

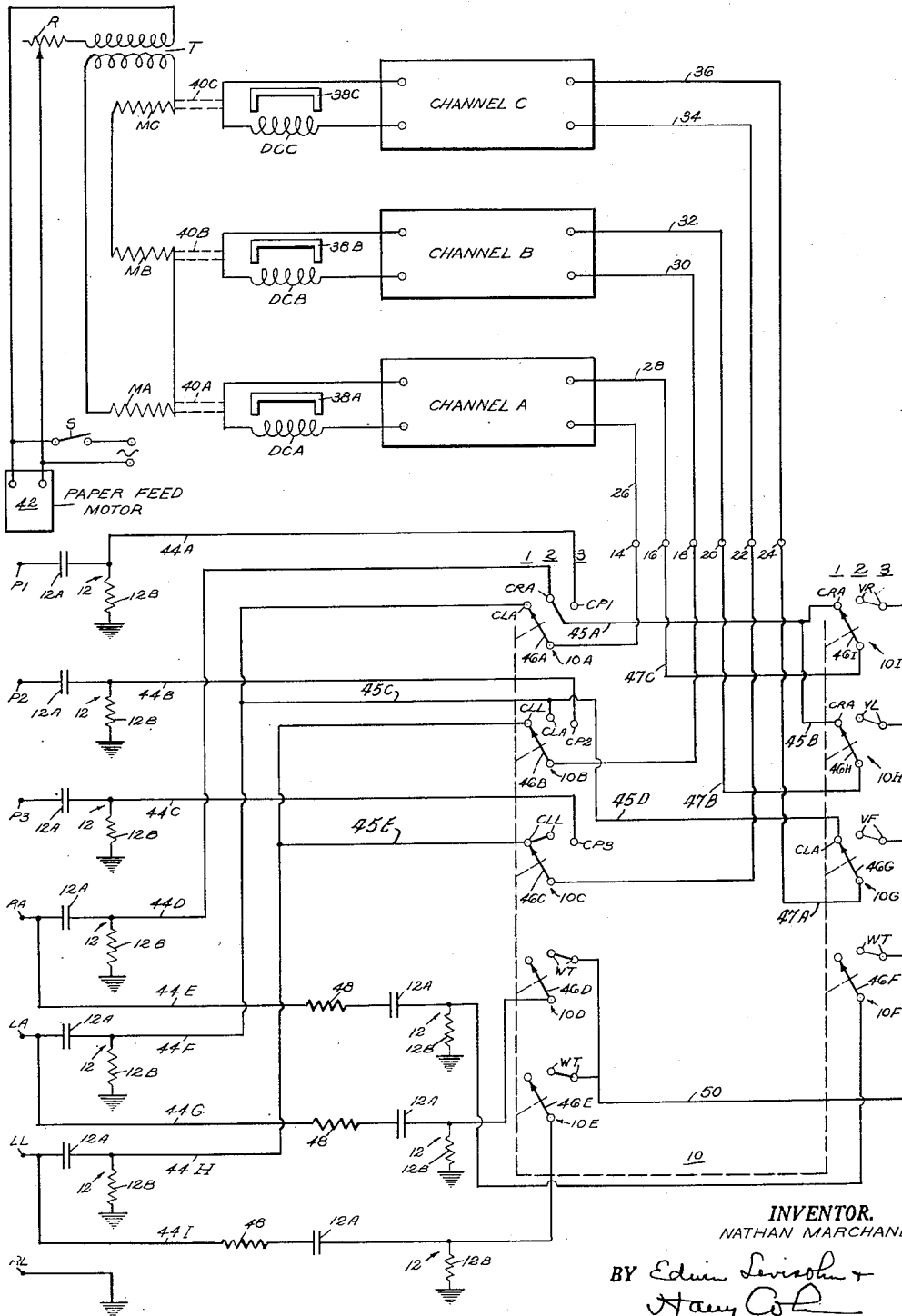
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ELECTROCARDIOGRAPH WITH CONTINUOUS RECORD MEANS

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ELECTROCARDIOGRAPH WITH CONTINUOUS RECORD MEANS

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The present invention relates to electro-cardiographs and to electrical and electronic circuits therefor.

