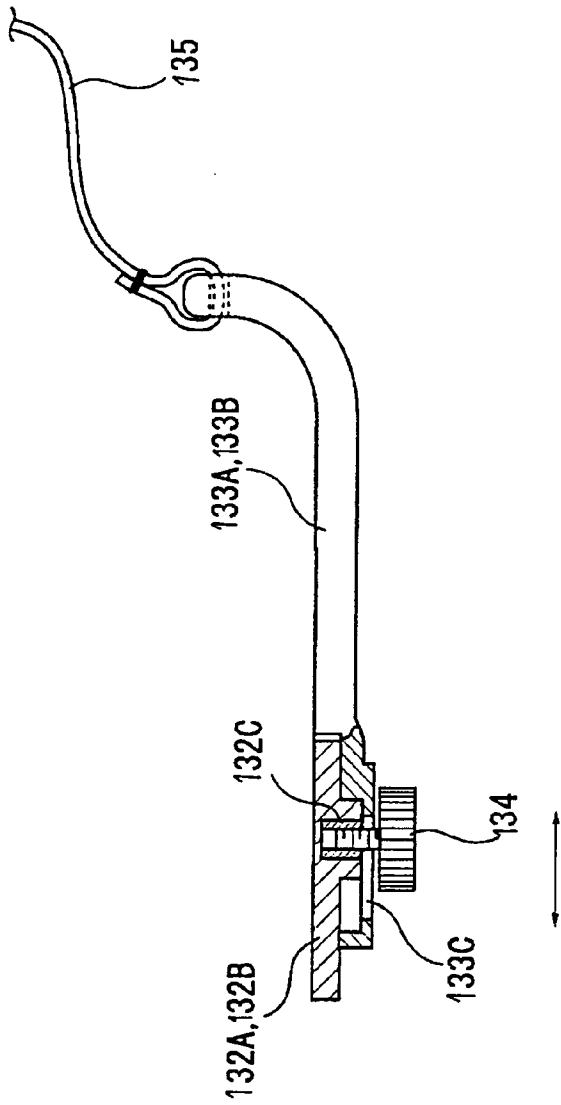


Fig. 12

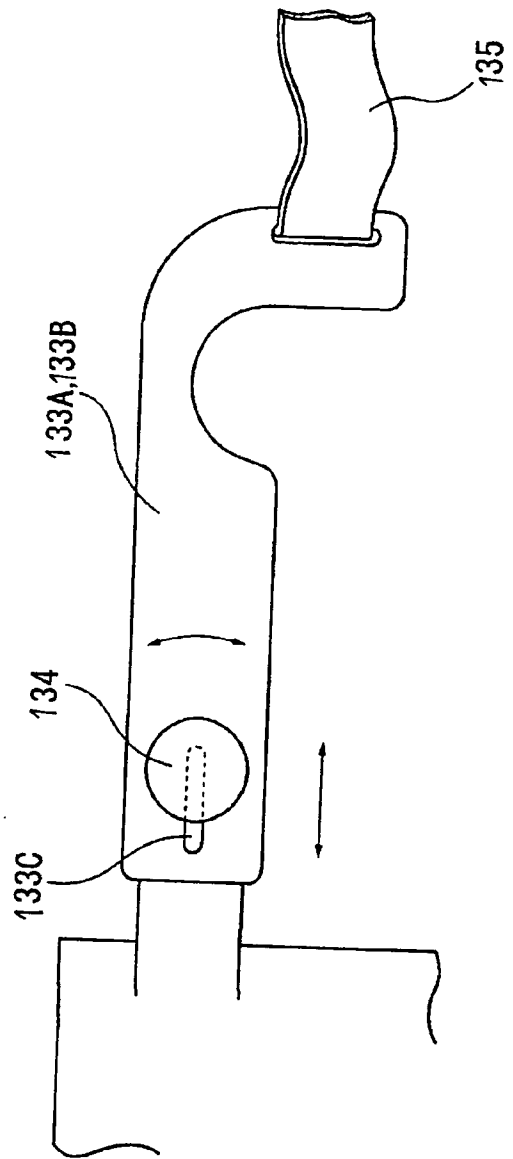


Fig. 13

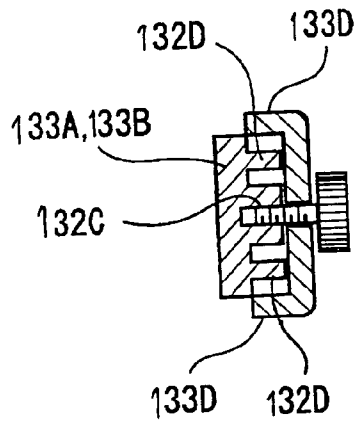


Fig. 14

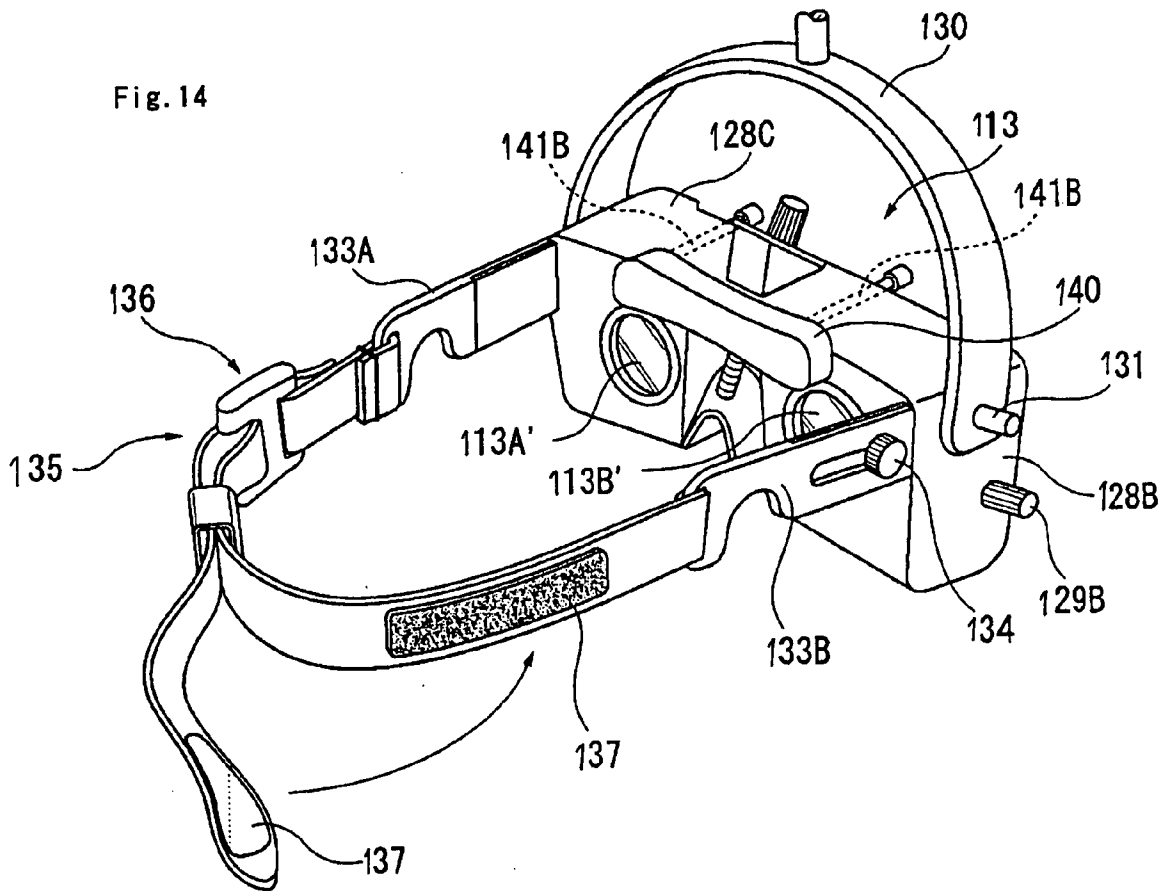


Fig. 15

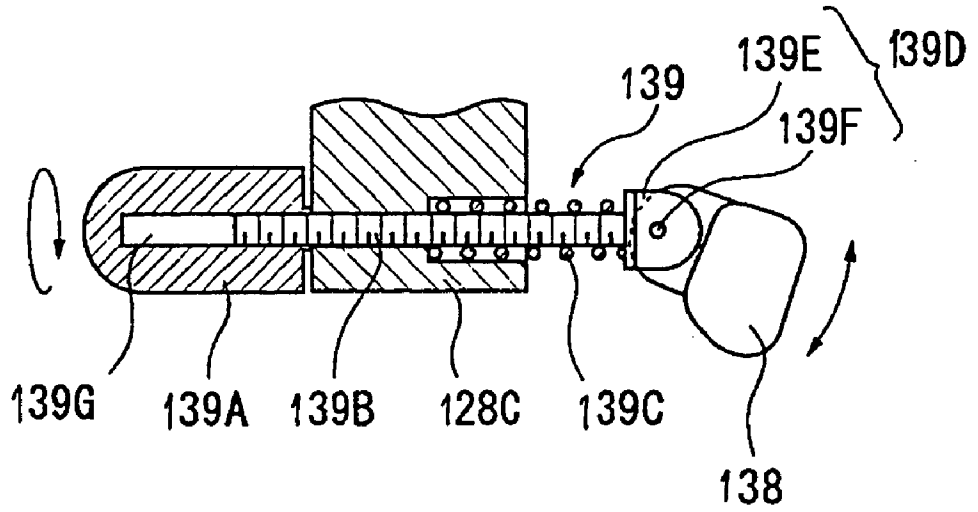


Fig. 16

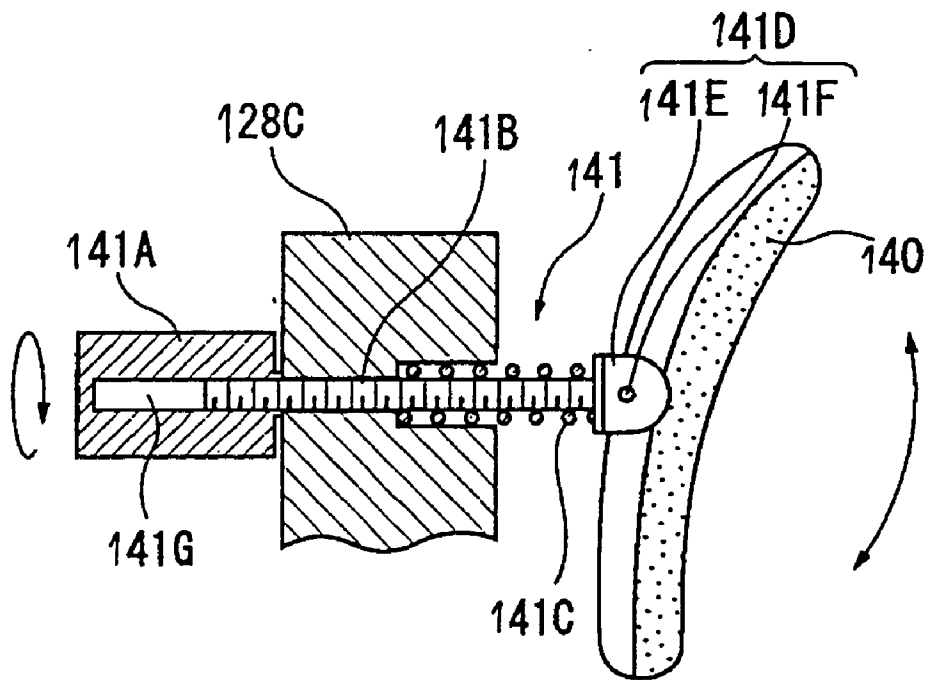


Fig. 17

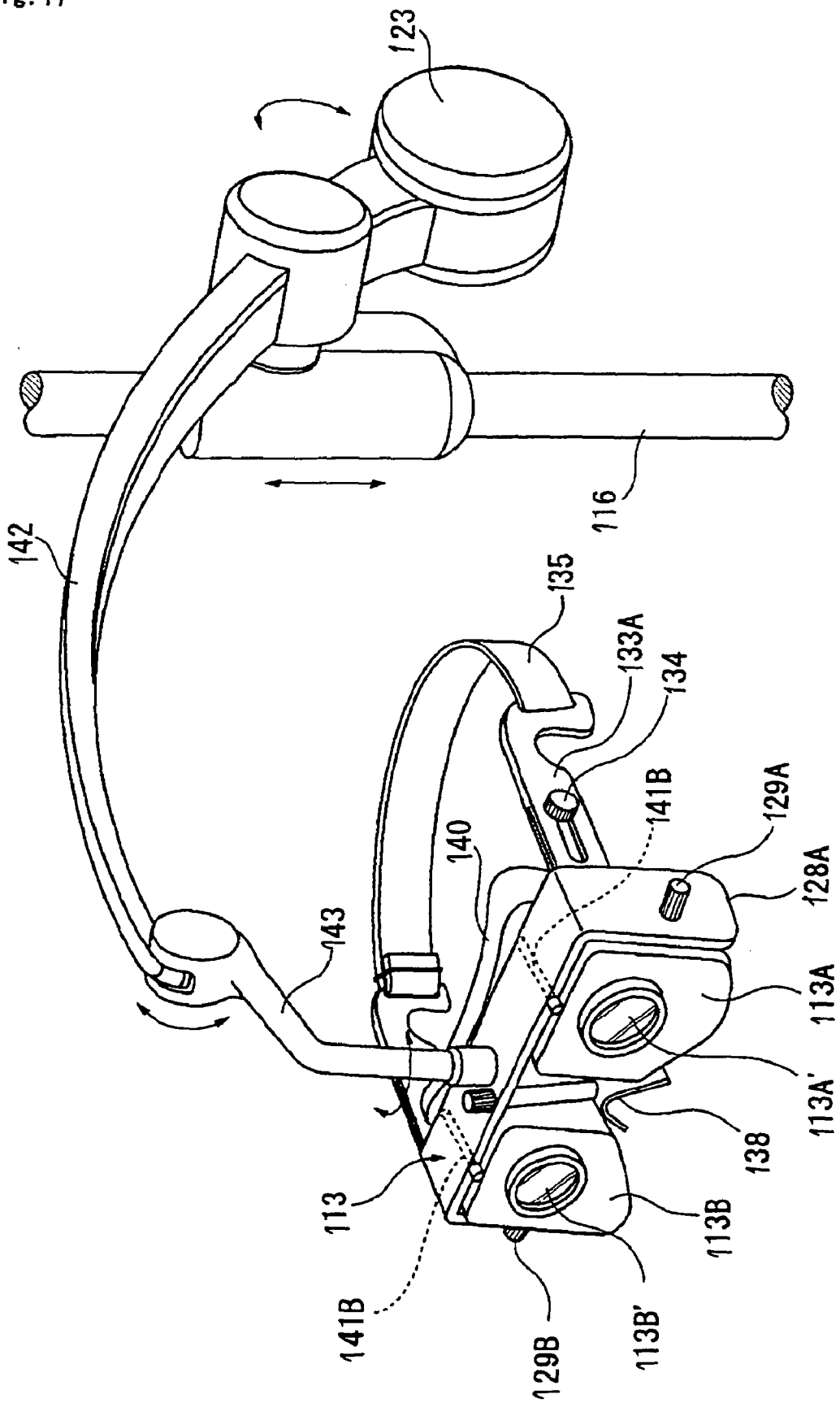


Fig. 18

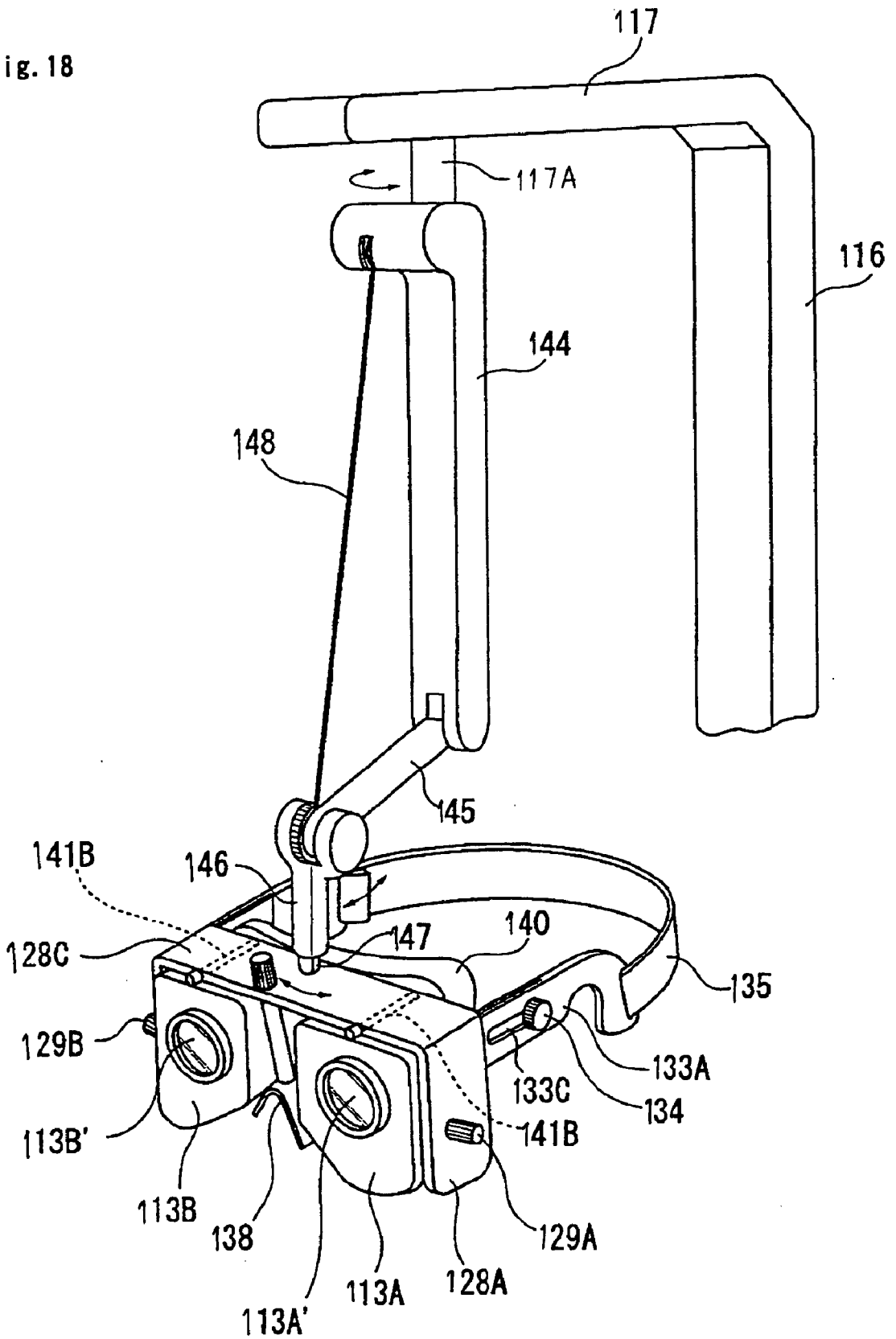


Fig. 19

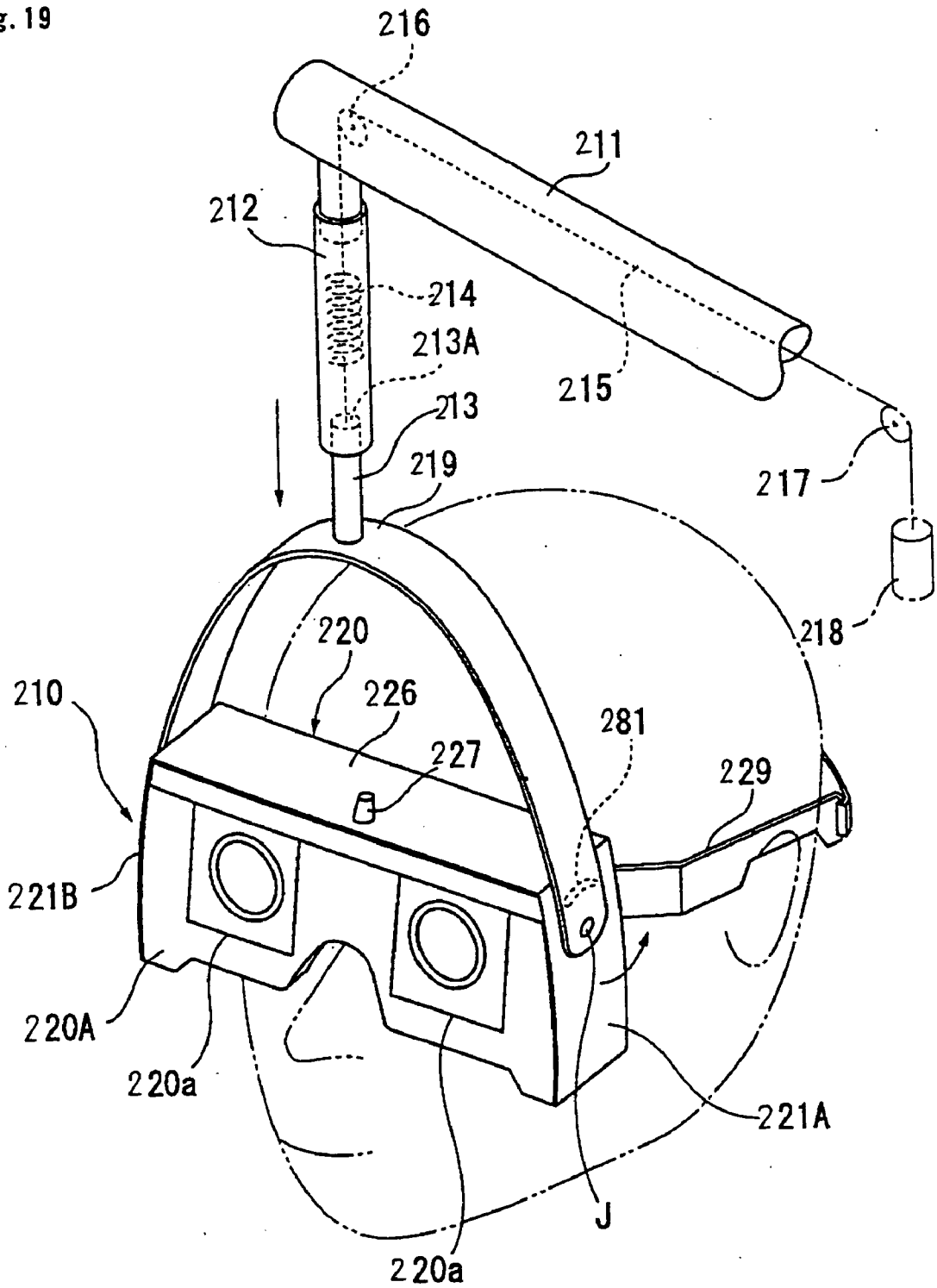


Fig. 20

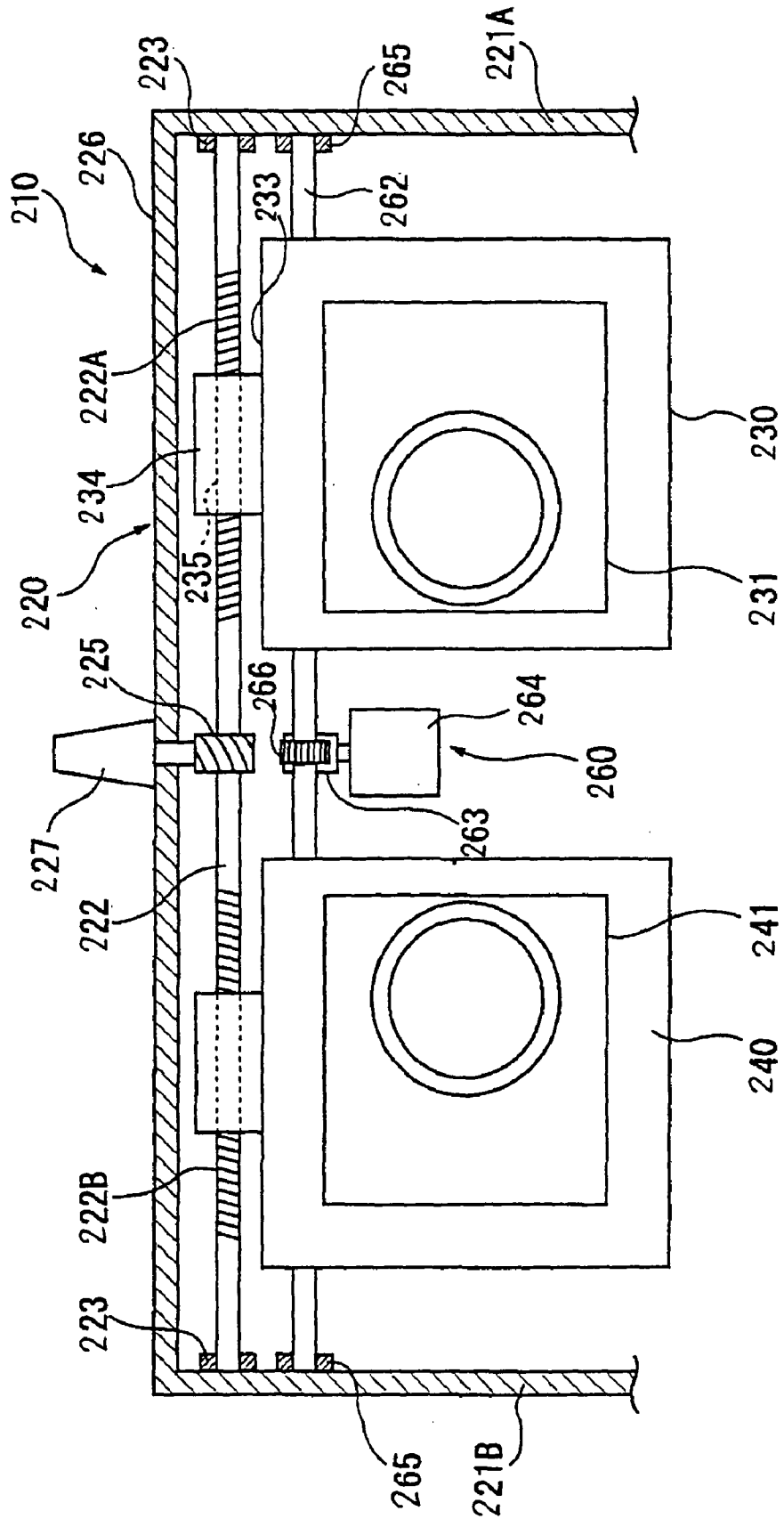




Fig. 22

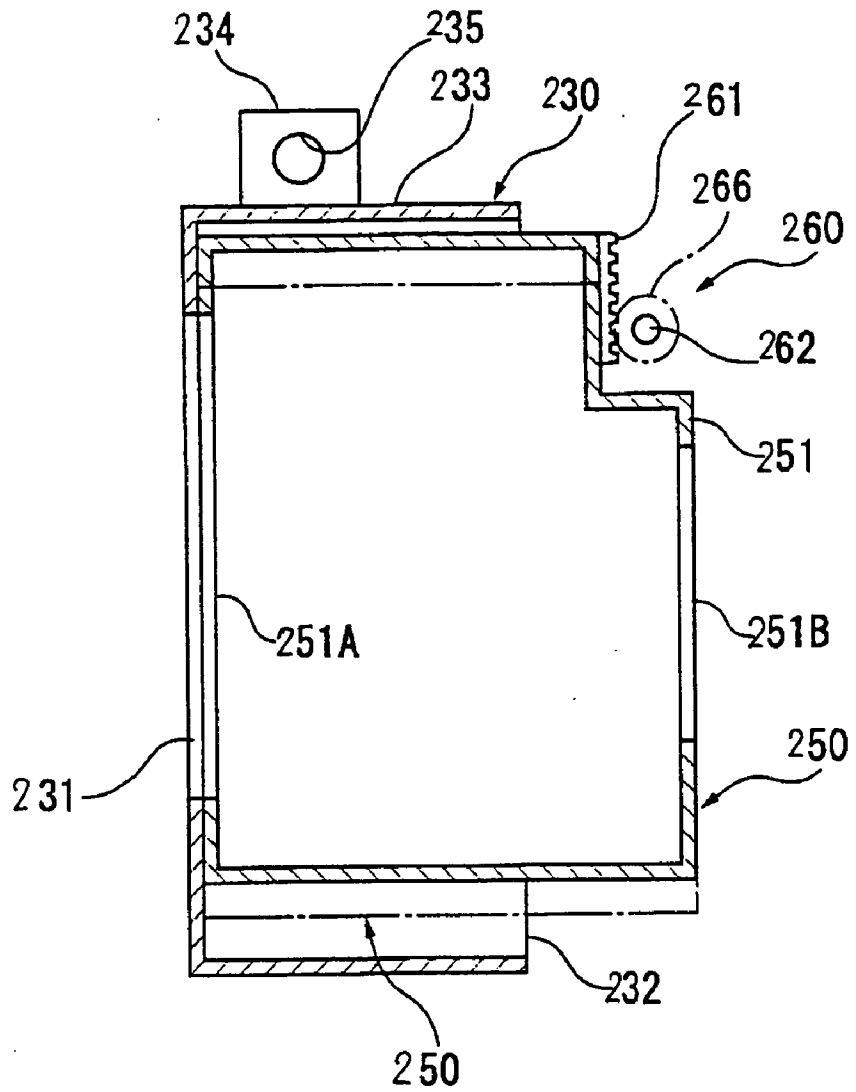


Fig. 23

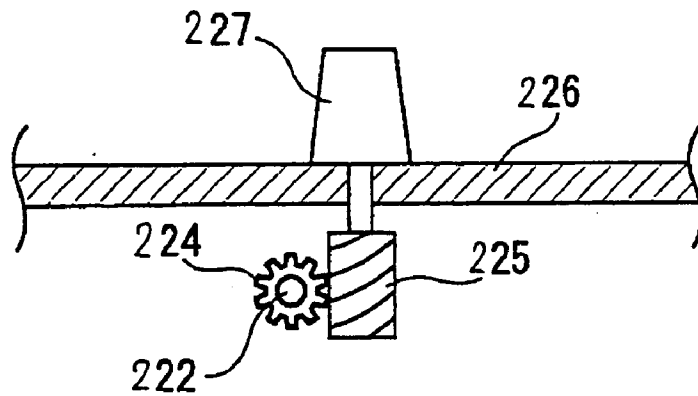


Fig. 24

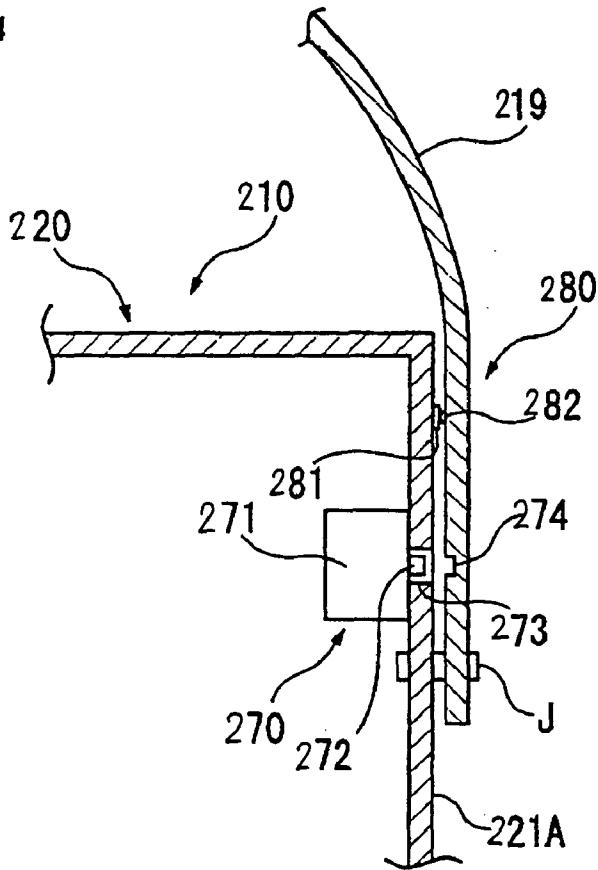


Fig. 25

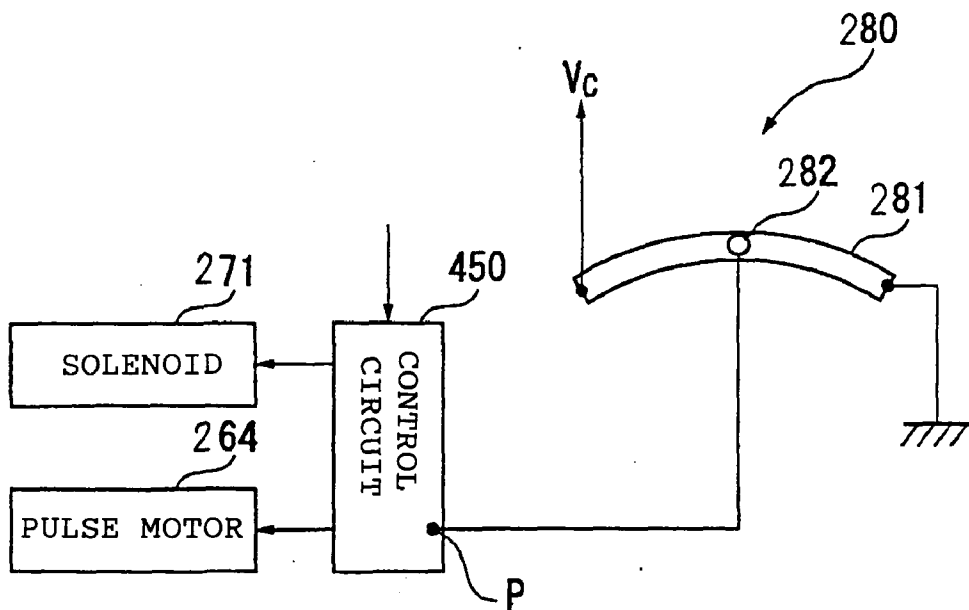


Fig. 26

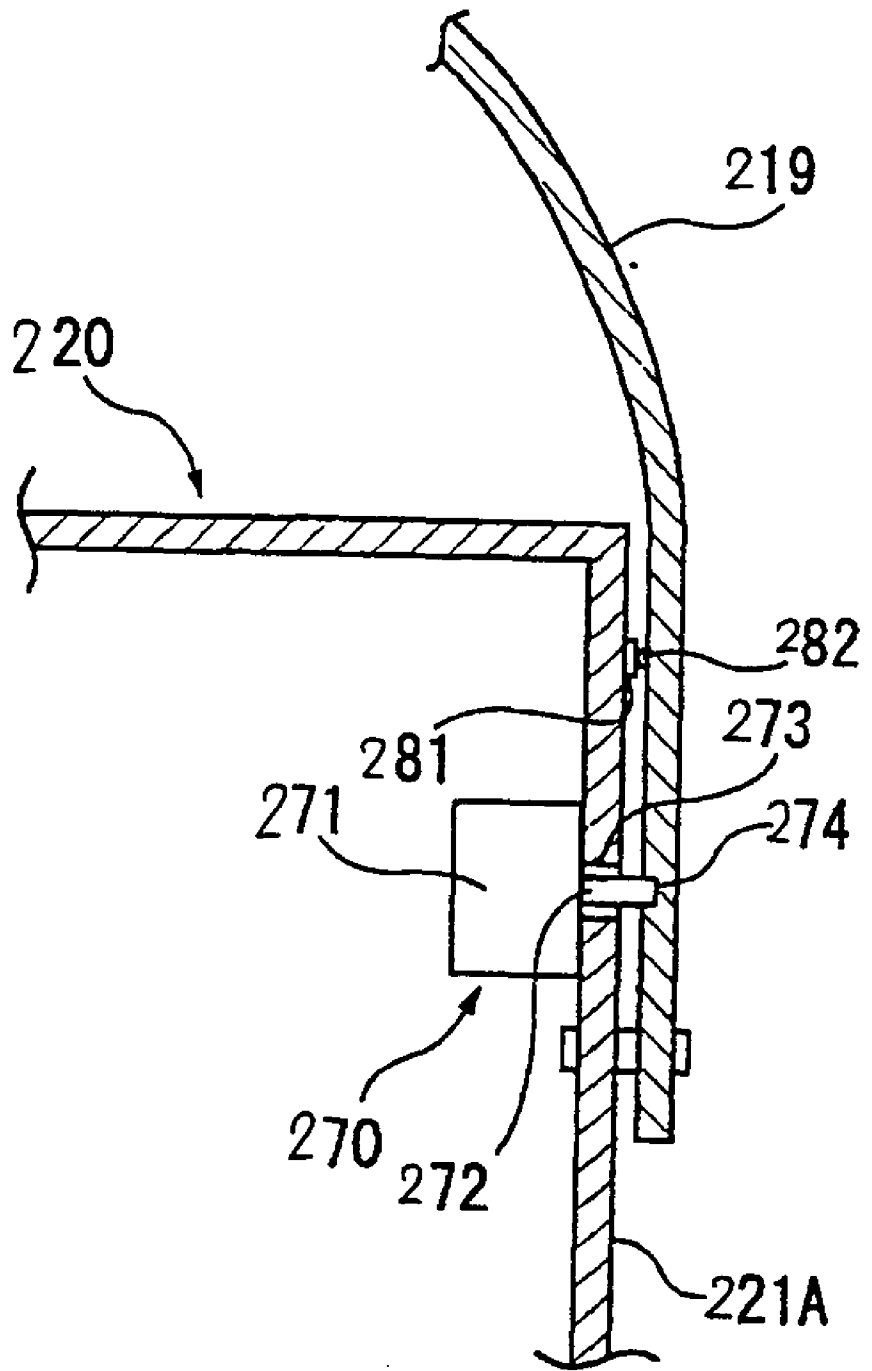


Fig. 27

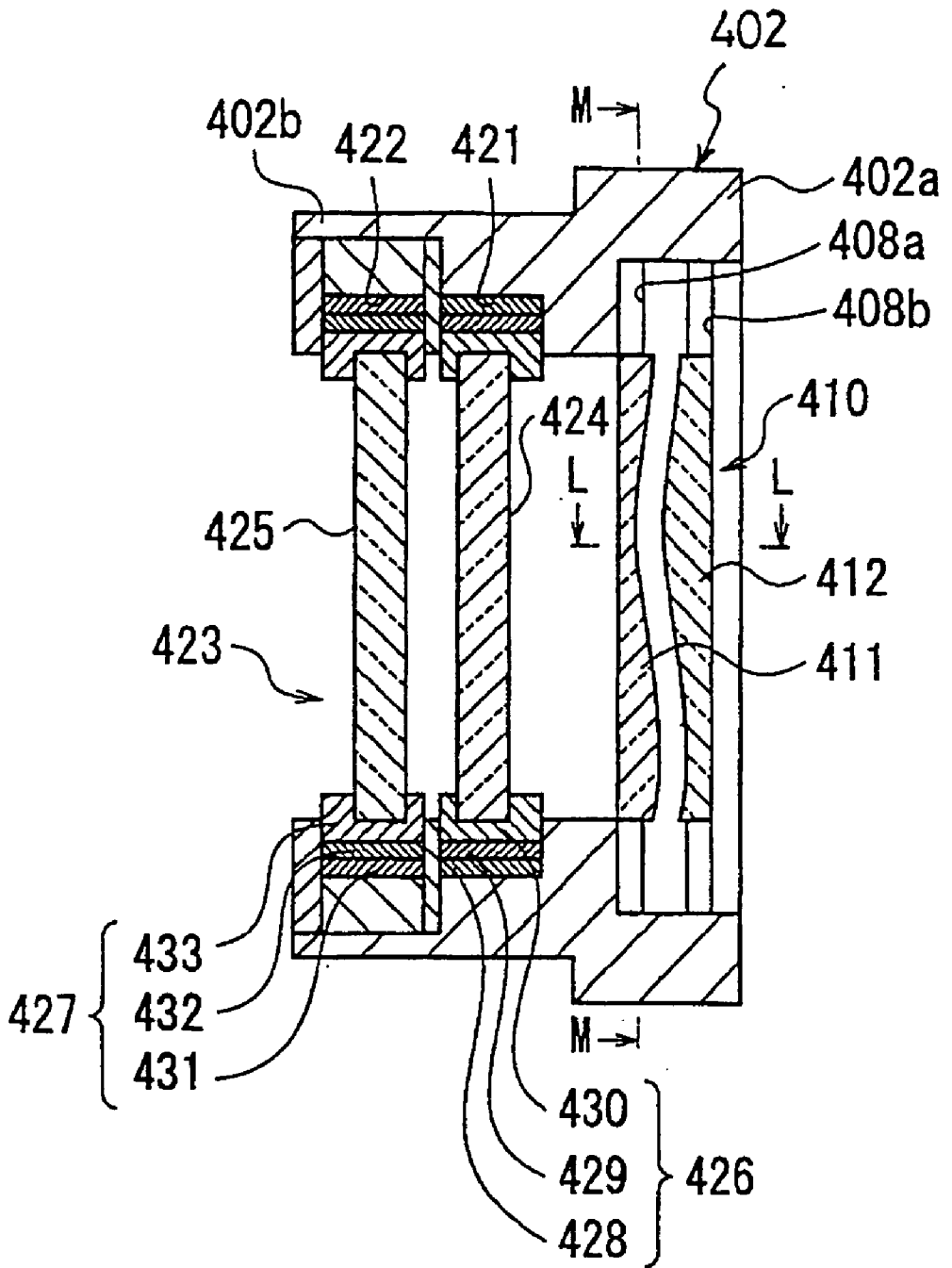


Fig. 28



Fig. 29

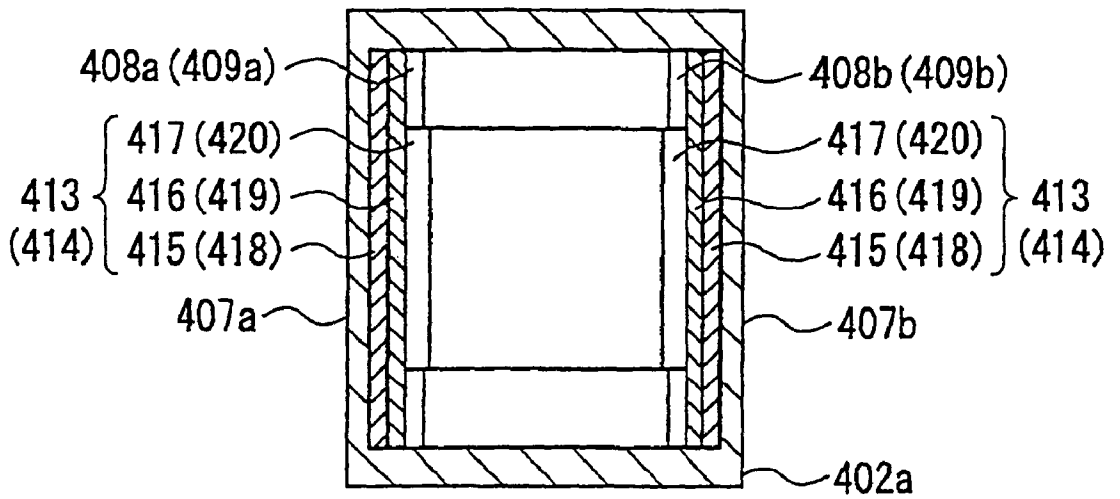


Fig. 30

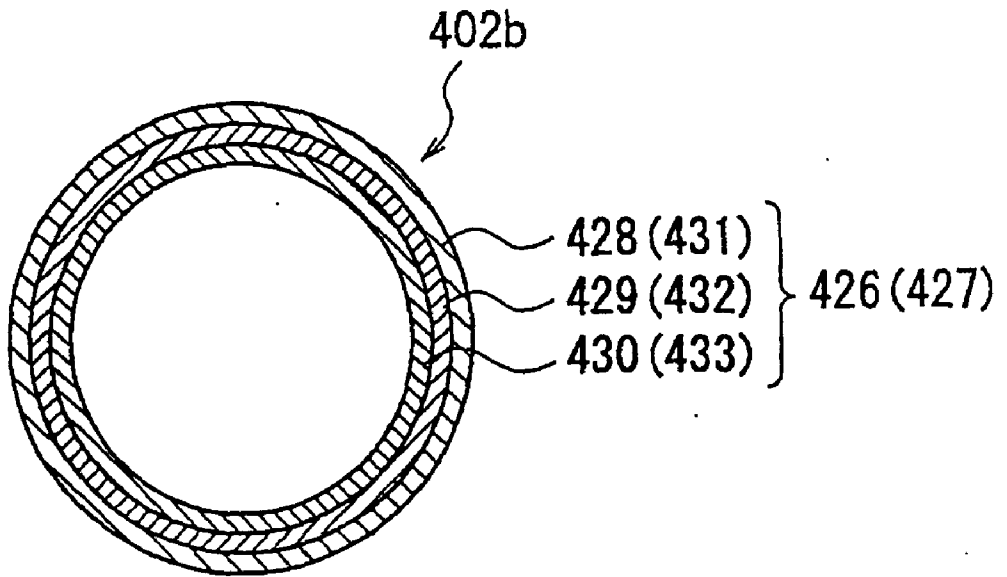


Fig. 31

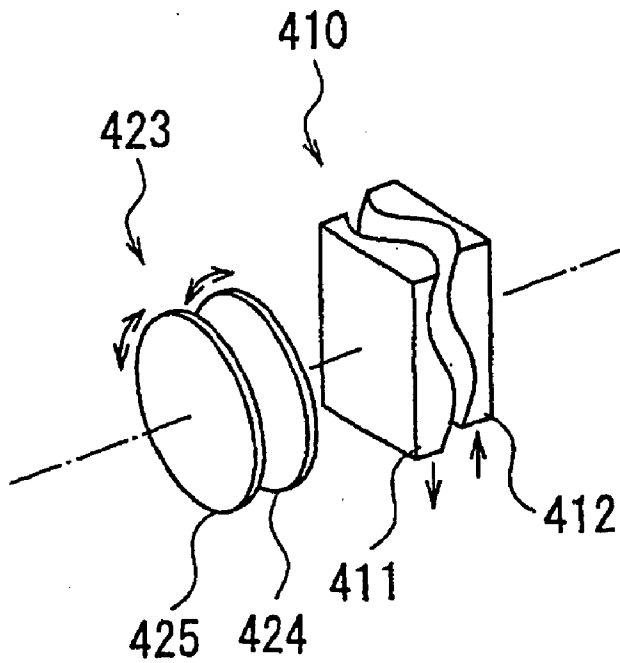
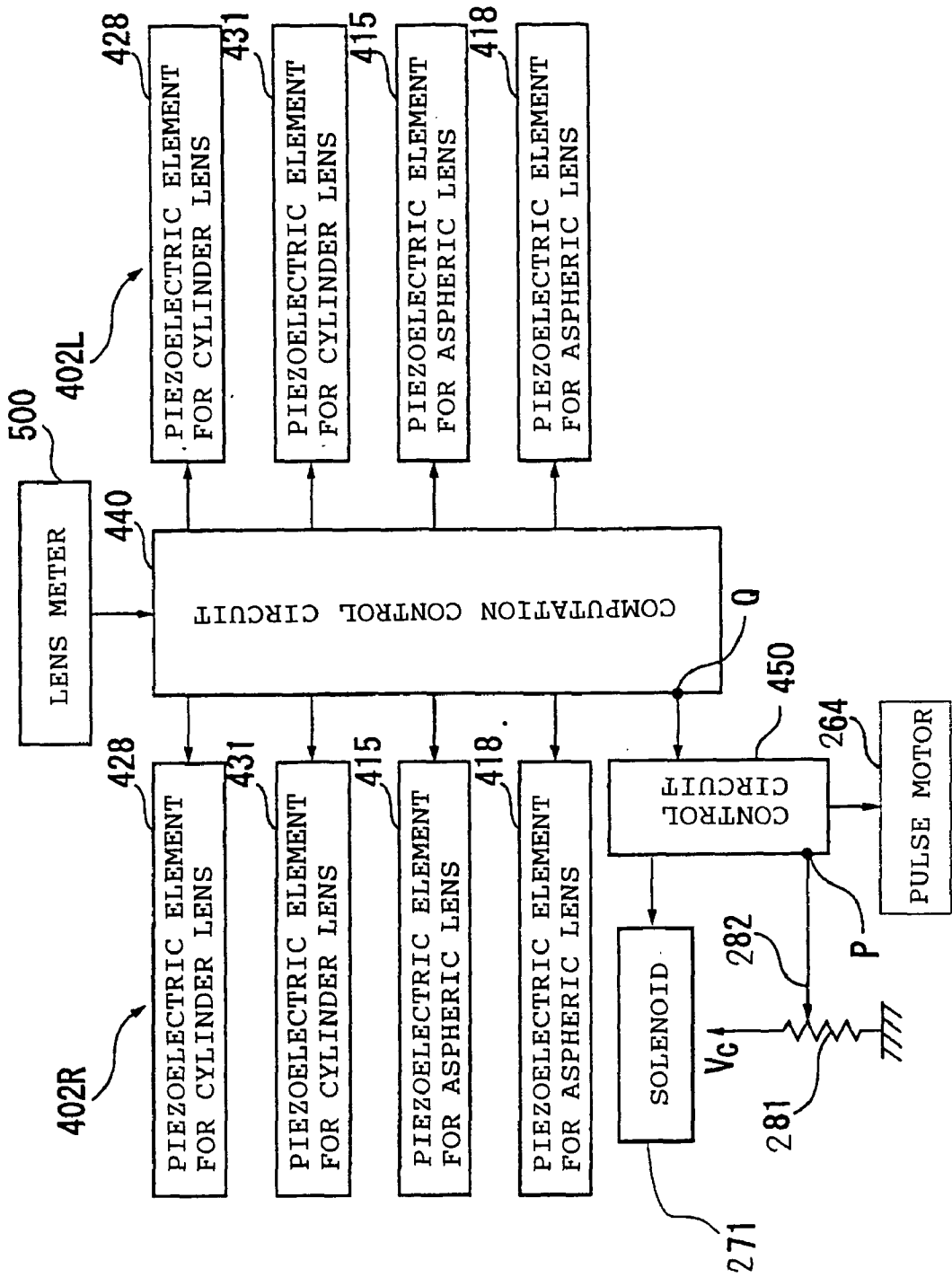


Fig. 32



## SUBJECTIVE OPTOMETRIC APPARATUS

### BACKGROUND OF THE INVENTION

#### [0001] 1. Field of the Invention

[0002] The present invention relates to an optometric apparatus which enables a subject to undergo subjective optometry in a manner as if wearing a trial frame.

#### [0003] 2. Description of the Related Art

[0004] There has conventionally been known a subjective optometric apparatus which has a refractor (subjective optometric device) and a controller and in which a target is presented to a subject through optometric windows formed in the refractor, with the refractor being suspended before the subject's eyes, thereby performing a vision test.

