March 14, 1939. H. E. HOLLMANN 2,150,223

DEVICE FOR OSCILLOGRAPHICALLY RECORDING THE ACTION VOLTAGES OF THE HUMAN HEART

Filed Aug. 11, 1936

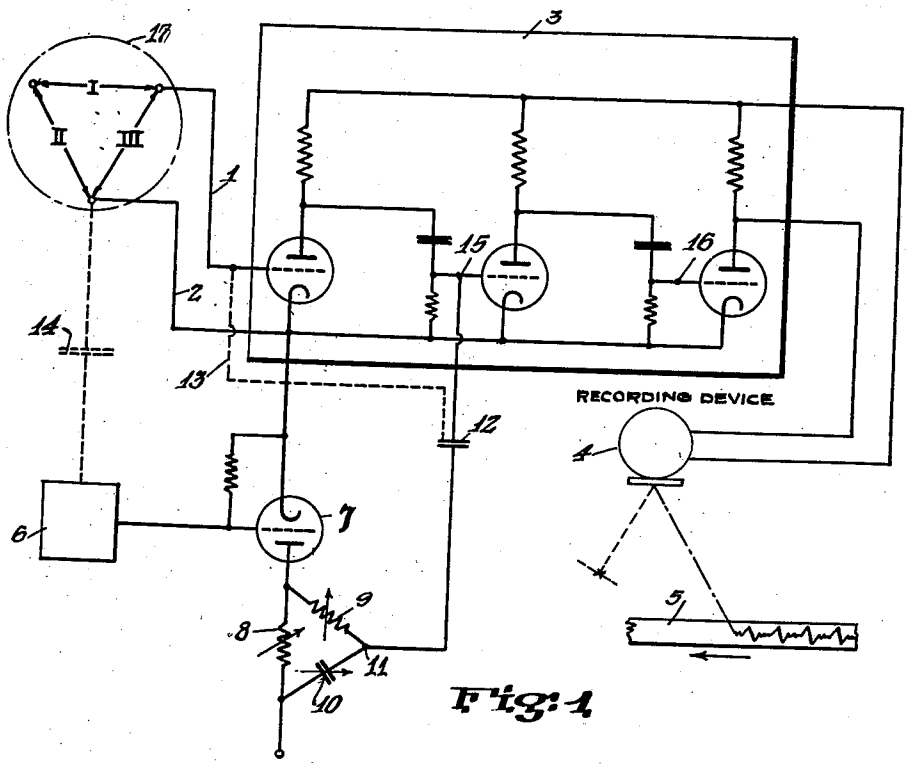


Fig. 1

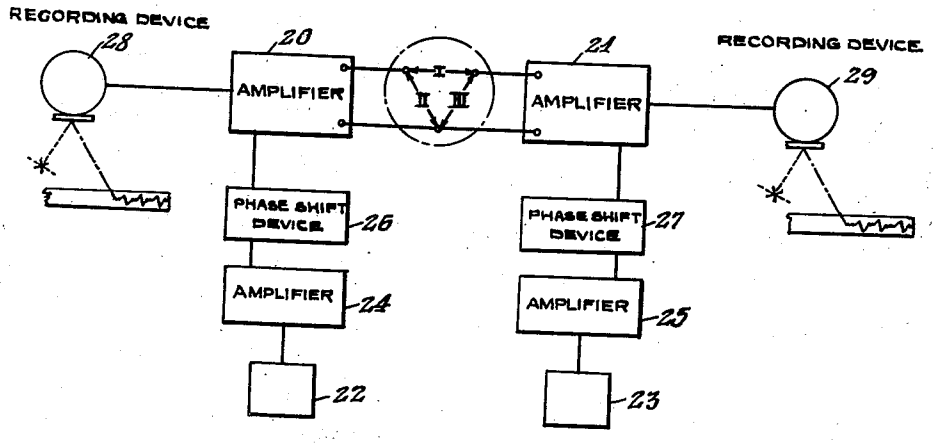


Fig. 2

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Patented Mar. 14, 1939 2,150,223

UNITED STATES PATENT OFFICE

2,150,223

DEVICE FOR OSCILLOGRAPHICALLY RECORDING THE ACTION VOLTAGES OF THE HUMAN HEART

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Application August 11, 1936, Serial No. 95,341
In Germany August 14, 1935

5 Claims. (Cl. 128—2.06)

The invention relates to a device for the elimination of interferences in electro-cardiographic recording devices.

