May 6, 1941. C. FENNING 2,241,190

METHOD AND APPARATUS FOR PHYSIOLOGICAL RESEARCH

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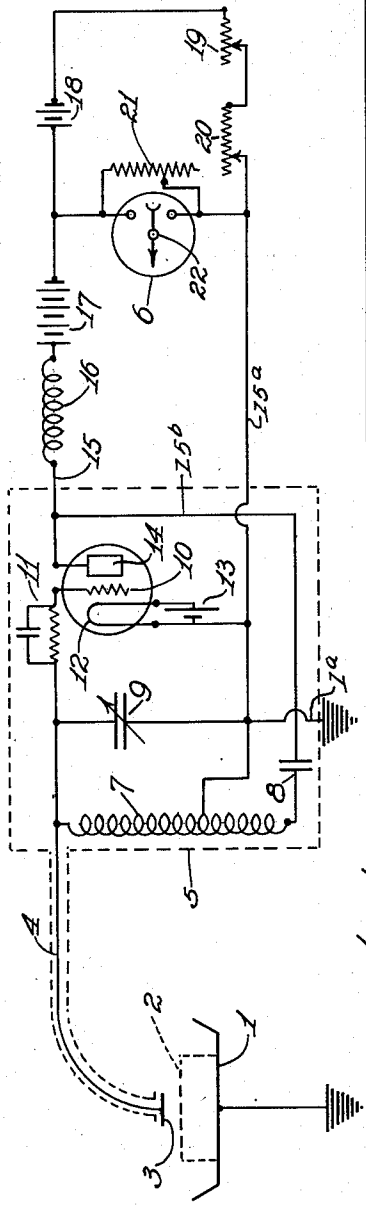


Fig. 1.

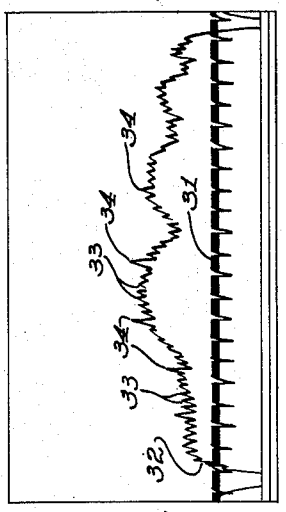


Fig. 3.

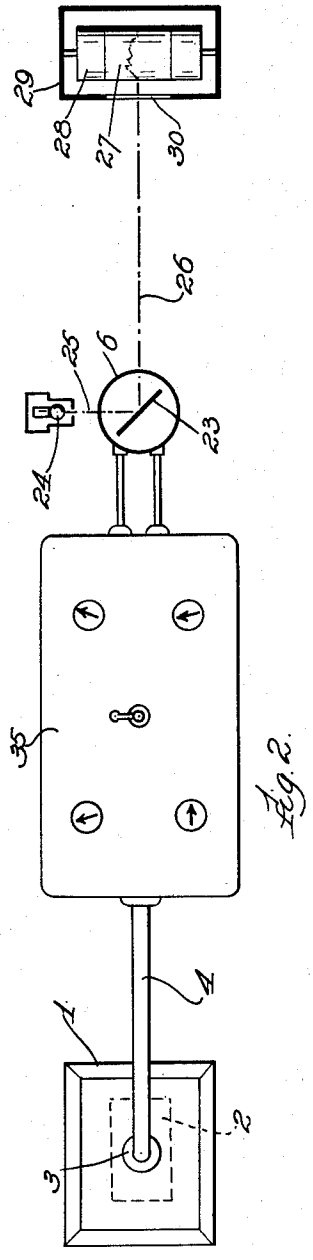


Fig. 2.

Witness.
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METHOD AND APPARATUS FOR PHYSIOLOGICAL RESEARCH

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4 Claims. (Cl. 128—2.1)

The purpose of this invention is to provide a convenient method and apparatus for observing certain physiological phenomena without the necessity of bringing any part of the apparatus into actual contact with the organ or part of the body under observation. The invention includes mechanism for making a continuous graphic record of the behavior of an organism so that its reaction under various conditions may be studied and compared. The invention consists in certain features and elements of construction in combination, and in the method of subjecting an organism to observation with the assistance of said combination of elements, as hereinafter described and illustrated in the drawing and as indicated by the claims.

In the drawing:

Figure 1 is a wiring diagram for an apparatus embodying this invention.

Figure 2 is a schematic diagram of the apparatus as arranged for use.

Figure 3 is a reproduction of a typical graphic record produced with the apparatus.

The method and apparatus which constitute this invention are applicable to a wide range of investigations, both in the nature of medical research and medical diagnosis. Certain applications will be obvious as the description proceeds.