[0005] In a case of the refractor of this conventional subjective optometric device, there are provided a rotating disc and a drive mechanism for driving this rotating disc. Further, the rotating disc has a circular opening, in which there are arranged various examination optical elements, such as a spherical power lens, an astigmatism lens, and a red filter.

[0006] When an examiner operates a controller according to the examination procedures, the drive mechanism for the rotating disc is controlled so as to appropriately set examination optical elements in the optometric windows. The examiner puts a series of questions to the subject, and, on the basis of the responses of the subject to the questions, performs a series of vision test (see Japanese Patent Application No. 2000-346302).

[0007] This conventional subjective optometric apparatus has a problem in that a slight change in the attitude of the subject or slight movement of his face results in the eyes being deviated from the optometric windows, making it impossible for the subject to see the target. Further, generally speaking, the refractor of a subjective optometric apparatus of this type is rather large, and, when placed between the examiner and the subject, the subject's view is obstructed, which means the subject cannot talk while looking at the examiner, making it difficult to perform smooth communication.

[0008] In the conventional method in which a subjective vision test is performed with a trial frame attached to the subject, communication is advantageously easy to perform. On the other hand, a great deal of expertise is required of the examiner, so that the efficiency in examination depends on the mastery of such expertise by the examiner.

### SUMMARY OF THE INVENTION

[0009] The present invention has been made in view of the above problems in the prior art. It is an object of the present invention to provide a subjective optometric apparatus enabling the subject to undergo a vision test in a manner as if wearing a trial frame.

[0010] According to a first aspect of the invention, there is provided a subjective optometric apparatus including: a subjective optometric unit which contains an Alvarez lens composed of a pair of optical elements and capable of continuous change in refraction characteristics through relative displacement of the pair of optical elements with respect

to an optical axis of an optometric window and which is at least equipped with a drive mechanism for driving the pair of optical elements; and a controller for controlling the subjective optometric unit, in which the subjective optometric unit is equipped with a left-eye examination unit, a right-eye examination unit, a support member which effects supporting so as to allow adjustment of a horizontal distance between the left-eye examination unit and the right-eye examination unit in order to adjust the distance between a pair of optometric windows according to an interpupillary distance of the subject, an attachment member provided on the support member and enabling the subjective optometric unit to be attached to the head of the subject, and a nose pad member provided on the support member and adapted to adjust a positional relationship with respect to the eyes of the subject.

[0011] A subjective optometric apparatus according to a second aspect of the invention relates to the subjective optometric apparatus according to the first aspect, characterized in that the attachment member consists of a pair of earpiece members.

[0012] A subjective optometric apparatus according to a third aspect of the invention relates to the subjective optometric apparatus according to the first aspect, characterized in that the subjective optometric unit is suspended from a support portion through a wire or coil spring, the wire being equipped with a balancing counterweight for balancing the weight of the subjective optometric unit, or the coil spring being functioned as a counterweight.

[0013] A subjective optometric apparatus according to a fourth aspect of the invention relates to the subjective optometric apparatus according to the third aspect, characterized in that the wire is equipped with an arcuate support arm for supporting the support member at horizontal ends of the arcuate support arm.

[0014] A subjective optometric apparatus according to a fifth aspect of the invention relates to the subjective optometric apparatus according to the fourth aspect, characterized in that a spring member is provided between the arcuate support arm and the wire.