In my application Ser. No. 762,633, filed July 22, 1947, I have disclosed and claimed a multiple lead electro-cardiograph operable to produce simultaneously and directly on a record web or sheet a plurality of graphs or traces of body voltage variations transmitted from the subject by the several leads, respectively, and to produce said graphs or traces on the web or record sheet in such manner that they all have an identical time relation with respect to each other. For example, the standard or inter-extremity potentials, namely, the left-arm-right-arm voltage variations, the right-arm-left-leg voltage variations, the left-arm-left-leg voltage variations are all recorded simultaneously on the record sheet in the same time relation so that the physician, cardiologist, or diagnostician can obtain not only the information as revealed by said three different voltage variations considered separately but also as revealed by said three voltage variations considered in their correlated aspects at any instant of time along a common time co-ordinate of the three cardiograms. In this connection it will be understood that even when cardiograms corresponding to different leads are obtained in immediate succession, the cardiologist cannot be certain that the condition of the subject's heart had not changed in the time intervals between the taking of the several cardiograms, even if such intervals are very short. Hence, he is not able to correlate the information revealed by the three different lead cardiograms, with the same degree of certainty of correct analysis which is possible when the several cardiograms are obtained at the same time.

In the apparatus described in my above mentioned application, provision is made not only for recording the standard (inter-extremity) potentials, referred to above, but also for recording the chest voltages, and for recording the extremity potentials with reference to a point of zero potential. A selector switch is provided in said apparatus for connecting the different sets of leads to the companion channels, respectively, each of which includes electronic amplifying means for amplifying the body voltages transmitted to said channels in accordance with the setting of the selector switch. Since the various leads connected to the patient introduce the patient's skin voltages into the amplifying channels, these voltages tend to become transient upon the actuation of the selector switch during the investigation operation due to their effect upon the capacitors in said channels. In order to stabilize the action of the amplifiers in the various channels before operating the marking elements of the recorder, a time-delay circuit is provided, said circuit operating whenever the

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selector switch is actuated to change the combination of leads which are connected to the channels, to prevent the marking elements from operating until the action of the amplifiers in the several channels become stable. Although the delay introduced by said time-delay circuit may be less than a minute, the condition of the subject's heart may change during each of these intervals, as the selector switch is rotated through its various positions. This is most evident in taking cardiograms during an exercise test where various voltage combinations are to be recorded immediately upon the cessation of the exercise. The time-delay introduced each time the selector switch is operated may tend to affect the accuracy of the cardiogram since the patient's heart is returning to a condition of normal patient activity, or rest, during the delay periods, and each successive switching operation, by introducing an additional delay, results in a cardiogram during a period farther removed from the condition of the patient's heart during the exercise period.

In accordance with the present invention and pursuant to the primary object thereof, provision is made to permit the recording of a cardiogram immediately after switching from one combination of leads to another without the customary time delay or waiting period.

Another object is to provide means for preventing the introduction of transient voltages into the electro-cardiograph equipment through the patient leads.

The above and other objects, features and advantages of the present invention will be fully understood from the following description considered in connection with the accompanying drawing which schematically illustrates a multiple lead electrocardiograph embodying the present invention.

Referring to the drawing herein, the electrocardiograph of the present invention comprises the continuous record switch 10 connected to a plurality of connecting points constituting the patient terminals, herein designated P1, P2, P3, RA, LA, LL, RL. It will be understood that said connecting points are adapted to be connected by suitable conductors and companion electrodes (not shown) to different parts, respectively, of the subject whose heart condition is to be investigated. The terminal RL is to be connected to the right leg of the subject and is grounded as shown. The terminals RA, LA and LL are the extremity terminals for connection, respectively, to the subject's right arm, left arm and left leg, in accordance with known principles of cardiology. The terminals P1, P2 and P3 are the precordial terminals. The patient terminals are provided with filter networks 12 and are connected to fixed input contacts CP1, CP2, CP3, CRA, CLA and CLL, respectively, of the switch.

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The switch 10 comprises the switch sections 10A, 10B, 10C, 10D, 10E, 10F, 10G, 10H, and 10I. Switch section 10A comprises the stationary input contacts CLA, CRA and CPI, and the companion movable contact 46A which is connected to the output terminal 14. Switch section 10B comprises the stationary contacts CLL, CLA and CP2 and the companion movable contact 46B which is connected to the output terminal 18. Switch section 10C comprises the interconnected stationary contacts CLL, the stationary contact CP3 and the companion movable contact 46C which is connected to the output terminal 22. Switch sections 10D, 10E and 10F comprise an unconnected stationary contact which represents an "off" position, as illustrated in the drawing, as well as the interconnected stationary contacts WT and the companion movable contacts 46D, 46E and 46F, respectively. Switch section 10G comprises the stationary contact CLA, the interconnected stationary contacts VF and the companion movable contact 46G which is connected to the output terminal 24. Switch section 10H comprises the stationary contact CRA, the interconnected stationary contacts VL and the companion movable contact 46H which is connected to the output terminal 28. Switch section 10I comprises the stationary contact CRA, the interconnected stationary contacts VR, and the companion movable contact 46I which is connected to the output terminal 16. All of said movable contacts are ganged for simultaneous operation to the three settings of switch 10, as represented by the three stationary contacts at each of its component switch sections. As will hereinafter more specifically appear, the patient terminals LA, LL and RA are also connected by the movable input contact members 46D, 46E and 46F, respectively, to form a common terminal at the interconnected contacts WT, known in the art of cardiology as the Wilson connection, the central terminal, or the indifferent electrode of zero potential. The movable contact members, 46A and 46I, 46B and 46H, 46C and 46G, are connected in pairs to the three pairs of output terminals 14—16, 18—20, and 22—24, respectively, of the switch 10. For example, in one setting of the switch 10, the LA and RA leads are connected to output terminals 14 and 16, respectively, the LL and RA leads are connected to the output terminals 18 and 20, respectively, and the leads LL and LA are connected to the output terminals 22 and 24, respectively. In other settings of the switch, the three leads are connected to different output terminals of the switch, as will appear.

