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(54) SURGICAL APPARATUS PERMITTING RECHARGE OF BATTERY-DRIVEN SURGICAL INSTRUMENT IN NONCONTACT STATE

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(73) Assignee: **Olympus Optical Co., Ltd.**

(21) Appl. No.: **10/728,264**

(22) Filed: **Dec. 3, 2003**

Related U.S. Application Data

(62) Division of application No. 09/492,711, filed on Jan. 27, 2000, now Pat. No. 6,666,875.

(30) **Foreign Application Priority Data**

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Publication Classification

(51) **Int. Cl.**[7] **A61B 17/32**

(52) **U.S. Cl.** **606/169**

(57) **ABSTRACT**

A surgical instrument can be disinfected or sterilized, and has a rechargeable secondary battery incorporated therein. A distal treatment section of the surgical instrument is ultrasonically oscillated using the secondary battery as a driving power source and used to perform surgery on a living tissue. Electromagnetic energy generated by an energy generation unit located outside the surgical instrument is received by a reception coil incorporated in the surgical instrument with the surgical instrument held in noncontact with the energy generation unit. The electromagnetic energy is then converted into charging power with which the secondary battery is recharged. Thus, the surgical instrument can be readily recharged while left clean.

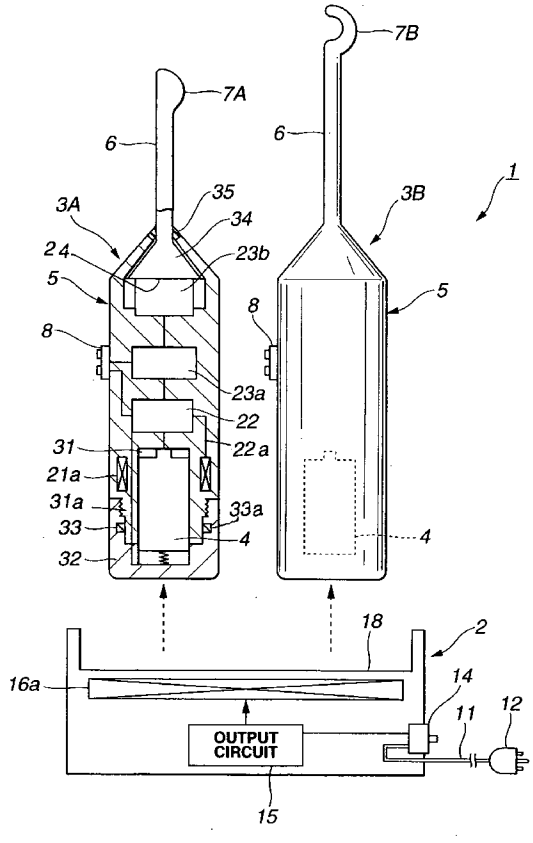


FIG.1

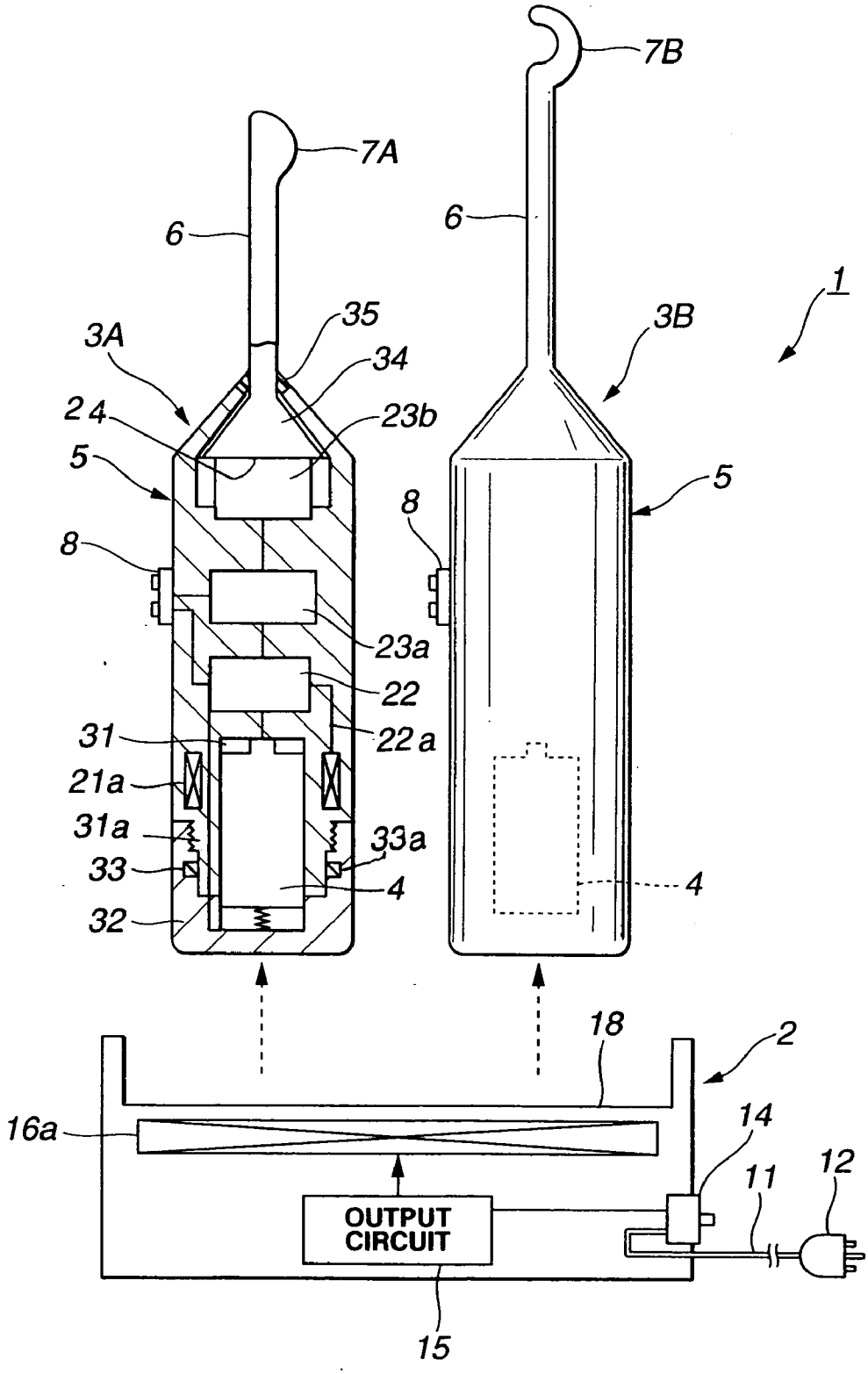

7B
7A
6
6
1
3A
3B
35
34
24
23b
5
5
8
8
23a
22
31
22a
21a
31a
33a
33
4
4
32
18
2
16a
14
11
12
OUTPUT CIRCUIT
15

FIG.2

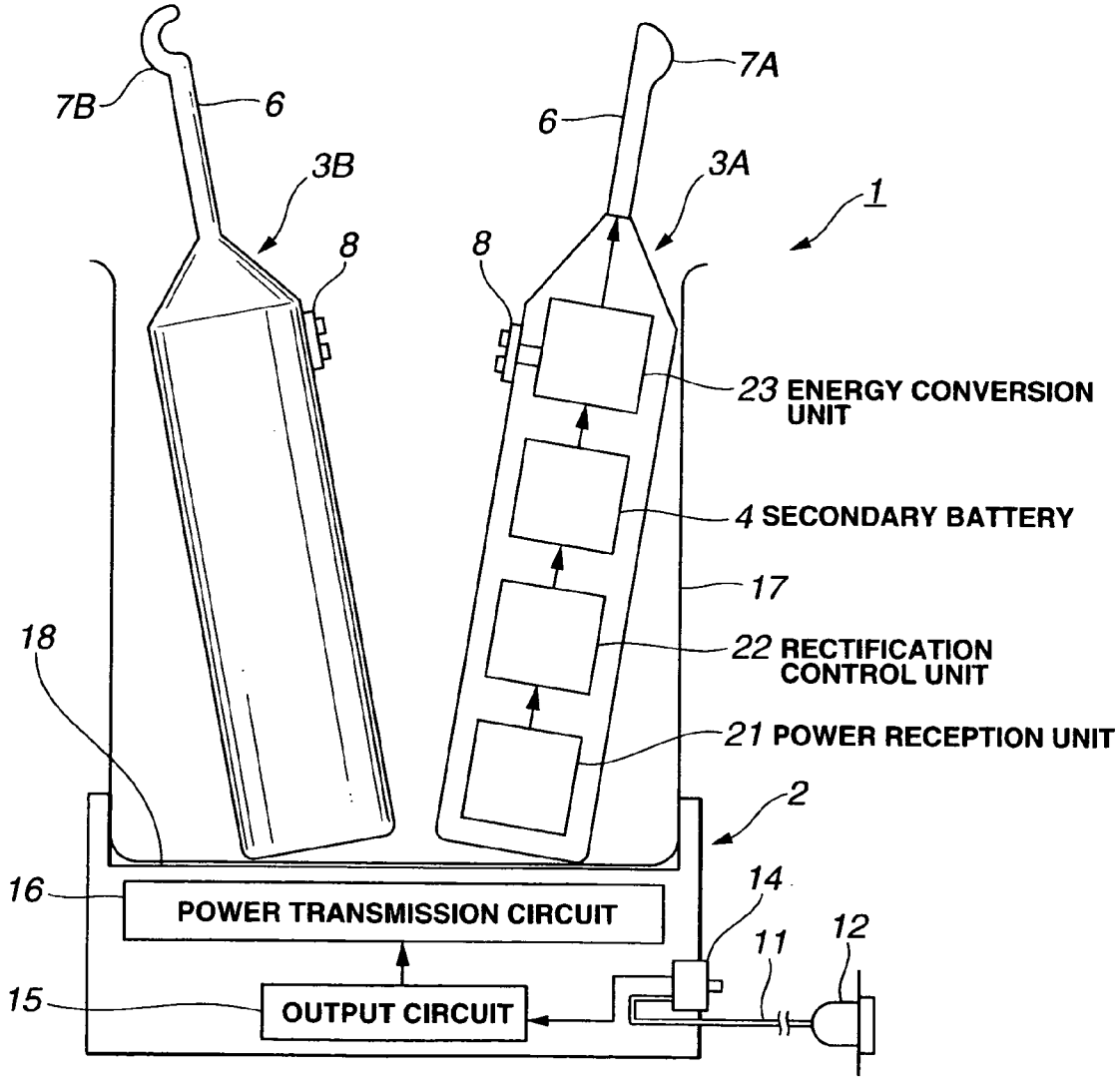

7B
6
3B
8
7A
6
3A
8
1
23 ENERGY CONVERSION UNIT
4 SECONDARY BATTERY
17
22 RECTIFICATION CONTROL UNIT
21 POWER RECEPTION UNIT
18
2
16
POWER TRANSMISSION CIRCUIT
14
11
12
15
OUTPUT CIRCUIT

FIG.3A

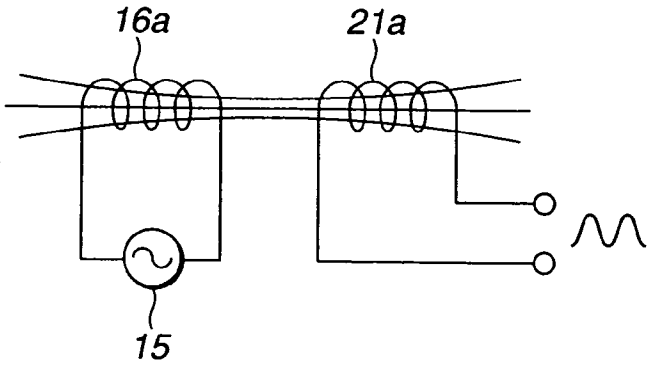


FIG.3B

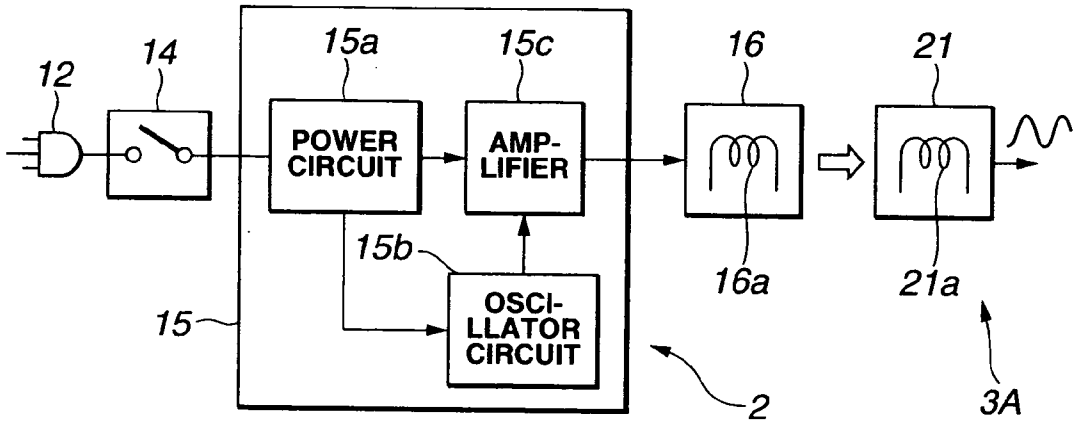
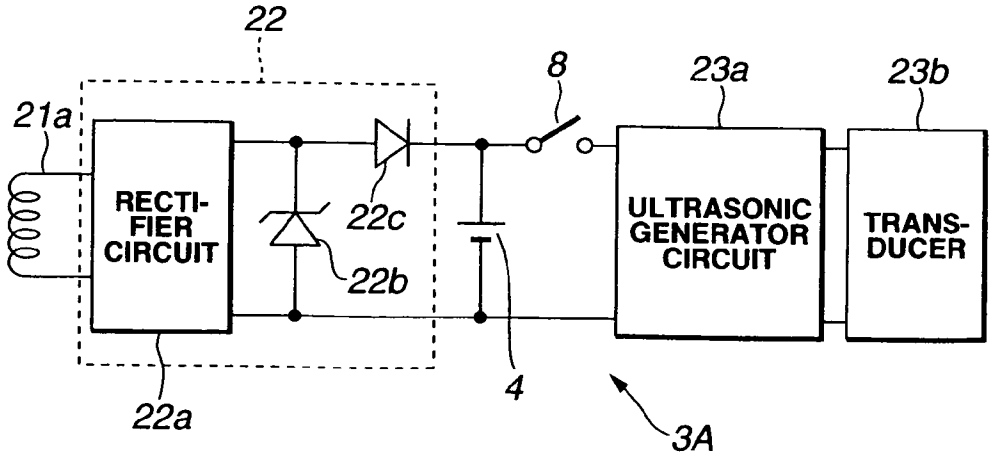


FIG.3C



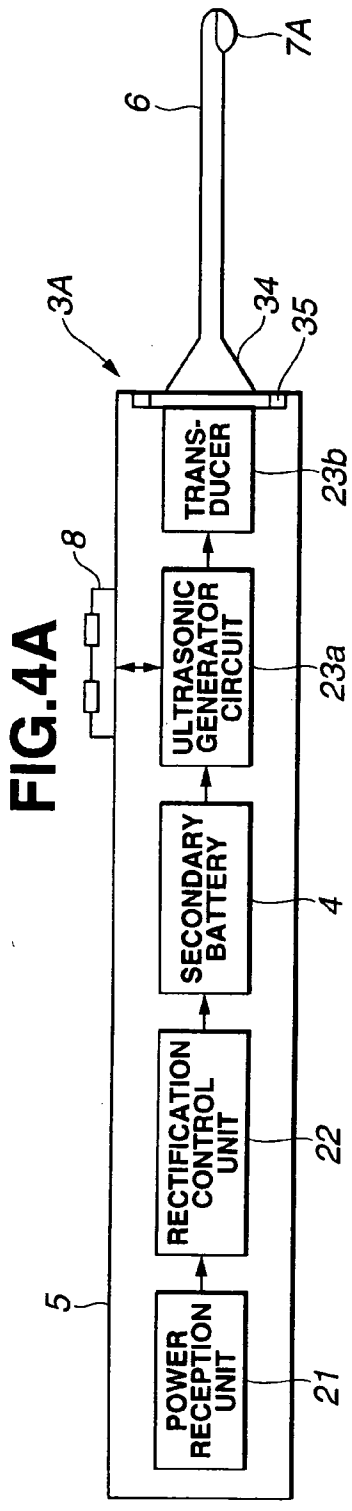


FIG.4A
3A
6
7A
34
35
TRANS-DUCER
23b
8
ULTRASONIC GENERATOR CIRCUIT
23a
SECONDARY BATTERY
4
RECTIFICATION CONTROL UNIT
22
POWER RECEPTION UNIT
21
5

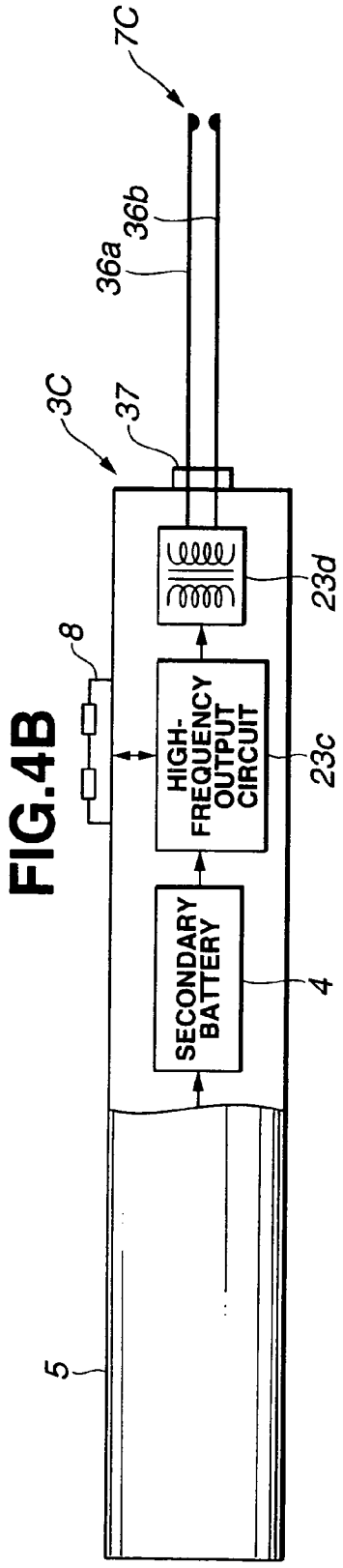


FIG.4B
7C
36a
36b
3C
37
23d
8
HIGH-FREQUENCY OUTPUT CIRCUIT
23c
SECONDARY BATTERY
4
5

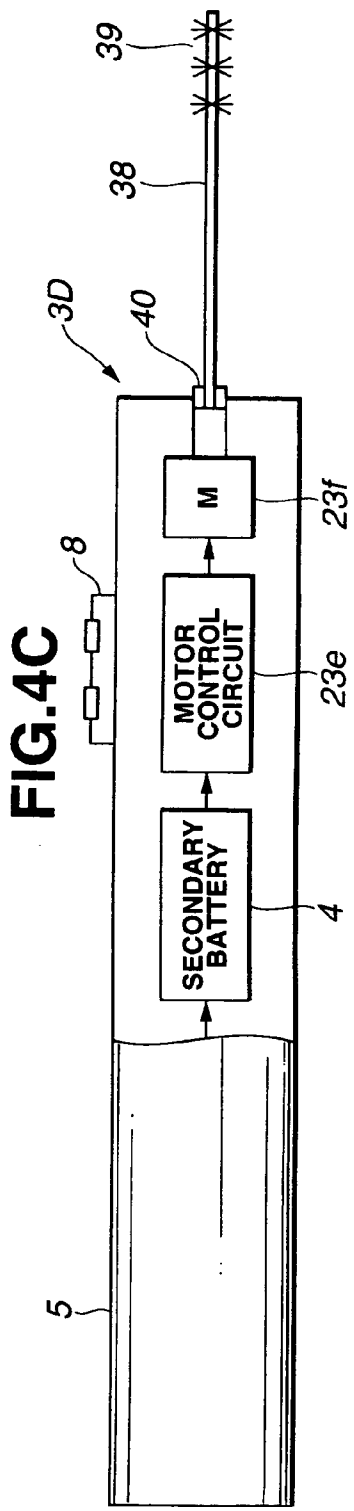


FIG.4C
39
38
3D
40
M
23f
8
MOTOR CONTROL CIRCUIT
23e
SECONDARY BATTERY
4
5

FIG.5A

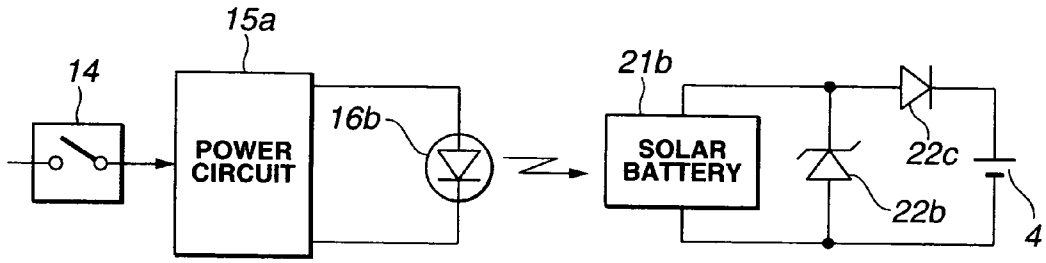

15a
14
POWER CIRCUIT
16b
21b
SOLAR BATTERY
22c
22b
4

FIG.5B

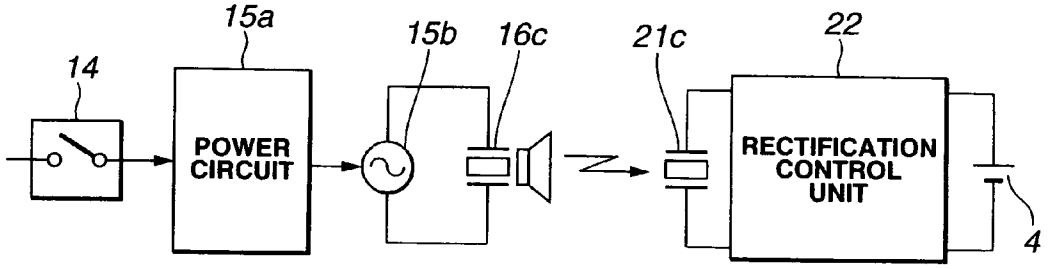

15a
14
POWER CIRCUIT
15b
16c
21c
22
RECTIFICATION CONTROL UNIT
4

FIG.6

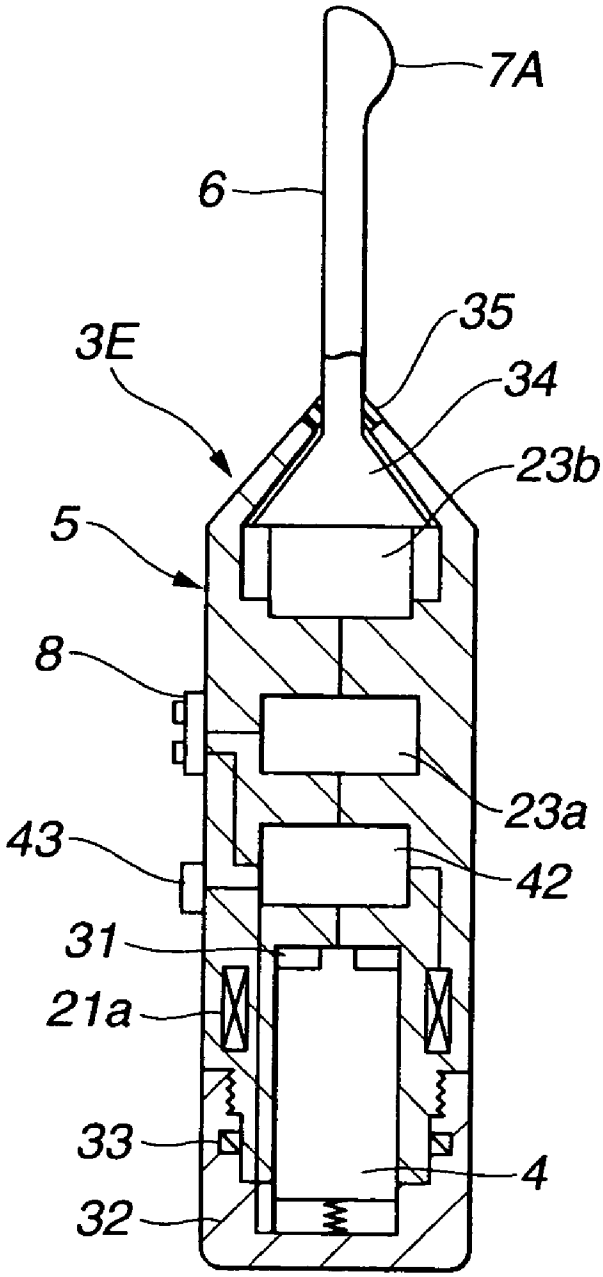


FIG.7

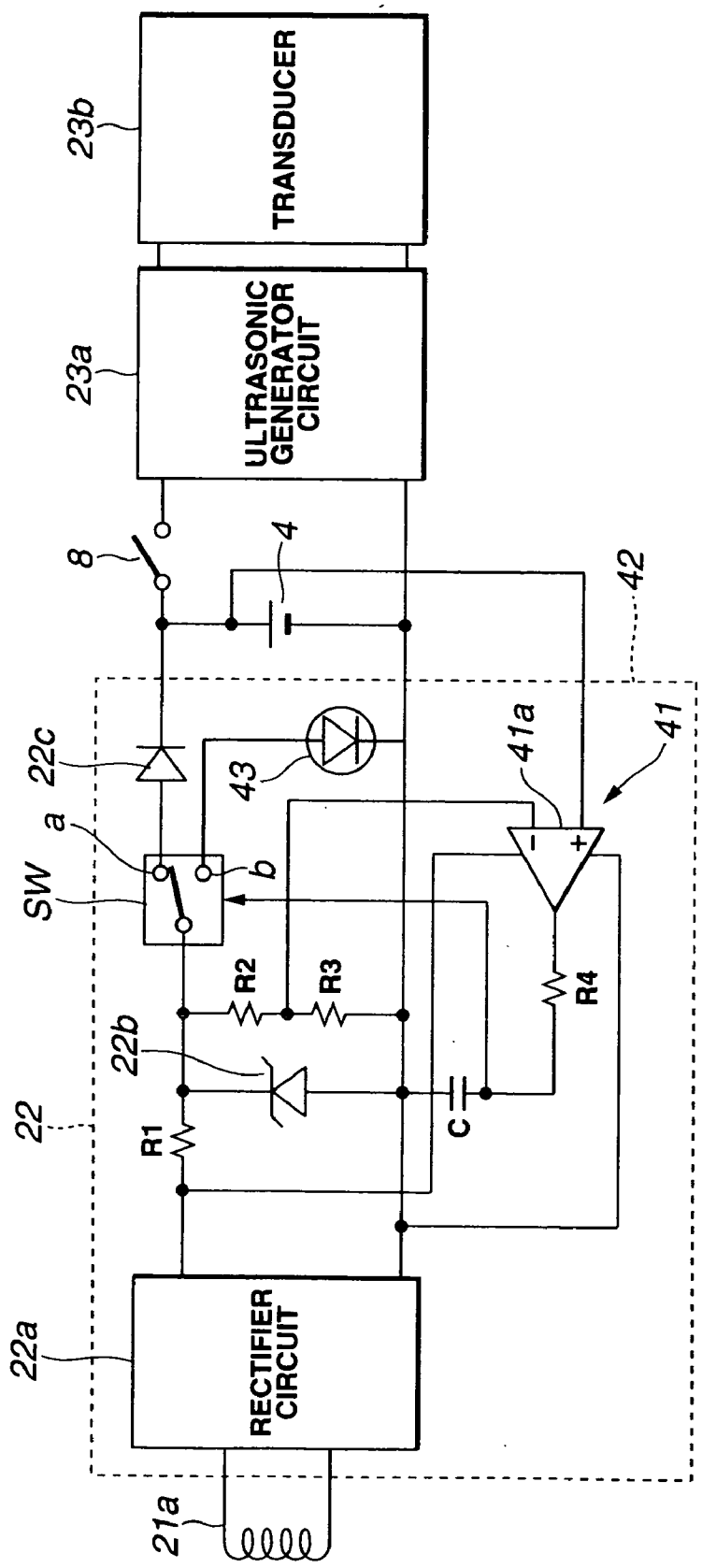

TRANSDUCER
23b
ULTRASONIC GENERATOR CIRCUIT
23a
8
4
42
22c
43
41a
41
a
SW
b
R2
R3
R4
22b
22
R1
C
RECTIFIER CIRCUIT
22a
21a

