United States Patent

[11] **3,580,241**

[72] Inventor **Berel Weinstein**
New York, N.Y.

[21] Appl. No. **751,078**
[22] Filed **Aug. 8, 1968**
[45] Patented **May 25, 1971**

[73] Assignee **Bio-Medical Sciences, Inc.**
New York, N.Y.

[54] **CARDIOGRAPHIC APPARATUS WITH STYLUS CONTROL MEANS**
7 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **128/2.06,** 346/33
[51] **Int. Cl.** **A61b 5/04**
[50] **Field of Search** 128/2.05, 2.06, 2.1; 346/33

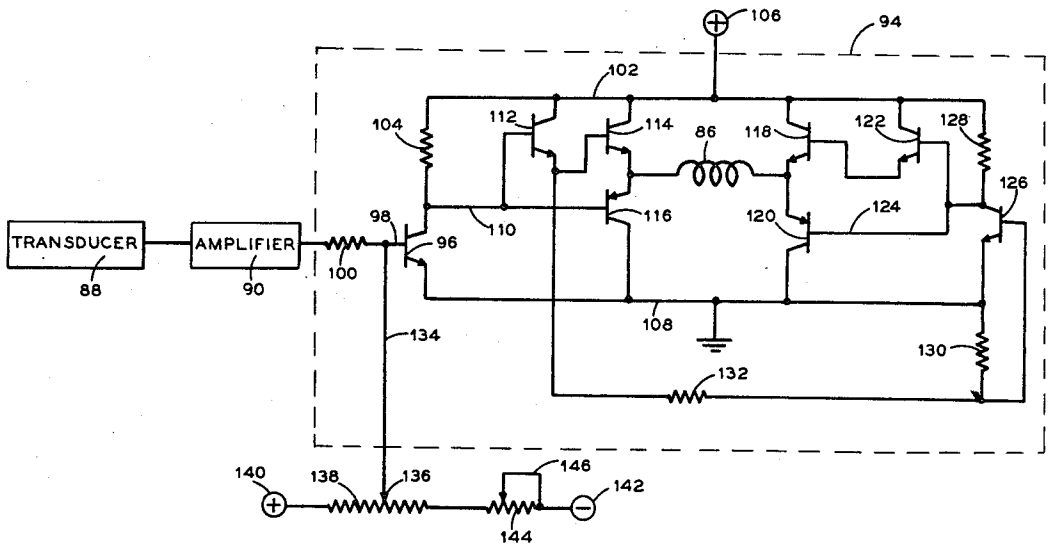
[56] **References Cited**

UNITED STATES PATENTS

2,273,532	2/1942	Lovell	128/2.05
2,346,098	4/1944	Williams et al.	128/2.06X
2,655,425	10/1953	Wood	128/2.06X
3,188,645	6/1965	Trumpy et al.	128/2.05X
3,221,334	11/1965	Jones, Jr.	128/2.06X
3,369,249	2/1968	Argy et al.	128/2.06X

Primary Examiner—William E. Kamm
Attorney—Irving Seidman

ABSTRACT: An electro- or phonocardiographic apparatus including a transducer adapted to convert the electric changes or sounds associated with the activity of the heart into corresponding graphic readings. A writing surface is provided and a stylus driven by a reversible servomotor is adapted to write on the surface. A first transistor switch connects the transducer with the motor so that the position or movement of the stylus is indicative of the heart activity as received by the transducer. A second transistor switch connects for restoring the stylus to a null position in the absence of a signal from the transducer.



