US 20190150898A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2019/0150898 A1
KAWASAKI et al.
(43) Pub. Date: May 23, 2019

(54) **ENERGY CONTROL DEVICE AND TREATMENT SYSTEM**

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(21) Appl. No.: **16/251,638**

(22) Filed: **Jan. 18, 2019**

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2016/071239, filed on Jul. 20, 2016.

Publication Classification

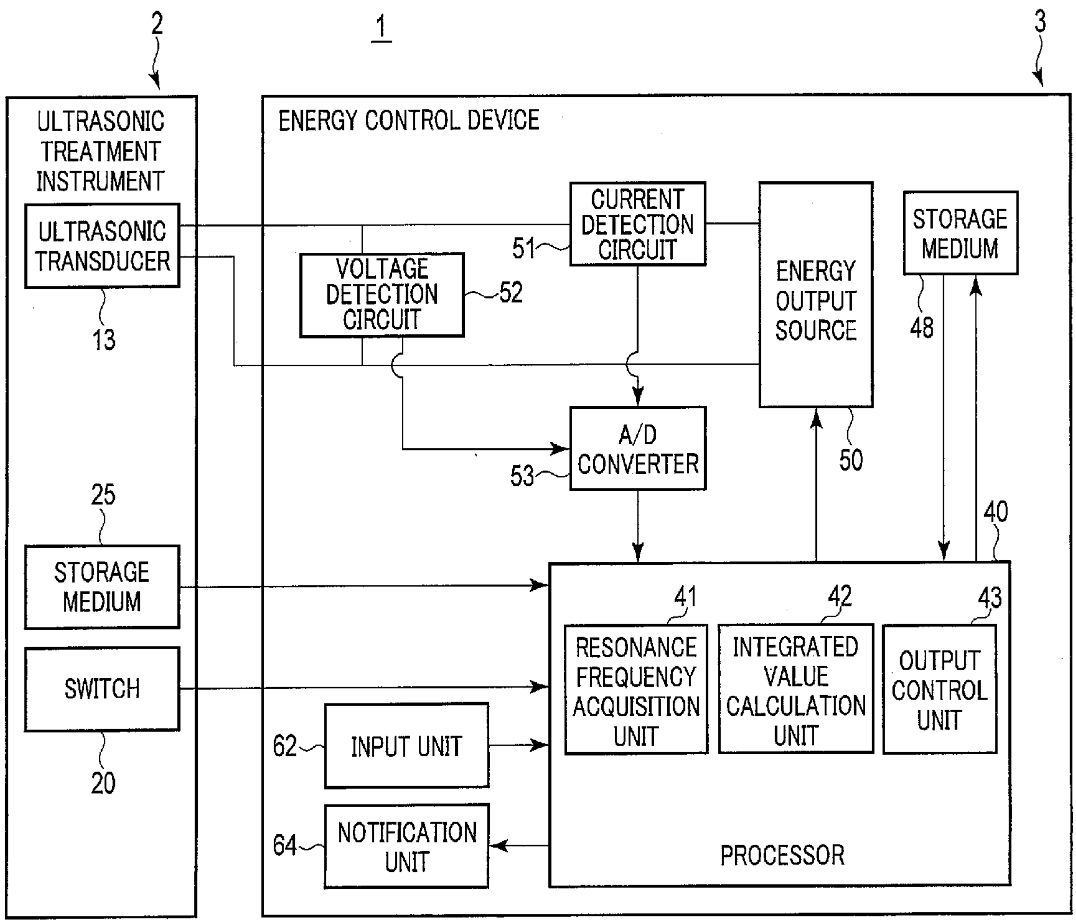
(51) **Int. Cl.**

A61B 8/00	(2006.01)
A61B 17/32	(2006.01)
A61B 8/08	(2006.01)

(52) **U.S. Cl.**
CPC *A61B 8/56* (2013.01); *A61B 8/5207* (2013.01); *A61B 8/4494* (2013.01); *A61B 17/320068* (2013.01)

(57) **ABSTRACT**

An energy control device supplies power to an ultrasonic treatment instrument including an end effector performing treatment using ultrasonic vibration generated by an ultrasonic transducer. The energy control device includes an energy source configured to output the power to the ultrasonic transducer, and at least one integrated circuit. The integrated circuit is configured to: acquire a resonance frequency of a vibration system including the ultrasonic transducer; calculate an integrated value of a difference between the resonance frequency and a predetermined frequency after the acquired resonance frequency has become a first threshold; and perform causing the energy source to stop or reduce an output of the power to the ultrasonic transducer, or notifying that the integrated value has reached the second threshold when the integrated value has reached a second threshold.



