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(54) **OPHTHALMOLOGICAL ULTRASONOGRAPHY SCANNING APPARATUS**

ABTASTEINRICHTUNG FÜR ULTRASCHALL-AUGENUNTERSUCHUNG

DISPOSITIF D'ULTRASONOGRAPHIE OPHTALMOLOGIQUE

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(73) Proprietor: **Ultralink Ophthalmics Inc.**
British Columbia V7X 1J1 (CA)

(72) Inventors:
- **FOSTER, Mark, Leighton**
  Victoria, British Columbia V8L 2K9 (CA)
- **PHILLIPS, Scott, Howard**
  Victoria, British Columbia V8V 3B5 (CA)
- **TAYLOR, Paul, Wesley**
  Sidney, British Columbia V8L 5L5 (CA)
- **REINSTEIN, Dan**
  Vancouver, British Columbia V6E 3J7 (CA)

(74) Representative: **Murnane, Graham John et al**
Murgitroyd & Company
165-169 Scotland Street
Glasgow G5 8PL (GB)

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Description

FIELD OF THE INVENTION

[0001] The invention is in the field of medical ultrasound apparatus, particularly apparatus for use in ultrasonography of the eye.

BACKGROUND OF THE INVENTION

[0002] Ultrasound may be used in a variety of medical applications, including diagnostic ultrasonography of the eye. Diagnostic information is typically provided by an ultrasound pulse from a piezoelectric transducer, which is directed into a tissue. Reflected acoustic energy is detected (as 'echoes'), so that the amplitude of the received energy may be correlated with the time delay in receipt of the echo. The amplitude of the echo signal is proportional to the scattering strength of the refractors in the tissue, and the time delay is proportional to the range of the refractors from the transducer. A variety of hand-held ultrasound instruments for measuring corneal thickness (called pachymeters) have been developed (for example see U.S. Patent Nos. 4,564,018; 4,817,432; 4,930,512). Many prior art ultrasonic pachymeters provide A-scan output, in the form of waveforms displayed on a cathode ray tube, representing acoustic reflections in a single dimensional 'column' of tissue.

[0003] In B-scan ultrasonography, a two-dimensional image is formed, in which pixel brightness reflects the amplitude of the reflected acoustic signal. A B-scan image therefore represents a cross-sectional slice of the imaged tissue. The cross-sectional information is typically provided by correlating information from a series of adjoining columnar scans (each of which may be used to produce A-scan output). For the purpose of producing B-scans, adjoining columnar scans may be produced by a number of methods: rectilinear translocation of a transducer over the tissue of interest; pivoting angular displacement of a single transducer over a fan-shaped area; or through the use of a linear array of transducers.

[0004] In some applications, three dimensional images may be reconstructed from a series of B-scans. U.S. Patent No. 4,932,414 to Coleman *et al*. for example describes a system in which the transducer is electronically swept or physically rotated to produce a series of sectored (fan-shaped) scan planes which are separated by a known angular distance, to produce a 3-dimensional display. In a similar fashion, U.S. Patent No. 5,487,388 to Rello *et al*. discloses an ultrasonic scanning system in which sequential fan-shaped B-scan image planes are obtained by movement of the transducer probe in an arc, a movement which allows the apex of the scanned 3-dimensional volume to be located below the probe to facilitate imaging between closely-spaced surface obstructions.

[0005] The structure of the eye, particularly the cornea, presents special problems for optimal ultrasonographic B-scan imaging. The human cornea is an asphere, flattening concentrically, typically approximately 11 mm across with an average central radius of curvature of 7.8mm which increases towards the periphery. The high resolution required for ultrasonic imaging of some corneal structures is optimally achieved if ultrasound data is collected from the focal point of the transducer, and the ultrasound beam is normal to the surface of the cornea. As a result, rectilinear scanning of the cornea provides optimal imaging information only from relatively small segments of the cornea which are normal to the transducer beam and in the plane of beam focus. Similarly, volumetric 3-dimensional scanning by reconstruction of a series of fan-shaped B-scan planes, as for example described in U.S. Patent Nos. 4,932,414 and 5,487,388, is not a system adapted to provide the degree of resolution required for biometry of the corneal surface.

[0006] High frequency ultrasound has been used in ophthalmological ultrasonography to obtain biometric B-scan images of the human cornea, by arcuate translocation of a single element focused transducer. Silverman et al., 1997, J. Ultrasound Med. 16:117-124, describe a system for sonographic imaging and biometry of the cornea in which a sophisticated programmable motion system permits ultrasonographic arc scanning. In the Silverman *et al*. system, the ultrasonic transducer is translated through an arc matched to the approximate radius of curvature of the cornea using five servo motors and a controller. Similarly, U.S. Patent No. 5,331,962 discloses an ultrasound system for corneal arc scanning, in which a transducer is translocated along a curved track that approximates the surface curvature of the cornea.

SUMMARY OF THE INVENTION

[0007] In one aspect of the invention, an apparatus for ultrasound scanning of the eye is provided comprising a virtual center translocation mechanism that facilitates precise arcuate motion of an ultrasonic transducer to maintain focal distance from the eye and to maintain normality of the ultrasound beam with surfaces of the eye. The arcuate movement of the transducer focal path may closely approximate the surface of the cornea. Some embodiments of the invention may include a radius adjust mechanism for changing the radius of ultrasound scanning, to accommodate different eye sizes and to facilitate positioning of the ultrasound transducer focal point on selected surfaces of the eye, such as the cornea. Centration optics may also be provided, for aligning the translocation path of the ultrasound transducer with an axis such as, but not limited to, the Purkinje axis of a patient's eye.

[0008] In one embodiment, the invention provides an ultrasound transducer support comprising a transducer mount adapted to accommodate an ultrasound transducer having a focal point. The support may be provided with a virtual centre mechanism attached to the transducer mount, for moving the ultrasound transducer along an arcuate translation path. The arcuate translation path of the transducer may be offset from a virtual centre of translocation by a radius of transducer translocation, so that the focal point of the ultrasound transducer traverses an arcuate focal path about the virtual centre of translocation. A radius adjust mechanism may be provided for adjusting the position of the transducer mount to change the radius of transducer translocation.

[0009] In an alternative embodiment, the invention provides a method of ophthamological ultrasonography comprising centring an ultrasound transducer having a focal point in alignment with the Purkinje or other optical or geometric axis of a patient's eye using centration optics, and moving the ultrasound transducer along an arcuate translation path intersecting the Purkinje or other optical or geometric axis of the patient's eye. The arcuate translation path of the transducer may be offset from a virtual centre of translocation by a radius of transducer translocation, so that the focal point of the ultrasound transducer traverses an arcuate focal path about the virtual centre of translocation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Figure 1A is a side elevational view of an ultrasound transducer support of the invention, showing a cam-actuated radius adjust mechanism.

Figure 1B is an isometric view of an alternative embodiment of the ultrasound transducer support of the invention, showing shaped arm linkages, as are also shown in Figure 4.

Figure 1C is a schematic diagram showing a linking element connecting the front and rear swinging linkages which may form part of the transducer part of the invention.

Figure 2 is a schematic diagram showing the motion of the transducer support of the invention.

Figure 3A and 3B are elevations views of the embodiment of the invention shown in Figure I, showing the cams that are part of the radius adjust system in different positions.

Figure 4A is a side elevational view showing the ultrasound transducer support of the invention with accessory apparatus for sealing a fluid-filled chamber against the patient's eye.

Figure 4B is a schematic illustration showing alternative optics which may be used in conjunction with methods of centering the transducer using the apparatus of the invention.

Figure 5 is a schematic illustration of a series of meridional ultrasound scanning paths which intersect at a point near the apex of the cornea.

Figure 6 is an isometric view of a stage for the scanning apparatus of the invention, providing for rotational movement of the scanning apparatus, as well as movement in X, Y and Z axes.

Figures 7 and 7A are cross-sectional side views showing a membrane which may be used in some embodiments to isolate a volume of fluid around a patient's eye.

Figure 8 is an elevational view showing a mechanical safety stop mechanism.

DETAILED DESCRIPTION OF THE INVENTION

[0011] In one aspect, the invention provides an ultrasound transducer support comprising a transducer mount adapted to accommodate an ultrasound transducer, and a virtual centre mechanism. Figure 1A illustrates an embodiment of a virtual center mechanism. First and second arm linkages 65A and 65B are each connected via three pivots to moving parts of the mechanism. Rear swinging pivots 96 connect first and second arm linkages 65A and 65B to rear radius adjust slider 71, and rear radius adjust slider 71 is attached to rear swinging linkage 81. Similarly, front swinging pivots 95 connect arm linkages 65A, 65B to front radius adjust slider 70, and front radius adjust slider 70 is attached to front swinging linkage 80. The front ends of the arm linkages 65A, 65B are connected by transducer pivots 60 to transducer mount 55, and transducer mount 55 is adapted to accommodate ultrasonic transducer 50. Front pivot 85 and rear pivot 86 are stationary relative to the swinging motion of front swinging linkage 80 and rear swinging linkage 81.