The three leads, thus connected to the selected output terminals, are connected by means of the conductors 26—28, 30—32, and 34—36, respectively, to three different channels A, B, and C, respectively. Each of said channels includes electronic amplifying means for amplifying the body voltages transmitted to said channels by said three leads from across three pairs of different parts of the subject's body. The electrical circuits of these channels preferably are all alike, and may be of any suitable type, for example, as in U. S. Patent No. 1,647,710 to H. E. Nichols, or of the type illustrated and described in my previously identified application. As these electrical circuits, per se, do not constitute the present invention, they are not illustrated or described herein. If desired, each channel may be provided with a step controlled sensitivity device, such as is described and claimed in my application Ser. No. 14,558, filed March 12, 1948, where-

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by the sensitivity of all the channels may be altered not only simultaneously but substantially instantaneously from one sensitivity to another, without loss of record of intermediate heart beats and without re-adjustment of any of the other controls of the amplifier.

The output terminals of said channels are connected to the driving coils DCA, DCB, and DCC, respectively, of the magneto-motive devices which are provided in the apparatus for operating the recorder. These magneto-motive devices include a strong permanent magnet, shown schematically as three permanent magnets 38A, 38B, and 38C. As illustrated and described in my above mentioned applications, the driving coils are mechanically connected individually to suitable pens or marking elements which are schematically represented by the resistances MA, MB and MC. It will be understood that such marking elements operate on a suitable recording material to record the voltage variations supplied to said channels and amplified by the amplifying means provided therein, as hereinbefore indicated. As is well known to those skilled in the art, such recording material may be preferably, but not necessarily, chemically treated paper of a known type and when such paper is used the pens or marking elements are electrically heated, as indicated by the resistances designated by the foregoing reference characters MA, MB, and MC which schematically represent electrically heated marking elements. As will be readily understood the paper is affected by the heat of said elements whereby visual records are produced directly on a length of said paper during the movement of the latter in the direction of its length. The connections of the driving coils to the companion marking elements are indicated schematically by the dotted lines 40A, 40B, and 40C, and are illustrated and described in my first above mentioned application. As indicated, a synchronous motor 42 is provided for moving the recording material or paper at uniform speed in the direction of its length. The motor is preferably energized by 60 cycle alternating current at 110 volts, and a step-down transformer T is provided for supplying heating current to the resistances of the marking elements or pens MA, MB, and MC. An adjustable resistance R is provided in the primary circuit of the transformer for regulating the heat of said marking elements.

The continuous record switch 10 comprises the switch sections 10A, 10B, 10C, 10D, 10E, 10F, 10G, 10H, and 10I. Lead 44A connects the patient terminal P1 to stationary contact CPI of section 10A. Lead 44B connects the patient terminal P2 to stationary contact CP2 of section 10B. Lead 44C connects the patient terminal P3 to stationary contact CP3 of section 10C. A filter unit 12 is interposed in each of said leads at a point between each patient terminal and the companion stationary switch contact. Lead 44D connects the patient terminal RA to stationary contact CRA of section 10A. Lead 45A connects the latter stationary contact to stationary contact CRA of section 10I and to lead 45B which is connected to stationary contact CRA of section 10H. A filter unit 12 is interposed in lead 44D between patient terminal RA and contact CRA of section 10A. Lead 44F connects patient terminal LA to stationary contact CLA of section 10A. Lead 45C connects lead 44F to stationary contact CLA of section 10B and lead 45D connects said stationary contact to stationary contact CLA of section 10G. A filter unit 12

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is interposed in lead 44F between patient terminal LA and contact CLA of section 10A, said filter unit also being interposed between the latter patient terminal and lead 45C which is connected as described. Lead 44H connects patient terminal LL to stationary contact CLL of section 10B. Lead 45E connects lead 44H to the interconnected stationary contacts CLL of section 10C. A filter unit 12 is interposed in lead 44H between patient terminal LL and stationary contact CLL of section 10B, said filter unit also being interposed between the latter patient terminal and lead 45E which is connected as described. Lead 44E is connected between patient terminal RA and the movable contact 46F of section 10F. A resistor 48 and a filter unit 12 are interposed in lead 44E between patient terminal RA and movable contact 46F. Lead 44G is connected between patient terminal LA and movable contact 46D of section 10D. A resistor 48 and a filter unit 12 are interposed in lead 44G between patient terminal LA and movable contact 46D. Lead 44I is connected between patient terminal LL and movable contact 46E of section 10E. A resistor 48 and a filter unit 12 are interposed in lead 44I between patient terminal LL and movable contact 46E.