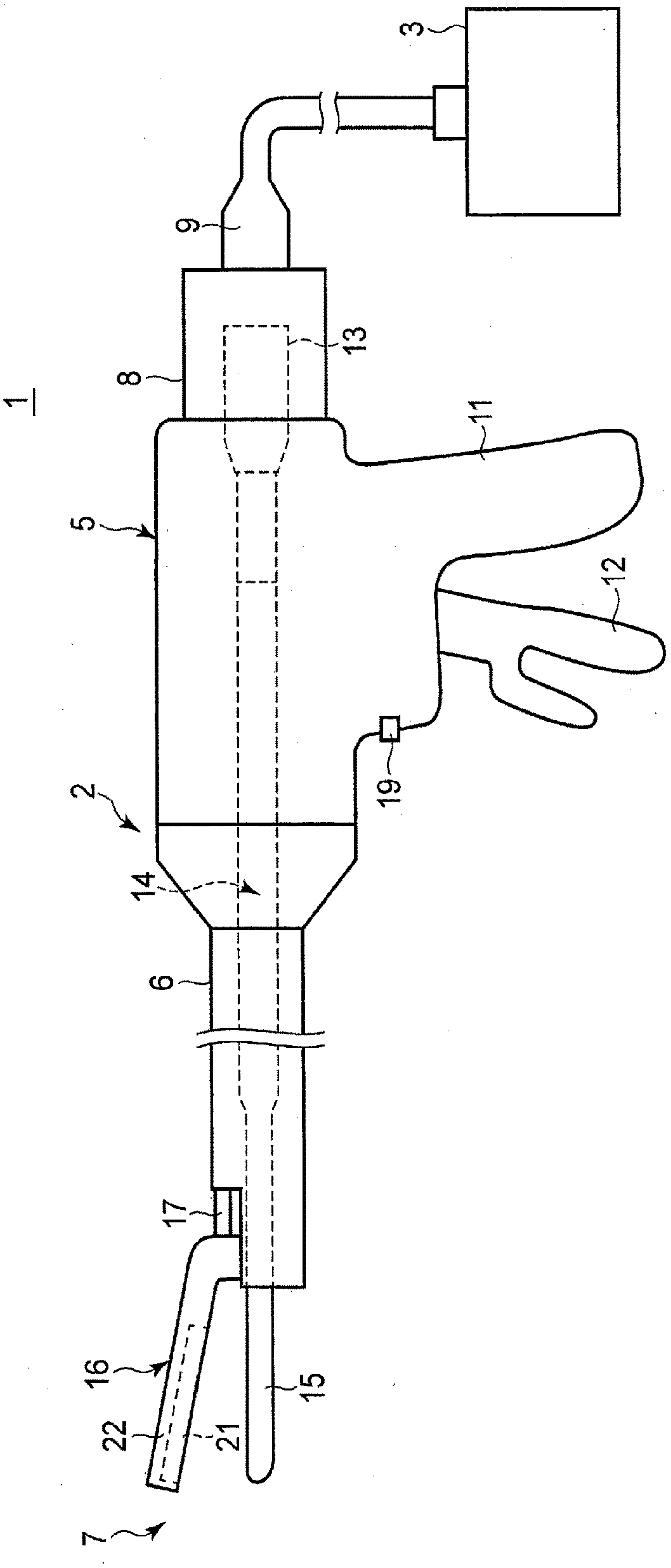
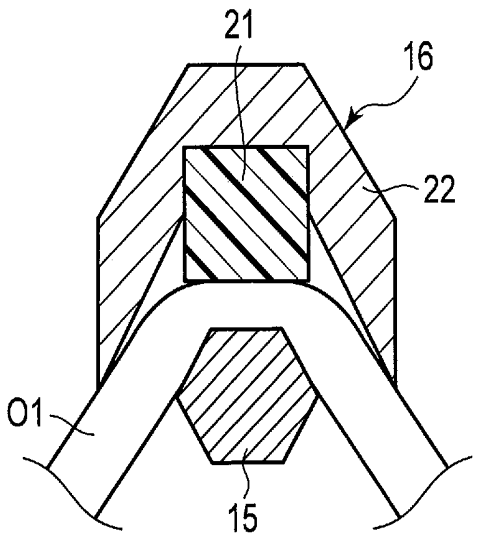
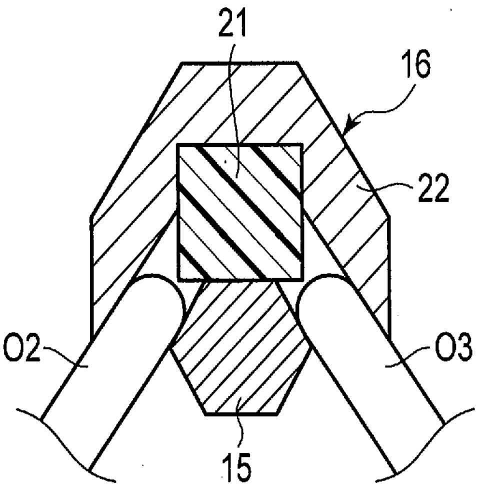


