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APPARATUS FOR THE TREATMENT OF SKIN DISEASES

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Fig. 1.

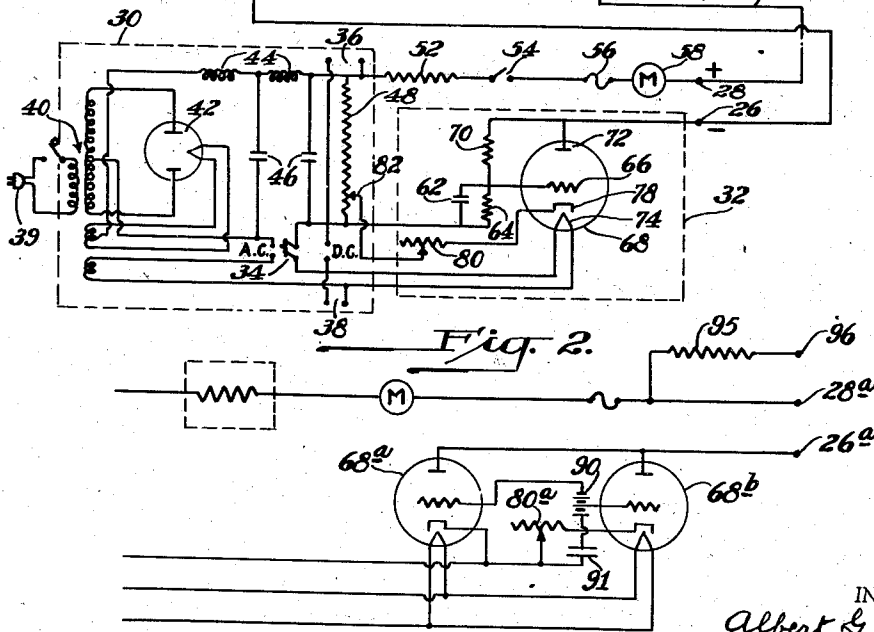
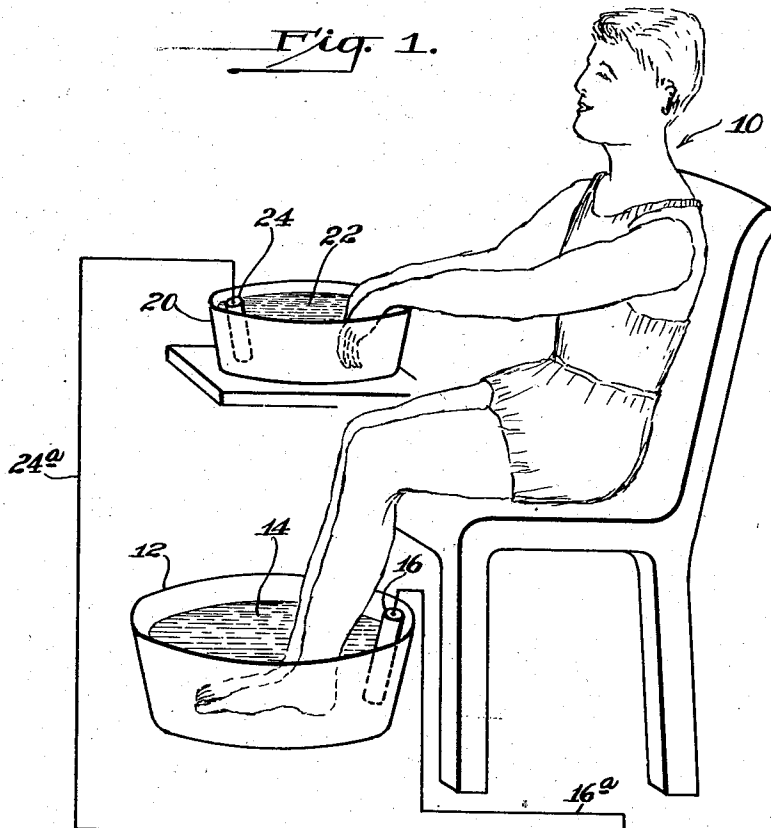


Fig. 2.

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UNITED STATES PATENT OFFICE

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APPARATUS FOR THE TREATMENT OF
SKIN DISEASES

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2 Claims. (Cl. 128—172.1)

This invention relates to methods and apparatus for the treatment of diseases of the human skin or other living tissue, and is more particularly concerned with an improved method and apparatus for electrically supplying a suitable therapeutic agent to the tissue to be treated.

A general object of the invention is the provision of new and useful methods and apparatus for electrolytically supplying a therapeutic agent to living tissue, particularly human skin, to treat disease thereof.

