

[54] **SURGICAL TOOL**

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[52] U.S. Cl. **128/305**

[51] Int. Cl. **A61b 17/32, A61f 9/00**

[58] Field of Search 128/24 A, 41, 48, 276,
128/303 R, 304, 305

[56] **References Cited**

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[57] **ABSTRACT**

The probe of a hand held surgical tool includes a surgical tip at the end of a rod which swings through a limited arc in one plane only at a rate of less than about 100 cycles per second. One or more stationary tubes supply fluid to and/or suction fluid from the region of the tip. For eye surgery, the probe may use a globular tip about 1 millimeter in diameter having a small (0.1 mm) lateral or forward cutting projection and/or an abrasive surface. The tool facilitates cataract removal through a small limbal opening, and is useful for other surgical procedures of the eye and other body areas.

18 Claims, 14 Drawing Figures

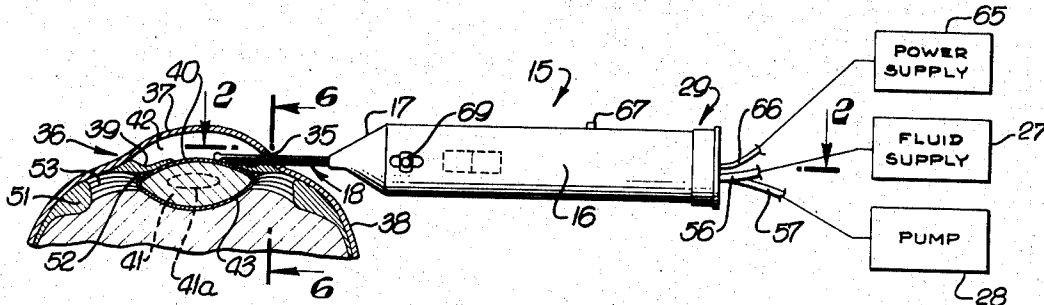


FIG. 1.

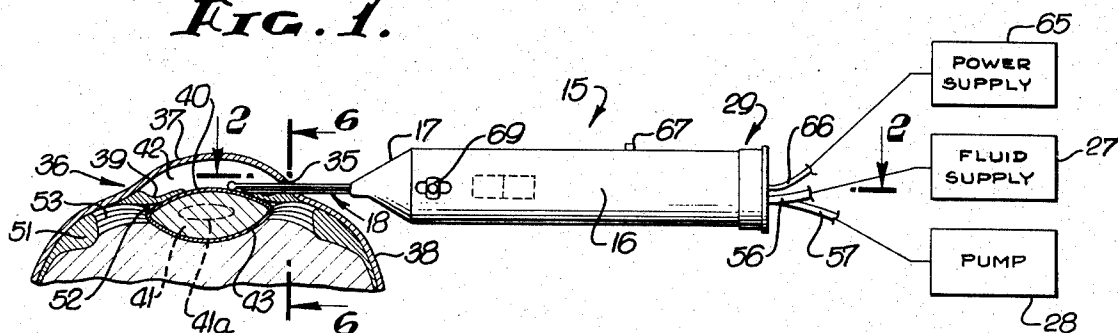


FIG. 2.

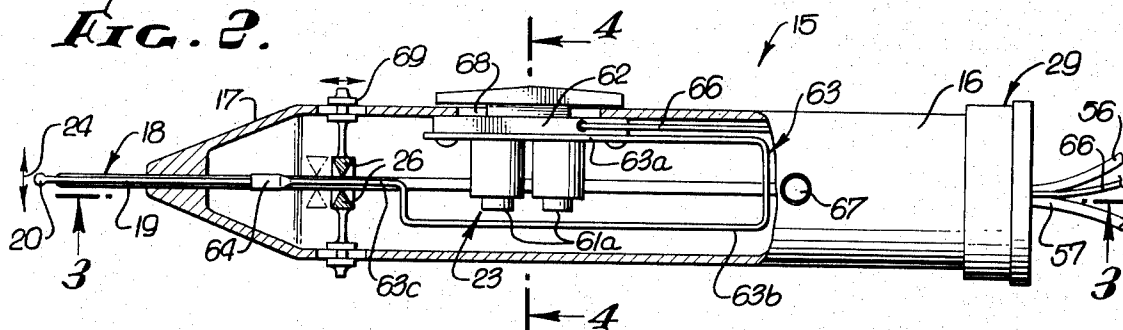


FIG. 3.