[0015] A subjective optometric apparatus according to a sixth aspect of the invention relates to the subjective optometric apparatus according to the fifth aspect, characterized in that the arcuate support arm is provided on the support member so as to allow fixation and rotation.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0016] In the accompanying drawings:

[0017] **FIG. 1** is a schematic diagram showing a subjective optometric apparatus according to the present invention;

[0018] **FIG. 2** is a schematic diagram showing an optical system provided inside the casing of the subjective optometric apparatus shown in **FIG. 1**;

[0019] **FIG. 3** is a main-portion see-through view of a temple lock mechanism;

[0020] **FIGS. 4A through 4C** are a perspective view and sectional views illustrating how switching between locked state and unlocked state is effected on the nose pad member and the forehead rest member;

[0021] FIG. 5 is an explanatory exploded perspective view showing a support bar in a separated state;

[0022] FIGS. 6A through 6C are schematic diagrams illustrating the temple movement when the subject puts on the main body of the device;

[0023] FIG. 7 is a main-portion see-through view showing an example of how operational connection between switching operations on a plurality of members is realized by a single push-button;

[0024] FIG. 8 is a schematic diagram showing the way a subjective optometric apparatus according to the present invention is used;

[0025] FIG. 9 is an enlarged perspective view of a main portion of a subjective optometric apparatus according to the present invention;

[0026] FIG. 10 is an optical diagram showing an example of the internal structure of the optometric unit shown in FIG. 9;

[0027] FIG. 11 is a partial sectional view of an example of an earpiece member as an attachment member;

[0028] FIG. 12 is a partial sectional view of the earpiece member shown in FIG. 11;

[0029] FIG. 13 is a longitudinal sectional view of a fastening portion of the earpiece member shown in FIG. 11;

[0030] FIG. 14 is a perspective view, as seen from the rear side, of the subjective optometric apparatus shown in FIG. 9;

[0031] FIG. 15 is a partial sectional view of an example of the nose pad member adjusting mechanism shown in FIG. 2;

[0032] FIG. 16 is a partial sectional view of an example of the forehead rest adjusting mechanism shown in FIG. 2;

[0033] FIG. 17 is a perspective view of a modification of the subjective optometric apparatus of the present invention;

[0034] FIG. 18 is a perspective view of another modification of the subjective optometric apparatus of the present invention;

[0035] FIG. 19 is an explanatory view showing how the main body of a subjective optometric apparatus according to the present invention is suspended;

[0036] FIG. 20 is a front view of a retaining case of the subjective optometric apparatus shown in FIG. 19;

[0037] FIG. 21 is a plan sectional view showing the construction of the main body of a subjective optometric apparatus;

[0038] FIG. 22 is an explanatory view illustrating a structure for vertically moving an optical unit;

[0039] FIG. 23 is an explanatory view illustrating a structure for horizontally moving a retaining case;

[0040] FIG. 24 is an explanatory view showing a structure in which the main body of a subjective optometric apparatus is rotatably mounted to a retaining member;

[0041] FIG. 25 is an explanatory view showing the construction of a tilt detecting means;

[0042] FIG. 26 is an explanatory view showing how the main body of a subjective optometric apparatus is locked;

[0043] FIG. 27 is an explanatory view showing an arrangement of the lens system of an optical unit;

[0044] FIG. 28 is a cross-sectional view of the Alvarez lens portion taken along the line L-L of FIG. 27;

[0045] FIG. 29 is a longitudinal sectional view of the Alvarez lens portion taken along the line M-M of FIG. 27;

[0046] FIG. 30 is an explanatory view of the drive system of a Vcc lens;

[0047] FIG. 31 is a perspective view illustrating the Alvarez lens and the Vcc lens of FIG. 27; and

[0048] FIG. 32 is a block diagram showing the construction of the control system of a subjective optometric apparatus.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] Embodiments of the subjective optometric apparatus of the present invention will now be described with reference to the drawings.

[0050] [First Embodiment]

[0051] FIG. 1 is a schematic diagram showing a subjective optometric apparatus according to an embodiment of the present invention.

[0052] In the drawing, a subjective optometric apparatus 100 is equipped with a main body 10 having casings 11 and 12 each containing an Alvarez lens 13 and a Vcc lens 14 as shown in FIG. 2. Further, on the outer side of the casings 11 and 12, (a plurality of) shift lenses 15 are provided so as to be selectively detachable. Further, the subjective optometric apparatus 100 is equipped with temples (earpiece members) 16 for suspending the main body 10 from the ears of a subject 80, a nose pad member 17 to be held in contact with the nose of the subject 80, and a forehead rest member 18 to be held in contact with the forehead of the subject 80.

[0053] Eye examination windows 11a and 12a are respectively formed in the casings 11 and 12. The subject 80 wearing the main body 10 of the subjective optometric apparatus 100 looks out of the optometric windows 11a and 12a through the Alvarez lenses 13, the Vcc lenses 14, and the shift lenses 15 to visually recognize an eye chart or the like.

[0054] To match the distance between the optometric windows 11a and 12a with the distance between the pupils (PD) of the subject 80, the casings 11 and 12 are supported so as to be longitudinally slidable along a horizontal frame 19 at the top of the main body 10.

[0055] As shown in FIG. 2, each Alvarez lens 13 is composed of a pair of transparent optical elements (for example, phase plates) 13a and 13b superimposed one upon the other. The superimposition surfaces (opposing surfaces) of these optical elements 13a and 13b are formed as cubically curved surfaces that can be expressed by the equation:  $x=A\{(\frac{1}{3})y^3+yz^2\}$ . The two optical elements 13a and 13b are vertically displaced relative to each other in a plane perpendicular to the optical axis X thereof, whereby it is possible

to continuously vary the refraction obtained through optical synthesis of the optical elements **13a** and **13b**.

[0056] In this embodiment, the maximum relative displacement amount in the vertical direction of the two optical elements **13a** and **13b**,  $L_{max}$  is, for example, approximately 12 mm.

[0057] Due to this displacement amount of 12 mm, it is possible to continuously vary the spherical degree  $S1$  of the Alvarez lens **13** within a range of  $-10$  D (diopter) to  $+10$  D.

[0058] Further, the Vcc lens **14**, arranged coaxially with the optical axis X of the Alvarez lens **13**, is composed of two cylinder lenses **14a** and **14b** provided so as to be rotatable around the optical axis X (by rotational displacements of  $\theta_1$  and  $\theta_2$ , respectively). In the Vcc lens **14**, it is possible to vary the cylindrical degree C and the axial angle A of the cylindrical axis by varying the rotational displacements of the cylinder lenses **14a** and **14b**.

[0059] The relative displacement L of the optical elements **13a** and **13b** of the Alvarez lens **13** and the rotational displacements of  $\theta_1$  and  $\theta_2$  of the Vcc lens **14** may be effected manually or electrically by incorporating motors in the casings **11** and **12**.

[0060] Formed in the optometric windows **11a** and **12a** are shift lens attachment portions **11b** and **12b** for attaching, selectively and detachably, the shift lenses **15** for uniformly shifting spherical degree S.

[0061] Tab portions **15a** of the shift lenses **15** are fitted into the shift lens attachment portions **11b** and **12b**, whereby the shift lenses **15** are attached.

[0062] As the shift lenses **15**, five lenses having spherical degrees  $S2$  of  $+10D$ ,  $+5D$ ,  $+0D$ ,  $-5D$ , and  $-10D$ , respectively, are prepared in advance. By combining one of the above lenses with the Alvarez lens **13**, it is possible to set the synthetic spherical degree S ( $S1+S2$ ) to one of the following ranges:  $-20D$  to  $\pm 0D$ ,  $-15D$  to  $+5D$ ,  $-10D$  to  $+10D$ ,  $-5D$  to  $+15D$ , and  $\pm 0D$  to  $+20D$ . The range width of the spherical degree S of the Alvarez lens **13** is substantially enlarged to the range of  $-20D$  to  $+20D$ .

[0063] A pair of temple base portions **19a** are pivoted to the side portions of the horizontal frame **19** of the main body **10**. The temple base portions **19a** are provided so as to be rotatable within a horizontal plane with respect to the horizontal frame **19**.

[0064] As shown in FIG. 3, the above-mentioned temples **16** are pivoted to the temple base portions **19a** so as to be capable of vertically tilting within a fixed angle range with respect to a horizontal plane so that they may allow adjustment to differences among individuals regarding the height of the ears of the subject **80**, etc.

[0065] A lock mechanism is provided in each temple base portion **19a**. To make it possible to effect switching with a single operation between an unlocked state in which the temple **16** can be tilted within the above tilting range and a locked state in which the temple **16** is fixed at a desired position within the tilting range, this lock mechanism is constructed as follows.

[0066] More specifically, as shown in FIG. 3, the lock mechanism includes a rotation shaft **16a**, a lock member **19b**, a push-button **19c**, and a spring (biasing means) **19d**.

The rotation shaft **16a** protrudes horizontally from the front side of the temple **16** and has a longitudinally extending groove. In the locked state, the lock member **19b** is engaged with the groove of the rotation shaft **16a** to prevent rotation of the rotation shaft **16a**. In the unlocked state, the lock member **19b** is detached from the groove of the rotation shaft **16a**, and allows the rotation shaft **16** to rotate freely. The push-button **19c** is used to switch the lock member **19b** between the locked state and the unlocked state with one motion. The spring **19d** urges the push-button **19c** such that the lock member **19b** is held in the locked state.

[0067] When it is being biased by the spring **19d**, the push-button **19c** protrudes upwards from the upper surface of the temple base portion **19a**.

[0068] The lock member **19b** is adapted to undergo a see-saw-like rotational displacement around an axle **19e**. When the push-button **19c**, upwardly biased by the spring **19d**, is depressed downwards as indicated by an arrow D against the biasing force, the lower portion of the push-button **19c** presses one end portion of the lock member **19b** (the left-hand end portion thereof as seen in FIG. 3) downwards. At this time, the other end portion of the lock member **19b** (the right-hand end portion thereof as seen in FIG. 3) is raised upwards as indicated by an arrow U, using the axle **19e** as the rotation center. Then, the engagement between the groove formed in the inner surface of the other end portion of the lock member **19b** and the groove of the rotation shaft **16a** is released to allow rotation of the rotation shaft **16a**, whereby the temple **16**, which is integral with the rotation shaft **16a**, is brought into the state in which the temple **16** can be tilted in the vertical directions as indicated by the arrows U and D.

[0069] When, on the other hand, the depression of the push-button **19c** is released, the push-button **19c** is restored to its upper position as indicated by the arrow U by the biasing force of the spring **19**, and the above-mentioned one end portion of the lock member **19b** is restored to its former position. At the same time, the other end portion of the lock member spring **19** is displaced downwards as indicated by the arrow D, and the groove in the inner surface thereof and the groove of the rotation shaft **16a** are engaged with each other again to thereby prevent rotation of the rotation shaft **16a**. As a result, the temple **16** is fixed at the tilting position when the depression of the push-button **19d** is released.

[0070] In the vicinity of the base of the rotation shaft **16a** of the temple **16**, there is arranged a helical spring **16b** for imparting upward torque to the temple **16**. Due to the helical spring **16b**, it is possible to reduce the requisite force for displacing the temple **16** in the unlocked state upward as indicated by the arrow U.

[0071] Portions of the temples **16** which are put on the ears of the subject **80** have cutouts **16c**. These cutouts **16c** are formed so as to be relatively long in the longitudinal direction so that the temples **16** may be appropriately placed on the ears of the subject **80** regardless of the individual differences in terms of the longitudinal positions of the ears of the subject **80**.

[0072] Further, connected to the rear end portions of the right and left temples **16** is a head band (Velcro strap) **16d** connecting these temples **16** to each other. By wrapping this head band **16d** around the back of the head of the subject **80**,

the main body **10** of the subjective optometric apparatus **100** is attached to the head of the subject **80**.

[0073] The nose pad member **17** is mounted to the main body **10** through the intermediation of a support bar **17a** extending through the horizontal frame **19**. Further, the forehead rest member **18** is mounted to the main body **10** through the intermediation of support bars **18a** and **18b** extending through the horizontal frame **19**.

[0074] As shown in FIGS. 4A through 4C, the nose pad member **17** and the support bar **17a** are connected together through the intermediation of a link member **17b** allowing the nose pad member **17** to rotate within a vertical plane. Further, the forehead rest member **18** and the support bars **18a** and **18b** are connected together through the intermediation of link members **18c** and **18d** allowing the forehead rest member to rotate within a vertical plane.

[0075] As shown in FIGS. 4A through 4C, an inner tube **20** is inserted into the horizontal frame **19**. Provided between the right-hand end outer wall of the inner tube **20** and the right-hand end inner wall of the horizontal frame **19** is a spring **20a** biasing the inner tube **20** toward the left-hand side as seen in the drawings. The left-end portion of the inner tube **20**, biased by the spring **20a**, protrudes beyond the left-hand end of the horizontal frame **19** to form a push-button **20b**.

[0076] Further, the inner tube **20** has, at positions substantially coinciding with the positions where the support bars **17a**, **18a**, and **18b** pass through the horizontal frame **19**, two through-holes **20c** through which the support bar **17a** is passed, two through-holes **20d** through which the support bar **18a** is passed, and two through-holes **20e** through which the support bar **18b** is passed.

[0077] The through-holes **20c**, **20d**, and **20e** are formed as elongated holes extending in the longitudinal direction of the inner tube **20** so that the passing of the support bars **17a**, **18a**, and **18b** is not hindered even if the inner tube **20** is displaced to the right against the biasing force of the spring **20a**.

[0078] Further, rubber members **20f** serving as anti-slip members are glued to the right-hand ends as seen in the drawings of the through-holes **20c**, **20d**, and **20e**.

