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(54) **ULTRASONIC SURGICAL APPARATUS WITH POWER REDUCTION**

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(57) **ABSTRACT**

An ultrasonic surgical includes a probe with an operative edge or surface at a distal end, an electromechanical transducer connected to the probe, and an activation circuit connected to the transducer for supplying thereto an electrical waveform having an ultrasonic frequency and an amplitude. The activation circuit includes a signal generator and further includes a power reduction circuit operatively connected to the signal generator for inducing the signal generator to automatically reduce the amplitude of the waveform upon a sensing by the power reduction circuit of reduced load on the probe.

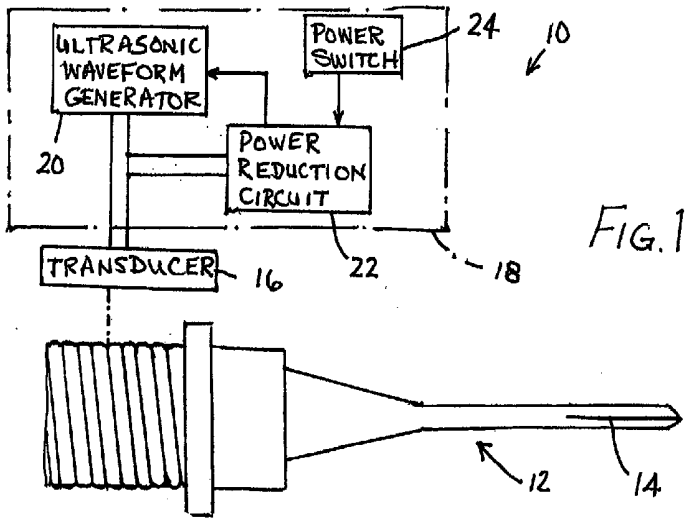
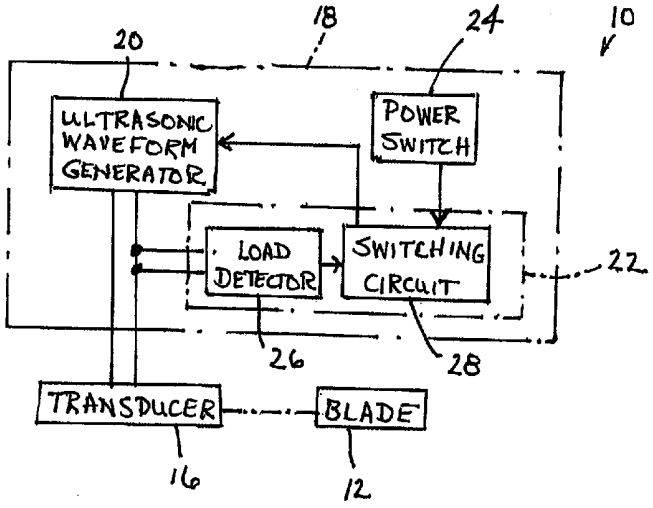