Figure 1 shows diagrammatically at 1 a grounded support which may be in the nature of a tray or pan or operating table, upon which the body of the individual under examination is placed. Such a body or organism is represented in dotted outline at 2. Suspended over the body, 2, is a metallic plate, 3, electrically connected by a conductor, 4, with the grid circuit of a tuned oscillator. The elements of this circuit, and also the conductor, 4, are suitably enclosed in shielding, 5, so as to be unaffected by bodily movements of the attendant or observer in the vicinity of the subject, 2. A second ground connection at 1a places the pan, 1, and plate, 3, in shunt relation to the oscillator circuit.

The circuit, as shown in Figure 1, includes an inductance, 7, connected to a condenser, 8, and having associated with it a variable condenser, 9. These elements are provided with conductors leading to the grid, 10, of a vacuum tube or "audion" which may be of the triode type, with a grid-leak and condenser interposed at 11. The filament, 12, is energized by any suitable source of current, such as a battery, 13, while the plate, 14, of the tube is connected by a conductor, 15, and through a radio frequency choke coil, 16, with a direct current source such as a battery, 17, which thus provides the high potential direct current input to the oscillator circuit. The other terminal of the battery is connected to an indicating instrument such as a galvanometer, 6, and thence by a conductor, 15a, to the filament, 12, of the audion. The direct high potential input passing through the electrical recording instrument, 6, is opposed by a balancing electromotive force which is supplied by a battery, 18, and which is adjustable to hold the indicating member of the instrument, 6, normally at its zero position by means of a resistance unit which may include a coil, 19, for coarse adjustment and a second coil, 20, for fine and delicate adjustment of the resistance in the circuit. As a result, any slight variation in distance between the metallic plate, 3, and the adjacent surface of the body will vary the electrical capacity of these parts acting as a condenser and this will alter the frequency of the oscillation of the oscillator, producing a change in the input direct current through the audion which will be reflected in the electrical recording instrument, 6.

The conductor, 15b, in connection with plate, 14, and condenser, 8, constitutes the path taken by the output radio frequency current. The electrical recording instrument, 6, is provided with a variable shunt, 21, so that with the balanced forces derived from opposing current sources, 17 and 18, the instrument may be rendered highly sensitive. Thus any slight movement of the surface of the subject, 2, in a direction normal to the plate, 3, or having a substantial component in that direction will react upon the oscillator circuit, changing its frequency of oscillation and thus the change will be reflected in the direct current input to unbalance the movable member of the electrical recording instrument, thus causing said movable member, 22, to swing in one direction or the other, depending upon whether the movement of the subject, 2, is toward the plate, 3, or away from it. Thus vibratory movements, such as those caused by respiration or pulse in an animal organism, will be detected by the apparatus and translated into a swinging movement of the indicator, 22, of the instrument, 6.

In order to make a permanent record, the galvanometer spindle may be fitted with a mirror, 23, indicated in Figure 2, and from any suitable source, such as an incandescent light bulb, 24, a beam of light is projected upon the mirror, 23, along the line, 25. The reflected beam, indicated at 26, is received upon a photo-sensitive surface,

such as a photographic paper, 27, carried upon a drum, 28, revolved by any suitable means, not shown. The drum is mounted in a lightproof casing, 29, provided with a slit or opening, 30, through which the beam, 26, has access to the surface of the paper, 27, moving past the slit as the drum, 28, rotates. Thus the photo-sensitive paper, 27, receives a record of the vibratory movements of the mirror, 23, corresponding to variations in the dielectric gap between the plate, 3, and the subject, 2.

Figure 3 is an example of such a record, in which a base line, 31, is sub-divided to represent units of time, and the zig-zag or wavy line, 32, represents movements of the light beam, 26, caused by the vibration of the galvanometer mirror, 23. It may be mentioned that this graph happens to be an approximate facsimile of a record taken with a female rat as the subject. The larger deviations of the line, 32, from the base line, 31, represent uterine contractions; the small undulations, 33, of the line, 32, indicate maternal respiration, while the occasional peaks, 34, were interpreted as indicating fetal respiratory movements.

In the diagrammatic presentation of the apparatus in Figure 2, the rectangle, 35, may be understood as a suitably shielded casing adapted to house the elements shown within the shielding, 5, in Figure 1, and also the choke coil, 16, batteries, 17 and 18, and resistance elements, 19 and 20. Suitable control knobs for the adjustable elements are indicated, as well as a switch lever, which may be understood as controlling the several batteries, although for the sake of simplicity, the representation of such a switch is omitted from the wiring diagram.

It will be understood that the utility of the apparatus herein described and of the method of investigation indicated, is not confined to physiological research, and that it may be of considerable value in other fields. When the apparatus can be set up so that the subject under investigation or an element of the subject will move toward and from the plate, 3, thus varying the dielectric gap, a record may be made of such movements and utilized as indicating the behavior of the part or element in question. Therefore, while this invention is shown and described in connection with a particular type of use, and is illustrated by means of certain specific structure embodying the invention, it will be manifest to those skilled in the art that various modifications and re-arrangements of the parts may be made without departing from the spirit and scope of the invention, and that the utility of the same is not limited to the particular situations specifically suggested herein, except in so far as indicated by the appended claims.