FIG. 1



F I G. 2A



F I G. 2B

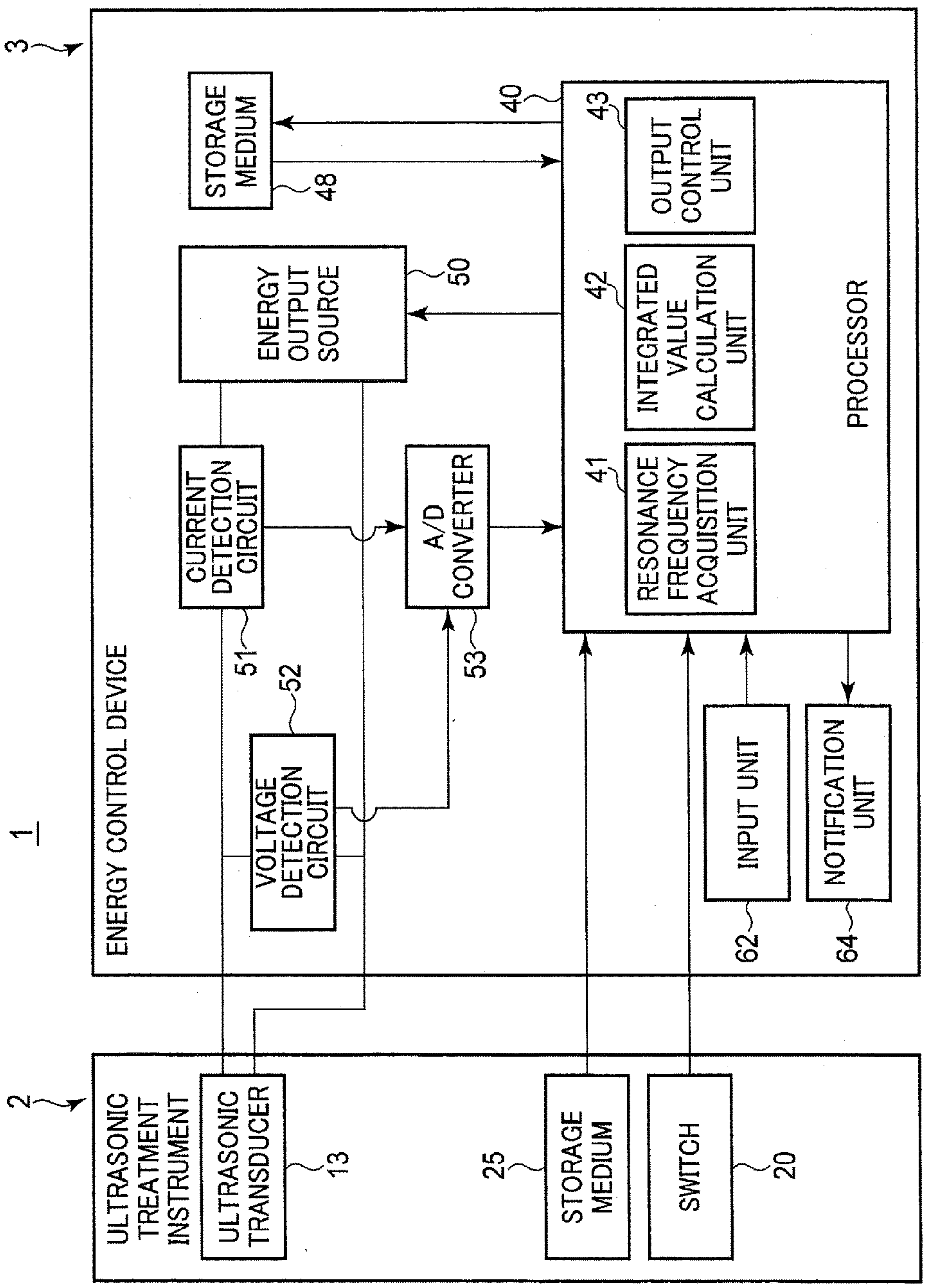

3
1
ENERGY CONTROL DEVICE
STORAGE MEDIUM
48
40
ENERGY OUTPUT SOURCE
50
CURRENT DETECTION CIRCUIT
51
VOLTAGE DETECTION CIRCUIT
52
A/D CONVERTER
53
OUTPUT CONTROL UNIT
43
INTEGRATED VALUE CALCULATION UNIT
42
RESONANCE FREQUENCY ACQUISITION UNIT
41
PROCESSOR
INPUT UNIT
62
NOTIFICATION UNIT
64
2
ULTRASONIC TREATMENT INSTRUMENT
ULTRASONIC TRANSDUCER
13
STORAGE MEDIUM
25
SWITCH
20

FIG. 3

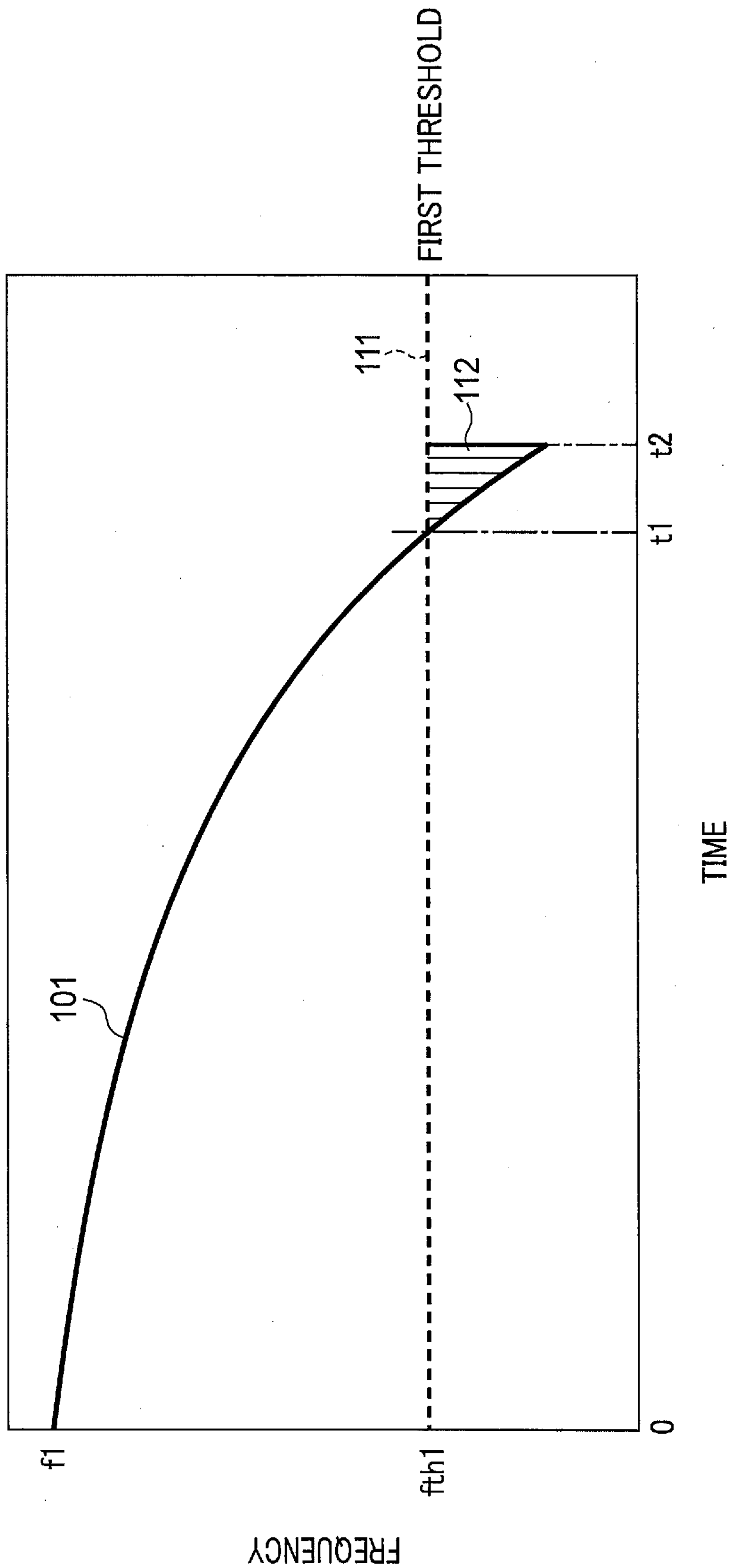
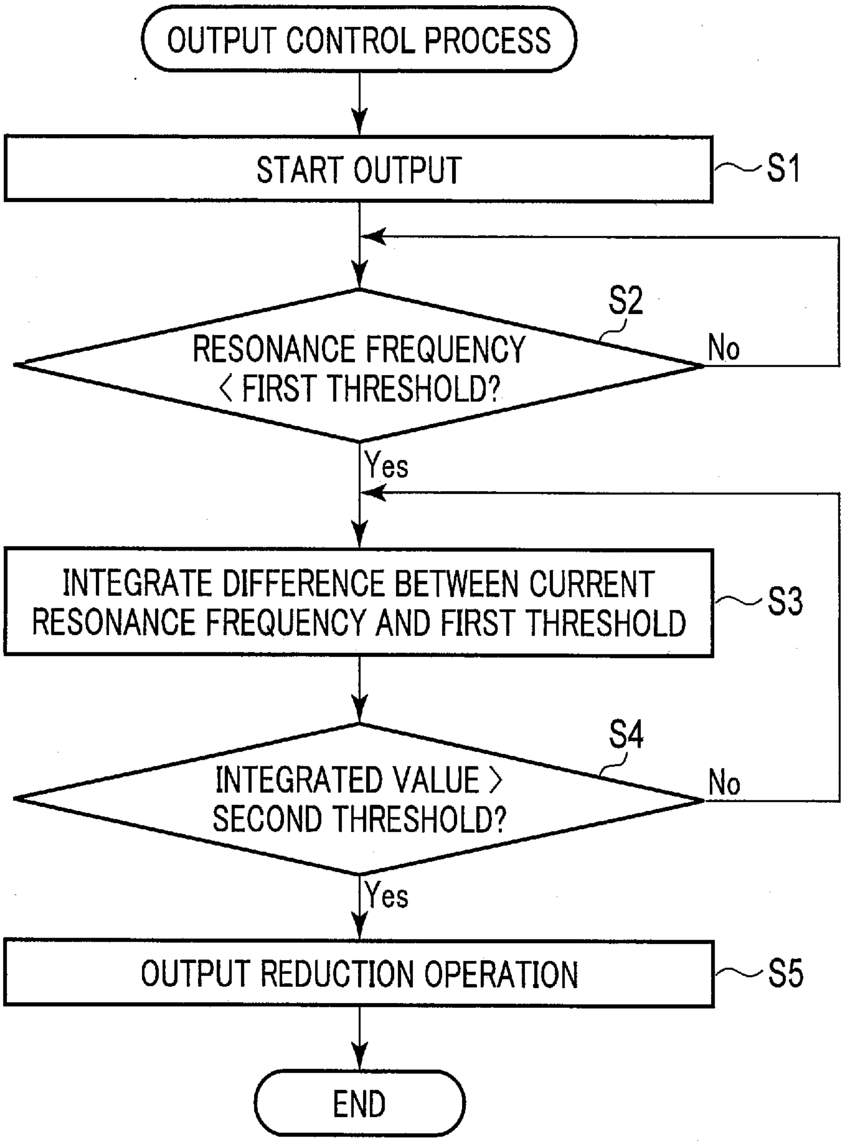