Each filter 12 comprises, as here shown, a capacitor 12A connected in series, in each of the leads 44A through 44I, said capacitor being in circuit, in each of said leads, between the patient, to whom the patient terminals are connected by suitable means (not illustrated), and the input side of the respective switch sections to which said leads are connected. More specifically, it will be noted that capacitors 12A in leads 44A, 44B and 44C are connected between patient terminals P1, P2 and P3, respectively, and the fixed contacts CP1, CP2 and CP3, respectively, of the switch sections 10A, 10B and 10C, respectively. The fixed contacts constitute the input sides of said sections, the movable contacts 46A, 46B and 46C thereof, being connected to output terminals 14, 18, and 22, respectively, and constituting the output sides of said switch sections. In the same manner it will be noted that capacitor 12A in lead 44D is connected between the patient terminal RA and fixed contacts CRA of switch sections 10A, 10I and 10H, that capacitor 12A in lead 44F is connected between patient terminal LA and each of fixed contacts CLA of switch sections 10A, 10B and 10G, the movable contact 46G in the latter switch section being connected to output terminal 24, constituting the output side of said section. Similarly, capacitor 12A in lead 44H is connected between patient terminal LL and the fixed contacts CLL in each of switch sections 10B and 10C, said contacts being in the input sides of said switch sections. Referring now to switch sections 10D, 10E and 10F, it will be noted that in these sections the movable contacts 46D, 46E and 46F are connected to the patient terminals LA, LL and RA, respectively, through leads 44G, 44I, and 44E, respectively, as described, said movable contacts therefor constituting the input sides of their respective switch sections. Each of the sections 10D, 10E and 10F has a pair of fixed contacts WT which are interconnected. Said interconnected contacts WT are all connected to the lead 50. Said lead is also connected to the interconnected pair of fixed contacts VF of switch section 10G, to the interconnected pair of fixed contacts VL of section 10H, and to the interconnected pair of fixed contacts VR of section 10I. The movable contact 46G is connected through lead 47A to output ter-

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terminal 24. The movable contact 46H is connected through lead 47B to output terminal 20, and the movable contact 46I is connected through lead 47C to output terminal 16. Therefore, it will be apparent that when the movable contacts 46I, 46H and 46G engage the fixed contacts VR, VL and VF, respectively, the stationary contacts WT of sections 10D, 10E and 10F are connected to output terminal 16 through contact 46I, to output terminal 20 through contact 46H, and to output terminal 24 through contact 46G. It will be noted that capacitors 12A in each of leads 44E, 44G and 44I, being connected to the movable contacts 46F, 46D and 46E, respectively, are therefore also connected to the input sides of the respective switch sections. Therefore, it will be apparent that no capacitor 12A is connected directly to one of the output terminals of switch 10 or to the side of a switch section which connects to an output terminal.

In addition to capacitor 12A, each filter 12 is provided with a resistor 12B connected in shunt between the side of the capacitor remote from its respective patient terminal and ground. Values for each filter component are chosen to provide a predetermined time constant for the filter action such that frequencies close to a direct-current condition will be blocked from feeding into the electro-cardiograph beyond switch 10, as will hereinafter more fully appear.

Referring now to leads 44E, 44G and 44I, it will be noted that each lead is provided with the previously mentioned resistor 48 connected in series between patient terminals RA, LA and LL, respectively, and the capacitor 12A of a filter 12, said leads being connected to the movable contacts 46F, 46D and 46E, respectively, of switch sections 10F, 10D and 10E, respectively. It will be noted that there is no circuit formed in station 1 of these switch sections. However, contacts WT are interconnected in each one of these switch sections and these interconnected contacts are all connected to lead 50. As is well known to those skilled in the art of cardiology, the Wilson terminal is formed by placing a resistor in series in each one of three leads. One end of each lead is connected to a patient extremity terminal, and the other ends of said three leads are joined to form a common terminal which is known as the Wilson terminal. Therefore, it will be apparent that in stations 2 and 3 of switch sections 10F, 10D and 10E, with the movable contacts 46F, 46D and 46E each engaged with a stationary contact WT which is connected to lead 50, the leads 44E, 44F, and 44G are all joined at one end thereof. The other ends of said leads are connected to the patient terminals RA, LL, and LA, respectively, and each of said leads is provided with a resistor 48 of a predetermined value in series therewith. Therefore, it will be understood that the Wilson terminal is formed when switch sections 10D, 10E and 10F are moved to stations 2 or 3 thereof. By making each resistor 48 have the same resistance value, it is apparent that the Wilson terminal provides an equipotential or reference point for the use of the cardiologist.