[0012] The virtual centre mechanism is attached to transducer mount 55 for moving the ultrasound transducer 50 along an arcuate translation path 56 offset from a virtual centre of translocation 52 by a radius of transducer translocation, so that the focal point 51 of the ultrasound transducer 50 traverses an arcuate focal path 59 about virtual centre of translocation 52. As shown in Figure 2, when rear swinging linkage 81 rotates about rear pivot 86, rear swinging pivots 96 describe arcuate paths about rear pivot 86. Arm linkages 65A, 65B move front swinging pivots 95, so that front swinging pivots 95 describe identical paths about front pivot 85. Similar triangles 53 show that this swinging motion causes ultrasonic transducer 50 to move in an arc such that its axis pivots about virtual center 52. In addition, transducer focus point 51 traverses an arc 59 about virtual center 52 at image radius 54. The pivoting motion of the apparatus may be driven by scanning driver 82, which may for example be a servo motor. It will be seen that focal point 51 may also lie behind virtual center 52, for example to scan the back of the eye.

[0013] The mounting of transducer 50 in transducer mount 55 may be adapted so that the position of transducer 50 is adjustable relative to transducer mount 55. Such an adjustment may be difficult to accomplish during operation, due to the configuration of the assembled apparatus, as shown in Figure 4. A radius adjust mechanism for adjusting the radius of transducer translocation may be provided, for example by radius adjust sliders 70, 71 which are movable relative to the respective pivot points 85, 86. In operation, the effect of movement of radius adjust sliders 70, 71 is to elongate similar triangles 53. The elongation of triangles 53 reflects simultaneous changes to three radii: a 'first' radius of rotation of front swinging pivots 95; a 'second' radius of rotation of rear swinging pivots 96, and the radius of transducer translocation circumscribed by transducer pivots 60. In addition, image radius 54 is changed (the distance between virtual centre 52 and the arcuate focal path 59 traversed by the focal point 51 of transducer 50). The radius adjustment may be driven by rotating radius adjust cams 75, 76 relative to swinging linkages 80, 81. Radius adjust cams 75, 76 may be linked by a rotation linking mechanism, such as anti-backlash belt 90, which operates so that adjusting one cam automatically adjusts the other cam by the same amount. Alternatively, a single cam 75 or 76 could be used on either slider 70 or 71, in which case the other slider would follow. Mechanisms other than cams, such as motors, gears, or other mechanical linkages may be used to actuate sliding movement of radius adjust sliders 70, 71.

[0014] To provide extra rigidity to the mechanism supplementary linking such as that shown in figure 1C may be used. Linking element 203 may for example be a steel band or a belt or a chain or a cable and may engage sheaves 201 and 202. Alternatively the linking may be supplied many other ways including driving both swinging linkages 80 and 81 directly with wormgears or flexures.

[0015] Ultrasonic transducers for use in accordance with various aspects of the invention may be high frequency transducers, operating for example at frequencies between 50 and 100 MHz. A saline bath may be used to acoustically couple ultrasound transducer 50 to patient's eye 105. Figure 4A shows the general arrangement of an embodiment of the ultrasound transducer support of the invention with accessory apparatus including a saline bath adapted for diagnostic use. In the illustrated embodiment, a patient may be scanned in a seated position by placing the patient's orbit against eye seal 15. The patient's head may be supported by head support 170 which may be adapted to immobilize the patient's head during ultrasound scanning. The overall axis of the apparatus, shown as line 25 in Figure 4, may be at an angle of about 45 degrees to horizontal. Alternative angles from horizontal to vertical may also be used. In some embodiments, a patient's mandible may be supported with an upward force which encourages the teeth into mechanical contact to stabilize the patient's head. Arranging the apparatus at an overall axis of 45 degrees may help to reduce the accumulation of bubbles in the vacinity of the patient's orbit, particularly when saline fluid fills reservoir 20 and eye seal 15.

[0016] Coarse alignment of the eye on axis 25 may be done visually, for example using video camera 140, which preferably has a very high sensitivity. The seal may be tested by slowly filling the saline chamber with saline and watching for leaks. The position of the patient's head may be adjusted, or the eye seal changed, in order to achieve a good seal. Once an acceptable position has been found, the patient's head may be locked into position by immobilizing the head support. With the head stationary the scanning mechanism 10 can be moved relative to saline chamber 15 to make scan axis 25 coincident with the Purkinjie (or other optical or geometric) axis of the patient's eye.

[0017] In accordance with one aspect of the invention, corneal scanning may be undertaken along a series of meridional paths which intersect at a point near the apex of the cornea, as shown in Figure 5. In some embodiments, this intersection point may be the Purkinje (or other optical or geometric) axis of the eye, which may be used as an approximation of the optical axis of the eye (defined by the line between the object of regard and the fovea of the retina). The Purkinje axis may be located by shining a focused beam of light into the patient's eye, and examining the Purkinje reflections from four optical surfaces of the eye: the front and rear surfaces of the cornea, and the front and rear surfaces of the lens. The Purkinje reflections are observable along the axis of the light beam. The Purkinje axis is located when the reflections from these four surfaces are coincident. A light beam used to locate the Purkinje axis may also conveniently serve as a view target for the patient. Other axes may be used as an intersection point for meridional scanning such as the vertex-fixation axis. When a light is shone axially toward the eye onto the corneal surface, two reflected images can be seen - the specular (Normal to incident light) reflection and the diffuse reflection (not necessarily Normal reflection). When the position of the light source is adjusted such that the specular and diffuse reflections from the corneal surface are coincident, the light source will now be perpendicular to the vertix of the cornea. The vertex fixation axis is obtained when the patient's eye is looking directly at a fixation target, while observing coincidence of the diffuse and specular corneal surface reflections.

[0018] Figure 4A shows an embodiment that includes accessory centration optics for centering the transducer in alignment with the Purkinje axis of the patient's eye. Centration light source 120 may be refined using aperture 126 and focused using centration optics 125. Centration light source 120 may for example be a laser, laser diode, light emitting diode or incandescent source. The centration light beam may be aligned with machine axis 25 using reflector 130, such as a prism or mirror, and beam splitter 135. The centration light beam then passes through fluid-sealed camera window 136 and through the fluid (saline) in cavity 175 before reaching the patient's eye 105. As shown in figure 4B in order to address potential back reflection problems from window 136, both camera 140 and window 136 may be tipped relative to machine axis 25 in such a way that the centration beam still travels along the machine axis 25 within the saline chamber 175. The centration light beam thereby intersects the arcuate translation path of transducer 50. The Purkinje reflections then return back through beam splitter 135 and may be recorded by camera 140 through lens 145. As shown in Figure 4, in order for the light to reach the patient's eye 105, transducer 50 must be swung over to the side as shown in Figure 2. During an ultrasound scan, because the centration light beam intersects the arcuate translation path of transducer 50, the patient using the centration light as a view target will see the light disappear momentarily as the light is blocked by the passing transducer. This flashing behavior may be helpful in facilitating alignment of the eye, since the photoreceptors in the retina would otherwise saturate after a few seconds of staring at a fixed target light which may cause the eye to shift slightly to compensate.

[0019] Figure 4A also illustrates focus point illuminator 155, which shines through focus point optics 160 and aperture 161 to produce a focus point spot on eye 105. The angle of focus point illuminator 155 is set so that when the focus point spot is appropriately positioned on the eye, the transducer apparatus is in a selected vertical position at a known distance from eye 105. The centration optics may for example be used to determined when the focus point spot joins the Purkinje (or other axis) reflections from the centration light 120. In some embodiments, this positioning of the focus point spot may be used to identify the point at which the apparatus of the invention is positioned at the correct distance from the eye to have the cornea within the focal point of transducer 50.

[0020] For extra illumination to improve the eye image on camera 140, an infra-red light may be shone through either of windows 136, 150, in which case the camera will be adapted to be sensitive to the wavelength selected.

[0021] In addition to the scanning motion shown in Figure 5, several other motions may be produced by the mechanism of the invention to scan an eye. In order to produce various meridian angles theta as shown on Figure 5, the scan mechanism 10 may rotate about the machine axis 25 (shown in Figure 4). Rotational motion of the scanning apparatus may be accomplished using rotary table 210. Motion in the Z axis, which shifts the mechanism toward or away from the eye, may be used to compensate for the degree of insetting of a patient's eye. Motion in the Z axis may be accomplished using a Z-slide 215, which may be motorized or manually controllable. Motion along the X and Y axes, perpendicular to the machine axis 25, may be used to adjust the position of the ultrasound scanning apparatus once a patient has been positioned in front of the machine. These motions may be produced by X slide 220 and Y slide 225. In some embodiments, the X and Y slides may be motorized to facilitate X and Y motion of the scanning apparatus in planar scans of eye structures, such as the iris plane. These axes may of course be arranged differently than shown in figure 6 while retaining the same essential operation.

[0022] In order to provide a mechanical means of preventing the transducer from approaching an eye too closely, a safety stop as shown in figure 8 may be used. The transducer may be shifted closer to the eye by either a radius adjustment or Z axis adjustment. A curved stop bar 212 may be fixed to the body of the Z axis stage 215. Stop pads 210 and 211 are fixed to radius adjust slider 205 so that an excess motion of either the radius or Z axes causes one of the pads to touch the stop bar. These stop pads 210, 211 may be supplemented with sensors for operator feedback.