FIG. 4


OUTPUT CONTROL PROCESS
START OUTPUT
S1
RESONANCE FREQUENCY
< FIRST THRESHOLD?
S2
No
Yes
INTEGRATE DIFFERENCE BETWEEN CURRENT
RESONANCE FREQUENCY AND FIRST THRESHOLD
S3
INTEGRATED VALUE >
SECOND THRESHOLD?
S4
No
Yes
OUTPUT REDUCTION OPERATION
S5
END

F I G. 5

ENERGY CONTROL DEVICE AND TREATMENT SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation Application of PCT Application No. PCT/JP2016/071239, filed Jul. 20, 2016, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to an energy control device for an ultrasonic treatment instrument and a treatment system including the same.

2. Description of the Related Art

[0003] There is known an ultrasonic treatment instrument that grasps a living tissue to be treated with a pair of grasping pieces and ultrasonically vibrates one of the grasping pieces to perform coagulation, incision, or the like of the grasped living tissue. An example of such an ultrasonic treatment instrument is disclosed in International Publication No. 2012/044600. A resonance frequency of a vibration system including a grasping piece that ultrasonically vibrates decreases as temperature rises. Therefore, when the resonance frequency of the vibration system is acquired, it is possible to grasp a state of treatment that is being performed to a certain extent. In the ultrasonic treatment instrument disclosed in the above literature, a control device detects a resonance frequency of the vibration system that ultrasonically vibrates, and determines that grasping piece has become sufficiently high temperature when the resonance frequency has fallen below a certain threshold, and reduces an amplitude of ultrasonic vibration.

[0004] It is not preferable to continue the vibration in the ultrasonic treatment instrument that grasps a living tissue with the pair of grasping pieces to perform the treatment of the tissue by ultrasonic vibration even after the treatment has been completed and the tissue has been divided. If the grasping piece vibrates in a state where the pair of grasping pieces is in direct contact with each other, there is a risk that the grasping piece may be damaged. A technique of apprehending the temperature of the grasping piece by detecting the resonance frequency of the vibration system as disclosed in the above literature can also be used to detect division of the tissue to be treated, for example, to stop the output after the division.

BRIEF SUMMARY OF THE INVENTION

[0005] According to an aspect of the present invention, an energy control device supplies power to an ultrasonic treatment instrument including an end effector performing treatment using ultrasonic vibration generated by an ultrasonic transducer. The energy control device includes an energy source and at least one integrated circuit. The energy source is configured to output the power to the ultrasonic transducer. The integrated circuit is configured to: acquire a resonance frequency of a vibration system including the ultrasonic transducer; calculate an integrated value of a difference between the resonance frequency and a predetermined frequency after the acquired resonance frequency has become a first threshold; and perform at least one of causing the energy source to stop or reduce an output of the power to the ultrasonic transducer and notifying that the integrated value has reached the second threshold when the integrated value has reached a second threshold.

[0006] Advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0007] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

[0008] FIG. **1** is a view illustrating an example of an outline of a treatment system according to one embodiment;

[0009] FIG. **2**A is a view illustrating a schematic cross section perpendicular to a longitudinal axis of an end effector regarding the end effector and a tissue to be treated according to one embodiment;

[0010] FIG. **2**B is a view illustrating a schematic cross section perpendicular to the longitudinal axis of the end effector regarding the end effector and the tissue to be treated according to one embodiment;

[0011] FIG. **3** is a block diagram illustrating an example of a configuration relating to supply of power from an energy control device to an ultrasonic treatment instrument according to one embodiment;

[0012] FIG. **4** is a view for describing a frequency change with respect to an elapsed time and a threshold for determination; and

[0013] FIG. **5** is a flowchart schematically illustrating an example of an output control process according to one embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0014] <Configuration of Treatment System>

[0015] One embodiment of the present invention will be described with reference to the drawings. The present embodiment relates to a treatment system that uses ultrasonic vibration to perform treatment of a living tissue. FIG. **1** is a view illustrating a treatment system **1**. As illustrated in FIG. **1**, the treatment system **1** includes an ultrasonic treatment instrument **2** and an energy control device **3** that supplies power to the ultrasonic treatment instrument **2**.