FIG. 1



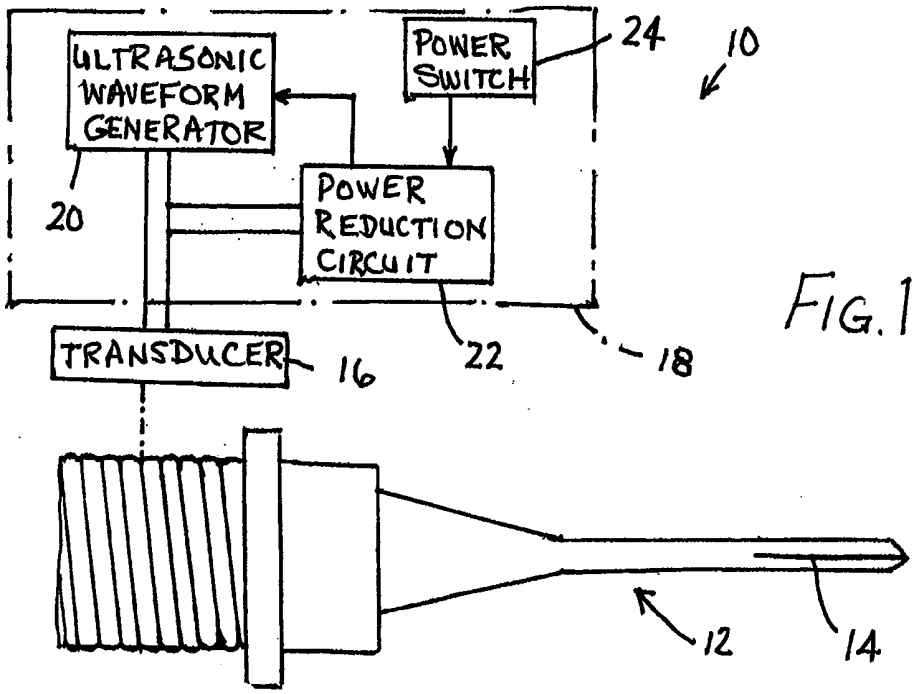

ULTRASONIC WAVEFORM GENERATOR
POWER SWITCH
24
10
20
POWER REDUCTION CIRCUIT
22
18
TRANSDUCER
16
12
14

FIG. 1

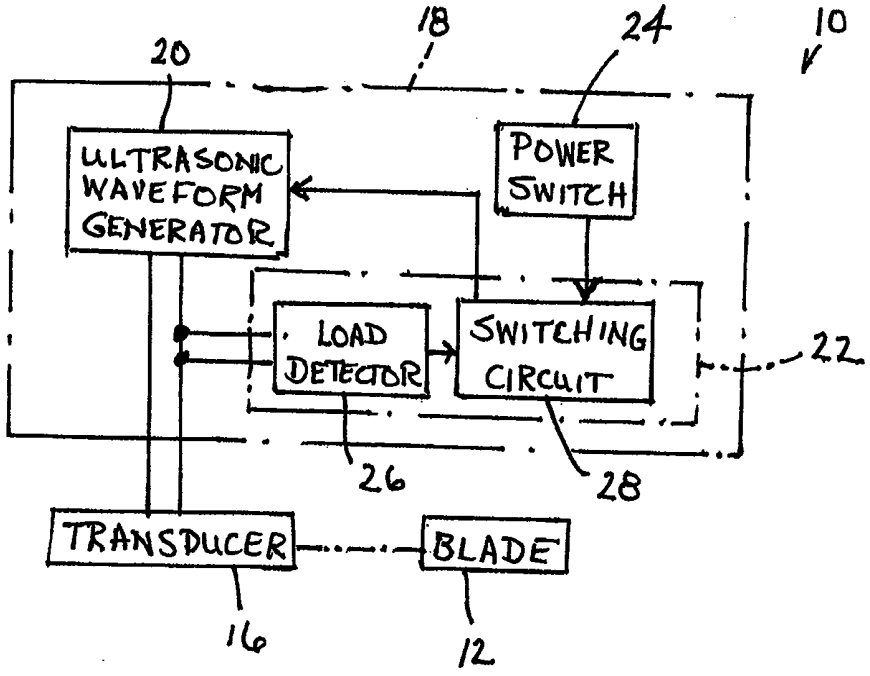

18
24
10
20
ULTRASONIC WAVEFORM GENERATOR
POWER SWITCH
LOAD DETECTOR
SWITCHING CIRCUIT
22
26
28
TRANSDUCER
BLADE
16
12

FIG. 2

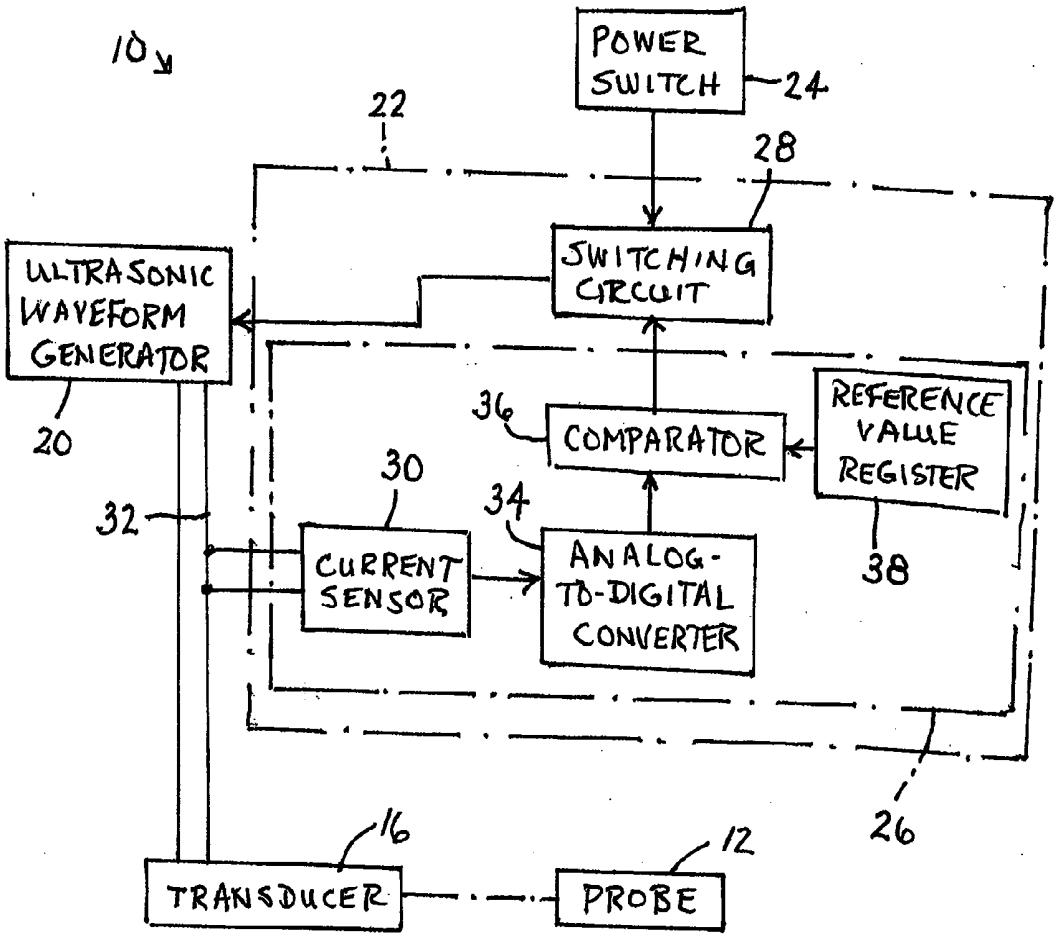

10
POWER SWITCH
24
22
28
SWITCHING CIRCUIT
ULTRASONIC WAVEFORM GENERATOR
20
36
COMPARATOR
REFERENCE VALUE REGISTER
38
30
32
34
CURRENT SENSOR
ANALOG-TO-DIGITAL CONVERTER
26
16
12
TRANSDUCER
PROBE

FIG. 3

ULTRASONIC SURGICAL APPARATUS WITH POWER REDUCTION

BACKGROUND OF THE INVENTION

[0001] This invention relates to an ultrasonic surgical apparatus. More particularly, this invention relates to an ultrasonic bone cutting apparatus. The invention also relates to an associated surgical method.

[0002] Ultrasonic surgical blades for cutting bone have known for several years. U.S. Pat. No. 6,379,371 and U.S. Pat. No. 6,443,969 disclose such a surgical blade. Ultrasonic bone cutting tools exhibit significant advantages over more traditional instruments such as power saws and rotary cutters. Ultrasonic bone cutting blades have been devised for enabling a separation of bone and soft tissue, along an interface between the two, with a minimum of damage to the soft tissue. Such an instrument is disclosed in U.S. Pat. No. 8,343,178.

OBJECTS OF THE INVENTION

[0003] It is an object of the present invention to provide and improved ultrasonic bone cutting apparatus.

[0004] A more particular object of the present invention is to provide an ultrasonic bone cutting apparatus the use of which entails a reduced probability of damage to soft tissues adjacent to a bone being cut.

[0005] Another particular object of the present invention is to provide an ultrasonic bone cutting apparatus configured to automatically protect soft tissues adjacent to a bone from being cut during an operation on the bone.

