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[54] **ELECTRONICALLY POWERED KNIFE**

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[51] **Int. Cl.** **B26b 7/00**

[58] **Field of Search** .... 30/272, DIG. 1, 45; 310/28, 29, 30, 34; 128/303.14, 305

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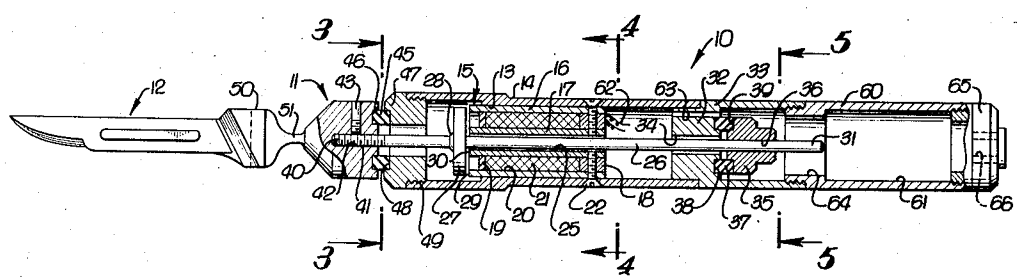
Assistant Examiner—J. C. Peters

[57] **ABSTRACT**

A single blade electronically powered knife has a cylindrical case in which is located a solenoid having a centrally mounted longitudinally oscillating rod. The inner end of the rod is slidably retained in a bearing which has a resilient isolation mounting within the case. On the outer end of the rod is secured a mounting block which carries the knife blade and the mounting block is isolated from the case by a resilient bearing. An electric power source acting through an electronic circuit housed in the case causes the solenoid to reciprocate the mounting block in a longitudinal direction and impart sinusoidal elastic longitudinal wave energy to the knife blade which translates into a cutting and parting knife blade action.