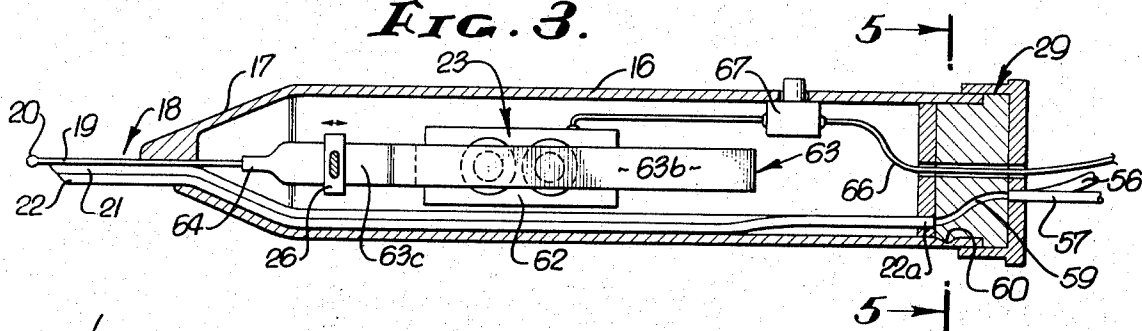


FIG. 4.

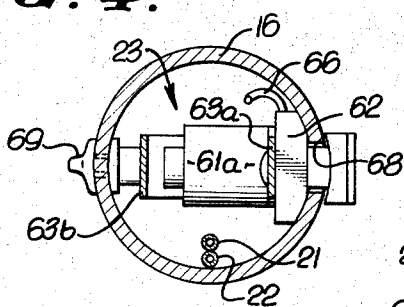


FIG. 5.

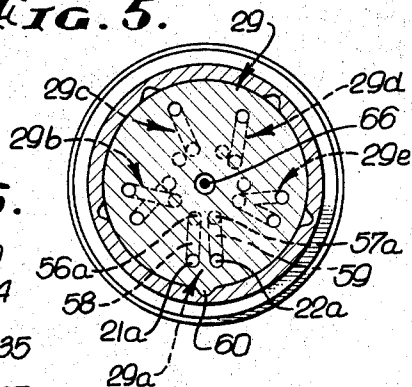


FIG. 6.

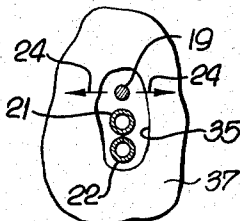


FIG. 7.

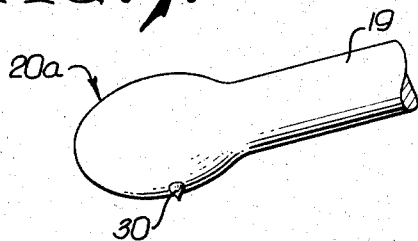


FIG. 9.

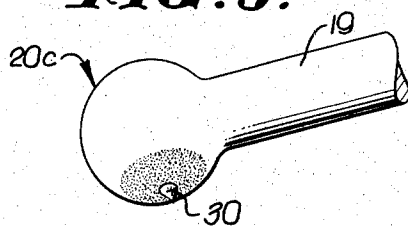


FIG. 8.

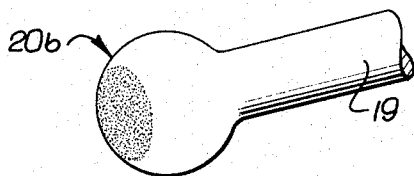


FIG. 10.

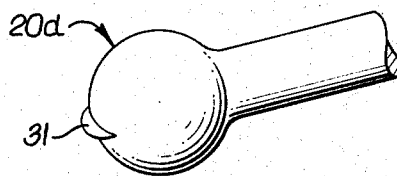


FIG. 11.

