

Jan. 28, 1941.

H. E. HOLLMANN
ELECTROCARDIOGRAPH
Filed June 15, 1937

2,229,698

2 Sheets-Sheet 1

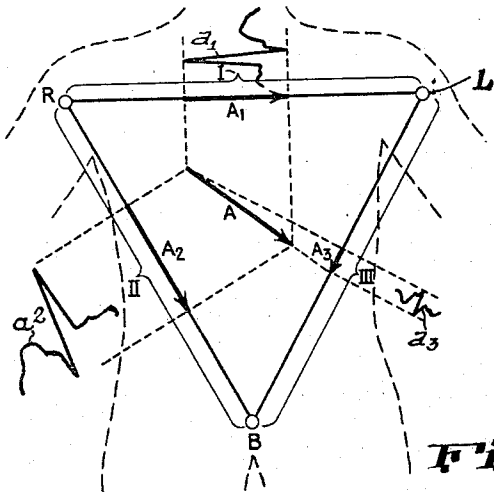


Fig. 1

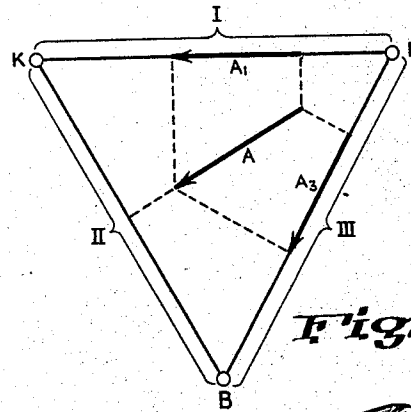


Fig. 2

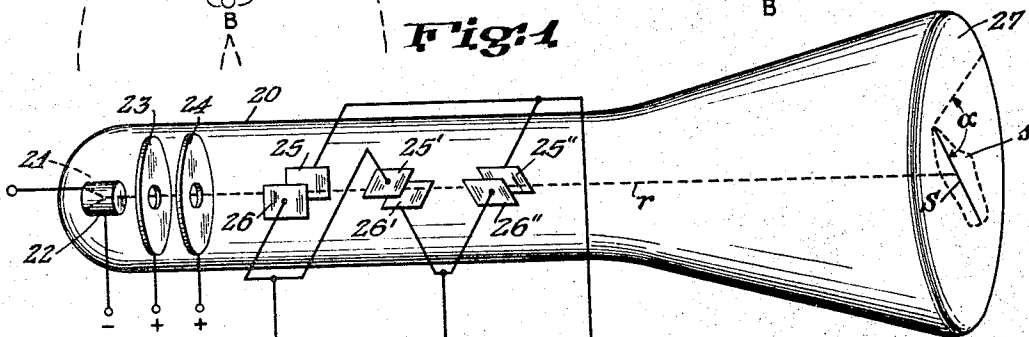


Fig. 3

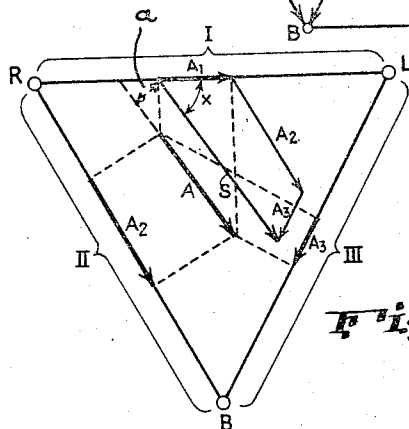
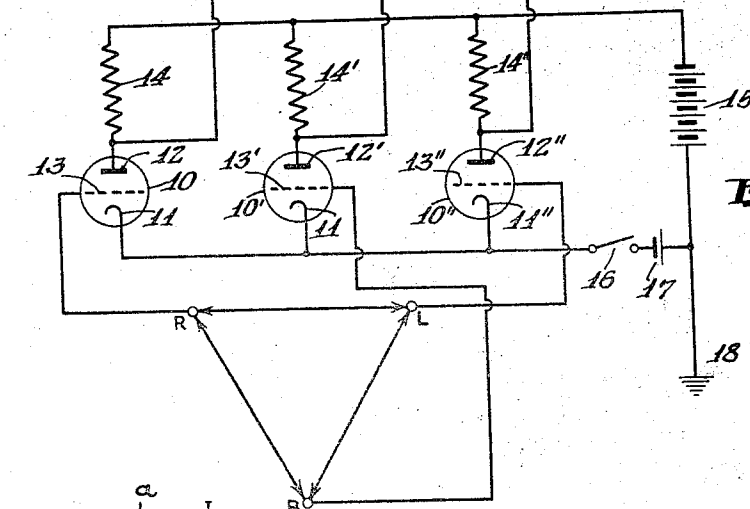