11 Claims, 10 Drawing Figures



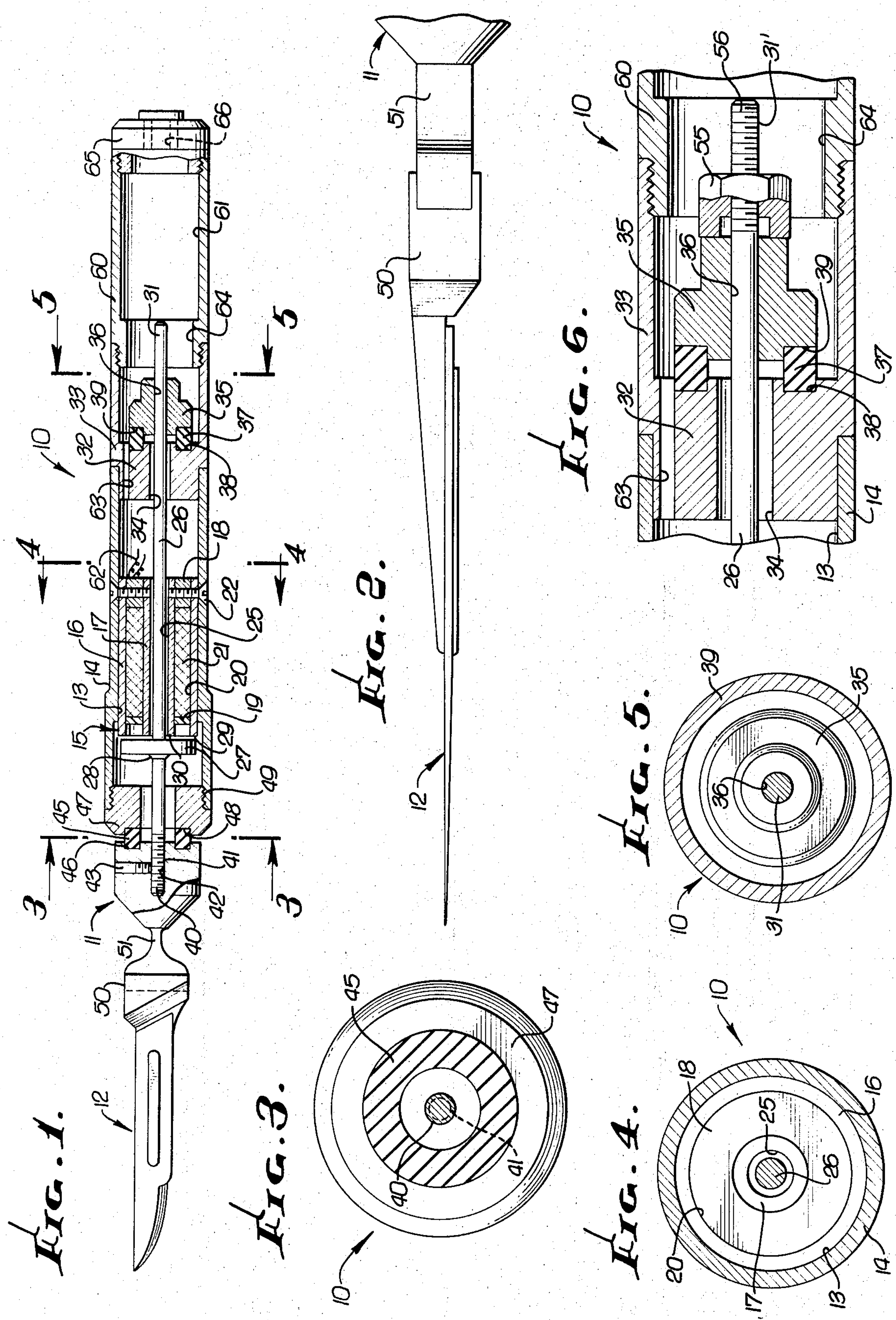


FIG. 1.
FIG. 2.
FIG. 3.
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FIG. 6.