FIG.8

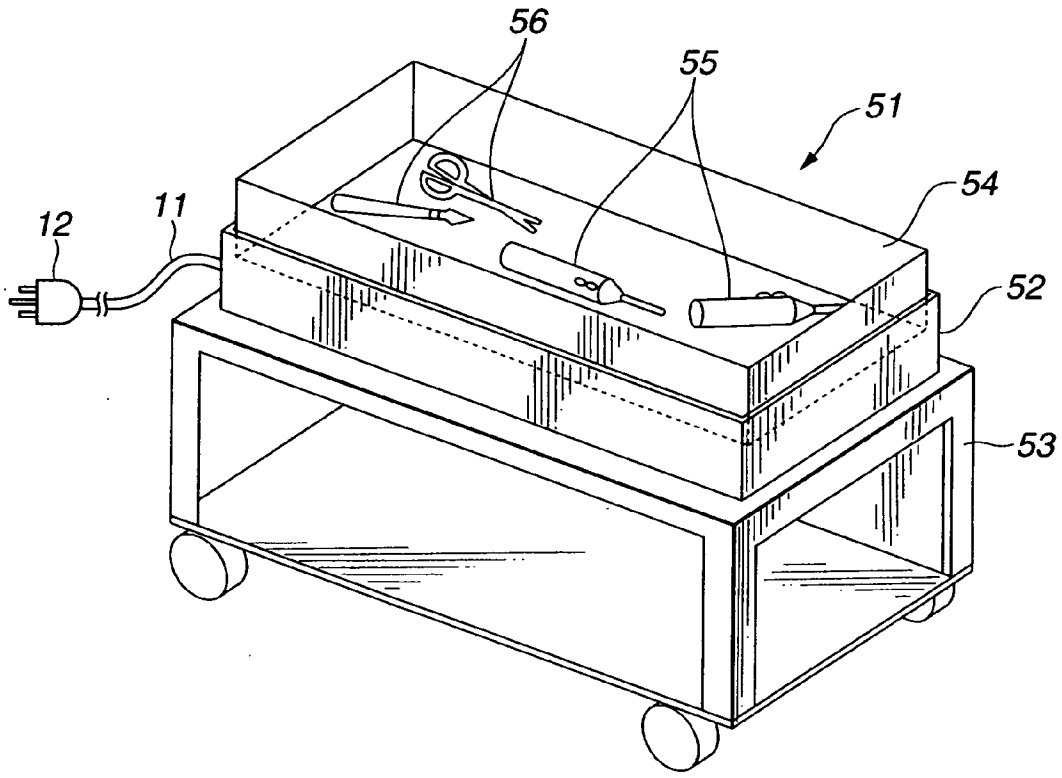

56
55
51
54
12
11
52
53

FIG.9

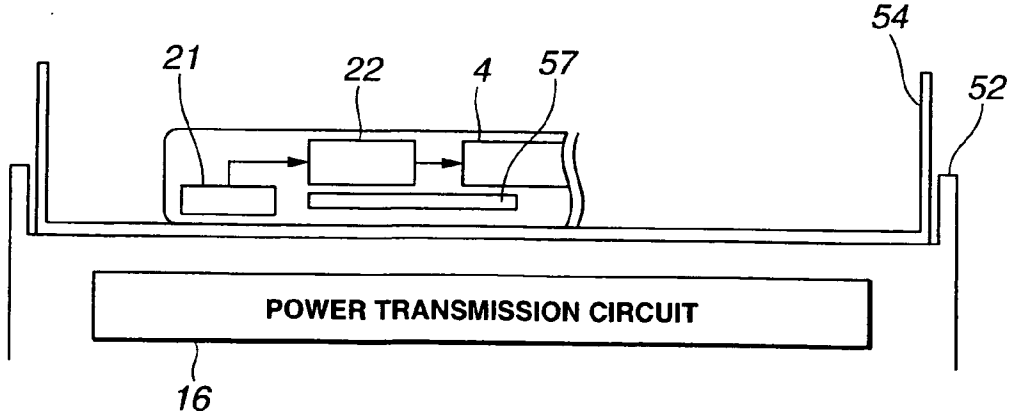

54
21
22
4
57
52
POWER TRANSMISSION CIRCUIT
16

FIG.10

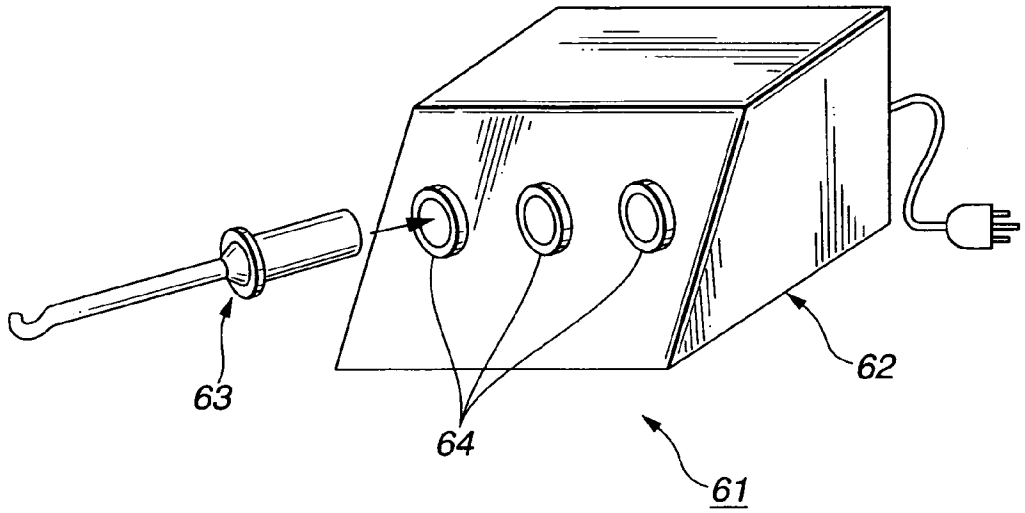


FIG.12

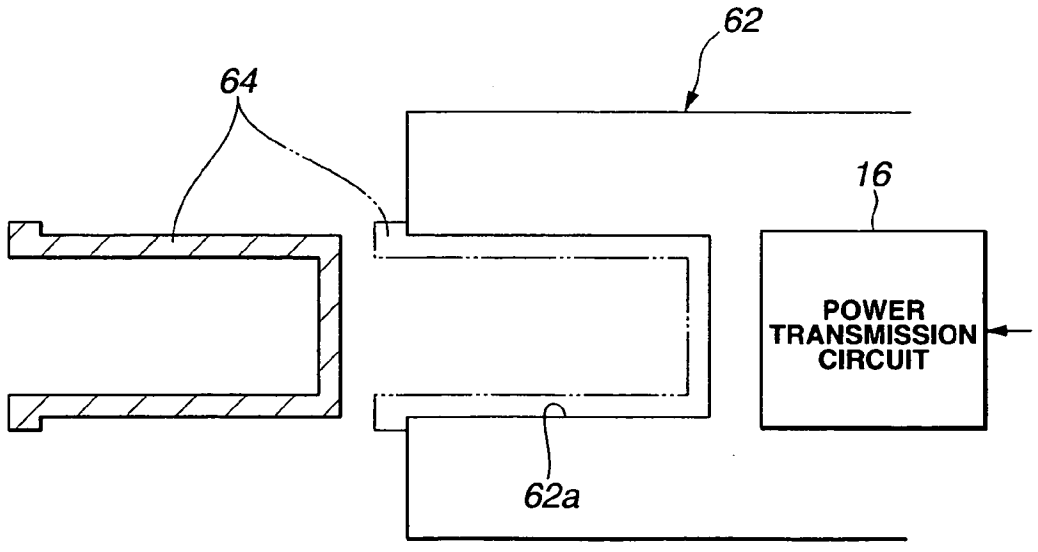


FIG.11

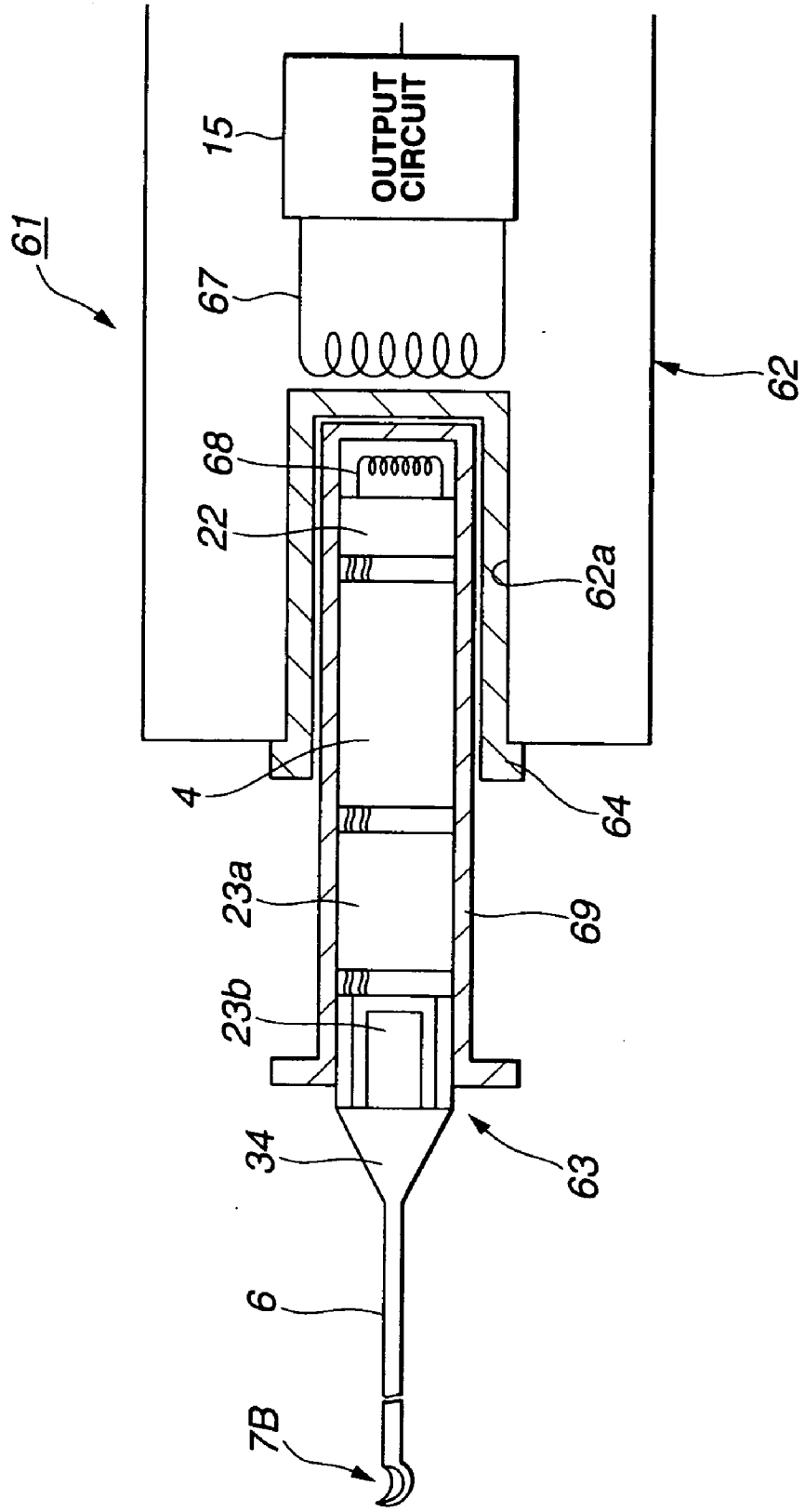


FIG.13A

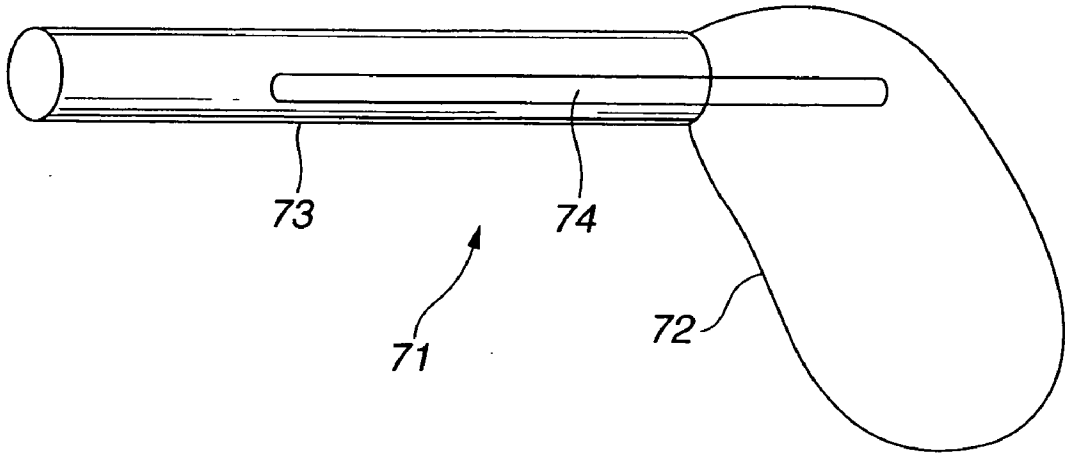


FIG.13B

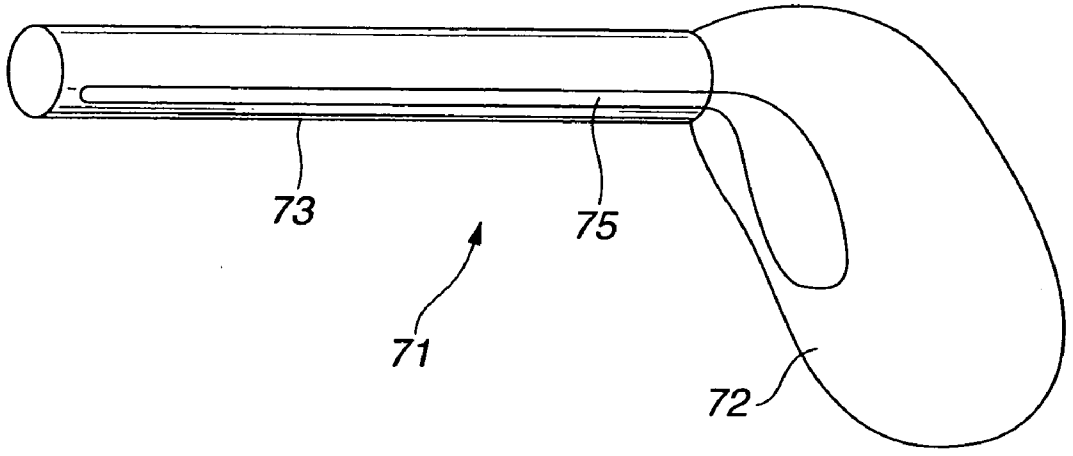


FIG.14

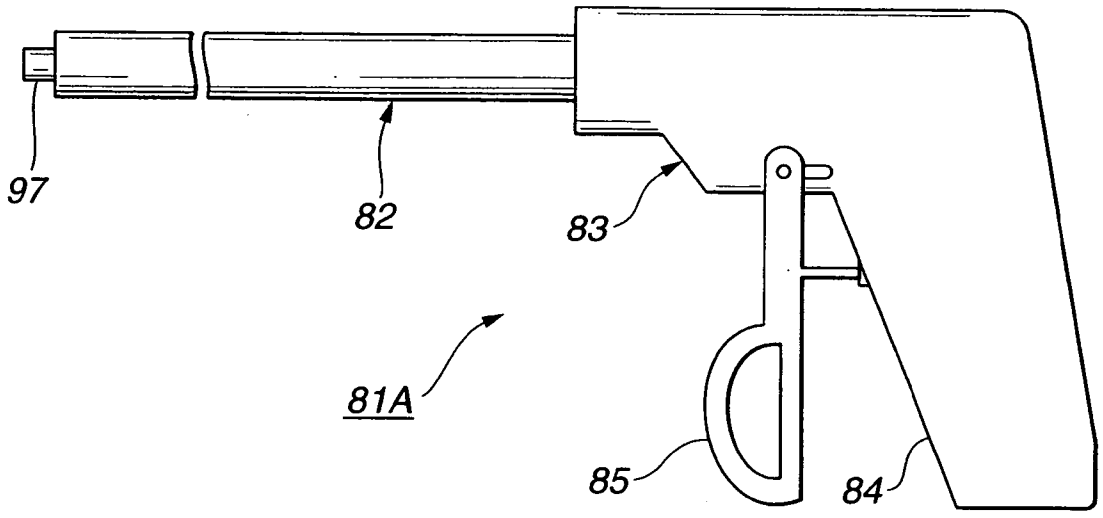


FIG.15

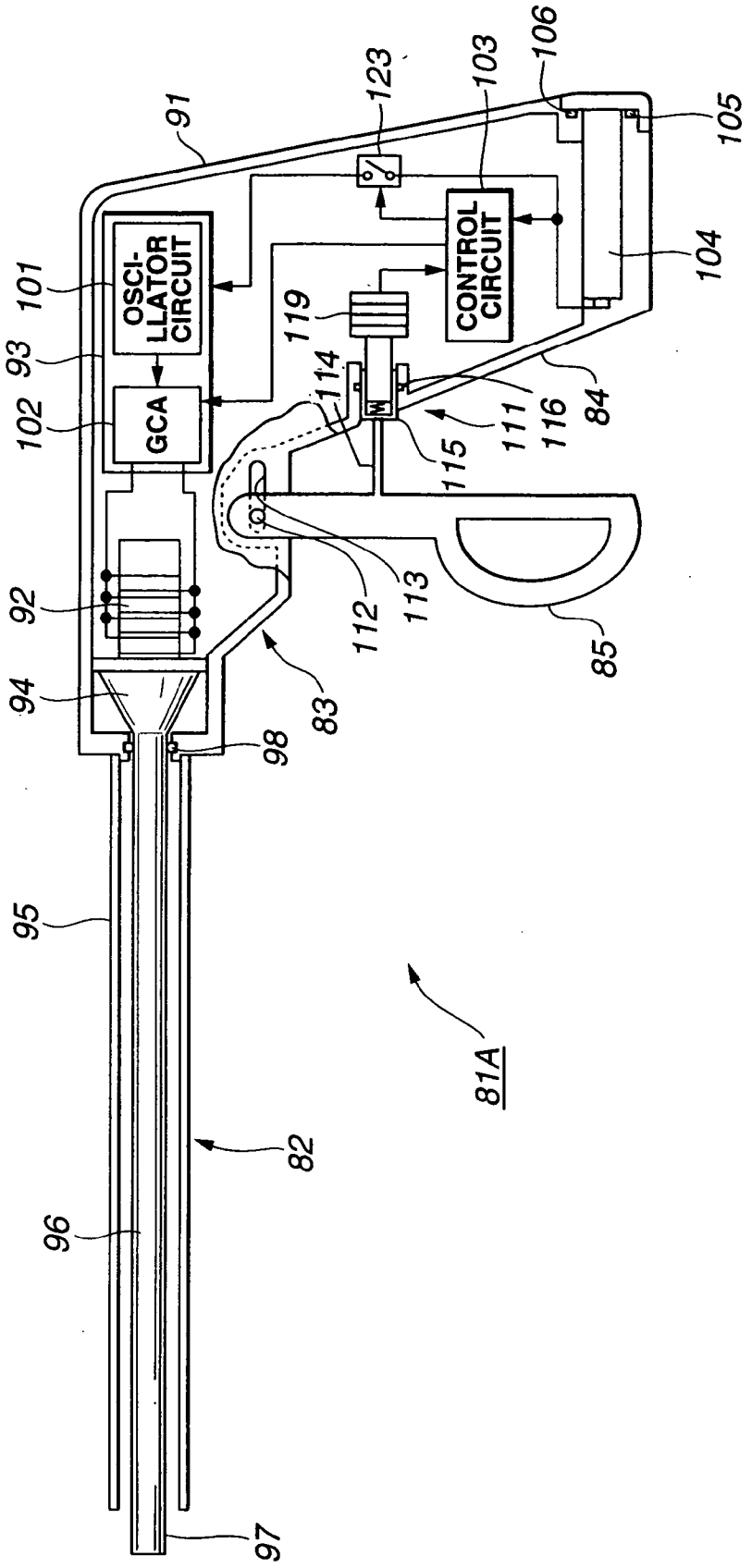

91
123
103
106
105
104
OSCI-LLATOR CIRCUIT
CONTROL CIRCUIT
101
93
102
GCA
119
114
111
116
84
115
112
113
92
94
83
85
98
95
96
82
97
81A

FIG.16

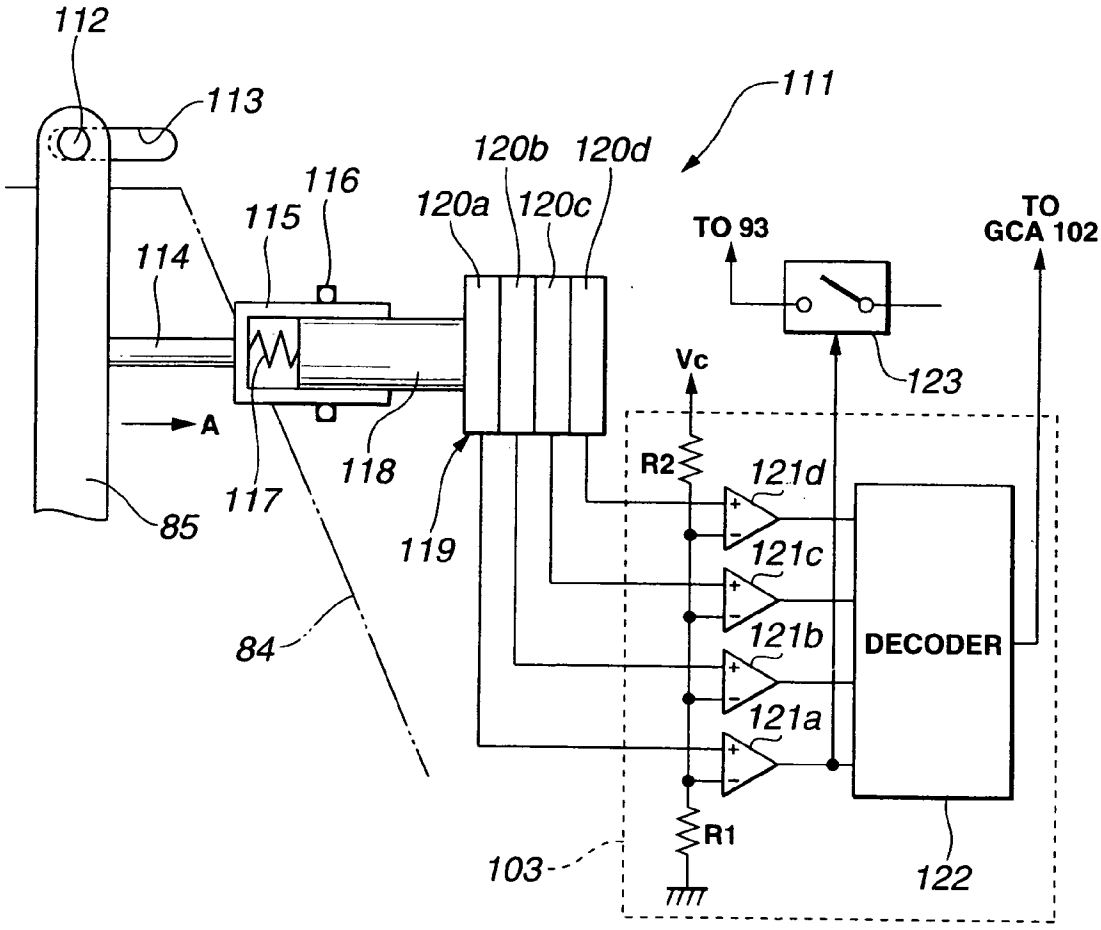

112
113
111
120b
120d
116
120a
120c
115
TO 93
TO GCA 102
114
Vc
123
A
R2
121d
118
117
119
121c
121b
DECODER
85
121a
84
R1
103
122