A particular object is to treat epidermophytosis (athlete's foot) or other moldy dermatological infection by electrolytic deposition of copper at the situs of the infection.

Another object of my invention is the provision of a relatively inexpensive, portable and easily operated apparatus for treating skin or other living tissue diseases in the manner described.

Another object of my invention is to provide apparatus for electrolytically supplying a therapeutic agent to living tissue which can be used safely and without sensory or motor discomfort to the person undergoing treatment. Specifically, it is an object of the invention to avoid electrically shocking a human being using my apparatus.

Another object of the invention is the provision of therapeutic apparatus of the character described and including means for adjusting the current to any desired value, and means for limiting the maximum current to a value below an injurious value without completely interrupting the current.

Another object of the invention is the provision of apparatus for electrolytically supplying a therapeutic agent to living tissue from a liquid wherein the removal of the tissue from the liquid automatically resets the adjustment of the circuit in such a way that the sudden replacement of the tissue does not result in sensory or motor discomfort to the tissue.

Another object of my invention is the provision of an improved method for rapidly and inexpensively applying a therapeutic agent in particularly efficacious form to living tissue without discomfort to the tissue and without requiring skill or technical directions or supervision.

Yet another object is to provide a method of and apparatus for treating diseased tissue by electrodeposition of a therapeutic agent in or on such tissue.

A further object of my invention is the provision of a method of and apparatus for removing hair from living tissue.

The foregoing and other objects of the invention are achieved by the provision of an apparatus for the treatment of skin and tissue diseases which comprises in combination an electric circuit including a conducting liquid capable of supplying therapeutic agent, and means for connecting the tissue as one electrode in the liquid to effect application or production of therapeutic agent thereon, together with means for supplying an electric current to the circuit to supply the therapeutic agent to the tissue. The means for supplying current to the circuit is characterized by means providing little or no flow of current immediately upon the completion of the circuit, followed by the gradual rise of current flow thereafter, whereby a relatively large amount of current flow can be obtained without sensory or motor discomfort to the tissue.

In accordance with the method of the invention, I therapeutically treat skin and tissue diseases by placing the tissue to be treated in a conducting liquid capable of supplying therapeutic agent, and then connecting the tissue as an electrode in an electric circuit in such manner that the therapeutic agent will be formed on or in the tissue to be treated. In accordance with the invention the current flow in the circuit is so regulated as to supply the therapeutic agent on the tissue without sensory or motor discomfort thereto when the circuit is established. In this manner the therapeutic agent is deposited in unusually intimate contact with the tissue, so that it is peculiarly well adapted to exert its desired effect.

Although not limited thereto, as will appear more fully hereinafter, the invention is particularly adapted to supplying diseased tissue with therapeutic agent by electro-deposition phenomena, and will be described in further detail with particular reference thereto.

For a better understanding of the invention, reference should be had to the accompanying drawing in which Fig. 1 is a diagrammatic illustration of one embodiment of the apparatus of my invention and illustrates the manner of its use; and Fig. 2 is a view illustrating a modified circuit for supplying electric current.

Referring to Fig. 1 of the drawing, the numeral 10 indicates a human being having a skin disease, such as epidermophytosis, on his feet. The feet are placed in a conducting liquid which in this embodiment is an electrolyte 14 contained in a tank or basin 12 of enameled metal, glass or other material not attacked by the electrolyte. The electrolyte used in the practice

of the invention is capable of supplying a desired therapeutic agent which is deposited on the feet of the human being under the influence of current passed through electrolyte 14. The exact nature of the material used, the mode in which the therapeutic agent is released, and the particular agent supplied can vary widely and are dependent upon the particular type of disease and tissue to be treated. However, it is generally desirable to use an aqueous solution of a salt or other compound which ionizes to form ions of the therapeutic agent which are carried to and deposited on the tissue acting as an electrode of polarity appropriate to that end. Likewise, therapeutic agent may be formed through secondary reactions at an electrode, it being possible in this manner to form therapeutic agents of both organic and inorganic character in or on the tissue being treated. It will be understood thus that the tissue to be treated is caused to act in the electroplating circuit as that electrode at which the therapeutic agent is liberated or formed.

For many purposes metallic salts are desirable because of the therapeutic value of metals, particularly in the state in which they are supplied to the tissue by the practice of this invention. For instance, in the embodiment being described the tissue being treated will act as the cathode so that the metal will be deposited thereon.