Patented May 25, 1971 3,580,241

2 Sheets-Sheet 1

FIG. 1

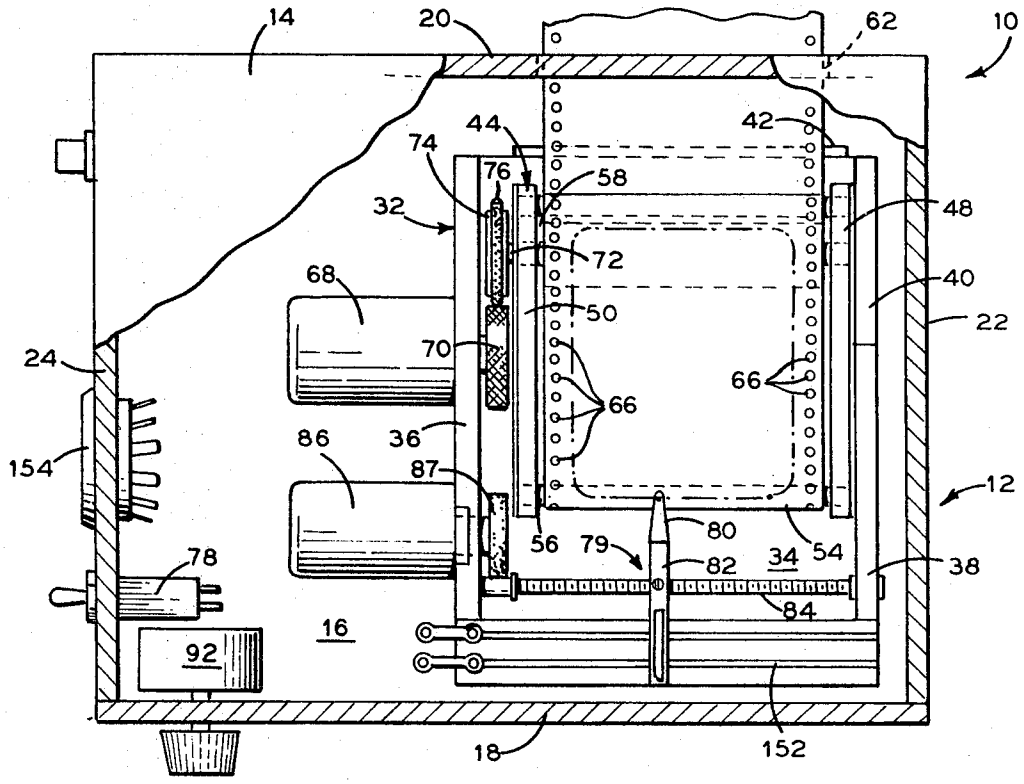
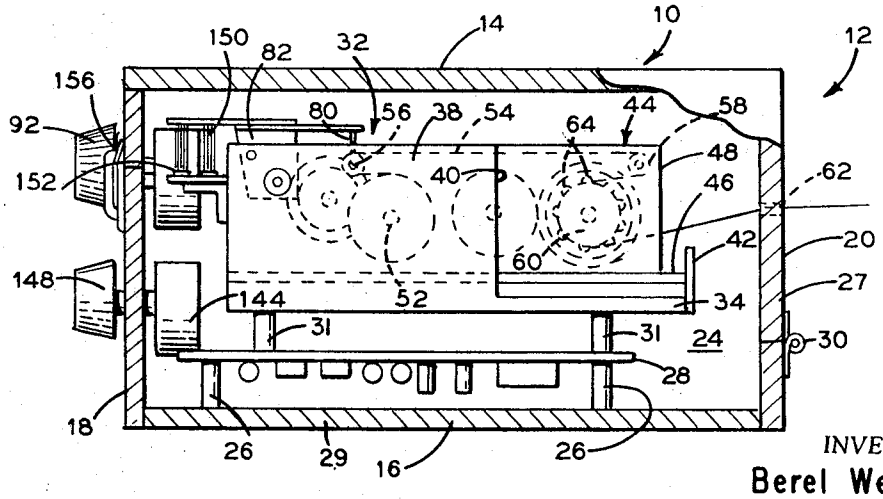