[0016] The ultrasonic treatment instrument **2** includes a housing **5**, a shaft **6** connected to the housing **5**, and an end effector **7** provided at an end of the shaft **6**. A side on which the end effector **7** is provided will be referred to as a distal end side and a side on which the housing **5** is provided will be referred to as a proximal end side. The housing **5** is provided with a grip **11** and a handle **12**. A user grasps the grip **11** to hold the ultrasonic treatment instrument **2**. The handle **12** is configured to be opened and closed with respect to the grip **11**.

[0017] An ultrasonic transducer unit **8** is provided on the proximal end side of the housing **5**. The ultrasonic transducer unit **8** has an ultrasonic transducer **13** including at least one piezoelectric element. The ultrasonic transducer unit **8** is detachably connected to the energy control device **3** via a cable **9**. The ultrasonic transducer **13** vibrates as AC power is supplied from the energy control device **3** to the ultrasonic transducer **13** of the ultrasonic transducer unit **8**.

[0018] A rod member **14** is connected to the ultrasonic transducer **13** of the ultrasonic transducer unit **8**. The rod member **14** passes through the inside of the housing **5** and the shaft **6** and reaches the end effector **7**. That is, a distal end portion of the rod member **14** forms a first grasping piece **15** of the end effector **7**. The rod member **14** is made of a material having a high vibration transmissibility such as a titanium alloy. The ultrasonic vibration generated by the ultrasonic transducer **13** is transmitted to the rod member **14**. As a result, the first grasping piece **15** vibrates. The first grasping piece **15** vibrates at a frequency corresponding to arbitrarily designed resonance of a vibration system. This resonance frequency is, for example, about several tens of kHz although not limited thereto, and may be, for example, 46 kHz to 48 kHz (about 47 kHz).

[0019] A second grasping piece **16** is attached to a distal end portion of the shaft **6** so as to be open or closed with respect to the first grasping piece **15**. The second grasping piece **16** and the handle **12** are connected by a movable member **17** passing through the inside of the shaft **6**. The movable member **17** moves to the distal end side or the proximal end side by opening or closing the handle **12** with respect to the grip **11**, and the second grasping piece **16** rotates with respect to the shaft **6** to be open and closed with respect to the first grasping piece **15**. In this manner, the first grasping piece **15** and the second grasping piece **16** of the end effector **7** are open or closed along with the opening or closing operation of the handle **12** with respect to the grip **11**. The end effector **7** is configured to grasp a living tissue to be treated by the first grasping piece **15** and the second grasping piece **16**.

[0020] The second grasping piece **16** includes a pad member **21** and a holder member **22** to which the pad member **21** is attached. The pad member **21** is made of a resin such as polytetrafluoroethylene (PTFE). In a state where the first grasping piece **15** and the second grasping piece **16** are closed, the pad member **21** of the second grasping piece **16** is in contact with the first grasping piece **15**, and the other portion of the second grasping piece **16** is not in contact with the first grasping piece **15**.

[0021] FIGS. **2**A and **2**B are views illustrating cross sections perpendicular to longitudinal axes of the first grasping piece **15** and the second grasping piece **16** when using the ultrasonic treatment instrument **2**. FIG. **2**A illustrates a state where a tissue O1 to be treated is sandwiched between the first grasping piece **15** and the second grasping piece **16**. The ultrasonic treatment instrument **2** can incise the tissue O1 while coagulating the tissue O1 as the first grasping piece **15** ultrasonically vibrates with the tissue O1 sandwiched between the first grasping piece **15** and the second grasping piece **16**. FIG. **2**B illustrates a state where the tissue is divided into a first tissue piece O2 and a second tissue piece O3. At this time, the pad member **21** is in contact with the first grasping piece **15**.

[0022] The housing **5** is provided with an operation button **19**. An operation to switch on and off of the supply of power from the energy control device **3** to the ultrasonic transducer unit **8** is input to the operation button **19**. Incidentally, the treatment system **1** may be provided with a foot switch having the same function as the operation button **19** instead of the operation button **19** or together with the operation button **19**.

[0023] FIG. **3** is a diagram schematically illustrating a configuration example of the treatment system **1** relating to the supply of power from the energy control device **3** to the ultrasonic treatment instrument **2**.

[0024] As illustrated in FIG. **3**, the ultrasonic treatment instrument **2** is provided with the ultrasonic transducer **13**, a switch **20**, and a storage medium **25**. The ultrasonic transducer **13** is an ultrasonic transducer serving as a vibration source provided in the ultrasonic transducer unit **8** described above. The switch **20** is provided inside the housing **5** of the ultrasonic treatment instrument **2**. The switch **20** is switched between an on-state and an off-state as the operation is input by the operation button **19**. Further, information on the treatment instrument is stored in the storage medium **25**.

[0025] The energy control device **3** includes a processor **40** controlling an operation of the treatment system **1** and a storage medium **48**. The processor **40** operates based on, for example, a program stored in the storage medium **48**, and controls an operation of each unit of the energy control device **3**. In the storage medium **48**, a processing program to be used by the processor **40**, a parameter, a table, and the like to be used for computation performed by the processor **40** are stored.

[0026] Further, the energy control device **3** includes an energy output source **50**, a current detection circuit **51**, a voltage detection circuit **52**, and an A/D converter **53**. The energy output source **50** supplies AC power to the ultrasonic transducer **13** of the ultrasonic treatment instrument **2**. The energy output source **50** outputs power under the control of the processor **40**. The current detection circuit **51** detects a current value of an output current I from the energy output source **50** to the ultrasonic transducer **13**. The voltage detection circuit **52** detects a voltage value of an output voltage V from the energy output source **50** to the ultrasonic transducer **13**. Analog signals output from the current detection circuit **51** and the voltage detection circuit **52** are converted into digital signals via the A/D converter **53** and the converted signals are transmitted to the processor **40**.