FIG.17

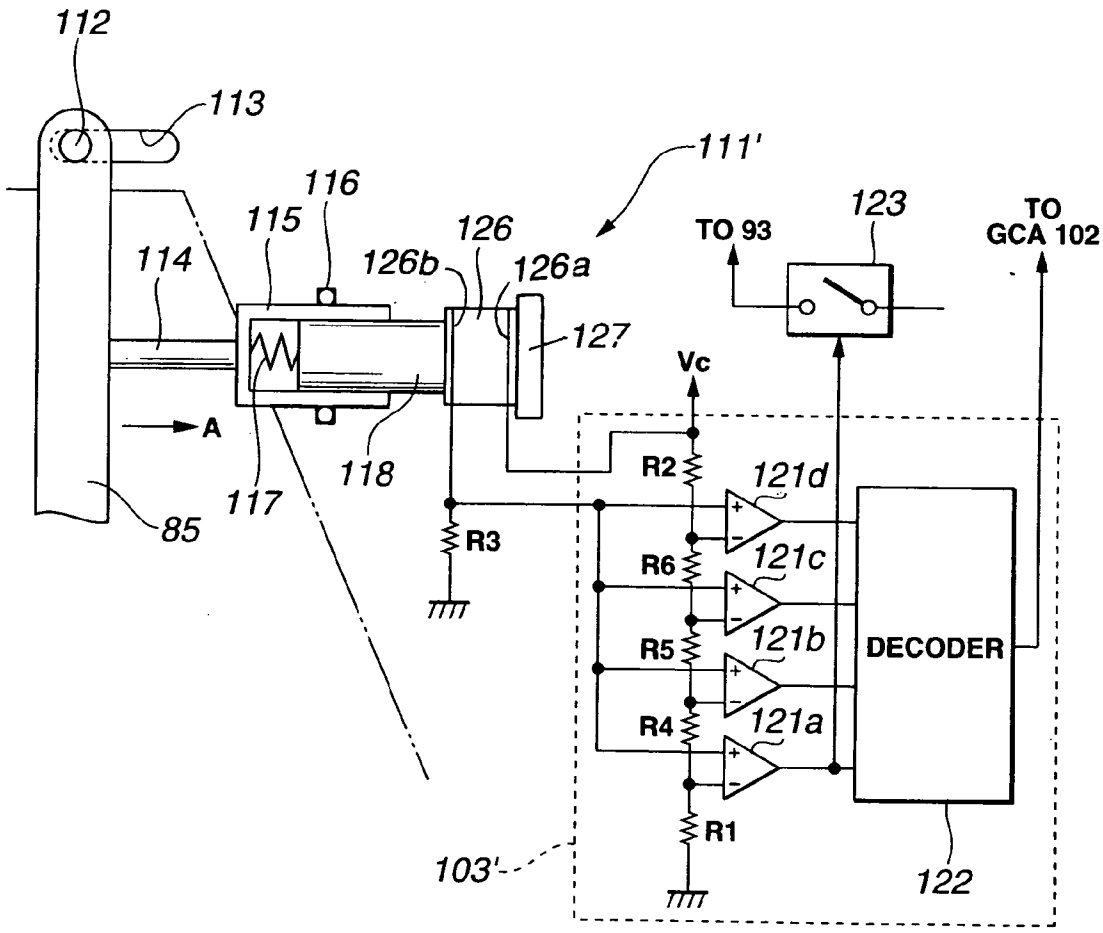

112
113
111'
116
115
126
114
126b
126a
TO 93
123
TO
GCA 102
127
Vc
A
R2
121d
118
117
85
R3
R6
121c
R5
121b
DECODER
R4
121a
R1
103'
122

FIG.18

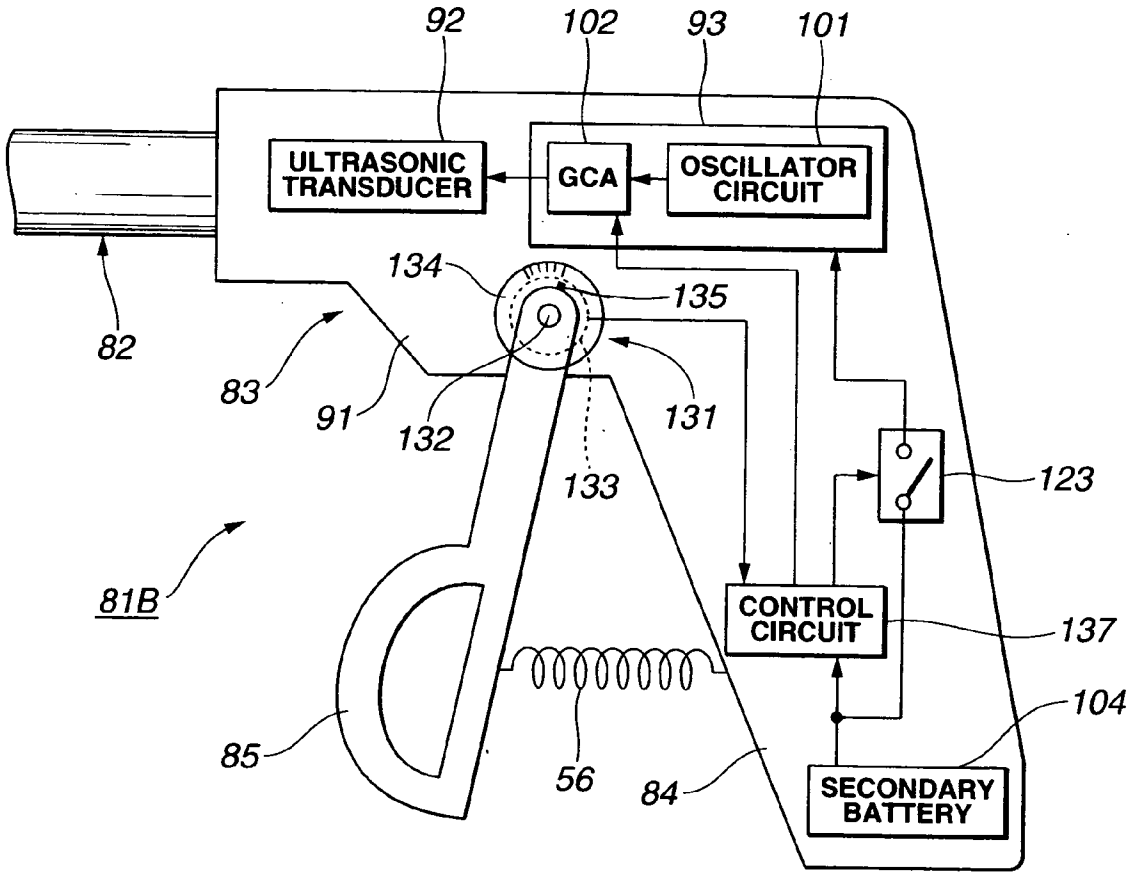

92
102
93
101
ULTRASONIC TRANSDUCER
GCA
OSCILLATOR CIRCUIT
134
135
82
83
91
132
131
133
123
81B
CONTROL CIRCUIT
137
104
85
56
84
SECONDARY BATTERY

FIG.19

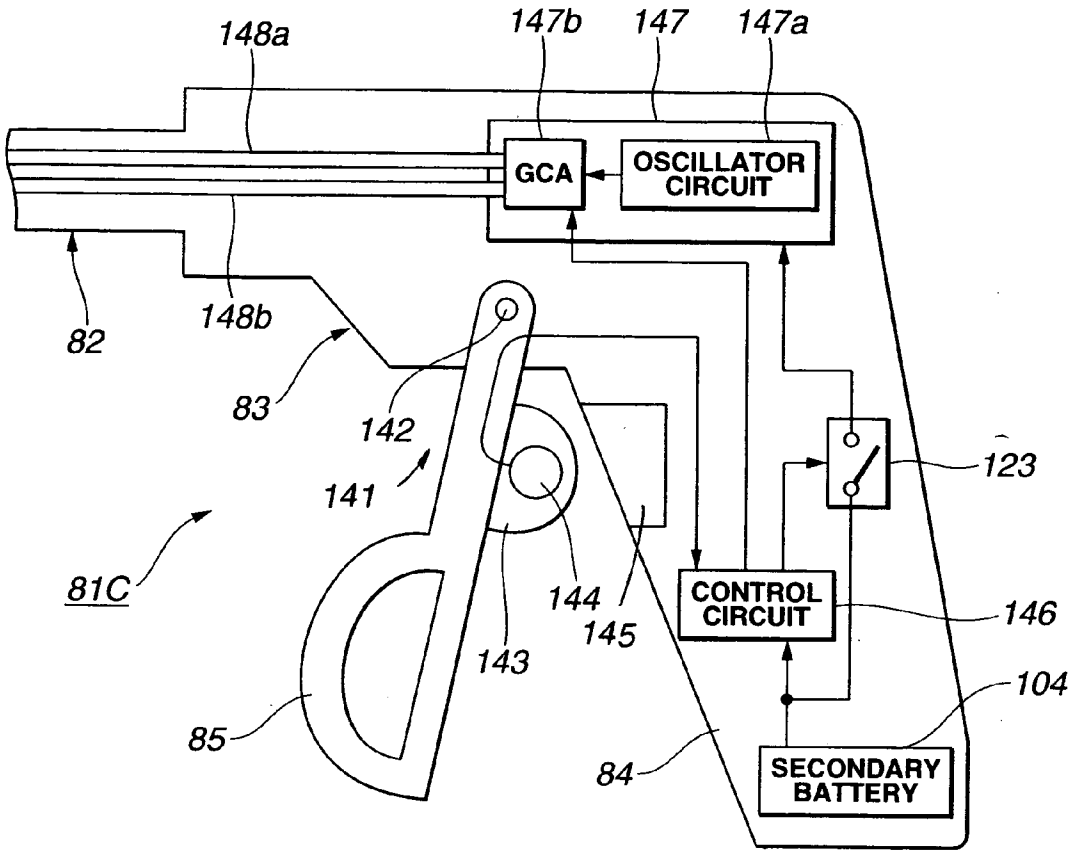

148a
147b
147
147a
GCA
OSCILLATOR CIRCUIT
82
148b
83
142
141
123
81C
144
145
143
CONTROL CIRCUIT
146
104
85
84
SECONDARY BATTERY

FIG.20

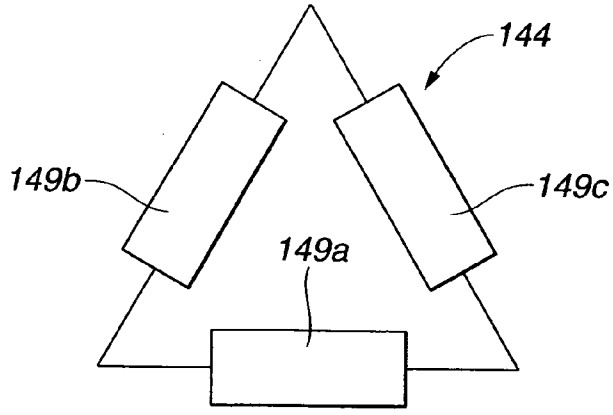

144
149b
149c
149a

FIG.21

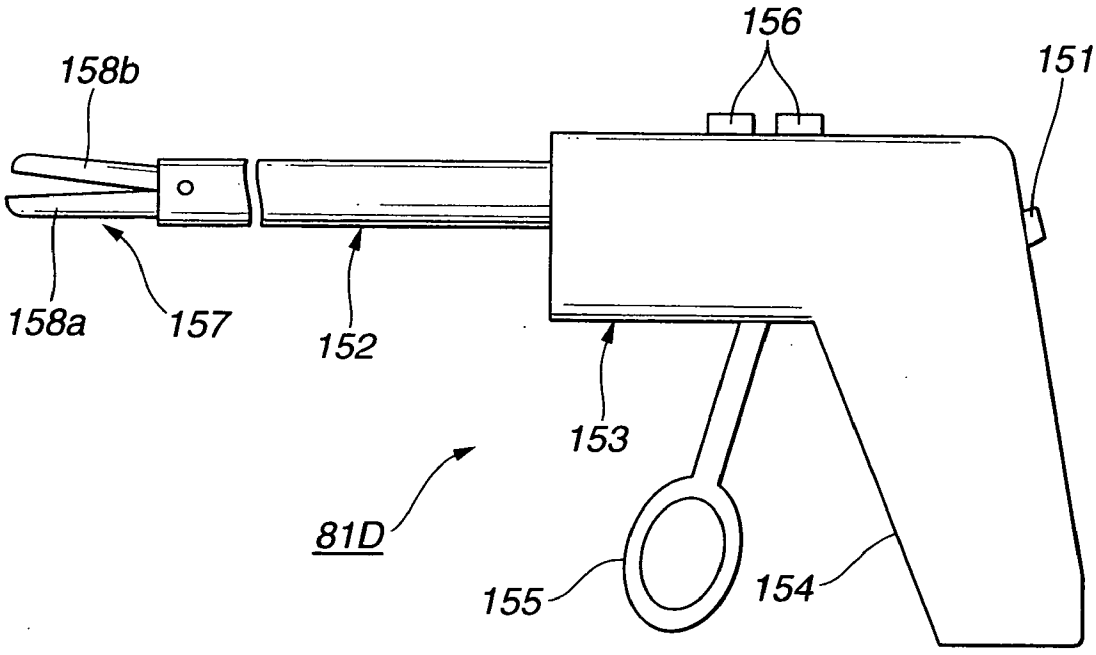


FIG.22

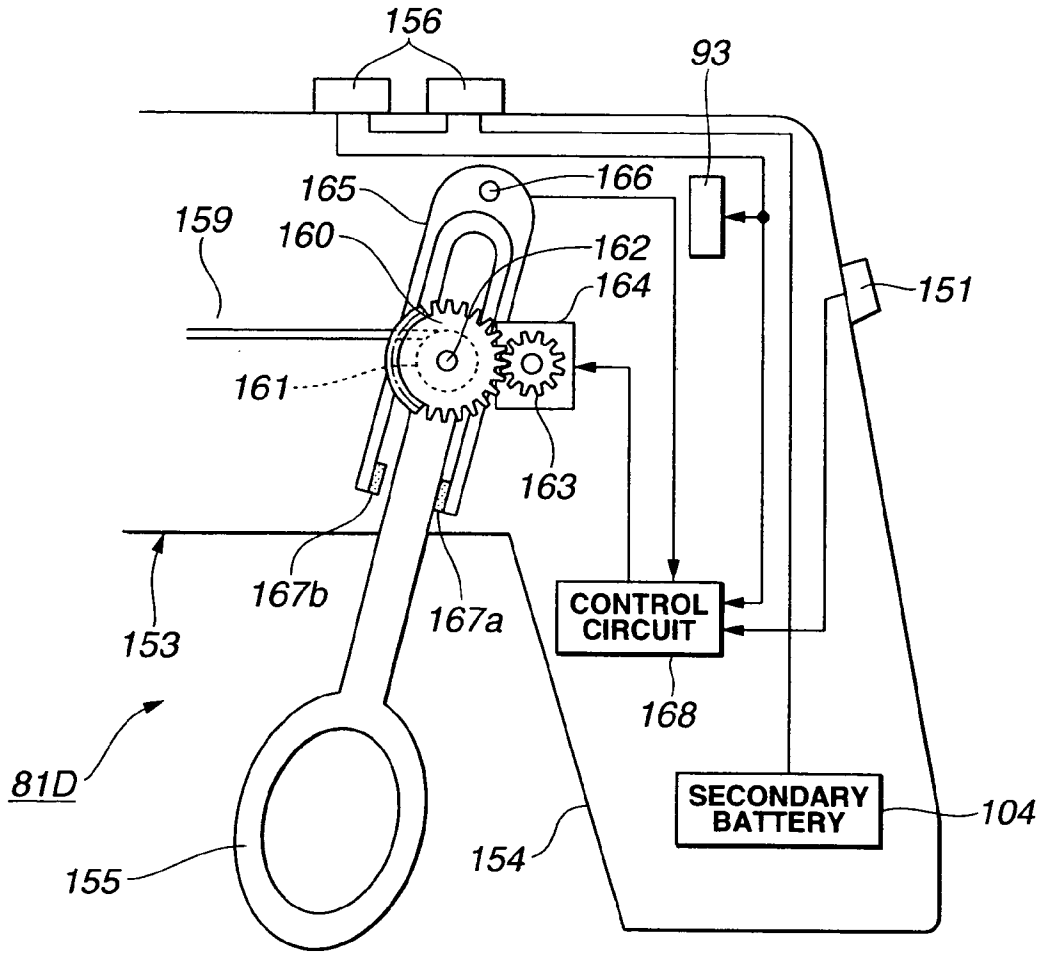

156
93
165
166
159
160
162
164
151
161
163
167b
167a
153
CONTROL CIRCUIT
168
81D
SECONDARY BATTERY
104
155
154

FIG.23

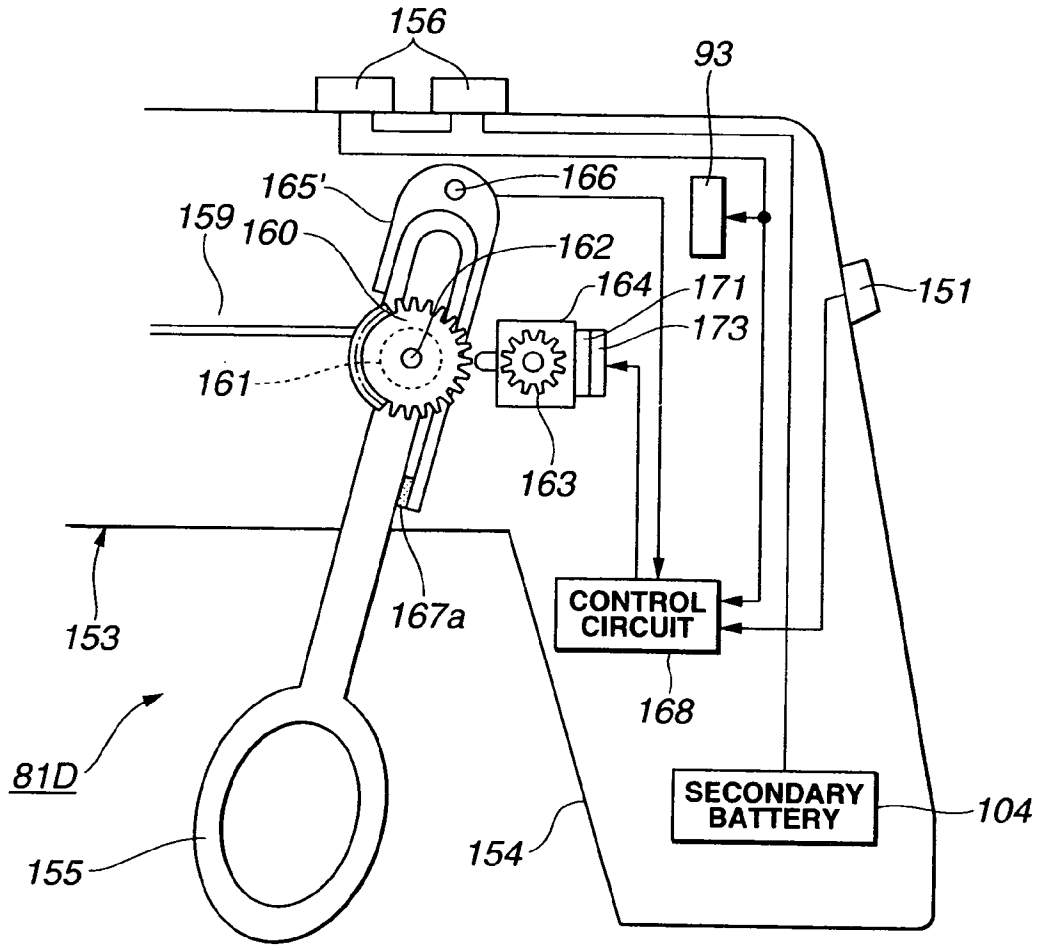

156
93
165'
166
159
160
162
164
171
173
151
161
163
153
167a
CONTROL CIRCUIT
168
81D
SECONDARY BATTERY
104
155
154

FIG.24

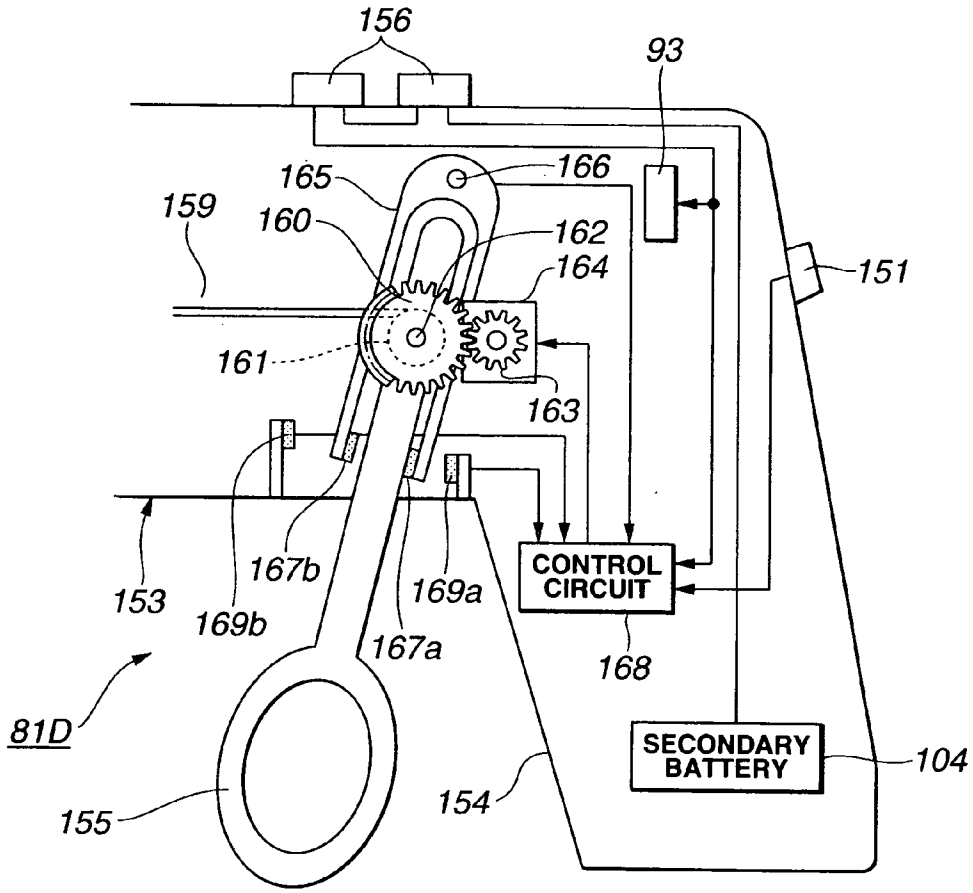

156
93
165
166
159
160
162
164
151
161
163
153
167b
169a
CONTROL CIRCUIT
169b
167a
168
81D
SECONDARY BATTERY
104
155
154

FIG.25

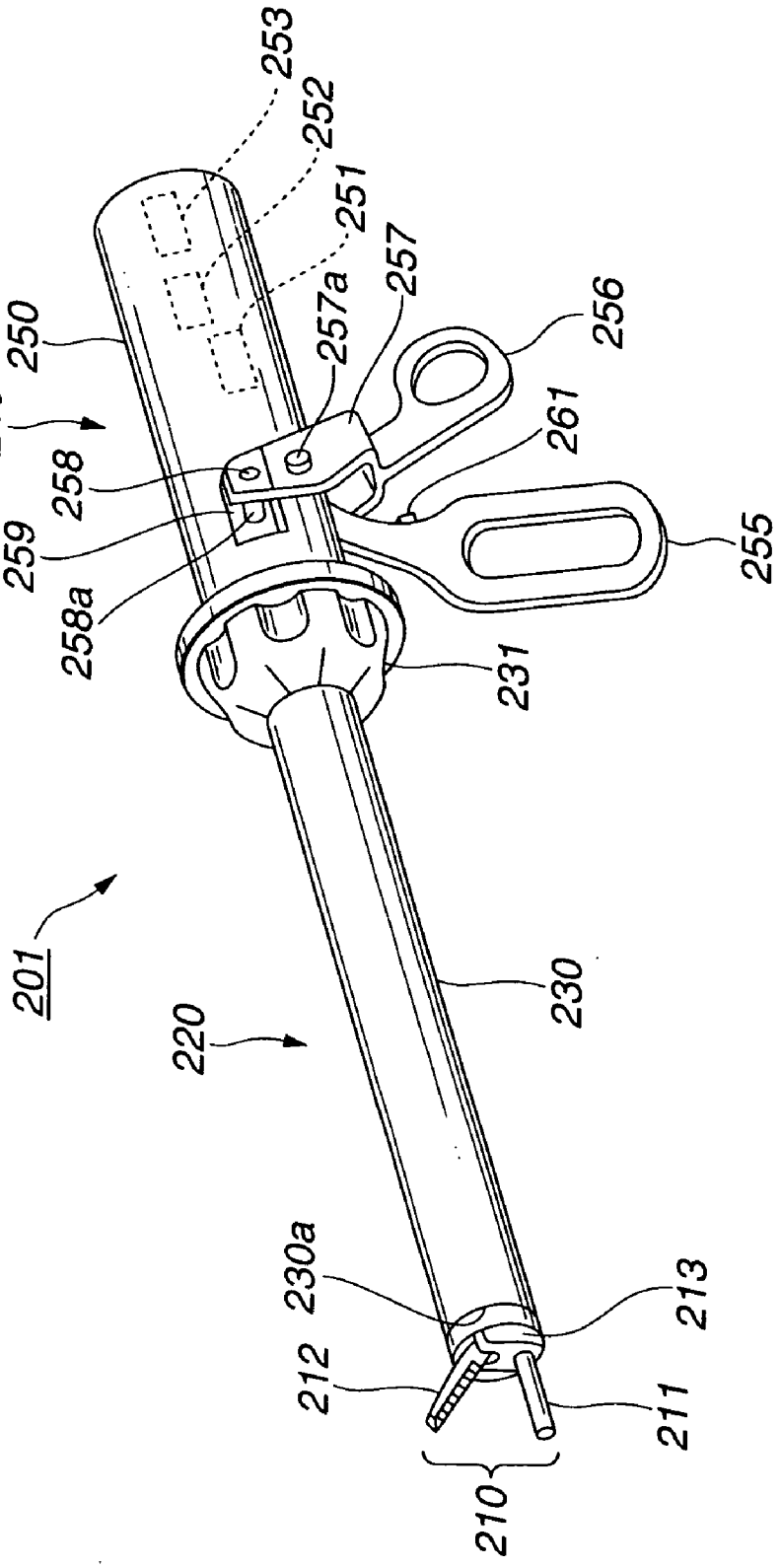

253
252
251
257a
257
256
250
240
261
258
259
255
258a
231
201
230
220
230a
213
212
211
210