Fig. 4

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2 Sheets-Sheet 2

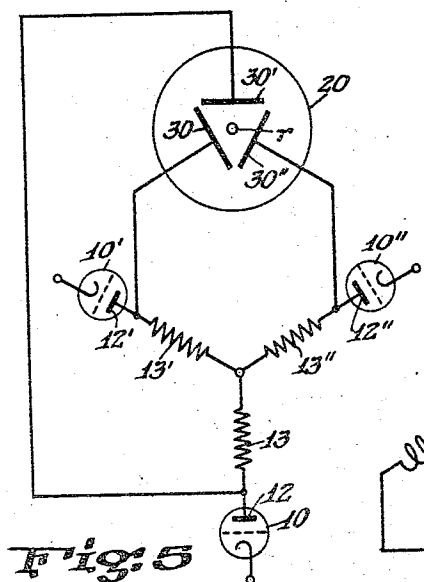


Fig. 5

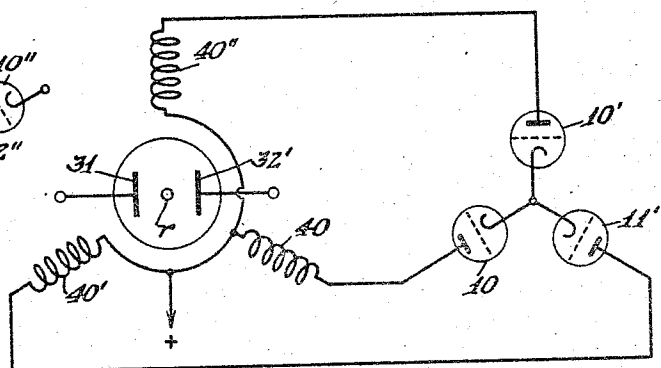


Fig. 7

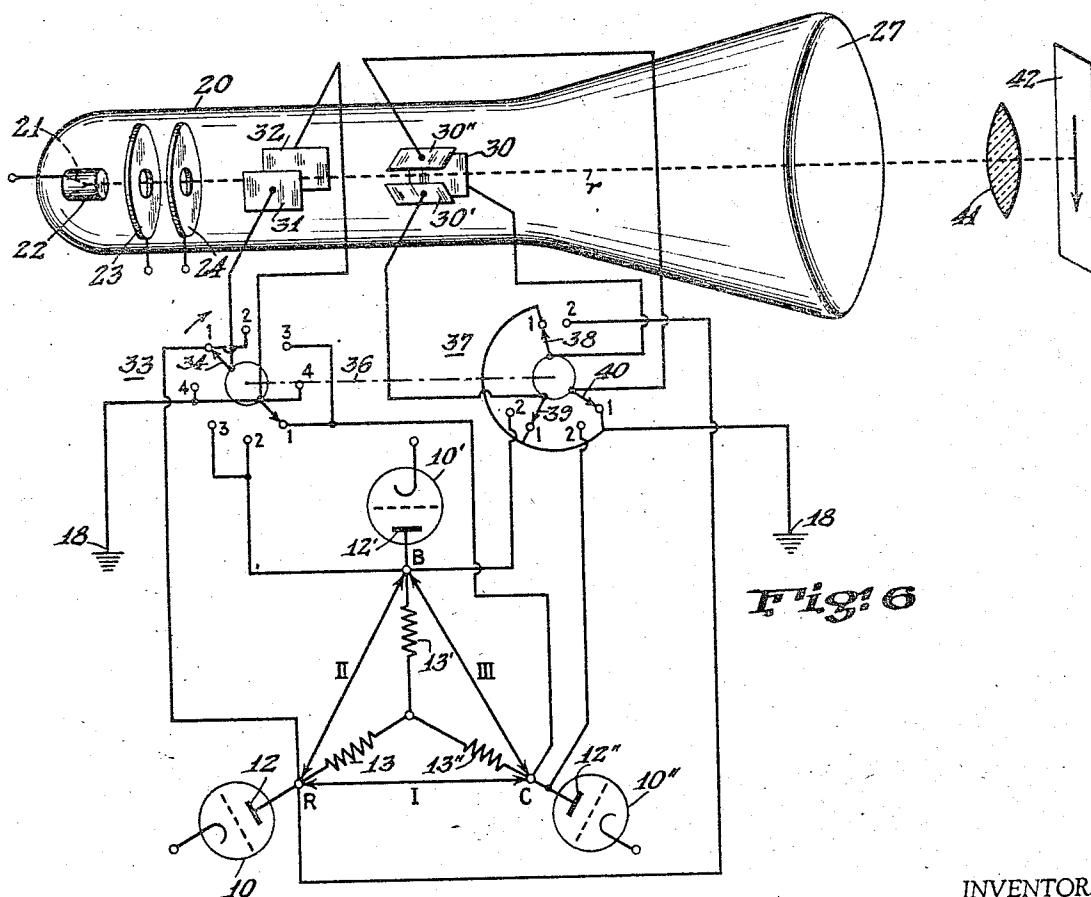


Fig. 6

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2,229,698

ELECTROCARDIOGRAPH

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Application June 15, 1937, Serial No. 148,326
In Germany July 1, 1936

