

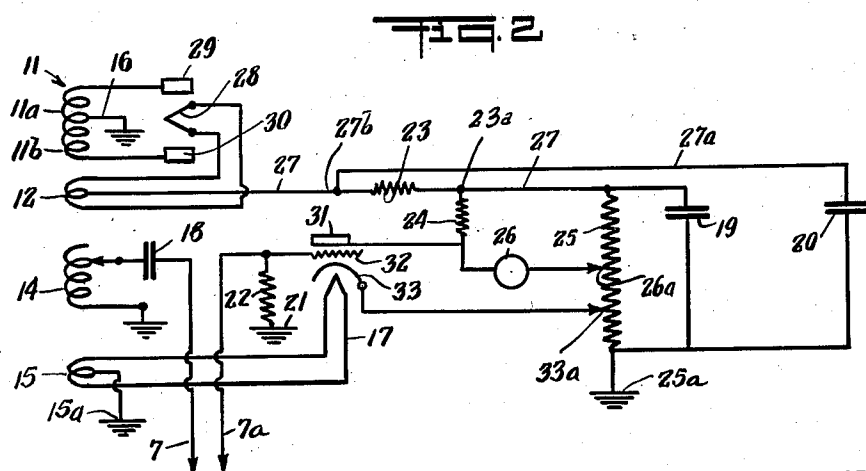
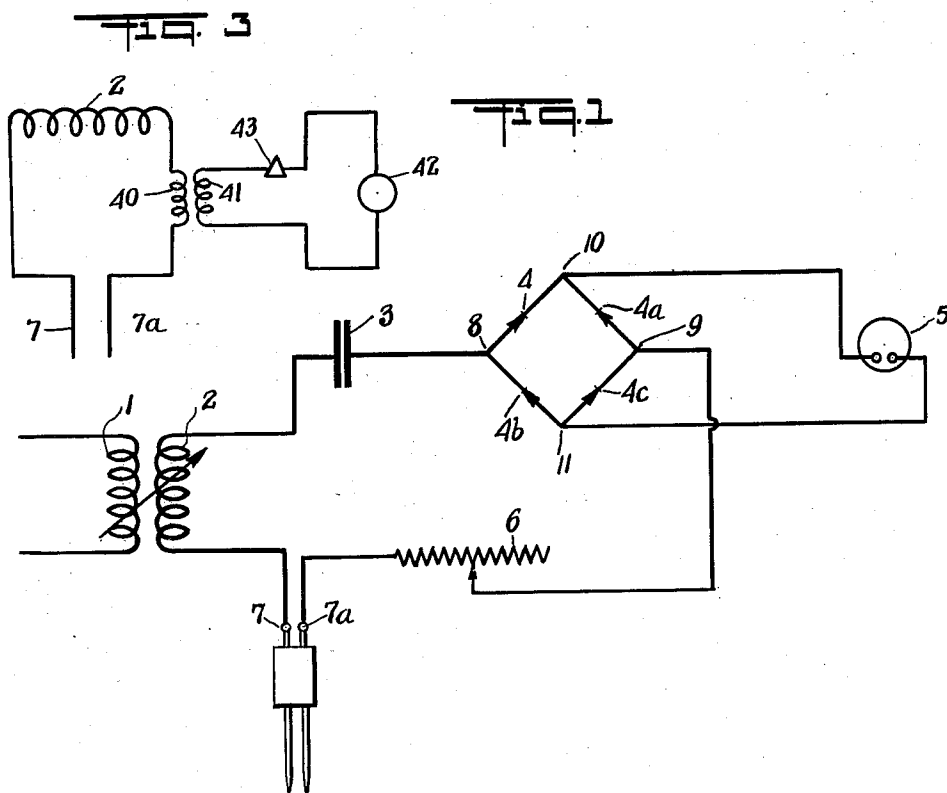
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METHOD FOR EXPLORING LIVING TISSUE

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METHOD FOR EXPLORING LIVING TISSUE

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1 Claim. (Cl. 128-2.1)

My invention relates to a new and improved method and device for exploring living tissue, including the tissue of a human being.

One of the objects of the invention is to explore tissue located underneath the skin, and more particularly tissue located directly underneath the inner layer of the human skin. This subcutaneous tissue has blood vessels.

Another object of the invention is to provide an improved method and means for diagnosing the allergy of a patient to a substance or substances.