[0079] When the push-button **20b** is pushed in to displace the inner tube **20** to the right in the drawings, the support bars **17a**, **18a**, and **18b** are made movable in the direction in which they are passed through the horizontal frame **19** and the inner tube **20** (unlocked state). In contrast, in the state in which the inner tube **20** is being biased to the left by the spring **20a**, the rubber members **20f** of the through-holes **20c**, **20d**, and **20e** are firmly pressed against the peripheral surfaces of the support bars **17a**, **18a**, and **18b**, whereby movement of the support bars **17a**, **18a**, and **18b** with respect to the horizontal frame **19** and the inner tube **20** is prevented (locked state).

[0080] On the portion of the support bar **17a** between the link member **17b** and the horizontal frame **19**, there is arranged a spring **17c** for biasing the nose pad member **17** toward the subject **80**. Further, on the portion of the support bar **18a** between the link member **18c** and the horizontal frame **19**, there is arranged a spring **18e** for biasing the forehead rest member **18** toward the subject **80**. Similarly, a spring **18e** is also arranged on the support bar **18b**.

[0081] As shown in FIG. 5, the support bar **17a** supporting the nose pad member **17** can be separated into a cylindrical body portion **17d** and a disc-like end portion **17f**.

[0082] The body portion **17d** and the end portion **17f** are integrated into the support bar **17a** through threaded engagement of a female screw **17e** formed in the body portion **17d** and a male screw **17g** formed on the end portion **17f**.

[0083] Due to the construction in which the support bar **17a** can be separated into the body portion **17d** and the end portion **17f**, it is possible to detach the nose pad member **17** from the main body **10** for replacement or washing.

[0084] The support bars **18a** and **18b** supporting the forehead rest member **18** have a construction similar to that of the support bar **17a**, making it possible for the forehead rest member **18** to be detached from the main body **10** for replacement or washing.

[0085] Next, the operation of the subjective optometric apparatus **100** of this embodiment will be described.

[0086] First, the oculist or the like holds the subjective optometric apparatus **100** with both hands, directing it toward the subject **80**. At this time, the oculist or the like holds the right and left temple base portions **19a** with his right and left hands, respectively, depressing the push-button **19c** of each temple base portion **19a** with a finger of each hand (e.g., the first finger). At the same time, he maintains a state, with another finger of his left hand (e.g., the second finger), in which the push-button **20b** of the horizontal frame **19** is pushed in to the right.

[0087] As described above, by pressing downwards the push-buttons **19c** of the temple base portions **19a**, the temples **16** become capable of tilting vertically as indicated by the arrows U and D.

[0088] Further, by pushing in the push-button **20b** of the horizontal frame **19**, the support bars **17a**, **18a**, and **18b** are released from the frictional force of the rubber members **20f** of the through-holes **20c**, **20d**, and **20e**. Then, the support bar **17a** is moved by the spring **17c**, and the nose pad member **17** is biased toward the subject **80**. Further, the support bars **18a** and **18b** are moved by the springs **18e**, and the forehead rest member **18** is biased toward the subject **80**.

[0089] The right and left temples **16**, which have become capable of tilting, tilt downwardly due to their own weight.

[0090] In this state, as shown in FIG. 6A, the oculist or the like puts the main body **10** on the face of the subject **80** from above while maintaining the temples **16** in the tiltable state by keeping the push-buttons **19c** depressed.

[0091] At this time, the rear end portions of the downwardly tilted temples **16** are placed on the ears of the subject **80** (FIG. 6A). Then, the main body **10** is lowered slowly while keeping the push-buttons **19c** pressed downwards, until the positions of the eyes of the subject **80** are matched with the height of the optometric windows **11a** and **12a**.

[0092] All this while, the temples **16** are tiltable with respect to the main body **10**, so that it is possible to lower the main body **10**, with the temples **16** remaining on the ears of the subject **80**.

[0093] When the eye positions are matched with the height of the optometric windows **11a** and **12a** (FIG. 6B), the oculist or the like removes his fingers from the push-buttons **19c** (FIG. 6C).

[0094] By the operation of removing the fingers from the push-button 19c, the temples 16 are fixed at the tilting positions where the eye positions are matched with the height of the optometric windows 11a and 12a.

[0095] Thus, the temples 16 are secured in position in a state in which they are properly placed on the ears of the subject 80. It is to be noted, in particular, that even in a case in which the heights of the right and left eyes differ from each other, it is possible for the main body 10 to be attached properly in conformity with such difference.

[0096] All this while, the push-button 20b of the horizontal frame 19 remains pushed in, so that the forehead rest member 18 can be freely displaced forwards and backwards (i.e., in the direction in which the support bars 18a and 18b are passed) in conformity with the configuration of the forehead while being kept in contact with the forehead of the subject 80 by the biasing force of the springs 18e.

[0097] Similarly, the nose pad member 17 can be freely displaced in an oblique direction (i.e., in the direction in which the support bar 17a is passed) in conformity with the configuration of the nose while being kept in contact with the nose of the subject 80 by the biasing force of the spring 17c.

[0098] Next, the oculist or the like removes his finger from the push-button 20b of the horizontal frame 19. Then, the rubber members 20f of the through-holes 20c, 20d, and 20e of the inner tube 20 are firmly pressed against the support bars 17a, 18a, and 18b to place the device in the locked state.

[0099] In this way, the nose pad member 17 is secured in position while in proper contact with the nose of the subject 80, and the forehead rest member 18 is secured in position while in proper contact with the forehead of the subject 80.

[0100] Thus, an improvement is achieved in terms of the intimacy with which the main body 10 is held in contact with the face of the subject 80, thereby making it possible to prevent the main body 10 from slipping down the face, i.e., moving relative to the face during optometry.

[0101] In this way, in the subjective optometric apparatus 100 of this embodiment, which uses the Alvarez lens 13 instead of the conventional turret type lens group, it is possible to substantially reduce the size and weight of the main body 10. Further, due to the provision of the temples 16, the nose pad member 17, and the forehead rest member 18, it is possible to attach the main body 10 directly to the face of the subject 80 like a trial frame.

[0102] Further, it is possible to attach the main body 10 to the face of the subject 80 properly solely through the simple operation of releasing the push-buttons 19c and 20b from the pushed-in state.

[0103] Thus, it is possible to perform fitting for each subject 80 by a simple operation and in a very short time, so that the burden on the oculist or the like is relieved, and the subject 80 suffers no excessive stress.

[0104] Further, it is also possible to adopt an arrangement in which a synthetic spherical degree S (as mentioned above) is automatically obtained on the basis of the spherical degree of the Alvarez lens 13 and the spherical degree of the shift lenses 15 to thereby relieve the inspection burden on the operator and achieve an improvement in inspection accuracy.

[0105] For example, there is provided a detecting means for detecting the relative vertical displacement amount of the optical elements 13a and 13b of the Alvarez lens 13, and there are provided, in the tab portions 15a or the like of the shift lenses 15, reflection patterns for optically identifying the shift lenses 15 and photo detectors for optically reading the reflection patterns. The spherical degree of the Alvarez lens 13 is obtained from the displacement amount of the optical elements 13a and 13b detected by the detecting means, and the spherical degrees of the shift lenses 15 are identified from the reflection patterns detected by the photo detectors, computation for synthesizing these spherical degrees being executed to automatically obtain a synthetic spherical degree S.

[0106] As the detecting means for the Alvarez lens 13, it is possible, for example, to adopt the following construction. First, by using a motor and a rack-and-pinion gear for converting rotation of this motor to vertical displacement, the optical elements 13a and 13b are caused to make a relative vertical movement. By detecting the amount of displacement of the rack-and-pinion gear from a reference position by an encoder, such as a rotary encoder or a linear encoder, it is possible to detect the relative vertical displacement of the optical elements 13a and 13b corresponding to the above displacement amount.

[0107] When obtaining the spherical degree from the detection result obtained by the detecting means, a table or the like is referred to in which the displacement amount of the rack-and-pinion gear (the relative displacement amount of the optical elements 13a and 13b) and the spherical degree the Alvarez lens exhibits are related to each other. Further, also when obtaining the spherical degree from the detection result obtained by the photo detector, a table or the like is similarly referred to in which the pattern configuration of the reflection patterns and the spherical degree of the shift lenses 15 are related to each other.

[0108] In identifying the shift lenses 15, it is possible, apart from the above optical method, to appropriately adopt an electrical method, a magnetic method, a mechanical method, etc. As for an electrical method, it is possible, for example, to provide the tab portions 15a, etc. with electrical contacts with patterns differing according to the spherical degrees of the shift lenses 15, and to provide a detector for electrically reading the patterns of the electrical contacts. As an example of a magnetic method, the tab portions 15a, etc. are provided with magnetic contacts of a pattern differing according to the spherical degrees of the shift lenses 15, and a detector for magnetically reading the patterns of the magnetic contacts may be provided. As a mechanical method, the tab portions 15a are adapted to have different configurations according to the spherical degrees of the shift lenses 15, and there is provided a detector for reading the difference in configuration mechanically, electrically, magnetically, or optically.

[0109] Further, it is also possible to separately provide a display device, such as a monitor, for indicating various items of data, such as the spherical degree of the Alvarez lens 13 as detected by the detecting means, the spherical degrees of the shift lenses 15 as identified by the photo detectors, or the synthetic spherical degree thereof, and, further, the refraction characteristics of the Vcc lens 14, such as the cylindrical degree and the axial angle of the cylin-

dricial axis. Further, it is also possible to provide a controller for controlling the various portions of the device while referring to the data as displayed on the display device, thereby achieving an improvement in operability.

[0110] [Modification]

[0111] In the subjective optometric apparatus 100 of the abovedescribed embodiment, the switching of the temples 16 between the locked and unlocked states, and the switching of the nose pad member 17 and the forehead rest member 18 between the locked and unlocked states, are effected by separate push-buttons 19c and 20b. However, the subjective optometric apparatus of the present invention is not restricted to this form. It is also possible, for example, to adopt a construction in which the switching of the temples 16, the nose pad member 17, and the forehead rest member 18 between the locked and unlocked states is effected by a single lock mechanism (push-button or the like). Further, it is also possible to adopt a construction in which only the operations of switching between the locked and unlocked states for the temples 16 and the forehead rest member 18 are united so as to be effected with a single lock mechanism.

[0112] FIG. 7 is a main-portion see-through view showing an example of a construction in which the switching between the locked and unlocked states for the temples 16, the nose pad member 17, and the forehead rest member 18 is effected with a single push-button 20b. In the construction shown, the movement of the push-button 20b shown in FIG. 4 and the movement of the lock member 19b shown in FIG. 3 are operationally connected. In the construction shown in FIG. 7, the push-button 20b and the lock member 19b are connected by a flexible wire 30 wrapped around a pulley 31 rotatably supported by a horizontal frame 20 and around pulleys 32 and 33 rotatably supported by a temple base portion 19a.

[0113] In this construction, when the push-button 20b is pushed in as indicated by the arrow, the nose pad member 17 and the forehead rest member 18 are unlocked. Further, the wire 30, one end of which is connected to a pin 21 provided on the inner tube 20, is displaced in the direction of the arrow, and the lock member 19b of the temple 16, which is connected to the other end of the wire 30, is unlocked. When the push-button 20b is restored to the former position, the nose pad member 17, the forehead rest member 18, and the temples 16 are locked through an operation reverse to the above.

[0114] Thus, solely by operating a single push-button 20b (lock mechanism), switching between the locked and unlocked states can be effected on the temples 16, the nose pad member 17, and the forehead rest member 18, whereby a further improvement is achieved in terms of operability.

[0115] In the case in which switching between the locked and unlocked states is effected on a plurality of members by a single lock mechanism, the switching may be effected simultaneously on the members, or may be effected with appropriately different timings as needed.

[0116] To effect the switching with different timings, it is possible, for example, to make the thickness of the rubber members 20f provided in the through-holes 20c of the inner tube 20 different from that of the rubber members 20f provided in the through-holes 20d and 20e. Due to this arrangement, there is a difference between the timing with

which the rubber members 20f of the through-holes 20c abut the support bar 17a of the nose pad member 17 and the timing with which the rubber members 20f of the through-holes 20d and 20e abut the support bars 18a and 18b of the forehead rest member 18, so that it is possible to effect switching on the nose pad member 17 and the forehead rest member 18 with different timings.

[0117] [Second Embodiment]

[0118] While the subjective optometric apparatus of the first embodiment described in detail above is worn by the subject and is completely unrestrained from outside, the subjective optometric apparatus of the present invention is not restricted to this form. In the following, another embodiment of the present invention will be described.

[0119] FIG. 8 schematically shows an optometric system using a subjective optometric apparatus according to the present invention. In the drawing, numeral 110 indicates a target presenting device, numeral 111 indicates a target, numeral 112 indicates a controller, numeral 113 indicates a subjective optometric apparatus (refractor head), numeral 114 indicates a subject, numeral 115 indicates an examiner, and numeral 116 indicates a post as a support portion.

[0120] The post 116 is equipped with an arm 117. As shown in FIG. 9, which is an enlarged view, this arm 117 is equipped with pulleys 118 through 120. Further, a wire 121 is provided in the arm 117. This wire 121, one end portion 121a of which is fixed to the arm 117, is passed around the pulleys 118, 122, 119, and 120, and the other end portion 121b thereof is guided into the post 116. A balancing counterweight 123 is mounted to the other end portion 121b of this wire 121. Further, the pulley 122 is equipped with a spring member 124.

[0121] The subjective optometric apparatus 113 has a left-eye examination unit 113A and a right-eye examination unit 113B. The left-eye examination unit 113A and the right-eye examination unit 113B have optometric windows 113A' and 113B', respectively. Further, each of the left-eye examination unit 113A and the right-eye examination unit 113B is equipped with an Alvarez lens 125 and a Vcc lens 126 as shown in FIG. 10. The Alvarez lens 125 is composed of a pair of transparent optical elements 125a and 125b, such as phase plates. The Vcc lens 126 is composed of two cylindrical lenses 126a and 126b. The Alvarez lens 125 and the Vcc lens 126 are arranged coaxially with the optical axis 0 of the optometric window 113A', 113B'.