[0027] The energy control device **3** further includes an input unit **62** and a notification unit **64**. The input unit **62** is a part that receives an input of a user with respect to the energy control device **3**. The input unit **62** includes, for example, a touch panel, a button switch, a keyboard, or the like. The notification unit **64** is a part that notifies the user of information. The notification unit **64** includes, for example, a display, a speaker, or the like.

[0028] The energy control device **3** according to the present embodiment performs the following operation. That is, when the switch **20** of the ultrasonic treatment instrument **2** is turned on, the supply of power to the ultrasonic treatment instrument **2** is started with detection of such an on-state. Along with the treatment, the temperature of the first grasping piece **15** of the ultrasonic treatment instrument **2** rises, and the resonance frequency of the vibration system having temperature dependence decreases. The energy control device **3** adjusts an output frequency in accordance with the changing resonance frequency. Further, a progress state of the treatment is determined based on the resonance frequency, and the output is stopped or the like. The processor **40** performs computation relating to the operation of the energy control device **3** as described above.

[0029] The processor **40** executes functions as a resonance frequency acquisition unit **41**, an integrated value calculation unit **42**, and an output control unit **43**. The resonance frequency acquisition unit **41** acquires a resonance frequency of the vibration system including the ultrasonic transducer **13**, the rod member **14**, and the like of the ultrasonic treatment instrument **2**. The resonance frequency acquisition unit **41** can acquire the resonance frequency based on an output current and an output voltage from the energy output source **50** supplied to the ultrasonic transducer **13**. The integrated value calculation unit **42** calculates an integrated value of a difference between a resonance frequency and a first threshold after the resonance frequency of a vibration system has become the first threshold. The output control unit **43** controls the output of the energy output source **50**. Such control includes detection of a state of the switch **20** and controlling of the output of the energy output source **50** based on the detection result. For example, when the integrated value of the difference between the resonance frequency and the first threshold has reached a second threshold, the output control unit **43** causes the energy output source **50** to stop or reduce the output of power to the ultrasonic transducer **13**, or notifies that the integrated value has reached the second threshold.

[0030] The processor **40** includes an integrated circuit such as a central processing unit (CPU), an application specific integrated circuit (ASIC), and a field programmable gate array (FPGA). The processor **40** may be constituted by one integrated circuit or the like, or a combination of a plurality of integrated circuits or the like. Such operations of the integrated circuit are performed in accordance with programs recorded in, for example, the storage medium **48** or a recording area in the integrated circuit.

[0031] <Operation of Treatment System>

[0032] The operation of the treatment system **1** according to the present embodiment will be described. When an object to be treated such as a living tissue is treated using the treatment system **1**, the user holds the grip **11** and the handle **12**, and inserts the end effector **7** into a body cavity such as an abdominal cavity. The user arranges a living tissue or the like to be treated between the first grasping piece **15** and the second grasping piece **16**, and closes the handle **12** with respect to the grip **11**. As a result, the second grasping piece **16** is closed with respect to the first grasping piece **15**, and the living tissue is grasped between the first grasping piece **15** and the second grasping piece **16**.

[0033] In this state, the user turns on the operation button **19**. At this time, the processor **40** detects that the switch **20** has been turned on. The output control unit **43** of the processor **40** causes the energy output source **50** to start outputting the power to the ultrasonic transducer **13**. As a result, ultrasonic vibration is generated by the ultrasonic transducer **13**, and the generated ultrasonic vibration is transmitted to the first grasping piece **15** via the rod member **14**. When the first grasping piece **15** ultrasonically vibrates in a state where the tissue to be treated is grasped between the first grasping piece **15** and the second grasping piece **16**, frictional heat is generated between the first grasping piece **15** and the grasped tissue. Due to the frictional heat, the tissue is incised at the same time of being coagulated.

[0034] As illustrated in FIG. **2**B, a state where the first grasping piece **15** and the second grasping piece **16** are in contact with each other is formed in a situation where the tissue to be treated has been cut. When the first grasping piece **15** continues ultrasonic vibration in this state, the pad member **21** and the like of the second grasping piece **16** is likely to be damaged. Therefore, in the present embodiment, when the processor **40** detects the situation where the tissue has been cut, the processor **40** stops or reduce the supply of power to the ultrasonic transducer **13** from the energy output source **50**, and stops or reduces the output of the ultrasonic treatment instrument **2**.

[0035] An operation relating to the stop or reduction of output according to the present embodiment will be described with reference to a schematic view illustrated in FIG. **4**. FIG. **4** schematically illustrates a change of a resonance frequency of the vibration system including the ultrasonic transducer **13** with respect to an elapsed time from an output start. At the time of treatment, the temperature of the first grasping piece **15** gradually increases. Along with such a temperature rise, the resonance frequency of the vibration system including the first grasping piece **15** decreases. In the present embodiment, the processor **40** stops or reduces the output or notifies the user of the fact that the resonance frequency is decreasing (the temperature is rising) based on the decrease in the resonance frequency.

[0036] For example, the resonance frequency which was at a frequency f**1** at a treatment start decreases with a lapse of time as indicated by a solid line **101** in FIG. **4**. The processor **40** sets a first threshold at a frequency fth**1** as indicated by a broken line **111**, for example. The processor **40** calculates an integrated value **112** by integrating a difference between the resonance frequency and the first threshold from a time (time t**1** in FIG. **4**) when the resonance frequency of the vibration system has reached the first threshold. When the integrated value **112** exceeds a predetermined second threshold (time t**2** in FIG. **4**), the processor **40** stops or reduces the output or notifies that the integrated value **112** has reached the second threshold.

[0037] When a tissue is present between the first grasping piece **15** and the second grasping piece **16** and the tissue is being cut, heat generated in the first grasping piece **15** is used for the cutting of the tissue. Therefore, when there is a tissue between the first grasping piece **15** and the second grasping piece **16** before the tissue is divided, a temperature rises gently as compared with a case where there is no tissue between the first grasping piece **15** and the second grasping piece **16**. Therefore, an increase rate of the integrated value of the difference between the resonance frequency of the vibration system and the first threshold is relatively small before the tissue is divided, and the increase rate of the integrated value of the difference between the resonance frequency of the vibration system and the first threshold is relatively large after the tissue has been divided. Therefore, it is possible to detect the division of the tissue by using the integrated value of the difference between the resonance frequency of the vibration system and the first threshold.

