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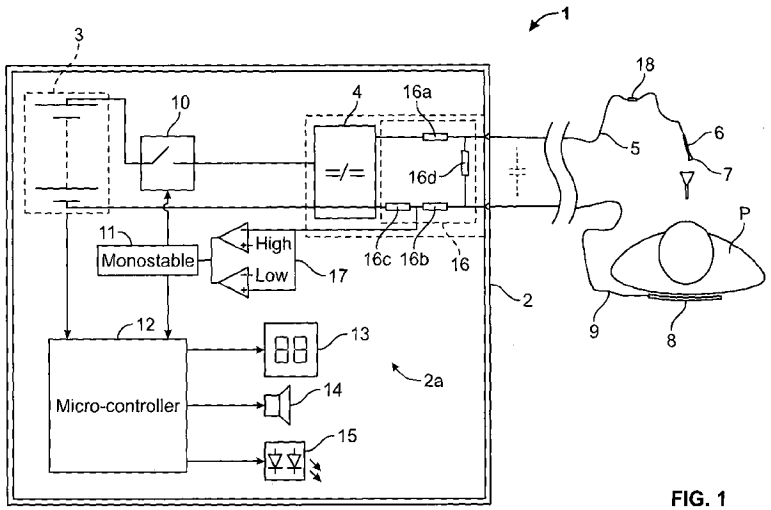

FIG. 1

(57) Abstract: A DC driven ionisation apparatus is provided for ionising a local atmosphere in which a corporeal surgical or cosmetic procedure is to be performed, the ionisation apparatus including a safety circuit comprising detector means for detecting when a hazard condition exists, such as a short circuit or high charge level condition, a circuit controller for actuating switch means to turn the DC supply off and thereafter to cyclically reconnect and disconnect the DC supply until the hazard condition has been rectified, and re-set means for thereafter re-setting a continuous DC supply to the circuit until the next occurrence of a hazard condition or until the procedure is complete.

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IMPROVEMENTS IN AND RELATING TO LAPAROSCOPIC INSTRUMENTS

This invention relates to laparoscopic instruments such as ionisation instruments of the type described in WO2011/010148.

Laparoscopic, or "keyhole" surgery involves a surgeon performing a surgical procedure on a patient using instruments that are inserted into the body, but which are manipulated using hand/robotic controls located externally of the patient. The surgeon usually sees what is happening by using an endoscope which is inserted at or near the operation site and in order to gain access to the operation site and to provide space for the instruments, a cavity is usually opened up within the patient's body by inflation using a suitably inert gas, such as CO_2.

Many laparoscopic procedures involve the use of thermal cutting instruments, such as lasers and diathermy devices, which can cut and cauterise tissues by ablation, heating, freezing and the like. In certain situations, the surgeon's view can be become obscured by smoke, vapours or other aerosols and it is therefore often necessary to provide means for extracting the smoke, vapours or aerosols from the operation site. The extraction of smoke, vapours and aerosols can be achieved in a number of ways, such as by over-pressurising the cavity and providing a gas bleed tube fitted with a filter.

This invention is particularly concerned with smoke/vapour removal via ionisation in the manner as described in WO2011/010148, the disclosure of which is incorporated herein by reference, which involves inserting an ionising electrode disposed at the end of an insulated rod or "wand", into the operation site, which electrode is maintained at an electrical potential with respect to the

patient's body so that the smoke/vapour particles/droplets in the air become ionised and are attracted to the patient's body. The smoke/vapour is thus removed from the surrounding atmosphere and transferred to a surface where it can thereafter be removed periodically by washing etc.

When using such an ionising electrode, precautions must be taken to ensure that electrical contact is not made between the electrode and other surgical instruments within the cavity, which could lead to instrument failure or short-circuiting, and that hazardous electric charge levels do not build-up within the patient, which have the potential to cause atrial fibrillation (AF), if neglected. In addition, any electrical devices connected to patients must satisfy rigorous safety standards to ensure that interference between different devices is minimised such that the risks of electric shock and harm to the patient are minimised.

The present invention is derived from the realisation that, unlike surgical instruments that couple low voltage DC or reversing polarity, AC waveforms, to a patient, surgical instruments or devices that couple high voltage DC waveforms to the patient are capable of storing electrical charge either directly or indirectly, such as by storing electrical charge within the instrument or within the corporeal body on which a procedure is to be performed in much the same manner as a capacitor stores electrical charge, with the consequence that because of the electrical potential difference between the charged instrument or corporeal body and the ground there is a risk of unwanted electrical discharge.

According to the invention, there is provided DC driven ionisation apparatus for ionising a local atmosphere in which a corporeal surgical or

cosmetic procedure is to be performed, the ionisation apparatus including a safety circuit comprising detector means for detecting when a hazard condition exists, such as a short circuit or high charge level condition, a circuit controller for actuating switch means to turn the DC supply off and thereafter to cyclically reconnect and disconnect the DC supply until the hazard condition has been rectified, and re-set means for thereafter re-setting a continuous DC supply to the circuit until the next occurrence of a hazard condition or until the procedure is complete.

With this arrangement accidental damage to surgical instruments due to them inadvertently coming into contact with the ionising discharge electrode can be obviated by immediate interruption of the high voltage DC supply for a duration sufficient for the cause of the short circuit to be found and rectified, such as by the surgeon moving a surgical instrument away from the ionising electrode. Similarly, where the hazard condition detected is the build up of an unacceptably high level of electrical charge, which may be due to a number of reasons including a cumulative build-up of capacitance in the corporeal body or in surgical instruments and associated cabling, immediate action can be taken by disconnecting the DC power supply and monitoring the charge within the system until it falls below a required maximum safe level.

Conveniently, the safety circuit includes a network of high voltage resistors coupled to the DC supply, which circuit may include two or more series-wired resistors for limiting current output, one or more current sensing resistors for enabling the level of current to be sensed, one or more shunt resistors which are arranged to consume a signature level load and thus provide an assurance

of the integrity of the safety monitoring controls. The safety circuit further comprises one or more series-wired resistors at or near the output electrode of the ionisation apparatus, which may be two or more orders of magnitude less than the impedance of the series-wired resistors so as to have no significant impact on the functional efficacy of the ioniser but being able to prevent or inhibit discharge of charge stored between the output electrode and the return electrode of the ionisation apparatus.

Using the foregoing concepts, high voltage DC current can be coupled to a patient via series-wired resistors having a cumulative value relative to the applied voltage resulting in a maximum possible current of typically, between 5 and 50 μA and preferably between 10 to 50 μA, with resistors being placed in both the output and return connections. Additionally, active control of current to limit it to a maximum of 10 μA may be used to maximise particle clearing at lower output electrode impedances by combining the use of the active current limit and a resistive current limit where the relationship between the high voltage and the combined resistance provides a current limit of between 20 and 50 μA.

The invention also provides a means for responding to excessively low output electrode impedances by cyclically interrupting the output voltage and through the use of a resistor placed near to the moveable wand and the output electrode so as to avoid unwanted electrical discharge when the output electrode is close to patient tissue and which would otherwise be perceived by the user of the wand.