7 Claims. (Cl. 128—2.06)

The present invention relates to electrocardiographs as used in the medical sciences for observation and/or registry of the minute potential variations between various points of the human body caused by the action of the heart, and objects of the invention are to provide a novel means for and a method of producing electrocardiograph records.

As is well known, electrocardiographs depend for their action upon the fact that the action of the heart in the human or animal body is accompanied by voltage impulses known as biological action voltages or potentials of the order of about .001 volt between the limbs such as between the right and left arms or between the arms and legs. By studying the characteristics of such impulses when they are recorded as continuous waves by an electric oscillograph on a light sensitive surface, such as the luminescent screen of a cathode ray oscillograph or a photographic film or paper strip, physicians are enabled to determine certain facts concerning the function and condition of the heart.

According to an improved method and system of electrocardiography, various points of the body are tapped by means of suitable electric connectors strapped to the patient to observe and/or record variations of the reaction potentials between these points.

According to a well established method known as the Einthoven system, it has become customary to use the following tappings or leads as they will be referred to hereinafter for the purpose of this specification for drawing several action voltages from the body of a patient:

Lead I: between right arm to left arm
Lead II: between right arm to left leg
Lead III: between left arm to left leg

By simultaneously observing the potential fluctuations between these points, valuable conclusions can be drawn on the function and condition of the heart.

As is understood, however, other tappings or leads may be used, such as between different points of the breast encircling the heart, or between the breast and the back and others.

An object of the present invention is the provision of a novel method of and system for electrocardiography especially adapted to the Einthoven system of deriving action voltages from the patient enabling a direct indication and/or recording of the action voltages and their relation to each other.

Another object is the provision of an electro-

cardiograph adapted to produce a direct indication and/or record of the electrical axis of the heart and its various positions during each palpitation or heart beat cycle.

Further objects and aspects of the invention will become more apparent from the following detailed description taken with reference to the accompanying drawings forming a part of this specification and wherein—

Figures 1 and 2 are theoretical diagrams explanatory of the function and operation of the invention,

Figure 3 illustrates an electrocardiograph recording system comprising a cathode ray oscillograph designed and constructed in accordance with the invention,

Figure 4 is a theoretical diagram explanatory of the function of Figure 3.

Figure 5 illustrates a modification of a deflecting system for a cathode ray oscillograph for use in an arrangement according to Figure 3,

Figure 6 shows an electrocardiograph system of the type according to the invention combined with means for additionally producing the ordinary electrocardiographic records by means of a single oscillograph device,

Figure 7 is a partial view of a modified cathode ray oscillograph constructed in accordance with the invention showing the use of magnetic deflecting means.

Similar reference characters identify similar elements throughout the different views of the drawings.

The conditions created by the three leads in accordance with the Einthoven principle may be best understood by considering the tapping points at the limbs as the corners of an equilateral triangle containing the heart in its center. This is shown in Figure 1 wherein R represents the tapping point at the right arm, L the tapping point at the left arm, and B the tapping point at one of the legs such as the left leg, whereby the leads or potential differences between these points are represented by the connecting lines I, II, III of these points. Since the exciting action through the muscular system of the heart proceeds from the base to the top during each contraction, the heart has a definite electrical axis determined by the connecting line between the points of greatest biological potential difference which connecting line coincides approximately with the anatomical axis of the heart. From the Einthoven lead triangle, the relative magnitudes of the separate action voltages produced by the individual leads may be determined for which

purpose it is only necessary to project a voltage vector A in the direction of the electrical heart axis whose length is preferably equal to the maximum potential difference during the so-called initial peak of the heart beat curve (a_1 , a_2 and a_3) upon the three sides of the lead triangle as shown at A₁, A₂, A₃. In case of normal position of the heart, such as shown in Figure 1, the electrical axis of the heart is approximately parallel to the lead II, while the derivation III supplies the weakest potential component. If the heart vector within the triangle has a different position or is rotated, the relative magnitudes and the polarity of the separate leads will vary accordingly. From the above it is seen that a clear picture of the anatomical position of the heart may be obtained on the basis of a simple geometrical scheme, such as is not always possible by means of X-ray recording or other methods.