FIG.26

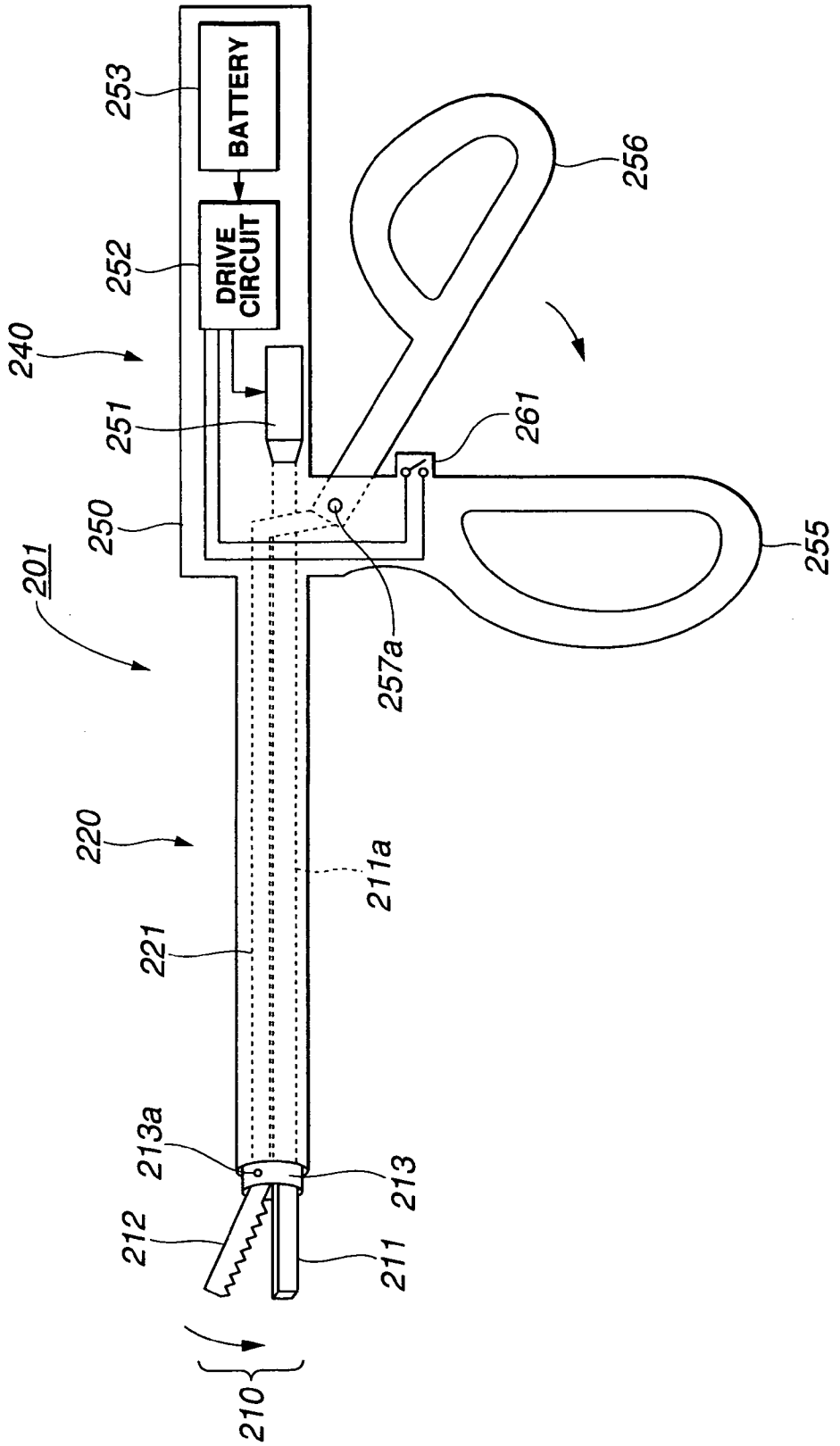

253
BATTERY
252
DRIVE CIRCUIT
240
251
250
201
220
221
213a
212
213
211
210
211a
257a
261
256
255

FIG.27

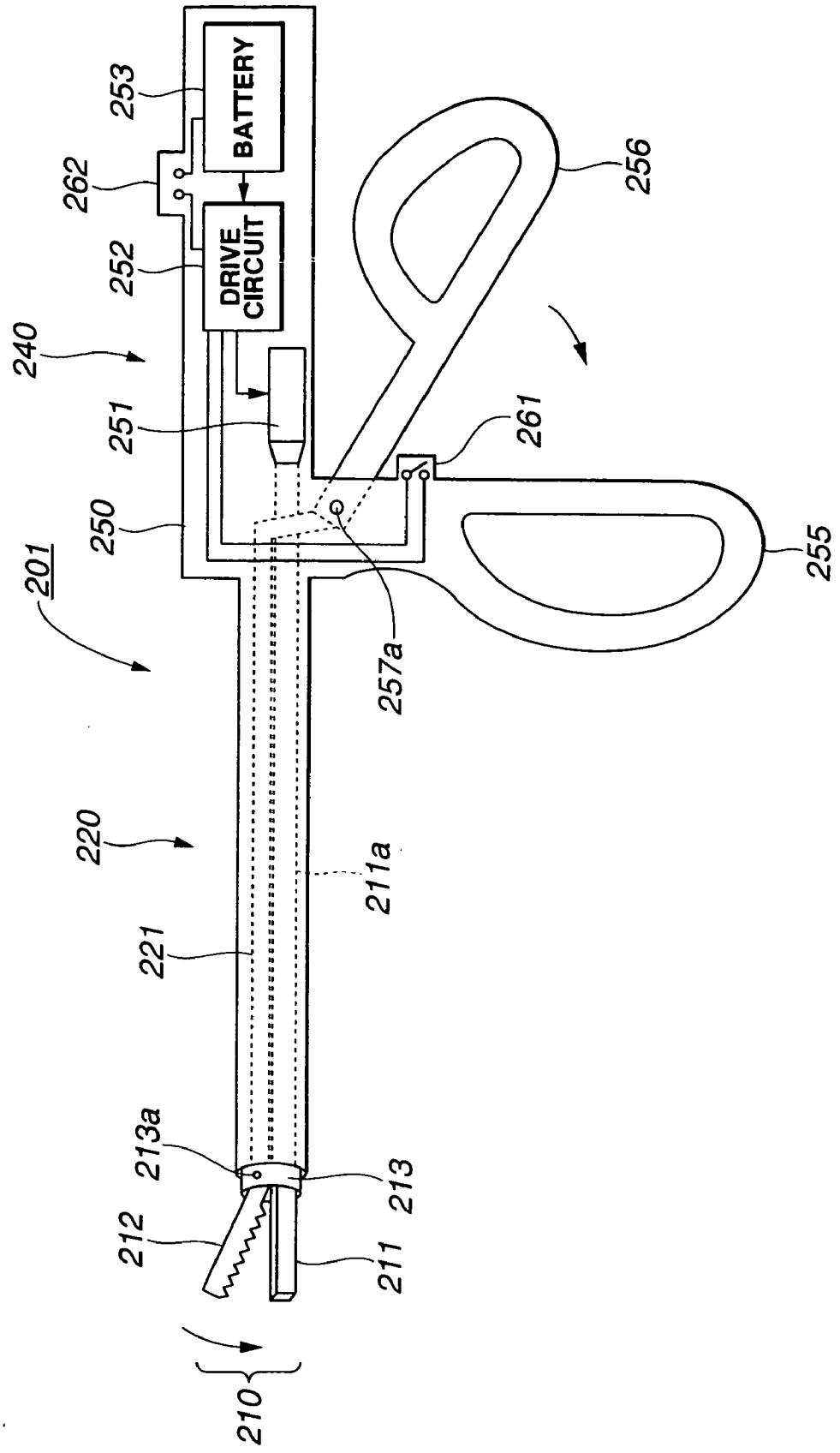

BATTERY
DRIVE CIRCUIT
253
262
252
240
251
250
201
220
221
213a
213
212
211
210
211a
257a
261
256
255

FIG.28

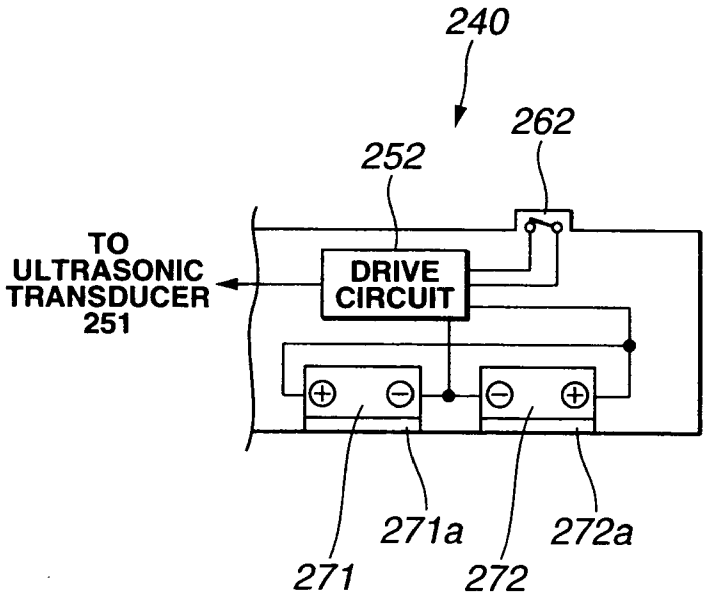

240
262
252
TO
ULTRASONIC
TRANSDUCER
251
DRIVE
CIRCUIT
271a
272a
271
272

FIG.29

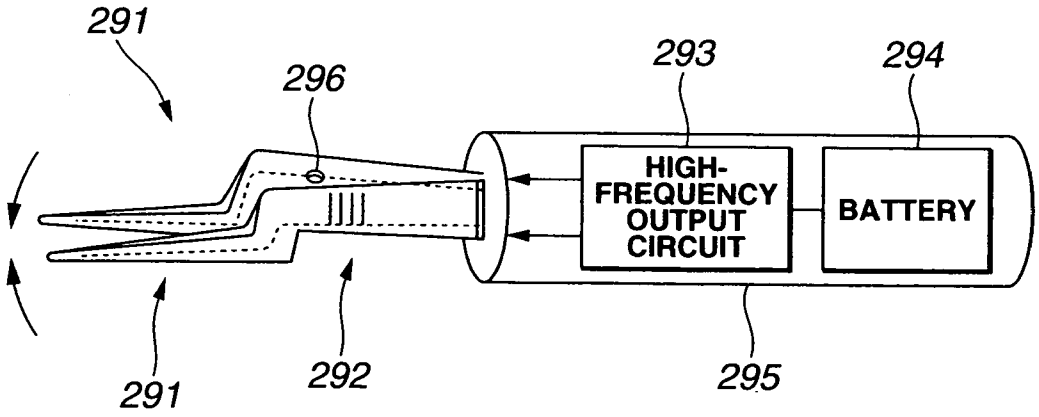

291
296
293
294
HIGH-
FREQUENCY
OUTPUT
CIRCUIT
BATTERY
291
292
295

FIG.30

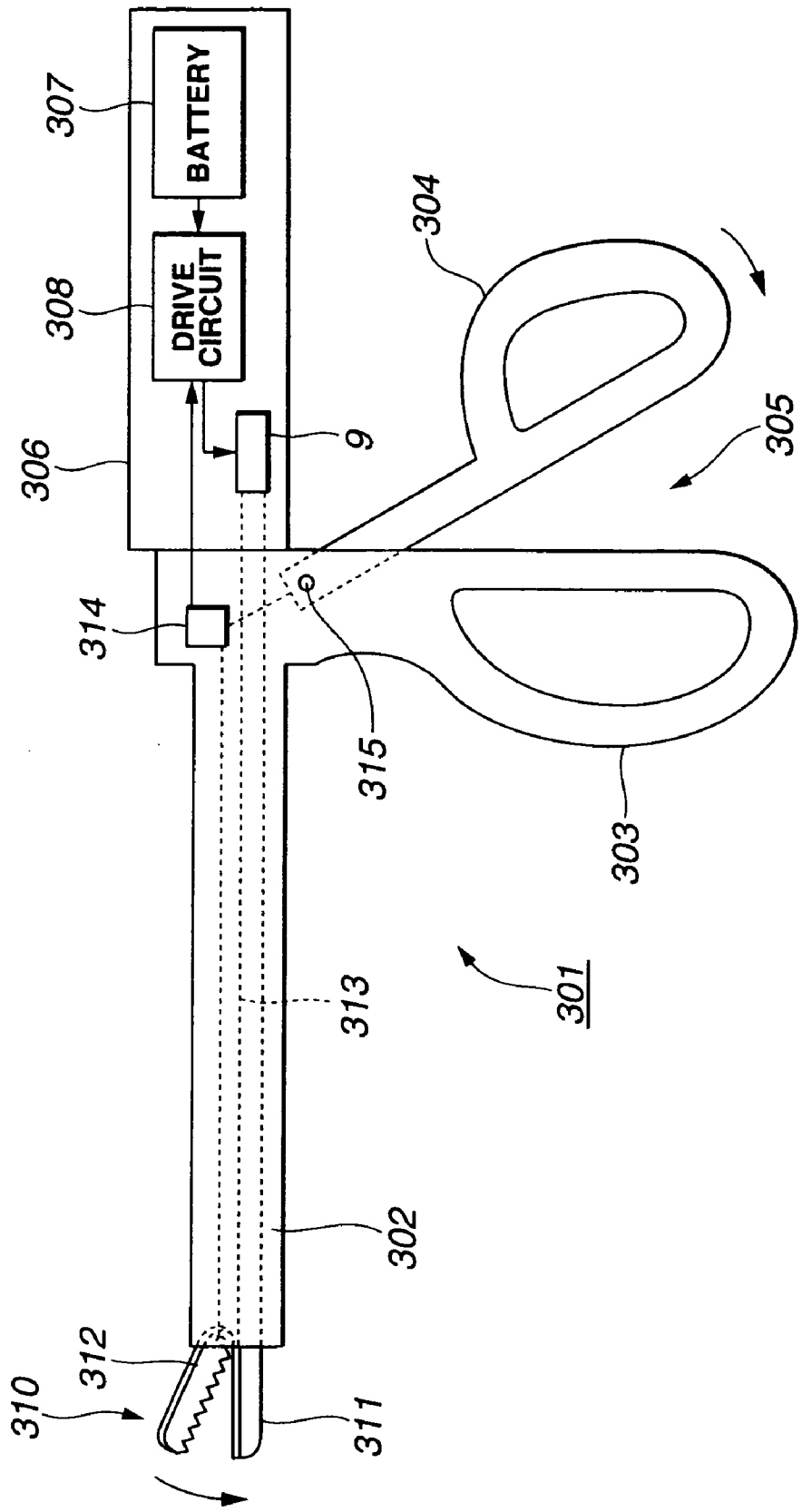

BATTERY
DRIVE CIRCUIT
307
308
306
9
304
305
314
315
303
313
301
302
312
310
311

FIG.31

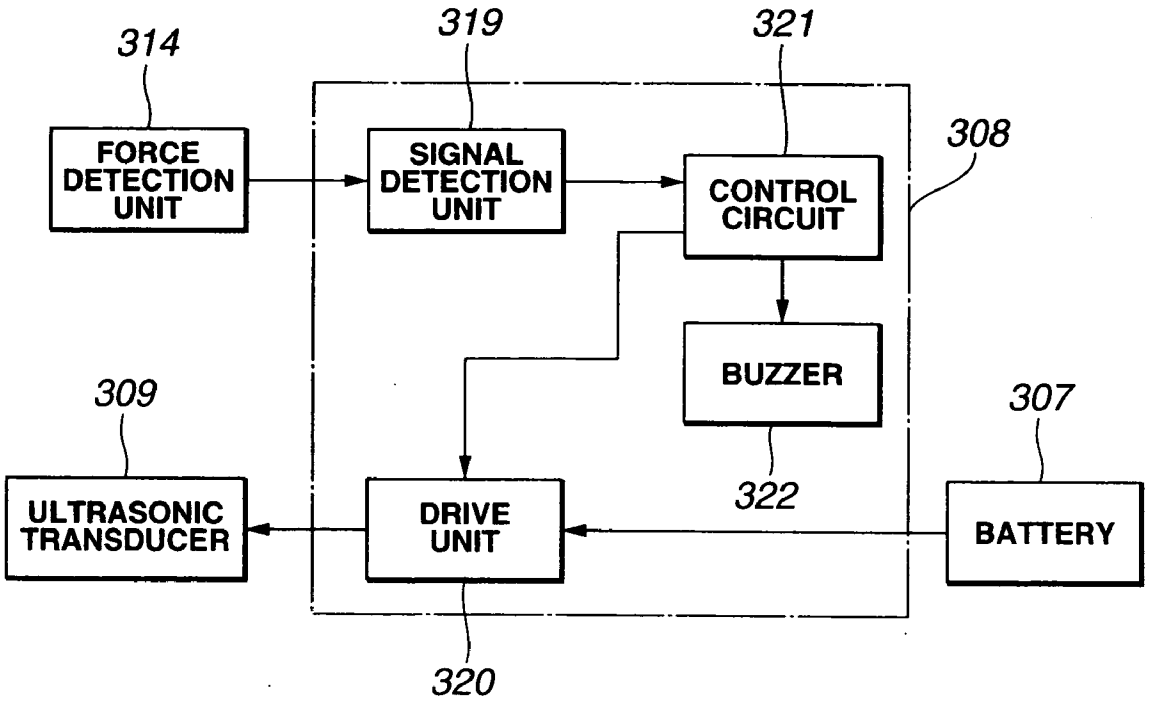

314
319
321
308
FORCE DETECTION UNIT
SIGNAL DETECTION UNIT
CONTROL CIRCUIT
BUZZER
309
307
322
ULTRASONIC TRANSDUCER
DRIVE UNIT
BATTERY
320

FIG.32

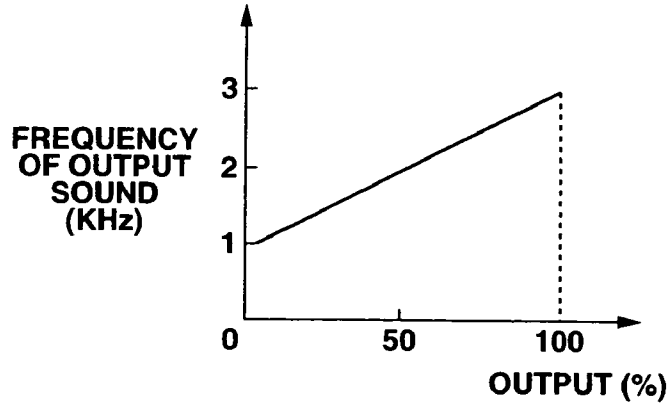

FREQUENCY OF OUTPUT SOUND (KHz)
3
2
1
0
50
100
OUTPUT (%)

