

March 12, 1940.

E. T. BOTH

2,193,471

ELECTROCARDIOGRAPH

Filed Oct. 2, 1937

3 Sheets-Sheet 1

FIG. 1

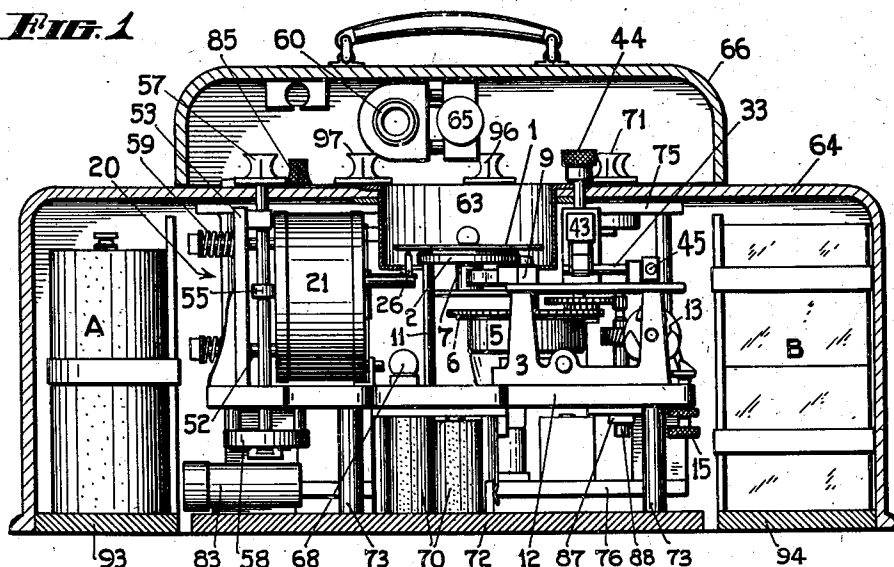
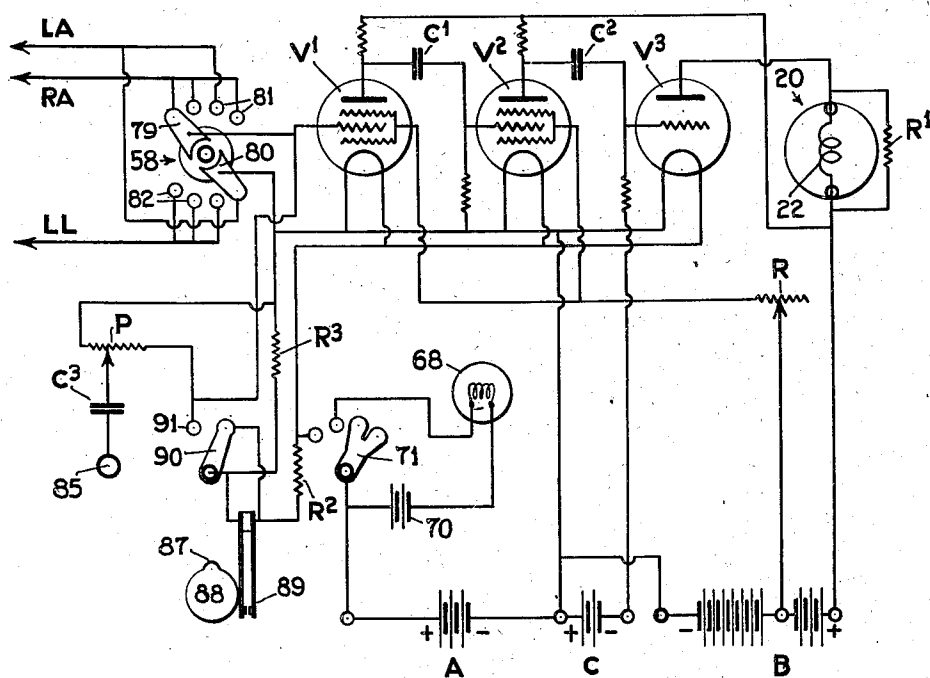