For the practising physician, it is highly inconvenient and cumbersome to carry out separately for each patient the vectorial summation of definite instantaneous values obtained from the three Einthoven leads on the basis of the scheme shown in Figure 1. To overcome this inconvenience it has been proposed to apply two of the action voltages to separate deflecting systems of a cathode ray oscillograph arranged with their axis at a right angle whereby a kind of Lissajou figure is obtained upon the viewing or recording screen whose shape depends on the phase displacement between the action voltages being recorded and from the main axis of which certain conclusions may be drawn on the anatomical orientation of the heart. In order to fully complete the analogy with the Einthoven system, the coordinates of the recording system should form angles similar to those of the equilateral lead triangle.

This obviously simple method, however, has a serious disadvantage preventing its general adoption in practice. For better illustration the following case will be considered. It is assumed that the electron beam in the cathode ray oscillograph is deflected in two rectangular coordinates by potentials supplied by the leads I and II. Assuming further a specific case as illustrated in Figure 2 corresponding to the so-called "situs inversus" or inverted position of the heart axis, the action voltage supplied by lead II might be equal to zero, while the voltages supplied by the leads I and II might be equal to each other. If the deflecting systems of the oscillograph are connected as mentioned above, that is, if lead III is entirely disconnected, no potential is produced by lead II so that the electron beam is deflected only by the potential produced by lead I. As a result, the electron beam is deflected in one direction only which has no relation whatsoever to the direction of the heart vector or the anatomical position of the heart to be determined. These conditions are substantially the same if in place of rectangular coordinates deflecting systems oriented at a 60° angle are used.

A determination of the position of the heart is thus impossible under the circumstances described.

In order to obtain a Lissajou figure in the above case, it would be necessary to connect the deflecting systems to the leads I and III. From this, however, it follows that this method is not absolutely reliable but subject to the discretion on the part of the physician who may choose any one of the three leads for diagnosing purposes. As a result, the clinical value of this

method is rather limited and impracticable in more complicated cases than the one considered where an entirely false diagnosis with serious consequences may be the result.

By the new method and system according to the present invention, the above drawbacks and disadvantages are substantially overcome. According to the invention, all three leads are equally utilized for the recording of the electrical heart vector in such a manner that arbitrary combinations are impossible. Accordingly, the new method employs three deflection simultaneously in three directions forming angles of 60° with each other and cooperating with the Einthoven leads or in other words, the cathode ray or other recording beam is deflected by the three action voltages simultaneously and in directions forming angles of 60°.

According to one embodiment of the invention, a cathode ray oscillograph is used comprising three deflecting systems each controlled by one of the action voltages drawn from the patient's body and related according to the Einthoven or any equivalent diagram. The three deflecting systems are successively or simultaneously passed by the electron beam in such a manner that the resultant deflection of the luminous recording spot produced on the fluorescent screen of the oscillograph is determined by the vectorial sum of the instantaneous values of the action voltages applied to the deflecting systems.

For the recording of the biological action potentials by means of a cathode ray oscillograph, it is necessary to provide an amplifier for increasing the heart action potentials (which are of the order of one millivolt) sufficiently to effect the deflection of the electron beam. Great difficulties are often experienced in practice due to the fact that the highly sensitive amplifier having its input connected to the patient who acts as an antenna is liable to pick up a great amount of interference or disturbing potential variations originating either from the 60 cycle house lighting systems or from other sources of disturbance such as high frequency medical devices, diathermy or X-ray and other electrical apparatus. By grounding the system, a certain protection against interference may be obtained, but under circumstances the ground connection by which a definite reference point is established in the interfering field may result in a substantial increase of the disturbance potentials applied to the system to such an extent as to render the records obtained substantially unintelligible. In order to reduce disturbances of this kind, it was necessary heretofore to carry out the observation or registry of the action potentials in an electrostatically screened room or a so-called Faraday cage, or if no screened room was available, to screen the patient by a metallic or metal fabric cover. All these expedients, however, involve great difficulties in practice besides being expensive and not affording a complete protection as in the case of a metal fabric screen surrounding the patient. Moreover, the latter is impossible in very serious cases of illness where any annoyance or irritation of the patient has to be carefully avoided to prevent reactions and distortions of the cardiographic records obtained.

According to the present invention a more efficient and reliable method of eliminating disturbances is proposed based on the differential principle for eliminating undesirable potentials. The novel method is based on the assumption that the space occupied by the patient and the

apparatus is small compared with the extension of a disturbing field, the origin of which is usually at a far distance so that the interfering field in the vicinity of the patient and the apparatus may be regarded as homogeneous. From this it follows that the disturbing potentials wherever they enter the patient or the apparatus may be assumed to be of equal phase. In order to separate the disturbance potentials from the action potentials produced by the heart, the arrangement is made such that the action potentials are applied to a differential or push-pull amplifier and that the indicator or recording device is also connected in differential fashion between the outputs of the amplifiers. In this manner only the potentials produced by the heart action are applied to the input of the amplifiers while the equally phased disturbance potentials, although they may be considerably amplified, are mutually balanced by the differential action of the indicator or recording device.