I claim:

1. The method of investigating physiological phenomena which consists in placing the subject in proximate relation to a condenser plate but out of contact therewith, constituting the subject an opposing plate of the condenser, then for the purpose of observing changes in the capacity of such condenser caused by movement of the subject toward and from the plate, coupling the condenser into the variable tuned grid tank of an oscillator and providing an indicating device responsive to direct current variations produced in the plate circuit of the oscillator by changes in the resistance of the circuit resulting from modulation of the frequency of oscillation occurring from said changes in capacity of the condenser.

2. In an apparatus for investigating physiological phenomena, a variable tuned grid tank of an oscillator, said tank consisting of an inductance and a variable condenser, a direct current plate circuit which includes a source of direct current and a measuring instrument responsive to variations of current flow in said circuit, an audion having its plate and filament included in said direct current plate circuit and arranged with its grid connected by way of a grid leak and bias to the variable tuned grid tank and with a fixed condenser and an inductance connecting the plate circuit to said grid tank, together with a metallic plate and a support disposed for holding an organism under observation in spaced relation to said plate, means connecting said metallic plate to the grid end of said grid tank, and means connecting said support to the other end of the variable tuned grid tank, whereby said metallic plate and said organism on the support constitute elements of a condenser in tuning relation to the variable condenser of the variable tuned grid tank so that changes in the spacing between said condenser elements alter the capacity of the condenser, thus altering the frequency of oscillation of the oscillator which provides for reversible variations of grid bias of the oscillator to cause said grid to act as a reversible automatic variable resistance operating in a directional manner upon the flow of direct current in the direct current plate circuit for actuating the instrument in said circuit to indicate by automatic, directional and reversible movements the relative and absolute movements of the organism relative to said metallic plate.

3. In an apparatus for investigating physiological phenomena, consisting of an audion of the triode type associated with a modified oscillator circuit, said circuit consisting of a variable tuned grid tank including inductance and a variable condenser, a grid leak and fixed condenser interposed between the grid end of the grid tank and the grid of the audion, a fixed tuned plate tank consisting of a fixed condenser and an inductance which are inductively and conductively coupled to the grid tank, said plate tank serving by its radio frequency feed-back to set up and maintain oscillations of the oscillator, a direct current circuit which includes a source of direct current and a measuring instrument responsive to variations of current flow in said circuit together with means connnecting the plate and filament of the audion into said direct current circuit, a metallic plate and a support disposed adjacent to the plate for holding an organism in spaced relation thereto, and connections to the grid tank whereby the plate and organism constitute elements of a condenser in tuning relation to the variable condenser of the grid tank so that changes in the spacing between said elements automatically alter the capacity of the grid tank capacitance, thus actuating the measuring instrument in response to direct current variations produced in the plate circuit of the oscillator by changes in the resistance of the circuit resulting from modulation of the frequency of oscillation occurring from changes in capacity of the condenser composed of said metallic plate and organism.

4. An apparatus for investigating physiological phenomena which comprises in combination with an oscillating circuit, a fixed plate supported in proximity to the surface of a body under in-

vestigation whereby the fixed plate and the surface of said body constitute a variable condenser; the oscillating circuit including a grid tank comprising an inductance and a capacitance in the form of a variable condenser, together with a grid leak and condenser interposed between the grid of the audion and the grid end of said inductance and capacitance, the other end of said inductance and capacitance being grounded; a shielded lead connecting the said fixed plate to the grid end of the grid tank inductance and capacitance at a point between them and the grid leak and condenser, the surface of the body under investigation being connected to the grounded end of the grid tank inductance and capacitance whereby the condenser comprising the fixed plate and the surface of the said body are thus in parallel with the grid tank capacitance; the plate circuit of the oscillator consisting of two portions, one comprising an inductance and a fixed condenser, the plate of the audion being connected to one end of the plate circuit inductance with said fixed condenser interposed, the other end of said inductance being grounded, the other portion of said plate circuit comprising a high potential direct current source, a choke and a recorder all connected in series with the plate of the audion, together with the balancing source of direct current connected across the terminals of the recorder and means for adjusting the strength of said balancing current; the cathode of the audion being grounded and the negative lead of the high potential direct current source being grounded by way of the recorder; whereby in said apparatus any change in the position of the surface of the said body relative to the said fixed plate serves to modulate the frequency of the oscillator by a change in the total grid capacitance resulting in a specific change in the natural frequency of the grid tank and such frequency modulation produces observable directional and quantity changes in the direct current passing in the plate circuit through the audion from the plate of the latter to its cathode.

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