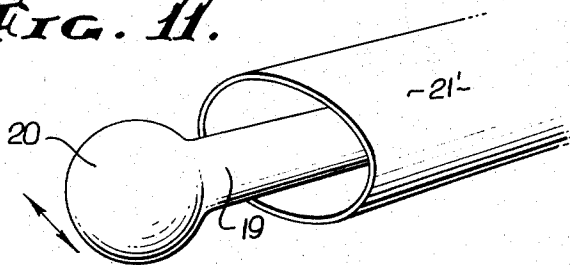


FIG. 12.

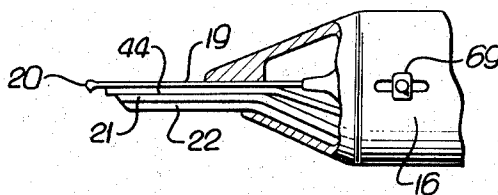


FIG. 13.

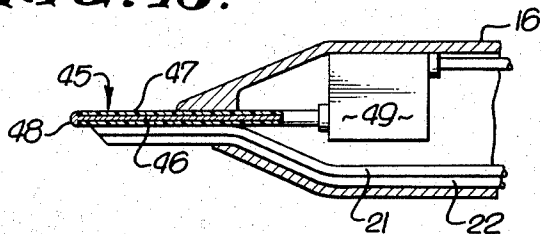
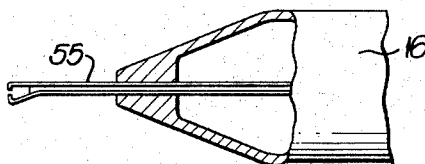


FIG. 14.



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SURGICAL TOOL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a surgical tool having a globular cutting and/or abrasive tip at the end of a rod driven through a limited arc in a single plane.

2. Description of the Prior Art

Cataract surgery is necessitated when the lens of an eye becomes so occluded or opaque as to prevent light entering through the cornea to reach the retina. In conventional intracapsular extraction, a semicircular (150° to 180°) incision is made along the limbus where the cornea joins the opaque sclera of the eye. The entire lens is removed intact through this opening. Alternatively, in extracapsular extraction, a knife and forceps inserted through the large opening are used to sever and remove the anterior lens capsule, the lens material itself, and possibly the posterior capsule. The incision is closed with multiple sutures.

Although a high success rate is associated with such cataract removal procedures, certain complications are not uncommon. Considerable trauma is experienced, and a hospital stay of 4 or more days following the operation is typical. The relatively large knife and forceps may create some difficulty in completely removing all minute lens particles. Fluid loss through the opening may be so great as to cause collapse of the cornea or a flat anterior chamber.

Certain improvements in surgical procedures and tools have been suggested. Two-way syringe-like devices are known wherein eye fluid, possibly containing particles of lens material, is removed through one tube while a sterile isotonic fluid is supplied through a second tube. This maintains the necessary pressure in the anterior aqueous chamber to prevent corneal collapse. A manual tool has been suggested in which such tubes are concentric, the inner tube containing a knife blade rotated within the outer tube to cut lens material extruded or suctioned into the tubes through lateral openings. Such a device, while effective for the removal of relatively soft lens material, is not useful for incising the lens capsule, and may be ineffective in the removal of senile cataracts.

An ultrasonic emulsifier for cataract surgery is described in the U.S. Pat. No. 3,589,363 to Banko and Kelman. That instrument uses a knife-tipped probe reciprocated longitudinally at an ultrasonic rate, typically from 1,000 to 100,000 cycles per second, to break up lens material. Use of the emulsifier is described in "Highlights of Ophthalmology," Volume XIII, No. 1 beginning at page 38. A small limbal incision first is made, and a cystotome, iris forceps and scissors are used to remove a V-shaped section of the anterior capsule. The ultrasonically vibrated knife probe is inserted through this opening into the lens. The rapid reciprocation acts like a miniature jack hammer to break up and emulsify lens cortex and nucleus material, which is suctioned out by a tube surrounding the tip. A second tube supplies fluid to replace that removed and maintain the necessary chamber pressure.