In my copending application Serial No. 58,048, filed January 8, 1936, now Patent No. 2,133,140 issued October 11, 1938, there is disclosed a method by which the Einthoven action potentials may be amplified and recorded by the aid of only two amplifiers each serving to amplify one of the action potentials while the third potential is represented as the sum or difference of the two former and serves to operate an oscillograph connected between the output circuits of the amplifiers. In an arrangement of this type, the differential principle is employed only for the third potential and in fact substantially no interference peaks appear in the corresponding record. The other derivations or potentials, however, which are directly amplified and recorded are subject to interference to the full extent.

By the present application a new method and system is proposed for utilizing the differential principle for a triple electrocardiograph system which has the further advantage of a considerable saving of amplifiers and other parts. For this purpose both the input and output circuits of the three amplifiers are arranged in star connection while the deflecting systems of the cathode ray oscillograph are also arranged in either star or delta and connected to the output circuits of the amplifiers.

An arrangement of this type designed and constructed in accordance with the invention is illustrated diagrammatically by Figure 3. In the latter there is shown a cathode ray oscillograph comprising an evacuated vessel 20 having mounted therein an arrangement for producing a concentrated electron beam r known as an electron gun and consisting in the example shown of a cathode 21 which may be a directly heated or indirectly heated cathode surrounded by a pre-concentration cylindrical electrode 22 negatively biased with respect to the cathode in a known manner. The thus produced electron beam emitted from the cathode is further concentrated or focussed by means of an electron-optical lens system of any known type, consisting in the example illustrated of a pair of apertured acceleration electrodes 23 and 24 which are suitably positively biased with respect to the cathode so as to produce a sharply concentrated electron beam impinged upon the luminescent screen 27 applied to the opposite wall of the tube or arranged in any other suitable manner. Any other known ray generating system may be provided, the details thereof having been omitted from the disclosure and drawings for the sake

of simplicity and as not forming part of the present invention. There are further shown three pairs of electrostatic deflecting plates 25—26, 25'—26', 25''—26'' arranged with their axes forming angles of 60° with each other and serving to effect deflection of the electron beam simultaneously in three directions in accordance with the respective action potentials drawn from the patient at the points R, L and B in the manner described hereinabove. Before application to the deflecting plates 25—26, 25'—26', 24'—26'', the potentials are amplified by means of separate amplifiers such as vacuum tube amplifiers shown at 10, 10' and 10'', respectively, for which purpose the tapping points R, L and B are connected to the grids or input electrodes 13, 13' and 13'', respectively, of the amplifiers in the manner shown. The cathodes 11, 11' and 11'' of the amplifiers are connected to ground at 18 or to any other reference point of the system through a switch 15 and a biasing battery 17 the purpose of which will be described later. The anodes 12, 12' and 12'' of the amplifiers are connected to the load impedances 14, 14' and 14'', respectively, which may be ohmic resistors whose opposite ends are joined together and connected to the positive pole of a common anode potential source 15 having its negative pole grounded to complete the direct current anode circuits. In this manner, the load impedances 14, 14' and 14'' form a star connection similar to the input circuit represented by the leads between the points R, L and B. The star points or anodes of the amplifiers 10, 10' and 10'' are connected to the junction points between successive deflecting plates of the three deflecting systems of the cathode ray oscillograph connected in delta in the example illustrated. For the latter purpose, plate 26 of the first deflecting system is connected to plate 25' of the second deflecting system, the junction point thereof being connected to the anode 12, plate 26' of the second deflecting system is connected to the plate 26'' of the third system and the junction therebetween is connected to the anode 12', while the plate 25'' of the third system is connected to the plate 25 of the first system and their junction is connected to the anode 12''. In this manner by connecting both the input and output circuits of the amplifiers in star and by further connecting the deflecting systems of the cathode ray oscillograph in concatenated fashion to the output circuits of the amplifiers only the potential differences between the points R, L and B are effective in causing the deflection in the electron beam while all other equally phased potentials applied to the input of the amplifiers such as the undesirable disturbance or interfering potentials are eliminated by the differential action in all three amplifying and recording channels.

As is understood, any desired number of amplifying stages as well as any suitable type of amplifying circuit may be used for the purpose of the invention, one amplifying stage having been shown only for simplicity of the disclosure and drawing.