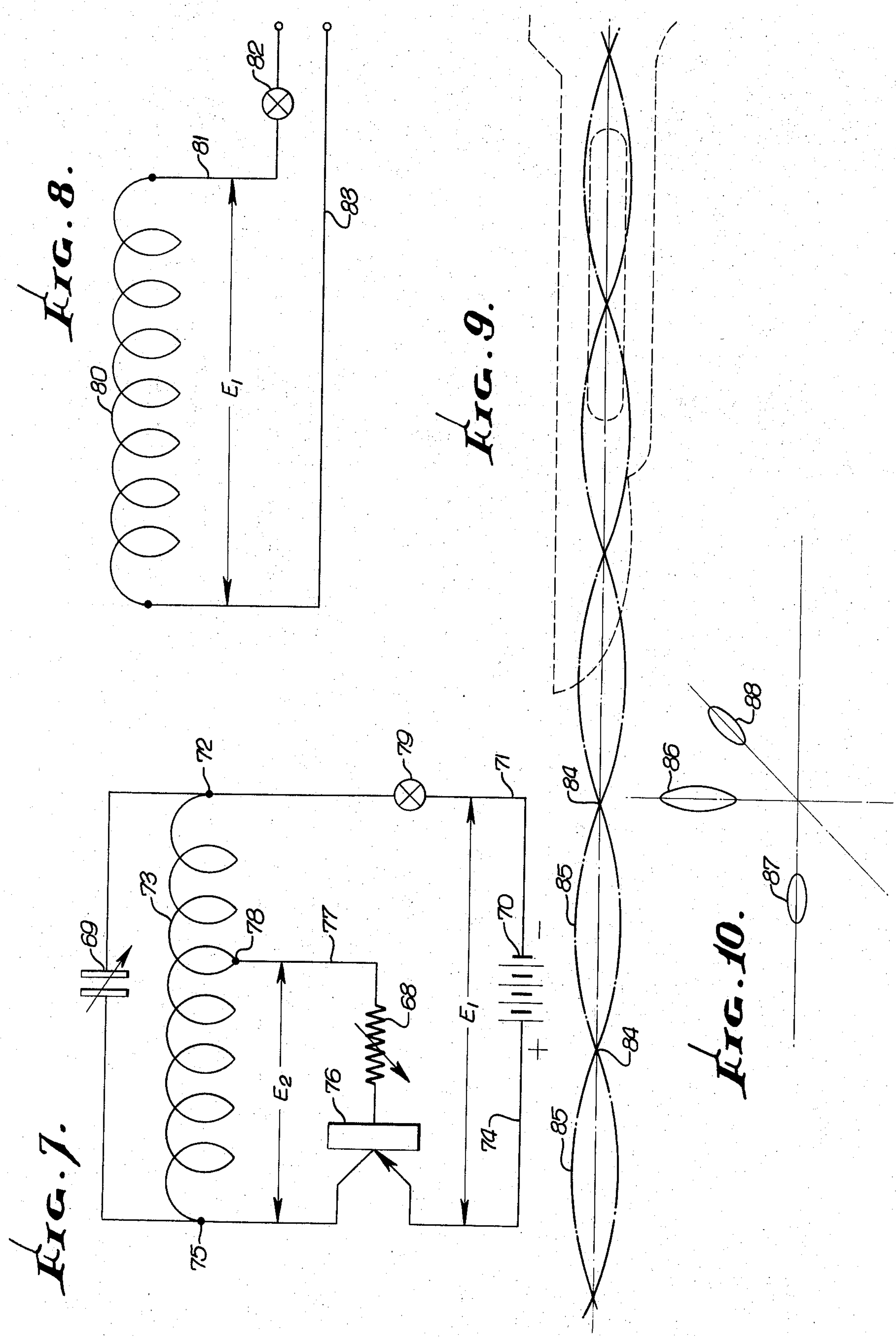

FIG. 7.

FIG. 8.

FIG. 9.

FIG. 10.

ELECTRONICALLY POWERED KNIFE

SPECIFICATION

Electrically powered knives heretofore available have invariably consisted of two blades mounted side by side in a handle with one or both blades so manipulated that they reciprocate longitudinally with respect to each other and produce a sawing action the nature of which is similar to that of clippers. Such blades have the disadvantage of always needing to be removed from the handle after use in order to be cleaned separately and thereafter reinserted in the handle when they are to be used again. Electric knives of this description have been relatively large knives suited mainly for carving meats and cutting bread. Although single blade knives have been employed for cutting multiple layers of textiles in the garment industry, such commercial type knives all need special accessories and special handling in order to be useful.

Heretofore there has been little or no interest in making use of electric or electronically powered knives for extremely fine and precise cutting such as may be required, for example, in surgery. Surgical knives currently in use, commonly known as scalpels, both large and small, are hand manipulated single blades in one or another of the great many forms, often involving detachable blades on a special handle for specific applications. Such blades generally have microscopic saw type teeth machined into the cutting edge of the blade. Incisions and cutting are performed by oscillating the blade in a motion which is in line with the center line of the blade. For extremely precise work disadvantages attend blades of this kind as for example there is invariably some indentation of the skin or tissue during the cutting process which is undesirable, such being particularly noticable in delicate operations involving plastic surgery, eye operations, nerve operations and such operations where delicate tissues are involved. Since the scalpel is used in a slow back and forth motion the tissue to be cut is minutely shreaded and this is undesirable. Further still, the scalpel blade in itself has no parting action, that is to say parting the tissues on opposite sides of the incision, and this being necessary, it is done by hand manipulation dependent on the skill of the surgeon.

It is therefore among the objects of the invention to provide a new and improved single blade electrically powered knife which may, if desired, be permanently mounted in the handle, and which is essentially easy to clean or sterilize.

Another object of the invention is to provide a new and improved electrically powered single blade knife which can be self contained with the power supply compactly housed in a small handle and which is capable of making an extremely precise incision virtually without indentation of the material to be cut and which is gently parted during the cutting operation by action of the knife blade itself.

Still another object of the invention is to provide a new and improved single blade electronically powered knife, capable of being constructed in any one of a number of different sizes and which is suitable for precise cutting operations such as those encountered in surgery.

Still further among the objects of the invention is to provide a new and improved single blade electronically powered knife which is simple, positive and compact to the extent that a serviceable cutting tool of high precision cutting ability can be made and assembled without the use of complicated technique and which requires virtually a negligible amount of service, the device moreover being such that it can be powered either by a battery contained in the knife handle or by an extension to a conventional power supply.

With these and other objects in view, the invention consists of the construction, arrangement, and combination of the various parts of the device, whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

FIG. **1** is a longitudinal sectional view of the electronically powered assembly complete with blade.

FIG. **2** is a fragmentary plan view of the blade and the mounting.

FIG. **3** is a cross-sectional view on the line **3—3** of FIG. **1.**

FIG. **4** is a cross-sectional view on the line **4—4** of FIG. **1.**

FIG. **5** is a cross-sectional view on the line **5—5** of FIG. **1.**

FIG. **6** is a fragmentary longitudinal sectional view of a second form of internal construction of the device.