[0006] These and other objects of the present invention will be apparent from the descriptions and drawings herein. Although every object of the invention is attainable by at least one embodiment of the invention, there is not necessarily any single embodiment that achieves all of the objects of the invention.

SUMMARY OF THE INVENTION

[0007] An ultrasonic surgical apparatus in accordance with the present invention comprises a probe with an operative edge or surface at a distal end, an electromechanical transducer connected to the probe, and an activation circuit connected to the transducer for supplying thereto an electrical waveform having an ultrasonic frequency and an amplitude. The activation circuit includes a signal generator and further includes a power reduction circuit operatively connected to the signal generator for inducing the signal generator to automatically reduce the amplitude of the waveform upon a sensing by the power reduction circuit of reduced load on the probe.

[0008] The power reduction circuit may include a load detector, and the load detector may include a current sensor. The load detector may further include a comparator operatively connected to the current sensor for comparing an output of the sensor with a pre-established reference value. The comparator may be a digital device, so that a digitizer is required to convert an analog output signal of the current sensor to a digital or binary signal for use by the comparator.

[0009] Pursuant to another feature of the present invention, the activation circuit includes a manually actuatable power switch and the power reduction circuit further includes a switching circuit operatively connected at inputs to the power switch and the comparator and at an output to the signal generator. The switching circuit acts to automatically override an instruction from the manual power switch in the event that a current reduction indicates that the ultrasonic blade has penetrated through a bone and encountered soft tissue adjacent thereto.