It will be noted that all the movable contacts of the various switch sections are mechanically ganged for conjoint movement. For convenience it may be assumed that all of the movable contacts move rectilinearly in moving to and from each of the several stations 1, 2, and 3.

At station 1, the movable contacts for the three channels are connected to the LA—RA, LL—RA, and LL—LA patient terminals to form the stand-

ard leads, designated in cardiology as I, II and III.

At station 2, the movable contacts for the three channels are connected to record the unipolar limb leads, designated in cardiology as VR, VL and VF. Lead VR records the potential between the right arm and the Wilson terminal. Lead VL records the potential between the left arm and the Wilson terminal, and lead VF records the potential between the left leg and the Wilson terminal. The circuit for recording the VR lead includes the patient terminal RA, lead 44D, engaged contacts CRA and 46A of section 19A, output terminal 14 connected to contact 46A, and line 26 from terminal 14 to channel A which is also connected to patient terminal RA through line 28, output terminal 16 connected to the engaged contacts 46I and VR of section 10I, said contacts being connected by lead 50 to the previously described Wilson terminal connection, which, in turn, is connected through lead 44E to patient terminal RA, and through leads 44G and 44I to the patient terminals LA and LL, respectively. The circuit for recording the VL lead includes the patient terminal lead LA, lead 44F, engaged contacts CLA and 46B of section 10B, output terminal 18 connected to contact 46B, and line 30 to channel B which is also connected to patient terminal LA through line 32, output terminal 20 which is connected to engaged contacts 46H and VL of section 10H, said contacts being connected by lead 50 to the previously described Wilson terminal connection which, in turn, is connected to each of the patient terminals LA, RA and LL, as previously described. The circuit for recording the VF lead includes the patient terminal LL, lead 44H, engaged contacts CLL and 46C of section 10C, output terminal 22 connected to contact 46C, and line 34 to channel C which is also connected to patient terminal LL through line 36, output terminal 24 which is connected to engaged contacts 46G and VF of section 10G, said contacts being connected by lead 50 to the previously described Wilson terminal connection which, in turn, is connected to each of the patient leads LL, LA and RA, as previously described. Thus, at station 2, the voltages between the right arm and a common point, essentially at zero potential, are transmitted over channel A to the companion recording element. Said common point is the Wilson terminal to which the three extremities are connected, each through a resistor 48. At the same time the voltages between the left arm and the common Wilson terminal, connected to the three extremities, are transmitted over channel B to the companion recording element of the recording apparatus. Also at the same time the voltages between the left leg and the common Wilson terminal, connected to the three extremities, are transmitted over channel C. Thus, the potentials are transmitted simultaneously to the three channels, respectively, when the movable switch contacts are at station 2 so that said potentials can be recorded simultaneously by the corresponding marking elements in the recording web in the same time relation.

At station 3, provision is made for recording three unipolar precordial or chest leads which record the potentials from the anterior surface of the heart. The Wilson terminal is used in recording the precordial potentials. At station 3, the circuits for the precordial leads are completed in the following manner: The precordial patient terminal P1, is connected by lead 44A to engaged contacts CP1 and 46A of section 19A, said contacts being connected to output terminal 14

which is connected to channel A by line 26, said channel being also connected through line 28 to output terminal 16 which is connected to engaged contacts 46I and VR of section 10I which, in turn, are connected through lead 50 to the Wilson terminal which, in turn, is connected to the three extremity terminals, as previously described. The precordial patient terminal P2 is connected by lead 44B to engaged contacts CP2 and 46B of section 10B, said contacts being connected to output terminal 18 which is connected to channel B by line 30, said channel being also connected through line 32 to output terminal 20 which is connected to engaged contacts 46H and VL of section 10H which in turn, are connected through lead 50 to the Wilson terminal which, in turn, is connected to the three extremity terminals, as previously described. The precordial patient terminal P3 is connected by lead 44C to engaged contacts CP3 and 46C of section 10C, said contacts being connected to the output terminal 22 which is connected to channel C by line 34, said channel being also connected through line 36 to output terminal 24 which is connected to engaged contacts 46G and VF of section 10G which, in turn, are connected through lead 50 to the Wilson terminal which, in turn, is connected to the three extremity terminals, as previously described.

As previously indicated, the patient's skin voltages charge the capacitors in the various amplifying channels. Upon the actuation of the selector switch during the operation of the electrocardiograph, these charges become transient and tend to render the amplifiers in the various channels unstable as they pass through the channels.

