Dec. 30, 1958 KENSAKU SUZUKI 2,866,461

APPARATUS FOR PRODUCING ELECTRIC ANESTHESIA

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Fig. 1.

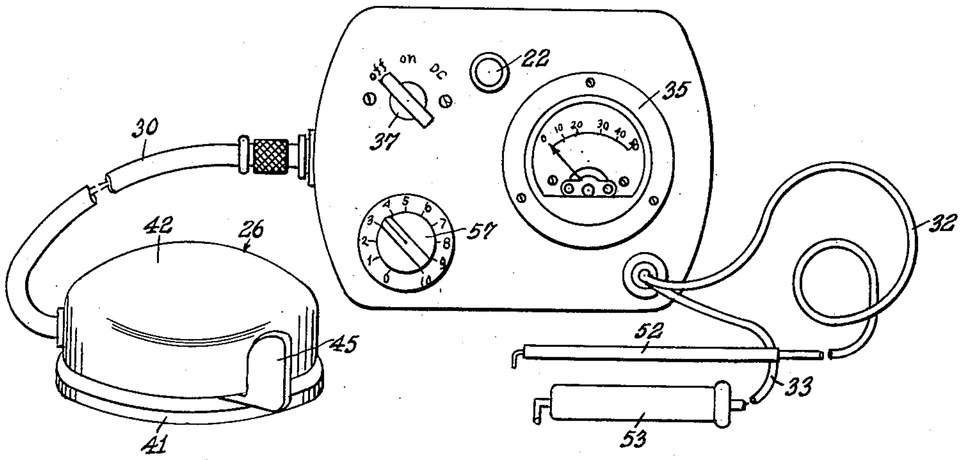

Fig. 2.

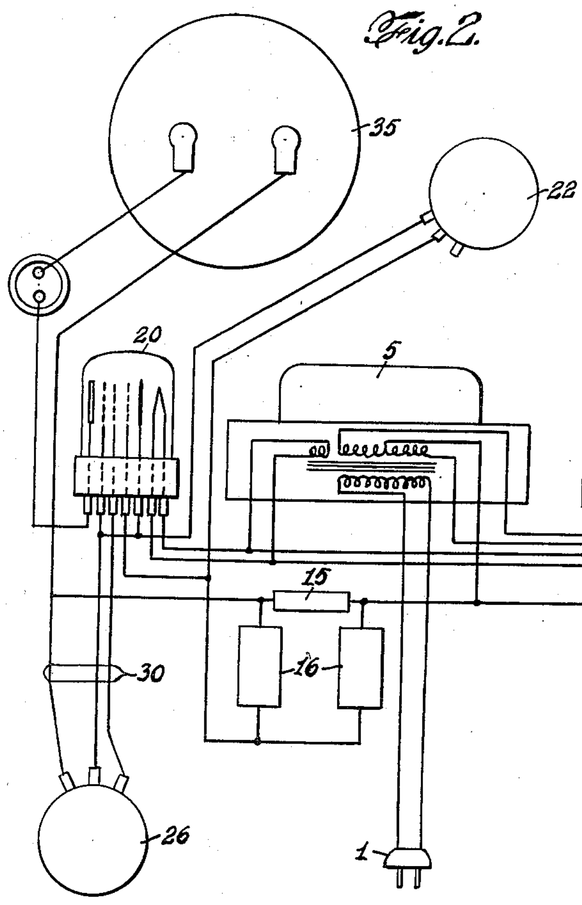

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Fig. 3.