The invention also extends to the concept of linking the activation of the ionisation apparatus with the activation of particle-producing surgical

instruments, such as by the use of commonly-wired foot switches, wireless signalling from the particle producing surgical instrument or detection of signature radio frequency emissions in the case of electro-surgical instruments being used.

The invention will now be described, by way of example only, in which:-

Figure 1 is a schematic arrangement of an ionising apparatus according to a first embodiment,

Figure 2 is a graph showing a hypothetical short circuit hazard event while using the apparatus in Figure 1,

Figure 3 is an alternative schematic arrangement to that shown with reference to Figure 1, which includes a high voltage relay switch,

Figure 4 is a graph showing the variation of output electrode voltage and electrical charge over time,

Figure 5 shows the output voltage characteristics vs. output electrode current as they affect efficiency of particle collection,

Figure 6 is a schematic arrangement of a further embodiment of ionising apparatus and,

Figure 7 shows the ioniser load curves resulting from the embodiment shown in Figure 6.

Referring firstly to Figure 1, ionising apparatus shown generally at 1 comprises an insulated housing 2 comprising safety circuitry 2a for operating the ionising apparatus 1. The safety circuit 2a comprises a DC power source battery 3 for powering a DC switch mode power supply DC to DC voltage converter 4 which steps up the voltage to approximately 10kV to an active cable

5 on the free end of which is a non-conductive rod or wand 6 from which protrudes the free end of the active cable 5 in the form of an output electrode 7. A return electrode in the form of an electrically conductive pad 8 is connected to a return cable 9 to the battery 3, the electrodes 7 and 8 providing, in use, an ionisation path therebetween in the manner as described in WO2011/010148.

The housing 2 is sufficiently insulated so as to prevent the possibility of any significant electrical path being established with its surroundings and, indirectly, with a patient P, whilst still allowing the internal circuitry of the housing 2 to assume a voltage potential of up to the same order of magnitude as that applied to the patient P during the surgical procedure in which the ionising wand 6 is being used intra-corporeally such as e.g., during a laparoscopic procedure.

Referring now to the internal circuitry components, these include an isolation switch 10 for the converter 4, a monostable 11 for re-enabling the switch 10 and a micro-controller 12 coupled to user interfaces in the form of, respectively, a digital display 13, audio output speaker 14 and LEDs 15, which collectively advise the user of the apparatus 1 of the charge status of the battery 3 and other parameters concerning the status of the converter 4, active cable 5 and associated components connected thereto or therewith.

The output from the converter 4 is coupled to the active cable 5 and the return cable 9 via a high voltage resistor network shown generally in broken outline at 16. This comprises a pair of series wired resistors 16a, 16b close linked between 0.4 and 1.2G Ohm, a series current sense resistor 16c of 3 to 5 orders of magnitude lower resistance, and a shunt resistor 16d in parallel across the active outward cable 5 and the return cable 9, typically having a resistance

an order of magnitude greater than the accumulative resistance from the series connected resistors 16a, 16b and 16c.

The converter 4 and high voltage resistor network 16 is suitably encapsulated in an inert medium such as epoxy resin not prone to providing an ionising path that might otherwise bypass the effects of the resistor network 16.

Between the monostable 11 and the return cable 9, between resistors 16b and 16c, is a window comparator 17 which defines the acceptable limits of current for safe operation.

In accordance with the invention, multiple means are provided for limiting current output from the high voltage converter 4 to and from the patient P via the active cable 5 and return cable 9, the first being in the converter 4 itself which is appropriately limited by design to a maximum current of 30μA of steady-state output current.

A second means of limiting current output is provided by the presence of the series-wired resistors 16a, 16b which rely on the converter 4 coupling a known maximum high voltage to the whole of the resistor network 16. This second limiting means is configured under low impedance conditions between the active cable 5 and associated wand 6 and the output electrode-return pad 8 and return cable 9 to provide instantaneous current limit of up to 10μA, which limit is considered to present a negligible risk of causing interference with the cardiac sinus rhythm.

Where the safety circuit 2a for the ionisation apparatus comprises two or more resistors wired in series, a degree of protection is still available in the event that one fails with a low impedance. In such a situation, the patient current is

limited to no more than, say, 20μA, or less than 20μA if more than 2 resistors are used in series. In accepted safety analysis methodology, the slight increase in risk of interference in patient sinus rhythm at 20μA is factored down by the low probability of component failure, and so the combined likelihood of sinus rhythm interference remains negligible. In addition, it has also been found to be advantageous to place high impedances without which there would be a risk that high frequency current from third party devices such as electro-surgical systems would couple through the controls via stray capacitance to the immediate surroundings. This aim may conveniently be achieved by means of a suitably placed series-wired resistor 16b.

A third safety feature utilises the voltage across the current sense resistor 16c which is required by the window comparator 17 to reside between a first, lower limit resulting from the current drawn from the minimum possible load, caused by the effect of the shunt resistor 16d on the voltage from the converter $4V_{hv}$, as applied to the resistor network 16, and a second, upper, limit reached at the lower of 10μA and V_{hv}/(R16a+R16b) being the patient current level between the output and return electrodes 7, 8, where V_{hv} is the amplitude of the high voltage output from the DC to DC converter when no load current is being drawn. In the event of the current through the sense resistor 16c falling outside the acceptable limits defined by the window comparator 17, the connection between the battery 3 and the converter 4 is broken by the isolation switch 10 for a duration defined by the monostable 11. Concurrent with this interruption, the monostable circuit 11 signals to the user interface micro controller 12 to provide

an audio visual indication of the event via the display 13, speaker 14 and LED's 15.

The interruption duration can be between 0.2 to 10 seconds but is optimally between 2 and 3 seconds, this being considered long enough to allow the surgeon to respond to the hazard condition, which may have been caused by an inadvertent contact between the output electrode 7 and a third party instrument being used by the surgeon, or by an unacceptably close proximity to the patient corporeal tissue. Whatever the cause, at the end of the interruption the monostable 11 re-enables the isolating switch 10 and allows an attempt to re-establish an acceptable output current over a shorter period of time, such as 200ms. This time is needed to allow expected stray capacitances in the high voltage circuit to be recharged by the output from the resistor network 16. These capacitances can be estimated to be of the order of 10pF to 100 pF and so can take 0.1 to 0.5 seconds to recharge, depending on both the size of stray capacitance and the value of the series resistors 16a, 16b.

A useful feature of this timing arrangement is that where the over-current condition is caused by connection to large capacitances in patient connections from third party surgical equipment, a dramatic reduction in the rate of build up of uncontrolled charge is afforded. In the preferred embodiment, the output charge delivered into third party equipment capacitance can be reduced by a factor of about 10, compared to that delivered without the interruption of the isolator switch 10.

As an example of a capacitor hazard, a monopolar electrosurgical generator is allowed by medical device standards to couple to the patient via a

5μF capacitor. Once charged to just a few volts, there is sufficient energy stored to cause involuntary motor nerve stimulation when the active electrode is next brought into contact with a muscle, which is seen as an undesirable twitch of the patient muscle during surgery. This improvement both provides an alarm to the surgeon while extending the time needed to reach such an undesirable level of third party capacitor charge from around 2 seconds to around 20 seconds.