An object of the present invention is to provide an improved cataract removal tool requiring a single small opening to the eye, which facilitates the cutting and removal of both capsule and lens material, and which may be used without the traumatic effects associated

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with prior art large opening and ultrasonic emulsification techniques. In addition to cataract removal, the inventive tool is useful for other surgical procedures both of the eye and of other body areas.

SUMMARY OF THE INVENTION

The foregoing and other objectives are achieved by providing a hand held surgical tool having a probe which is driven back and forth through a limited arc in a single plane at a selectable rate of between 0 and about 100 cycles per second. For eye surgery, the probe may comprise a rod having a diameter of 0.5 millimeter and a globular tip about 1 millimeter in diameter. The tip may include a lateral or forward cutting projection extending about 0.1 millimeter from the globe, which itself may be smooth or abrasive. The probe may include one or more tubes for communicating fluid to and/or suctioning fluid from the region of the tip. In other embodiments, the tool may include a freezing or heating tip, a fiber optic light guide, and/or a forceps tip.

BRIEF DESCRIPTION OF THE DRAWINGS

A detailed description of the invention will be made with reference to the accompanying drawings wherein like numerals designate corresponding elements in the several figures.

FIG. 1 is a pictorial view of the inventive surgical tool with the probe operatively positioned in the anterior aqueous chamber of an eye (shown in section).

FIG. 2 is a longitudinal sectional view of the surgical tool, as seen along the line 2—2 of FIG. 1.

FIG. 3 is a longitudinal sectional view of the same surgical tool in a plane perpendicular to FIG. 2, as viewed along the line 3—3 thereof.

FIGS. 4 and 5 are transverse sectional views of the surgical tool, as viewed along the lines 4—4 and 5—5 of FIGS. 2 and 3 respectively. FIG. 5 showing the fluid distribution control.

FIG. 6 is a sectional view of the surgical tool probe extending through a corneal opening, as seen along the line 6—6 of FIG. 1.

FIGS. 7 through 10 are greatly enlarged perspective views of alternative probe tips for the tool of FIG. 1.

FIG. 11 is a greatly enlarged perspective view of a surgical tool embodiment wherein the probe rod extends through a fluid communicating tube.

FIGS. 12, 13 and 14 are fragmentary perspective views, partly in section, of surgical tool embodiments incorporating respectively a fiber optic light guide, a freezing tip and a forceps.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following detailed description is of the best presently contemplated modes of carrying out the invention. This description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention since the scope of the invention best is defined by the appended claims.

Operational characteristics attributed to forms of the invention first described shall also be attributed to forms later described, unless such characteristics are obviously inapplicable or unless specific exception is made.

Referring now to the drawings, the surgical tool 15 includes a generally cylindrical handle 16 having a conical end 17. Projecting from the end 17 is a probe 18 which, in the embodiment of FIGS. 1 through 6, includes a rod 19 having a generally globular surgical tip 20, and a pair of fluid communicating tubes 21, 22. Contained within the handle 16 is a mechanism 23, described below, for imparting an arcuate or swinging motion to the rod 19 and tip 20 in a plane (see the arrows 24 in FIGS. 2 and 6) not including the tubes 21, 22. The extent of arcuate motion is limited, as by an adjustable stop 26. Each stationary tube 21, 22 may deliver fluid from a supply 27 or may suction fluid from the region of the tip 20 in cooperation with a pump 28. A distributor 29 on the handle 16 controls such fluid delivery and suction.

For eye surgery the rod 19 may have a length of about 18 millimeter and a diameter of about 0.5 millimeters. The surgical tip 20 may be ellipsoidal or spherical with a maximum dimension of about 1 millimeter. In the embodiment of FIG. 7, useful for cutting the anterior lens capsule, the tip 20a is generally ellipsoidal and has a pointed or knife edged projection 30 extending laterally about 0.1 millimeters. The globular tip 20b may have an abrasive surface with no cutting projection (FIG. 8) or a lateral cutting projection 30 may be combined with an abrasive surface as in the tip 20c of FIG. 9. In FIG. 10, a generally crescent shaped cutting projection 31 extends from the forward end of the surgical tip 20d. The rod 19 may be situated within a fluid flow tube 21' (FIG. 11) having a diameter sufficient for the rod 19 to swing through a desired arc.