FIG. **7** is a wiring diagram of a D.C. power source usable with the device.

FIG. **8** is a wiring diagram for an A.C. power source.

FIG. **9** is a schematic view of a sinusoidal elastic longitudinal wave motion within the solid material of the rod, the blade and blade mounting.

FIG. **10** is a schematic view of ellipsoid force motions of the blade when activated.

In an embodiment of the invention chosen for the purpose of illustration there is shown a drive assembly indicated generally by the reference character **10** at one end of which is a blade mount **11** which carries a blade **12.** The blade **12** may be any one of a number of different blade types depending upon the size and power of the drive assembly, the blade illustrated being a scalpel. The action imparted to the blade will, however, be the same whether it chances to be a scalpel, a utility knife, a carving blade, or other comparable single blade knife or chisel.

Located within a chamber **13** of a case **14** is a solenoid **15.** The solenoid is constructed with a cylindrical outer jacket **16** of magnetic material and an inner sleeve **17** of magnetic material spaced apart at one end by use of an annular spacer block **18** of magnetic material and at the other end by use of a washer **19** of non-magnetic material. The structure thus defined forms an annular space **20** substantially occupied by a coil **21.** Screws **22** extending through the case into the solenoid hold it in position where it has a snug sliding fit within the chamber **13.**

The sleeve **17** provides a central bore **25** through which extends a relatively long rod **26,** the rod being of non-magnetic material as for example, stainless steel. A clapper **27** which is of magnetic material is anchored to the rod **26** by an appropriate weldment **28,** the clapper extending transversely over adjacent annular edges **29** and **30** respectively of the jacket **16** and sleeve **17.**

To properly support an inside end **31** of the rod **26** use is made of an annular inner section **32** of a tubular joint **33,** therebeing a bore **34** through the inner section which amply accommodates the rod **26.** A bearing **35** of non-magnetic material is provided with a central bore **36** forming a snug and freely sliding fit for the rod **26.** An annular resilient spring isolation mount **37** is bonded to the intersection **32** in a recess **38.** The isolation mount **37** is likewise bonded to the bearing **35** in a recess **39.**

The opposite outer end **40** of the shaft **26** is provided with threads **41** which threadedly engage a recess **42** thereby to secure the blade mount **11** in threaded engagement with the outer end of the rod. Once in proper adjustment the set screw **43** anchors the parts together. Separating the blade mount **11** from the case **14** is an annular resilient spring isolation bearing **45.** The isolation bearing is bonded to the blade mount in a recess **46** and bonded to a plug **47** in a recess **48.** The plug, as shown, has a threaded engagement **49** in the adjacent end of the case **14.** In the chosen embodiment there is at the base of the knife blade **12** a mass from which the blade extends, the mass being connected to the blade mount **11** by a neck **51** of substantially rectangular cross-sectional configuration, the long dimension being transverse to the flat dimension of the knife blade and the short dimension being **90** degrees removed.

For varying the amplitude of endwise motion of the rod **26** the blade mount **11** can be adjusted with respect to the outside end **40** of the rod whereby to change the spacing of the clapper **27** from the adjacent edges **29** and **30** of the solenoid.

The form of device of FIG. **6** shows another adjustment embodied in a lock nut **55** engaging threads **56** at the inner end **31'** of the rod **26.** By making use of the lock nut **55** adjustment of pressure on both the isolation mount **37** and the spring isolation bearing **45** are made use of in an opposing manner to alter the resonant frequency, depending on the direction of adjustment.

When the drive assembly is to be self contained an annular housing **60** providing a chamber **61** may be attached to the adjacent end of the case **10.** The chamber **61** provides room for electric circuitry and may be made large enough to contain an appropriate conventional battery. A wire **62** from the solenoid **15** passes through a wire channel **63** thence through a passage **64** into the chamber **61.** A cap **65** closes the outside end of the chamber and when electrical energy is to be supplied by an outside source the cap is provided with an opening **66** through which wires from the power supply may pass.