A further refinement in user-perceived safety is achieved if a means is additionally provided to limit the peak displacement current that flows from the output electrode 7 when brought into abrupt electrical contact with patient tissue. This contact may be direct, or it may instead be in the form of air discharge or arcing of typically less than two millimetres in length between the first electrode 7 and patient tissue. Such a discharge is supported by the capacitance between the active cable 5 and the return cable 9, which may typically be between 10pF to 100pF, including items connected in common, such as the patient tissue bulk itself. Such unwanted electrical discharge can be prevented by the use of a series-wired resistor 18 between the proximal end of the wand 6 and the distal portion of the active cable 5 i.e. outside the housing 2. The placing of such a series-wired resistor 18, if of two or more orders of magnitude less than the impedance of the series output resistors 16a, 16b, has no significant impact on the functional efficacy of the ioniser 1, but can prevent the user-perceivable discharge of the charge stored between active cable 5 and the return cable 9, and in practice it has been found that a value of 1MΩ for resistor 18 to be effective.

Operation of the circuit shown in Figure 1 is hypothetically represented in Figure 2, which depicts a short-circuit event occurring 0.5 seconds into the cycle, analogous to e.g. a third party surgical instrument accidently coming into contact with the output electrode 7 at the end of the wand 6. From the start point at zero seconds the potential at the output electrode 7 quickly ramps up to its desired maximum level of around 9kV whilst at the same time output current sharply falls from the allowable limit of 10μA to near zero. At 0.5 seconds the hypothetical contact between the output electrode 7 and the third party instrument, which may be deemed to have a capacitance at this point of 300nF, causes the immediate collapse of the voltage as the electric charge is conserved but distributed between the capacitance of the active cable 5 and the capacitance of the third party instrument. The output current therefore rises to the allowable limit of 10μA and stays there for long enough to trigger the monostable 11 to open the isolating switch 10 for 2 seconds, with zero output current from the converter 4. At the end of the 2 second duration the isolator switch 10 is re-enabled for a few tenths of a second and, again, the output current rises to the allowable limit of 10μA for as long as the isolator switch 10 remains closed and this triggers the monostable 11 to again open the isolator switch 10, the cycle repeating for as long as the third party instrument with its 300nF capacitance is in contact with the output electrode 7.

As will be seen from Figure 2, for the duration of this cycle the voltage at the output electrode 7 stays low while the cumulative charge resulting from the third party contact is seen to take step-like rises every 2 seconds, reflecting the charge added to the output electrode 7 during the periods while the isolator

switch 10 is closed. In the scenario depicted, shortly after 10 seconds has elapsed and during the next 2 second disable period, contact between the third party instrument and the output electrode 7 is broken, representing removal of the third party instrument from the vicinity by the surgeon upon receiving audio/visual alarm signals prompted by the micro controller 12, whereafter there is an immediate fall in charge at the output electrode 7. At the end of that particular 2 second disabled period the voltage at the output electrode 7 is seen to rise back to its operational level of about 9kV and the current sharply falls back from 10μA to near zero resulting in normal continuous output voltage beyond about 11 seconds from the start of the cycle. In this example, in the interest of clarity the independently variable functional current required for ionisation of the laparoscopic space between the electrode 6 and the patient P is chosen to be negligible.

In Figure 3 there is shown an improved safety circuit for the ionizer apparatus 1 where a high voltage relay switch 19, which may suitably be a reed type switch with normally open contacts, is positioned in shunt across the high voltage output of the converter 4. In this improved arrangement, whenever the isolator switch 10 is opened in response to an unacceptably high patient charge being detected the contact of the high voltage switch 19 is closed so as to cause a comparatively low impedance across the output and return electrodes 7, 8 and hence the patient. In this embodiment the impedance across the patient connections 7, 8 must still be low enough to avoid the risk of discharge current being drawn from a third party instrument acting as a capacitor exceeding levels deemed as likely to cause interference with the normal cardiac sinus rhythm.

This is assured via the series resistors 16a, 16b as a result of the provision of the high voltage relay switch 19 which makes it is possible to establish an equilibrium condition where a charge undesirably charged to a third party instrument during periods when the isolator switch 10 is closed is withdrawn through the high voltage relay switch 19 during the periods when the isolator switch 10 is open. As a consequence, the condition where inadvertent contact is made with a third party instrument can be rendered benign, other than that during this event particle clearing is halted until the contact has been broken and normal operation of the ionizing apparatus 1 is resumed.

As with Figure 2, Figure 4 depicts a variation of voltage and electrical charge at the output electrode 7 over time, assuming a 1GΩ series resistor network 16a, 16b and a 100 pF capacitance for the active cable 5 to the return electrode/pad 8. In contrast with Figure 2, due to the discharging effect of the high voltage relay 19 shown in Figure 3, the charge in contact with the output electrode 7 during the intermittent output period after 0.5 seconds is seen to fall back during the 2 second intervals when the isolation switch 10 is closed. The time base includes a time lapse to allow illustration of the equilibrium point being reached. The long-term outcome is that at equilibrium, the output voltage at the output electrode 7 remains low compared to the normal 9 kV level as a result of an equal charge being removed through the contacts of the high voltage relay 19 as the charge is replaced during the shorter periods when the isolation switch 10 is closed.

As a result of the presence of the second current limiting means in accordance with the invention, provided by the series resistors 16a, 16b, the

output voltage characteristic of the generator 8 with increasing output electrode current 7 is as shown in Figure 5. In this example the converter 4 is set to couple 10 kV to the resistor network 16. The series resistors 16a, 16b are cumulatively set to provide 1GΩ impedance and the shunt resistance 16d is set to 10GΩ.

Under normal particulate-clearing operation, the impedance of the ionised pathway between the output electrode 7 and the return electrode/pad 8 is a function of the particulate type and density, the path length between the output electrode and the patient bulk tissue, and the effective surface area of the output electrode 7 and surrounding bulk patient tissue.

In practice it has been observed that a voltage of greater than 3 kV and preferably 5 kV to the output electrode 7 is required to achieve satisfactory particulate clearing, but where the output electrode 7 is placed too close to the patient bulk tissue, particulate clearing can cease as the ionised pathway impedance falls below 400MΩ.

Where the particles to be cleared are the result of electro surgery, it has been observed that the higher ionised pathway impedances occur at higher densities of electro surgical smoke particles. As such the basic configuration depicted in Figure 1 is optimised to offer the highest voltage between the output electrode 7 and the return electrode/pad 8 with the greatest ionising potential under conditions with the highest-particle pollution. As particle clearing completes, the ionisation pathway current between the output electrode 7 and return electrode/pad 8 is seen to rise, for example from 1.3 μA at the start of clearing to 5 μA upon completion.