Referring to Figure 4, the deflection of the electron beam in an arrangement of the type according to Figure 3 is further illustrated. The case considered corresponds substantially to the general case shown by Figure 1 wherein the vector of the electrical heart voltage A forms an angle α with the horizontal or lead I. The resulting deflection of the electron beam caused by the individual components A_1, A_2, A_3 which

as pointed out are obtained by projecting the vector A upon the sides of the equilateral triangle is found by vectorially adding the components A₁, A₂, A₃ at angles of 60°. By this geometrical summation a resulting vector S as shown in Figure 4 is obtained including an angle α with the horizontal or derivation I. It can be shown by a detailed theoretical analysis as presented in an article appearing in "Zeitschrift für Instrumentenkunde" Vol. 47, 1937, No. 4, especially on pages 149, 156 and 157, of which the inventor is co-author that the two vectors A and S are parallel or in other words, that the angle α is equal to the angle α as shown in the diagram so that the vector S appearing upon the screen of the oscillograph directly indicates the direction of the electrical axis of the heart. The analysis further shows that this law which has been demonstrated purely graphically in Figure 4 applies to all possible cases and for all positions of the electrical heart vector.

As seen from the diagram, the length of the resulting vector S differs from the length of the heart vector A. It is found that the two vectors have a constant ratio of

$$\frac{S}{A} = 1.5$$

which is independent of the angle α . This may be taken into account in the calibration of the device.

A further advantage of the arrangement according to the invention compared with the previously described arrangement using only two derivations for producing a Lissajou figure, aside from its universal applicability and increased efficiency, is the fact that the direction of the heart vector S as observed is substantially independent of any phase displacement between the separate action potentials. While, as is well known, the main axis of a normal Lissajou figure produced by deflections in two directions depends on the phase relation between the deflecting potentials, this is not the case in an arrangement and method according to the invention based on the Einthoven voltage diagram wherein the absolute sum of the three derivation vectors at any time is equal to zero. On the basis of this general relation the effect of any phase shift between the separate action potentials such as caused by the time delay in the connecting lines and the like is substantially eliminated as can be proven by detailed analysis.

For the purpose of clinical diagnosis, the principle underlying the new method implies that the vector S should be a straight line provided that the heart vector during the contraction of the heart retains a fixed direction. The latter assumption is by no means fulfilled anatomically since the paths along which the exciting action progresses are not along a straight line but are more or less curved depending on the anatomical structure of the muscular system of the heart. Thus, if the direction of the deflection of the electron beam during the initial peak of a heart beat cycle as shown at a_1 , a_2 , a_3 in Figure 1 varies or rotates, there is no longer produced a straight line upon the luminescent screen, but rather a curved line as shown at s in Figure 3 which shows the progress of the exciting action through the heart muscular system. This phenomenon enables the physician to recognize disturbances in the function of the heart and propagation of the exciting action in a most simple manner which has not been possible with any one of the devices and methods heretofore known in the art.

In order to simultaneously observe and/or record the instantaneous values of the action potentials or heart beat curves as shown in a_1 , a_2 , a_3 in Figure 1 in addition to the indication and/or recording of the electrical heart axis and its rotation during the individual palpitations or heart beat cycles, the novel method may be combined with an arrangement comprising three separate oscillographs for individually recording the action potentials, or a multi-gun oscillograph tube may be provided for this purpose of the type described in my above mentioned copending application.

In the construction of a cathode ray oscillograph of the type shown in Figure 3 care should be taken that all three deflecting system have an equal deflecting sensitivity. Since the systems are displaced in the direction of the electron beam this can be obtained by varying the length of the deflecting plates or the distance between cooperating plates to compensate for the different leverage or distance from the center of the deflecting fields to the luminescent screen. In order to check the balance or sensitivity of deflection of the separate systems including equality of gain of the amplifiers, the key 16 is provided which when depressed will apply a small testing potential supplied by the battery 17 between the star point or the cathodes of the amplifier and ground. If the amplifiers and deflecting systems are balanced, the electron beam should remain in its zero position independently of whether the key 16 is depressed or in its open position since no potential difference is introduced in this case in one of the sides of the triangle and since only the average potentials at the corners of the input and output triangles are lifted and depressed uniformly.

Referring to Figure 5, there is shown a simplified arrangement for effecting a triple deflection of the electron beam in accordance with the invention wherein equal deflecting sensitivity is obtained. According to this embodiment the three deflecting plates 30, 30' and 30'' connected to the anodes 12, 12' and 12'' of the amplifiers, respectively, are arranged so as to form the sides of an equilateral triangle. As long as the deflection of the electron beam is small compared with the distance between the plates, which practically is always the case in view of the increased beam leverage in a construction of this type, the operation of a triple plate deflecting system of this type is substantially the same as in the case of separate deflecting systems shown in Figure 3. Only after the electron beam has been deflected from its zero position to such an extent as to enter the marginal zones of the deflecting field disturbances, are field distortions observed. Otherwise, the function and vectorial summation in the case of a triple plate system of this type is substantially the same as in the case of three separate plate systems shown in the previous illustration.