FIG. 2



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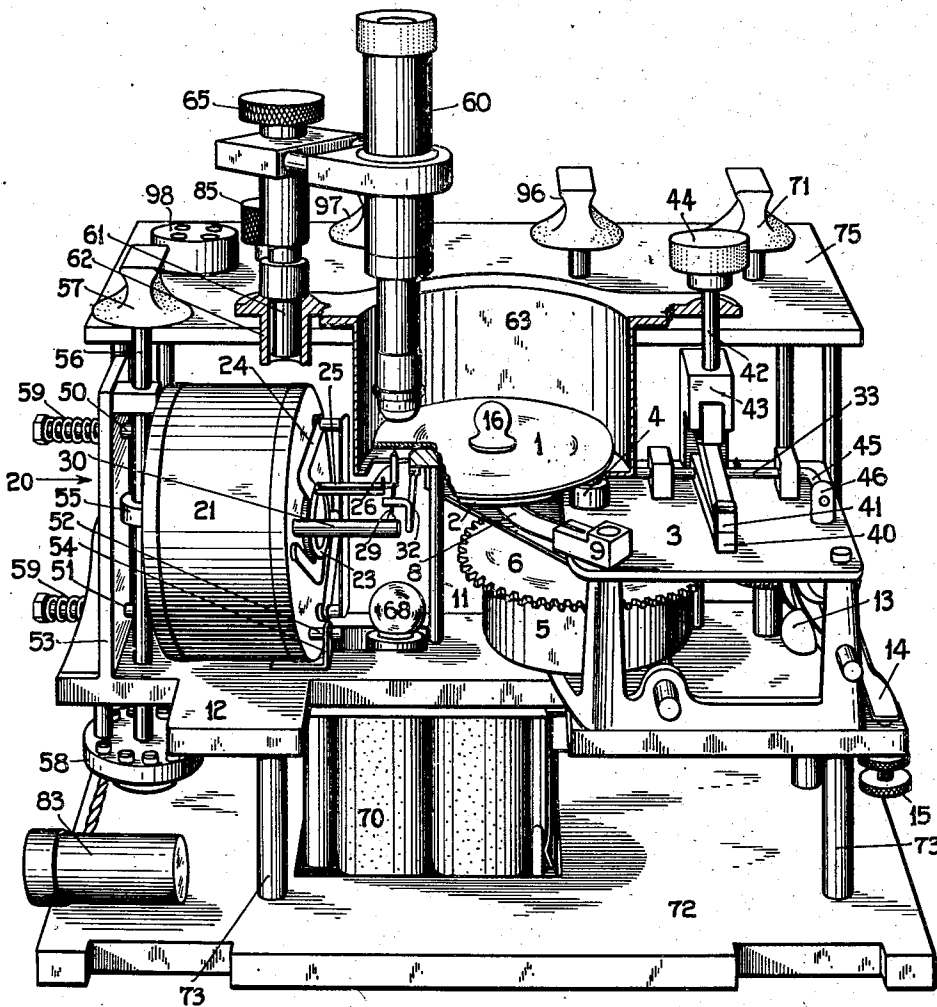
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FIG. 3



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FIG. 6

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UNITED STATES PATENT OFFICE

2,193,471

ELECTROCARDIOGRAPH

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Application October 2, 1937, Serial No. 166,919

8 Claims. (Cl. 128—2.06)

This invention relates to an improved electro-cardiograph for use in recording the action current of the heart by taking cross readings such as between the right arm and left arm, the right arm and left leg, and between the left arm and left leg, the principal object of the invention being to provide recording means by which a linear record is made which can be viewed while it is being made and which remains readily available thereafter, further objects being a construction by means of which simplicity and ruggedness together with sensitivity and standardisation are attained.

According to this invention the recording means comprise a removable cardiogram disc of transparent material having on one side an opaque coating which may be easily removed, a narrow line of which coating is in operation removed by a fine-pointed scriber which forms a trace by cutting through the coating, means being provided to support and revolve the disc, to amplify the action current of a heart, and to convert such amplified action current to mechanical movement which is applied to the scriber.

The features of the invention will however be better understood if reference is had to the following description which will be made with reference to the accompanying drawings in which—

Fig. 1 is a sectional side elevation showing an embodiment of the improved cardiograph arranged in its case,

Fig. 2 is a diagram of the electrical circuit,

Fig. 3 is a sectional perspective view of the mechanism,

Fig. 4 is a sectional plan of same,

Fig. 5 is a sectional perspective view of the scriber supporting means showing the moving coil and the cardiogram disc and turntable, and

Fig. 6 is an enlarged view of the grating which is placed in the microscope upon the usual platform provided in the eyepieces of microscopes.

The trace is made to a small scale on a transparent cardiogram disc 1 which has its underside treated with a material which renders such underside opaque but which can be easily removed by a scriber in contact with such disc. A suitable method of rendering the disc opaque is to deposit carbon by smoking such disc. The term "opaque" is intended to include a semi-opaque state as it is not always necessary to have the coating completely opaque.