Another object of the invention is to provide improved means and method for determining various gland conditions, the reaction of the patient to glandular extracts and the like.

Another object of the invention is to provide electrical means, whose reading is unaffected by the direct currents which are generated in various parts of a living organism, and more particularly the human being.

Other objects of the invention will be stated in the annexed description and drawing which illustrates preferred embodiments thereof, it being understood that the above statement of the objects of my invention is intended to generally explain the same without limiting it in any manner.

Fig. 1 is a circuit diagram of one embodiment of the invention.

Fig. 2 is a circuit diagram of a second embodiment of the invention.

Fig. 3 is a circuit diagram of a third embodiment of the invention.

Heretofore, in determining allergic diseases or reactions, it has been customary to apply test substances or solutions to the skin and then to observe the condition of the outer surface of the skin. This method was superficial and uncertain. According to the improved method, the condition of the living tissue underneath the innermost layer of the skin is reliably and carefully tested.

Fig. 1 shows the primary coil 1 of a transformer which can be connected to any suitable source of alternating current. This current may be the usual sixty cycle current, whose voltage is 110 volts. The voltage and the frequency of the primary current may be varied without limitation, but it is preferable to use a current having a relatively low frequency. An alternating current is induced in the secondary coil 2 of the transformer. The R. M. S. voltage at the end of the secondary coil may be about 2.5 volts. One terminal of the secondary coil 2 is connected to the electrode 7. This electrode may be made

of any conducting material. The electrode may be an ordinary steel rod. It may be made of a non-rusting metal or alloy, such as platinum, stainless steel, etc. The other terminal of the secondary coil 2 is connected to one side of a condenser 3, whose capacity may be a microfarad. The other side of the condenser 3 is connected to a terminal 8. The terminal 8 and a second terminal 9 are connected in parallel. One pair of legs of this parallel circuit has the rectifiers 4 and 4a and the other pair of legs has the rectifiers 4b and 4c. These rectifiers may be of any suitable type, such as copper oxide rectifiers. As indicated by the arrows, the rectifier 4 transmits current only in a direction from the terminal 8 towards the terminal 9 and the rectifier 4a transmits current only in the opposite direction. The rectifier 4b can transmit current only in a direction from the terminal 9 to the terminal 8, and the rectifier 4c transmits current only in the opposed direction.

The medium points 10 and 11 are connected to a suitable microammeter 5. In effect, the circuit has four legs between the points 8, 10, 9, and 11. Each of these legs has a rectifier. These legs are substantially or wholly identical. The terminal 9 is connected through a resistance 6 to a second electrode 7a, which is preferably identical in all respects with the electrode 7. The resistance 6 may be quite high, such as 20,000 ohms.

When the points of the electrodes 7 and 7a are applied to the subcutaneous living tissue, alternating current can flow in one direction from the upper terminal of secondary coil 2, through the condenser 3, to the terminal 8, through the rectifier 4, to the terminal 10, through the meter 5 to point 11, through rectifier 4c to terminal 9, and through the resistance 6 to the electrode or conducting member 7a. When the current is flowing in this direction, it will not flow from the terminal 10 to the terminal 9. Likewise it will not flow from the terminal 8 to the terminal 11. During the next half-cycle of the induced alternating current of the secondary coil 2, the direction of the current is reversed. Current will then flow from the electrode 7a through the resistance 6, to the terminal 9, through the rectifier 4a to the terminal 10, through the meter 5 to the terminal 11, through the rectifier 4b to the terminal 8, and through the condenser 3 to the upper terminal of the secondary coil 2. The condenser 3 blocks the flow of direct current which may be flowing in the living tissue between the points of the electrodes 7 and 7a so that the

meter reading is a substantially direct and accurate reading which measures the amperage of the alternating current which is passed through the subcutaneous living tissue between the points of electrodes 7 and 7a, although the meter is of the direct current type. The meter 5 can be of any suitable type which can measure the flow of direct current.

In order to diagnose allergic diseases, the points of the electrodes 7 and 7a are forced lightly through the skin of any suitable part of the body, until said points contact with the tissue underneath the skin and the blood vessels of said subcutaneous tissue. This may be done on the arm of the patient, and the distance between the points may be approximately one centimeter. It is preferable to take the reading or readings, by measuring the resistance of the tissue directly underneath the innermost layer of the skin. Under the conditions above mentioned the reading of the ammeter or other meter 5 will show a normal current flow of 12-13 microamperes.