In Figure 6 there is shown an improvement over the circuit described in Figure 1 in terms of the characteristics of the output voltage of the ionising apparatus 1 with changing output current. In this case the series resistors 16a, 16b which ordinarily provide the second means of current limiting in the manner as described with reference to Figure 1, are instead reduced by a factor of up to 5 so that the maximum current deliverable from the ionisation apparatus 1 under short circuit conditions rises from 10μA towards 50μA, governed by the relationship V_{hv}/(R16a+R16b). In lieu of the series resistors 16a, 16b assuring a 10μA current limit, additional control circuitry is added, taking the current signal at the sense resistor 16c and feeding that into a closed loop servo for rapidly reducing the voltage from the DC to DC converter 4 as the required current limit of 10μA is approached. In this example a current summing junction 20 determines the difference between the current through the sense resistor 16c and the allowable limit, such as 10μA. The result is fed into a proportional-integrating-differentiating (PID) amplifier 21 with a one-sided function output, where current summing junction 20 signals indicating acceptable output current conditions this results in a zero amplitude output, but where summing junction 20 signals indicate excessive output current conditions, this results in a rapidly increasing amplitude output. This signal is fed into both the upper limit window 17a of the window comparator 17 and into a first voltage summing junction 22 for the voltage control of the DC to DC converter 4. The polarity of signals is such that signals from the current summing junction 20 indicative of excess output current result in a reduction of output from the first voltage control summing junction 22, the output from which is then compared with the actual

output voltage in a second voltage control summing junction 23. The output from the second voltage summing junction 23 is in turn fed into a second PID amplifier 24 and used to control the intensity of operation of the DC to DC converter 4 in a manner familiar to those skilled in the art.

The composite results of the current limiting provided by the series resistors 16a, 16b and the closed loop current limit circuit described above is shown in Figure 7 where the output voltage starts at a maximum when the output electrode 7 of the return electrode 8 is zero and then falls as the output current rises, but significantly less deeply than would have been the case for the embodiment shown in Figure 1. This is as a result of the up to 5 to 1 reduction of the values of the series resistors 16a, 16b. As impedance of the atmosphere medium between the output electrode 7 and return electrode 8 reduces further and the desired current limit, such as 10μA, is reached, the output voltage falls asymptotically towards zero without any functionally significant increase in output current for further reductions in output electrode 7 to return electrode 8 collective impedance.

At an output voltage of approximately 3kV or less, ionisation of the atmospheric medium between the output electrode 7 and return electrode 8 results in significantly less particulate precipitation and this condition is detected by the upper limit 17a of the window comparator 17 based on the amplitude of the signals from the first PID amplifier 21 with the one-sided output function. In a similar fashion to that implemented in the embodiment shown in Figure 1, an out-of-range signal at the window comparator 17 results in the monostable 11 being triggered for a period of 2 to 3 seconds, during which the isolator switch 10

opens, disabling the DC to DC converter 4. In this manner an improved output voltage characteristic is achieved while output electrode 7 to return electrode 8 impedances permit an effective particulate-clearing voltage to be established between them. However, a return to intermittent operation occurs if the impedance is too low for effective particulate-clearing, or are indicative of a short circuit between the electrodes 7, 8 via human tissue or because of third party equipment capacitance.

Although several embodiments of the invention have been described it will be understood that the invention also extends to variations to these embodiments including combinations of embodiments and variations apparent to the skilled addressee.

Claims

1. DC driven ionisation apparatus (1) for ionising a local atmosphere in which a corporeal surgical or cosmetic procedure is to be performed, the ionisation apparatus including a safety circuit (2a) comprising detector means (16c,17) for detecting when a hazard condition exists, a circuit controller (12) for actuating switch means (10) to turn the DC supply (3) off and thereafter to cyclically reconnect and disconnect the DC supply until the hazard condition has been rectified, and re-set means (11) for thereafter re-setting a continuous DC supply to the circuit until the next occurrence of a hazard condition or until the procedure is complete.

2. Apparatus according to claim 1 wherein the safety circuit (2a) includes a network (16) of high voltage resistors coupled to the DC supply.

3. Apparatus according to claim 1 or Claim 2 wherein two or more series-wired resistors (16a,16b)are provided for limiting current output.

4. Apparatus according to any preceding claim wherein one or more current sensing resistors (16c) are provided for enabling the level of current to be sensed.

5. Apparatus according to any preceding claim wherein one or more shunt resistors (16d) are provided for consuming a signature level load and thus providing assurance of the integrity of the safety monitoring controls.

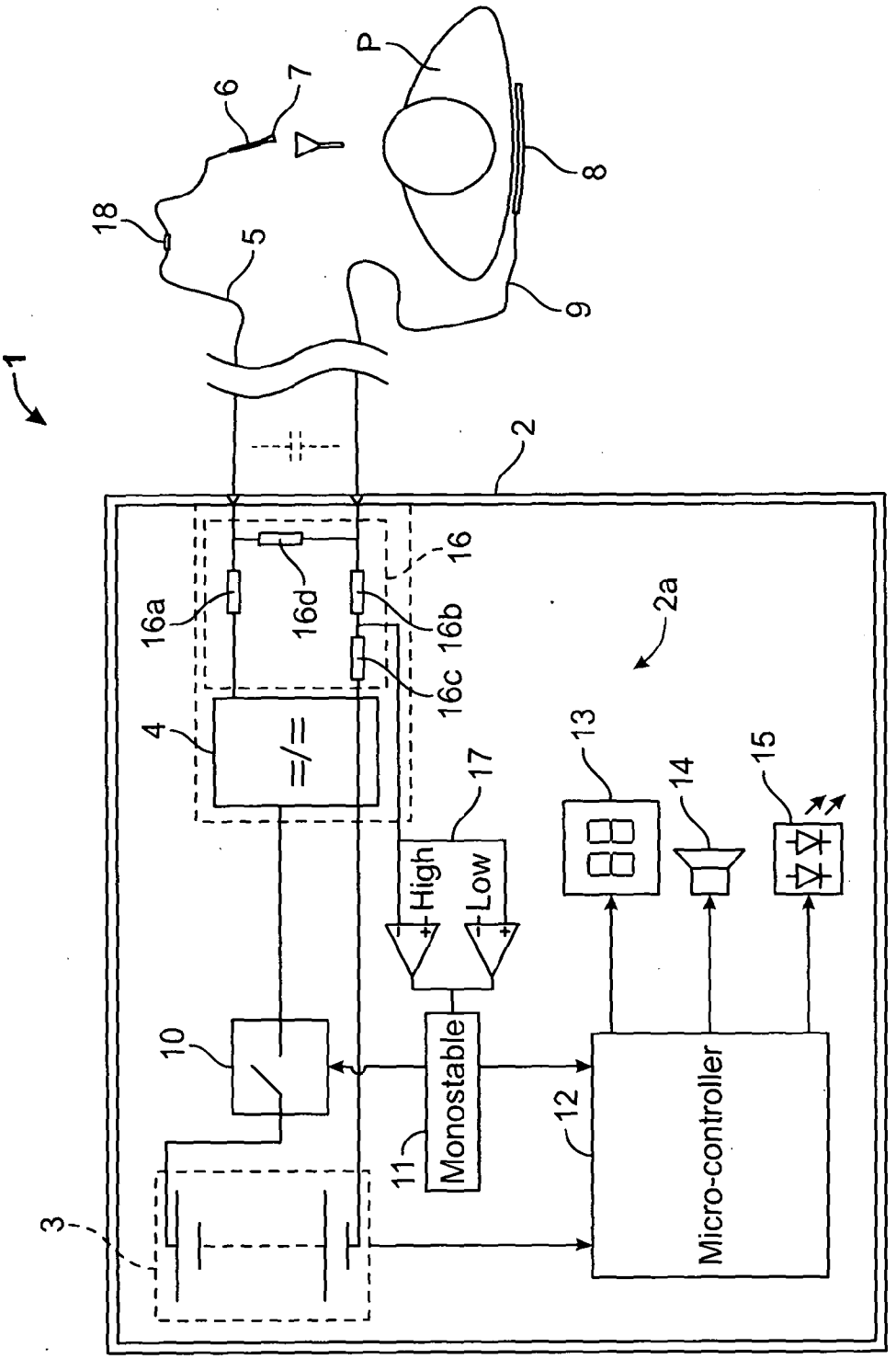
6. Apparatus according to any preceding claim wherein one or more series-wired resistors (18) are provided at or near the output electrode (7) of the ionisation apparatus.