The disc is supported upon a turntable 2 which is of smaller diameter than the cardiogram disc

1 and this turntable 2 is slowly driven by means of a spring motor 3 by extending the shaft 4 of the spring casing 5 which is attached to the gear wheel 6 and bringing the edge of the turntable 2 against such shaft 4. The turntable is supported by a bearing member 7 mounted upon the end of a spring arm 8 projecting from a block 9 secured upon the motor 3. A ball-bearing 10 is interposed between the disc and the member 7 and the disc is steadied by resting it upon a post 11 projecting upwardly from a frame 12 which also supports the motor 3. The member 7 bears upon a plate 17 secured to the motor.

The spring arm 8 forces the turntable 2 against the shaft 4 and the turntable is thus given a very steady rotation at a low rate of revolution. The motor 3 can be of any usual or approved construction provided the gear wheel 6 of the spring can be coupled to the shaft 4 to revolve same. The spring motor has the usual governor 13 and speed regulating means 14 these latter being adjusted by a screw 15.

The location of the disc 1 upon the top of the turntable 2, and the location of the scriber to operate upon the coated underside of the disc, ensures that the space above the turntable is clear of mechanism and easy positioning and removal of the disc results, the danger of damaging the delicate scriber during positioning and removal of the disc being removed, and mounting of the scriber being made more practical.

The disc 1 (of which a number are provided) has at its centre a knob 16 which has a downwardly-projecting centering portion.

The unit for converting the amplified current variation to mechanical motion is a moving-coil unit 20 comprising a permanent magnet 21 and a moving coil 22 the coil former 23 of which is supported on flexible arms 24 in any usual or approved manner to permit free axial movement.

Secured to the coil former 23 is an arm 25 which projects in the direction of axial movement of the coil, the arm having on its projecting end an upwardly-projecting scriber 26 in the top of which is a diamond point. The arm 25 is constructed to be rigid excepting at 27 at which point it can flex to allow the scriber 26 to move up and down. This arm transmits to the scriber 26 the axial movement of the moving coil 22 due to current variation and when such scriber is in contact with the revolving cardiogram disc 1 such axial movement is faithfully recorded on the disc.

It will be realised that other suitable converters could be used in place of the moving-coil unit

provided one is chosen which has a sufficiently quick response.

It is, however, very necessary to support the scribe 26 against movement in a direction at right-angles to the said axial movement under influence of the revolving disc and this is achieved by an arm 29 secured at its one end to the scribe 26 and at its other end to a bracket 30 projecting from the magnet 21. The arm 29 must be rigid in a direction to withstand any tendency to tilt of the scribe 26 due to friction between the scribe and the rotating disc but must at the same time be flexible so as not to resist the axial movement of the coil former 23. This is achieved by having the arm 29 in the form of a flexible blade having the portion near the scribe 26 set upright but having the portion near the bracket 30 twisted at right-angles thereto.

From the foregoing it will be realised that the scribe 26 is held against tilting by the arms 25 and 29 but is free to move up and down and to move axially under influence of the moving coil unit 20. The arms 25 and 29 are so arranged that the scribe 26 is projected lightly against the cardiogram disc 1 when a trace is being made, but the scribe may be manually retracted from the disc 1 by means of an arm 32 mounted upon a rockable shaft 33 when a trace is not being made.

It is sometimes desirable to damp the scribe 26 against a too free up and down movement and this is achieved by securing a spring bracket 34 to the coil former 23 immediately adjacent the arm 25, the end of such spring bracket having an upwardly-projecting damper 35 which bears lightly against the arm 25. The spring bracket 34, as will be seen, consists of a flat strip arranged on edge so that it can flex to press the damper 35 against the arm 25 but will not allow vertical movement of the damper 35. A small lug 36 upon the bracket 34 prevents the arm 25 from moving down too far.

The aforesaid shaft 33 has attached to it an arm 40 which has its end coupled to the end of an arm 41 which is rigidly secured to the lower end of a vertical rod 42 slidable in a support 43. The rod 42 is provided with a knob 44 and when this is pulled upwardly the arm 41 is moved upwards, thus moving the end of the arm 40 upward and rocking the shaft 33 with the member 32 and thus allowing the scribe 26 to rise and contact with the cardiogram disc 1.

The rocking of the shaft 33 at the same time allows the motor 3 to start, this being achieved by an arm 45 upon the end of the shaft 33 engaging the usual brake control 46 of the motor. It will thus be seen that upward movement of the knob 44 allows the motor to start and simultaneously brings the scribe 26 into contact with the cardiogram disc 1 and that downward movement stops the motor and simultaneously moves the scribe away from the disc.