A scratch is then made upon the skin between the electrodes, and the material to be tested is then placed in said scratch, so that it will act upon the tissue directly underneath the innermost layer of the skin. This scratch preferably extends wholly through the various layers of the skin. The test material is preferably a liquid extract of the food or substance which is being tested. It consists preferably of an isotonic solution. This test material may be of the standard types which are now used for testing allergic conditions.

If the patient is allergic or susceptible to the test material, this will manifest itself by a rapid lowering of the resistance between the points of the test electrodes. The meter 5 will quickly record a current of about 50 microamperes.

Tests can therefore be made with foods, dusts, pollens, spores and molds, and cultures of various bacteria, such as *Staphylococcus aureus* and *Albus aureus*.

The material to be tested need not necessarily be in the liquid condition, or in the form of a solution or dispersion or culture, as long as the test material can react with the living tissue. I can likewise use extracts of various glands, and more particularly extracts of the ductless glands, in order to measure the activity of the corresponding glands in the living organism. For example, liquid thyroid extract can be utilized. A rapid lowering of the resistance of the living tissue between the test points will indicate a hypothyroid condition.

It is well known that direct currents flow between various portions of the human body, but these direct currents are blocked by the condenser 3 so that they do not affect the accuracy of the reading. The circuit preferably has minimum inductance, save for the inductance of the secondary coil 2. However, the circuit may have inductance additional to the inductance of said secondary coil 2, without departing from the invention. The transformer may have an iron core, or else I can use a transformer which does not have an iron core, in order to minimize the inductance of the test circuit.

If the patient does not react unduly to the test substance, there will be little or no change in the reading of the meter. The test points may be used for measuring the resistance of a substantial cross-sectional area of the tissue, such as a cross-sectional area of two to three square centimeters, since the current penetrates the

subcutaneous tissue, including its blood vessels to some extent. The distance between the points of the electrodes is about one-half inch, although this may be varied. The instrument may be used for exploring living tissue, a centimeter or even more below the inner surface of the outer skin. It is unnecessary to insert the points of the needles more deeply because the current penetrates the tissue inwardly of the points of the needles.

If the patient is allergic or sensitive to the test substance, the blood will inflate the blood vessels in tissues in the test area, below the skin of the arm, thus lowering the resistance between the points of the electrodes.

While I prefer to block the direct current of the living tissue from the measuring instrument 5, in order to eliminate the resultant error, the invention is not limited to this and the invention is not necessarily limited to the use of alternating current, although such current is highly preferred.

I prefer that the scratch which is used for causing contact between the test substance and the living tissue should extend completely through the various layers of the skin.

The rectifiers 4-4c constitute full-wave rectifying means and they can be replaced by other suitable full-wave rectifying means so that current pulses are passed through the measuring instrument 5 in the same direction.

In its broadest aspect, the invention includes the use of any type of electric current, including current pulses in the same direction, or current pulses in successive opposed directions. It is preferred to eliminate from the measurement the direct current which is self-generated in the living tissue. The substance which produces the change in electrical resistance may be administered in any manner.

Likewise in determining many conditions, the measurement of the electrical resistance of living tissue is sufficient, as comparison can be made with the resistance of tissue under normal conditions. Under such circumstances, it is not necessary to administer or to apply a test substance.

Instead of using contact needles which are applied to the tissue underneath the skin of the arm or other part of the body, I can use electrodes having contact discs. Each said disc may have a diameter of about $\frac{1}{8}$ of an inch. These discs are applied to a mucous membrane, such as the mucous membrane of the nose. It is unnecessary to pierce this mucous membrane. The reading which is thus secured directly on the outer surface of the mucous membrane may be used as a norm reading, which may be used independently of the norm reading secured on the tissue underneath the skin of the arm or the like. These respective norm readings may also be compared.

The mucous membrane of the nose is similar to the skin of the arm, but the thickness and resistance of the skin of said mucous membrane are negligible. The reading which is therefore secured at the exposed outer surface of the mucous membrane of the nose, without penetrating said mucous membrane, is steady and gives a definite and clear norm for the respective individual. This provides simple and easy means for standardizing the instrument.

In making a test on the tissue under the skin of the arm, for example, in order to establish a norm for the particular patient, experience has shown that the first reading between the first

pair of selected points of the tissue is usually too high. After making this first test, a series of additional tests are made quickly at other pairs of selected points of the arm, so that the current is passed through about eight or ten different pairs of selected points of the arm.