[0023] In some embodiments, it may be desirable to provide a barrier to inhibit the passage of an infection from one patient to another. In some embodiments, it will be necessary for the centration light beam and the Purkinje (or other axis) reflections to pass through such a barrier without significant shifting or distortion. In one embodiment, membrane 180 as shown in Figure 7 may be used, which has saline fluid on both sides of it and is selected to have a similar index of refraction to saline so that light rays passing through membrane 180 will be affected very little by its presence. A filling and draining system may be provided, as shown by tube 181 in Figure 7. The outer edges of the membrane 180 may be draped over the eye seal and provide the sealing surface for the face. Near its center membrane 180 may be attached by clamp 190 to transducer 50. Clamp 190 may be adapted to accommodate rotation of transducer 50 relative to the eye seal 15 during a scan, for example by permitting rotational movement of transducer 50 within clamp 190. Alternatively, membrane 180 may be continuous, and adapted to permit transmission of ultrasonic vibrations through the membrane itself as shown in Figure 7A. In some embodiments, bellows seal 173 may be provided over ultrasound transducer 50 and linkage arms 65A, 65B.

[0024] Although various embodiments of the invention are disclosed herein, many adaptations and modifications may be made within the scope of the invention in accordance with the common general knowledge of those skilled in this art. Such modifications include the substitution of known equivalents for any aspect of the invention in order to achieve the same result in substantially the same way. Numeric ranges are inclusive of the numbers defining the range. In the claims, the word "comprising" is used as an open-ended term, substantially equivalent to the phrase "including, but not limited to".

Claims

1. An ultrasound transducer support comprising:

a) a transducer mount (55) adapted to accommodate an ultrasound transducer (50) having a focal point (51);
b) a virtual centre mechanism attached to the transducer mount (55) for moving the ultrasound transducer (50) along an arcuate translation path (56) offset from a virtual centre of translocation (52) by a radius of transducer translocation, so that the focal point (51) of the ultrasound transducer (50) traverses an arcuate focal path (59) about the virtual centre of translocation (52); and,

characterized in that there is a radius adjust mechanism for adjusting the position of the transducer mount (55) to change the radius of transducer translocation.

2. The ultrasound transducer support of claim 1, wherein the virtual centre mechanism comprises:

a) first and second arm linkages (65A, 65B) connecting the transducer mount (55) to front and rear swinging linkages (80, 81), the front swinging linkage (80) being mounted for rotational movement about a front pivot (85), the rear swinging linkage (81) being mounted for rotational movement about a rear pivot (86), wherein:

i) the first and second arm linkages (65A, 65B) are connected to the transducer mount (55) by transducer pivots (60);
ii) the first and second arm linkages (65A, 65B) are connected to the front swinging linkage (80) by front swinging pivots (95);
iii) the first and second arm linkages (65A, 65B) are connected to the rear swinging linkage (81) by rear swinging pivots (96).

3. The ultrasound transducer support of claim 2, wherein the front swinging pivots (95) are radially spaced apart equidistant from the front (85) pivot on the front swinging linkage (80), and the rear swinging pivots (81) are radially spaced apart equidistant from the rear pivot (86) on the rear swinging linkage (81), so that when the front swinging linkage (80) rotates about the front pivot (85):

a) the front swinging pivots (95) traverse a first circular arc which is a first radius from the front pivot (85);
b) the rear swinging linkage (81) rotates about the rear pivot (86) so that the rear swinging pivots (96) traverse a second circular are which is a second radius from the rear pivot (86); and,
c) the transducer pivots (60) traverse the arcuate translation path (56) about the virtual centre of translocation (52), the arcuate translation path (56) being offset from the virtual centre of translocation (52) by the radius of transducer translocation;

wherein the first radius, the second radius and the radius of transducer translocation are the same magnitude.

4. The ultrasound transducer support of claim 3, wherein the radius adjust mechanism is adapted to simultaneously vary the first radius, the second radius and the radius of transducer translocation, the radius adjust mechanism comprising:

a) a front radius adjust slider (70) slidably mounted on the front swinging linkage (80), with the front swinging pivots (95) mounted on die front radius adjust slider (70);
b) a rear radius adjust slider (71) slidably mounted on the rear swinging linkage (81), with the rear swinging pivots (96) mounted on the rear radius adjust slider (71);

wherein the front and rear radius adjust sliders (70, 71) are operably linked so that sliding movement of the front and rear radius adjust sliders (70, 71) with respect to the front and rear swinging linkages (80, 81) simultaneously changes the first radius, the second radius and the radius of transducer translocation.

5. The ultrasound transducer support of claim 4, wherein the radius adjust mechanism further comprises a cam (75, 76) for actuating sliding movement of the front and rear radius adjust sliders (70, 71) with respect to the front and rear swinging linkages (80, 81).

6. The ultrasound transducer support of claim 1, wherein the ultrasound transducer is a single element focused transducer.

7. The ultrasound transducer support of claim 1, wherein the arcuate focal path (59) is between the virtual centre of translocation (52) and the ultrasound transducer (50).

8. The ultrasound transducer support of claim 1, wherein the virtual centre of translocation (52) is between the arcuate focal path (59) and the ultrasound transducer (50).

9. The ultrasound transducer support of claim 1, wherein the ultrasound transducer (50) is adjustably mounted in the transducer mount (55), so that adjustment of the position of the transducer (50) in the transducer mount (55), changes the arcuate focal path (59).

10. The ultrasound support of claim 1 further comprising centration optics for centring the ultrasound transducer (50) in alignment with an optical or geometric axis (25) of a patient's eye.

11. The ultrasound support of claim 10, wherein the axis (25) of the patient's eye is the Purkinje axis.

12. The ultrasound support of claim 10 or 11, wherein the centration optics comprises a centration light source (120) having a centration light beam alignable to intersect the arcuate translation path (56) of the transducer (50).

13. An ultrasound transducer support comprising:

a) a transducer mount (55) adapted to accommodate an ultrasound transducer (50) having a focal point (51);
b) a virtual centre mechanism attached to the transducer mount (55) for moving the ultrasound transducer (50) along an arcuate translation path (56) offset from a virtual centre of translocation (52) by a radius of transducer translocation, so that the focal point (51) of the ultrasound transducer (50) traverses an arcuate focal path (59) about the virtual centre of translocation; and **characterized by**
c) centration optics for centring the ultrasound transducer (50) in alignment with the an optical or geometric axis (25) of a patient's eye wherein the centration optics comprise a centration light source (120) having a centration light beam alignable to intersect the arcuate translation path (56) of the transducer (50).

14. The ultrasound transducer support of claim 13, wherein the optical or geometric axis (25) of the patient's eye is the Purkinje axis.

15. The ultrasound support of claim 1, further comprising a focus point illuminator (155) adapted to produce a focus spot appropriately positioned on a patient's eye (105) when the ultrasound transducer (50) is a known distance from a patient's eye (105).

16. A method of ophthamological ultrasonography comprising:

a) centering an ultrasound transducer (50) having a focal point (51) in alignment; with an optical or geometric axis (25) of a patient's eye (105) using centration optics;
b) moving the ultrasound transducer (50) along an arcuate translation path (56) intersecting the optical or geometric axis (25) of the patient's eye (105), wherein the arcuate translation path (56) is offset from a virtual centre of translocation (52) by a radius of transducer translocation, so that the focal point (51) of the ultrasound transducer (50) traverses an arcuate focal path (59) about the virtual centre of translocation (52).

17. The method of ophthamological ultrasonography of claim 16, wherein the optical or geometric axis (25) of the patient's eye (105) is the Purkinje axis.

18. The method of ophthamological ultrasonography of claim 16 or 17 further comprising the step of adjusting the radius of transducer translocation.

Patentansprüche

1. Eine Ultraschallwandlerstützvorrichtung, die Folgendes beinhaltet:

a) eine Wandlerfassung (55), die angepasst ist, einen Ultraschallwandler (50) mit einem Brennpunkt (51) unterzubringen;

b) einen an der Wandlerfassung (55) angebrachten Mechanismus des virtuellen Zentrums zum Bewegen des Ultraschallwandlers (50) entlang einem bogenförmigen Translationsweg (56), der von einem virtuellen Translokationszentrum (52) um einen Wandlertranslokationsradius versetzt ist, so dass der Brennpunkt (51) des Ultraschallwandlers (50) einen bogenförmigen Brennweg (59) um das virtuelle Translokationszentrum (52) durchläuft, und,

dadurch gekennzeichnet ist, dass ein Radiusregulierungsmechanismus zum Regulieren der Position der Wandlerfassung (55) vorhanden ist, um den Wandlertranslokationsradius zu verändern.

2. Ultraschallwandlerstützvorrichtung gemäß Anspruch 1, wobei der Mechanismus des virtuellen Zentrums Folgendes beinhaltet:

a) erste und zweite Armverbindungen (65A, 65B), die die Wandlerfassung (55) mit vorderen und hinteren Schwenkverbindungen (80, 81) verknüpfen, wobei die vordere Schwenkverbindungen (80) montiert ist, um um ein vorderes Drehgelenk (85) drehbar bewegt zu werden, und die hintere Schwenkverbindung (81) montiert ist, um um ein hinteres Drehgelenk (86) drehbar bewegt zu werden, wobei:

i) die ersten und zweiten Armverbindungen (65A, 65B) über Wandlerdrehgelenke (60) mit der Wandlerfassung (55) verknüpft sind;

ii) die ersten und zweiten Armverbindungen (65A, 65B) über vordere Schwenkdrehgelenke (95) mit der vorderen Schwenkverbindung (80) verknüpft sind;

iii) die ersten und zweiten Armverbindungen (65A, 65B) über hintere Schwenkdrehgelenke (96) mit der hinteren Schwenkverbindung (81) verknüpft sind.