As it is desirable to record a plurality of traces on each cardiogram disc 1, such as traces taken between the left arm and left leg, right arm and left leg, and left arm and right arm and sometimes one further trace, switching means are provided to enable this to be done.

This is achieved by shifting the scribe 26 to different positions, the entire moving-coil unit 20 and the parts carried by it being shifted. For this purpose the magnet 21 has upon it stems 50, 51 and 52 of which 50 and 51 are slidable in a bracket 53, and 52 is slidable in a bracket 54. The direction of the stems is one to give axial move-

ment to the unit 20. Movement of the unit 20 is effected by means of a cam 55 contacting with the back of the magnet 21, such cam being mounted upon a shaft 56 provided with a control knob 57 and having at its bottom switching means 58 which automatically change the leads from the patient. From this it follows that when the moving-coil unit 20 is shifted to any one of the said positions the corresponding leads from the patient are placed into the circuit. Springs 59 maintain the magnet 21 in contact with the cam 55.

To allow the trace to be viewed while being recorded a microscope 60 is provided, such microscope being of any usual or approved construction and being supported by having a stem 61 upon it engaging in a socket 62 forming part of a frame 63, which is secured to the case 64 which houses the cardiograph. A focussing knob 65 is provided for the microscope and the microscope is loosely mounted so that it can be removed from the socket 62 and stored in the lid 66 of the unit as is shown more particularly in Fig. 1. The microscope has within it a grating of radial lines 67 to indicate an exact time interval for both the outer trace inscribed on such disc and the other traces which are nearer the centre and has cross lines 69 to indicate the amplitude of deflection of the scribe.

A lamp 68, preferably opalescent, is mounted beneath the cardiogram disc 1 and in line with the microscope 60. The microscope is so located that the trace can be viewed immediately it has been traced on the cardiogram disc 1 by the scribe 26. The lamp is energised by a battery 70 through a switch 71.

The motor 3, the moving-coil unit 20, the lamp 68 and switch 58 are all supported upon the aforesaid frame 12 which is in turn supported upon a base 72 but is raised some distance above the base 72 by means of legs 73.

The electrical amplifying unit is mounted adjacent the just-described mechanisms, it comprising a frame having an upper panel 75 and a lower base 76 the latter carrying the amplifying valves and intervalve coupling means and the former carrying the various variable resistances and switches.

The amplifier may be of any usual or approved construction and may conveniently be as shown in Fig. 2 of the drawings.

In this the switch 58 which controls the input in synchronism with the scribe position has two arms 79 and 80 which each co-act with contacts, the arm 79 engaging contacts 81 and the arm 80 engaging contacts 82. The contacts are interconnected with the leads LA, RA, and LL which lead respectively to the left arm, right arm and left leg of the patient for three-position readings. It will be seen that in the position of the arms 79 and 80 shown the reading is taken between LA and RA, in the next position between RA and LL, in the next position between LA and LL, and in the fourth position again between RA and LL. The duplication of the position RA and LL is to enable a fourth trace to be made by say removing RA from the patient's right arm and placing it on his chest. Any one of the positions may also be used for calibration later to be described.

It will be noted that the input from the switch 58 is across the grid and filament of the valve V1. The valves V2 and V3 are resistance coupled, large condensers C1 and C2 of say two microfarads being used to ensure adequate response to the low frequency impulses. Sensitivity control is by means of the voltage control R which regu-

lates the screen voltage of V1 and V2. The resistance R1 across the winding of the moving coil 22 of the coil unit 20 damps the movement to ensure faithful response of the coil to the impulses. A suitable way to construct this resistance is to wind the coil upon a former of aluminium or other electrically-conductive material but an ordinary independent resistance may be used.

The filament supply is indicated by the conventional A, the high tension potential supply to the plates of the valves V1, V2 and V3 by the right hand portion of B, and the grid bias supply to the grid of the output valve V3 by C while the bias for valves V1 and V2 is provided by the left hand portion of B. The latter battery is housed in the casing 83. It will be seen that the switch 71 has three positions, one to allow the apparatus to be switched off, another to allow the lamp 68 to be energised independently of the amplifier as for viewing of a trace after recording, and another to energise both the lamp 68 and the amplifier.

