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(54) **OFFSET ULTRASONIC HAND PIECE**

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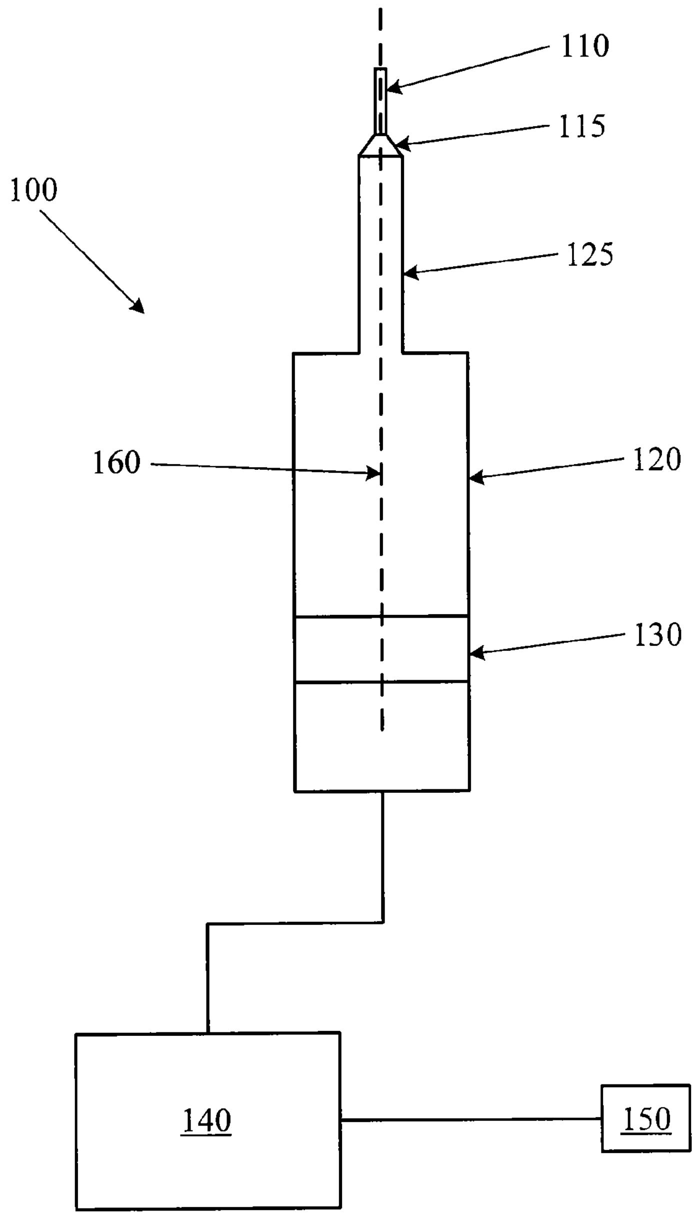
(57) **ABSTRACT**

An ultrasonic hand piece has a horn, piezoelectric crystals, and a cutting tip. The piezoelectric crystals and cutting tip are coupled to the horn. A centerline of the piezoelectric crystals is offset from a center line of the cutting tip such that oscillatory movement is produced in the cutting tip when the piezoelectric crystals are excited.