In recording the electro-biological action voltages or currents which are produced by the rhythmic action of the human heart and which as is known are preferably drawn or tapped from the extremities, the recording devices consuming current which were formerly used such as moving coil or string galvanometers have been replaced in recent time by electro-statically working recording devices, such as cathode ray oscillographs of well known construction, which have a practically infinitely high input resistance and do not load the body electrically. However, in view of the fact that the action voltages of the heart at the extremities are of the order of one millivolt, it is necessary to use valve amplifiers in order to obtain the currents or voltages required for operating an oscillograph. For recording the electro-cardiograms, oscillographic devices are used which are substantially free from inertia such as for instance the Braun cathode ray tube which reproduces all details of the characteristic curve of the action voltages without any distortion.

As is well known, in recording electro-cardiograms through an amplifier, the patient is connected with the grid of the input tube of one or more amplifiers. In this case the patient acts as a quasi-antenna with respect to the electric interfering fields which are nowadays almost anywhere existing and are produced by atmospheric discharges, alternating current of 50 cycles, high frequency medical devices, diathermy or X-ray devices. As a result all interfering voltages induced or influenced in the patient are fed to the amplifier additionally to the action voltages of his heart. These interfering voltages are superposed upon the action voltages of the heart and are reproduced together therewith especially in recording devices which are free from inertia, whereby an electro-cardiogram may be distorted to indiscernibleness.

Of course, the patient may be screened with respect to the influence of these interfering fields, by arranging him, possibly together with the whole cardiographic apparatus, in an all-round closed so-called Faraday's cage, or by wrapping him into metallic screening blankets. The first mentioned method cannot always be applied, first of all not in portable devices. On the other hand, the screening blankets are not equivalent to the Faraday's cage because they offer only a very imperfect protection.

If the interferences get into the apparatus from the outside and their source is well-known and their frequency well-defined, the interfering component of voltage caused thereby may be eliminated by artificially introducing the interfering voltages or frequencies through a line into the recording device or into the patient circuit, i. e. with reverse phase and with such amplitude that the interferences produced by the antenna-effect of the patient are just compensated at zero. This method is particularly simple in case of cardiographs which are operated from a house lighting circuit and if the interference or statics are only originating from the lighting circuit because in this case the interfering voltage is directly available for drawing a compensation voltage of contrary phase. But even in case of battery-operated portable devices an interference by the frequency of the alternating current in the lighting circuit can be eliminated if a connection to the lighting circuit is available, by directly drawing the compensation voltage from it.

If no connection to the lighting circuit is available or if the frequency of the interfering currents cannot be defined as will mostly be the case for example with the above-mentioned apparatus, the afore-described compensating method would not be suitable. The present invention remedies this difficulty in a manner which is effective and safe under all circumstances that is to say including the aforementioned cases, by drawing a compensation voltage from the interfering field and introducing the same with the reverse phase into the amplifier circuit for the action voltages of the heart. This procedure remains effective for any desired interfering frequency if it is within the frequency range of the amplifier and moreover this procedure is independent of any connection to a house lighting system.

According to the invention the interfering voltages are drawn from the same electric field of interference in which the patient is positioned, by means of a special auxiliary antenna, and then after suitable adjustment of their amplitude and phase position these voltages are superposed upon the action voltages of the heart in a suitable manner so that the interfering components of voltage contained therein are compensated. Since the interfering voltages supplied from a small antenna are too small for operating a phase changing device and an amplitude regulator, the interfering voltage supplied by the auxiliary antenna according to the invention is fed to the grid of a separate am-

plifier tube the anode circuit of which contains the regulating devices.

In order to further make clear the idea according to the invention an arrangement for the compensation is schematically shown in the drawing wherein Figure 1 is a circuit diagram illustrating an electrocardiograph system constructed in accordance with the invention. Figure 2 is a schematic block diagram illustrating the invention embodied in a multiple electrocardiograph. In the drawing, Figure 1, the patient furnishing the electro-cardiogram record is symbolically represented by the well-known Einthoven delt-diagram of the three extremity poles or electrodes applied to the human body for drawing off the action potentials as follows: I: from right arm to left arm, II: from right arm to left leg, III: from left leg to left arm.