Use of the surgical tool 15 for cataract removal is illustrated in FIG. 1. Initially a small limbal opening 35 (typically less than 3 millimeters diameter) is made in the eye 36 where the cornea 37 joins the sclera 38. The probe 18 is inserted through the opening 35 in a plane generally parallel to the iris 39. The mechanism 23 is energized to swing the probe 19 back and forth through an arc of less than about 3 millimeters, preferably at a selected rate of from 0 to about 100 cycles per second.

Using the surgical tip 20a (FIG. 7), multiple small incisions are made in the anterior capsule 40 of the lens 41. Alternatively, the roughened tip 20b or 20c may be used to macerate the capsule 40. The distributor 29 is adjusted to suction fluid from the region of the tip 20 via one of the tubes 21, 22 and to supply an appropriate sterile isotonic fluid to the same region via the other tube 21, 22. As small particles of the capsule 40 material are cut away or macerate, they are suctioned or aspirated from the eye 36 via the tool 15. The supplied fluid replaces that removed, insuring a substantially constant pressure within the anterior chamber 42 to prevent collapse of the cornea 37.

With part of the capsule 40 cut away, the probe 18 is inserted within the lens and used to break up and remove occluded cortex 41 and/or nucleus 41a material. The tool 15 then may be used to cut and remove the posterior lens capsule 43. Particles, if any, too large to be suctioned through the tube 21 or 22 may escape or be withdrawn through the opening 35. If a different surgical tip 20 is desired, the probe 18 may be removed from the eye 36, a new tip substituted, and the instrument reinserted to continue the operation. When all lens material has been removed, the probe 18 is withdrawn and a single suture used to close the opening 35.

An entire senile cataract can be removed with the surgical tool 15 in less than about 15 minutes. There is little trauma and a very short recovery period.

The surgical tool 15 is useful for other types of eye surgery. Thus an iridotomy may be performed using any of the surgical tips 20a, 20b, 20c or 20d to form small holes in the iris 39. The iridotomy may be combined with a cataract procedure making a separate iridectomy unnecessary. Using the surgical tool 15 for iridencleisis, the probe 18 is used to make small openings through the sclera 38 from inside the iris angle (trabecular meshwork) to permit material of the iris 39 to escape. Such procedures are useful to drain or relieve excess internal pressure in the treatment of congenital or acquired glaucoma. The tool 15 may be used for vitreous surgery and for treatment of flat chambers. Since the tips 20a - 20d are dull and rounded, the chance of inadvertent damage to eye tissue is minimal.

Other forms of the probe 18 increase the versatility of the surgical tool 15. For example (FIG. 11) a fiber optic light guide 44 may be used to illuminate the operative area at the surgical tip 20. A freezing probe 45 (FIG. 13) may be incorporated either instead of or in addition to the rod 19. Such a freezing probe 45 may comprise a metal rod 46 having an insulative sheathing 47 and communicating between a freezing tip 48 and a reservoir 49 containing freon or other liquid at an appropriate cryogenic temperature. The probe 45 is useful for freezing tumors or cysts. Tumors of the iris 39 or ciliary body 51 (FIG. 1) may be reached interiorly of the eye 36, via the anterior chamber 42 or the posterior chamber 52, to be frozen by the tip 48. The freezing tip 48 or a heating tip (not shown) may be used to affect the ciliary body production of aqueous in the treatment or control of glaucoma by direct application from inside the anterior chamber 42.

Alternatively, the freezing tip 48 or heating tip may be used to cauterize blood vessels, as in the zonular region 53. A forceps tip 55 (FIG. 14) is useful for removing sections of eye tissue too large to be aspirated via the tube 21 or 22.