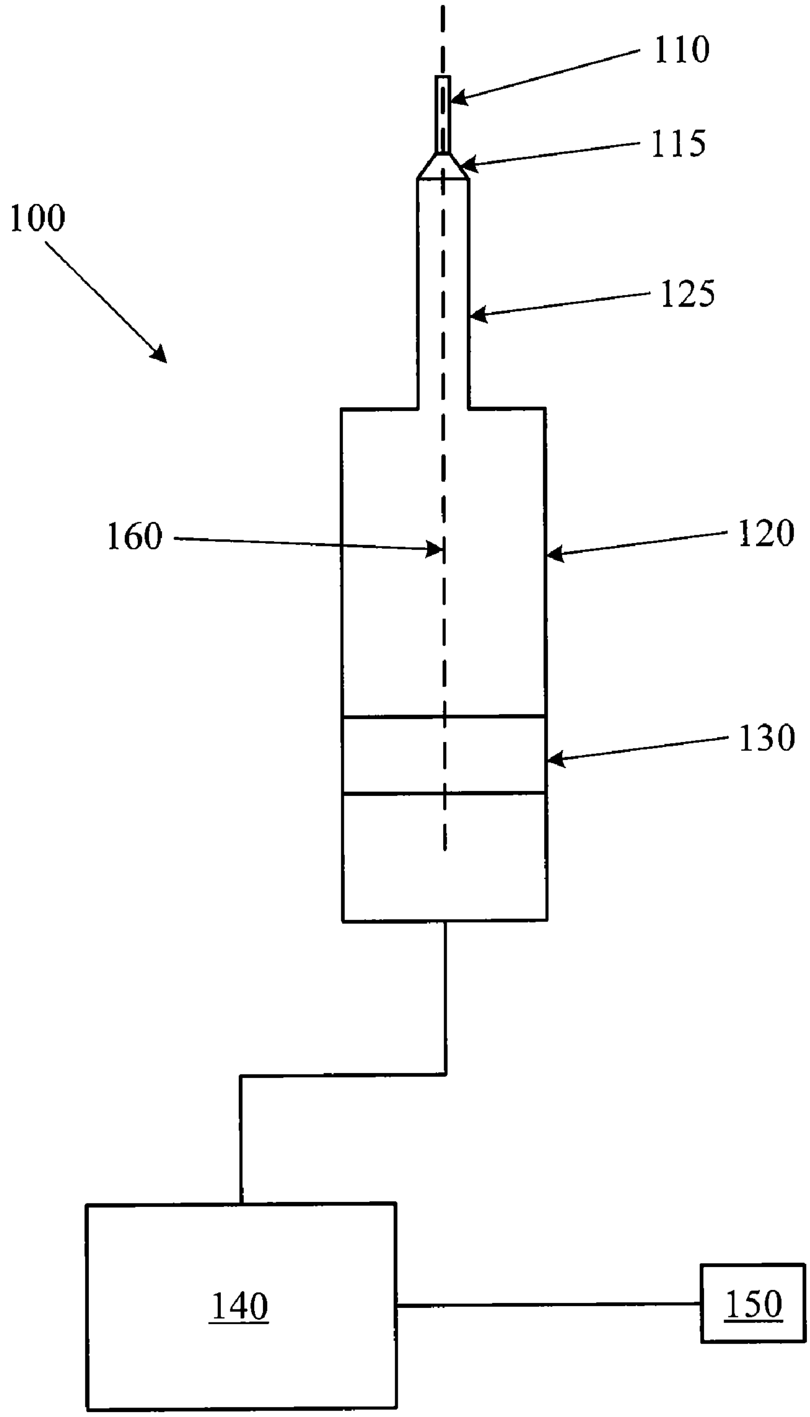


Fig. 1

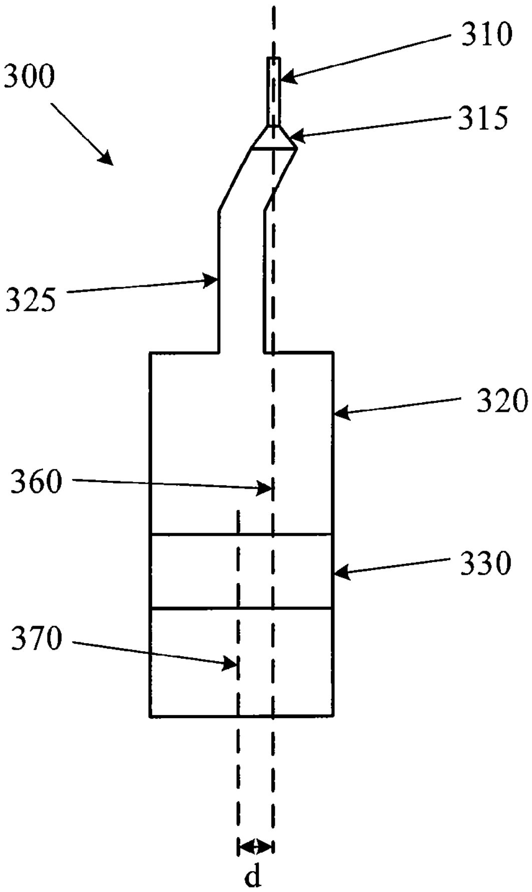

300
310
315
325
320
360
330
370
d

Fig. 3

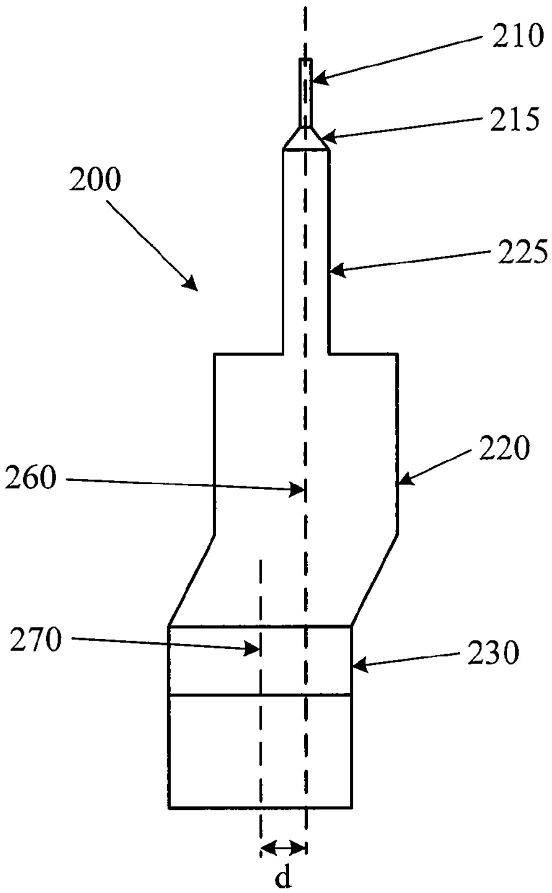

210
215
200
225
220
260
270
230
d

Fig. 2

OFFSET ULTRASONIC HAND PIECE

BACKGROUND OF THE INVENTION

[0001] The present invention relates to cataract surgery and more particularly to a phacoemulsification hand piece with an offset that produces an oscillatory motion.

[0002] The human eye functions to provide vision by transmitting light through a clear outer portion called the cornea, and focusing the image by way of the lens onto the retina. The quality of the focused image depends on many factors including the size and shape of the eye, and the transparency of the cornea and lens.

[0003] When age or disease causes the lens to become less transparent, vision deteriorates because of the diminished light that can be transmitted to the retina. This deficiency is medically known as a cataract. An accepted treatment for cataracts is to surgically remove the cataract and replace the lens with an artificial intraocular lens (IOL). In the United States, the majority of cataractous lenses are removed using a surgical technique called phacoemulsification. During this procedure, a thin needle with a distal cutting tip is inserted into the diseased lens and vibrated ultrasonically. The vibrating cutting tip liquefies or emulsifies the lens so that the lens may be aspirated from the eye. The diseased lens, once removed, is replaced by an artificial intraocular lens (IOL).

[0004] A typical ultrasonic surgical device suitable for an ophthalmic procedure includes an ultrasonically driven hand piece, an attached cutting tip, an irrigating sleeve and an electronic control console. The hand piece assembly is attached to the control console by an electric cable or connector and flexible tubing. A surgeon controls the amount of ultrasound power that is delivered to the cutting tip of the hand piece and applied to tissue at any given time by depressing a foot pedal. Flexible tubing supplies irrigation fluid to and draws aspiration fluid from the eye through the hand piece assembly.