The left arm and the left leg electrodes are connected by the two leads 1 and 2 to the grid and to the cathode, respectively, of the first tube of the amplifier 3, the output of which is connected to a suitable recording instrument 4 by which the characteristic curve of the action voltages is recorded on a movable recording strip 5.

The patient may be situated in a strong interference field and may draw or receive therefrom voltages of any frequency which are superposed upon the action voltages in the manner described. In order to segregate these interfering voltages from the patient and from the action voltages of the heart, the auxiliary antenna 6 is provided which if so desired, may consist of sheet metal or wire gauze indicated at 17 in the drawing which may be either laid out in the examination room or positioned underneath the patient, being protected against direct contact with the patient by an insulating intermediate layer. This antenna 6 is connected with the grid of a separate valve 7, at the anode resistance 8 of which voltages of the frequency just prevailing in the interference field are available accordingly. In order to vary the amplified interfering voltages as to their phase and for reversing them, a phase changing device is provided in the anode circuit which in the example comprises an adjustable resistance 9 and an adjustable capacity 10 connected in series and across the load resistance 8. The amplitude of the compensation voltages may be variable by varying the anode resistance 8.

The compensation voltages tapped from the point 11 of the phase changing device may be introduced into the recording device by connecting point 11 through a small capacity 12 serving to block the anode voltage of the tube 7 from the grid of the first amplifier tube, as illustrated by the conductor 13 indicated in dotted lines. However, it has been found that this is not fully satisfactory because the amplified anode voltages of the valve 7 may be fed back to the grid of the valve 7 through the stray capacity 14 existing between the patient and the antenna 6 so that self-excitation may result in this closed electric circuit.

The danger of self-excitation is eliminated by applying the compensation voltages to an intermediate amplifier stage, for example at the point 15. In this manner a closed feedback path is avoided by the interposition of the first valve of the amplifier 3, thereby preventing self-excitation of valve 7.

Since the interference voltages originating from the patient and from the antenna 6 in most cases have the same phase, the phase changing device 9, 10 in nearly all cases has to be so adjusted that it changes the phase by exactly 180°. According to the invention, the phase changing or reversing may alternatively be effected within the tube 7, if a tube with descending characteristic, for example a double-grid or multi-electrode tube with loaded screen grid is used. If the interfering potentials originating from the patient and from the antenna 6 are slightly out of phase with each other due to any cause such as unequal connecting leads, and a phase change beyond 180° is required, the phase may be reversed by 180° by the valve 7 in the aforementioned manner, while the additional correction may be effected by the aid of the network 9, 10. In this case only the amplitude of the compensation voltage has to be adjusted in a suitable manner. If the interfering voltages supplied by the antenna are sufficiently high, a phase changing device may be dispensed with by using a normal tube and introducing the compensation voltage from the anode circuit of the tube 7 at the point 16, that is to say, behind the second amplifier tube. The reversing of the phase in this case takes place in the second amplifier tube. In this connection it has to be considered that the interference voltages picked up by the patient are already amplified to a certain extent by this tube and that the compensation potential supplied by the tube 7 must be of the same magnitude as the interfering potential at point 16 originating from the patient.

If two amplifiers are connected with a patient, for example for recording two or all of the three extremity voltages according to the differential principle, a separate antenna and a separate compensation valve may be provided for each amplifier. An arrangement of this type is shown in block diagram form in Figure 2. In the latter, a pair of amplifiers 20 and 21 are provided for amplifying the action voltages II and III to operate separate recording devices 28 and 29, respectively, which may be arranged close to each other for simultaneous observation and/or recording upon a single screen or record strip. To each amplifier there are coordinated separate auxiliary antenna structures 22 and 23, amplifiers 24 and 25, and phase shift devices 26 and 27, respectively, from which latter the interference compensating potentials are impressed upon the main amplifiers 20 and 21 in substantially the same manner as shown in Figure 1. The interfering voltages may also be taken or drawn from a single antenna, amplified in one tube and then split up by two phase changing devices arranged in parallel into two components which may be adjusted as desired and introduced into the two amplifiers in one of the manners described. In some instances a single compensation voltage may be sufficient which is coupled with the second amplifier from point 11 over a second coupling capacity which is the analogue of the capacity 12. In order to be able to vary the amplitude of this second compensation voltage independently of the first one, this coupling capacity may be variable.