Details of the fluid distributor control 29 are shown in FIGS. 2 and 5. The tubes 21, 22 extend through the handle 16 to terminations 21a, 22a opening into the distributor 29. The fluid supply 27 and the pump 28 respectively are connected to the handle 16 via a pair of flexible tubes 56, 57 leading to distributor openings 56a, 57a. The distributor control 29 is rotatable relative to the handle 16 and has five sets of channels for selectively connecting the tubes 21, 22 to the tubes 56, 57.

With the distributor 29 set to the position 29a (FIG. 5), the tube 21 communicates via the termination 21a, the channel 58 and the opening 56a to the supply tube 56. Similarly, the tube 22 is connected via the distributor channel 59 to the suction tube 57. Accordingly, fluid from the supply 27 is supplied to the region of the tip 18 via the tube 21, and fluid is suctioned via the tube 22 to the pump 28.

In the position 29b, the distributor 29 interchanges the supply and suction lines so that fluid is supplied via the tube 22 and pumped via the tube 21. In the positions 29c, 29d and 29e the pump 29 is connected to neither tube 21, 22 so that no suctioning takes place. However, fluid is delivered respectively via the tube 21, the tube 22, or both tubes 21 and 22. An appropriate de-

tent 60 maintains the distributor control 29 at the selected position.

In the embodiment of FIGS. 2 through 4, a simple electromagnetic vibrator 23 imparts swinging motion to the rod 19. Thus the mechanism 23 includes an electromagnet 61 mounted within the handle 16 by a support 62 of plastic or like insulating material. One leg 63a of a generally U-shaped flat metal strip 63 also is mounted to the support 62. The other leg 63b is spaced from the pole pieces 61a so as to be attracted by the electromagnet 61. The free end 63c of the strip 63 is situated along the longitudinal axis of the handle 16 and terminates at a fitting 64 which releasably retains the rod 19. The strip section 63c extends between the arc limiting stops 26.

The electromagnet 35 is energized by a signal from a power supply 65 supplied via a cable 66. The signal may comprise voltage pulses supplied at a rate adjusted by a control 67 in the handle 16. Each pulse energizes the magnet 61 so as to attract the metal section 63b and cause the rod 19 to move upward as viewed in FIG. 2. When the pulse terminates, the magnet 61 is deenergized and the resiliency of the member 63 causes the section 63b to swing away from the pole pieces 61a, carrying the rod 19 downward (FIG. 2). The stops 26 limit the extent of arcuate travel of the tip 20. Typically, the pulse rate may be selected so that the rod 19 swings back and forth at a rate in the range of from 0 to about 100 cycles per second.

An electrical contact (not shown) may be provided in circuit with the magnet 61 to be opened and closed as the member 63b vibrates. The member 63b thus may interrupt a dc voltage supplied via the line 66 to the magnet 61. The magnitude of the voltage could be adjusted by the control 67 to affect the swing rate of the rod 19. In other embodiments (not shown), the mechanism 23 might be replaced by a spring wound vibrator, by a small motor powered by batteries within the handle 16 itself, or by other well known devices for imparting arcuate motion.

The member 62 may slide longitudinally within a slot 68 (FIG. 2) in the handle 16. Since the member 62 carries the strip 63, longitudinal movement of the member 62 will adjust the position of the leg 63c relative to the stops 26, and thereby control the arc of the rod 19. Alternatively, the stops 26 may be positionable separately by means of a finger control member 69. The tubes 21, 22 might be coiled around the mechanism 23 so that the fluid flowing through the tubes will cool the mechanism. Foot controls (not shown) may be provided to control the rod 19 swing rate and/or adjust the fluid flow and suction rates through the stationary tubes 21 and 22.

The tool 15 is by no means limited to use in eye surgery, but is equally useful in other applications where tissue is to be sectioned, incised, frozen or cauterized in any accessible body cavity or subcutaneous location. The tool 15 is useful for biopsies and eviscerations, and may be utilized in the oral cavity, in nasal passages (as to remove nasal polyps), in vaginal or uterine cavities or elsewhere. The tool may be used for obtaining and/or implanting cell groups for transplants such as pancreatic islets. With the application of a voltage to the rod 19 together with axial rotation of the handle 16, the tool 15 may be used for acupuncture type breakdown of sensory nerve "pain pathways." For such applica-

tions, the probe dimensions may differ from those described above for ophthalmological surgery.