[0005] The operative part of the hand piece is a centrally located, hollow resonating bar or horn that is attached to a set of piezoelectric crystals. The crystals are controlled by the console and supply ultrasonic vibrations that drive both the horn and the attached cutting tip during phacoemulsification. The crystal/horn assembly is suspended within the hollow body or shell of the hand piece by flexible mountings. The hand piece body terminates in a reduced diameter portion or nose cone at the body's distal end. The nose cone is externally threaded to accept the irrigation sleeve. Likewise, the horn bore is internally threaded at its distal end to receive the external threads of the cutting tip. The irrigation sleeve also has an internally threaded bore that is screwed onto the external threads of the nose cone. The cutting tip is adjusted so that the tip projects only a predetermined amount past the open end of the irrigating sleeve.

[0006] In use, the ends of the cutting tip and the irrigating sleeve are inserted into a small incision in the cornea or sclera. One known cutting tip is ultrasonically vibrated along its longitudinal axis within the irrigating sleeve by the crystal-driven ultrasonic horn, thereby emulsifying the selected tissue. The hollow bore of the cutting tip communicates with the bore in the horn that in turn communicates with the aspiration line from the hand piece to the console. Other suitable cutting tips include piezoelectric elements that produce both longitudinal and torsional oscillations. One example of such a cutting tip is described in U.S. Pat. No. 6,402,769 (Boukhny).

[0007] A reduced pressure or vacuum source in the console draws or aspirates the emulsified tissue from the eye through the open end of the cutting tip, the cutting tip and horn bores and the aspiration line, and into a collection device. The aspiration of emulsified tissue is aided by a saline solution or other fluid that is injected into the surgical site through the small annular gap between the inside surface of the irrigating sleeve and the cutting tip.

[0008] One known surgical technique is to make the incision into the anterior chamber of the eye as small as possible in order to reduce the risk of induced post operative corneal curvature changes (astigmatism). These small incisions result in very tight wounds that squeeze the irrigating sleeve tightly against the vibrating tip. Friction between the irrigating sleeve and the vibrating tip generates heat. The risk of the tip overheating and burning tissue is reduced by the cooling effect of the aspirated fluid flowing inside the tip.

[0009] When the tip becomes occluded or clogged with emulsified tissue, the aspiration flow can be reduced or eliminated, which allows the tip to heat up. This practice also reduces cooling and results in a temperature increase, which may burn the tissue at the incision if left unchecked. In addition, during occlusion, a larger vacuum can build up in the aspiration tubing so that when the occlusion eventually breaks, a larger amount of fluid can be quickly suctioned from the eye, possibly resulting in the globe collapsing or other damage to the eye. Thus, it is important to dissipate the heat buildup at the incision to avoid tissue damage, and to prevent undesirable fluid surges from the eye during occlusion breaks.

[0010] Various heat generation reduction techniques are known. One way to reduce the amount of generated heat is to lessen the friction coefficient of the material that the vibrating phacoemulsification needle contacts. For instance, instead of allowing the needle to touch the rather sticky infusion sleeve made of liquid injection molded silicone, an intervening tubing made from a lower friction material such as polyimide may be employed to significantly reduce the amount of heat generated by friction. Another way is to divert irrigation flow though a bypass opening in the phacoemulsification needle in the event that the tip port of the needle becomes occluded by lens fragments. That way, irrigation flow continues to cool the needle despite the occlusion. Reduction in heat generation may also be realized by lowering the vibration amplitude and/or reducing the operating duty cycle of the phacoemulsification tip.

[0011] Another way to reduce heat build up is with the use of torsional movement of the hand piece tip. Torsional movement involves a twisting and preferably rotating movement of the tip about the longitudinal axis of the tip. Such torsional movement may be accomplished by the ultrasonic hand piece having a programmable ultrasound driver capable of producing both a torsional frequency drive signal and a longitudinal frequency drive signal. Such hand pieces are well-known to those in the art, with one example being described in U.S. Pat. No. 6,028,387. Torsional movement also allows for more effective lens removal

[0012] Instead of traditional torsional movement, an oscillatory movement of the hand piece tip can produce similar beneficial results. In addition to lessening heat build up, an oscillatory movement results in more effective lens removal. Like a torsional movement, an oscillatory movement produces less repulsion of lens fragments at the cutting tip. The reduction in repulsion allows for more effective aspiration of lens fragments. It would be desirable to have a hand piece that produces an oscillatory movement of the cutting tip.