7. Apparatus according to claim 6 wherein the series-wired resistors (18) at or adjacent to the output electrode (7) are two or more orders of magnitude less than the impedance of the wired resistors (16a,b) of the resistor network (16).

8. Apparatus according to any preceding claim wherein means are provided for responding to excessively low output electrode impedances by cyclically interrupting the output voltage through the use of a resistor (18) placed near to the moveable wand (6) and the output electrode (7) so as to avoid unwanted electrical discharge when the output electrode is close to patient tissue and which would otherwise be perceived by the user of the wand.

9. Apparatus according to any preceding claim wherein means (12) are provided for linking the activation of the ionisation apparatus (1) with the activation of particle-producing surgical instruments.

10. Apparatus substantially as hereinbefore described with reference to Figure 1 or Figure 3 or Figure 6.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Low
Monostable
Micro-controller

FIG. 1

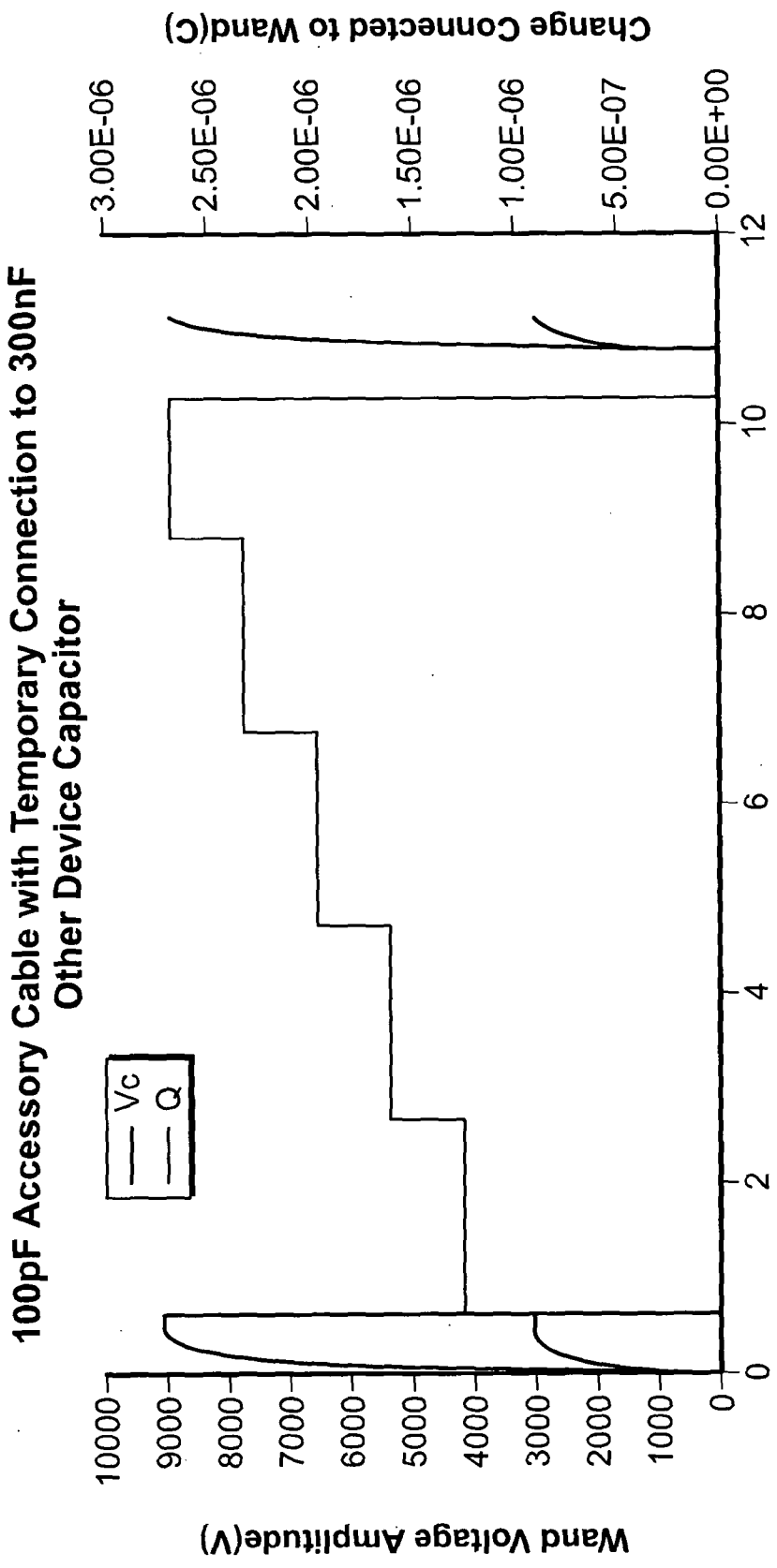
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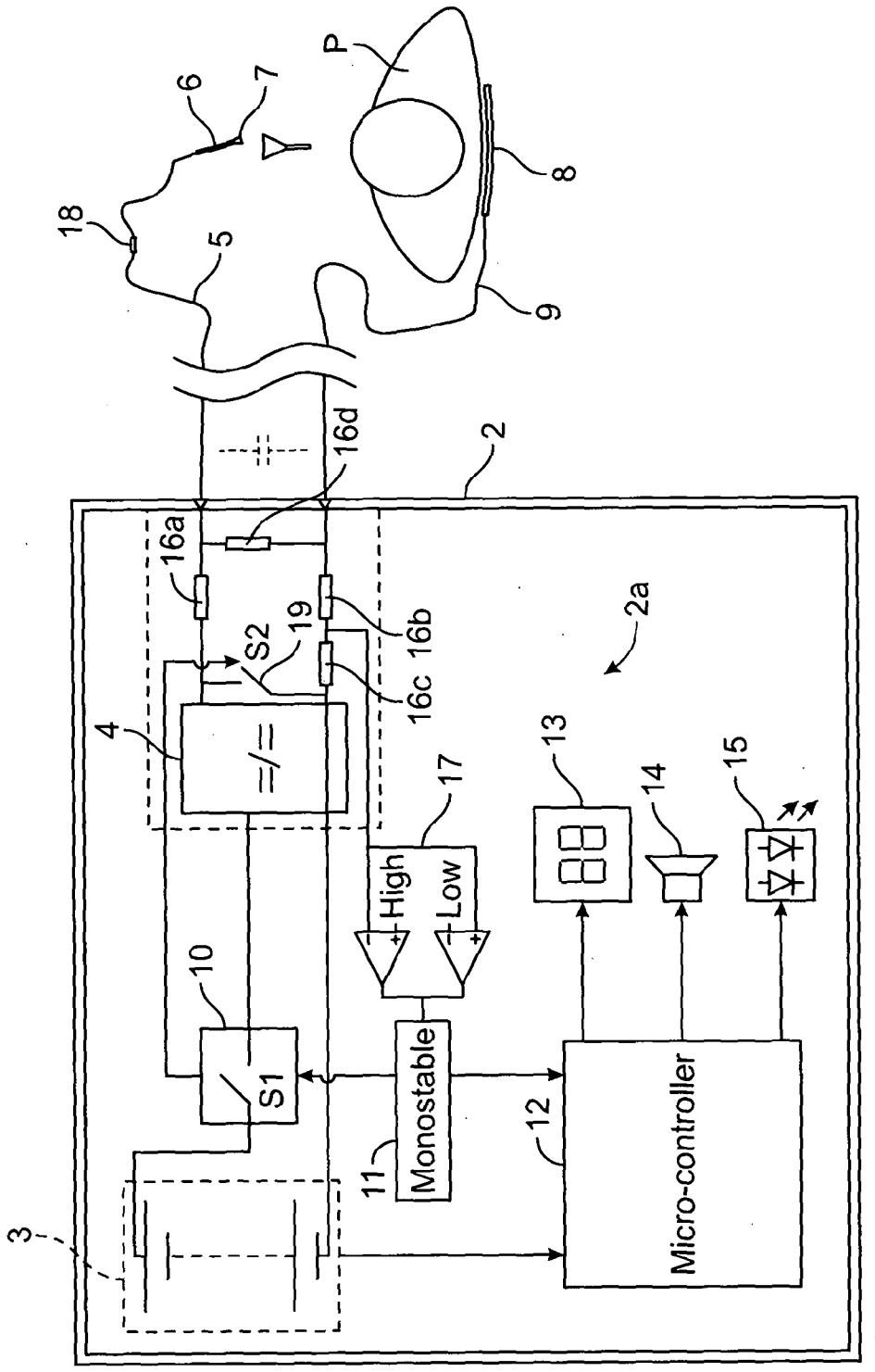
FIG. 2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16a
19
S2
16b
16c
2a
4
13
14
15
17
High
Low
10
S1
Monostable
11
12
Micro-controller
3