Of course, instead of the antenna plate 6, any other antenna structure which, however, has to be positioned in the same field of force as the patient or has to effect a sufficient coupling with the source of interference may be used. For example the compenastion voltage may be drawn from a metallic envelope (17 as shown in the drawing) which surrounds the patient in insulated manner provided that the screening effect

of this metallic envelope in grounded condition is not sufficient to eliminate the interferences.

I claim:—

1. In electrocardiographic apparatus, contact members adapted for drawing an action voltage from a human body, means for amplifying said action voltage, means for recording the amplified action voltage, an antenna structure adapted for absorbing a voltage from an electric interfering field in which said human body is positioned, a thermionic valve having a descending characteristic curve for amplifying the voltage absorbed by said antenna structure and for changing its phase by 180°, and means for impressing the amplified antenna voltage upon an intermediate point of said amplifying means for counter-balancing the interference voltage superimposed upon said action voltage by the antenna effect of said human body.

2. In electrocardiographic apparatus, a plurality of pairs of electrodes adapted for drawing a plurality of separate action voltages from a human body, means for separately amplifying said action voltages, means for separately recording the amplified action voltage, a separate antenna structure associated with each of said pairs of electrodes and adapted for absorbing a voltage from an electric interfering field in which said human body is positioned, means for separately amplifying the voltages absorbed by each of said antenna structures, means for changing the phase and amplitude relation of each of the amplified antenna voltages for superimposing the same upon the associated action voltage for counterbalancing the interference voltages superimposed upon the action voltages produced by the antenna effect of said human body.

3. In electro-cardiographic apparatus, a pair of contact members for drawing action potentials from separate points of a patient's body, a first amplifier having a pair of input terminals and an output, connections from each of said contact members to an input terminal of said amplifier, a recording device connected to the output of said amplifier, a metallic collector insulated from and arranged in the vicinity of the patient, whereby both said contact members and said metallic collector are subject to the effect of an alternating electric stray field originating from a source exterior of the patient, a second amplifier having a pair of input terminals and an output, connections from each of the input terminals of said second amplifier to one of said contact members and to said collector, respectively, and means including phase shifting and amplitude regulating means for impressing output potential from said second amplifier upon a point in said first amplifier, to compensate interference picked up from said stray field by the patient and by said metallic collector, respectively.

4. In electro-cardiographic apparatus, a pair of contact members for drawing action potentials from separate points of a patient's body, a first multi-stage electron valve amplifier having a pair of input terminals and an output, connections from each of said contact members to an input terminal of said amplifier, a recording device connected to the output of said amplifier, a metallic collector insulated from and arranged in the vicinity of the patient, whereby both said contact members and said metallic collector are subject to the effect of an alternating electric stray field originating from a source exterior of the patient, connections from each of the input terminals of said second amplifier to one of said contact members and to said metallic collector, respectively, and means including amplitude regulating means for impressing interfering potential from the output of said second amplifier to a point in an intermediate stage of said first amplifier carrying amplified interfering potential picked up by the patient in phase opposition to the interfering potential impressed from said second amplifier, to compensate the effect of said stray field in the output of said first amplifier.

5. In electro-cardiographic apparatus, a pair of contact members for drawing action potentials from separate points of a patient's body, a first multi-stage electron valve amplifier having a pair of input terminals and an output, connections from each of said contact members to an input terminal of said amplifier, a recording device connected to the output of said amplifier, a metallic collector insulated from and arranged in the vicinity of the patient, whereby both said contact members and said metallic collector are subject to the effect of an alternating electric stray field originating from a source exterior of the patient, connections from each of said input terminals of said second amplifier to one of said contact members and to said metallic collector, respectively, and means including phase shifting and amplitude regulating means for impressing interfering potential from the output of said second amplifier picked up by said collector to a point in an intermediate stage of said first amplifier carrying amplified interfering potential picked up by the patient's body in phase opposition to the interfering potential impressed from said second amplifier, to compensate the effect of said stray field in the output of said first amplifier.

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