While there has been shown a cathode ray oscillograph for illustration of the novel principle and arrangement according to the invention, it is understood that any other suitable type of oscillograph known for the recording of Lissajou figures or the like may be employed for the purposes of the invention.

It is furthermore possible to use a single amplifier in place of three separate amplifiers in conjunction with a pair of synchronous switching devices periodically connecting the input and output circuits of the amplifier with the points R—L, R—B and L—B and the corresponding deflecting systems, respectively, at a rate which is high

relative to the frequency of the heart beat cycles, such as is described and shown in detail in my above mentioned compending application.

Referring to Figure 6, there is shown an electrocardiograph system embodying a single cathode ray oscillograph for indicating and/or recording both the individual action potentials or heart beat curves as well as the position and rotation of the electrical axis or heart vector. According to this embodiment of the invention there are provided means for first applying the individual amplified action potentials to a separate deflecting system thereby to produce an ordinary electrocardiographic record upon a moving light sensitive strip such as a photographic film or bromide paper, whereupon the first deflecting system is rendered inactive and the three action potentials derived from the Einthoven tap points are applied to a second triple deflecting arrangement according to the present invention for producing a record of the electrical heart axis on the same recording strip, thereby to supply the physician with direct detailed information regarding both the instantaneous values of the heart action potentials as well as their functional relation on one and the same record in a most simple and easy manner and by means of a single recording apparatus.

There is shown in Figure 6 a cathode ray oscillograph substantially similar as shown in Figure 3, but provided with a triple deflecting system comprising deflecting plates 30, 30' and 30'' similar to those shown in Figure 5. In addition to the triple deflecting system there are provided a pair of parallel deflecting plates 31 and 32 serving to produce a record of the instantaneous values or heart beat curves. Numerals 33 and 37 represent a pair of switching devices which are preferably mechanically coupled such as indicated at 36. The device 33 has a pair of movable contacts 34 and 35 arranged to cooperate with four pairs of stationary contacts 1-1, 2-2, 3-3 and 4-4, connected to the anodes 12, 12' and 12'' on the one hand, and to the deflecting plates 31 and 32 on the other hand in the manner shown. The switching device 37 is provided with three movable contacts 38, 39 and 40 arranged for cooperation with two sets of stationary contacts 1-1, 2-2 and 3-3, of the switch 33, the action potentials I, II and III are successively connected to the deflecting plates 31 and 32 whereby normal electrocardiographic records such as shown at a1, a2 and a3 in Figure 1 may be recorded upon a moving light sensitive strip or film 42 by means of a lens 41 in a known manner. At the same time the plates 30, 30' and 30'' are connected to ground 18 by the position of the contacts 38, 39 and 40 of switch 37 as shown in the drawings. If the contacts 34 and 35 are moved to position 4-4 and grounded, the contacts 38, 39 and 40 are moved into position 2-2-2 whereby the amplified action potentials are applied to the triple deflecting system 30, 30' and 30'' and a record is produced on the fluorescent screen indicating the position and rotation of the electrical axis of the heart in the manner described hereinbefore. If a photographic record is desired in the latter case the movement of the recording strip 42 has to be stopped and the strip exposed by means of a photographic shutter in a known manner. As is understood,

any other desired records may be produced in succession by means of a system of this type upon the same viewing screen and/or record strip.

In place of electrostatic deflection, the cathode ray beam may be deflected by means of a magnetic field in a known manner. Thus, the electrostatic deflecting plates 31 and 32 may be replaced by a pair of magnetic field coils arranged on the outside of the tube in a manner well known. Furthermore, in place of the triple deflecting plate system, three magnetic field coils 40, 40' and 40'' may be provided with their axis arranged at 60° and connected in star with the common star point leading to the positive pole of the anode potential source and with the open terminals directly connected to the anodes of the amplifiers such as illustrated in Figure 7.

While I have described my invention with specific reference to the method of operation and arrangement of parts and circuits disclosed and shown herein for illustration, it is understood that the novel concept and underlying idea of the invention is susceptible of numerous variations and modifications coming within the broad scope and spirit of the invention as defined in the appended claims. The specification and drawing are accordingly to be regarded in an illustrative rather than in a limiting sense.