SUMMARY OF THE INVENTION

[0013] In one embodiment consistent with the principles of the present invention, the present invention is an ultrasonic hand piece including a horn, piezoelectric crystals, and a cutting tip. The piezoelectric crystals and cutting tip are coupled to the horn. A centerline of the piezoelectric crystals is offset from a center line of the cutting tip such that oscillatory movement is produced in the cutting tip when the piezoelectric crystals are excited.

[0014] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are intended to provide further explanation of the invention as claimed. The following description, as well as the practice of the invention, set forth and suggest additional advantages and purposes of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the invention and together with the description, serve to explain the principles of the invention.

[0016] FIG. **1** depicts a traditional ultrasonic hand piece.

[0017] FIG. **2** depicts an offset ultrasonic hand piece according to the principles of the present invention.

[0018] FIG. **3** depicts an offset ultrasonic hand piece according to the principles of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] Reference is now made in detail to the exemplary embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used throughout the drawings to refer to the same or like parts.

[0020] FIG. **1** depicts a traditional ultrasonic hand piece. In FIG. **1**, hand piece **100** is coupled to console **140**. Console **140** is coupled to foot switch **150**. Hand piece **100** has a cutting tip **110**, a horn **120**, and a set of piezoelectric crystals **130**. A tip interface **115** connects cutting tip **110** to a reduced diameter portion **125** of horn **120**. A centerline **160** of the hand piece **100** is also depicted.

[0021] Tip **110** is typically a thin needle made of titanium or stainless steel that is designed to emulsify a lens when vibrated ultrasonically. Tip **110** is typically cylindrical in shape, has a small diameter of about 20-30 gauge, and has a length suitable for removal of a lens when inserted into the anterior chamber of the eye. Tip **110** has a central longitudinal axis that passes through its center of gravity in a longitudinal direction. For example, when tip **110** approximates a cylinder, its central longitudinal axis is the central axis of the cylinder. The central longitudinal axis of tip **110** is depicted by dashed line (center line) **160**. In hand piece **100**, centerline **160** passes though the center of tip **110** and the center of piezoelectric crystals **130**. In this manner, tip **110** is aligned with piezoelectric crystals **130**. Such an alignment typically causes a longitudinal movement in tip **110** when piezoelectric crystals **130** are excited.

[0022] Horn **120** is typically made of a rigid material suitable for medical use (such as a titanium alloy). Horn **120** has a reduced diameter section **125** that is connected to a tip interface **115**. Tip interface **115** typically has a threaded connection that accepts tip **110**. In this manner tip **110** is screwed onto horn **120** at tip interface **115**. This provides a rigid connection between tip **110** and horn **120** so that vibration can be transmitted from horn **120** to tip **110**.

[0023] Piezoelectric crystals **130** supply ultrasonic vibrations that drive both the horn **120** and the attached cutting tip **110** during phacoemulsification. Piezoelectric crystals **130** are affixed to horn **120**. Crystals **130** are typically ring shaped, resembling a hollow cylinder and constructed from a plurality of crystal segments. When excited by a signal from console **140**, crystals **130** resonate, producing vibration in horn **120**. Typically, this vibration produces longitudinal movement in tip **110**.

[0024] Console **140** includes a signal generator that produces a signal to drive piezoelectric crystals **130**. Console **140** has a suitable microprocessor, micro-controller, computer, or digital logic controller to control the signal generator. In operation, console **140** produces a signal that drives piezoelectric crystals **130**. Piezoelectric crystals **130**, when excited, cause horn **120** to vibrate. Tip **110**, connected to horn **120**, also vibrates. When tip **110** is inserted into the anterior chamber of the eye and vibrated, it acts to emulsify a cataractous lens.