3. Ultraschallwandlerstützvorrichtung gemäß Anspruch 2, wobei die vorderen Schwenkdrehgelenke (95) in gleichem Abstand radial von dem vorderen (85) Drehgelenk der vorderen Schwenkverbindung (80) angeordnet sind, und die hinteren Schwenkdrehgelenke (81) in gleichem Abstand radial von dem hinteren Drehgelenk (86) auf der hinteren Schwenkverbindung (81) angeordnet sind, so dass, wenn die vordere Schwenkverbindung (80) sich um das vordere Drehgelenk (85) dreht:

a) die vorderen Schwenkdrehgelenke (95) einen ersten kreisförmigen Bogen, der ein erster Radius vom vorderen Drehgelenk (85) ist, durchlaufen;

b) sich die hintere Schwenkverbindung (81) um das hintere Drehgelenk (86) dreht, so dass die hinteren Schwenkdrehgelenke (96) einen zweiten kreisförmigen Bogen, der ein zweiter Radius zum hinteren Drehgelenk (86) ist, durchlaufen; und

c) die Wandlerdrehgelenke (60) den bogenförmigen Translationsweg (56) um das virtuelle Translokationszentrum (52) durchlaufen, wobei der bogenförmige Translationsweg (56) von dem virtuellen Translokationszentrum (52) um den Wandlertranslokationsradius versetzt ist;

wobei der erste Radius, der zweite Radius und der Radius der Wandlertranslokation von der selben Größenordnung sind.

4. Ultraschallwandlerstützvorrichtung gemäß Anspruch 3, wobei der Radiusregulierungsmechanismus angepasst ist, gleichzeitig den ersten Radius, den zweiten Radius und den Wandlertranslokationsradius zu ändern, wobei der Radiusregulierungsmechanismus Folgendes beinhaltet:

a) einen vorderen Radiusregulierungsschieber (70), der verschiebbar auf der vorderen Schwenkverbindung (80) montiert ist, wobei die vorderen Schwenkdrehgelenke (95) auf dem vorderen Radiusregulierungsschieber (70) montiert sind;

b) einen hinteren Radiusregulierungsschieber (71), der verschiebbar auf der hinteren Schwenkverbindung (81) montiert ist, wobei die hinteren Schwenkdrehgelenke (96) auf dem hinteren Radiusregulierungsschieber (71) montiert sind;

wobei der vordere und der hintere Radiusregulierungsschieber (70, 71) betriebsbereit verbunden sind, so dass die Schiebebewegung des vorderen und des hinteren Radiusregulierungsschiebers (70, 71) hinsichtlich der vorderen und hinteren Schwenkverbindungen (80, 81) gleichzeitig den ersten Radius, den zweiten Radius und den Wandlertranslokationsradius verändert.

5. Ultraschallwandlerstützvorrichtung gemäß Anspruch 4, wobei der Radiusregulierungsmechanismus ferner eine Nocke (75, 76) zum Betätigen der Schiebebewegung der vorderen und der hinteren Radiusregulierungsschieber (70, 71) hinsichtlich der vorderen und hinteren Schwenkverbindungen (80, 81) beinhaltet.

6. Ultraschallwandlerstützvorrichtung gemäß Anspruch 1, wobei der Ultraschallwandler ein fokussierter Einzelelementwandler ist.

7. Ultraschallwandlerstützvorrichtung gemäß Anspruch 1, wobei der bogenförmige Brennweg (59) zwischen dem virtuellen Translokationszentrum (52) und dem Ultraschallwandler (50) liegt.

8. Ultraschallwandlerstützvorrichtung gemäß Anspruch 1, wobei das virtuelle Translokationszentrum (52) zwischen dem bogenförmigen Brennweg (59) und dem Ultraschallwandler (50) liegt.

9. Ultraschallwandlerstützvorrichtung gemäß Anspruch 1, wobei der Ultraschallwandler (50) regulierbar in der Wandlerfassung (55) montiert ist, so dass die Regulierung der Position des Wandlers (50) in der Wandlerfassung (55) den bogenförmigen Brennweg (59) verändert.

10. Ultraschallwandlerstützvorrichtung gemäß Anspruch 1, die ferner ein optisches Zentriersystem zum Zentrieren des Ultraschallwandlers (50) in Ausrichtung mit einer optischen oder geometrischen Achse (25) des Auges eines Patienten beinhaltet.

11. Ultraschallstützvorrichtung gemäß Anspruch 10, wobei die Achse (25) des Auges eines Patienten die Purkinje-Achse ist.

12. Ultraschallstützvorrichtung gemäß Anspruch 10 oder 11, wobei das optische Zentriersystem eine Zentrierlichtquelle (120) mit einem Zentrierlichtstrahl beinhaltet, der ausrichtbar ist, um den bogenförmigen Translationsweg (56) des Wandlers (50) zu kreuzen.

13. Eine Ultraschallwandlerstützvorrichtung, die Folgendes beinhaltet:

a) eine Wandlerfassung (55), die angepasst ist, einen Ultraschallwandler (50) mit einem Brennpunkt (51) unterzubringen;

b) einen an der Wandlerfassung (55) angebrachten Mechanismus des virtuellen Zentrums zum Bewegen des Ultraschallwandlers (50) entlang einem bogenförmigen Translationsweg (56), der von einem virtuellen Translokationszentrum (52) um einen Wandlertranslokationsradius versetzt ist, so dass der Brennpunkt (51) des Ultraschallwandlers (50) einen bogenförmigen Brennweg (59) um das virtuelle Translokationszentrum durchläuft, und **gekennzeichnet ist durch**

c) ein optisches Zentriersystem zum Zentrieren des Ultraschallwandlers (50) in Ausrichtung mit einer optischen oder geometrischen Achse (25) des Auges eines Patienten, wobei das optische Zentriersystem eine Zentrierlichtquelle (120) mit einem Zentrierlichtstrahl beinhaltet, der ausrichtbar ist, um den bogenförmigen Translationsweg (56) des Wandlers (50) zu kreuzen.

14. Ultraschallwandlerstützvorrichtung gemäß Anspruch 13, wobei die optische oder geometrische Achse (25) des Auges eines Patienten die Purkinje-Achse ist.

15. Ultraschallstützvorrichtung gemäß Anspruch 1, die ferner einen Brennpunktilluminator (155) beinhaltet, der angepasst ist, um einen auf adäquate Weise auf das Auge (105) eines Patienten gerichteten Brennfleck zu erzeugen, wenn der Ultraschallwandler (50) sich in einer bekannten Entfernung zu dem Auge (105) eines Patienten befindet.

16. Verfahren der ophthalmologischen Ultraschalldiagnostik, das Folgendes beinhaltet:

a) Zentrieren eines Ultraschallwandlers (50) mit einem Brennpunkt (51) in Ausrichtung mit einer optischen oder geometrischen Achse (25) des Auges (105) eines Patienten unter Verwendung eines optischen Zentriersystems;

b) Bewegen des Ultraschallwandlers (50) entlang einem bogenförmigen Translationsweg (56), der die optische oder geometrische Achse (25) des Auges (105) eines Patienten kreuzt, wobei der bogenförmige Translationsweg (56) von einem virtuellen Translokationszentrum (52) um einen Wandlertranslokationsradius versetzt ist, so dass der Brennpunkt (51) des Ultraschallwandlers (50) einen bogenförmigen Brennweg (59) um das virtuelle Translokationszentrum (52) durchläuft.

17. Verfahren der ophthalmologischen Ultraschalldiagnostik gemäß Anspruch 16, wobei die optische oder geometrische Achse (25) des Auges (105) eines Patienten die Purkinje-Achse ist.

18. Verfahren der ophthalmologischen Ultraschalldiagnostik gemäß Anspruch 16 oder 17, das ferner den Schritt des Regulierens des Wandlertranslokationsradius beinhaltet.

Revendications

1. Un support de transducteur à ultrasons comportant :

a) une monture de transducteur (55) adaptée pour accueillir un transducteur à ultrasons (50) ayant un point focal (51) ;

b) un mécanisme de centre virtuel attaché à la monture de transducteur (55) destiné à déplacer le transducteur à ultrasons (50) suivant une trajectoire de translation arquée (56) décalée par rapport à un centre virtuel de translocation (52) d'un rayon de translocation de transducteur, de sorte que le point focal (51) du transducteur à ultrasons (50) parcourt une trajectoire focale arquée (59) autour du centre virtuel de translocation (52) ; et,

caractérisé en ce qu'il y a un mécanisme d'ajustement de rayon destiné à ajuster la position de la monture de transducteur (55) afin de changer le rayon de translocation de transducteur.