The potentiometer P across the input to V1 has a metal knob 85 which is connected through a condenser C3 with the slider of such potentiometer. The purpose of this is to enable alternating current introduced by the patient to V1 to be cancelled by feeding in alternating current of opposite phase (by reason of the condenser C3) from an operator who holds and adjusts the knob 85.

The before-mentioned means for producing a calibration trace comprise a cam 87 upon a shaft 88 which forms part of the motor 3 and which revolves at a suitable speed, such cam actuating contacts 89 which are interposed between two resistances R2 and R3, this series arrangement being connected across the filament supply of the amplifier. The cam periodically closes the contacts and applies a small voltage to such contacts which is transferred through the switch 90 (when the arm thereof engages the contact 91) to the grid of V1. When the arm of the switch 90 is in the position shown such switch shortcircuits the contacts.

The value of the resistances R2 and R3 and the sensitivity of the amplifier is preferably such that one millivolt applied to V1 results in a scribe deflection of .3 of a millimeter. The speed of rotation of the disc is such that approximately .03 of an inch is inscribed for each second of time.

The batteries A and B are supported upon bases 93 and 94 respectively which are placed upwardly into the case 64 and are secured thereto. The base 72 with the parts upon it is also placed upwardly into the case 64 and is secured thereto. The knobs 96 and 97 operate the switch 90 and the resistance R. The socket 98 allows the leads LA, RA, and LL from the patient to be plugged in to the cardiograph.

In operation the leads LA, RA, and LL are attached to the left arm, right arm and left leg respectively of the patient.

The amplifier is then switched on by operating the switch 71 and preferably a standardisation trace is made, this being achieved by moving the switch arm 90 on to the contact 91 and then operating the resistance R to adjust the sensitivity of the valves V1 and V2 to bring the amplitude of the recorded impulses to the correct dimensions. The motor 3 must of course be started to revolve the cardiogram disc 1 and the shaft 88 before the trace can be recorded.

The sensitivity having been adjusted the switch

90 is returned to the position shown in Fig. 2 and the switch 58 is operated to place two leads from the patient into the amplifier circuit.

The action current of the heart introduced to the amplifier will cause actuation of the moving coil 22 of the unit 20 and this movement will be inscribed on the disc by the scribe 26.

One such trace having been obtained the switch 58 is set to its next position to place other leads from the patient into the amplifier input, this movement of the switch at the same time locating the scribe in a new position upon the disc by reason of the cam 55 upon the operating shaft 56.

A third reading is similarly taken and if desired also a fourth reading. The fourth reading is achieved by placing the lead RA on the chest.

The fourth position may also be used to record on the disc a standardization trace but as a rule this is not necessary for when the amplifier has been adjusted the correct amplitude will be maintained for all traces.

During this recording the operator by means of the microscope 60 may watch the recording of the actual beats of the heart so that a direct diagnosis can be made.

The trace upon the disc can be photographically recorded upon sensitized paper enlarged to a size to give a standardised reading, or the disc may be stored as the record and viewed from time to time under the microscope if required.

Should, during the recording of the trace, alternating current interference be introduced from the patient radiated to him from an alternating current lighting supply or the like to the amplifier the operator who will also have the current radiated to him places his hand upon the metal knob 85 and adjusts the potentiometer to introduce to the amplifier a current in phase opposition to that introduced by the patient and of balancing magnitude. It will be appreciated that the operator and the patient will in practice be reasonably close together and therefore will both pick up radiations such as those referred to (if such radiations are present) the contact of the operator's hand with the metal knob of the potentiometer P making the necessary electrical connection to the said knob and thus to the condenser C3.

What I claim is:

1. An improved electrocardiograph comprising; a removable cardiogram disc of transparent material having on one side an opaque coating which may be easily removed, a turntable to support said disc, a motor to drive said turntable, electrical means to amplify the action current of a heart, a moving-coil magnetic unit to change the electrical impulses from the amplifier to mechanical movement, an arm projecting from the moving coil of the said unit disposed parallel to the axis of movement of the coil, a scribe secured upon the projecting end of such arm, and a second arm secured at one end to the scribe and at its other end to a bracket projecting from the magnet of the said unit the last-said arm being tangentially disposed (at the point of contact of the scribe) to the trace being inscribed, both said arms being flexible to normally project the scribe against the said cardiogram disc.