Although not restricted thereto, the invention may be described with particular reference to the treatment of epidermophytosis, commonly called athlete's foot, because it is a skin disease of common occurrence and has been shown to respond to treatment in accordance with this invention. For this purpose good results are obtained by depositing copper at the afflicted area. A convenient electrolyte for this treatment is an aqueous solution of copper sulfate. Associated in insulated relation with the container 12 is an anode 16 which may suitably be made of copper because thereby impoverishment of the electrolyte of copper ions is avoided.

The living tissue being treated, which in the example shown in the drawing is the foot of the human being, forms the cathode of the electroplating circuit. Various ways of connecting the cathode electrically into the electroplating circuit may be employed in the practice of my invention. One convenient manner of achieving this result is to provide a second basin 20 containing a solution 22 of an electrolyte in which the hands are immersed. One satisfactory solution for this purpose is a solution of ordinary salt. The basin 20 receives an electrode 24 which is connected by a lead 24a to the negative output terminal 26 of a source of electric current. Completing the electroplating circuit is a connection 16a from the positive output terminal 28 of the source of electric current to the anode 16. If the basin 20 is made of electroconductive material, as for example aluminum, then electrode 24 may be dispensed with, the wire 24a being connected directly to the basin. With this apparatus copper will be deposited at the affected areas of the feet immersed in the electrolyte 14 when the electroplating circuit is established.

An important part of my invention is the provision of apparatus for supplying electric current to the electric circuit so that the flow of current in the circuit is initially very low but builds up gradually to a desired higher value.

This prevents the apparatus from affecting the living tissue with discomfort through or to its sensory or motor nerves. As illustrated in Fig. 1, this apparatus may conveniently take the form, of a source of electric current, indicated as a whole by the dotted box 30 in the wiring diagram, which is controlled through a regulator, outlined by the dotted box 32 in the wiring diagram.

The source of current 30 may be adapted to operation on either alternating or direct current. To this end, a double pole, double throw switch 34 is adapted to be connected either to the direct current supply terminals 36 and 38 or, and preferably, to a standard alternating current transformer and rectifying circuit. The transforming and rectifying circuit which permits the apparatus to be plugged, by way of cord 39, into the standard 110-volt, 60-cycle house current includes a transformer, indicated as a whole by the numeral 40, a rectifier tube 42, filter chokes 44, filter condensers 46, and a bleeder resistance 48 connected in the standard manner shown. The transforming and rectifying system used in the practice of the invention is adapted to transfer the 110-volt, 60-cycle house current to smooth, non-cyclic, direct current at about 300 volts.

Regardless of whether the source of current supply is from direct current or rectified alternating current, the positive side thereof is connected, as shown in Fig. 1, through a resistance 52 of approximately 15,000 to 20,000 ohms, an on-and-off switch 54, a fuse 56, and a milliammeter 58 to the positive output terminal 28. The milliammeter 58 is adapted to read approximately from zero to 15 milliamperes. The negative side of the source of electric current is connected to a condenser 62 of approximately 2 microfarads capacity which is shunted by a resistance 64 of approximately 6 megohms. The condenser 62 and resistance 64 are connected to the grid 66 of a three-element vacuum tube 68 and are also connected through a resistance 70 of approximately 1½ megohms to the plate 72 of the vacuum tube and then to the negative output terminal 26. The heater 74 of the vacuum tube is operated by any suitable source of electric current and may be conveniently connected in the manner shown in the wiring diagram so that the switch 34 will energize the heater regardless of whether alternating current or direct current is used as the source of current supply.

The cathode 78 of the vacuum tube 68 is connected through a variable resistance 80 of approximately 50,000 ohms to a variable tap 82 on the bleeder resistance 48 which is conveniently of about 10,000 ohms.

It is believed that the operation of the apparatus just described will be evident to those skilled in the art. However, briefly reviewing the operation, if the apparatus is used where ordinary house lighting current is available, the switch 34 is thrown to the alternating current position and the transformer and rectifying unit is plugged, by way of cord 39, into the house lighting circuit. If direct current is used the switch 34 is thrown to the direct current side and, of course, direct current at approximately 300 volts is applied to the terminals 36 and the proper heater voltage to the terminals 38.

Now assuming that the living tissue to be treated is the foot or feet of the human being 10, the human being places his foot or feet in the basin 12 and his hand or hands in the basin

20. Thereupon, the switch 54 is thrown to connect the source of electric current to the electroplating circuit. However, it should be understood that the switch 54 may be closed prior to placing the hands in the basin 20, as will be evident as the description proceeds.