2. Le support de transducteur à ultrasons de la revendication 1, dans lequel le mécanisme de centre virtuel comporte :

a) un premier et un deuxième mécanisme de liaison formant bras (65A, 65B) raccordant la monture de transducteur (55) à des mécanismes de liaison oscillants avant et arrière (80, 81), le mécanisme de liaison oscillant avant (80) étant monté pour effectuer un déplacement rotatif autour d'un pivot avant (85), le mécanisme de liaison oscillant arrière (81) étant monté pour effectuer un déplacement rotatif autour d'un pivot arrière (86), dans lequel :

i) le premier et le deuxième mécanisme de liaison formant bras (65A, 65B) sont raccordés à la monture de transducteur (55) par des pivots de transducteur (60);

ii) le premier et le deuxième mécanisme de liaison formant bras (65A, 65B) sont raccordés au mécanisme de liaison oscillant avant (80) par des pivots oscillants avant (95) ;

iii) le premier et le deuxième mécanisme de liaison formant bras (65A, 65B) sont raccordés au mécanisme de liaison oscillant arrière (81) par des pivots oscillants arrière (96).

3. Le support de transducteur à ultrasons de la revendication 2, dans lequel les pivots oscillants avant (95) sont radialement espacés de façon équidistante par rapport au pivot avant (85) sur le mécanisme de liaison oscillant avant (80), et les pivots oscillants arrière (96) sont radialement espacés de façon équidistante par rapport au pivot arrière (86) sur le mécanisme de liaison oscillant arrière (81), de sorte que lorsque le mécanisme de liaison oscillant avant (80) tourne autour du pivot avant (85) :

a) les pivots oscillants avant (95) parcourent un premier arc de cercle qui est à un premier rayon du pivot avant (85) ;

b) le mécanisme de liaison oscillant arrière (81) tourne autour du pivot arrière (86) de sorte que les pivots oscillants arrière (96) parcourent un deuxième arc de cercle qui est à un deuxième rayon du pivot arrière (86) ; et

c) les pivots de transducteur (60) parcourent la trajectoire de translation arquée (56) autour du centre virtuel de translocation (52), la trajectoire de translation arquée (56) étant décalée par rapport au centre virtuel de translocation (52) du rayon de translocation de transducteur ;

dans lequel le premier rayon, le deuxième rayon et le rayon de translocation de transducteur sont de la même magnitude.

4. Le support de transducteur à ultrasons de la revendication 3, dans lequel le mécanisme d'ajustement de rayon est adapté pour faire varier simultanément le premier rayon, le deuxième rayon et le rayon de translocation de transducteur, le mécanisme d'ajustement de rayon comportant :

a) une pièce coulissante d'ajustement de rayon avant (70) montée de façon à pouvoir coulisser sur le mécanisme de liaison oscillant avant (80), les pivots oscillants avant (95) étant montés sur la pièce coulissante d'ajustement de rayon avant (70) ;

b) une pièce coulissante d'ajustement de rayon arrière (71) montée de façon à pouvoir coulisser sur le mécanisme de liaison oscillant arrière (81), les pivots oscillants arrière (96) étant montés sur la pièce coulissante d'ajustement de rayon arrière (71) ;

dans lequel les pièces coulissantes d'ajustement de rayon avant et arrière (70, 71) sont liées de façon opérationnelle de sorte que le déplacement coulissant des pièces coulissantes d'ajustement de rayon avant et arrière (70, 71) par rapport aux mécanismes de liaison oscillants avant et arrière (80, 81) change simultanément le premier rayon, le deuxième rayon et le rayon de translocation de transducteur.

5. Le support de transducteur à ultrasons de la revendication 4, dans lequel le mécanisme d'ajustement de rayon comporte de plus une came (75, 76) destinée à déclencher le déplacement coulissant des pièces coulissantes d'ajustement de rayon avant et arrière (70, 71) par rapport aux mécanismes de liaison oscillants avant et arrière (80, 81).

6. Le support de transducteur à ultrasons de la revendication 1, dans lequel le transducteur à ultrasons est un transducteur focalisé à élément unique.

7. Le support de transducteur à ultrasons de la revendication 1, dans lequel la trajectoire focale arquée (59) est entre le centre virtuel de translocation (52) et le transducteur à ultrasons (50).

8. Le support de transducteur à ultrasons de la revendication 1, dans lequel le centre virtuel de translocation (52) est entre la trajectoire focale arquée (59) et le transducteur à ultrasons (50).

9. Le support de transducteur à ultrasons de la revendication 1, dans lequel le transducteur à ultrasons (50) est monté de façon à pouvoir être ajusté dans la monture de transducteur (55), de sorte que l'ajustement de la position du transducteur (50) dans la monture de transducteur (55) change la trajectoire focale arquée (59).

10. Le support à ultrasons de la revendication 1 comportant de plus une optique de centrage destinée à centrer le transducteur à ultrasons (50) en alignement sur un axe optique ou géométrique (25) de l'oeil d'un patient.

11. Le support à ultrasons de la revendication 10, dans lequel l'axe (25) de l'oeil du patient est l'axe de Purkinje.

12. Le support à ultrasons de la revendication 10 ou de la revendication 11, dans lequel l'optique de centrage comporte une source de lumière de centrage (120) ayant un faisceau de lumière de centrage pouvant être aligné afin de couper la trajectoire de translation arquée (56) du transducteur (50).

13. Un support de transducteur à ultrasons comportant :

a) une monture de transducteur (55) adaptée pour accueillir un transducteur à ultrasons (50) ayant un point focal (51) ;

b) un mécanisme de centre virtuel attaché à la monture de transducteur (55) destiné à déplacer le transducteur à ultrasons (50) suivant une trajectoire de translation arquée (56) décalée par rapport à un centre virtuel de translocation (52) d'un rayon de translocation de transducteur, de sorte que le point focal (51) du transducteur à ultrasons (50) parcourt une trajectoire focale arquée (59) autour du centre virtuel de translocation ; et **caractérisé par**

c) une optique de centrage destinée à centrer le transducteur à ultrasons (50) en alignement sur l'axe optique ou géométrique (25) de l'oeil d'un patient dans lequel l'optique de centrage comporte une source de lumière de centrage (120) ayant un faisceau de lumière de centrage pouvant être aligné afin de couper la trajectoire de translation arquée (56) du transducteur (50).

14. Le support de transducteur à ultrasons de la revendication 13, dans lequel l'axe optique ou géométrique (25) de l'oeil du patient est l'axe de Purkinje.

15. Le support à ultrasons de la revendication 1, comportant de plus un illuminateur de point foyer (155) adapté pour produire un spot foyer positionné de façon appropriée sur l'oeil d'un patient (105) lorsque le transducteur à ultrasons (50) est à une distance connue de l'oeil d'un patient (105).

16. Une méthode d'ultrasonographie ophtalmologique comportant :

a) centrer un transducteur à ultrasons (50) ayant un point focal (51) en alignement sur un axe optique ou géométrique (25) de l'oeil d'un patient (105) en utilisant une optique de centrage ;

b) déplacer le transducteur à ultrasons (50) suivant une trajectoire de translation arquée (56) coupant l'axe optique ou géométrique (25) de l'oeil (105) du patient, dans laquelle la trajectoire de translation arquée (56) est décalée par rapport à un centre virtuel de translocation (52) d'un rayon de translocation de transducteur, de sorte que le point focal (51) du transducteur à ultrasons (50) parcourt une trajectoire focale arquée (59) autour du centre virtuel de translocation (52).

17. La méthode d'ultrasonographie ophtalmologique de la revendication 16, dans laquelle l'axe optique ou géométrique (25) de l'oeil (105) du patient est l'axe de Purkinje.

18. La méthode d'ultrasonographie ophtalmologique de la revendication 16 ou de la revendication 17 comportant de plus l'étape d'ajuster le rayon de translocation de transducteur.