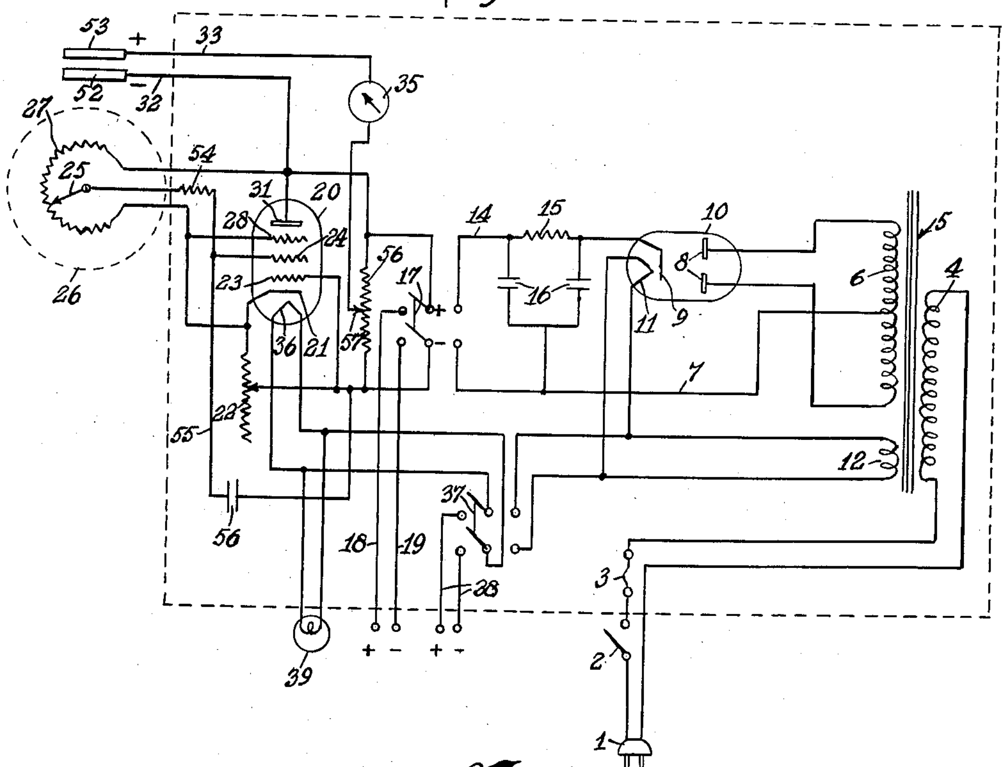


Fig. 4.

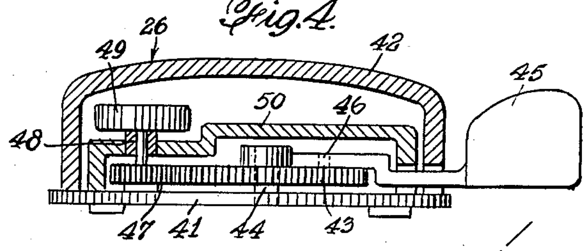
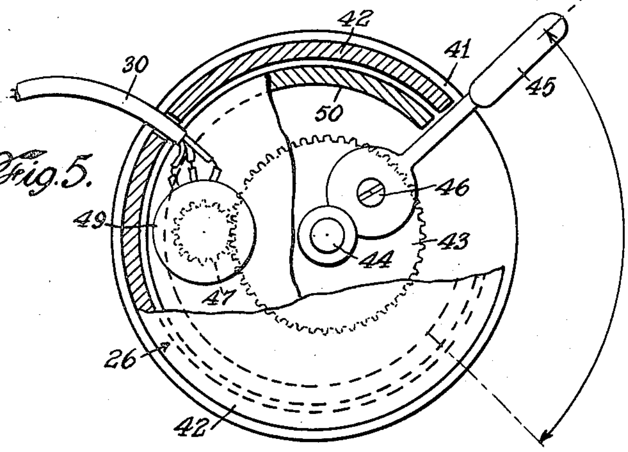


Fig. 5.



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APPARATUS FOR PRODUCING ELECTRIC ANESTHESIA

Kensaku Suzuki, Senju, Adachi-ku, Tokyo, Japan

Application January 21, 1954, Serial No. 405,458

Claims priority, application Japan October 23, 1950

6 Claims. (Cl. 128—419)

The present invention relates to apparatus for producing electro-anesthesia whereby an operation on a living body can be performed without a feeling of pain. The invention is particularly applicable to dentistry and will be described with reference to use in connection with dental instruments but it will be understood that the invention is in no way limited to dental use.

It has been found that a direct current of constant intensity applied to the body, for example by electrodes, acts to decrease the conductivity of nerves in the area of the positive electrode and to decrease the sensitivity of that area of the body to pain. However, in order to have this anesthetic effect, the current must not only be of a predetermined small value but must be kept constant at that value. Any fluctuations in the current produce irritation and pain rather than anesthesia.

In performing an operation on the body, the operating instrument itself is advantageously used as the positive electrode. A negative electrode is applied to the body at an area remote from that on which the operation is to be performed. In order to avoid irritation where the negative electrode is applied to the body, the latter electrode is made to contact a much larger area than the positive electrode. The current from the positive electrode is relatively concentrated and then spreads out in the body so that the current density is rapidly decreased and is of a very low value in the area of the negative electrode.