[0025] FIG. **2** depicts an offset ultrasonic hand piece according to the principles of the present invention. The components of FIG. **2** perform in a similar manner and have similar characteristics as like components in FIG. **1**. In FIG. **2**, tip **210** is offset from piezoelectric crystals **230**. This offset is accomplished by a bend or step in horn **220**. As such, tip center line **260** is offset from crystal center line **270** by a distance "d." This distance can be small to produce a small oscillatory movement of tip **210**, or it can be large to produce a larger oscillatory movement of tip **210**. As such, the distance "d" is proportional to the amount of oscillatory movement seen at tip **210**. Such a configuration causes tip **210** to oscillate or wobble in a side to side or circular fashion. Vibration from piezoelectric crystals **230** is transferred to horn **220** such that tip **210** wobbles or oscillates.

[0026] Tip center line **260** of tip **210** generally passes through the center of gravity of tip **210**. Likewise, crystal center line **270** generally passes through the center of piezoelectric crystals **230**. When piezoelectric crystals **230** are arranged in a ring, crystal center line **270** passes through the center of that ring. Tip center line **260** is generally parallel to crystal center line **270**. However, these two lines need not be parallel. For example, tip center line **260** may be at a small angle with respect to crystal center line **270**. In this manner, tip **210** may extend from tip interface **215** at a slight angle in addition to being offset from piezoelectric crystals **230**.

[0027] FIG. **3** depicts an offset ultrasonic hand piece according to the principles of the present invention. The components of FIG. **3** perform in a similar manner and have similar characteristics as like components in FIG. **1**. In FIG. **3**, tip **310** is offset from piezoelectric crystals **330**. This offset is accomplished by a bend or step in the reduced diameter section **325** of horn **320**. As such, tip center line **360** is offset from crystal center line **370** by a distance "d." This distance can be small to produce a small oscillatory movement of tip **310**, or it can be large to produce a larger oscillatory movement of tip **310**. As such, the distance "d" is proportional to the amount of oscillatory movement seen at tip **310**. Such a configuration causes tip **310** to oscillate or wobble in a side to side or circular fashion. Vibration from piezoelectric crystals **330** is transferred to horn **320** such that tip **310** wobbles or oscillates.

[0028] Tip center line **360** of tip **310** generally passes through the center of gravity of tip **310**. Likewise, crystal center line **370** generally passes through the center of piezoelectric crystals **330**. When piezoelectric crystals **330** are arranged in a ring, crystal center line **370** passes through the center of that ring. Tip center line **360** is generally parallel to crystal center line **370**. However, these two lines need not be parallel. For example, tip center line **360** may be at a small angle with respect to crystal center line **370**. In this manner, tip **30** may extend from tip interface **315** at a slight angle in addition to being offset from piezoelectric crystals **370**.

[0029] From the above, it may be appreciated that the present invention provides an offset ultrasonic hand piece useful for the removal of a cataractous lens. In the present invention, the cutting tip is offset from the piezoelectric crystals that drive the hand piece. Such an offset produces oscillatory movement of the hand piece tip. The present invention is illustrated herein by example, and various modifications may be made by a person of ordinary skill in the art.

[0030] Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. An ultrasonic hand piece comprising:

a horn;

piezoelectric crystals coupled to the horn; and

a cutting tip coupled to the horn;

wherein a centerline of the piezoelectric crystals is offset from a center line of the cutting tip such that oscillatory movement is produced in the cutting tip when the piezoelectric crystals are excited.

2. The hand piece of claim **1** wherein the horn has a reduced diameter segment.

3. The hand piece of claim **2** wherein the reduced diameter segment is bent to produce the offset.

4. The hand piece of claim **1** wherein the horn is bent to produce the offset.

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[标]申请(专利权)人(译)	BOUKHNY MIKHAIL CHON JAMES		
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[标]发明人	BOUKHNY MIKHAIL CHON JAMES		
发明人	BOUKHNY, MIKHAIL CHON, JAMES		
IPC分类号	A61B8/00		
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摘要(译)

超声波手持件具有喇叭，压电晶体和切削尖端。压电晶体和切削尖端连接到喇叭。压电晶体的中心线偏离切削尖端的中心线，使得当压电晶体被激励时在切削尖端中产生振荡运动。