FIG. 3

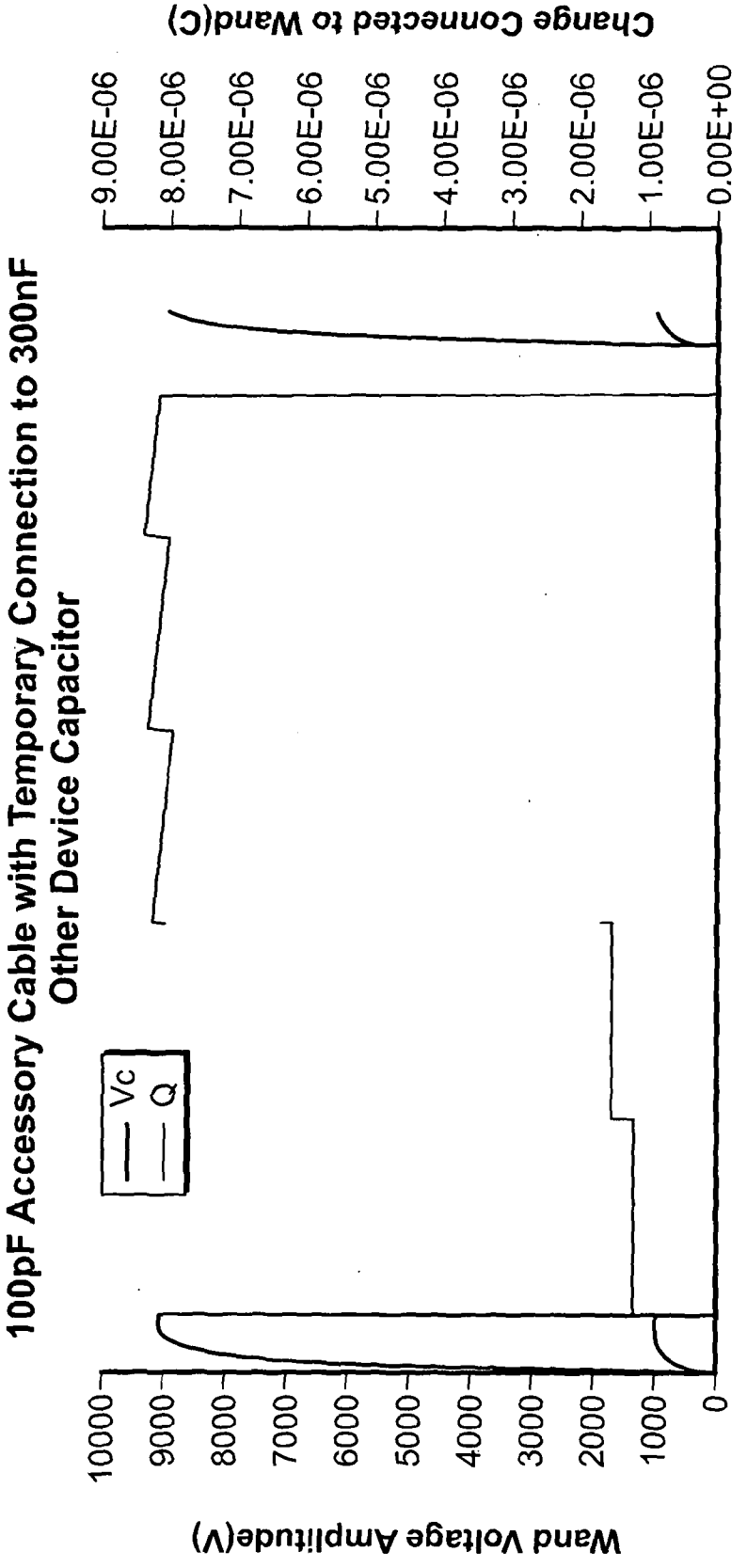
100pF Accessory Cable with Temporary Connection to 300nF Other Device Capacitor
Vc
Q
Wand Voltage Amplitude(V)
Change Connected to Wand(C)
Time(s)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
9.00E-06
8.00E-06
7.00E-06
6.00E-06
5.00E-06
4.00E-06
3.00E-06
2.00E-06
1.00E-06
0.00E+00