FIG.33

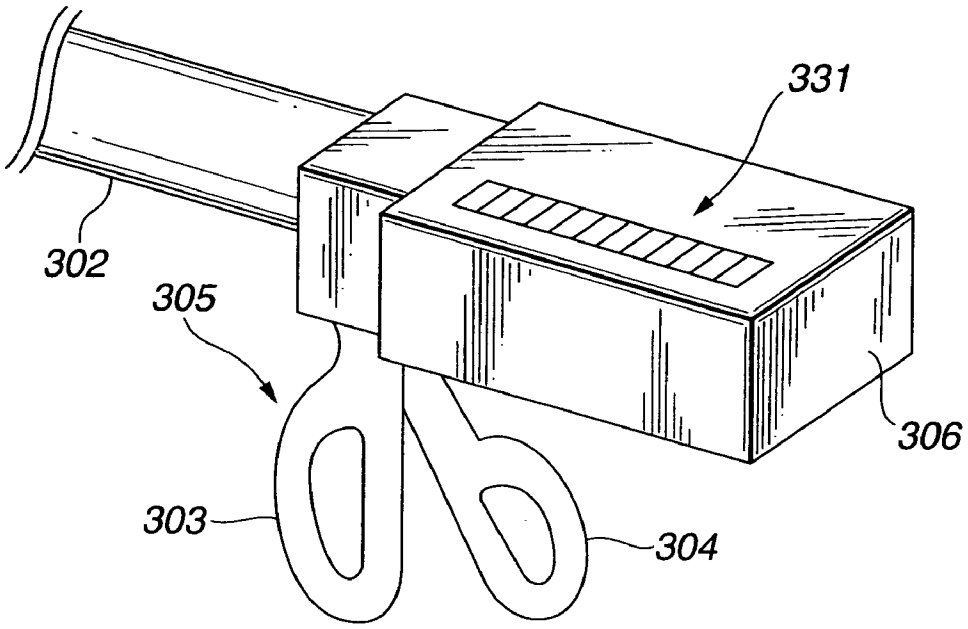


FIG.34

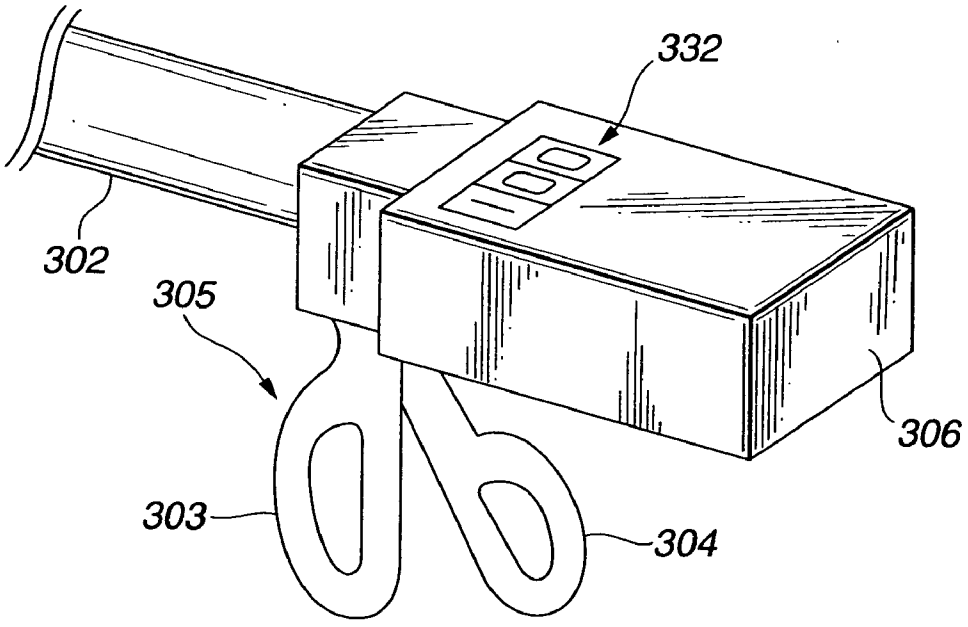


FIG.35

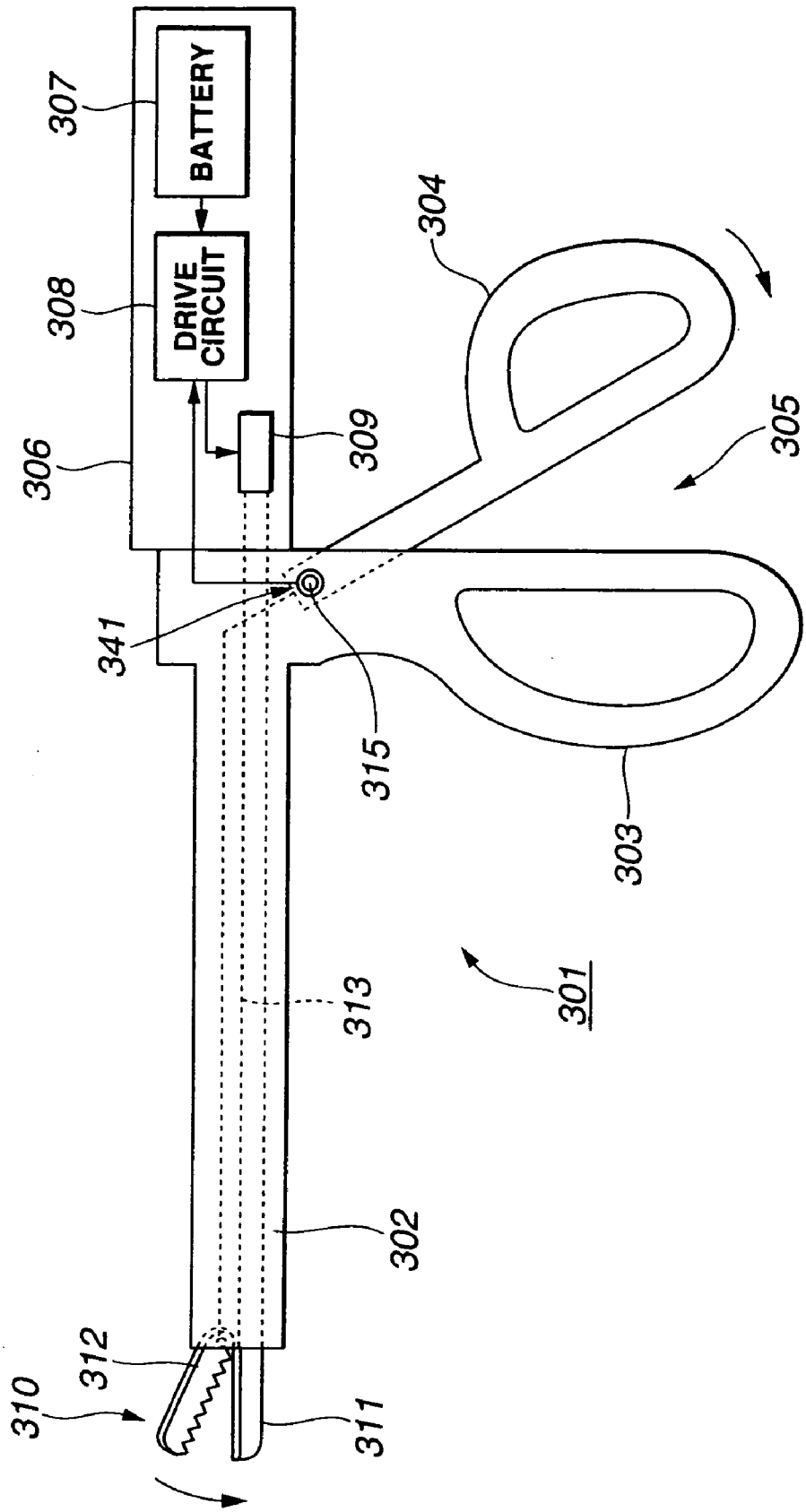

BATTERY
DRIVE CIRCUIT
307
308
309
304
305
306
341
315
303
313
301
302
312
310
311

FIG.36

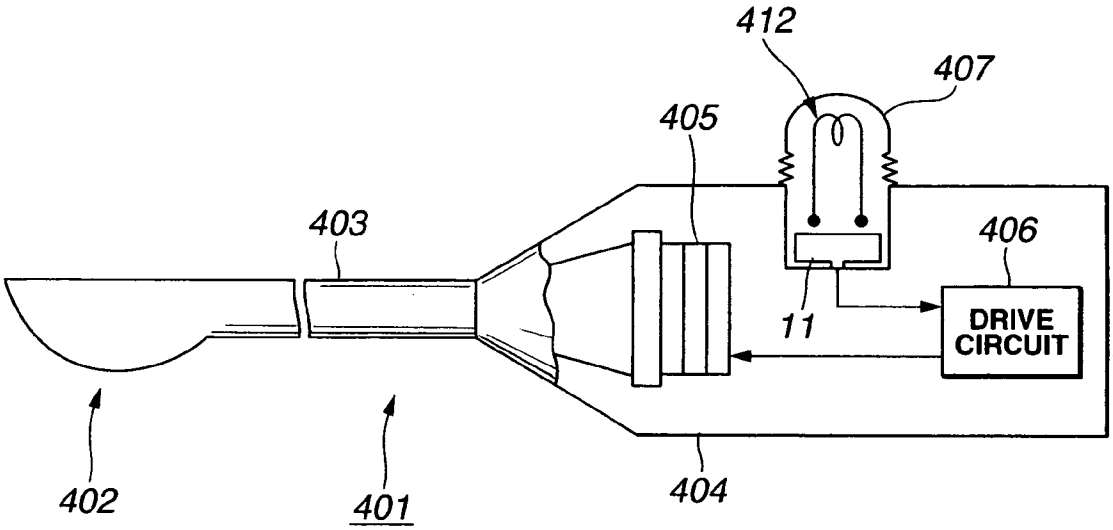

412
407
405
403
406
11
DRIVE CIRCUIT
402
401
404

FIG.37

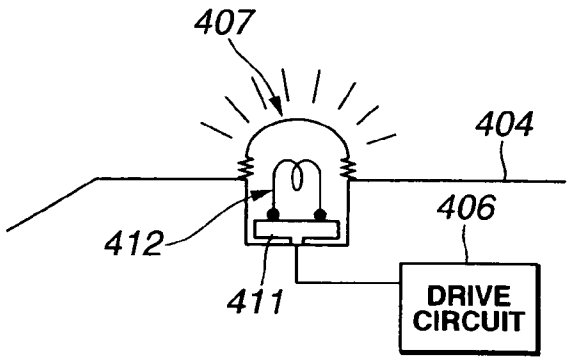

407
404
406
412
411
DRIVE CIRCUIT

FIG.38A

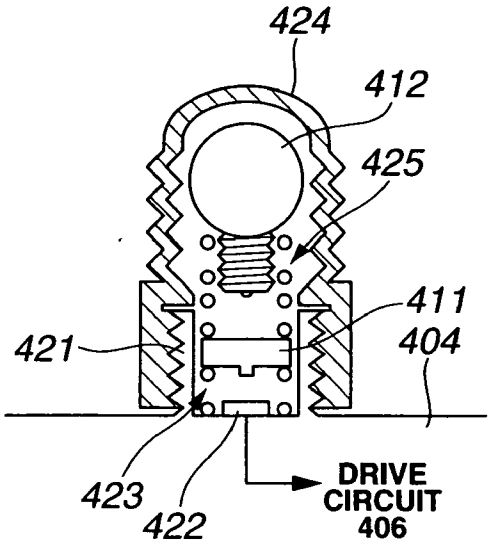


FIG.38B

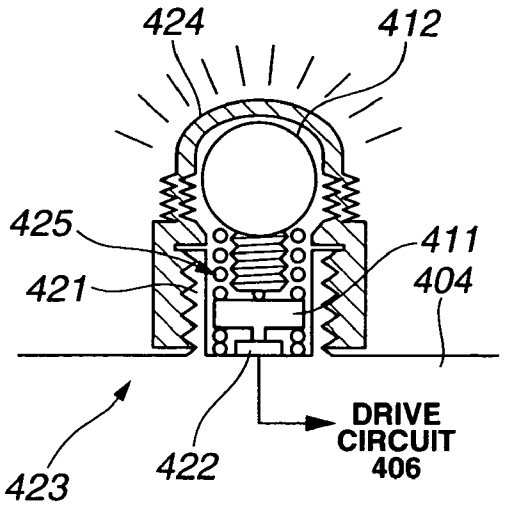


FIG.39

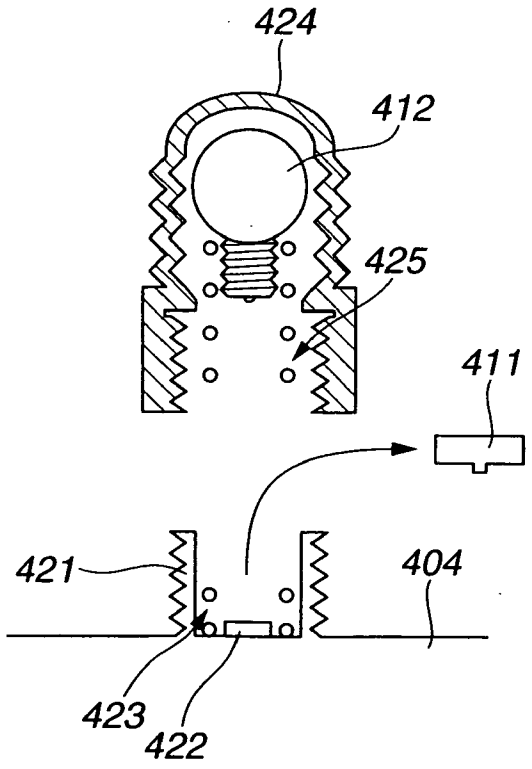


FIG.40

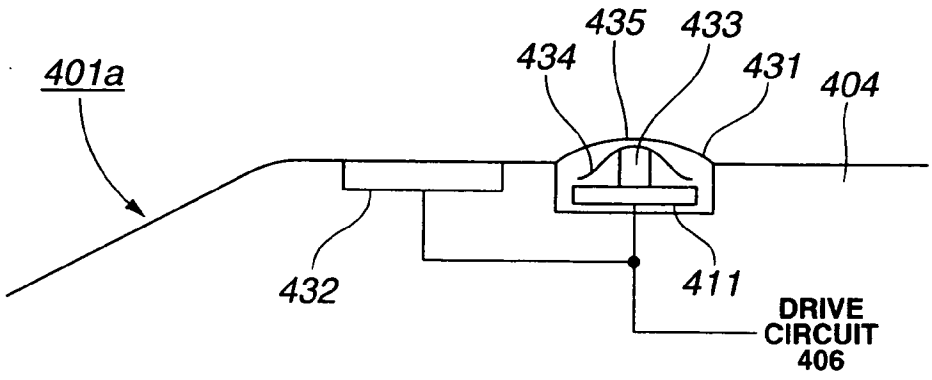
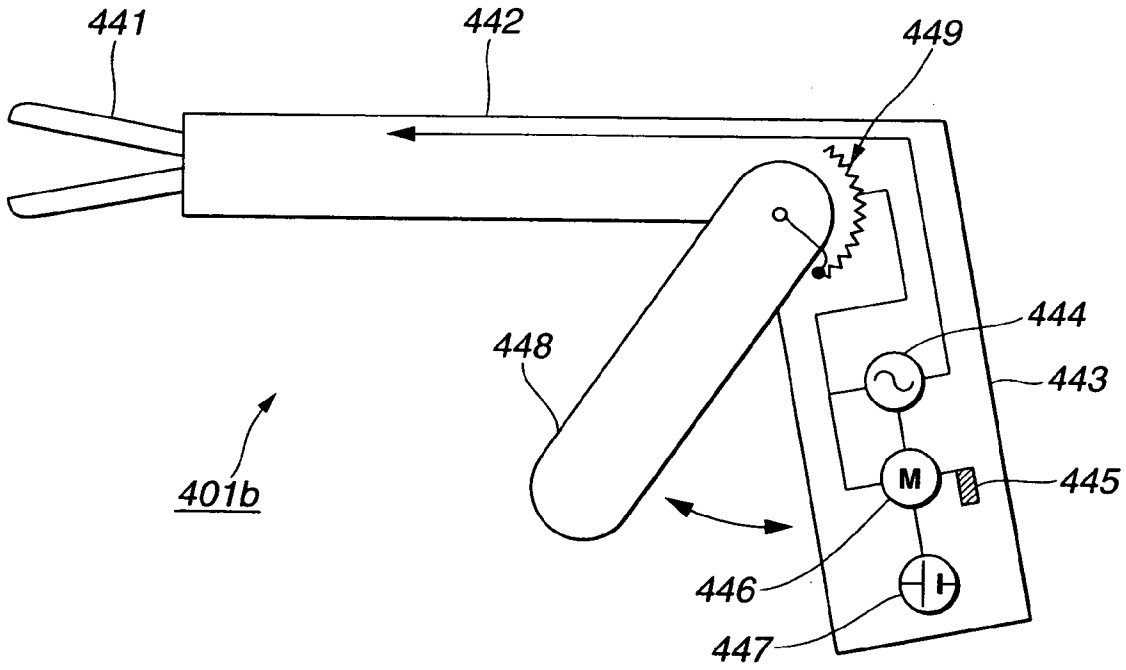

401a
435
433
434
431
404
432
411
DRIVE
CIRCUIT
406

FIG.41


441
442
449
444
448
443
401b
M
445
446
447

SURGICAL APPARATUS PERMITTING RECHARGE OF BATTERY-DRIVEN SURGICAL INSTRUMENT IN NONCONTACT STATE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a divisional of U.S. application Ser. No. 09/492,711 filed Jan. 27, 2000, entitled SURGICAL APPARATUS PERMITTING RECHARGE BATTERY-DRIVEN SURGICAL INSTRUMENT IN NONCONTACT STATE, which claims the benefit of Japanese Patent Application No. 11-059271 filed in Japan on Mar. 5, 1999, Japanese Patent Application No. 11-076336 filed in Japan on Mar. 19, 1999, Japanese Patent Application No. 11-080534 filed in Japan on Mar. 24, 1999, Japanese Patent Application No. 11-084350 filed in Japan on Mar. 26, 1999, and Japanese Patent Application No. 11-089393 filed in Japan on Mar. 30, 1999, the contents of which are incorporated by this reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a surgical apparatus making it possible to recharge a secondary battery included in a battery-driven surgical instrument with an energy generation unit such as a recharger and the surgical instrument held in noncontact with each other.

[0004] 2. Description of the Related Art

[0005] In recent years, surgical procedures to be performed under endoscopic observation have been developed.

[0006] A surgical instrument in accordance with a related art disclosed in, for example, Japanese Examined Patent Publication No. 2-43501 has a battery incorporated in a handpiece. Moreover, a motor and a treatment instrument are unified, and the motor is powered with the built-in battery.

[0007] According to the related art, the necessity of a power cord that is annoying an operator who manipulates the surgical instrument can be obviated to improve the maneuverability of the surgical instrument. There is a drawback that when electrical energy contained in the battery runs out, treatment cannot be performed any longer.

[0008] To avoid having to replace the battery during surgery it must be done prior to the surgery. However, this is added work, and if the surgical instrument has merely been used at some steps of a surgical procedure, there is a possibility that the battery need not be renewed. Nevertheless, to avoid the trouble of renewing the battery during surgery, the battery is replaced beforehand.

[0009] Moreover, when replacing a battery in a sterilized surgical instrument, the surgical instrument must be handled very carefully for fear it may be contaminated. A nurse or the like is obliged to incur a large burden.

[0010] For overcoming this drawback, a rechargeable battery may be incorporated in the surgical instrument and recharged using a recharger. However, the related art has a drawback that the sterilized surgical instrument must be sterilized again or must be handled carefully so as not to be contaminated during connection of the recharger. Moreover, measures must be taken to maintain the watertightness of the junction between the surgical instrument and recharger.

SUMMARY OF THE INVENTION

[0011] An object of the present invention is to provide a surgical apparatus making it possible to recharge a sterilized surgical instrument without risk of contamination.

[0012] Another object of the present invention is to provide a surgical apparatus substantially obviating the necessity of renewing a battery during surgery.

[0013] A surgical apparatus according to the invention is comprised of a surgical instrument, an energy generation unit, an energy radiating device, and a charging energy producing device. The surgical instrument has a rechargeable secondary battery and a treatment section to be electrically driven by the secondary battery, and can be disinfected or sterilized. The energy generation unit is located outside the surgical instrument and used to recharge the secondary battery. The energy radiating device included in the energy generation unit radiates energy. The charging energy producing device is incorporated in the surgical instrument, receives energy without the need for the surgical instrument and energy generation unit to be in contact with each other, and produces energy used to recharge the secondary battery.

[0014] Consequently, the secondary battery can be recharged without the sterilized surgical instrument being contaminated. Moreover, the recharge substantially obviates the necessity of renewing the battery during surgery.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] **FIG. 1** to **FIG. 5B** relate to the first embodiment of the present invention;

[0016] **FIG. 1** shows the configuration of a surgical system including the first embodiment;

[0017] **FIG. 2** shows the configuration of the surgical system being recharged;

[0018] **FIG. 3A** to **FIG. 3C** show the principles of operation for noncontact recharge and the electrical systems of a surgical instrument and a recharger;

[0019] **FIG. 4A** to **FIG. 4C** are block diagrams showing examples of the configurations of surgical instruments;

[0020] **FIG. 5A** and **FIG. 5B** show the electrical systems of a surgical instrument and a recharger in accordance with a variant;

[0021] **FIG. 6** and **FIG. 7** relate to the second embodiment of the present invention;

[0022] **FIG. 6** is a sectional diagram showing the configuration of a surgical instrument employed in the second embodiment;

[0023] **FIG. 7** is a circuit diagram showing the electrical system of the surgical instrument;

[0024] **FIG. 8** and **FIG. 9** relate to the third embodiment of the present invention;

[0025] **FIG. 8** shows the appearance of a surgical system having the third embodiment;

[0026] **FIG. 9** shows the configuration of part of the surgical system shown in **FIG. 8**;

[0027] **FIG. 10** to **FIG. 12** relate to the fourth embodiment of the present invention;

[0028] **FIG. 10** shows the appearance of a surgical apparatus in accordance with the fourth embodiment;

[0029] **FIG. 11** shows the internal configurations of a surgical instrument and a recharger;

[0030] **FIG. 12** is a sectional view showing a recharge receptacle freely attachable or detachable to or from the recharger;

[0031] **FIG. 13**A and **FIG. 13B** schematically show a surgical instrument in accordance with the fifth embodiment of the present invention;

[0032] **FIG. 14** to **FIG. 17** relate to the sixth embodiment of the present invention;

[0033] **FIG. 14** shows the appearance of an ultrasonic treatment instrument in accordance with the sixth embodiment;

[0034] **FIG. 15** details the configuration of the ultrasonic treatment instrument shown in **FIG. 14**;

[0035] **FIG. 16** shows the configuration of an output adjustment mechanism included in the ultrasonic treatment instrument;

[0036] **FIG. 17** shows an output adjustment mechanism in accordance with a variant;

[0037] **FIG. 18** shows the configuration of an output adjustment mechanism and others included in an ultrasonic treatment instrument in accordance with the seventh embodiment of the present invention;

[0038] **FIG. 19** and **FIG. 20** relate to the eighth embodiment of the present invention;

[0039] **FIG. 19** shows the configuration of an output adjustment mechanism included in a high-frequency treatment instrument in accordance with the eighth embodiment;

[0040] **FIG. 20** shows the configuration of a strain detection device;

[0041] **FIG. 21** and **FIG. 22** relate to the fourth embodiment of the present invention;

[0042] **FIG. 21** shows the appearance of an ultrasonic treatment instrument in accordance with the fourth embodiment;

[0043] **FIG. 22** shows the configuration of the major portion of the ultrasonic treatment instrument;

[0044] **FIG. 23** shows the configuration of the major portion of an ultrasonic treatment instrument in accordance with the tenth embodiment of the present invention;

[0045] **FIG. 24** shows the configuration of the major portion of an ultrasonic treatment instrument in accordance with the eleventh embodiment of the present invention;

[0046] **FIG. 25** to **FIG. 27** relate to the twelfth embodiment of the present invention;

[0047] **FIG. 25** is an oblique view showing the appearance of an ultrasonic coagulation/incision instrument in accordance with the twelfth embodiment;

[0048] **FIG. 26** is an explanatory diagram showing the internal configuration of the ultrasonic coagulation/incision instrument shown in **FIG. 25**;

[0049] **FIG. 27** is an explanatory diagram showing another example of the ultrasonic coagulation/incision instrument;

[0050] **FIG. 28** shows an operation unit for an ultrasonic coagulation/incision instrument in accordance with the thirteenth embodiment of the present invention;

[0051] **FIG. 29** shows a bipolar coagulator in accordance with the fourteenth embodiment of the present invention;

[0052] **FIG. 30** to **FIG. 34** relate to the fifteenth embodiment of the present invention;

[0053] **FIG. 30** shows the configuration of a battery-powered ultrasonic coagulation/incision instrument in accordance with the fifteenth embodiment;

[0054] **FIG. 31** shows the configuration of a drive circuit shown in **FIG. 30**;

[0055] **FIG. 32** shows the relationship between an amount of energy output from a control circuit shown in **FIG. 31** to a drive unit and the frequency of an output sound of a buzzer;

[0056] **FIG. 33** shows the first example of a cylinder shown in **FIG. 30**;

[0057] **FIG. 34** shows the second example of the cylinder shown in **FIG. 30**;

[0058] **FIG. 35** shows the configuration of a battery-powered ultrasonic coagulation/incision instrument in accordance with the sixteenth embodiment of the present invention;

[0059] **FIG. 36** to **FIG. 39** relate to the seventeenth embodiment of the present invention;

[0060] **FIG. 36** shows the configuration of a surgical instrument in accordance with the seventeenth embodiment;

[0061] **FIG. 37** shows a conducting state of a battery unit shown in **FIG. 36**;

[0062] **FIG. 38**A and **FIG. 38B** details the configuration of the battery unit shown in **FIG. 37**;

[0063] **FIG. 39** is an explanatory diagram concerning renewal of a battery in the battery unit;

[0064] **FIG. 40** shows the major configuration of a surgical instrument in accordance with the eighteenth embodiment of the present invention; and

[0065] **FIG. 41** shows the configuration of a surgical instrument in accordance with the nineteenth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0066] Embodiments of the present invention will be described with reference to the drawings below.

[0067] (First Embodiment)

[0068] An surgical system **1** according to the first embodiment as shown in **FIG. 1** and **FIG. 2**, is comprised of a recharger **2** and a surgical instrument **3**A or **3**B. The recharger **2** serves as an energy generation unit and is constructed to generate energy used for recharge and radiate the energy. The surgical instrument **3**A or **3**B is used to perform surgery (treatment) on a living body for cure. A charging energy producing device described below which receives energy from the recharger **2**, and a rechargeable secondary battery **4** is incorporated in the surgical instrument **3**A or **3**B.

[0069] Surgical instrument **3**A or **3**B further include a hand-held portion **5** held by an operator and a shaft portion **6** extending out of the hand-held portion **5**. A treatment section **7**A or **7**B used to treat a living tissue or the like is formed as the distal part of the shaft portion **6**.

[0070] The hand-held portion **5** has a switch **8**. The switch **8** is turned on or off for activating or deactivating treatment section **7**A or **7**B.

[0071] Recharger **2** has a power cord **11** to be plugged into the mains. A plug **12** attached to the distal end of the power cord **11** is fitted into a mains receptacle, whereby alternating electrical energy is supplied from the mains to an output circuit **15** via a power switch **14**.

[0072] The output circuit **15** converts the alternating electrical energy into, electrical energy of a higher frequency. The output circuit **15** is connected to a power transmission circuit **16** including a power transmission coil **16***a*.

[0073] The output circuit **15** may include, as shown in **FIG. 3B, a** power circuit **15***a*, an oscillator circuit **15***b*, and an amplifier **15***c*. The oscillator circuit **15***b* oscillates with direct voltage produced by the power circuit **15***a*. Direct current is supplied from the power circuit to the amplifier **15***c* that amplifies an oscillating signal output from the oscillator circuit **15***b*. The power transmission coil **16***a* included in the power transmission circuit is connected to the output terminal of the amplifier **15***c*.

[0074] The oscillator circuit **15***b* oscillates at frequencies ranging from, for example, several kilohertz to several megahertz. The (high-frequency signal is amplified by the amplifier **15***c* and sent to the power transmission coil **16***a* serving as a power transmitting means.

[0075] Then, electromagnetic energy is radiated from the power transmission coil **16***a* to the surroundings.

[0076] As shown in **FIG. 2, a** concave vial placement section **18** is formed on the top of the recharger **2**. A vial **17** in which the clean surgical instruments **3**A and **3**B that have been washed and disinfected (or sterilized) is put is placed on the vial placement section **18**. The vial **17** can be washed and disinfected (or sterilized).

[0077] The body of recharger **2** having the power transmission coil **16***a* embedded therein, and the vial **17** are made of a material transparent to electromagnetic energy, for example, a glass or a resin such as Teflon.

[0078] The surgical instruments **3**A and **3**B are put in the clean vial **17**. Secondary batteries **4** in the surgical instruments **3**A and **3**B are recharged from the recharger **2** by the energy radiated by power transmission coil **16***a*.

[0079] Specifically, with surgical instruments **3**A and **3**B are held separated from the recharger **2** in vial **17**, electromagnetic energy used for recharge is supplied to power reception units **21**, which are incorporated in the surgical instruments **3**A and **3**B, via the vial **17**.

[0080] As shown in **FIG. 2**, surgical instrument **3**A is comprised of the power reception unit **21**, a rectification control unit **22**, the secondary battery **4**, an energy conversion unit **23**, and the treatment section **7**A. The power reception unit **21** receives electromagnetic energy radiated from the power transmission circuit **16**. The rectification control unit **22** converts the electromagnetic energy received by the power reception unit **21** into direct current and adjusts the voltage to a level suitable for recharging the secondary battery **4**. The battery may be comprised of nickel-hydrogen cells, nickel-copper cells or the like that are rechargeable with an output of the rectification control unit **22**.

[0081] The energy conversion unit **23** is driven by the secondary battery **4**. The treatment section **7**A, for example, a knife, may be driven directly by the energy conversion unit **23** or via the shaft portion **6** serving as a propagation member.

[0082] When the surgical instrument **3**A is, for example, an ultrasonic knife, the energy conversion unit **23** is, as shown in **FIGS. 3C and 4A**, comprised of an ultrasonic generator circuit **23***a* and an ultrasonic transducer **23***b*.

[0083] **FIG. 1** shows a practical configuration of a surgical instrument such as an ultrasonic knife.

[0084] The surgical instrument **3**A has a battery chamber **31** near the back end of the hand-held portion **5**. The back end **31***a* of the battery chamber **31** is open, and terminates in a threaded portion which mates with a threaded lid **32**. A seal such as an O ring **33** is located in a groove **33***a* in lid **32**. When the lid **32** is engaged with the battery chamber **31**, the interior of the battery chamber can thus be held watertight.

[0085] A power reception coil **21***a* included in the power reception unit **21** is wound about the battery chamber **31**. Electrical energy induced in the power reception coil **21***a* is input to the rectification control unit **22** over a lead **22***a*. The rectification control unit **22** adjusts an amount of electrical energy according to voltage suitable for recharging the secondary battery **4** and supplies the electrical energy to the battery.

[0086] The secondary battery **4** is connected to the ultrasonic generator circuit **23***a* via the switch **8**. The ultrasonic transducer **23***b* is connected to the output terminal of the ultrasonic generator circuit **23***a*. When an output signal of the ultrasonic generator circuit **23***a* is applied to the ultrasonic transducer **23***b*, the ultrasonic transducer **23***b* oscillates at an ultrasonic frequency.

[0087] In **FIG. 1**, the power reception coil **21***a*, rectification control unit **22**, and ultrasonic generator circuit **23***a* are embedded in an insulating member.