The test is now repeated at the first pair of selected points, and the reading is usually lower than the initial reading. This final reading, which is the lowest that can be secured, is taken as the norm.

The test on the mucous membrane of the nose can be used as a check on this norm reading taken on the arm.

In the embodiment shown in Fig. 2, the coils 11, 12, 14 and 15 are inductively coupled to a primary coil which is similar to the coil 1. This primary coil may be supplied with an alternating current of the type above mentioned, having a potential of 110 volts, and a frequency of 60 cycles per second.

The secondary coil 11 has a ground connection 16 which divides the same into equal sub-coils 11a and 11b, each of which has a root mean square (R. M. S.) voltage of 90 volts. The coil 12 delivers an R. M. S. voltage of 5 volts. The coil 14 has one end thereof grounded. It delivers an R. M. S. voltage which can be varied between zero and 25 volts. The coil 15 is grounded at its centre. It delivers an R. M. S. voltage of 6.3 volts.

The capacity of the condenser 18 is one microfarad (1 mfd.). This is preferably a paper condenser. Each of the condensers 19 and 20 has a capacity of 16 microfarads. These condensers 19 and 20 are preferably electrolytic condensers. The electrode or disc 7a is grounded at 21, through a resistance 22 which is equal to 20,000 ohms. The resistances 23, 24 and 25 are respectively 5,000 ohms, 7,000 ohms, and 15,000 ohms. The microammeter 26 can read from zero to 1000 microamperes. The wire 27 is connected to the central point of the secondary coil 12. One terminal of the microammeter 26 is connected through the resistance 24 to the wire 27 after the resistance 23, and the other terminal is connected to the central point or other selected point of the resistance 25.

The coil 12 heats the filament 28 of a full-wave electronic tube rectifier, which has the plates 29 and 30. Positive current therefore passes alternately from the plates 29 and 30 to the filament 28. The wire 27 is connected to the central point of the coil 12 of the filament 28. Positive current will therefore pass from the central point of the coil 12 through the wire 27, through the resistances 23 and 24 to one terminal of the microammeter 26, through said microammeter 26 to a selected portion of the resistance 25, and to the ground at 25a. Since the central point of the coil 11 is grounded at 16, this completes the circuit of the microammeter 26, which is independent of the resistance of the tissue. Each of the condensers 19 and 20 has one side thereof connected to the ground at 25a. The condenser 20 has the other side thereof connected by the wire 27a to the point 27b of the wire 27. These condensers 19 and 20 are merely used to equalize the current pulses which are delivered by the rectifying electronic tube so as to maintain a substantially constant direct current through the microammeter 26.

The coil 15 heats a filament 17 which heats the cathode 33 of an electronic tube. One end of the cathode 33 is connected at an adjustable point

33a of the resistance 25 so as to impart a slight positive bias or voltage to the cathode 33. Since the grid 32 is grounded through the resistance 22, the grid receives a corresponding predetermined negative bias so that normally only a slight current passes from the plate 31 to the cathode 33. The internal resistance of the electronic tube forms one leg of a circuit which is similar in principle to a Wheatstone bridge. The other three legs of the Wheatstone bridge are the resistance 24, that part of the resistance 25 which is located between the point 26a and the wire 27, and that part of the resistance 25 which is located between the points 33a and 26a. The terminals of the meter 26 are connected to the neutral points of the aforesaid Wheatstone bridge, so that ordinarily zero current passes through the meter 26. For this purpose, the point 26a may be adjusted along the resistance 25.

The current divides at the point 23a. Part of said current goes through the resistance 24 and through the electronic tube to the cathode 33, then to the point 33a, and then through a portion of the resistance 25 to the ground at 25a. The other part of the current passes through the two portions of the resistance 25 which are located respectively between the wire 27 and the point 26a, and between the points 26a and 33a. That part of the resistance 25 which is between the ground connection 25a and the point 33a, is common to both legs of the circuit.

The ungrounded end of the coil 14 is connected to the electrode 7 through the condenser 18. The electrode 7a is connected to the grid 32 and it is also connected to the ground at 21, through the resistance 22.