FIG. 4

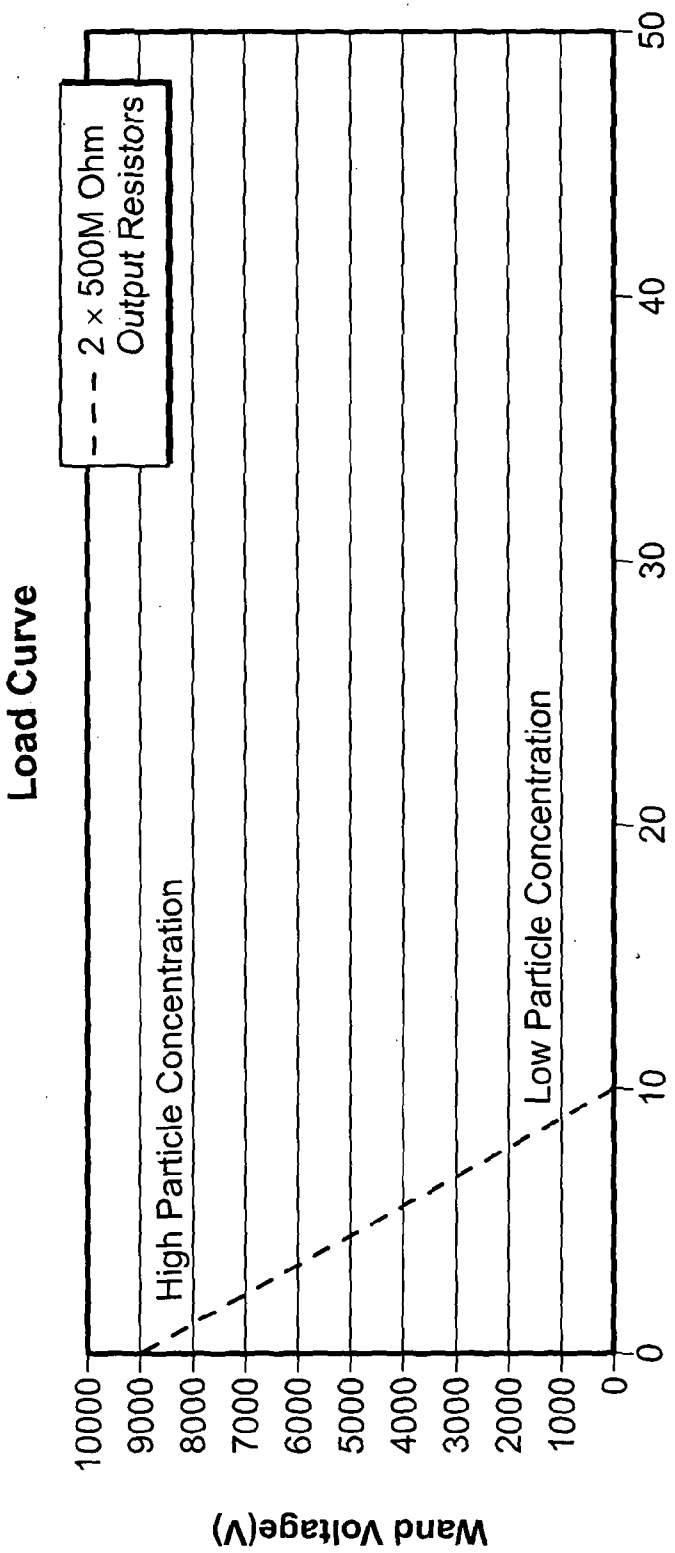
Load Curve
2 x 500M Ohm Output Resistors
High Particle Concentration
Low Particle Concentration
Wand Voltage(V)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Wand Current(μA)
0
10
20
30
40
50

FIG. 5

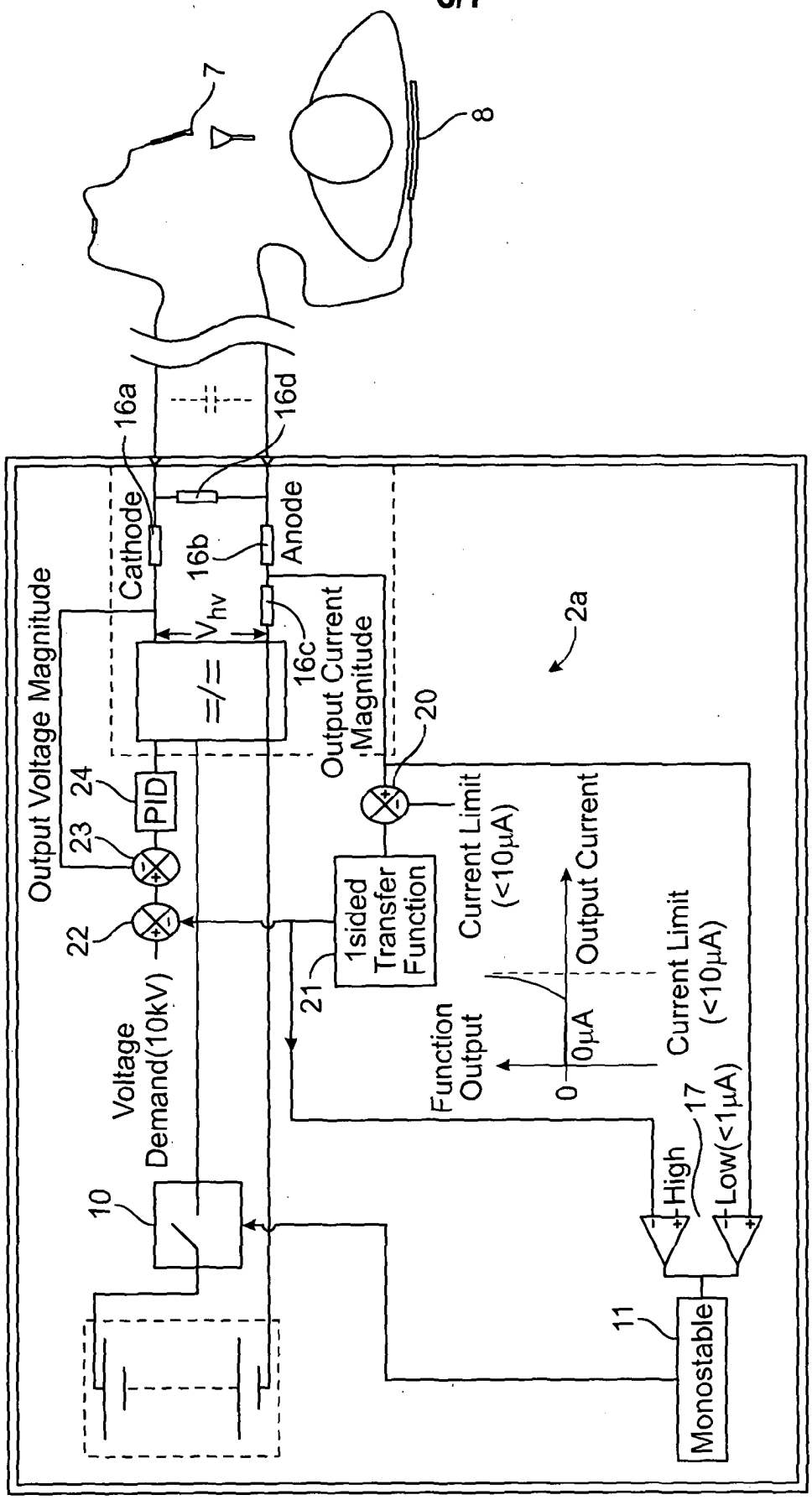
7
8
16a
16d
Cathode
Anode
16b
16c
V_{hv}
=/=
Output Voltage Magnitude
Output Current Magnitude
2a
20
24
PID
23
22
Voltage Demand(10kV)
10
1sided Transfer Function
21
Current Limit (<10μA)
Output Current
Function Output
0
0μA
Current Limit (<10μA)
17
High
Low(<1μA)
11
Monostable