[0122] Inside each of the left-eye examination unit 113A and the right-eye examination unit 113B, there is provided a displacement drive mechanism 127 for causing the optical elements 125a and 125b to make relative displacement vertically and horizontally. This displacement drive mechanism 127 is composed, for example, of a rack and pinion, a drive motor, and a control circuit. In FIG. 10, the displacement drive mechanism for causing the optical elements 125a and 125b to make relative displacement in the horizontal direction is not shown.

[0123] Further, in each of the left-eye examination unit 113A and the right-eye examination unit 113B, there is provided a rotation drive mechanism (not shown) for rotating the cylindrical lenses 126a and 126b. The controller 112 and the subjective optometric apparatus 113 are electrically

connected to each other, and the displacement drive mechanism 127 and the rotation drive mechanism are controlled by the controller 112.

[0124] As shown in FIG. 9, the left-eye examination unit 113A and the right-eye examination unit 113B are retained by a retaining frame member 128 in a U-shaped configuration serving as a support member. This retaining frame member 128 has side plate portions 128A and 128B and a top plate portion 128C. In the lower surface of the top plate portion 128C, there is formed a guide groove (not shown) extending from the side plate portion 128A to the side plate portion 128B.

[0125] In each of the left-eye examination unit 113A and the right-eye examination unit 113B, there is formed an engagement portion (not shown) to be engaged with the above-mentioned guide groove of the retaining frame member 128. Provided on the side plate portion 128A is a movement adjustment knob member 129A for moving the left-eye examination unit 113A along the guide groove. Also provided on the side plate portion 128B is a movement adjustment knob member 129B for moving the right-eye examination unit 113B along the guide groove. By adjusting the movement adjustment knob members 129A and 129B, the left-eye examination unit 113A and the right-eye examination unit 113B are moved toward and away from each other along the above-mentioned guide groove, whereby the positions of units 113A and 113B in accordance with the interpupillary distance PD of the subject 114 are adjusted.

[0126] An arcuate support arm 130 bridges the side plate portions 128A and 128B of the support frame member 128 so as to be rotatable around axles 131. The subjective optometric apparatus 113 is longitudinally rotatable around the axles 131 with respect to the arcuate support arm 130. A coil spring 124 is hooked onto the top portion of the arcuate support arm 130. While in this example the arcuate support arm 130 is rotatable with respect to the retaining frame member 128, it is also possible for the arcuate support arm 130 to be fixed to the retaining frame member 128.

[0127] The side plate portions 128A and 128B of the retaining frame member 128 are respectively equipped with guide plates 132A and 132B as shown in FIG. 11. Further, as shown in FIGS. 12 and 13, connected to the guide plates 132A and 132B are earpiece members 133A and 133B serving as the attachment members provided so as to be slidable in the direction in which they extend. Further, each of the guide plates 132A and 132B is equipped with a screw hole 132C to be threadedly engaged with a cap screw 134. Each of the earpiece members 133A and 133B is equipped with an elongated hole 133C extending in the direction in which it slides. Each of the guide plates 132A and 132B is equipped with a tilting angle regulating protrusion 132D. Further, formed on each of the earpiece members 133A and 133B is an engagement portion 133D to be engaged with the tilting angle regulating protrusion 132D.

[0128] The adjustment of the length of the earpiece members 133A and 133B and the adjustment of the tilting angle thereof are effected by loosening the cap screws 134, allowing the earpiece members 133A and 133B to slide, and fastening them at positions where they are fit by the cap screws 134.

[0129] An attachment belt 135 is provided at the rear ends of the earpiece members 133A and 133B. Due to a buckle

mechanism 136 as shown in FIG. 14, the attachment belt 135 allows adjustment of the force with which the device is fastened to the head 114A of the subject 114. Further, there is also provided a lock member 137 (consisting, for example, of Magic Tape (registered trademark)) for locking the forward end portion of the attachment belt 135.

[0130] At the center of the top plate portion 128C of the retaining frame member 128, there is provided a nose pad member 138. The nose pad member 138 is adjusted in position by an adjusting mechanism 139 so that it may fit the nose. As shown in FIG. 15, the adjusting mechanism 139 is substantially composed of an adjusting knob member 139A, an adjusting rod 139B, an biasing spring 139C, and a swinging mechanism 139D. The adjusting rod 139B is passed obliquely downwards from above through the top plate portion 128C. At the forward end of the adjusting rod 139B, there are provided a pair of brackets 139E forming the swinging mechanism 139D. A rotation shaft 139F bridges the brackets 139E. The nose pad member 138 is supported so as to be rotatable around this rotation shaft 139F.

[0131] The adjusting knob member 139A is provided at the rear end of the adjusting rod 139B. This adjusting knob member 139A is equipped with a screw hole 139G. Further, the outer periphery of the adjusting rod 139B is threaded. Between the lower portion of the top plate portion 128C and the brackets 139E, there is provided a biasing spring 139C for adjusting the pressurizing force applied to the nose.

[0132] Further, as shown in FIG. 16, the top plate portion 128C is equipped with a forehead rest 140. This forehead rest 140 is adjusted in position by a (forehead rest) adjusting mechanism 141 so as to fit the forehead of the subject 114. The adjusting mechanism 141 is substantially composed of an adjusting knob member 141A, adjusting rods 141B, biasing springs 141C, and swinging mechanisms 141D. As shown in FIG. 14, there are provided right and left adjusting rods 141B, which longitudinally pass through the top plate portion 128C. At the forward end of each adjusting rod 141B, there are provided a pair of brackets 141E constituting the swinging mechanism 141D. A rotation shaft 141F bridges the brackets 141E. The forehead rest 141 is supported so as to be rotatable around the rotation shaft 141F. The adjusting knob member 141A is equipped with a screw hole 141G. Further, the outer periphery of each adjusting rod 141B is threaded. Between the top plate portion 128C and the brackets 141E, there are provided biasing springs 141C for adjusting the pressurizing force with which the forehead rest 141 is applied to the forehead.

[0133] Due to the above-described construction, the weight of the subjective optometric apparatus 113 is balanced by the balancing counterweight 123. Thus, if the subject 114 shakes his head with the subjective optometric apparatus 113 on, he does not practically perceive the weight of the device, thus relieving the burden on the subject 114. Further, if the subject nods his head, the subjective optometric apparatus 113 follows the nodding movement, so that the burden on the subject 114 is relieved.

[0134] The above-described embodiments should not be construed restrictively. It is also possible to adopt the following constructions.

[0135] [Modification 1]

[0136] In the first modification shown in FIG. 17, an arcuate arm member 142 allowing vertical adjustment is

provided on the post 116. At the forward end of this arcuate arm member 142, there is provided a vertically rotatable suspension arm member 142. Further, at the lower end of the suspension arm 143, a subjective optometric apparatus 113 is provided so as to be horizontally rotatable. Further, at the rear end of the arcuate arm member 142, there is provided a balancing counter 123 for balancing the weight of the subjective optometric apparatus 113.

[0137] [Modification 2]

[0138] In the second modification shown in FIG. 18, the arm 117 of the post 116 is equipped with a rotation shaft 117A, and at the lower end of this rotation shaft 117A, there is provided a horizontally rotatable first arm 144. The first arm 144 is equipped with a second arm 145 on whose one end the second arm 145 is vertically rotatable. A third arm 146 is connected to the other end of the second arm 145 so as to be longitudinally rotatable. The subjective optometric apparatus 113 is connected to a horizontal rotation shaft 147 of the third arm 146. Further, the other end of the second arm 145 is suspended from the first arm 144 by a coil spring type wire 148. In this modification, the coil spring type wire 148 functions as the balancing counterweight 123.

[0139] While in the above-described constructions a pair of earpiece members 133A and 133B are used as the attachment members, it is also possible to additionally provide the subjective optometric apparatus 113 with a chin strap, which is hooked on the chin of the subject 114 as an auxiliary attachment member.

[0140] In the subjective optometric apparatus of this embodiment described above, it is possible for the subject to perform subjective optometry with a feel as if wearing a trial frame, without suffering the burden of the weight of the device.

[0141] [Others]

[0142] Incidentally, when performing optometry on the subject reading a magazine or the like with a subjective optometric apparatus according to the present invention being on his face, it is usual for the subject to slightly tilt his face downwards and to direct his eyes downwards. This tendency is conspicuous with a subject who has had an experience of wearing progressive lenses. However, in this case, the line of vision of the subject is deviated from the optical axis of the measurement lens, making it impossible to perform accurate measurement.

[0143] To cope with this, it is necessary to adopt an arrangement for matching the optical axis of the measurement lens with the line of vision. For example, in the case in which the subjective optometric apparatus is suspended as in the second embodiment, the above problem can be coped with by making the device capable of tilting with respect to the horizontal direction, arranging the optical unit of the device so as to be vertically movable, and moving the optical unit downwardly in accordance with the tilting angle when the device is tilted with respect to the horizontal direction. In the following, an example of a subjective optometric apparatus further equipped with such a construction will be described.

[0144] FIG. 19 shows a subjective optometric apparatus having a main body 210 suspended from an arm 211 mounted to an extendable post, as in the second embodiment

described above. Mounted to the forward end portion of the arm 211 is a connection pipe 212 extending vertically downwards. An upper portion 213A of a connection shaft 213 is inserted into the connection pipe 212 so as to be vertically movable and rotatable. Further, the upper portion 213A of the connection shaft 213 is mounted to one end of a spring 214 arranged in the connection pipe 212, and the upper end of this spring 214 is connected to a wire 215. This wire 215 is wrapped around a pulley 216 provided in the arm 211 and is passed through the arm 211 to be further wrapped around a pulley 217 provided in the post. A balancing counterweight 218 is suspended from the pulley 217 side end of the wire 215.

[0145] Further, a reverse-U-shaped retaining member 219 is fixed to the lower portion of the connection shaft 213. The lower end portions of this retaining member 219 are pivoted to side wall portions 221A and 221B of a case 220 of the main body 210, enabling the main body 210 to rotate around the axis J with respect to the retaining member 219. The retaining member 219 is retained in the vertical state by the connection pipe 212. Further, the main body 210 is suspended from the wire 215 through the intermediation of the retaining member 219, the connection shaft 213, and the spring 214, and the weight of the balancing counterweight 218 is equal to the total weight of the main body 210, the retaining member 219, the connection shaft 213, and the spring 214, whereby the weight of the main body 210, etc. is prevented from being applied to the subject wearing the main body 210.

[0146] As shown in FIGS. 20 through 22, the main body 210 is equipped with the case 220, a pair of horizontally movable retaining cases 230 and 240 provided in the case 220, optical units 250 provided inside the retaining cases 230 and 240 so as to be vertically movable, a vertical movement mechanism 260 for vertically moving the optical units 250, a main body lock mechanism 270 for locking the main body 210, a tilt detecting means 280 for detecting tilting of the main body 210, etc.

[0147] Mounted to the case 220 is a head band 229 for attaching the main body 210 to the subject as shown in FIG. 19. Further, although not shown, the case 220 is equipped with a nose pad member and a forehead rest like those of the first embodiment. Further, a pair of openings 220a are formed in the front surface 220A of the case 220, and a pair of openings 220b are formed in the rear surface 220B of the case 220.

[0148] Further, in the upper portion of the interior of the case 220, there is arranged a shaft 222 extending in the horizontal direction. The end portions of this shaft 222 are rotatably supported by bearing portions 223 provided on the side walls 221A and 221B of the case 220. The end portions of the shaft 222 are equipped with male screw portions 222A and 222B formed so as to be reverse to each other. Further, as shown in FIG. 23, a gear 224 is attached to the central portion of the shaft 222. This gear 224 is in mesh with a worm 225, which is adapted to rotate upon rotating operation on a knob 227 provided on the upper wall portion 226 of the case 220.

[0149] As shown in FIGS. 24 and 25, the tilt detecting means 280 is equipped with a slide resistor 281 provided on the side wall 221A of the case 220, and a contact 282 adapted to slide on the slide resistor 281. A voltage  $V_c$  is

applied to one end of the slide resistor **281**, whose other end is grounded. A contact **282** is provided on the inner side of the retaining member **219**. Further, the contact **282** is connected to an input port P of a control circuit **450**.

[0150] The contact **282** slides on the slide resistor **281** according to the tilting amount of the main body **210** with respect to the retaining member **219**, and a voltage corresponding to its displacement position is input to the input port P of the control circuit **450**. The control circuit **450** reads the input voltage, and obtains through computation the amount by which the main body **210** is tilted from the horizontal direction with respect to the retaining member **219**.

[0151] As shown in FIG. 24, the main body lock mechanism **270** has a solenoid **271** provided in the case **220**. As shown in FIG. 26, when this solenoid **271** operates, a rod **272** protrudes from a hole **273** of the case **220**, and is engaged with a recess **274** provided on the inner side of the retaining member **219**, whereby the main body **210** is locked in a state in which it does not tilt with respect to the retaining member **219**.

[0152] As shown in FIGS. 20 through 22, the retaining case **230** is formed as a casing having openings **231** and **232** in the front and rear surfaces. The openings **231** and **232** are respectively opposed to the openings **220a** and **220b** of the case **220**.

[0153] A rectangular protrusion **234** is formed on the top wall portion **233** of the retaining case **230**. Formed in this protrusion **234** is a female screw **235** extending horizontally therethrough in FIG. 20. The shaft **222** is passed through this female screw **235**, and the male screw **222A** of the shaft **222** and the female screw **235** are threadedly engaged with each other. Upon rotating operation on the knob **227**, the retaining case **230** is moved to the right or left according to the rotating direction of the shaft **222**.