FIG. 2



INVENTOR.
Berel Weinstein
BY
Irving Feidman
ATTORNEY

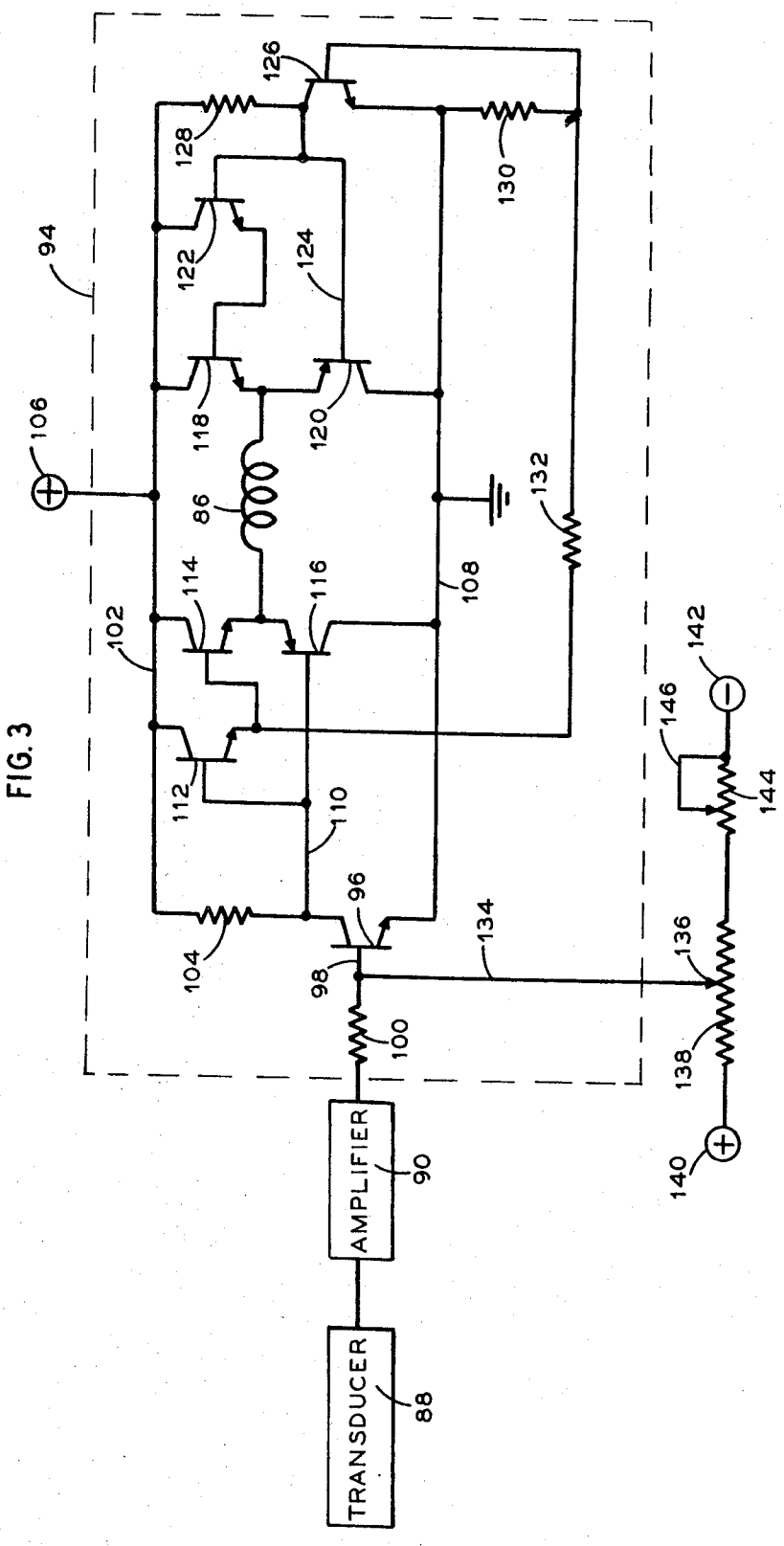

94
106
86
102
114
116
118
120
122
124
126
128
130
132
108
112
110
96
104
98
100
134
136
138
140
142
144
146
AMPLIFIER
90
TRANSDUCER
88

FIG. 3

CARDIOGRAPHIC APPARATUS WITH STYLUS CONTROL MEANS

This invention relates generally to cardiographic apparatus and the like and, more particularly, pertains to a compact and relatively inexpensive apparatus for visually displaying the operation of a heart.