When the circuit between the electrodes 7 and 7a is closed through the human tissue, there will be a voltage drop between the points of the electrodes 7 and 7a, depending upon the resistance of the human tissue between the points of these electrodes. There will be another voltage drop across the resistance 22, to the ground connection 21. The voltage which is impressed upon the grid 32 therefore depends upon the resistance between the points of the electrodes 7 and 7a, since the resistance 22 is maintained fixed. The internal resistance of the tube will therefore vary in accordance with the resistance between the points 7 and 7a, thus unbalancing the aforesaid Wheatstone bridge and causing a current to flow through the meter 26.

In each of the respective embodiments the condensers 3 or 18 eliminate from the measurement, the effect of any direct current which is self-generated in the living tissue.

Fig. 3 shows another method of eliminating the effect of the self-generated direct current, without using a blocking condenser. For practical purposes, it may be assumed that such self-generated direct current is substantially constant between respective points of the body, at least in the mucous membrane or in the living tissue under the skin of the arm. Fig. 3 shows the secondary coil 2 of a transformer connected to the electrodes 7 and 7a, without the use of any rectifying means. The circuit of the electrodes 7 and 7a includes a coil 40. This is inductively coupled to a coil 41, which is connected to a microammeter 42. Since it is desirable to use a direct current meter, the circuit of the coil 41 can include a rectifier 43, but the rectifier 43 can be eliminated by using a sufficiently sensitive alternating current meter, instead of a direct current meter. The coil 2 can be replaced by

any suitable generator of alternating current. Since the direct current which may be self-generated between the points to which the electrodes 7 and 7a are applied, is constant in direction and substantially constant in value, such self-generated direct current will not affect the reading of the meter 42. Instead of using an inductive coupling between the circuit of the electrodes and the circuit of the meter, I can use capacity coupling. Likewise, the terminals of the meter circuit can be connected directly to the ends of the coil 40, because the voltage drop across the coil 40 will vary with the A. C. voltage drop between the points of the electrodes 7 and 7a. The resistance of the coil 40 is negligible, so that under such conditions, the reading will not be affected by any voltage drop of the direct current. If a resistance coupling is used between the circuit of the electrodes and the circuit of the meter in Fig. 3, it will be necessary to insert a blocking condenser of suitable capacity in the circuit of the meter 42.

I have shown preferred embodiments of my invention, but it is clear that numerous changes and omissions can be made without departing from its spirit.

For example, the measuring instrument need not be one which has a scale. It can be any device which will indicate a change in electrical resistance.

Heretofore, pure distilled water has been used in preparing the solutions or dispersions or suspensions of the test materials, such as pollens, dusts, particles of food, etc. Some of these substances, such as white wheat flour, will form a stable and uniform mixture with distilled water, in the form of a very thin paste. Other test materials, such as heavy dust, will settle rapidly in the distilled water.

I prefer to increase the conductivity of the distilled water by dissolving a salt or salts therein, so as to produce an isotonic solution, whose osmotic pressure is substantially equal to that of the blood serum. I may dissolve a single salt, such as sodium chloride, in the water. I prefer

to dissolve sodium chloride, potassium chloride, and calcium chloride in the distilled water. The use of a plurality of salts makes it possible to further increase the conductivity of the solution, without exceeding said limit of osmotic pressure. The use of an isotonic solution is preferred, but the invention is not limited thereto.

Without limiting the invention to the practical formula which is given as an example, I dissolve in 100 cc. of water about 0.9 gm. of sodium chloride, and equivalent amounts of the other two salts, namely, potassium chloride and calcium chloride, in the proportions of their respective molecular weights, so that each dissolved salt will exert the same osmotic pressure.

Since the total osmotic pressure of the salt solution is equal to that of the blood, if I use a single salt or a plurality of salts, little or none of the salt solution will pass into the blood stream except through the scratch. The use of the salt solution will increase the reading, thus facilitating the observation.

The salts are examples of ionizable materials which can be dissolved in water.

I claim:

A method of determining the effect of a test substance upon a patient, which consists in applying the test substance to the outer walls of the blood vessels of the patient at a selected part of the tissue of the patient, inflating the blood vessels in said selected part by means of said test substance so as to lower the electrical resistance of the blood vessels in said selected part, passing an alternating current through said selected part by means of electrodes whose tips substantially contact with the outer walls of said blood vessels so that the resistance to the passage of the electric current is substantially the resistance of the blood vessels, measuring the decrease in the resistance of said blood vessels which results from the application of the test substance, while substantially eliminating the effect of any self-generated current of the tissue from said measurement.

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