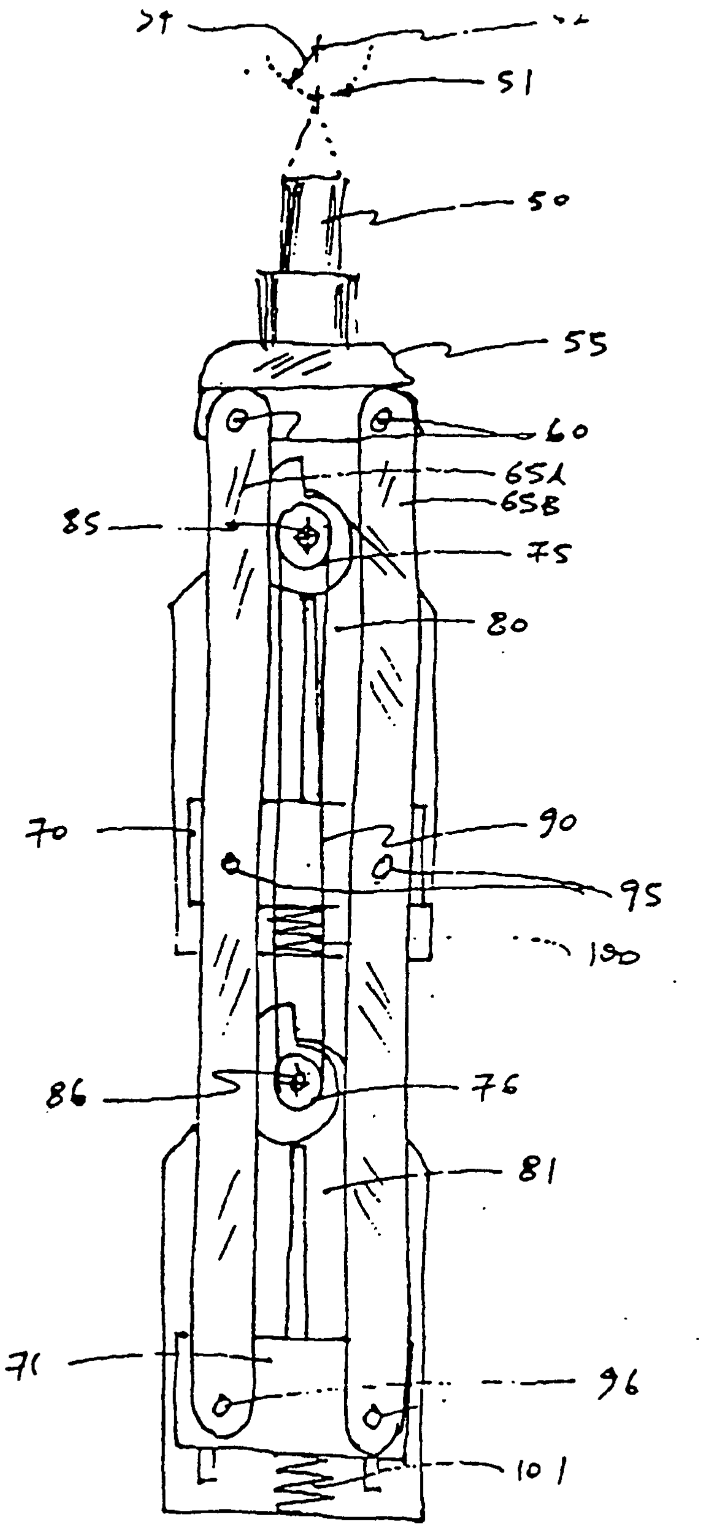

Fig. 1A

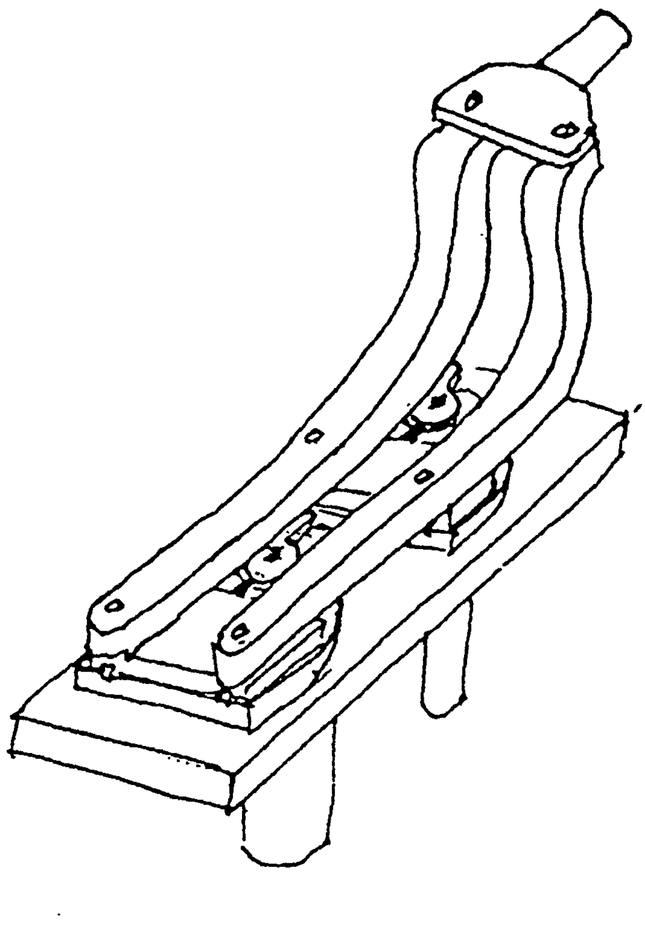

Fig. 1B

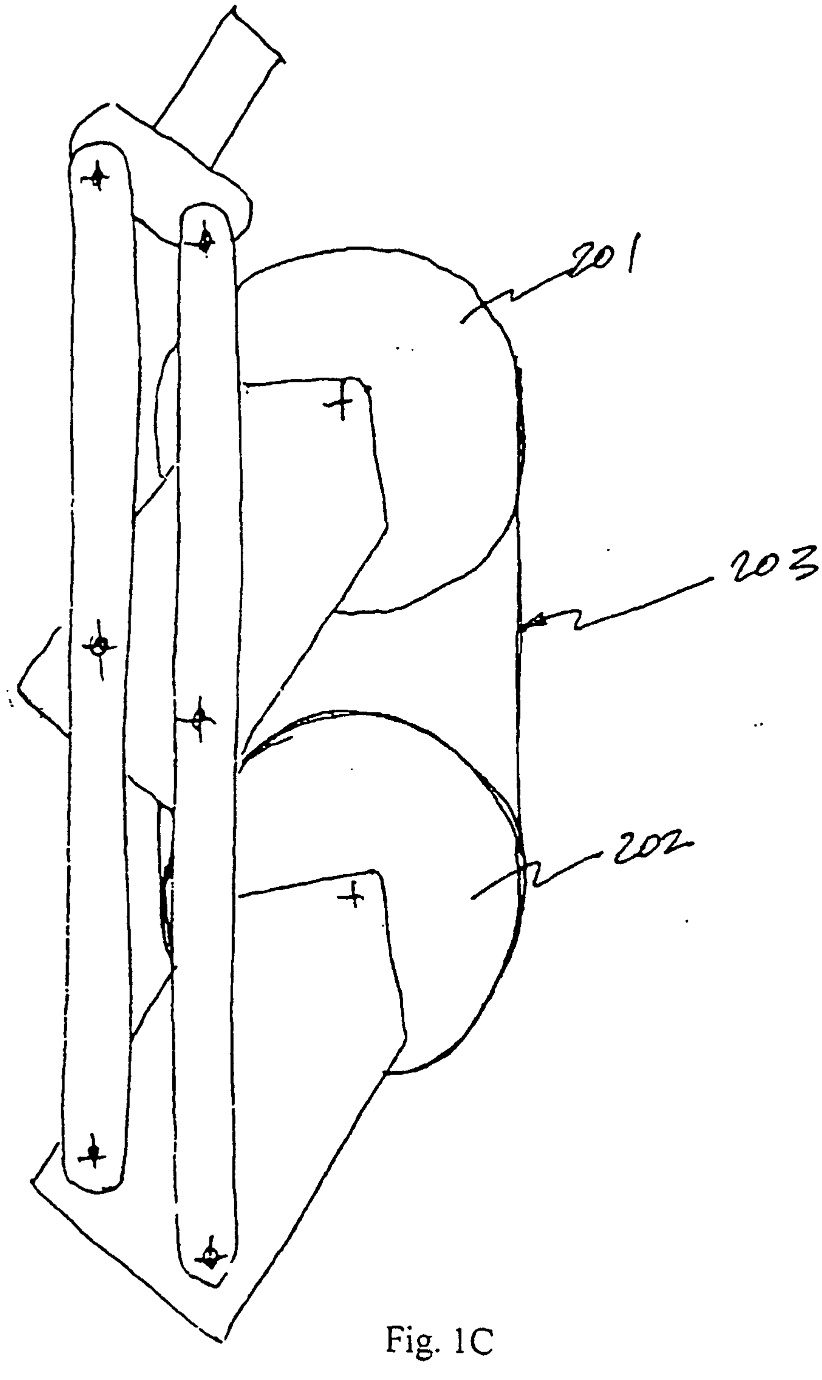

Fig. 1C

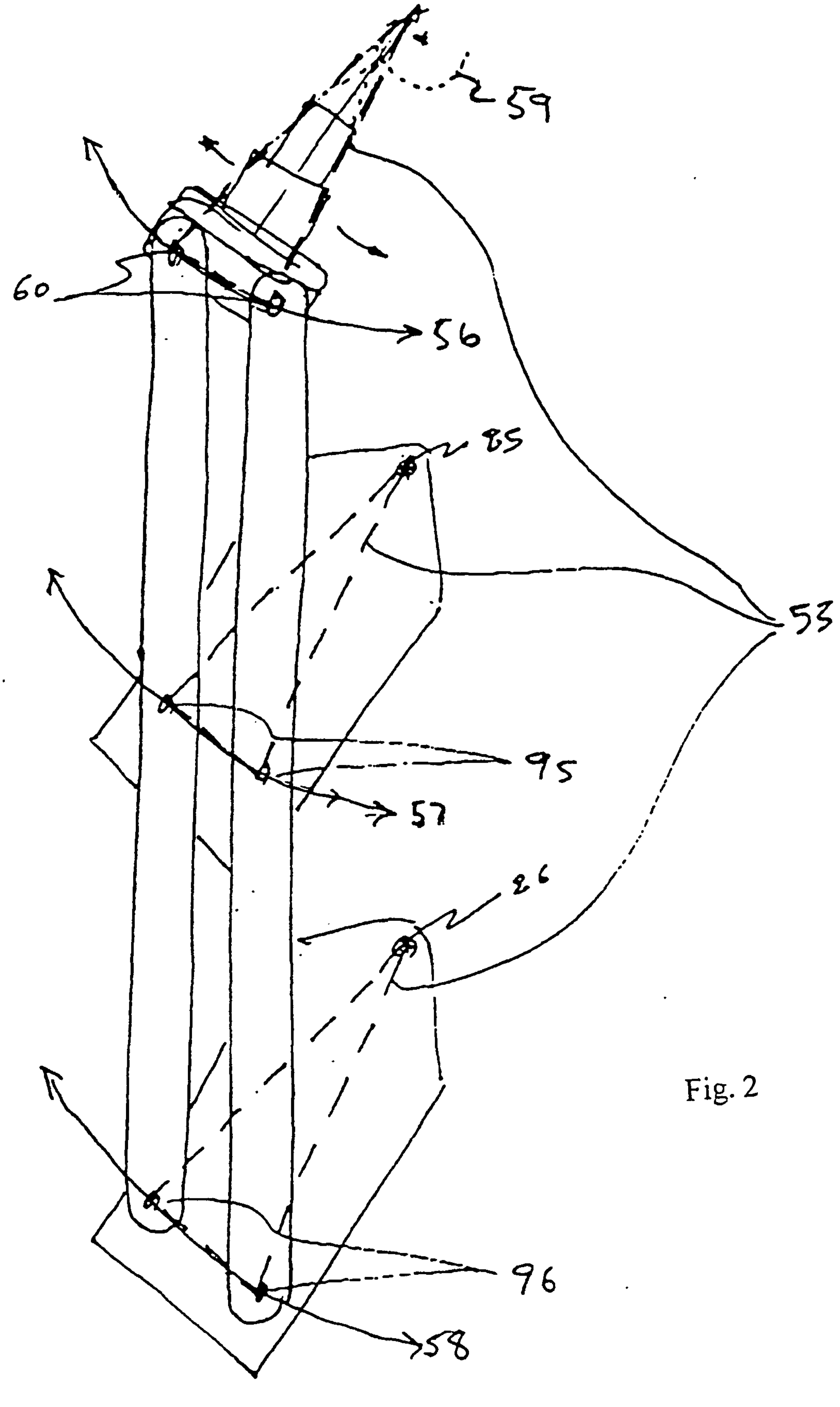

Fig. 2

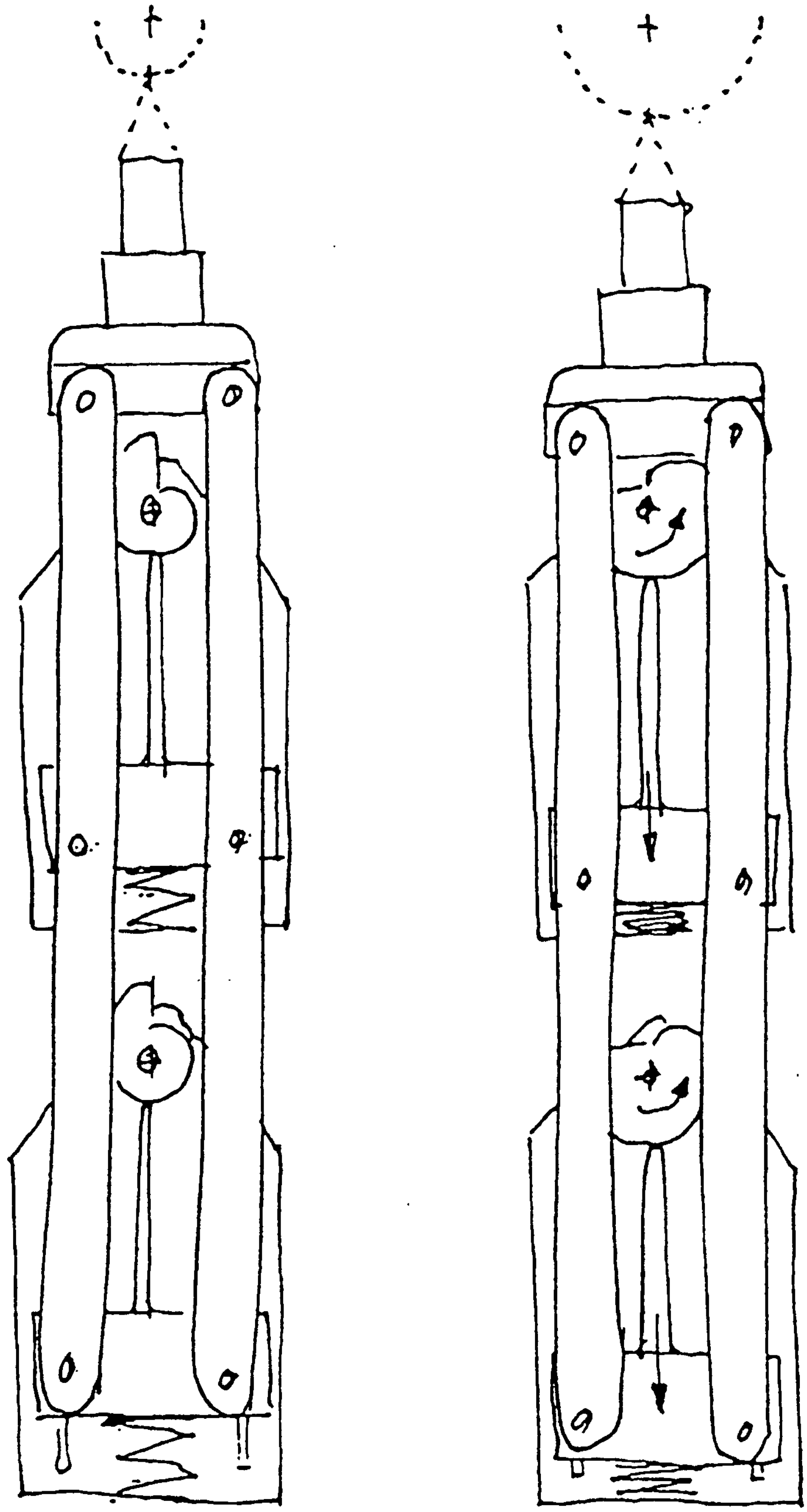

Fig. 3

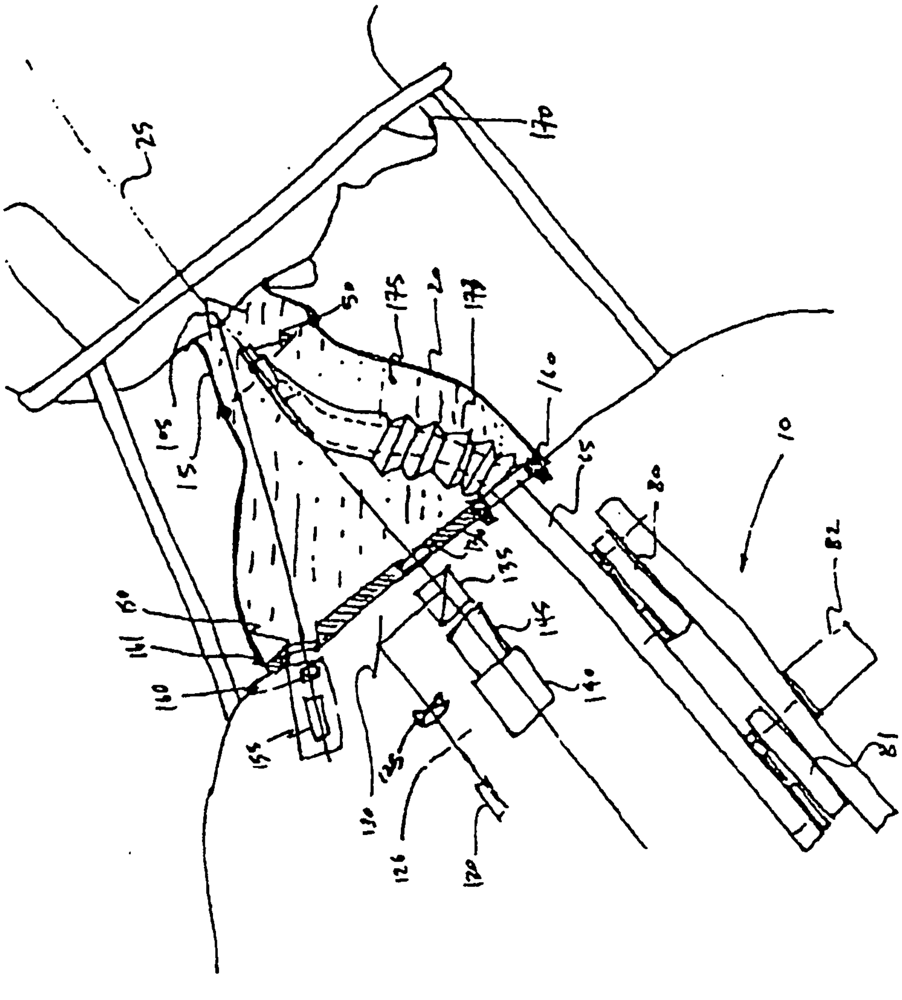

Fig. 4A

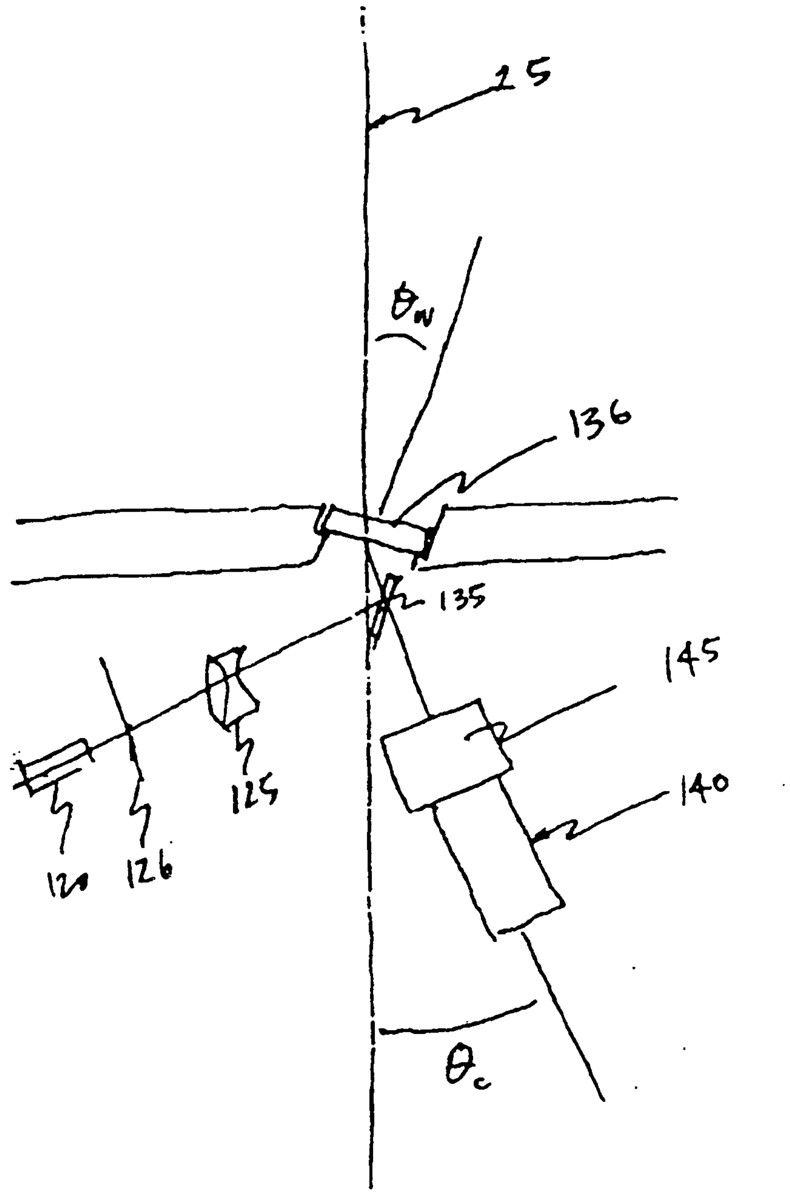

Fig. 4B

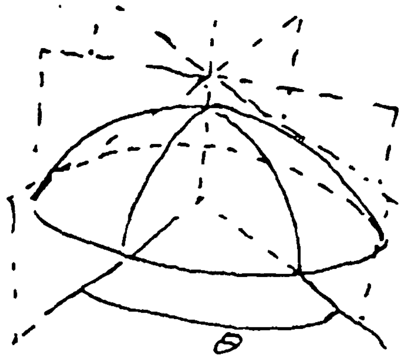

Fig. 5

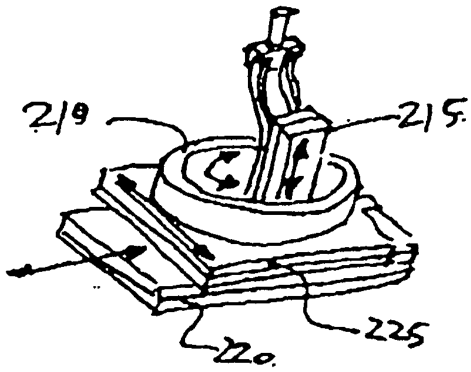