[0154] For example, when the shaft **222** is rotated clockwise as seen in FIG. 23, the retaining case **230** is moved to the right as seen in FIG. 20. Conversely, when the shaft **222** is rotated counterclockwise, the retaining case **230** is moved to the left.

[0155] The retaining case **240** has a construction similar to that of the retaining case **230**. When the shaft **222** is rotated clockwise as seen in FIG. 23, the retaining case **240** is moved to the left as seen in FIG. 20, and when the shaft **222** is rotated counterclockwise as seen in FIG. 20, the retaining case **240** is moved to the right.

[0156] The distances through which the retaining cases **230** and **240** move upon rotating operation on the knob **227** are set to be the same.

[0157] As shown in FIG. 22, the optical unit **250** has a unit case **251** with openings **251A** and **251B** in the front and rear surfaces, a lens mounting frame **402** (See FIG. 27) provided in the unit case **251**, an Alvarez lens **410** composed of a pair of optical elements **411** and **412**, a Vcc lens **423**, etc. The Alvarez lens **410** and the Vcc lens are mounted to the lens mounting frame **402** and constitute a measurement optical system. The opening **251A** of the unit case **251** is opposed to the opening **231** of the retaining case **230**, and the opening **251B** is opposed to the opening **220b** of the case **220**. The unit case **251** of the retaining case **240** has a similar construction.

[0158] As shown in FIG. 27, the lens mounting frame **402** has a first lens mounting portion **402a** and a second, cylindrical lens mounting portion **402b**.

[0159] The first lens mounting portion **402a** has left and right side wall portions **407a** and **407b**. The side wall portion **407a** has vertically extending guide grooves **408a** and **409a** as shown in FIGS. 28 and 29. Similarly, the side wall portion **407b** has vertically extending guide grooves **408b** and **409b**.

[0160] The Alvarez lens **410** is arranged between the side wall portions **407a** and **407b**. Further, ultrasonic linear motors (ultrasonic motors) **413** and **414** are respectively arranged in the guide grooves **408a** and **408b**.

[0161] The ultrasonic motor **413** has a piezoelectric element array **415** formed in a linear configuration by alternately connecting a multitude of electrodes and piezoelectric elements (not shown), a linear vibrating member (stator) **416** in which a multitude of teeth (not shown) are longitudinally arranged on the opposite side of the piezoelectric element array **415** and which is vibrated by the piezoelectric element array **415**, and movable members **417** held in frictional contact with the multitude of teeth of the vibrator **416**. The piezoelectric element array **415** is glued to the vibrating member **416**. Further, the movable members **417** of the guide grooves **408a** and **408b** are fixed to the side portions of the optical element **411** of the Alvarez lens **410**.

[0162] In this construction, the voltage applied to each electrode of the piezoelectric element array **415** is controlled to vary the phase of the bending standing-wave vibration (progressive wave) generated on the teeth side of the stator **416**, whereby the movable members **417** are driven upwards or downwards by the teeth of the stator **416**. In this way, the ultrasonic motor **413** may adopt a well-known construction.

[0163] Similarly, the ultrasonic motor **414** has a piezoelectric element array **418**, a vibrating member (stator) **419**, and movable members **420**. The movable members **420** of the guide grooves **409a** and **409b** are fixed to the side portions of the optical element **412** of the Alvarez lens **410**.

[0164] As shown in FIG. 30, the second lens mounting portion **402b** is formed in a cylindrical configuration, and in the inner peripheral surface thereof, there are formed a pair of annular grooves **421** and **422** spaced apart from each other in the axial direction. Cylinder lenses **424** and **425** (See FIG. 31) of the Vcc lens **423** are rotated by ultrasonic motors **426** and **427** arranged in the annular grooves **421** and **422**.

[0165] The ultrasonic motor **426** has a piezoelectric element array **428** formed in an annular configuration by alternately connecting a multitude of electrodes and piezoelectric elements (not shown), an annular vibrating member (stator) **429** having a multitude of teeth (not shown) arranged circumferentially on the opposite side of the piezoelectric element array **428** and adapted to be vibrated by the piezoelectric element array **428**, and an annular movable member **417** held in frictional contact with the multitude of teeth of the vibrating member **429**. The piezoelectric element array **428** is glued to the outer peripheral surface of the vibrating member **429**. Further, a cylinder lens **424** is fixed in a movable member **430** of the annular groove **421**.

[0166] In this construction, the voltage applied to each electrode of the piezoelectric element array **428** is controlled

to vary the phase of the progressive wave generated on the teeth side of the stator 429, whereby the movable member 430 is caused to make normal or reverse rotation by the teeth of the stator 429. In this way, the ultrasonic motor 413 may adopt a well-known construction.

[0167] Similarly, the ultrasonic motor 427 has a piezoelectric element array 431, an annular vibrating member (stator) 432, and an annular movable member 433. The piezoelectric element array 431 is glued to the outer peripheral surface of the vibrating member 432. Further, a cylinder lens 425 is fixed in the movable member 433 of the annular groove 422.

[0168] As shown in FIGS. 20 through 22, the vertical movement mechanism 260 is composed of racks 261 provided on the right and left sides of the back surface of the unit case 251 of the optical unit 250, a spline shaft 262 extending horizontally (See FIG. 20) in the case 220, a worm 263, a pulse motor 264 for rotating the worm 263, etc.

[0169] The both end portions of the spline shaft 262 are rotatably retained by the bearing portions 265 provided in the side walls 221A and 221B of the case 220. Further, the spline shaft 262 has a groove (not shown) extending in the axial direction thereof. This groove is engaged with the rack 261, so that rotation of the spline shaft 262 causes the unit case 251 to move vertically with respect to the retaining cases 230 and 240. Further, the rack 261 is capable of making relative axial movement along the groove of the spline shaft 262, so that it does not hinder horizontal movement of the optical unit 250.

[0170] The worm 263 is in mesh with the gear 266 provided at the center of the spline shaft 262. The spline shaft 262 is rotated upon rotation of the worm 263 transmitted through the gear 266. Further, the pulse motor 264 is mounted in the case 220 through the intermediation of a bracket (not shown).

[0171] FIG. 32 shows the construction of the control system used in this subjective optometric apparatus.

[0172] Numeral 440 indicates a computation control circuit consisting of a CPU or the like. The computation control unit is mounted in an operation apparatus (not shown) having a keyboard or the like to be operated by the examiner. This computation control circuit 440 drive-controls the piezoelectric elements of the piezoelectric element arrays 415, 418, 428, and 431 in the lens mounting frames 402R and 402L mentioned above through a communication means (not shown). Here, the lens mounting frames 402R and 402L are respectively the lens mounting frames 402 of the optical units 250 for the right eye and the left eye. The above-mentioned communication means may be wireless or wired. Further, connected to the computation control circuit 440 are setting means, such as an operating means for setting or varying the spherical degree or for setting an axial angle of the cylindrical shaft, and a data input means. The setting means may consist of a keyboard, a mouse, or push-buttons (switches) for data setting. Further, it is also possible to use a means for taking in prescription data for glasses from other refractometers, lens meters or the like as the setting means.

[0173] Further, on the basis of measurement data obtained by a lens meter 500, the computation control circuit 440 makes a judgment as to whether the lens to be examined (not shown) is a progressive lens or a single lens. When it is

determined that the lens to be examined is progressive, a signal indicating that it is a progressive lens (a progressive signal) is output from an output port Q.

[0174] On the basis of the voltage at the input port P and the progressive signal from the computation control circuit 440, a control circuit 450 controls the pulse motor 264 to vertically move the optical unit 250, and controls the solenoid 271 to lock the main body 210. While this control circuit 450 is provided inside the case 220 as described above, it may also be mounted in the operation apparatus like the computation control circuit 440.

[0175] Next, the operation of the subjective optometric apparatus, constructed as described above, will be described.

[0176] First, as shown in FIG. 1, the main body 210 is attached to the subject by using the head band 229. Then, the examiner operates the knob 227 to move the retaining cases 230 and 240 horizontally to match the optical axis of the optical unit 250 to the position of each pupil of the subject.

[0177] Next, as in the prior art, a target is presented by a target presenting device (not shown), and the examiner asks the subject about the way the target presented by the target presenting device looks as he causes relative vertical movement of the optical elements 411 and 412 of the Alvarez lens 410 and rotates the cylinder lenses 424 and 425 of the Vcc lens 423, thereby measuring the optical characteristics of the eye to be examined (i.e., performing far vision test) to obtain the prescription values.

[0178] When the far vision test on the eye to be examined has been completed, checking is made on how a nearby object can be seen through the lens as prescribed while the subject is reading a magazine or the like (near vision test).

[0179] When reading a magazine or the like, the subject directs his face slightly downwards. At this time, with a subject with no experience of wearing progressive lenses, the inclination of the face is generally somewhat larger as compared with that of a subject with such experience (of wearing progressive lenses).

[0180] The main body 210 rotates around the axis J of the retaining member 219 in correspondence with the inclination of the face of the subject, and is inclined with respect to the horizontal direction. Due to this inclination, the contact 282 of the retaining member 219 slides on the slide resistor 281, and a voltage corresponding to the moving position of the contact 282 is input to the input port P of the control circuit 450. That is, the tilt detecting means 280 outputs a voltage (detection signal) corresponding to the inclination angle of the main body 210 to be detected, and the control circuit 450 reads this detection signal input to the input port P to thereby obtain the inclination angle (tilting amount) of the main body 210.

[0181] When the inclination angle  $\alpha$  obtained is relatively large, that is, when it is larger than the (second) threshold value E2, the control circuit 450 judges that the subject has no experience of wearing progressive lenses, and maintains the pulse motor 264 in the non-operating state. In this case, the optical unit 250 keeps the position as shown in FIG. 22.

[0182] When the inclination angle  $\beta$  obtained is small, that is, when the inclination angle  $\beta$  is larger than a (first) threshold value E1 ( $E1 < \beta < E2$ ) and smaller than the threshold value E2 ( $E1 < \beta < E2$ ), the control circuit 450 judges that the

subjective has an experience of wearing progressive lenses, and operates the pulse motor **264**, moving the optical unit **250** downwardly from the position shown in **FIG. 22** by a distance corresponding to the inclination angle  $\beta$ . That is, the optical unit **250** is moved to the chain-line position shown in **FIG. 22**. By this downward movement of the optical unit **250**, the subject with an experience of wearing progressive lenses can look at a magazine or the like through the optical axis portion of the measurement optical system of the optical unit **250**, so that it is possible to perform measurement in a natural state. Thus, it is possible to accurately determine the power of the near vision part of the progressive lens.

[**0183**] When the inclination angle detected by the tilt detecting means **280** is larger than the threshold value **E1**, the optical unit **250** may be moved downwardly by a fixed distance.

[**0184**] When the measurement data on the lens obtained by the lens meter **500** is input, the computation control circuit **440** makes a judgment, from this data, as to whether the lens concerned is a progressive lens or a single lens, making a judgment as to whether the subject has an experience of wearing progressive lenses or not. When it is determined that the subject has such experience, the computation control circuit **440** outputs a progressive signal from the output port **Q**.

[**0185**] Upon receiving the progressive signal from the computation control circuit **440**, the control circuit **450** operates the solenoid **271**, and causes the rod **272** to be engaged with the recess **274** of the retaining member **219**, whereby the main body **210** is locked so as not to tilt with respect to the retaining member **219**. As a result, the face of the subject is maintained in the horizontal state, so that the subject can fix his eye on the target presented in the horizontal direction, with the line of vision being stable and without feeling the weight of the main body **210**.

[**0186**] In particular, when performing optometry on an infant or an aged person, it is difficult to maintain the face in a fixed state. With the above construction, however, it is possible to maintain the face in a fixed state without involving any pain.

[**0187**] When near vision test is to be performed after performing far vision test in this state, this locked state is canceled.

[**0188**] In accordance with the present invention constructed as described above, the subject can undergo a subjective vision test in a manner as if wearing a trial frame.

[**0189**] In particular, since spherical degree and astigmatism degree can be measured by using an Alvarez lens, it is

possible to achieve a reduction in the weight and size of the drive mechanism for the measurements. Thus, when the subject undergoes measurement with the subjective optometric unit on, the burden on the subject can be advantageously reduced.

What is claimed is:

1. A subjective optometric apparatus comprising: a subjective optometric unit which contains an Alvarez lens composed of a pair of optical elements and capable of continuous change in refraction characteristics through relative displacement of the pair of optical elements with respect to each of optical axes of an optometric windows and which is equipped with a drive mechanism for driving the pair of optical elements; and a controller for controlling the subjective optometric unit,

wherein the subjective optometric unit is equipped with a left-eye examination unit, a right-eye examination unit, a support member which effects supporting so as to allow adjustment of a horizontal distance between the left-eye examination unit and the right-eye examination unit in order to adjust the distance between a pair of optometric windows according to an interpupillary distance of the subject, an attachment member provided on the support member and enabling the subjective optometric unit to be attached to the head of the subject, and a nose pad member provided on the support member and adapted to adjust a positional relationship of the subjective optometric unit with respect to the eyes of the subject.

2. A subjective optometric apparatus according to claim 1, wherein the attachment member consists of a pair of ear-piece members.

3. A subjective optometric apparatus according to claim 1, wherein the subjective optometric unit is suspended from a support portion through a wire or coil spring, the wire being equipped with a balancing counterweight for balancing a weight of the subjective optometric unit or the coil spring being functioned as counterweight.

4. A subjective optometric apparatus according to claim 3, wherein the wire is equipped with an arcuate support arm for supporting the support member at horizontal ends of the arcuate support arm.

5. A subjective optometric apparatus according to claim 4, wherein a spring member is provided between the arcuate support arm and the wire.

6. A subjective optometric apparatus according to claim 5, wherein the arcuate support arm is provided on the support member so as to allow fixation and rotation.

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