2. An improved electrocardiograph comprising; a removable cardiogram disc of transparent material having on one side an opaque coating which

may be easily removed, a turntable to support said disc, a motor to drive said turntable, electrical means to amplify the action current of a heart, a converting unit to change the electrical impulses to mechanical movement, a scribe having a hard very fine point and coupled to move with a moving part of said converting unit and arranged to inscribe a minute trace upon the disc by cutting through the coating, means to shift the said converting unit in a direction parallel to the direction of movement of the scribe to enable such scribe to inscribe a number of traces upon the said cardiogram disc, and switching means coupled to operate with the shifting of the said converting unit to place different leads from the patient into circuit with the electrical amplifier when the said converting unit is in different positions.

3. An improved electrocardiograph comprising: a removable cardiogram disc of transparent material having on one side an opaque coating which may be easily removed, a turntable to support said disc, a motor to drive said turntable, electrical means to amplify the action current of a heart, a moving-coil magnetic unit to convert the electrical impulses from the amplifier to mechanical movement, an arm projecting from the moving coil of the said unit said arm being disposed parallel to the axis of movement of the coil, a scribe secured upon the projecting end of such arm, a second arm secured at one end to the scribe and at its other end to a bracket projecting from the magnet of the said unit the last-said arm being tangentially disposed (at the point of contact of the scribe) to the trace being inscribed, both said arms being flexible to normally project the scribe against the said cardiogram disc, means to stop and start the said motor, and means coupled to such last-said means to move the said scribe away from the cardiogram disc when the motor is stopped.

4. An improved electrocardiograph comprising: a removable cardiogram disc of transparent material having on its underside an opaque coating which may be easily removed, a horizontally-disposed turntable of smaller diameter than the said disc to support said disc upon its top, a motor to drive said turntable, electrical means to amplify the action current of a heart, a converting unit to change the electrical impulses to mechanical movement, a scribe having a hard very fine point coupled to move with a moving part of the said converting unit and arranged to inscribe minute traces upon the disc on that part thereof which overhangs the turntable, means to move the converting unit to bring the scribe near to or further from the centre of the said disc, a light source beneath such cardiogram disc, and a microscope disposed above such cardiogram disc to permit viewing of the inscribed traces.

5. An improved electrocardiograph as defined in claim 4 characterised by the combination therewith of a calibrated grid in the microscope to allow the amplitude of the deflection of the scribe to be read and to allow the time of the heart cycle to be read, the latter calibrations having their time-indicating lines radially ar-

anged to compensate for differences in the distance of the traces from the centre of the disc.

6. An improved electrocardiograph comprising: a removable cardiogram disc of transparent material having on one side an opaque coating which may be easily removed, a turntable to support said disc, a motor to drive said turntable, electrical means to amplify the action current of a heart, a converting unit to change the electrical impulses to mechanical movement, a scribe having a hard very fine point and coupled to move with a moving part of said converting unit and arranged to inscribe a minute trace upon the disc by cutting through the coating, and standardisation means to adjust the amplitude of the deflection of the scribe comprising, contacts operated periodically by the motor, voltage supply means associated with such contacts, sensitivity control means for the amplifier to allow adjustment of the deflection of the scribe, and a switch to place such standardisation means into the amplifier circuit.

7. An improved electrocardiograph comprising: a removable cardiogram disc of glass having its one side smoked, a turntable to support said disc, a spring motor to drive said turntable, electrical means to amplify the action current of the heart, a magnetic moving-coil unit to which the electrical impulses are applied, a scribe coupled to such unit and having a diamond point, said scribe being coupled to move with the moving coil of the said unit and arranged to inscribe a minute trace upon the disc by cutting through the coating when the disc is revolved, means to shift the magnetic moving-coil unit in a direction parallel to the movement of the moving coil of such unit, leads from a patient to allow the action current of a heart to be introduced to the amplifier, a switch in such leads to place different leads in circuit for different positions of the switch, and coupling means between the magnetic unit and the switch to cause synchronous positioning of said switching means and said magnetic unit.

8. An improved electrocardiograph comprising: a removable cardiogram disc of glass having its underside smoked, a horizontally-disposed turntable of greater diameter than the said disc to support said disc upon its top, a spring motor to drive said turntable, electrical means to amplify the action current of a heart, a magnetic moving-coil unit to change the electrical impulses from the amplifier to mechanical movement, a scribe having a diamond point arranged to inscribe a minute trace upon the underside of said disc by cutting through the coating when the disc is revolved, an arm connecting the scribe with the said moving coil, said arm being disposed parallel to the axis of the moving coil, a second arm secured at one end to the scribe and tangentially disposed (at the point of contact of the scribe) to the trace being inscribed, and a bracket projecting from the magnet of the said moving coil unit supporting the projecting end of the last-said arm.

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