Fig. 6

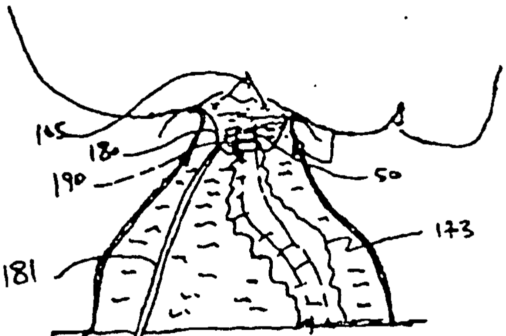

Fig. 7

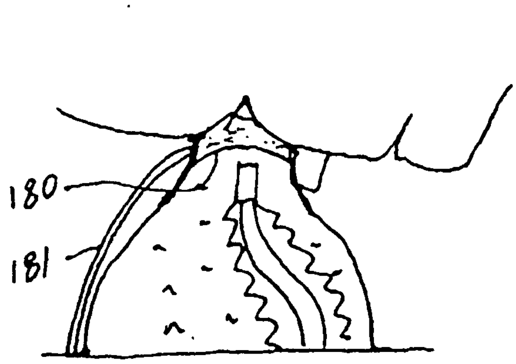

FIG 7A

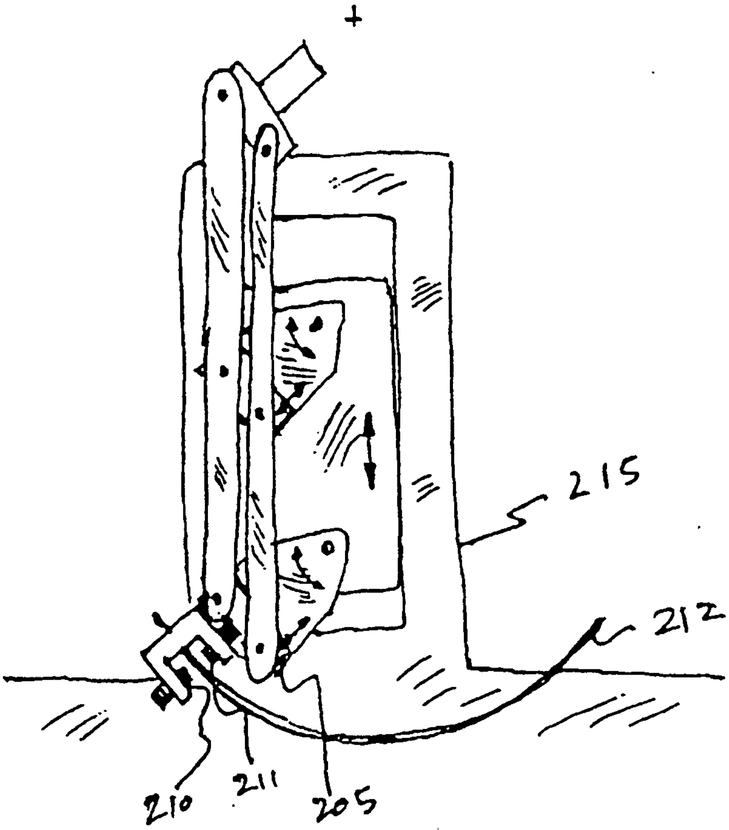

Fig. 8

专利名称(译)	眼科超声波扫描仪		
公开(公告)号	EP1175177B1	公开(公告)日	2005-09-07
申请号	EP2001900348	申请日	2001-01-05
[标]申请(专利权)人(译)	ULTRALINK眼药		
申请(专利权)人(译)	ULTRALINK眼药INC.		
当前申请(专利权)人(译)	ULTRALINK眼药INC.		
[标]发明人	FOSTER MARK LEIGHTON PHILLIPS SCOTT HOWARD TAYLOR PAUL WESLEY REINSTEIN DAN		
