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.
ELECTRONICALLYPOWEREDKNIFESPECIFICATION

Electricallypoweredknivesheretoforeavailable 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.

Herefore 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 scalpeis, 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 noticeable 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 shredded and this is undesirable. Further still, the scalpel blade in itself has no cutting action, that is to say paring 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, 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 nonmagnetic 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, there being 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 in a 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 circuity. 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 circuit 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 and 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 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.

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.