I claim:

1. In an electrocardiograph, means for drawing a plurality of action voltages from different tapping points of a patient forming a ring connected multi-phase system with the heart in the centre, means for amplifying said voltages, a cathode ray oscillograph comprising means for producing a concentrated electron beam and a plurality of deflecting arrangements adapted to deflect said electron beam in different directions related substantially as the lines connecting said tapping points, means for impressing each of the amplified action potentials upon one of said deflecting arrangements to deflect said beam according to the vectorial sum of the instantaneous values of the voltage vectors of said multi-phase system, a further deflecting arrangement for deflecting said electron beam in a single direction, and a switching arrangement between the output of said amplifying means and said deflecting arrangements for recording each of said action voltages independently by said second deflecting arrangement and for recording the vectorial resultant of all of said action voltages by said first deflecting arrangements.
2. In an electrocardiograph, means for drawing a plurality of action voltages from different tapping points of a patient forming a ring connected multi-phase system with the heart in the center, means for amplifying said voltages, a cathode ray oscillograph comprising means for producing a concentrated electron beam and a first deflecting arrangement adapted to deflect said electron beam in different directions related substantially as the lines connecting said tapping points, means for impressing the amplified action potentials upon one of said deflecting arrangements to deflect said beam according to the vectorial sum of the voltage vectors of said multi-phase system, a second deflecting arrangement for deflecting said electron beam in a single direction, means comprising switching means between said tapping points and said first and second deflecting arrangements for temporarily rendering ineffective said first deflecting means and for successively controlling said further de-

deflecting arrangement by the individual action voltages, and a luminescent screen impinged by said electron beam.

3. An electrocardiographic recording system comprising leads for drawing three component action potentials from tapping points on both arms and one leg of a patient, means for equally amplifying the action potentials drawn, a cathode ray oscillograph comprising means for producing, accelerating and focussing an electron beam and three deflecting systems oriented relative to one another so as to deflect said beam simultaneously in three directions at 60° to one another, a luminescent screen arranged to be impinged by said beam, and means for impressing each of the amplified action potentials upon a separate deflecting system, to produce a resultant trace on said screen indicative of the instantaneous orientation of the electrical heart axis during the cardiac cycle.

4. An electrocardiographic recording system comprising leads for drawing three component action potentials from tapping points on both arms and one leg of a patient, a triple amplifier having each of its input electrodes excited by a separate one of the action potentials drawn, a cathode ray oscillograph comprising means for producing, accelerating and focussing a concentrated electron beam and three pairs of electrostatic deflecting plates having axes relatively oriented at 60° from one another, said deflecting plates being connected in star, a luminescent screen arranged to be impinged by said beam, and coupling connections from each of the star points of said deflecting plates to a separate one of the output electrodes of said triple amplifier to simultaneously deflect said beam by said component action potentials, to produce a resultant trace upon said screen indicative of the instantaneous orientation of the electrical heart axis during the cardiac cycle.

5. An electrocardiographic recording system comprising leads for drawing three component action potentials from tapping points on both arms and one of the legs of a patient, a cathode ray oscillograph comprising means for producing, accelerating and focussing a concentrated electron beam and three electrostatic deflecting plates arranged in the form of an equilateral triangle, a luminescent screen arranged to be impinged

by said beam, and coupling connections from each of said plates to a separate one of the output electrodes of said amplifier to simultaneously deflect said beam by said component action potentials, to produce a resultant trace upon said screen indicative of the instantaneous orientation of the electrical heart axis during the cardiac cycle.

6. An electrocardiographic recording system comprising leads for drawing three component action potentials from tapping points on both arms and one leg of a patient, a triple electron tube amplifier having its input grids coupled each to a separate tapping point, a source of space current for said amplifier, output impedances for said amplifier connected in star with the star point coinciding with the positive pole of said source, a cathode ray oscillograph comprising means for producing, accelerating and focussing an electron beam and three deflecting systems oriented relative to one another so as to deflect said beam simultaneously in three directions at 60° to one another, a luminescent screen arranged to be impinged by said beam, means for controlling each of the deflecting systems by a separate one of the amplified action potentials supplied by said amplifier, to produce a resultant trace upon said screen indicative of the instantaneous orientation of the electrical heart axis during the cardiac cycle.

7. An electrocardiographic recording system comprising leads for drawing three component action potentials from tapping points on the body of a patient substantially equidistant from and equally angularly spaced with respect to the heart, means for equally amplifying the action potentials drawn, a cathode ray oscillograph comprising means for producing, concentrating and focussing an electron beam and three deflecting systems oriented relative to one another so as to deflect said beam simultaneously in three directions at 60° to one another, a luminescent screen arranged to be impinged by said beam, and means for impressing each of the amplified component action potentials upon a separate one of said deflecting systems, to produce a resultant trace on said screen indicative of the instantaneous orientation of the electrical heart axis during the cardiac cycle.

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