In accordance with the present invention, the various switching operations, described above, can take place without requiring a waiting period before the recorder can become operative, the filters 12, by preventing the generation of transient effects in the channels upon the actuation of the selector switch, permitting a continuous recording operation. As is well known to one skilled in the art, each filter 12 has a time-constant which is a function of the respective values of the filter components. Since the transient voltages, to which the apparatus is subjected, result from the patient's skin voltages which are extremely low frequencies approaching direct-current, said frequencies being of the order of a fraction of a cycle, the time-constant of the filter 12 should be such that only these extremely low frequency variations, close to direct-current will be blocked from passing through the apparatus without, however, blocking the desired extremely low body voltage frequencies. It has been found that a filter 12 constituted, for example and not by way of limitation, by a one microfarad capacitor and a resistor having 4.7 megohms of resistance, will provide a time-constant that will cause capacitor 12A to block these unwanted skin voltages.

In taking an electro-cardiograph recording, leads, provided at one end with electrodes for securement on the patient's body, are connected at their other ends to the terminals P1, P2, P3, RA, LA and LL, respectively. Therefore, it is apparent that capacitors 12A, which are connected between said terminals and the input terminals of switch 10, will be charged by the patient's skin voltages which are transmitted by said electrodes to said input terminals. This charge will be present at all times during the cardiac investigation since the filters 12 are connected at the input side of switch 10 and not be-

tween the switch and the amplifying channels. Therefore, the switch never interrupts the circuits between the patient and the filters 12, as would be the case if the filters were connected to the output side of the switch. In the latter case, the filter capacitors are charged when the circuit is completed through the switch to the patient. However, when said latter circuit is interrupted by the operation of the switch, it is apparent that the charged capacitors are disconnected from the source of skin voltage, even though this may be momentarily, and will discharge into the amplifier channels. This discharge produces transients which render the amplifier channels inoperable for as much as several seconds until the transient effects pass there-through. However, by connecting the filters at a point electrically remote from the companion amplifying channels, that is, between the patient and the input side of the switch 10, so that they are always being charged, regardless of the condition of the switch, and by providing a proper time constant, the switching operation will not result in the discharge of the capacitors into the amplifying channels. Consequently, transient voltages which render the apparatus temporarily inoperable for recording purposes will not be generated. Therefore, the switching operations can take place without requiring a waiting period.

Due to the presence of the resistors 48 which, as previously described, are joined to form the Wilson connection, the components of filter 12 in leads 44E, 44G and 44I are given values different from the values of the filter components in leads 44A, 44B, 44C, 44D, 44F and 44H. This is necessary to compensate for the presence of resistors 48 which affect the time constant of the associated filters. It has been found, for example, that using 5600 ohm resistors for the resistors 48, and assuming that filters 12, in all those leads not having a resistor 48, are comprised, for example, by a one microfarad capacitor and a 4.7 megohm resistor, that the filters in those leads having the resistors 48, can, for example, comprise a one microfarad capacitor and a 15 megohm resistor. It will be understood, of course, that all component values are merely illustrative and have been included only by way of illustration.

The continuous-record switch may be provided for the electrocardiograph instead of or in addition to the lead selector switch shown in my above mentioned applications Ser. No. 762,633, filed July 22, 1947, and Ser. No. 14,558, filed March 12, 1948. When provided for the electrocardiograph which is provided with said lead selector switch, as shown in my prior applications, just referred to, either said lead selector switch or said continuous-record switch may be used alternatively at the option of the cardiologist or the technician, suitable connections (not shown) being provided for this purpose. When provided for the electrocardiograph instead of the lead selector switch, the latter being omitted, the continuous-record switch is connected in the circuit as shown by the drawing of the present application. It will be noted that the time-delay means and circuit shown in Fig. 1 of each of my prior applications, Ser. Nos. 762,633 and 14,558 are omitted from the circuit when the continuous-record switch is used.

As illustrated, the present invention is embodied in a multiple-lead electrocardiograph but it will be readily understood that it is within the scope of my invention to apply the underlying idea to a uni-lead electrocardiograph for pre-

venting the transmission of transient voltages to the electrocardiograph. Also, the invention is not to be limited to direct-writing cardiographs.

It will be understood that the invention may be embodied otherwise than as hereinbefore described and that various changes may be made without departing from the underlying idea or principles of the invention within the scope of the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent, is:

1. For use in an electro-cardiograph which records potentials developed by the normal activities of a living body and which is provided with a plurality of channels for amplifying said potentials, said electro-cardiograph being provided also with electrodes adapted for contacting the body at spaced points on said body; circuit means interconnecting said electrodes and said channels, said circuit means including means for changeably selecting different pairs of electrodes for connection to said channels, respectively, whereby to changeably select the points on the body from which the potentials are to be transmitted through said circuit means to each of said channels, respectively, said circuit means additionally including means for blocking skin voltages of the body from said channels, said blocking means being connected to the side of said selecting means which is electrically remote from said channels, whereby the operation of said selecting means will be ineffective to discharge the voltages of said blocking means into said channels.