The flow of electric current in the electroplating circuit after the closing of the switch 54 is relatively small and minute and may be in the nature of one or two milliamperes. However, this current flow gradually builds up until it may reach as much as 15 milliamperes. This action is due to the valve control of the vacuum tube 68. Specifically when the electrode circuit is open the voltage across the tube is zero. Consequently the voltage across the resistors 70 and 64 and the condenser 62 is zero, making the potential of the grid of the tube 68 to have the same potential as the negative side (bottom) of the bleeder resistor 48. Since the cathode has the same potential as the tap on the bleeder, the grid 66 must be at a negative potential with respect to the cathode 78. If the electrode circuit is now closed a potential is established across the resistance capacitance circuit (70-64-62). At the instant of closing the circuit all of this potential appears across the resistance 70. This potential causes a current to flow through the resistance 70 which divides between the resistance 64 and the condenser 62. As this current continues to flow it builds up the voltage across the condenser 62. This charging effect of the condenser permits a gradual rise in voltage of the grid 66 with respect to the cathode 78. This rise in grid voltage causes a change in the plate to cathode resistance of the tube. This gradual change in resistance insures a gradual rise in plate current and consequently a gradual rise in the electroplating circuit. This gradual build-up in the current prevents sensory or motor discomfort to the human being connected in the electroplating circuit.

The copper sulfate in the electroplating circuit forms, of course, positive copper ions and negative sulfate ions. The positive copper ions are carried to and deposited on the tissue to be treated, namely, the foot or other part of the human being 10, which acts, in effect, as a cathode, and the negative sulfate ions are deposited on the anode 16 where they form more copper sulfate due to the fact that the anode 16 is formed of copper.

If the therapeutic agent to be deposited upon the tissue is other than copper, it will be understood that the electrolyte and anode 16 are formed to achieve the desired electroplating operation. Thus, zinc, silver, gold, or other metals might be used to treat specific disease conditions, in which event appropriate salts are used to form the electrolyte. Particularly, the electrolyte is selected so that the desired therapeutic agent is supplied to the tissue by ion deposition, by reaction effected thereby, or by other phenomena referred to hereinafter. The anode is generally formed of a material which combines with the other ion of the electrolyte to renew the electrolyte solution, although this is not essential.

An important feature of the electric circuit described, and more particularly of the regulator, indicated as a whole by the numeral 32, is that, once the circuit is broken, as, for example, when the human being 10 removes his hand or foot from either the container 12 or the container 20, the circuit is immediately put in its initial condition. In other words, the original conditions of the current supply circuit are established with the vacu-

um tube 68 acting as a valve to permit only a very small flow of electric current in the circuit when it is reestablished with a subsequent gradual building-up of the amount of current flow. This characteristic of my improved apparatus allows the human being to remove his hands or feet from the containers 12 and 20 to look at them or for any other reason, and thereafter the hands or feet can be immediately returned to the container without subjecting the person to sensory or motor discomfort due to the making of the electric circuit. Thus, electric shocks in the use of the apparatus which might frighten or injure the person being treated are eliminated.

In the operation of the apparatus described the current flow can be adjusted by adjusting the resistance 80. The initial setting of the variable contact 82 on the bleeder resistance 48 also has an effect on the current, as will be apparent. The rise of current is determined by the characteristics of the resistances 64 and 70 and by the condenser 62. Of course, the maximum current flow is also determined by the applied voltage and the characteristics of the resistance 52, tube 68 and the tissue.

It will be appreciated that in the actual practice of my invention the current supply and regulator apparatus is installed in a small neat box which is readily portable and of attractive appearance and on which all switches and controls are handy for operation.

The form of my invention shown in Fig. 2 of the drawing is very similar to that illustrated in Fig. 1 with the exception that two vacuum tubes marked 68a and 68b are used and grid biasing is obtained by the use of a small C-battery 90 which is connected to the grids of the vacuum tubes as shown. A variable resistance 80a performs the same function as the resistance 80 shown in Fig. 1. A condenser 91 is connected in parallel with the resistance 80a. The operation of the circuit shown in Fig. 2, and the flow of current to the terminals 26a and 28a, is exactly the same as that of the apparatus shown in Fig. 1 and above described. Briefly, the two vacuum tubes 68a and 68b act as valves controlling the flow of electric current in the electroplating circuit. Originally the negative biasing of the grids of the vacuum tubes holds the initial electric flow in the electroplating circuit to a very small amount. Thereafter the current flow builds up gradually as the negative biasing action of the grids is reduced until a point is reached where a fairly large amount of current is flowing in the circuit.

I have discovered that my apparatus can be used for removing hair by placing a needle in the skin beside the hair and applying a small amount of current to the needle for several minutes. In using my apparatus to this end I connect a large resistance 95, for example, of 300,000 ohms, in series with one of the current supply leads (see Fig. 2). The resistance 95 is connected to a terminal 96. Thus, when the apparatus is used to remove hair terminals 96 and 26a are employed instead of the regular terminals 26a and 28a. The resistance 95 may be used with the apparatus of Fig. 1, as will be understood.