发明人	FOSTER, MARK, LEIGHTON PHILLIPS, SCOTT, HOWARD TAYLOR, PAUL, WESLEY REINSTEIN, DAN		
IPC分类号	A61B8/10 A61F5/37 A61B8/00		
CPC分类号	A61B3/0083 A61B8/10 A61B8/4461 A61F5/3707		
优先权	2295431 2000-01-06 CA		
其他公开文献	EP1175177A2		
外部链接	Espacenet		

摘要(译)

提供了一种用于眼睛的超声扫描的装置，包括虚拟中心移位机构，其促进超声换能器的精确弓形运动以保持与眼睛的焦距并且保持超声波束与眼睛表面的正常性。本发明还提供了一种半径调节机构，用于改变超声扫描的半径，以便于将换能器焦点定位在眼睛的选定表面上。还提供了中心光学器件，用于将超声换能器与患者眼睛的浦肯野（或其他光学或几何）轴对准。

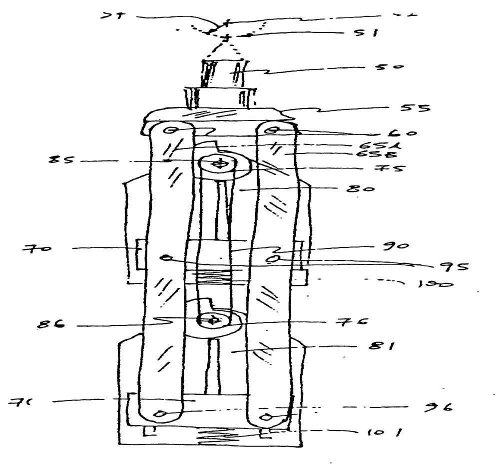

Fig. 1A