The value of the electric current effective to avoid pain is critical and must be precisely controlled. If the current is too high, it produces pain; if too low, satisfactory anesthesia is not obtained. The following examples indicate the correct values to be used for producing proper anesthesia:

(1) Cutting dentine: 2 μA to 15 μA, and preferably between 4 μA and 10 μA.
(2) Treatment of pathological dental pocket: 10 μA to 30 μA.
(3) Incision of parulis: 10 μA.
(4) Subcutaneous injection: 10 μA.
(5) Treatment of endometrium: 10 μA.

By reason of the resistance of the body, and particularly the contact resistance between the body and the electrode, the current tends to vary with the degree and nature of the contact. In accordance with the invention, the current is controlled in such a manner as to keep it substantially constant despite variations in body resistance and to prevent surges of current when contact with the body is made or broken. Moreover, provision is made for readily adjusting the current value while preventing the current from exceeding a predetermined critical amount. Provision is also made for avoiding ripple currents or other fluctuations in the current value that would interfere with obtaining effective anesthesia.

The nature and advantages of the invention will be more fully understood from the following description and claims in conjunction with the accompanying drawings, in which:

Fig. 1 is a front perspective view of apparatus in accordance with the invention.

Fig. 2 is a simplified schematic drawing showing the component elements of the apparatus.

Fig. 3 is a more detailed wiring diagram including provisions for using an auxiliary direct current source.

Fig. 4 is a vertical section of a foot-controlled regulating member.

Fig. 5 is a plan of the regulating member shown in Fig. 4 with certain portions broken away and shown in section.

The apparatus shown by way of example in the drawings comprises (1) a direct current supply circuit, (2) a control circuit for adjusting and regulating current from the supply to provide a non-fluctuating direct current output of predetermined value, and (3) electrodes connected to the output of the control circuit and adapted to contact the body.

As illustrated particularly in Figs. 2 and 3, the direct current supply circuit comprises a plug **1** adapted to be plugged into a conventional alternating current outlet, for example a 60-cycle, 110 volt outlet. The plug **1** is connected through a switch **2** and fuse **3** to the primary **4** of a transformer **5**. A secondary winding **6** of the transformer **5** is connected at its midpoint to a line **7** while the ends of the winding are connected respectively to plates **8** of a rectifier tube **10** e. g. a 6Y5 type tube having a cathode **9**. The cathode is heated by a coil **11** connected to another secondary coil **12** of the transformer **5**. A line **14** connected to the cathode **9** of the rectifier tube **10** contains a resistance **15** and is connected to the line **7** through two condensers **16** which are arranged in parallel to one another, being connected to the line **14** at opposite ends of the resistance **15**. The condensers **16**, together with the resistance **15**, eliminate any pulses, ripples or other transitory fluctuations in the direct current supplied by the full-wave rectifier tube **10**. The conductors **14** and **7** constitute positive and negative output leads, respectively, of the rectifier circuit. To provide for operation of the apparatus despite possible failure of the alternating current source to which the plug **1** is connected, a double-pole, double-throw switch **17** is adapted to connect the contorl circuit (described below) alternatively with the leads **14** and **7** of the rectifier circuit or with leads **18** and **19** connected to a battery or other direct current source (not shown).

The control circuit comprises a vacuum tube **20** having a high internal resistance, as for example, a pentode such as type 6C6 or 6SJ7. The cathode **21** of the tube **20** is connected through an adjustable resistance **22** to the negative pole of the switch **17**. As will be seen from Fig. 1, the rheostat **22** is adjustable by means of a knob and calibrated scale on the front panel of the apparatus. A control grid **23** is also connected to the negative pole of the input switch **17**. A screen grid **24** is connected through a fixed resistance **54** to the runner **25** of a rheostat **26** having a resistance coil **27** one end of which is connected to the positive terminal of the input switch **17** while the other end is connected to a third grid **28** and to the cathode **21**. The screen grid **24** is also connected through a lead **55** and condenser **56** to the negative terminal of the input switch **17** in order to eliminate interfering ripples from outside sources by induction. As illustrated in Figs. 1, 4 and 5, the rheostat **26** is a foot-operated unit (described more fully below), the connections with the rheostat **26** being preferably embodied in a three-conductor cable **30**. The plate **31** of the tube **20** is connected to the negative output terminal **32**. The positive output terminal **33** of the control circuit is connected through a micro-ammeter **35** to a movable tap **57** of a rheostat **56** connected across the terminals of the input switch **17**. The heater **36** of the tube cathode **21** is connected by a double-pole, double-throw switch **37** alternatively to the above mentioned secondary coil **12** of the transformer **5** or to a suitable direct current source **38**, for example a battery. A pilot light **39** connected across the cathode heater leads indicates when the apparatus is turned on.