[0010] A surgical method in accordance with the present invention comprises operating an ultrasonic cutting tool to cut through bone of a patient, operating a sensor to automatically monitor load on the cutting tool during the operating of the cutting tool, automatically detecting a change in output of the sensor indicative of a reduced load on the cutting tool owing to a passing of the cutting tool at least partially through the bone, and automatically reducing power to the cutting tool upon the detecting of reduced load on the cutting tool.

[0011] The detecting of a change in output of the sensor may include comparing output of the sensor with a preselected reference value.

[0012] The reducing of power to the cutting tool may include reducing amplitude of an ultrasonic electrical waveform fed to an electromechanical transducer.

[0013] The operating of the sensor may include detecting current flow to an electromechanical transducer connected to the tool.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is partially a block diagram and partially a schematic side elevation view, on an enlarged scale, of an ultrasonic bone cutting apparatus in accordance with the present invention.

[0015] FIG. **2** is a block diagram showing details of the apparatus of FIG. **1**.

[0016] FIG. **3** is a block diagram showing further detailed structure of the apparatus of FIGS. **1** and **2**.

DETAILED DESCRIPTION

[0017] As depicted in FIG. **1**, an ultrasonic surgical apparatus **10** comprises a probe or tool **12** with an operative (cutting) edge or surface **14** at a distal end. Probe of tool **12** particularly may take the form of an ultrasonic bone-cutting blade or drill. Apparatus **10** further comprises an electromechanical transducer **16** connected to probe **12** for energizing same with an ultrasonic standing wave of a preselected frequency (or wavelength) determined in part by the dimensions of the probe. Apparatus **10** also comprises an activation circuit **18** connected to transducer **16** for supplying thereto an electrical waveform having the preselected ultrasonic frequency and a predetermined amplitude. Activation circuit **18** includes a signal or waveform generator **20** and further includes a power reduction circuit **22** operatively connected to the signal generator for inducing the signal generator to automatically reduce the amplitude of the electrical waveform upon a sensing by the power reduction circuit of reduced load on probe **12**.

[0018] Surgical apparatus **10** typically includes further electrical and liquid-supply components as disclosed in U.S. Pat. No. 6,379,371 and U.S. Pat. No. 6,443,969, the disclosures of which are hereby incorporated by reference. For instance, apparatus **10** may incorporate a power switch **24** such as a foot-operated switch.

[0019] As illustrated in FIG. **2**, power reduction circuit **22** may include a load detector **26** and a switching circuit **28**. Switching circuit **28** is connected to power switch **24** and signal generator **20** for enabling the operation of the signal

generator in response to a signal from the power switch. Upon receiving a signal from load detector **26** occasioned by a drop in transducer load, switching circuit **28** induces signal generator **20** to reduce, or possibly interrupt, the power of the electrical waveform supplied to transducer **16**.

[0020] As illustrated in FIG. **3**, load detector **26** may include a current sensor **30** operatively connected to a lead **32** extending from signal generator **20** to transducer **16**. Load detector **26** further includes a digitizer or analog-to-digital converter **34** at an output of the current sensor **30**. A comparator **36** is operatively connected to current sensor **30** via digitizer **34** for comparing an output of the sensor with a pre-established reference value provided by a register **38**. Comparator **36** is thus a digital device, although an analog device such as an operational amplifier could alternatively be used.

[0021] Comparator **36** compares a digitized output of sensor **30** with the reference value from register **38** and, upon detecting that the current has fallen below a pre-established level encoded by the reference value, transmits a signal to switching circuit **28** which in turn causes signal generator **20** to reduce the power output to transducer **16**, particularly by reducing the amplitude of the electrical transducer-energizing waveform. Switching circuit **28** acts to automatically override an operator-induced instruction from manual power switch **24** in the event of a current reduction resulting when ultrasonic blade or tool **12** penetrate through bone and encounters soft tissue adjacent thereto.

[0022] A surgical method utilizing the apparatus of FIGS. **1-3** entails using apparatus **10** to have ultrasonic cutting tool **12** cut through a bone of a patient. Current sensor **30** is operated to automatically monitor load on cutting tool **12** during the operation. A change in output of sensor **30** indicative of a reduced load on cutting tool **12** is automatically detected owing, the reduction in load arising from a passing of the cutting tool at least partially through the bone.

[0023] One automatically reduces power to the cutting tool **12** upon detecting reduced load on the cutting tool. The detecting of a change in output of sensor **30** may include operating comparator **36** to automatically compare output of sensor **30** with the reference value from register **38**. The reducing of power to cutting tool **12** may be implemented by reducing amplitude of an ultrasonic electrical waveform fed to an electromechanical transducer, i.e., transducer **16**.