[0038] In general, it is preferable to set a resonance frequency corresponding to a temperature at which a tissue is divided as a value of the first threshold. An example of the temperature at which the tissue is divided is generally 200° C. or the like.

[0039] The frequency f**1** of the vibration system at the start of treatment and the frequency fth**1** of the first threshold are within a range of about 40 kHz to 60 kHz, for example. As an example, when the resonance frequency of the vibration system including the ultrasonic transducer **13** and the rod member **14** is 46 kHz to 48 kHz as described above, the frequency f**1** at the start of treatment and the frequency fth**1** of the first threshold also become values in the range of 46 kHz to 48 kHz. The time t**1** at which the resonance frequency of the vibration system reaches the first threshold and the time t**2** at which the integrated value reaches the second threshold are values within the range of several seconds to a dozen or so seconds, for example.

[0040] <Output Control Process>

[0041] The control of the output by the processor **40** will be described with reference to the flowchart illustrated in FIG. **5**. An output control process illustrated in FIG. **5** starts, for example, when the operation button **19** is pushed by the user.

[0042] In Step S**1**, the output control unit **43** of the processor **40** causes the energy output source **50** to start outputting ultrasonic waves. The energy output source **50** supplies predetermined power to the ultrasonic transducer **13** under the control of the processor **40**. As a result, the first grasping piece **15** vibrates at an ultrasonic frequency to perform treatment of a living tissue.

[0043] First, the processor **40** causes the energy output source **50** to perform a scan operation of an output frequency, and then, starts control using a phase locked loop (PLL) to cause the energy output source **50** to output power. That is, the output control unit **43** of the processor **40** causes the energy output source **50** to output power while gradually changing the output frequency from a high frequency to a low frequency, for example, in the range including the resonance frequency of the vibration system including the ultrasonic transducer **13**. The resonance frequency acquisition unit **41** of the processor **40** acquires a current and a voltage at this time and acquires a frequency at which phases of the current and the voltage coincide with each other, that is, the resonance frequency of the vibration system. The processor **40** uses the acquired resonance frequency as an initial value and makes the output frequency follow the resonance frequency of the vibration system using the PLL thereafter. Subsequently, the PLL is used to vibrate the first grasping piece **15** at the resonance frequency. In general, the temperature of the first grasping piece **15** gradually increases so that the resonance frequency of the vibration system gradually decreases as illustrated in FIG. **4**.

[0044] In Step S**2**, the processor **40** determines whether the current resonance frequency of the vibration system is lower than a predetermined first threshold. If the resonance frequency is not lower than the first threshold, the process repeats Step S**2**. That is, the processor **40** continues the output control using the PLL to continue the treatment using the ultrasonic treatment instrument **2**. When the resonance frequency has become lower than the first threshold, the process proceeds to Step S**3**.

[0045] Although it is described herein that the resonance frequency is lower than the first threshold, the value of the resonance frequency used for comparison is not limited to an instantaneous value but may be a moving average value or the like in order to prevent erroneous determination due to noise or the like.

[0046] In Step S**3**, the integrated value calculation unit **42** of the processor **40** integrates a difference between the current resonance frequency of the vibration system and the first threshold to calculate an integrated value. In Step S**4**, the processor **40** determines whether the integrated value is larger than a predetermined second threshold. When the integrated value is not larger than the second threshold, the process returns to Step S**3**. That is, the integration of the difference between the resonance frequency and the first threshold is repeated. As a result, the integrated value gradually increases. When the integrated value has become larger than the second threshold, the process proceeds to Step S**5**.

[0047] In Step S**5**, the output control unit **43** of the processor **40** performs an output reduction operation. The output reduction operation is, for example, an operation of stopping the output of power from the energy output source **50**. The output reduction operation may be, for example, an operation of decreasing the output power from the energy output source **50**. The output reduction operation may be an operation of notifying the user that the integrated value has reached the second threshold using the notification unit **64**. This operation may be, for example, display on a display, an output of a notification sound from a speaker, or the like. The output reduction operation may be a combination of the stop or decrease of the output power and the notification. The output control process is ended after the processing of Step S**5**.

[0048] The first threshold and the second threshold may be values set in advance. For example, the processor **40** reads and sets the first threshold and the second threshold stored in a storage medium **48** at the time of activation. The energy control device **3** may be configured such that the first threshold and the second threshold can be changed based on an instruction from the user input via an input unit **62**.

[0049] The first threshold and the second threshold may be different for each model of the ultrasonic treatment instrument **2**. Therefore, the first threshold and the second threshold may be set as follows. That is, for example, identification information indicating a model of the ultrasonic treatment instrument **2** is stored in the storage medium **25** of the ultrasonic treatment instrument **2**. Further, a correspondence between the first threshold and the second threshold for each model is stored in the storage medium **48** of the energy control device **3**. The processor **40** reads the identification information on the model from the storage medium **25** of the ultrasonic treatment instrument **2** and uses the first threshold and the second threshold corresponding to the identification information. Even if the model information of the ultrasonic treatment instrument **2** is not stored in the storage medium **25**, for example, different resistors may be provided in the ultrasonic treatment instrument **2** depending on the model of the ultrasonic treatment instrument **2**, and the energy control device **3** may acquire a resistance value of the resistor at the time of being connected to the ultrasonic treatment instrument **2** to discriminate the model of the ultrasonic treatment instrument **2**. The first threshold and the second threshold may be stored in the storage medium **25** of the ultrasonic treatment instrument **2**, and the processor **40** may read such information to set the first threshold and the second threshold.

[0050] The energy control device **3** may be configured such that a type of the output reduction operation or presence or absence of the output reduction operation according to the present embodiment is switched based on an instruction of the user input via the input unit **62**.