2. For use in an electro-cardiograph which records potentials developed by the normal activities of a living body and which is provided with a plurality of channels for amplifying said potentials, said electro-cardiograph being provided also with electrodes adapted for contacting the body at spaced points on said body; circuit means interconnecting said electrodes and said channels, said circuit means including means for changeably selecting different pairs of electrodes for connection to said channels, respectively, whereby to changeably select the points on the body from which the potentials are to be transmitted through said circuit means to each of said channels, respectively, said circuit means additionally including filter means for blocking skin voltages of the body from said channels, said filter means being connected between said electrodes and the side of said selecting means which is electrically remote from said channels, whereby the operation of said selecting means will be ineffective to discharge the skin voltage charge on said filter means into said channels.

3. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, means for changeably connecting a plurality of pairs of leads for voltages from across different parts, respectively, of different parts of the subject's body to said channels, and filter means provided with a time-constant for blocking skin voltages of the body from said channels, said filter means being connected to the side of said changeable connecting means which is electrically remote from said channels, whereby the operation of said changeable connecting means will be ineffective to discharge the skin voltage charge on said filter means into said channels.

4. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, means for changeably connecting a plurality of pairs of leads for voltages from

across different pairs, respectively, of different parts of the subject's body to said channels, said means having input portions to which said voltage-variations are applied and output portions connected to said channels, and filter means for blocking skin voltages of the body from said channels, said filter means being connected to said input portions, whereby the operation of said selecting means will be ineffective to discharge the skin voltage charge on said filter means into said channels.

5. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, means for changeably connecting a plurality of pairs of leads for voltages from across different pairs, respectively, of different parts of the subject's body to said channels, said means having input portions to which said voltage-variations are applied and output portions connected to said channels, and filter means provided with a time-constant for blocking skin voltages of the body from said channels, said filter means being connected to said input portions, whereby the operation of said selecting means will be ineffective to discharge the skin voltage charge on said filter means into said channels.

6. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, means for changeably connecting a plurality of pairs of leads for voltages from across different pairs, respectively, of different parts of the subject's body to said channels, said means having input portions connected to said channels, and filter means provided with a time-constant for blocking skin voltages of the body from said channels, said filter means being connected to said input portions, whereby the operation of said selecting means will be ineffective to discharge the skin voltage charge on said filter means into said channels, said filter means comprising reactance means in series with said input portions and impedance means in shunt therewith.

7. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, means for changeably connecting a plurality of pairs of leads for voltages from across different pairs, respectively, of different parts of the subject's body to said channels, said means having input portions connected to said channels, and filter means provided with a time-constant for blocking skin voltages of the body from said channels, said filter means being connected to said input portions, whereby the operation of said selecting means will be ineffective to discharge the skin voltage charge on said filter means into said channels, said filter means comprising capacitance means in series with said input portions and resistance means in shunt therewith.

8. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, means for changeably connecting a plurality of pairs of leads for voltages from across different pairs, respectively, of different parts of the subject's body to said channels, and filter means connected in said leads to the input side of said connecting means for blocking skin voltages of the body from said channels, whereby the operation of said changeable connecting means will be ineffective to discharge the skin voltage charge on said filter means into said channels.

9. For use in an electro-cardiograph having a plurality of channels for amplifying body-volt-

age variations, means for changeably connecting a plurality of pairs of leads for voltages from across different pairs, respectively, of different parts of the subject's body to said channels, and filter means connected in said leads to the input side of said connecting means, said filter means having a time-constant for blocking skin voltages of the body from said channels, whereby the operation of said changeable connecting means will be ineffective to discharge the skin voltage charge on said filter means into said channels.

10. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, a multi-pole selector switch for connecting a plurality of pairs of leads for voltages from across different pairs, respectively, of different parts of the subject's body to said channels, respectively, each of said leads being provided with a filter for blocking the subject's skin voltages from said channels, said filter being interposed in each lead between the portion thereof which is adapted to be connected to the subject's body and the side of said switch electrically remote from said channels, whereby the operation of said switch will be ineffective to discharge the skin voltage charge on said filters into said channels.

11. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, a multi-pole selector switch for connecting a plurality of pairs of leads for voltages from across different pairs, respectively, of different parts of the subject's body to said channels, respectively, said switch having input contacts connected to said leads and output contacts connected to said channels, and a filter connected in each of said leads for blocking the subject's skin voltages from said channels, said filter being interposed in each lead between the end thereof adapted to be connected to the subject's body and the end thereof connected to an input contact of the switch, whereby the operation of the switch will be ineffective to discharge the skin voltage charge on said filters into said channels.