The control grid voltage of the vacuum tube **20** is regulated by adjustment of the resistance **22**, being determined by the formula

$$V=R(I_p+I_s)$$

where V is the control grid voltage, R is the resistance **22**, I_p is the plate current and I_s is the screen current. Therefore, when the resistance of the resistor **22** is large, the plate current will be decreased and when the resistance is small, the plate current will be increased. If, however, the plate current is increased by external factors, the voltage drop of the control grid becomes larger, so that the plate current is decreased in order to maintain it substantially constant.

Within the limits permitted by the setting of the resistor **22**, the plate current can also be varied by varying the screen grid voltage by means of the rheostat **26**. When the screen grid voltage is increased, the plate current is correspondingly increased. When the runner **25** of the rheostat **26** is at the cathode end of the resistance **27**, the plate current will be zero. When the runner **25** of the rheostat **26** is at the anode end of the resistance **27**, the plate current will have the maximum value permitted by the control grid voltage, as described above. Since the maximum current is determined by the adjustment of the resistor **22**, a current larger than said maximum current cannot be obtained. The resistance **22** thus determines the limits within which the current can be varied by the foot-actuated rheostat **26**.

As illustrated more particularly in Figs. 4 and 5, the foot-controlled rheostat **26** has a base **41** and a cover **42**. A large flat gear **43** is rotatable on a post **44** projecting up from the base. An operating vane **45** is adjustably secured to the gear **43** by means of a screw **46** and extends out through an arcuate opening in the cover. The gear **43** can thus be turned through a limited range by means of the operating vane **45**. A pinion **47** meshes with the gear **43** and is fixed on the rotatable shaft **48** of a variohm device **49** mounted on a supporting member **50** and comprising a resistance **27** (Fig. 3) and a slider or runner **25** fixed to the shaft **48**. As described above, the control device **26** is connected to the set by means of a three-conductor cord **30**.

The electrodes of the apparatus comprise a negative electrode **52** connected to the negative output terminal **32** of the control circuit and a positive electrode **53** connected to the positive terminal **33** of the control circuit. The negative electrode **52** is illustrated as being a metal hand grip. The positive electrode **53** is illustrated as a dentist's drill but may instead be some other instrument, as, for example, a probe, knife, needle, etc. The positive electrode **53** is preferably insulated except for a metallic part that is intended to engage the body being operated upon.

Assuming that the apparatus is to be operated from an A. C. source, the plug **1** is inserted in a suitable electrical outlet receptacle and the switch **2** is closed to energize the transformer **5** and the rectifier tube **10**. The switches **17** and **37** are normally in a position to connect the control circuit to the transformer and rectifier circuit. A voltage of, for example, 50 volts is thereby impressed between the plate and cathode of the vacuum tube **20**. The resistor **22** is adjusted to its maximum value, for example 200,000 ohms. The slider of the rheostat **26** is moved to the plate end of the resistance **27**, having, for example, a resistance of 50,000 ohms, so as to bring the screen grid voltage to approximately the same value as that of the plate though there is a small resistance **54**. With the controls in this position, the positive and negative output terminals are connected, for example by touching the electrode **52** to electrode **53**. The dial of the resistance **22** is then turned so as to bring the plate current as measured by the micro-ammeter **35** to the optimum value for producing electro-anesthesia in the operation to be performed. The setting of the resistance **22** is then maintained fixedly at that point. The foot-controlled rheostat **26** is then moved to its opposite limit so as to make the plate current zero.

When this condition has been reached, the negative terminal of the output of the apparatus is connected to some area of the patient that is far removed from the operating field and the positive terminal is connected to the operating instrument, for example a dental drill. The operating instrument is then brought into contact with the operation field of the patient and the rheostat **26** is gently moved to the desired position to produce the optimum current for avoiding pain. As the operation proceeds, any desired regulation of the current is made by adjusting the foot-controlled rheostat **26**, the setting of the resistance **22** normally remaining constant.