Presently, when a doctor wishes to do an in depth study of a patient's heart action, he utilizes an electrocardiographic device which produces a graphic record of the operation of the heart. However, these devices are usually quite bulky and are not easily transportable. As a result, the patient is required either to go to the doctor's office (if the doctor is fortunate to have such a device in his office) or to a hospital so that he may avail himself of electro- or phonocardiographic analysis. In many instances, however, the patient may be too ill to get off the bed much less to travel outside the home. As a result, those people who can most benefit from such an analysis turn out to be those people who are least able to obtain such services.

Accordingly, an object of the present invention is to provide an improved cardiographic apparatus.

A more specific object of the invention is to provide a compact and easily carried cardiographic apparatus.

A further object and feature of the present invention resides in the novel details of construction which provide a cardiographic apparatus of the type described which is reliable in operation and produces a permanent record of the operation of a heart.

Accordingly, cardiographic apparatus constructed according to the present invention comprises a writing surface and a stylus operatively associated therewith for producing on the surface a written record of the electrical changes and/or sounds associated with cardiac activity. A transducer is provided for converting the electrical changes and/or sounds associated with cardiac activity into electrical signals representative of the heart action being measured. Motor means responsive to such signals is provided for moving the stylus in accordance with the amplitude of such signals. Circuit means interconnects the transducer with the motor means for supplying a bidirectional current to the motor means to effect movement of the motor means in opposite directions. The circuit means includes first conducting means operable to establish a current path through said motor means in a first direction, and second conducting means operable to establish a current path through said motor means in a second direction. Control means is connected between the first and second conducting means for controlling the operation of the second conducting means in response to the operation of the first conducting means.

Other features and advantages of the present invention will become more apparent from a consideration of the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a top plan view of a cardiographic apparatus constructed in accordance with the present invention with parts broken away in the interest of clarity;

FIG. 2 is a right side elevational view thereof with the sidewall removed for clarity; and

FIG. 3 is a schematic circuit wiring diagram of the device.

A cardiographic apparatus constructed according to the present invention is shown in FIG. 1 and is designated generally by the reference numeral **10**. The apparatus **10** includes an enclosed housing **12** having a top wall **14**, a bottom wall **16**, a front wall **18**, a rear wall **20** and opposed sidewalls **22** and **24**. The rear wall **20** includes an upper section **27** connected to a lower section **29** by spaced hinges **30**, one of which is shown in FIG. **2**. The upper section **27** is connected to the top wall **14** and it is adapted to pivot about the hinges **30** so that the top and a portion of the rear wall of the housing **12** may be opened to provide access to the interior of the housing **12**.

Connected to the bottom wall **16** of the housing **12** are spacers **26** which support an electric component printed circuit board **28**. The board **28** supports and connects together the electric circuit elements described below. However, it is to be noted that this is by way of illustration only and is not to be interpreted as being a limitation of the present invention since the electric components may be located elsewhere in the housing **12**. Spaced above the board **28** by spacers **31** is a record support designated generally by the reference numeral **32**.

More specifically, the record support **32** includes a bottom wall **34**, a left sidewall **36** (as taken in FIG. **1**), and a right sidewall **38**. The sidewall **38** terminates before the rear edge of the bottom wall **34** to define an opening **40**. Connected to the rear edge of the bottom wall **34** of the record support **32** is an upwardly extending flange **42** having a top portion which projects above the wall **34** to provide a lip for reasons which will become apparent hereinbelow.

Removably received on the record support **32** is a record carrier designated generally by the reference numeral **44**. The record carrier **44** includes a bottom platform **46** and upstanding sidewalls **48** and **50**. Removably and rotatably supported by the sidewalls **48** and **50** is a feed roll **52** which supports a roll of graph paper **54** which provides a writing surface in the manner noted below. Also rotatably supported by the sidewalls **48** and **50** are an idler roller **56**, an idler roller **58** and a capstan or drive roll **60**.