12. For use in an electro-cardiograph having a plurality of channels for amplifying body-voltage variations, a multi-pole selector switch for connecting a plurality of pairs of leads for voltages from across different pairs, respectively, of different parts of the subject's body to said channels, respectively, said switch having input contacts connected to said leads and output contacts connected to said channels, and a filter connected in each of said leads for blocking the subject's skin voltages from said channels, said filter being interposed in each lead between the end thereof adapted to be connected to the subject's body and the end thereof connected to an input contact of the switch, whereby the operation of the switch will be ineffective to discharge the skin voltage charge on said filters into said channels, each filter comprising capacitor means in series with its respective lead and resistance means in shunt therewith.

13. For use in an electro-cardiograph which records potentials developed by the normal activities of a living body and which is provided with a plurality of channels for amplifying said potentials, said electro-cardiograph being provided also with electrodes adapted for contacting the body at spaced points on said body; switching means connected between said electrodes and channels for changeably selecting dif-

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ferent pairs of electrodes for connection to said channels, respectively, whereby to changeably select the points on the body from which the potentials are to be transmitted to each of said channels, respectively, and capacitance and resistance means for blocking skin voltages of the body from said channels, said blocking means being connected between each of said electrodes and the side of said switching means electrically remote from said channels, whereby the operation of said switching means will be ineffective to discharge the skin voltage charge on said capacitance means into said channels, respectively.

14. For use in an electro-cardiograph which records potentials developed by the normal activities of a living body and which is provided with a plurality of channels for amplifying said potentials, said electro-cardiograph being provided also with electrodes adapted for contacting the body at spaced points on said body; switching means connected between said electrodes and channels for changeably selecting different pairs of electrodes for connection to said channels, respectively, whereby to changeably select the points on the body from which the potentials are to be transmitted to each of said channels, respectively, and capacitance and resistance means for blocking skin voltages of the body from said channels, said blocking means being connected between each of said electrodes and the side of said switching means electrically remote from said channels, whereby the operation of said switching means will be ineffective to discharge the skin voltage charge on said capacitance means into said channels, respectively, a capacitance means being connected in series between each electrode and said switching means and a resistance means being connected in shunt between each capacitance means and said switching means, each capacitance and resistance means having a time-constant adapted to block said skin voltages.

15. For use in an electro-cardiograph which records potentials developed by the normal activities of a living body and which is provided with a plurality of channels for amplifying said potentials, said electro-cardiograph being provided also with electrodes adapted for contacting the body at spaced points on said body; means for changeably selecting different pairs of electrodes for connection to said channels, respectively, whereby to changeably select the points on the body from which the potentials are to be transmitted to each of said channels, respectively, and means for blocking skin voltages of the body from said channels, said blocking means being connected to the side of said selecting means which is electrically remote from said channels, whereby the operation of said select-

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ing means will be ineffective to discharge the voltages of said blocking means into said channels.

16. For use in an electro-cardiograph having amplifying means for amplifying body-voltage variations from a subject's body, means in a circuit with said amplifying means for changeably selecting a plurality of pairs of leads for voltages from across different pairs, respectively, of the subject's body to said amplifying means, and means for blocking skin voltages from said amplifying means, said blocking means being in the circuit with said selecting means at the side thereof electrically remote from said amplifying means, whereby the operation of said selecting means will be ineffective to discharge the skin voltage charge on said blocking means into said amplifying means.

17. For use in an electro-cardiograph having amplifying means for amplifying body-voltage variations from a subject's body, means in a circuit with said amplifying means for changeably selecting a plurality of pairs of leads for voltages from across different pairs, respectively, of the subject's body to said amplifying means, and skin-voltage time-constant means for blocking skin voltages from said amplifying means, said blocking means being in the circuit with said selecting means at the side thereof electrically remote from said amplifying means, whereby the operation of said selecting means will be ineffective to discharge the skin voltage charge on said blocking means into said amplifying means.

18. For use in an electro-cardiograph having amplifying means for amplifying body-voltage variations from a subject's body, means in a circuit with said amplifying means for changeably selecting a plurality of pairs of leads for voltages from across different pairs, respectively, of the subject's body to said amplifying means, and skin-voltage time-constant means for blocking skin voltages from said amplifying means, said time-constant means being connected to said selecting means at the side thereof electrically remote from said amplifying means, whereby the operation of said selecting means will be ineffective to discharge the skin voltage charge on said time-constant means into said amplifying means.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,647,711	Nichols	Nov. 1, 1927
1,888,139	Nichols	Nov. 15, 1932
2,400,583	White	May 21, 1946