An important feature of the apparatus in accordance with the invention is that it provides a constant nonfluctuating direct current of a predetermined optimum value in spite of any variation of resistance of the body of the patient. Moreover, since the current range is predetermined by the setting of the resistance **22**, the desired maximum value cannot be exceeded accidentally by manipulation of the foot-controlled rheostat **26**.

It will be understood that the embodiment of the invention illustrated in the drawings and particularly described above is given by way of a non-limiting example and that various modifications of the invention will be apparent to those skilled in the art.

This application is a continuation-in-part of my application Serial No. 239,656 filed August 1, 1951, and now abandoned.

What I claim and desire to secure by Letters Patent is:

1. In an apparatus for producing electric anesthesia during an operation on a body, in combination, an operating instrument having an electrically conductive body-engaging portion, a negative electrode adapted to be applied to the body at a region remote from the region of operation, the body-engaging area of said electrode being much greater than that of said instrument, a first electrical circuit comprising means for supplying substantially steady direct current to said operating instrument, a vacuum tube current-control circuit for controlling current flow between the instrument and negative electrode comprising connections to said first circuit and connections to said instrument and said electrode, a vacuum tube connected in said control circuit, first means connected to cooperate with said tube for adjustably determining the maximum current output of he apparatus and for preventing the current from exceeding a predetermined critical value corresponding to said maximum current output, and second means connected to cooperate with said vacuum tube for adjustably and selectively varying the current output within the limit determined by said first means in cooperation with said tube, whereby the current applied to the portion of the body being operated is applied without irritation and kept substantially constant regardless of variations in body resistance, and current surges are prevented when contact with the body is made or broken by said operating instrument.

2. In an apparatus according to claim 1, in which said means for supplying substantially steady direct current comprises a source of direct current.

3. In an apparatus according to claim 1, in which said first circuit comprises connection means for selectively connecting the apparatus to a source of alternating current, and in which said means for supplying substantially

steady direct current comprises full-wave rectifier means connected to rectify the alternating current, capacitor means and a resistance connected to eliminate pulses, ripples and other transitory fluctuations in the direct current output of the full-wave rectifier means.

4. In an apparatus for producing electric anesthesia during an operation on a body, in combination, an operating instrument having an electrically conductive body-engaging portion, a negative electrode adapted to be applied to the body at a region remote from the region of operation, the body engaging area of said electrode being much greater than that of said instrument, a first electrical circuit comprising means for supplying substantially steady direct current to said operating instrument, a vacuum tube current control circuit for controlling current flow between the instrument and negative electrode comprising connections to said first circuit and connections to said instrument and said electrode, a single vacuum tube having a substantially high internal resistance connected in said control circuit, first means connected to cooperate with said tube for adjustably determining the maximum current output of the apparatus and for preventing the current from exceeding a predetermined critical value corresponding to said maximum current output, and second means connected to cooperate with said vacuum tube for adjustably and selectively varying the current output within the limit determined by said first means in cooperation with said tube whereby the current applied to the portion of the body being operated is applied without irritation and kept substantially constant regardless of variations in body resistance, and current surges are prevented when contact with the body is made or broken by said operating instrument.

5. In an apparatus for producing electric anesthesia during an operation on a body, in combination, an operating instrument having an electrically conductive body-engaging portion, a negative electrode adapted to be applied to the body at a region remote from the region of operation, the body-engaging area of said electrode being much greater than that of said instrument, a first electrical circuit comprising a full-wave current rectifying electron discharge device for supplying substantially steady direct current to said operating instrument, a vacuum tube current-control circuit for controlling current flow between the instrument and negative electrode comprising connections to said first circuit and connections to said instrument and said electrode, a single vacuum tube connected in said control circuit, first variable resistance means connected to cooperate with said tube for adjustably determining the maximum current output of the apparatus and for preventing the current from exceeding a predetermined critical value corresponding to said maximum current output, and second variable resistance means connected to cooperate with said vacuum tube for adjustably and selectively varying the current output within the limit determined by said first resistance means in cooperation with said tube, whereby the current applied to the portion of the body being operated is applied without irritation and kept substantially constant regardless of variations in body resistance, and current surges are prevented when contact with the body is made or broken by said operating instrument.

6. In an apparatus for producing electric anesthesia according to claim 5, in which said second variable resistance means comprises a foot-operated rheostat.

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