[0088] The front end **24** of the ultrasonic transducer **23***b* is connected to the shaft portion **6** through an intermediate horn **34**. Ultrasonic waves generated by the ultrasonic transducer **23***b* are amplified by the horn **34**, and propagated into the distal treatment section **7**A by way of the shaft portion **6**.

[0089] The junction between the front end of the horn **34** and the shaft portion **6** is shielded with a cover member (armor member) covering the hand-held portion **5** via a seal member **35** such as a rubber member. The interior of the hand-held portion **5** is held watertight so that the hand-held portion **5** can not only be washed with a cleaning solvent but also be disinfected (or sterilized) with a disinfectant (or a sterilant). Moreover, the hand-held portion **5** resists sterilization to be performed using a sterilization gas.

[0090] Shaft portion **6** may be sealed at the proximal end of the horn **34** as shown in **FIG. 4A**.

[0091] **FIG. 3C** shows a practical example of the electrical system of the surgical instrument **3**A.

[0092] Specifically, the power reception coil **21***a* has both ends thereof connected to input terminals of a rectifier circuit **22***a* included in the rectification control unit **22**. After alternating current is rectified and smoothed, the resultant current is stabilized by a constant-voltage diode **22***b* so that constant voltage will be developed at the secondary battery. The constant-voltage diode **22***b* is connected to the secondary battery **4** via an anti-reverse flow diode **22***c*.

[0093] The secondary battery **4** has one terminal thereof connected directly to an input terminal of the ultrasonic generator circuit **23***a*. The other terminal of the secondary battery **4** is connected to the input terminal of the ultrasonic generator circuit via the switch **8**. The ultrasonic transducer **23***b* is connected to the output terminals of the ultrasonic generator circuit **23***a*.

[0094] The surgical instrument **3**B has the same configuration as the surgical instrument **3**A except that the shaft portion **6** thereof is longer than that of the surgical instrument **3**A and that the distal treatment section **7**B thereof is shaped like, for example, a hook. The surgical instrument **3**B can be disinfected in the same manner as the surgical instrument **3**A.

[0095] Surgical instruments **3**A and **3**B have been described as ultrasonic knives. Alternatively, the surgical instrument **3**A or **3**B may be an electric cauterizer **3**C as shown in **FIG. 4**B, or may be a motor-driven treatment instrument **3**D as shown in **FIG. 4C**.

[0096] As shown in **FIG. 4**B, the electric cauterizer **3**C has a high-frequency output circuit **23***c* in place of the ultrasonic generator circuit included in the ultrasonic knife **3**A. The high-frequency output circuit **23***c* oscillates at a high frequency. An oscillating output of the high-frequency output circuit is amplified and output. The output terminal of the high-frequency output circuit **23***c* is connected to the primary winding of an output transformer **23***d*. A high-frequency output signal is supplied to the secondary winding thereof isolated from the primary winding.

[0097] A pair of high-frequency electrodes **36***a* and **36***b* is connected to the secondary winding of the output transformer **23***d*. A high-frequency output signal is transmitted to the treatment section **7**C is located distally to the high-frequency electrodes. The treatment section **7**C is brought into contact with a living tissue to be treated, whereby resection or cauterizer can be achieved.

[0098] A section of the hand-held portion **5** from which the high-frequency electrodes **36***a* and **36***b* extend is sealed to be watertight and airtight using an insulating member **37**.

[0099] The motor-driven treatment instrument **3**D shown in **FIG. 4C** has a motor control unit **23***e* in place of the ultrasonic generator circuit **23***a* included in the ultrasonic knife **3**A shown in **FIG. 4A**. A motor **23***f* is driven to rotate with an output signal of the motor control unit **23***e*.

[0100] A shaft portion **38** extending from the hand-held portion **5** is coupled to the axis of rotation of the motor **23***f*. A rotary brush **39**, for example, may be formed as a treatment section in the distal part of the shaft portion **38**. The rotary brush **39** is used to peel off surface tissue or perform any other treatment.

[0101] A seal member **40** such as an O ring is put on a section of the hand-held portion **5** from which the shaft portion **38** extends, whereby watertightness is maintained.

[0102] Operations to be exerted by the first embodiment having the foregoing components will be described below.

[0103] For performing surgery using the surgical instruments **3**A and **3**B shown in **FIG. 1**, the lid **32** is opened in order to stow the secondary battery **4** in the battery chamber **31**. The lid **32** is then closed. At this time, the surgical instruments **3**A and **3**B are held watertight and airtight, and can therefore be washed and disinfected (or sterilized).

[0104] The surgical instruments **3**A and **3**B are then washed and disinfected (or sterilized), and put in the vial **17** placed on the vial placement section **18** on the top of the recharger **2**. The vial **17** has been washed and disinfected (or sterilized).

[0105] The plug **12** of the recharger **2** is fitted into a mains receptacle, and the switch **14** is turned on. Consequently, an oscillating signal output from the oscillator circuit **15***b* included in the output circuit **15** of the recharger **2** shown in **FIG. 3B** is amplified by the amplifier **15***c*, and applied to the power transmission coil **16***a*. An A.C. electromagnetic field is produced around the power transmission coil **16***a*. The electromagnetic field induces A.C. current flow in power reception coil **21***a*. Thus, energy is propagated to the power reception coil **21***a* without the need for a conductive connection with the power transmission coil.

[0106] As shown in **FIG. 3**C, the high-frequency signal produced by the power reception circuit **21***a* is supplied to the rectification control unit **22**, rectified by the rectifier circuit **22***a*, and adjusted so that a voltage suitable for recharge will be developed at the secondary battery. The resultant signal is applied to the secondary battery **4**, whereby the secondary battery **4** is recharged.

[0107] When the time required for recharge elapses, surgery can be performed using the secondary battery **4**. An operator picks up, for example, the surgical instrument **3**A from the vial **17**, holds the hand-held portion **5**, and presses an On switch of the switch **8**. Driving power is then supplied from the secondary battery **4** to the ultrasonic generator circuit **23***a*. The ultrasonic generator circuit **23***a* in turn produces oscillations at an ultrasonic frequency. The ultrasonically oscillating output of the ultrasonic generator circuit is applied to the ultrasonic transducer **23***b*. This causes the ultrasonic transducer to oscillate at the ultrasonic frequency. The ultrasonic waves are propagated to the distal treatment section **7**A by way of the shaft portion **6**. This brings the treatment section **7**A into contact with a living tissue. Consequently, resection or any other treatment is carried out.

[0108] After use, the surgical instrument **3**A is washed and disinfected (or sterilized), put in the vial **17** again, and recharged.

[0109] Owing to the foregoing components, the secondary battery **4** incorporated in the surgical instrument **3**A is recharged so that the surgical instrument **3**A can be reused repeatedly. The surgical instrument **3**A or the like must be washed and sterilized prior to every use. The recharger **2** is unclean. The vial **17** that has been washed and sterilized in advance is placed on the recharger **2**. The surgical instrument **3**A or the like is then put in the vial **17**. Thus, the surgical instrument **3**A or the like that has been sterilized can be recharged without risk of contamination.

[0110] If the number of times by which the secondary battery **4** is recharged reaches a limit due to repeated use, the secondary battery **4** may be replaced with a new one.

[0111] **FIGS. 5A and 5B** show energy propagating devices.

[0112] Referring to **FIG. 5A, a** light-emitting device such as a light-emitting diode (LED) **16***b* is caused to glow using a direct-current power source that is the power circuit **15***a*. Light emitted from the LED **16***b* is received by a photoelectric converter such as a solar battery **21***b*, whereby electromotive force causing direct current to flow is induced. The electromotive force is applied to the secondary battery **4** via a control unit comprised of a constant-voltage diode **22***b* and anti-reverse flow diode **22***c*.

[0113] In this case, a light-emitting section of the recharger **2** above the LED **16***b* as well as the vial **17** should be made of a material transparent to light, such as, a glass. Moreover, the solar battery **21** is embedded in the back end of the surgical instrument, for example, in the lid **32** so that the light-receiving section of the solar battery **21** will be opposed to the outer surface of the surgical instrument.

[0114] Referring to **FIG. 5**B, the oscillator circuit **15***b* is oscillated using a direct-current source that is the power circuit **15***a*. An oscillating output of the oscillator circuit causes a sound travelling device such as an ultrasonic loudspeaker **16***c* to output acoustic energy such as ultrasonic energy. An ultrasonic microphone **21***c* or the like receives the acoustic energy and converts it into electrical energy. The electrical energy is supplied to the secondary battery **4** via the rectification control unit **22**. The secondary battery **4** may thus be recharged.

[0115] The present embodiment provides advantages described below.

[0116] According to the present embodiment, the secondary battery **4** incorporated in the battery-driven surgical instrument **3**A or the like is recharged repeatedly. This makes the surgical instrument **3**A or the like reusable many times. Contacts that are electrically coupled to each other are not needed for recharging the battery. The secondary battery can be recharged while held in noncontact with an unclean recharger. Consequently, the secondary battery can be recharged with the surgical instrument left sterilized.

[0117] In short, the surgical instrument will not be contaminated but be recharged readily. The recharge work is simplified greatly, and recharge control is simplified.

[0118] Since recharge is thus achieved, the trouble that a battery is exhausted during surgery (electrical energy runs short) and other troubles can be avoided.

[0119] (Second Embodiment)

[0120] Next, the second embodiment of the present invention will be described with reference to **FIG. 6** and **FIG. 7**. The present embodiment is identical to the first embodiment except that a device for indicating that recharge is completed is in the surgical instrument **3**A of the first embodiment.

[0121] **FIG. 6** shows a surgical instrument **3**E in accordance with this embodiment. The surgical instrument **3**E will be described in comparison with the surgical instrument **3**A shown in **FIG. 1**. Namely, instead of the rectification control unit **22**, a rectification control judgment unit **42** formed by adding a recharged state judgment block **41** to the rectification control unit **22** is included in the hand-held portion **5**. A recharge completion indicator LED **43** connected to the rectification control judgment unit **42** is mounted on the outer surface of the hand-held portion **5**.

[0122] **FIG. 7** shows the electrical system of the surgical instrument **3**E. As shown in **FIG. 7**, the output terminals of the rectifier circuit **22***a* are connected to the positive and negative power terminals of a comparator **41***a* included in the recharged state judgment block **41**. A constant-voltage diode **22***b* is connected to the rectifier circuit **22***a* via a current limiting resistor R1.

[0123] The cathode of the constant-voltage diode **22***b* is connected to the anode of the secondary battery **4** via a selection switch SW and the anti-reverse flow diode **22***c*.

[0124] The anode voltage of the secondary battery **4** is applied to the noninverting input terminal of the comparator **41***a*. A voltage stabilized by the constant-voltage diode **22***b* is lowered at resistors R2 and R3. A resultant reference voltage is applied to the inverting input terminal of the comparator **41***a*.

[0125] A resistor R4 and a capacitor C are connected to the output terminal of the comparator **41***a*. When the voltage at the secondary battery **4** exceeds the reference voltage, a voltage applied to charge the capacitor C is used to change the selection switch SW from a contact a to a contact b. Consequently, the LED **43** connected to the contact b is allowed to glow.

[0126] Incidentally, the resistances given by the resistors R2 and R3 are determined so that a voltage developed at the secondary battery **4** will be equal to the reference voltage at the completion of recharge.

[0127] Moreover, the selection switch SW is formed with, for example, an analog switch. The selection switch SW is, similarly to the comparator **41**, powered by the rectifier circuit **22***a* (omitted from **FIG. 7** for brevity's sake). The other components are identical to those of the first embodiment.

[0128] The present embodiment operates in the same manner as the first embodiment. In addition, when recharging the secondary battery is completed, the fact is detected by checking if the voltage at the secondary battery has exceeded the reference voltage. The contacts of the selection switch SW are then changed to prevent charging current from flowing into the secondary battery **4**. Besides, the LED **43** is allowed to glow (lit).

[0129] When the LED **43** is lit, an operator recognizes that recharging the surgical instrument **3**E has been completed.

The operator should use a surgical instrument whose LED **43** is lit. It can thus be reliably prevented that a battery is exhausted during surgery.

[**0130**] The present embodiment can provide the same advantages as the first embodiment. In addition, by checking if the LED **43** is lit (or unlit), it can be recognized whether recharging the secondary battery **4** has been completed. Moreover, excessive recharge can be prevented, thereby lengthening the service life of the secondary battery **4**.

[**0131**] In the present embodiment, a detecting means is included for detecting whether recharge is completed. When completion of recharge is detected, the LED **43** is lit in order to notify a user of completion of recharge. Alternatively, the LED **43** may be lit during recharge. When recharge is completed, the LED **43** may be put out. Whether recharge is in progress or completed may thus be notified.

[**0132**] For charging indication, the anode of the LED **43** shown in **FIG. 7** is connected together with the anode of the diode **22***c* to the contact a of the selection switch SW. When recharge is in progress, a dedicated LED may be lit. When recharge is completed, the LED **43** for emitting light whose wavelengths are different from those of light emitted from the LED may be lit. Whether recharge is in progress or completed may thus be notified.

[**0133**] In this case, the LED **43** shown in **FIG. 7** is realized with an LED that glows in green. To indicate charging, the cathode and anode of another LED that glows in red are connected to the cathode of the LED **43** and the contact a of the selection switch SW that are shown in **FIG. 7**.

[**0134**] (Third Embodiment)

[**0135**] A third embodiment of the present invention will be described with reference to **FIG. 8** and **FIG. 9**.

[**0136**] **FIG. 8** shows a tray-like surgical system **51**. The surgical system **51** consists of a recharger **52**, a cart **53** on which the recharger **52** is placed, a sterilization tray **54** placed on the recharger **52**. One or more battery-driven surgical instruments **55** may be placed in the sterilization tray **54**, along with ordinary surgical instruments **56**.

[**0137**] A cord **11** is extended from the recharger **52**, and a plug **12** is attached to the distal end of the cord **11**.

[**0138**] The recharger **52** has the same components as that in the first embodiment. The power transmission circuit **16** is, as shown in **FIG. 9**, included for supplying energy to the power reception units **21** incorporated in the battery-driven surgical instruments **55** placed on the recharger **52**. At this time, the power transmission circuit **16** is in noncontact with the power reception units **21**. Energy received by the power reception unit **21** is supplied to the secondary battery **4** via the rectification control unit **22**. The secondary battery **4** is thus recharged.

[**0139**] When the surgical system is of the tray type, the surgical instruments **55** can be freely oriented in any direction. A weight **57** is therefore incorporated in each battery-driven surgical instrument **55**, so that the power transmission circuit **16** and power reception unit **21** will be oriented so properly as to efficiently transmit energy. For example, when the power transmission circuit **16** and power reception unit **21** are formed with coils, they are oriented so that the axial directions of the coils will be parallel to each other. Thus, energy generated by the coil of the power transmission circuit **16** can be received efficiently by the coil of the power reception unit **21**.

[**0140**] According to the third embodiment, the surgical instruments **55** oriented freely are put in the large sterilization tray **54**. Nevertheless, the surgical instruments are recharged reliably.

[**0141**] Similarly to the second embodiment, when recharging the secondary battery **4** is completed, charging current may be prevented from flowing into the secondary battery **4**. The LED **43** or the like maybe used to notify a user of the completion of recharge.

[**0142**] (Fourth Embodiment)

[**0143**] Next, the fourth embodiment of the present invention will be described with reference to **FIG. 10** to **FIG. 12**.

[**0144**] **FIG. 10** shows a rechargeable ultrasonic coagulation/incision apparatus **61** comprised of a recharger **62** and an ultrasonic coagulation/incision instrument **63** having a built-in secondary battery **4** (see **FIG. 11**).

[**0145**] The recharger **62** has receptacle attachment/detachment recesses **62***a* (see **FIG. 12**) which receive recharge receptacles. The receptacles are removable for washing and sterilization.

[**0146**] Prior to surgery, the ultrasonic coagulation/incision instrument **63** and recharge receptacles **64** are sterilized. For use, the recharge receptacles **64** are mounted in the recharger **62**, and the ultrasonic coagulation/incision instrument **63** is inserted.

[**0147**] As shown in **FIG. 11**, the recharger **62** has, for example, a primary coil **67** as the power transmission circuit **16**. A secondary coil **68** (serving as the power reception unit **21**) is placed inside a housing **69** of the hand-held portion **5** of the ultrasonic coagulation/incision instrument **63**. Energy is propagated to the secondary coil **68** due to electromagnetic induction. The energy is converted into a voltage suitable for recharge by means of the rectification control unit **22** connected to the secondary coil **68**, and then applied to the secondary battery **4**. The secondary battery **4** is thus recharged.

[**0148**] The recharge receptacles **64** are made of a resin such as Teflon or a ceramic that is resistant to disinfection and sterilization. The recharge receptacles **64** are electrically insulated. Although each recharge receptacle **64** is interposed between the primary coil **67** and secondary coil **68**, electromagnetic energy induced in the primary coil **67** can be propagated to the secondary coil **68**.

[**0149**] The secondary battery **4** is connected to the ultrasonic generator circuit **23***a* via a switch (not shown). When the switch is turned on, an oscillating output of the ultrasonic generator circuit **23***a* is applied to the ultrasonic transducer **23***b*. Ultrasonic waves generated from the ultrasonic transducer **23***b* are propagated to the distal treatment section **7**B via the horn **34** and axial portion **6**, and cause the distal treatment section **7**B to oscillate at an ultrasonic frequency.

[**0150**] According to the fourth embodiment, each recharge receptacle **64** is interposed between the primary

coil **67** and secondary coil **68**. Consequently, recharge can be achieved with the ultrasonic coagulation/incision instrument left sterilized.

[**0151**] (Fifth Embodiment)

[**0152**] The fifth embodiment of the present invention will be described with reference to **FIG. 13A**. **FIG. 13A** shows a battery-driven treatment instrument **71** to be employed in endoscopic surgery. The battery-driven treatment instrument **71** is comprised of an operation unit **72** and an insertion unit **73**. A secondary battery **74** extends through the operation unit **72** and insertion unit **73**.

[**0153**] **FIG. 13B** shows another battery-driven treatment instrument **71'** to be employed in endoscopic surgery. A differently-shaped secondary battery **75** extends through the operation unit **72** and insertion unit **73**. The power reception unit **21** employed in, for example, the first embodiment is incorporated in the operation unit **72** (not shown).

[**0154**] An advantage of the fifth embodiment is that the relatively heavy secondary battery **74** or **75** is extends through the both insertion unit **73** and operation unit **72**, the treatment instrument is well balanced and easy to use.

[**0155**] As mentioned previously, according to the first to fifth embodiments, a secondary battery in a surgical instrument can be recharged while held in noncontact with an energy generation unit. In other words, the secondary battery can be recharged with the sterilized surgical instrument left uncontaminated. Moreover, the necessity of renewing a battery during surgery can be substantially obviated.

[**0156**] In the embodiments of surgical instruments described below, it will be understood that charging units as described in connection with the first through fifth embodiments may be employed, and further description will be omitted.

[**0157**] Several embodiments will not be described in which treatment energy output from a treatment section can be adjusted readily and quickly, and an amount of energy output to the treatment section can be adjusted to facilitate delicate or precise treatment.

[**0158**] (Sixth Embodiment)

[**0159**] As shown in **FIG. 14**, an ultrasonic treatment instrument **81A** that is a motor-driven surgical instrument is comprised of an elongated insertion unit **82** to be inserted into a body cavity and an operating unit **83** formed at the back end of the insertion unit **82**. The operating unit **83** is hand-held for manipulating the ultrasonic treatment instrument **81A**. The operating unit **83** includes a handle portion **84** and a movable manipulation lever **85**.

[**0160**] As shown in **FIG. 15**, the ultrasonic treatment instrument **81A** has an ultrasonic transducer **82** located in a housing **91** of operating unit **83**. The ultrasonic transducer **92** oscillates at an ultrasonic frequency in response to a driving signal sent from a transducer drive unit **93**.

[**0161**] Ultrasonic waves (driving force) generated by the ultrasonic transducer **92** are propagated to an ultrasonic treatment section **97** via a horn **94** and an ultrasonic propagation rod **96**. The ultrasonic propagation rod **96** is linked to the horn **94** and run through a hollow sheath **95** which forms an insertion unit. The ultrasonic treatment section **97** is formed by the distal part of the ultrasonic propagation rod **96** (extending out of the distal end of the sheath **95**). The ultrasonic treatment section **97** may be in contact, for example, with a lesion. The lesion is ultrasonically heated and incised or coagulated by utilizing the ultrasonic waves.

[**0162**] The junction between the horn **94** and ultrasonic propagation rod **96** is sealed using a sealing O ring **98**. Thus, the interior of the treatment instrument behind the horn **94** is held watertight.

[**0163**] The transducer drive unit **93** is comprised of an electrical oscillator circuit **101** and a gain control amplifier (GCA) **102**. The gain control amplifier **102** amplifies an output of the oscillator circuit **101** at a variable amplification factor (or by a variable gain). A control circuit **103** varies the gain produced by the GCA **102**. The oscillating output amplified by the gain by the GCA **102** is applied to the ultrasonic transducer **92**.

[**0164**] The ultrasonic transducer **92** is formed, for example, by a bolted Langevin transducer having piezoelectric ceramics layered.

[**0165**] A battery **104** is positioned in a battery chamber in the lowermost area inside the handle portion **84**.

[**0166**] The battery **104** supplies operating power to the control circuit **103** via a power switch (not shown). Power is supplied from the battery **104** to the transducer drive unit **93** via a switch **113**.

[**0167**] The open end of the battery chamber is blocked with a lid **105**. When the lid **105** is moved downward, the battery **104** can be replaced with a new one. A seal member such as an O ring **106** is put on the open end and abutting on the lid **105**, whereby the interior of the handle portion **84** is held watertight.

[**0168**] According to the present embodiment, the manipulation lever **85** is movable. An output adjustment mechanism **111** cooperates with control circuit **103** to adjust ultrasonic treatment energy generated by ultrasonic treatment section **97** according to the magnitude of movement of manipulation lever **85**.

[**0169**] Specifically, as shown in **FIG. 15** and **FIG. 16**, the manipulation lever **85** has a pin **112** piercing the proximal end thereof. The pin **112** is fitted in a guide groove **113** in the body of operating unit **83** and movable longitudinally therein.

[**0170**] As shown in **FIG. 15**, the portion of the housing **91** in which the guide groove **113** is bored is made thicker.

[**0171**] An arm **114** projects from near the center position in a longitudinal direction of the manipulation lever **85** towards the handle portion **84**. The manipulation lever **85** is pulled towards the handle portion **84**, e.g., by a finger put on the manipulation lever **85**. This causes a cylinder **115** to move in a direction parallel to a longitudinal direction of the guide groove **113** (direction of arrow A in **FIG. 16**). The cylinder **115** is attached to the distal end of the arm **114** on the side of the handle portion.

[**0172**] The housing **91** of the handle portion **84** has a cylinder fitting hole into which the cylinder **115** is fitted. An O ring **116** on the perimeter of the cylinder fitting hole, provides a watertight seal.

[0173] A piston **118** based by a compression spring **112** extends out of cylinder **115**. A piezoelectric switch **119** is attached to the extending portion of piston **118**.

[0174] As shown in **FIG. 16**, the piezoelectric switch **119** has, for example, four piezoelectric elements **120***a*, **120***b*, **120***c*, and **120***d* layered. Voltage is developed across a piezoelectric element proportional to an applied force. The voltage is output to the control circuit **103** through electrodes, which are not shown, formed on both sides of the piezoelectric element.

[0175] Each the four piezoelectric elements **120***a* to **120***d* has a different sensitivity to applied force. For example, the piezoelectric element **120***a* has the highest sensitivity, and the piezoelectric element **120***b* has the second highest sensitivity. The piezoelectric element **120***c* has the third highest sensitivity, and the piezoelectric element **120***d* has the lowest sensitivity. When the piezoelectric switch **119** is pressed with feeble force exerted by the spring **117**, even the most sensitive piezoelectric element **120***a* will not generate any voltage.

[0176] Outputs (voltages) from the piezoelectric elements **120***a* to **120***d* are input to four comparators **121***a*, **121***b*, **121***c*, and **121***d* in the control circuit **103**, and compared with a reference voltage that has undergone voltage drops caused by, for example, resistors R1 and R2. Outputs of the four comparators **121***a* to **121***d* are input to a decoder **122**. The decoder **122** decodes the four outputs, produces a gain control signal whose level is proportional to the applied force, and provides the signal to the gain control terminal of the GCA **102**.

[0177] The GCA **102** amplifies an input signal by a gain proportional to the voltage level of the gain control signal applied to the gain control terminal, and outputs the resultant signal. An output signal of the oscillator circuit **101** input to the GCA **102** is amplified by a gain proportional to the voltage level of the gain control signal applied to the gain control terminal of the GCA **102**, and then applied to the ultrasonic transducer **92**.

[0178] The output of the comparator **121***a* is also used to control whether an analog switch **123** is turned on or off. The analog switch **123** is connected in series with the power switch (not shown), and interposed between the secondary battery **104** and the power terminal of the transducer drive unit **93**. When the manipulation lever **85** is manipulated to the extent that the threshold force for piezoelectric element **120***a* is exceeded, an output from the most sensitive comparator **121***a* is driven high, driving power is supplied from the secondary battery **104** to the oscillator circuit **101** and GCA **102**.

[0179] In other words, according to the present embodiment, when the power switch is manipulated, power is supplied from the secondary battery **104** to the control circuit **103** and analog switch **123**. Power is supplied to the transducer drive unit **93** only when the manipulation lever **85** is moved to such an extent that the output from the comparator **121***a* assumes a certain voltage level or more. This is intended to save electrical energy to be consumed by the transducer drive unit **93** when the manipulation lever **85** remains unmoved.

[0180] Operations to be exerted by the ultrasonic treatment instrument **81**A of the sixth embodiment having the foregoing components will be described below.

[0181] Assume that, for example, the ultrasonic treatment instrument is inserted into the abdominal cavity for resetting a lesion or performing surgery to arrest bleeding. In this case, an endoscope (not shown) is inserted into the abdominal cavity using a trocar and cannula so that a lesion can be observed, and the ultrasonic treatment **81**A is inserted while guided with the trocar and cannula.