FIG. 6

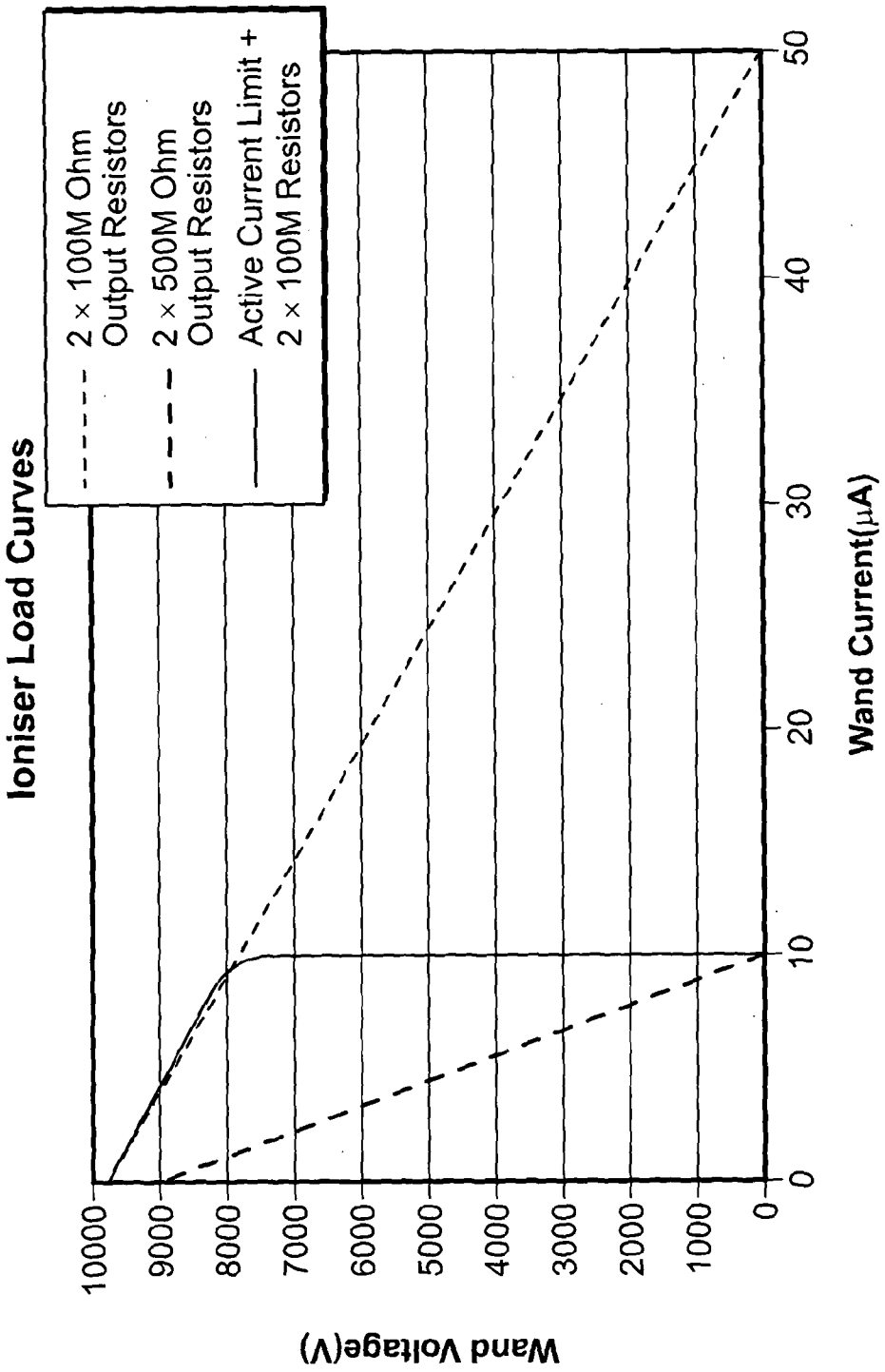
Ioniser Load Curves
2 × 100M Ohm Output Resistors
2 × 500M Ohm Output Resistors
Active Current Limit + 2 × 100M Resistors
Wand Voltage(V)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Wand Current(μA)
0
10
20
30
40
50

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/052707

A. CLASSIFICATION OF SUBJECT MATTER
INV. B03C3/68 A61B18/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B B03C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/010148 A2 (ASALUS MEDICAL INSTR LTD [GB]; WARREN NEIL [GB]; CROSSLEY ROBIN [GB];) 27 January 2011 (2011-01-27) cited in the application the whole document	1-10
A	WO 2004/062516 A1 (GYRUS MEDICAL LTD [GB]) 29 July 2004 (2004-07-29) page 3, line 30 - page 5, line 18 page 14, line 32 - page 16, line 9; figure 3	1-10
A	EP 0 558 318 A2 (G2 DESIGN LTD [GB] G2 DESIGN LTD [FR]) 1 September 1993 (1993-09-01) column 11, line 5 - line 38; figure 5	1-10

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 March 2013	13/03/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Skaropoulos, N

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/052707

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2006/059067 A1 (GYRUS MEDICAL LTD [GB]) 8 June 2006 (2006-06-08) page 7, line 29 - page 9, line 16 page 17, line 26 - page 18, line 9; figure 3 -----	1-10

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2012/052707

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		CA 2768603 A1	27-01-2011
		CN 102470009 A	23-05-2012
		EP 2456379 A2	30-05-2012
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		JP 5337129 A	21-12-1993
		US 5451224 A	19-09-1995
WO 2006059067 A1	08-06-2006	NONE	

专利名称(译)	腹腔镜器械的改进和相关的改进		
公开(公告)号	EP2776169A1	公开(公告)日	2014-09-17
申请号	EP2012791528	申请日	2012-10-31
[标]申请(专利权)人(译)	阿萨卢斯医疗器械有限公司		
申请(专利权)人(译)	ASALUS医疗器械有限公司		
当前申请(专利权)人(译)	ASALUS医疗器械有限公司		
[标]发明人	AMOAH FRANCIS KWEKU EGYIN		
发明人	AMOAH, FRANCIS KWEKU EGYIN		
IPC分类号	B03C3/68 A61B18/00		
CPC分类号	A61B18/1233 A61B2018/1266 A61B2218/008 B03C3/38 B03C3/68 B03C2201/26 A61B2018/00636 A61B18/18 A61B2018/00827		
优先权	2011019134 2011-11-07 GB		
外部链接	Espacenet		

摘要(译)

提供一种DC驱动的电离装置，用于电离局部气氛，其中进行有形的外科手术或美容手术，该电离装置包括安全电路，该安全电路包括用于检测何时存在危险情况的检测器装置，例如短路或高充电水平条件，用于致动开关的电路控制器意味着关闭直流电源，然后循环重新连接和断开直流电源，直到危险情况得到纠正，并重新设置装置，然后重新设置连续直流电源到电路，直到下一次发生危险情况或直到程序完成。