[0051] Although the description has been given in the above example by exemplifying the case where the integrated value is the integrated value of the difference between the first threshold and the resonance frequency at the corresponding point in time, the invention is not limited thereto. The integrated value may be an integrated value of a difference between a predetermined frequency other than the first threshold and a resonance frequency at the corresponding point in time

[0052] The case where only one second threshold is set is illustrated in the above example, but two or more second thresholds may be set. For example, the energy control device **3** may be configured such that the output is reduced when the integrated value of the difference between the resonance frequency and the first threshold becomes larger than a first second threshold, and the output is stopped when the integrated value of the difference between the resonance frequency and the first threshold becomes larger than a second threshold.

[0053] In the present embodiment, the ultrasonic treatment instrument **2** has been described as the instrument that performs treatment by ultrasonic vibration of the first grasping piece **15**, but is not limited thereto. The ultrasonic treatment instrument **2** may have a function as a high-frequency treatment instrument that applies a high-frequency voltage between the first grasping piece **15** and the second grasping piece **16** in addition to the ultrasonic vibration. The high-frequency treatment instrument causes a high-frequency current to flow to a tissue to be treated to perform treatment with heat generated by the current flowing through the tissue. The ultrasonic treatment instrument **2** may be a treatment instrument in which a heater is provided on the first grasping piece **15** or the second grasping piece **16** to treat a tissue to be treated by heat of the heater together with ultrasonic vibration.

[0054] According to the treatment system **1** according to the present embodiment, the ultrasonic vibration of the first grasping piece **15** is reduced or stopped when the treatment of the living tissue to be treated has been completed and the tissue has been divided. Therefore, the ultrasonic vibration of the first grasping piece **15** is prevented while the first grasping piece **15** and the pad member **21** of the second grasping piece **16** are in contact with each other. As a result, abrasion or deformation of the pad member **21** is suppressed.

[0055] Further, the determination on whether to reduce or stop the ultrasonic vibration of the first grasping piece **15** is made based on the fact that the integrated value of the difference between the resonance frequency and the first threshold has become larger than the second threshold. Here, a situation of a living tissue between the first grasping piece **15** and the second grasping piece **16** is reflected on the difference between the resonance frequency and the first threshold, that is, a degree of the decrease in the resonance frequency when the resonance frequency has become lower than the first threshold. Therefore, the appropriate output control according to the treatment situation can be realized.

[0056] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. An energy control device that supplies power to an ultrasonic treatment instrument comprising an end effector performing treatment using ultrasonic vibration generated by an ultrasonic transducer, the energy control device comprising:

an energy source configured to output the power to the ultrasonic transducer; and

at least one integrated circuit configured to:

acquire a resonance frequency of a vibration system including the ultrasonic transducer;

calculate an integrated value of a difference between the resonance frequency and a predetermined frequency after the acquired resonance frequency has become a first threshold; and

perform at least one of causing the energy source to stop or reduce an output of the power to the ultrasonic transducer and notifying that the integrated value has reached the second threshold when the integrated value has reached a second threshold.

2. The energy control device according to claim **1**, wherein

the integrated circuit is configured to calculate an integrated value of a difference between the resonance frequency and the first threshold as the integrated value.

3. The energy control device according to claim **1**, wherein

the integrated circuit is configured to use a frequency corresponding to a temperature at which an object to be treated is cut as the first threshold.

4. The energy control device according to claim **1**, further comprising an input device that receives an instruction from a user,

wherein the integrated circuit is configured to adjust at least one of the first threshold and the second threshold based on an input to the input device.

5. The energy control device according to claim **1**, further comprising an input device that receives an instruction from a user,

wherein the integrated circuit is configured to switch a type of an operation or presence or absence of an operation when the integrated value has reached the second threshold based on an input to the input device.

6. The energy control device according to claim **1**, wherein

the predetermined frequency is the first threshold.

7. A treatment system comprising:

the energy control device according to claim **1**;

the ultrasonic transducer configured to be supplied with power from the energy control device; and

the ultrasonic treatment instrument.

8. The treatment system according to claim **7**, wherein

the end effector comprises a first grasping piece configured such that ultrasonic vibration is transmitted and a second grasping piece configured to be open and closed with respect to the first grasping piece, and

the second grasping piece comprises a pad member that is brought into contact with the first grasping piece in a state where the first grasping piece and the second grasping piece is closed.

9. The treatment system according to claim **7**, wherein
the ultrasonic treatment instrument comprises a memory in which the first threshold and the second threshold are stored, and
the integrated circuit is configured to read the first threshold and the second threshold from the memory and use the read first and second thresholds when the ultrasonic treatment instrument is connected to the energy control device.

10. The treatment system according to claim **7**, wherein
the ultrasonic treatment instrument comprises a first memory in which identification information is stored,
the energy control device comprises a second memory in which a correspondence between the identification information and the first threshold and a correspondence between the identification information and the second threshold are stored, and
the integrated circuit is configured to read the identification information from the first memory and to read the first threshold and the second threshold stored in the second memory corresponding to the identification information and use the read first and second thresholds when the ultrasonic treatment instrument is connected to the energy control device.

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patsnap

专利名称(译)	能量控制装置和处理系统		
公开(公告)号	US20190150898A1	公开(公告)日	2019-05-23
申请号	US16/251638	申请日	2019-01-18
[标]申请(专利权)人(译)	奥林巴斯株式会社		
申请(专利权)人(译)	OLYMPUS CORPORATION		
当前申请(专利权)人(译)	OLYMPUS CORPORATION		
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发明人	KAWASAKI, MINORU TSUBUKU, YOSHIHIRO KATO, GEN		
IPC分类号	A61B8/00 A61B17/32 A61B8/08		
CPC分类号	A61B8/56 A61B17/320068 A61B8/4494 A61B8/5207 A61B17/320092 A61B2017/0003 A61B2017/00123 A61B2017/2825 A61B2017/320094		
外部链接	Espacenet USPTO		

摘要(译)

能量控制装置向超声波治疗仪器供电，该超声波治疗仪器包括使用超声波换能器产生的超声波振动进行治疗的末端执行器。能量控制装置包括能量源，其被配置为将功率输出到超声换能器，以及至少一个集成电路。集成电路被配置为：获取包括超声换能器的振动系统的共振频率;在获取的共振频率变为第一阈值之后，计算共振频率与预定频率之间的差的积分值;并且执行使能量源停止或减少超声换能器的功率输出，或者当积分值达到第二阈值时通知积分值已达到第二阈值。