Intending to claim all novel, useful and unobvious features shown or described, I make the following claims:

1. A surgical tool for ophthalmological surgery comprising:

an elongated tubular handpiece,

a probe extending from one end of said handpiece, said probe having a globular surgical tip with a maximum diameter of less than about 1.5 millimeters,

means mounted in said handpiece for imparting only swinging motion to said probe through a limited arc in one plane only, at a rate of swinging of less than about 100 cycles per second, and

at least one fluid flow tube extending from said handpiece end generally parallel to said probe but spaced from said plane for communicating fluid to or from the region of said tip.

2. A surgical tool according to claim 1 wherein said surgical tip includes a lateral cutting projection which protrudes less than about 0.2 millimeter.

3. A surgical tool according to claim 1 wherein said globular tip includes a forward cutting projection which protrudes less than about 0.2 millimeter.

4. A surgical tool according to claim 1 wherein said probe extends from said handpiece less than about 25 millimeters, wherein said probe diameter is less than about 1 millimeter, wherein said tube is less than about 2 millimeters in diameter, and wherein said arc is limited to a maximum tip excursion of less than about 3 millimeters.

5. A surgical tool according to claim 4 further comprising means, in said handpiece, for selectively adjusting the limits of said arc.

6. A surgical tool according to claim 1 and having two fluid flow tubes extending from said handpiece, together with means for selectively supplying fluid via one or both of said tubes and means for suctioning fluid from the region of said tip via one of said tubes.

7. A surgical tool according to claim 6 together with control means for selectively interconnecting said tubes and said means for supplying and suctioning.

8. A surgical tool according to claim 1 wherein said tube surrounds said probe and is of sufficient diameter to permit said probe to swing through said limited arc within said surrounding tube.

9. A surgical tool according to claim 1 wherein said probe is detachable from said means for imparting said swinging motion.

10. A surgical tool according to claim 1 together with fiber optic means for guiding light to the region of said tip.

11. A surgical tool according to claim 1 wherein said means for imparting said swinging motion comprises: a lever arm extending through a portion of said, handpiece and

electromagnetic means for periodically attracting said arm toward one side of said handpiece, said arm thereafter resiliently returning toward the other side of said handpiece, such action imparting said swinging motion to said probe.

12. A hand held tool for ophthalmological surgery comprising:
a handpiece,

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probe means extending from an end of said handpiece and consisting of a probe having a surgical tip,

means mounted in said handpiece for swinging said probe through a limited arc at a rate less than about 100 cycles per second, the probe being prevented from longitudinal motion in a direction parallel to the handpiece, the surgical tip of said probe being globular and having a maximum diameter of less than about 1.5 millimeters, said probe extending from said handpiece less than about 25 millimeters and having a diameter less than about 1 millimeter, said arc being limited to a maximum tip excursion of less than about 3 millimeters, and

means, in said handpiece, for selectively adjusting the limits of said arc.

13. A surgical tool according to claim 12 further comprising:

a pair of tubes extending from said handpiece generally parallel to said probe, together with means for supplying fluid, means for suctioning fluid, and dis-

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tributor control means in said handpiece for selectively interconnecting said tubes and said means for supplying and suctioning.

14. A surgical tool according to claim 12 further comprising a light guide extending beside said probe from said handpiece to the vicinity of said surgical tip.

15. A surgical tool according to claim 12 wherein said surgical tip is globular and includes a lateral cutting projection.

16. A surgical tool according to claim 12 wherein said surgical tip is globular, at least a portion of the surface of said globular surgical tip being abrasive.

17. A surgical tool according to claim 12 wherein said surgical tip is globular and includes a forward cutting projection.

18. A surgical tool according to claim 1 wherein said globular surgical tip includes an abrasive surface region.

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