[0024] Although the invention has been described in terms of particular embodiments and applications, one of ordinary skill in the art, in light of this teaching, can generate additional embodiments and modifications without departing from the spirit of or exceeding the scope of the claimed invention. Accordingly, it is to be understood that the drawings and descriptions herein are proffered by way of example to facilitate comprehension of the invention and should not be construed to limit the scope thereof.

What is claimed is:

1. An ultrasonic surgical apparatus comprising: a probe including an operative edge or surface at a distal end; an electromechanical transducer connected to said probe; and an activation circuit operatively connected to said transducer for supplying thereto an electrical waveform having an ultrasonic frequency and an amplitude, said activation circuit including a signal generator and further including a power reduction circuit operatively connected to said signal generator for inducing said signal generator to automatically reduce the amplitude of said waveform upon a sensing by said power reduction circuit of reduced load on said probe.

2. The apparatus defined in claim **1** wherein said power reduction circuit includes a load detector.

3. The apparatus defined in claim **2** wherein said load detector includes a current sensor.

4. The apparatus defined in claim **3** wherein said load detector further includes a comparator operatively connected to said current sensor for comparing an output of said sensor with a pre-established reference value.

5. The apparatus defined in claim **4** wherein said activation circuit includes a manually actuatable power switch and wherein said power reduction circuit further includes a switching circuit operatively connected at inputs to said power switch and said comparator and at an output to said signal generator.

6. The apparatus defined in claim **1** wherein said power reduction circuit includes a current sensor, said sensor being operatively connected to a lead extending from said signal generator to said transducer.

7. The apparatus defined in claim **1** wherein said load power reduction circuit includes a comparator configured to compare a sensed load parameter with a pre-established reference value.

8. The apparatus defined in claim **1** wherein said activation circuit includes a manually actuatable power switch and wherein said power reduction circuit further includes a switching circuit operatively connected at an input to said power switch and at an output to said signal generator.

9. A surgical method comprising: operating an ultrasonic cutting tool to cut through bone of a patient; during the operating of said cutting tool, operating a sensor to automatically monitor load on said cutting tool; during the operating of said cutting tool, automatically detecting a change in output of said sensor indicative of a reduced load on said cutting tool owing to a passing of said cutting tool at least partially through the bone; and automatically reducing power to said cutting tool upon the detecting of reduced load on said cutting tool.

10. The method defined in claim **9** wherein the detecting of a change in output of said sensor includes comparing output of said sensor with a preselected reference value.

11. The method defined in claim **9** wherein the reducing of power to said cutting tool includes reducing amplitude of an ultrasonic electrical waveform fed to an electromechanical transducer.

12. The method defined in claim **9** wherein the operating of said sensor includes detecting current flow to an electromechanical transducer connected to said tool.

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专利名称(译)	超声波手术器具功率降低		
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[标]申请(专利权)人(译)	米松尼克斯股份有限公司		
申请(专利权)人(译)	MISONIX INCORPORATED		
当前申请(专利权)人(译)	MISONIX INCORPORATED		
[标]发明人	DARIAN ALEXANDER		
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摘要(译)

超声外科手术包括探头，该探头在远端具有操作边缘或表面，连接到探头的机电换能器，以及连接到换能器的激活电路，用于向其提供具有超声频率和振幅的电波形。激活电路包括信号发生器，并且还包括功率减小电路，其可操作地连接到信号发生器，用于在功率降低电路检测到探头上的负载减小时感应信号发生器自动减小波形的幅度。

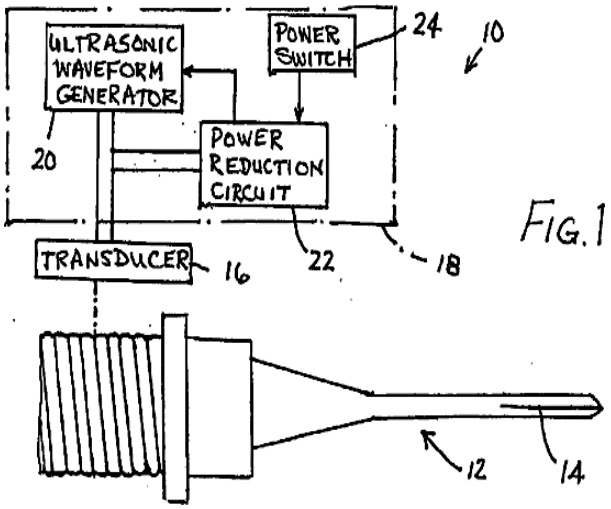

FIG. 1