[0182] When it becomes possible to observe the lesion and the distal part of the ultrasonic treatment instrument **81**A using the endoscope, the power switch of the ultrasonic treatment instrument **81**A is turned on to actuate the control circuit **103**. The distal treatment section **97** of the insertion unit **82** is abutted against the lesion. In this state, the handle portion **84** of the operation unit **83** is held with a hand, and a finger is rested on the finger rest of the manipulation lever **85**. The manipulation lever **85** is then pulled towards the handle portion **84**.

[0183] When the piston **118** is left pressed against the piezoelectric switch **119** due to elastic force exerted by the spring **117**, pressing force is applied to the four piezoelectric elements **120***a* to **120***d* constituting the piezoelectric switch **119**. The pressing force is proportional to manipulating force with which the manipulation lever **85** is pulled towards the handle portion **84**.

[0184] When voltage generated by the most sensitive piezoelectric element **120***a* exceeds a reference level due to the pressing force, an output of the comparator **121***a* is driven high and the switch **123** is turned on. Consequently, power is supplied to the transducer drive unit **93**.

[0185] The oscillator circuit **101** then oscillates. An oscillating output of the oscillator circuit is applied to the ultrasonic transducer **92** via the GCA **102**.

[0186] Assuming that the applied force is small, when voltage generated by the piezoelectric element **120***a* exceeds the reference level, voltages generated by all the piezoelectric elements **120***a* to **120***d* have exceeded the reference level.

[0187] When the output of the comparator **121***a* alone is driven high, the gain produced by the GCA **102** is small, and the amplitude of a transducer driving signal to be applied to the ultrasonic transducer **92** is small. Consequently, the amount of ultrasonic treatment energy output from the treatment section **97** is small.

[0188] Moreover, when the outputs of all the comparators **121***a* to **121***d* are driven high, the gain produced by the GCA **102** is the largest and the amplitude of the transducer driving signal to be applied to the ultrasonic transducer **92** is the largest. Consequently, the amount of ultrasonic treatment energy output from the treatment section **97** is large.

[0189] Consequently, force with which the manipulation lever **85** is pulled towards the handle portion **84** is adjusted so that an amount of ultrasonic output energy suitable for incision can be produced.

[0190] For coagulating a bleeding lesion, the force with which the manipulation lever **85** is pulled towards the handle portion **84** is adjusted to thus set the amount of ultrasonic treatment output energy to a value proportional to the magnitude of force. Consequently, the lesion to be coagulated can be treated with the ultrasonic treatment energy output from the magnitude suitable for coagulation.

[0191] According to the present embodiment, the manipulation lever **85** is manipulated with a finger of a hand holding the operation unit **83** of the ultrasonic treatment instrument **81**A. The output of the distal treatment section **97** of the insertion unit **82** can be readily varied nearly proportionally to the manipulating force. An operator can therefore readily set the amount of treatment output energy to his/her desired value.

[0192] Moreover, since an amount of energy can be varied with a simple manipulation performed with a hand holding the ultrasonic treatment instrument, a surgical procedure requiring a precise and delicate skill can be carried out smoothly.

[0193] **FIG. 17** shows an alternative output adjustment mechanism **111**'. In this variant, an elastic-conducting device **126** having conductivity and elasticity is used instead of the piezoelectric switch **119** shown in **FIG. 16**. When the elastic-conducting device **126** is compressed, its resistance decreases.

[0194] The elastic-conducting device **126** has one end thereof fixed to a restriction plate **127** positioned in the housing and the other end abutted on piston **118** biased by spring **117**.

[0195] One of the electrodes **126***a* formed on elastic-conducting device **126** is connected to a power terminal Vc (the positive electrode of the secondary battery **104**), and the other electrode **126***b* is connected to a ground terminal via a resistor R3. Electrode **126***b* is also connected to the noninverting output terminals of the comparators **121***a*, **121***b*, **121***c*, and **121***d* comprising a control circuit **103**'.

[0196] The inverting output terminal of the comparator **121***a* shown in **FIG. 16** is grounded via a resistor R1, and the inverting input terminal of comparator **121***d* is connected to the power terminal via a resistor R2.

[0197] In the variant shown in **FIG. 17**, resistors R4, R5, and R6 are connected, respectively, between the inverting input terminals of the comparators **121***a* and **121***b*, **121***b* and **121***c*, and **121***c* and **121***d*. Resistors R4-R6 are also connected in series with resistors R1 and R2 between the battery and ground.

[0198] The other components are identical to those of the sixth embodiment. Accordingly, in the variant of **FIG. 17**, when manipulation lever **85** is pressed, the piston **118** exerts force, elastic-conducting device **126**, and the resistance thereof is reduced. Voltage to be applied to the noninverting output terminals of the comparators **121***a* to **121***a* increases accordingly.

[0199] When the voltage exceeds a reference level determined with voltage applied to the noninverting input terminal of the comparator **121***a*, the switch **123** is turned on. The outputs of the comparators **121***a* to **121***d* are decoded by the decoder **122**. A gain control signal proportional to force with which the elastic-conducting device **126** experience is thus applied to the GCA **102**. The amplitude of a driving signal used to drive the ultrasonic transducer **92** is thus controlled.

[0200] Moreover, an amount of treatment energy output from the treatment section **97** is set to a value proportional to the amplitude of the driving signal. In short, this variant provides substantially the same operations and advantages as the sixth embodiment. In addition, however, it is observed that with a piezoelectric switch, voltages generated by the piezoelectric elements **120***a* to **120***d* are likely to be neutralized due to movement of charges made during a specific time interval. For this reason, if the manipulating force applied to lever **85** changes slowly, the generated voltages tend to decrease. This variant of **FIG. 17** is not susceptible to this phenomenon.

[0201] (Seventh Embodiment)

[0202] An ultrasonic treatment instrument **81**B in accordance with the seventh embodiment shown in **FIG. 18** has an output adjustment mechanism **131** partly different from the output adjustment mechanism **111** employed in the sixth embodiment.

[0203] An axis **132** piercing the proximal end of the manipulation lever **85** is fitted in a hole bored in the housing **91** and thus rotationally supported. An angle detection device **133** realized with, for example, a potentiometer is attached to the end of the axis **132** projecting into the housing **91**.

[0204] When the manipulation lever **85** is turned, the potentiometer serving as the angle detection device **133** and coupled to the axis **132** is rotated. Resistance varies proportionally to the angle of rotation.

[0205] Moreover, a scale plate **134** is attached on the perimeter of the axis **132** piercing the proximal end of the manipulation lever **85**. A pointer **135** is attached to lever **85**. An angle of rotation by which the axis **132** is rotated by moving the manipulation lever **85** is may be thus read from the scale plate using pointer **135**.

[0206] A spring **136** is interposed between the manipulation lever **85** and handle portion **84**. The spring **136** constrains the manipulation lever **85** to open. The angle detection device **133** outputs a resistance value or a voltage value, which is proportional to the angle of rotation by which the manipulation lever **85** is turned, to a control circuit **137**.

[0207] The control circuit **137** sends a signal, of which level is proportional to an output value of the angle detection device **133**, to the GCA **102** in the transducer drive unit **93**. The control circuit **137** includes the comparator **121***a* shown in **FIG. 16**. When the manipulation lever **85** is turned a little towards the handle portion **84**, if the output value of the angle detection device **133** exceeds a small reference value, power to be supplied to the transducer drive unit **93** is controlled by turning on or off the switch **123**.

[0208] The secondary battery **104** supplies operating power to the control circuit **137** and to the transducer drive unit **93** via the switch **123**.

[0209] The other components are identical to those of the sixth embodiment.

[0210] The present embodiment exerts the same operations as the sixth embodiment. Specifically, when the manipulation lever **85** is manipulated, the axis **132** is rotated by an angle substantially proportional to the magnitude of manipulating force. When the angle of rotation exceeds a reference value, the control circuit **137** turns on the switch **123** so that power will be supplied to the transducer drive unit **93**. The control circuit **137** outputs a gain control signal, of which level is proportional to the angle of rotation, to the GCA **102**, and thus controls the amplitude of a driving

signal, which is used to drive the ultrasonic transducer **92**, proportionally to the angle of rotation.

[**0211**] Consequently, an amount of treatment energy output from the treatment section **97** is set to a value nearly proportional to the magnitude of manipulating force with which the manipulation lever **85** is manipulated.

[**0212**] According to the present embodiment, the manipulation lever **85** is manipulated with a finger of a hand holding the operating unit **83** of the ultrasonic treatment instrument **81**. An output from the distal treatment section **97** of the insertion unit **82** can be readily varied nearly proportionally to the manipulating force. Consequently, an operator can readily set the amount of treatment output energy to his/her desired value, and can quickly perform treatment for cure.

[**0213**] Moreover, the amount of treatment output energy can be varied using a hand holding the operating unit. This is helpful in performing a delicate surgical procedure for precise treatment.

[**0214**] Moreover, according to the present embodiment, an angle of rotation or a magnitude of manipulating force with which the manipulation lever **85** is manipulated can be discerned from the reading of the scale plate **134**. The amount of treatment energy output from the treatment section **97** can be checked based on the angle of rotation or the magnitude of manipulating force. In short, according to the present embodiment, the variable amount of treatment output energy can be checked from the reading of the scale plate **134** pointed out by the jut **135**.

[**0215**] Even in the sixth embodiment, a scale may be formed in a longitudinal direction of the guide groove **113** so that the position within the guide groove **113** at which the pin **112** piercing the proximal end of the manipulation lever **85** is located can be discerned.

[**0216**] Moreover, the present invention is not limited to the means for discerning the amount of treatment output energy using the scale plate **134**. Alternatively, an indicator formed with an LED or the like maybe used to electrically indicate the amount of treatment output energy. Otherwise, the value of an output (voltage, current, or power) actually applied to the ultrasonic transducer **92** may be electrically indicated.

[**0217**] (Eighth Embodiment)

[**0218**] Next, the eighth embodiment of the present invention will be described with reference to **FIG. 19** and **FIG. 20**. A high-frequency treatment instrument in accordance with the present embodiment is different from that of the sixth embodiment in terms of an output adjustment mechanism.

[**0219**] A high-frequency treatment instrument **81**C shown in **FIG. 19** has an output adjustment mechanism **141**. The manipulation lever **85** has the proximal end thereof journaled so that the manipulation lever can pivot freely with an axis of rotation **142** as a center. A hemisphere projection **143** is formed near the proximal end of the manipulation lever **85**, and a strain detection device **144** is embedded in the projection. An elastic rubber insert **145** having elasticity is located at a position in the handle portion **84** at which it is opposed to the projection **143**. The projection **143** is formed with an elastic member whose hardness is higher than that of the insert **145**. Force applied to the projection **143** is conveyed to the strain detection device **144**.

[**0220**] When lever **85** is manipulated, the projection **143** abuts against insert **145** and presses it. An output proportional to the pressing force is then provided by the strain detection device **144** to a control circuit **146**. When the projection **143** hits insert **145**, it is deformed by projection **143**. This permits the lever **85** to pivot with the axis of rotation **142** as a center.

[**0221**] When a signal from the strain detection device **144** exceeds a reference level, the control circuit **146** turns on the switch **123**. Also, the control circuit **146** controls a high-frequency treatment instrument drive unit **147** according to an output signal proportional to the signal input from the strain detection device **144**.

[**0222**] The high-frequency treatment instrument drive unit **147** consists of, for example, an oscillator **147***a* and a GCA **147***b* for amplifying an oscillating output of the oscillator **147***a*. The control circuit **146** varies a gain, which is produced by the GCA **147***b*, proportionally to the signal input from the strain detection device **144**, and thus varies an amount of high-frequency treatment energy provided by distal treatment section via electrodes **148***a* and **148***b* connected to the GCA **147***b*.

[**0223**] **FIG. 20** shows the details of the strain detection device **144**. The strain detection device **144** consists of, for example, three strain gages **149***a*, **149***b*, and **149***c* which constitute a bridge. The strain detection device **144** outputs a signal, which represents a magnitude of strain proportional to the magnitude of pressing force with which the manipulation lever **85** is pressed, to the control circuit **146**.

[**0224**] The other components are identical to those of the sixth embodiment.

[**0225**] According to the present embodiment, high-frequency power generated by the high-frequency treatment instrument drive unit **147** is propagated to the distal treatment section over the electrodes **148***a* and **148***b*. The treatment section is used to perform treatment such as cautery using high-frequency energy.

[**0226**] Even in the present embodiment, an amount of treatment output energy with which high-frequency treatment is carried out can be varied. The treatment output energy is generated by the high-frequency treatment instrument drive unit **147** according to the manipulating force with which the manipulation lever **85** is turned, and then propagated to the treatment section over the electrodes **148***a* and **148***b*.

[**0227**] The present embodiment has substantially the same advantages as the sixth embodiment or its variant.

[**0228**] According to a variant of the present embodiment, strain detection device **144** may be embedded in the elastic rubber insert **145**. In this variant, an output signal of the strain detection device **144** can readily be provided to the control circuit **146** without need for a signal line laid down in the manipulation lever **85** that is movable. This results in a simpler configuration.

[**0229**] (Ninth Embodiment)

[**0230**] Next, the ninth embodiment of the present invention will be described with reference to **FIG. 21** and **FIG. 22**.

[0231] As shown in **FIG. 21**, an ultrasonic treatment instrument **81**D consists mainly of an insertion unit **152** and an operating unit **153**. The operating unit **153** has a handle portion **154** and a manipulation lever **155**. On and Off switches **156** are formed on the top of the operation unit **153**. An output adjustment switch **151** made of a conducting rubber is located at an upper position on the handle portion **154**.

[0232] The output adjustment switch **151** has basically the same structure as the elastic-conducting device **126** shown in **FIG. 17**. When the elastic-conducting device **126** is pressed, its electrical resistance varies depends on pressure applied by the thumb of the user. A control circuit **168** (see **FIG. 22**) detects the resistance in the form of a voltage drop, and varies the amplitude of a transducer driving signal output from the transducer drive unit **93**.

[0233] According to the present embodiment, a distal treatment section **157** of the insertion unit **152** consists of a stationary jaw **158***a* and a movable jaw **158***b*. The movable jaw **158***b* is coupled to a pulley **161** (see **FIG. 22**) by way of an operating wire **159** (see **FIG. 22**) passed through the insertion unit **152**. The pulley **161** is located near the proximal end of the manipulation lever **155**. When the manipulation lever **155** is turned, the movable jaw **158***b* pivots with a pin piercing the proximal end thereof as a center. The movable jaw **158***b* thus opens or closes relative to the stationary jaw **158***a*.

[0234] **FIG. 22** shows the details of the manipulation lever **155** and handle portion **154**. A gear **160** and the pulley **161** are located near the proximal end of the manipulation lever **154** so that they can rotate freely with respect to an axis of rotation **162**. The gear **160** is connected to a motor **164** via a gear **163** engaged with the gear **160**. The motor **164** is attached to the axis of rotation of the gear **163**. The gear **163** rotates along with rotation of the motor **164**.

[0235] Moreover, the back end of the operation wire **159** is linked to the pulley **161** freely rotational together with the gear **160**. When the pulley **161** is rotated, the movable jaw **158***b* opens or closes relative to the stationary jaw **158***a*.

[0236] A pressure sensor fixture **165** is formed to surround the proximal part of the manipulation lever **154**. The pressure sensor fixture **165** is shaped substantially like letter U, and journaled in, as shown in **FIG. 22**, an axis of rotation **166** at the upper end of the pressure sensor fixture. Pressure sensors **167***a* and **167***b* sensitive to pressure are attached to the ends of fork portions of the pressure sensor fixture **165**. The pressure sensors **167***a* and **167***b* can come into contact with the side edges of the manipulation lever **155**.

[0237] The secondary battery **104** supplies power to a control circuit **168** and the transducer drive unit **93** via the On and Off switches **156**.

[0238] Outputs of the pressure sensors **167***a* and **167***b* are input to the control circuit **168** and used to control rotation of the motor **164**.

[0239] To be more specific, when the pressure sensors **167***a* and **167***b* sense pressure, the pressure-sensitive outputs of the pressure sensors are input to the control circuit **168**. The control circuit **168** drives and rotates the motor **164** as long as pressure-sensitive outputs are provided. When pressure is not sensed any longer, the control circuit **168** stops driving and rotating the motor **164**.

[0240] In short, once the manipulation lever **155** is manipulated, the manipulation lever **155** is electrically driven using the motor **164**. Thus, the manipulation lever **155** can be moved with small force. Eventually, the movable jaw **158***b* can be opened or closed relative to the stationary jaw **158***a*.

[0241] The control circuit **168** inputs a signal stemming from a manipulation performed on the output adjustment switch **151**, and thus controls the transducer drive unit **93** (gain to be produced by the GCA **102**) according to the manipulating force applied to the output adjustment switch **151**. Assume that power is supplied to the control circuit **168** or the like using the switch **156**. When the manipulation lever **155** is moved slightly in a direction permitting the movable jaw to close (counterclockwise in **FIG. 22**), the side edge of the manipulation lever **155** presses the pressure sensor **167***a*. The pressure sensor **167***a* senses the pressure and supplies an output to the control circuit **168**. The control circuit **168** then drives the motor **164** to help turn the manipulation lever **155** in the close direction via the gears **163** and **160**. The operation wire **159** is thrust forward, whereby the distal movable jaw **158***b* is driven to close.

[0242] If the manipulation lever **155** is moved in the open direction permitting the movable jaw to open (clockwise in **FIG. 22**), the side edge of the manipulation lever **155** presses the pressure sensor **167***b*. The pressure sensor **167** senses the pressure and supplies an output to the control circuit **168**. The control circuit **168** in turn drives the motor **164** to thus help turn the manipulation lever **155** in the open direction via the gears **163** and **160**. Moreover, the operation wire **159** is wound about the pulley **161** and thus pulled backward, whereby the distal movable jaw **158***b* is driven to open.

[0243] When the output adjustment switch **151** is manipulated, a signal whose level is proportional to a magnitude of pressing force with which the output adjustment switch **151** is pressed is input to the control circuit **168**. The control circuit **168** controls the transducer drive unit **93** (a gain to be produced by the GCA **102**) according to the magnitude of pressing force.

[0244] In the present embodiment, the manipulation lever **155** can be manipulated in the open or close direction with small force. Moreover, the movable jaw **158***b* of the distal treatment section **157** of the insertion unit **152** can be opened or closed with small force.

[0245] To stop driving the motor **164**, the manipulation lever **155** is moved to an intermediate position at which it contacts neither the pressure sensor **158***a* nor the pressure sensor **158***b*.

[0246] Moreover, the output adjustment switch **151** may be used to vary an amount of ultrasonic treatment energy output from the treatment section **157**. Thus, the present embodiment has the same advantages as the sixth embodiment.

[0247] (Tenth Embodiment)

[0248] Next, the tenth embodiment of the present invention will be described with reference to **FIG. 23**. The tenth embodiment is identical to the ninth embodiment except that

the movable jaw **158***b* is normally open and can be closed with a small manipulating force.

[**0249**] Ultrasonic treatment instrument **81**E shown in **FIG. 23** is comprised of a pressure sensor fixture **165**' shaped like letter J, and magnet **171** is attached to the motor **164** having the gear **163**. The shaft of the motor **164** (on the side of the motor opposite to the side thereof on which the gear **163** is located) is fitted in a guide groove **172** so that the shaft can be freely moved in horizontal directions.

[**0250**] An electromagnet **173** is placed on the magnet **171**. The electromagnet **173** is connected to the control circuit **168**. When current is supplied to the electromagnet **173** under the control of the control circuit **168**, magnetic force repulsing the magnet **171** is generated. Consequently, the motor **164** and gear **163** can be moved towards the gear **160** along the guide groove **172**.

[**0251**] As long as no current is supplied to the electromagnet **173**, the magnet **171** is, as shown in **FIG. 23**, attracted to the electromagnet **173**. In this state, the gear **163** is separated from the gear **160**.

[**0252**] The other components are identical to those of the ninth embodiment shown in **FIG. 22**.

[**0253**] When the manipulation lever **155** is moved a little in the close direction, the side edge of the manipulation lever **155** presses on pressure sensor **167***a*. An output of the pressure sensor **167***a* is input to the control circuit **168**. Electricity is conducted to the electromagnet **173**. The resultant repulsion force causes the magnet **171** and motor **164** to move along the guide groove **172** towards the gear **160**. Consequently, the gears **163** and **160** are meshed with each other. The gears **163** and **160** are rotated due to the motor **164**, whereby the manipulation lever **155** is turned in the close direction.

[**0254**] When the side edge of the manipulation lever **155** does not press the pressure sensor **167***a*, the pressure sensor **167***a* does not produce an output signal. Accordingly, the control circuit **168** that receives an output of the pressure sensor **167***a* stops supplying current to the electromagnet **173**. The magnet **171** is therefore attracted to the electromagnet **173**. The gears **160** and **163** are separated from each other and the motor **164** stops rotating.

[**0255**] Moreover, when the output adjustment switch **151** is manipulated, a signal whose level is proportional to the magnitude of the manipulating force with which the output adjustment switch **151** is pressed is input to the control circuit **168**. The control circuit **168** in turn controls the transducer drive unit **93** (a gain to be produced by the GCA **102**) according to the magnitude of pressing force.

[**0256**] According to the present embodiment, almost the same advantage as that of the ninth embodiment is provided when the manipulation lever is moved in the close direction.

[**0257**] (Eleventh Embodiment)

[**0258**] Next, the eleventh embodiment of the present invention will be described with reference to **FIG. 24**. This embodiment has, in addition to the same components as the ninth embodiment, a limiter means for detecting a manipulation zone in which the manipulation lever **155** can be manipulated. When the limiter means detects that the manipulation lever **155** has been manipulated beyond the manipulation zone, the motor **164** is stopped driving the manipulation lever.

[**0259**] In other words, the ultrasonic treatment instrument **81**F shown in **FIG. 24** is different from the ultrasonic treatment instrument **81**D shown in **FIG. 22** in that limit switches **169***a* and **169***b* for detecting the limits of the manipulation zone are located outside the pressure sensors **167***a* and **167***b* respectively.

[**0260**] Output signals of the limit switches **169***a* and **169***b* are input to the control circuit **168**. In response to the signal outputs from the limit switches **169***a* and **169***b*, the control circuit **168** gives control to stop rotation of the motor **164**.

[**0261**] Specifically, a space between the limit switches **169***a* and **169***b* provides a movable zone within which the manipulation lever **155** is movable. As long as the manipulation lever **155** is manipulated within the movable zone, the control circuit **168** gives the same control as that mentioned in conjunction with **FIG. 22**. When lever **155** is moved beyond the movable zone, the control circuit **168** stops rotation of the motor **164**.

[**0262**] The other components are identical to those of the ultrasonic treatment instrument **81**D shown in **FIG. 22**.

[**0263**] If the manipulation lever **155** is moved slightly in the close direction, the side edge of the manipulation lever **155** presses on pressure sensor **167***a*. An output of the pressure sensor **167***a* is then input to the control circuit **168**. The control circuit **168** in turn drives the motor **164** to help turn the manipulation lever in the close direction via the gears **163** and **160**.

[**0264**] When the manipulation lever is moved in the open direction opposite to the close direction, the side edge of the manipulation lever **155** presses the pressure sensor **167***b*. An output of the pressure sensor **167***b* is input to the control circuit **168**. The control circuit **168** in turn drives the motor **164** to help turn the manipulation lever **155** in the close direction via the gears **163** and **160**.

[**0265**] The limit switches **169***a* and **169***b* are located outside the pressure sensor fixture **165**. When the manipulation lever **155** is moved in the close direction, the fork portion of the pressure sensor fixture **155** presses the limit switch **169***a*. The limit switch **169***a* senses the pressure and sends a signal to the control circuit **168**. The control circuit **168** in turn stops rotation of the motor **164**.

[**0266**] When the manipulation lever **155** is moved in the open direction, the fork portion of the pressure sensor fixture **165** presses the limit switch **169***b*. The limit switch **169***b* then senses the pressure and sends a signal to the control circuit **168**. The control circuit **168** in turn stops rotation of the motor **164**.

[**0267**] Moreover, when the output adjustment switch **151** is manipulated, a signal whose level is proportional to the magnitude of the force with which the output adjustment switch **151** is pressed, is provided to the control circuit **168**. The control circuit **168** in turn controls the transducer drive unit **93** (a gain to be produced by the GCA **102**) according to the magnitude of the force.

[**0268**] According to the present embodiment, the same advantage as that of the ninth embodiment is provided when

the manipulation lever **155** is moved within the movable zone. When the manipulation lever **155** is manipulated beyond the movable zone, it can be moved electrically. Thus, the manipulation lever can be prevented from being manipulated to an unnecessary extent.

[**0269**] Next, a description will be made of embodiments of a surgical instrument of improved maneuverability in which manipulation of an operating lever or the like turns a power switch on or off.

[**0270**] (Twelfth Embodiment)

[**0271**] As shown in **FIG. 25**, an ultrasonic coagulation/incision instrument **201** is comprised of an insertion unit **220**, a sheath **230**, and a handpiece **250**. The insertion unit **220** has a treatment section **210**. The sheath **230** is elongated and cylindrical, and serves as a protecting member for protecting the insertion unit **220**. The handpiece **250** includes a hand-held operating unit **240**. The proximal end of the sheath **230** is coupled to the operating unit **240** so that the proximal end can be uncoupled freely. An ultrasonic transducer **251** for generating ultrasonic waves, a drive circuit **252** for driving the ultrasonic transducer **251**, and a secondary battery **253** are incorporated in the handpiece **250**. The battery **253** can be renewed and serves as a power source for supplying driving power to the drive circuit **252**. The ultrasonic coagulation/incision instrument **201** is a battery-powered treatment instrument having the built-in battery **253** as a driving power source.

[**0272**] As shown in **FIG. 26**, ultrasonic waves generated by the ultrasonic transducer **251** in the operation unit **240** are propagated to a distal jaw **211**, which is shaped like a bar, over a propagation rod **211***a*.

[**0273**] The distal treatment section **210** of the insertion unit **220** consists of the distal jaw **211** and a movable part **212** adjoining the distal jaw **211**. The movable part **212** cooperates with the distal jaw **211** in clamping or freeing a living tissue. The back end of the movable part **212** is supported with a distal coupler **213** so that the movable part **212** can be opened or closed.