A D.C. power circuit is shown in FIG. **7** supplied by a battery **70** from which a negative lead **71** is connected to a tap **72** at one end of a coil **73** and a positive lead **74** is connected to a tap **75** at the opposite end of the coil **73.** A transistor oscillator **76** connects to the positive lead **74** and from it a lead **77** connects to an intermediate coil tap **78** to provide a trigger voltage, there being a resistor **68** in the line. A switch **79** in the negative lead is made use of to start and stop the operation. In the oscillator circuit is a capacitor **69** connected across the coil **73** to form a tank circuit.

When an A.C. power supply is to be made use of there is provided an A.C. coil **80** accommodating a push-pull solenoid, the coil being supplied by one lead **81** in which is a start/stop switch **82.** A second lead **83** supplies the opposite end of the coil **80.**

When, for example, the D.C. circuit is used for operation of the device, the switch **79** is activated causing a magnetic field to be set up in the solenoid **15** through the outer jacket **16,** the inner jacket **17,** the spacer block **18** and the clapper **27.** This causes the clapper to be attracted toward the solenoid imparting a corresponding endwise motion to the rod **26** in a direction from left to right as viewed in FIG. **1.** When the excitation is momentarily released, the attraction of the clapper **27** is likewise momentarily released and the reversal of current in the coil effects an opposite endwise motion in the rod **26** in a direction from right to left as viewed in FIG. **1.** These reversals of motion occur at a specified frequency depending upon the design of the device. Acting in the manner described a sinusoidal elastic longitudinal wave energy pattern is generated represented by the nodal points **89** and anti-nodal points **85** in FIG. **9.** This wave pattern exists in the rod **26** and is conveyed by the rod to the blade mount **11** and mass **50** to the blade **12** where a comparable wave pattern is set up. The result of this wave pattern is the ellipsoid force motions schematically shown in FIG. **10,** there being an ellipsoid motion **86** in a direction toward and away from the cutting edge of the blade, an ellipsoid motion **87** in a direction transverse to the cutting edge of the blade and an ellipsoid motion **88** diagonal with respect thereto. The motion in the direction in alignment with the cutting edge of the blade promotes the cutting force and the motion **87** in a direction transverse to the cutting edge causes a parting motion in whatever the material may be which is being cut.

When the electronically powered knife is to be made in a size suited to surgery, where the knife is comparable to that of the conventional scalpel, a low energy source employing a small D.C. 9 to 12 volt battery is found acceptable. The blade **12,** the rod **26,** the blade mount **11** and mass **50,** comprise a spring mass system which is excited into an oscillating motion in line with the blade structure by means of the solenoid and its associated circuitry. The sinusoidal frequency of the oscillation represents the natural frequency of the structure and its spring mass system which is always in phase with the electronic sinusoidal frequency of the system. The nodal natural frequency of the structure may be conveniently chosen by design for a specific value over a range from 300 to 1,000 cycles per second.

The back and forth, sinusoidal oscillation, frequency of the spring mass longitudinal structure which is excited by the solenoid oscillator in turn excites the free longitudinal rod and blade into their own natural frequency which transmits throughout the extremity and including the blade itself, thus to create an elastic longitudinal sinusoidal wave motion within the metallic structure material and which corresponds to the natural frequency.

A structure which is excited into its own natural frequency releases force motion ellipsoid patterns in three planes as made reference to in connection with FIG. **10,** this being a significant feature of the invention. For example, the sinusoidal longitudinal wave energy which travels and is released to the blade causes the blade to release ellipsoid wave energy motions within its own structure and of minute motional extent in the three planes indicated.

The oscillating motion of the blade causes high speed delicate cutting without causing indentation of the tissue or material to be cut, the transverse ellipsoid force motion of the blade creating its own minute parting action during incision.

Depending on the ultimate use to be made of the device an acceptable operating frequency range can be set up between 60 and 1,000 cycles per second. A typical D.C. circuit can be made to operate satisfactorily on either a 6 volt or 12 volt D.C. battery applied across the D.C. coil.

In the setup described for D.C. operation, the feedback voltage of the coil **73** causes the cricuit to go into oscillation at a frequency determined by the resonant frequency of the rod, blade mount and blade assembly which is in effect a free-free spring mass system. It is therefore a self excited oscillator. The oscillator circuit will automatically follow one of the nodes of natural frequency of the rod and blade assembly and its inherent spring mass structure by means of its own feedback nature.