From the foregoing it will be recognized that the objects of my invention have been achieved by the provision of methods and apparatus for electrically supplying a therapeutic agent to living human tissue. The methods and apparatus herein disclosed are relatively inexpensive and easily operated or practiced. Danger of electric

shock or discomfort has been eliminated, and my improved method and apparatus are characterized by a gradual building-up of the flow of current in the electroplating circuit so that sensory and motor discomfort to the living tissue is avoided while effecting the most efficient type of depositing action.

As an example of the therapeutic value of my invention, I have found that in the treating of epidermophytosis with copper sulfate solution as an electrolyte, in a treatment lasting for twenty minutes and with a flow of about 12 milliamperes of current, finely divided copper is carried into the skin with very beneficial therapeutic action. The copper acts as a highly effective fungicide, and even in an acute infection the blisters and vesicles usually disappear after the first treatment with my apparatus, and the ordinary case of epidermophytosis or ringworm infection is usually cleared up after several treatments of approximately twenty minutes with my apparatus. A very old and stubborn infection may require a greater number of treatments.

It will be understood that various modifications are within the scope of the invention. Thus, where the therapeutic agent is formed by an anion, or by reaction at an anode, the tissue is connected as anode. Likewise, one foot, in the example chosen, may be connected as anode and the other as cathode, by direct contact with leads 16a and 24a, to treat a single diseased foot, or to treat both feet by reversal of the connections after the cathode-connected foot has been treated sufficiently. Again, the feet may be placed in separate basins if desired for any reason, one containing an anode and the other a cathode, or both containing anodes 16 in the example of Fig. 1. Other modifications will occur to those skilled in the art.

The invention has been described in detail with reference to supplying therapeutic agent by electrodeposition phenomena, with or without secondary reactions, from electrolytes. It will be understood, however, that it is not restricted thereto but is applicable generally to the use of the electric current for supplying tissue with therapeutic agents. For example, the therapeutic agents may be supplied to the tissues by the phenomena of electrophoresis or of electro-osmosis instead of by electrodeposition. Thus, the electrolyte 14 may be replaced by a liquid having a therapeutic agent colloiddally dispersed therein which migrates by electrophoresis to the tissue under the influence of the electric current supplied to the electrodes. Or, a therapeutic liquid or solution thereof may be caused to enter the tissue by electro-osmosis when current is supplied to the electrodes. In such instances the electrodes are connected appropriately, as will be understood, according to the charge of the colloid or of the agent being supplied by the osmotic process.

The use of the phenomena of electrophoresis and electro-osmosis involves the movement of charged carriers in a liquid medium which therefore possesses conductance just as, considered broadly, ions impart conductance to a true electrolyte. Hence all such liquid media used in the practice of the invention may be considered as conducting liquids even though ionic conductance is not involved. That is, in all such instances there is relative movement in a liquid medium to supply therapeutic agent to tissue, whether the movement be by ionic migration, electrophoresis, or electro-osmosis.

From what has been said it will be understood also that the invention is applicable to supplying therapeutic agents not only at the surface of exposed tissue, e. g., the skin, but also within tissues or to the blood stream.

While in accordance with the patent statutes I have particularly illustrated and described my improved method and apparatus, it will be understood that I am not to be limited thereto or thereby but that my invention is defined in the appended claims.

I claim:

1. Apparatus for controlling the supply of electric current to living tissue which comprises a vacuum tube, a source of current supply, means adapted to connect one side of the current supply to the living tissue, means connecting the other side of the current supply to the cathode of the tube, means adapted to connect the plate of the tube to the living tissue, and means for biasing the grid of the tube negatively so that the flow of current in the tissue is small when the circuit is first established and yet builds up gradually due to the inherent gradual reduction of the negative biasing of the grid, said last-named means including a resistance and condenser connected in parallel between the grid and the side of the current supply connected to the cathode of the tube, and a resistance connected between the grid and the plate of the tube.

2. Apparatus for controlling the supply of electric current to living tissue which comprises a vacuum tube, a source of current supply, means adapted to connect one side of the current supply to the living tissue, means connecting the other side of the current supply to the cathode of the tube, means adapted to connect the plate of the tube to the living tissue, and means for so biasing the grid of the tube negatively that the flow of current in the tissue is small when the circuit is first established and yet builds up gradually due to the inherent gradual reduction of the negative biasing of the grid and that, when the flow is stopped, the circuit is immediately returned to its original condition.

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