[**0274**] As shown in **FIG. 25**, the distal end of the sheath **230** opens as an opening **230** having a substantially oval section. The treatment section **210** of the insertion unit **220** projects from the opening **230**. A rotary knob **231** is fixed as an integral part to the proximal end of the sheath **230** (end of the operating unit **240**). The rotary knob **231** is used to turn the movable part **212** of the treatment section **210** with respect to the center axis of the distal jaw **211**. The sheath **230** can be detached from the handpiece **250**.

[**0275**] The operating unit **240** has an integral stationary handle **255**, and a movable manipulation handle **256** movable toward or away from the stationary handle **255**. A U-shaped coupling arm **257** is formed at the upper end of the movable manipulation handle **256**. The substantially center position in a vertical direction on the coupling arm **257** is fixed to the operating unit **240** using a handle fulcrum pin **257***a* so that the coupling arm **257** can pivot freely.

[**0276**] A lock member **258** piercing the upper end of the coupling arm **257** is inserted towards a center-axis direction through a window **259** bored in the side of the operation unit **240**. The lock member **258** has a lock claw **258***a* projected therefrom. The lock claw **258***a* locks a drive shaft **221**, which will be described later, included in the insertion unit **220** within the operation unit **240** so that the drive shaft **221** can be unlocked freely (see **FIG. 26**).

[**0277**] As shown in **FIG. 26**, the propagation rod **211***a* and the drive shaft **221** are passed through the portion of the insertion unit **220** shielded with the sheath **230**. The propagation rod **211***a* has a distal part thereof jutted out as the distal jaw **211** of the treatment section **210**. The drive shaft **221** conveys a clamping or freeing motion, which is made using the movable manipulation handle **256**, to the movable part **212** of the treatment section **210**.

[**0278**] The proximal part of the propagation rod **211***a* is unified with the ultrasonic transducer **251** within the operation unit **240**. Ultrasonic waves generated by the ultrasonic transducer **251** are propagated to the distal jaw **211** over the propagation rod. Thus, the distal jaw **211** is used to ultrasonically treat a lesion in a body cavity.

[**0279**] The drive shaft **221** is an operating member for conveying a clamping or releasing instruction sent from the movable manipulation handle **256** to the movable part **212**. The movable part **212** is journaled in the distal end of the drive shaft **221** using a pin **213***a* thrust into the distal coupler **213**. The back end of the drive shaft **221** is passed through the operating unit **240** and coupled to the movable manipulation handle **256**.

[**0280**] When the movable manipulation handle **256** is moved towards the stationary handle **255**, the drive shaft **221** withdraws and the movable part **212** moves towards the distal jaw **211**. At this time, as the movable manipulation handle **256** is moved in order to close the movable part **212**, the movable part **212** is turned to close and meet the distal part of the distal jaw **211**. The movable part **212** and distal jaw **211** cooperate with each other in clamping a living tissue such as a blood vessel in a human body. In this state, when the ultrasonic transducer **251** is driven, the living tissue clamped by the distal jaw **211** and movable part **212** can be treated ultrasonically.

[**0281**] According to the present embodiment, a switch is formed on a side edge of the stationary handle **255**. When the movable manipulation handle **256** is opened or closed relative to the stationary handle **255**, the switch is turned on or off. Power is supplied from the battery **253** to the drive circuit **252** for driving the ultrasonic transducer **251** to propagate of ultrasonic waves from the ultrasonic transducer **251** to the distal jaw **211**.

[**0282**] A driving switch **261** electrically connected to the drive circuit **252** and turned on or off by opening or closing the movable manipulation handle **256** is formed on the side edge of the stationary handle **255**. Alternatively, a driving switch **261** to be turned on or off by opening or closing the movable manipulation handle **256** may be formed on the side edge of the movable manipulation handle **256**.

[**0283**] The drive circuit **252** is electrically connected to the battery **253** and ultrasonic transducer **251**. The drive circuit **252** consists mainly of an oscillator circuit (not shown) for receiving power from the battery **253** and generating a high-frequency signal, and an amplification circuit (not shown) for amplifying in power the high-frequency signal sent from the oscillator circuit and outputting a driving signal. The drive circuit **252** supplies the

driving signal output from the amplification circuit to the ultrasonic transducer **251** to drive the ultrasonic transducer **251**.

[**0284**] The distal jaw **211** and movable part **212** of the treatment section **210** are caused to clamp a living tissue by opening or closing the movable manipulation handle **256**. The movable manipulation handle **256** turns on the driving switch **261** nearly at the same time. Power is then supplied from the battery **253** to the drive circuit **252**, whereby the ultrasonic transducer **251** is driven. Ultrasonic waves generated by the ultrasonic transducer **251** are then propagated to the distal jaw **211**, which is the distal part of the propagation rod **211***a*, over the propagation rod **211**. Consequently, the living tissue is coagulated or incised.

[**0285**] When the movable manipulation handle **256** of the operation unit **240** is opened or closed, the driving switch **216** is turned on or off responsively. Treatment can therefore be performed only when needed. Besides, the maneuverability of the treatment instrument improves.

[**0286**] As shown in **FIG. 27**, in addition to the driving switch **216**, a second switch **262** may be formed on the operation unit **240**. After the second switch **262** is manually turned on, the movable manipulation handle **256** may be moved to turn on the driving switch **261**. Thus, when a living tissue must merely be clamped with the distal jaw **211** and movable part **212**, even if the movable manipulation handle **256** is opened or closed to turn on the driving switch **261**, neither ultrasonic coagulation nor incision will be carried out.

[**0287**] The present invention will not be limited to this mode. Alternatively, a switch may be formed on an operating unit of an electric cautery or the like for exerting the operation of incision or coagulation for a living tissue using high-frequency heat energy. The operating unit may be manipulated in order to turn on or off the switch.

[**0288**] Moreover, according to the present embodiment, the treatment instrument is of a battery-powered type that uses a battery as a driving power source to perform various kinds of treatment on a living tissue. The present invention is not limited to this type of treatment instrument. The present invention can also be applied to a treatment instrument in which driving power or a driving signal or the like used to drive the ultrasonic transducer **251** may be supplied from an external main unit in order to carry out various kinds of treatment. In this case, after a switch formed on, for example, the external main unit is turned on, the movable manipulation handle **256** may be opened or closed to thus turn on or off the driving switch **261**.

[**0289**] (Thirteenth Embodiment)

[**0290**] Next, the thirteenth embodiment of the present invention will be described with reference to **FIG. 28**.

[**0291**] According to the twelfth embodiment, one battery **253** is used as a driving power source for supplying driving power to an ultrasonic coagulation/incision instrument. Power supply from the battery **253** to the drive circuit **252** for driving the ultrasonic transducer **251** is controlled in order to supply ultrasonic waves from the ultrasonic transducer **251** to the distal jaw **211**. In contrast, according to the thirteenth embodiment, at least two replaceable batteries are used as the driving power source to supply power to the drive circuit **252**. The other components are identical to those shown in **FIG. 26**. The description of the components will therefore be omitted. The same reference numerals will be assigned to the identical components.

[**0292**] As shown in **FIG. 28**, two batteries **271** and **272** having lids **271***a* and **272***a*, being connected to the drive circuit **252**, and capable of being replaced with new ones are incorporated in the operation unit **240** of an ultrasonic coagulation/incision instrument. The battery **271** is placed with a positive electrode thereof located on the left side and a negative electrode thereof located on the right side. The battery **272** is placed with a negative electrode thereof located on the left side and a positive electrode thereof located on the right side. The batteries **271** and **272** are thus connected in parallel with each other.

[**0293**] Consequently, even when one of the two batteries **271** and **272**, for example, the battery **271** is removed, driving power can be supplied from the battery **272** to the drive circuit **252**.

[**0294**] According to the present embodiment, two batteries that can be removed and renewed are used as a driving power source to supply power to the drive circuit **252**. Three or more batteries that can be removed and renewed may be used to supply power to the drive circuit **252**.

[**0295**] (Fourteenth Embodiment)

[**0296**] Next, the fourteenth embodiment of the present invention will be described with reference to **FIG. 29**.

[**0297**] According to the twelfth and thirteenth embodiments, the ultrasonic coagulation/incision instrument **201** is used to ultrasonically coagulate or incise a living tissue. According to the present embodiment, a bipolar coagulator is used to coagulate a living tissue with high-frequency energy.

[**0298**] As shown in **FIG. 29, a** bipolar coagulator **290** is comprised of a treatment section **291**, a hand-held portion **292**, and a handpiece **295**. The treatment section **291** is used to treat a living tissue. The hand-held portion **292** is located at the proximal end of the treatment section **291** and is a hand-held operating unit by which to manipulate the treatment section **291**. A high-frequency output circuit **293** for providing high-frequency energy, and a battery **294** serving as a driving power source for driving the high-frequency output circuit **293** and capable of being renewed are incorporated in the handpiece **295**. The bipolar coagulator **290** is a battery-powered treatment instrument having the built-in battery **294** as the driving power source.

[**0299**] A driving switch **296** to be turned on or off by holding the hand-held portion **292** is formed on one side surface of one of two sections of the hand-held portion **292**. The hand-held portion **292** is held for clamping a living tissue with the treatment section **291**. When the driving switch **296** is thus turned on, power is supplied from the battery **294** to the high-frequency output circuit **293**. This causes high-frequency energy, which is used for coagulation, to develop at the treatment section **291**. The clamped living tissue is then coagulated with the high-frequency energy.

[**0300**] When the hand-held portion **292** is held, the driving switch **296** is turned on or off responsively. Coagulation

is therefore carried out only when needed. Besides, the maneuverability of the treatment instrument improves.

[0301] Similarly to the ultrasonic coagulation/incision instrument **201** described in conjunction with **FIG. 27**, in addition to the driving switch **296**, a second switch (not shown) may be formed on the handpiece **295**. After the second switch is manually turned on, the hand-held portion **292** may be held to thus turn on the driving switch. In this case, when a living tissue must merely be clamped with the treatment section **291**, even if the hand-held portion **292** is held to thus turn on the driving switch **296**, coagulation will not be carried out.

[0302] Similarly to the ultrasonic coagulation/incision instrument described in conjunction with **FIG. 28**, at least two batteries capable of being removed may be used as a driving power source to supply power to the high-frequency output circuit **293**.

[0303] According to the present embodiment, the treatment instrument is of a battery-powered type for performing various kinds of treatment on a living tissue using a battery as a driving power source. The present invention is not limited to this type of treatment instrument. The present invention can also be applied to a treatment instrument in which driving power used to drive the high-frequency output circuit **293** is supplied from an external main unit in order to carry out various kinds of treatment. In this case, for example, after a switch on the external main unit is turned on, the hand-held portion **292** may be held to thus turn on or off the driving switch **296**.

[0304] Next, a description will be made of a surgical instrument in which an amount of output treatment energy used for treatment is controlled based on a magnitude of holding force with which a hand-held portion is held.

[0305] (Fifteenth Embodiment)

[0306] As shown in **FIG. 30, a** battery-powered ultrasonic coagulation/incision instrument **301** in accordance with the fifteenth embodiment consists mainly of an insertion unit **302** and an operation unit **305**. The insertion unit **302** is inserted into a body cavity. The operation unit **305** is formed at the proximal end of the insertion unit **302** and composed of a stationary handle **303** and a movable handle **304**.

[0307] A cylinder **306** is placed along an axis of insertion as a proximal part of the operation unit **305**. A secondary battery **307**, a drive circuit **308**, and an ultrasonic transducer **309** are incorporated in the cylinder **306**. Energy to be output from the drive circuit **308** is supplied from the battery **307**.

[0308] A treatment section **310** is formed at the distal end of the insertion unit **302**, and is comprised of a probe **311** and a movable part **312**. A drive shaft **313** over which a manipulation performed on the movable handle **304** is conveyed to the movable part **312** extends through the insertion unit **302**. A handle **305** is rotatably mounted on a pin **315** extending through stationary handle **303**.

[0309] The stationary handle **303** has a force detection unit **314** for detecting the magnitude of a force to be propagated to the drive shaft **313**. One suitable force detection unit **314** is realized with an electrical capacitance force detector in which the capacitance is a function of the distance between electrodes thereof. Alternatively, a strain gage formed using a piezoelectric element or the like may be used.

[0310] As shown in **FIG. 31**, the drive circuit **308** consists of a signal detection unit **319**, a drive unit **320**, a control circuit **321**, and a buzzer **322**. The signal detection unit **319** detects a signal representing the magnitude of the force detected by the force detection unit **314**. The drive unit **320** drives the ultrasonic transducer **309**. The control circuit **321** controls the drive unit **320** according to the signal sent from the signal detection unit **319**.

[0311] The control circuit **321** provides a sound signal to the buzzer **322** according to an amount of energy to be provided to the drive unit **320**. The buzzer **322** produces sound whose level is proportional to the voltage level of an output of the drive unit **320** controlled by the control circuit **321**.

[0312] The frequency of the signal provided to buzzer **322** may also vary depending on the amount of output energy. **FIG. 32** shows a suitable relationship between the amount of energy output from the control circuit **321** to the drive unit **320** and the frequency of sound output from the buzzer **322**.

[0313] An operator perceives a change in the frequency of sound output from the buzzer **322** with his/her ears, and thus recognizes a change in the amount of output energy.

[0314] Next, a description will be made of operations to be exerted by the battery-powered ultrasonic coagulation/incision instrument **301** in accordance with the present embodiment.

[0315] When the battery-powered ultrasonic coagulation/incision instrument **301** is used to coagulate or incise a living tissue, the living tissue is clamped with the probe **311** and movable part **312** of the treatment section **310** by manipulating the movable handle **304**. The force detection unit **314** detects the magnitude of clamping force. An output signal of the force detection unit **314** is transmitted to the drive circuit **308**. The drive circuit **308** allows the control circuit **321** to control the drive unit **320**. Consequently, the ultrasonic transducer **309** is driven with output energy whose amount depends on the output signal of the force detection unit **314**.

[0316] The relationship between a magnitude of force detected by the force detection unit **314** and the amount of energy output from the drive circuit **308** will be described below.

[0317] Assume that a magnitude of force (no-load force) with which the operating unit **305** is moved with nothing clamped is FO(N), and a maximum magnitude of force exerted when the operating unit **305** is gripped is Fmax(N) (constant). When the operation unit **305** is gripped with the maximum magnitude of force, a maximum set amount of energy output from the drive circuit **308** shall be Pmax(W) (constant). Assuming that a magnitude of force detected by the force detection unit **314** when a living tissue is clamped by manipulating the operation unit **305** is F(N), an amount of energy output from the drive circuit **308**, P(W), is expressed as follows:

$$P=Pmax\times(F-F0)/(Fmax-FO)$$

[0318] The ultrasonic transducer **309** is driven with the amount of output energy P(W).

[0319] In the battery-powered ultrasonic coagulation/incision instrument **301** of the present embodiment, the force detection unit **314** detects a magnitude of force exerted for

manipulating the operation unit **305** to clamp a tissue. The control circuit **321** in the drive circuit **308** controls the drive unit **320**. The ultrasonic transducer **309** is driven with output energy whose amount depends on an output signal of the force detection unit **314**. By manipulating the operation unit **305**, a proper amount of output energy can be applied to a tissue from the ultrasonic transducer **309**. This obviates the necessity of determining the amount of energy output from the ultrasonic transducer **309** while manipulating the operation unit **305**. The maneuverability of the instrument can thus be improved readily and easily.

[**0320**] Body portion **306** need not be cylindrical. Instead, it may generally box-shaped as shown on **FIG. 33**. An indicator **331** composed of LEDs may be formed on the top of the body **306**. An amount of energy output from the drive circuit **308** and dependent on a magnitude of force detected by the force detection unit **314** may thus be indicated in the form of a bar. This helps an operator discern an amount of energy indicated with the indicator while performing surgery.

[**0321**] The indicator **331** indicates a ratio of output power to maximum output power (for example, a maximum output is 300 W) as an amount of energy in the form of a bar. Otherwise, the indicator **331** indicates a ratio of the amplitude of ultrasonic waves to a maximum amplitude in the form of a bar.

[**0322**] Instead of the indicator **331**, a display unit **332** composed of numerical indication LEDs may be provided as shown in **FIG. 34**, formed on the top of the body **306**. In this case, an amount of energy output from the drive circuit **308** according to a magnitude of force detected by the force detection unit **314** is indicated numerically.

[**0323**] Even in this case, an operator can discern an amount of energy displayed on the display unit **332** while performing surgery. Using the display unit **332**, output power (in the unit of the watt, for example, a maximum output is 300 W) or the amplitude of ultrasonic waves (a ratio % of the amplitude to a A maximum amplitude) is indicated in the form of a numerical value.

[**0324**] (Sixteenth Embodiment)

[**0325**] **FIG. 35** shows a battery-powered ultrasonic coagulation/incision instrument **301** in accordance with the sixteenth embodiment of the present invention.

[**0326**] This embodiment differs from the fifteenth embodiment only in that instead of the force detection unit **314**, a torque sensor **341** is, as shown in **FIG. 35**, embedded in the axis **315**. Torque applied to the axis **315** is measured.

[**0327**] The torque sensor **341** is formed with a strain gage. An output signal of the torque sensor **341** is transmitted as a magnitude of holding force, with which the movable handle **304** is held, to the drive circuit **308**.

[**0328**] The movable handle **305** is manipulated to clamp a tissue with the probe **311** and movable part **312** of the treatment section **310**. The torque sensor **341** detects the magnitude of holding force. An output signal from torque sensor **341** is transmitted to the drive circuit **308**. The drive circuit **308** drives the ultrasonic transducer **309** with output energy whose amount depends on the output signal.

[**0329**] Next, a surgical instrument having a means for notifying an operator of a driven state of a treatment section will be described below.

[**0330**] (Seventeenth Embodiment)

[**0331**] As shown in **FIG. 36, a** surgical instrument **401** in accordance with the seventeenth embodiment is comprised of an insertion unit **403** and a hand-held portion **404**. The insertion unit **403** has a knife section **402**, which is a treatment section for incising a tissue, as a distal part thereof. The hand-held portion **404** is located at the proximal end of the insertion unit **403**. A transducer **405** for causing the knife section **402** to vibrate, a drive circuit **406** for driving the transducer **405**, and a battery unit **407** extending from the top of the hand-held portion **404** for supplying power to the drive circuit **406** are incorporated in the hand-held portion **404**.

[**0332**] The battery unit **407** consists of a battery **411** formed with a secondary battery utilizing high polymer and serving as a power supplying means, and a light emitter (or LED) **412** serving as a drive acknowledging means. To operate the device shown in **FIG. 37**, the top of the light emitter **412** is pushed down to the hand-held portion **404**. This causes the battery **411** to supply power to the light emitter **412** and drive circuit **406**. The light emitter **412** is then lit. The drive circuit **406** drives the transducer **405**. Vibrations generated by the transducer **405** are then propagated to the knife section **402**.

[**0333**] To be more specific, as shown in **FIG. 38A, a** contact **422** electrically connected, for example, to a positive electrode of the drive circuit **406**, is formed on the inner bottom of a cylindrical screw section **421** of the outer surface of the hand-held portion **404**. As illustrated, a first spring **423** made of, for example, copper and conducting electricity to the periphery of the lower surface of the battery **411**, constrains the battery **411** to move upward. The first spring **423** is connected to the negative electrode of the drive circuit **406**, though it is not shown.

[**0334**] The light emitter such as a miniature bulb **412**, is located above battery **411** and is linked to the top of the battery **411** by a second spring **425**. A transparent cap **424** is screwed to the screw section **421**. The second spring **425** is made of, for example, copper and conducts electricity to the periphery of the top of the battery. The negative electrode of the light emitter **412** that is the side thereof conducts electricity to the second spring **425**.

[**0335**] The centers of the upper and lower surfaces of the battery **411** serve as the positive electrode of the battery **411**, and the peripheries thereof serve as the negative electrode thereof. The positive and negative electrodes are electrically isolated from each other. When the constraining forces exerted from the first spring **423** and second spring **425** are working, the center of the lower surface of the battery **411** serving as the positive electrode is, as shown in **FIG. 38**, not meeting the contact **422**. Similarly, the center of the upper surface of the battery **411** serving as the positive electrode is not meeting the lower end of the light emitter **412** serving as the positive electrode thereof. In this state, therefore, the light emitter **412** is not lit and the drive unit **406** is not actuated.

[**0336**] When the top of the transparent cap **424** is pushed down, the constraining forces exerted from the first and second springs **423** and **425** are overpowered. The center of the lower surface of the battery **411** serving as the positive electrode meets the contact **422**. Likewise, the center of the

upper surface of the battery **411** serving as the positive electrode meets the positive electrode of the light emitter **412**. In this state, therefore, the light emitter **412** is lit and the drive circuit **406** is actuated.

[**0337**] When the transparent cap **424** is, as shown in **FIG. 39**, disengaged from the screw section **421**, the battery **411** can be renewed.

[**0338**] As mentioned above, according to the present embodiment, when the surgical instrument **401** having the drive circuit **406** driven is in operation, the light emitter **412** that is a drive acknowledgment device lights up. An operator can acknowledge that the surgical instrument **401** is in operation. When the operation of the surgical instrument **401** is stopped, the light emitter **412** is put out. The operator can therefore acknowledge that the surgical instrument **401** has stopped operating.

[**0339**] (Eighteenth Embodiment)

[**0340**] **FIG. 40** shows a portion of a surgical instrument in accordance with an eighteenth embodiment.

[**0341**] This embodiment is nearly identical to the seventeenth embodiment, differing only in that a hand-held portion **404** of surgical instrument **401***a* has a switch **431** with a built-in battery **411** and a light-emitting diode (LED) **432** instead of the battery unit **407**. The switch **431** has a contact **434**. An elastic isolating member **433** is interposed between the contact **434** and the center of the battery **411** serving as the positive electrode thereof. The contact **434** is electrically connected to the drive circuit **406** and the negative electrode of the LED **432**, thought it is not shown.

[**0342**] The center of the lower surface of the battery **411** serving as the positive electrode thereof is electrically connected to the drive circuit **406** and the positive electrode of the LED **432**. The contact **434** is normally not in contact with the periphery of the battery **411** serving as the negative electrode thereof due to elastic force exerted from the elastic isolating member **433**. The contact **434** is therefore normally electrically floating.

[**0343**] When compressing force is applied from the top **435** of the switch **431** to the elastic isolating member **433**, the contact **434** meets the negative electrode of the battery **411**. Consequently, power is supplied to the LED **432** and drive circuit **406**. When the drive circuit **406** is actuated, the LED **432** is lit responsively.

[**0344**] (Nineteenth Embodiment)

[**0345**] **FIG. 41** shows a surgical instrument in accordance with a nineteenth embodiment of the present invention.

[**0346**] As shown in **FIG. 41, a** surgical instrument **401***b* of the present embodiment is comprised of an insertion unit **442** and a hand-held portion **443**. The insertion unit **442** is inserted into a body cavity and has a treatment section **441** formed at the distal end thereof. The hand-held portion **443** is formed at the proximal end of the insertion unit **442**. An oscillator **444** for supplying energy to the treatment section **441**, a motor **446** for rotating an eccentric weight **445** so as to vibrate the hand-held portion **443**, and a battery **447** for supplying power to the motor **446** and oscillator **444** are incorporated in the hand-held portion **443**.

[**0347**] The output of oscillator **444** is determined by the resistance of a variable resistor **449**, the resistance of which depends on a displacement in a turning direction of a handle **448** mounted on the hand-held portion **443**. Moreover, when the handle **448** is turned towards the distal part of the surgical instrument **401***b* opposite to the hand-held portion **443**, the variable resistor **449** becomes nonconducting. This disables power supply from the battery **447** to the motor **446** and oscillator **444**.

[**0348**] As mentioned above, according to the present embodiment, an output of the treatment section **444** is determined with a displacement made by the handle **448**, The hand-held portion **444** is vibrated using the motor **446** according to the output of the treatment section **444**. An operator can therefore recognize the output of the treatment section **444**.

[**0349**] Surgical apparatuses and surgical instruments in accordance with the present invention are not limited to the aforesaid embodiments. A variety of modifications can be made based on the gist of the present invention.

What is claimed:

1. An ultrasonic treatment instrument, comprising:

an ultrasonic transducer which generates ultrasonic waves and a drive circuit therefor;

a battery to supply energy, including to the drive circuit;

a housing incorporating the ultrasonic transducer, the battery and the drive circuit;

a probe having a distal end protruding from the housing and a part that is coupled with the ultrasonic transducer so that the ultrasonic waves are propagated by the probe outside the housing;

a movable member operable by an operator; and

a sensor circuit which detects movement of the movable member, and

wherein the drive circuit is structured to drive the ultrasonic transducer responsive to an output signal of the sensor circuit.

2. An ultrasonic treatment instrument according to claim 1,

wherein the sensor circuit is composed of a switch which is actuated by the movement of the movable member.

3. An ultrasonic treatment instrument according to claim 2, further comprising a second switch for supplying energy from the battery to the drive circuit.

4. An ultrasonic treatment instrument according to claim 1, wherein the sensor circuit is configured to detect the magnitude of a clamping force generated by the movable member, and to transmit an output signal corresponding to the clamping force to the drive circuit.

5. An ultrasonic treatment instrument according to claim 1,

wherein the sensor circuit is configured to detect the magnitude of a torque developed by the movable member, and to transmit an output signal corresponding to the torque to the drive circuit.

6. The ultrasonic treatment instrument of claim 5, wherein the sensor circuit comprises a torque sensor embedded within an axis of rotation associated with the movable member.

7. The ultrasonic treatment instrument of claim 6, in which the torque sensor comprises a strain gage.

8. The ultrasonic treatment instrument of claim 1, in which the sensor circuit comprises an electrical capacitance force detector.

9. The ultrasonic treatment instrument of claim 1, in which the sensor circuit comprises a piezoelectric element.

10. An ultrasonic treatment instrument, comprising:

an ultrasonic transducer to generate ultrasonic waves and a drive circuit therefor;

a probe coupled to the ultrasonic transducer and having a portion which is positioned adjacent a movable part;

a movable member which is operable to move the movable part; and

a sensor circuit which detects movement of the movable member and which provides an output to the drive circuit of the ultrasonic transducer.

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