The design of the coil is matched specifically to the characteristics of the oscillator circuit and to the resonant, frequency structure. The resonant frequency of the electrical circuit therefore is in resonance and in phase with the natural frequency of the mechanical structure. The total or combined electromechanical system therefore flows into electromechanical resonance thus only utilizing a minimum amount of power which is a significant aspect of the invention and work to be accomplished. The frequency generated is therefore the natural frequency of the circuit and is the frequency at which it will oscillate and in phase with the natural and resonant frequency of the rod and blade assembly which comprises the spring mass structure.

When an A.C. coil like the A.C. coil **80** is made use of on a 110 volt 60 cycle power supply the resonant rod and blade assembly is designed for a fixed frequency of 60 cycles per second. The resonant rod and blade assembly in such a design is designed for one of its modes of natural frequency which is excited by the fundamental frequency of 60 cycles per second. A desirable structure frequency in this case has been found to be within one of the modes of natural frequency by design, which may be chosen within an acceptable range of from 120 to 300 cycles per second.

While the invention has herein been shown and described in what is conceived to be a practical and effective embodiment, it is recognized that departures may be made therefrom within the scope of the invention.

Having described the invention, what is claimed as new in support of Letters Patent is:

1. A drive assembly for a single blade electronically powered knife, said drive assembly comprising: a case, longitudinally oscillatable rod extending into the case, a blade mount anchored to an outside end of the rod, a transversely and longitudinally acting resilient isolation means secured between said blade mount, said rod and the case, whereby to inhibit direct contact, and a sinusoidally oscillating electric power source acting between the case and the rod, which, when energized, imparts to the rod and to the blade mount a sinusoidal elastic longitudinal wave motion whereby to set up a sinusoidal elastic wave motion in the blade.

2. A drive assembly as in claim **1** wherein there is a blade on the blade mount, said blade having flat sides and a longitudinally extending cutting edge intermediate said sides, and a spring mass structure comprising the combination of blade, blade mount, and rod, said spring mass structure having an oscillation rate at or near resonant frequency and in phase with said power source.

3. A drive assembly as in claim **1** wherein the power source is a solenoid having a central bore therethrough and the rod extends through said central bore.

4. A drive assembly as in claim **3** wherein there is a transversely mounted clapper of magnetic material attached to the rod at a location adjacent to and spaced from one end of the solenoid forming part of a magnetic path through the solenoid when the solenoid is energized.

5. A drive assembly as in claim **4** wherein there is a means acting between the rod and the blade mount to adjust the distance between the clapper and the blade mount whereby to vary the amplitude of the sinusoidal motion.

6. A drive assembly as in claim **1** wherein there is a bearing block in the case having a bearing bore therethrough reciprocatably receiving the end of the rod which is in the case, there being a transversely and longitudinally acting resilient isolation mount secured between the bearing and the case.

7. A drive assembly as in claim **6** wherein there is a lock nut in engagement with the bearing block and in threaded engagement with the the rod end which is in the case whereby to selectively set the assembly at a different resonant frequency.

8. A drive assembly for a single blade electronically powered knife, said drive assembly comprising: a case, a longitudinally oscillatable rod extending into the case, a blade mount anchored to an outside end of the rod, a resilient isolation bearing secured between the blade mount and the case, and a sinusoidally oscillating electric power source acting between the case and the rod which when energized, imparts to the rod and to the blade mount a sinusoidal elastic longitudinal wave motion whereby to set up a sinusoidal elastic wave motion in the blade, the power source being a solenoid having a central bore therethrough and the rod having a position extending through said central bore, the power source being a D.C. battery driven circuit comprising a coil for the solenoid, and a transistor oscillator having leads connected respectively to opposite ends of the coil and to the coil at an intermediate location, whereby to periodically pulse said solenoid.

9. A drive assembly as in claim **8** wherein the frequency is between about 300 and 1,000 cycles per second.

10. A drive assembly as in claim **3** wherein the power source is an A.C. push pull coil for the solenoid in communication with an A.C. electric power source operating at a per second cycle rate of between about 60 and 1,000 cycles per second.

11. A drive assembly as in claim **2** wherein there is a neck of rectangular cross sectional shape forming an interconnection between the blade mount and the blade, the long axis of said neck lying in a direction transverse to the flat sides of the blade.

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