The record carrier **44** is positioned in the housing **12** with the bottom platform **46** in engagement with the bottom wall **34** of the record support **32**. The lip formed by the flange **42** engages the rear edge of the platform **46** to prevent any rearward movement of the carrier. Additionally, the walls **48** and **50** are in facing relationship with the respective walls **38** and **36**. The carrier **44** may be easily removed from the support **32** by tilting the carrier so that the rear edge of the platform **46** clears the flange **42** and sliding the carrier rearwardly. The opening **40** facilitates grasping the record carrier **32** to remove or replace the same. Moreover, it is to be noted that the feed roll **52** may be provided with a new roll of graph paper **54** when the carrier **44** is removed from the support **32**.

The roll or web **54** extends about idler rolls **56** and **58** and around and under drive roll **60** and through a slot **62** in the upper section **27** of the rear wall **20** of the housing. Movement of the web or roll **54** is effected by means of the drive roll **60** through circumferentially spaced radially extending members **64** which are positioned adjacent each end of the roll (only one end being shown in FIG. **2**). The members **64** are adapted to be received in perforations **66** which are spaced along the longitudinal edges of the web or roll **54** so that as the roll **60** rotates counterclockwise as taken in FIG. **2**, the web **54** is unrolled from the roll **52** and exits from the slot **62**.

Rotation of the roll **60** is effected by a web drive motor **68** which is mounted on the wall **36** of the record support **32**. The output shaft of the motor **68** extends through the wall **36** and fixedly receives a pulley **70**. Similarly, the drive roll or capstan **60** is provided with a shaft **72** which extends through the wall **50** and fixedly receives a pulley **74**. Received about the periphery of the pulley **74** is a ring **76** having a relatively high coefficient of friction as it is composed of rubber or the like.

The ring **76** is adapted to engage the pulley **70** when the record carrier **44** is operatively positioned on the record support **32** to provide a driving connection between the motor **68** and the drive roll **60**. Hence, when the motor **68** is energized, the drive roll **60** rotates to move the web or roll of graph paper past a writing station, as noted in detail below. The motor **68** may be energized from a source of power (not shown) which is connected in series with the motor and a single-pole single-throw switch **78** mounted on the wall **24** of the housing **12**. Accordingly, the switch **78** selectively controls the movement of the web **54**.

As noted above, the web or roll **54** is adapted to move past a writing station designated generally by the reference numeral **79**. More specifically, the station **79** includes a stylus **80** which is mounted on a block **82**. The block **82** is threaded, engaged with a threaded shaft **84** which is rotatably supported by the

sidewalls 36 and 38 of the record support 32. Thus, depending on the direction of rotation of the shaft 84, the stylus 80 will move toward the right or the left, as taken in FIG. 1.

Movement of the shaft 84 is controlled by a reversible servomotor 86 which is mounted on the sidewall 36 of record support 32. The motor 86 includes an output shaft which extends through the wall 36 and terminates in a drive pulley 87 composed of a substance having a relatively high coefficient of friction, such as rubber or the like. The pulley 87 is in driving engagement with the shaft 84.

The servomotor 86 is of the type which produces an output rotation of the pulley 87 in accordance with the amplitude and direction of the signal applied thereto. That is, the angle that the pulley 87 rotates through is proportional to the signal applied to the motor 86. Moreover, this rotational motion of the pulley 87 is translated to a linear movement of the stylus 80 via the motion of the threaded shaft 84. Thus, the movement of the stylus 80 on the web 54 is directly proportional to the signal applied to the motor 86.

The electrical portion of the present invention is illustrated in FIG. 3 and includes transducer 88 which is adapted to convert the sound or electrical activity of a heart into electrical signals which are representative of such input. The transducer 88 may comprise, as an alternative to plates measuring changes in electrical potential, a microphone which is placed upon the chest wall and produces electrical signals from the audible heart signals. In this case, the cardiographic apparatus operates as a phonocardiograph.

Connected to the transducer 88 is an amplifier 90 having a relatively high gain. In practice, the amplifier 90 has a variable gain which may be selectively adjusted by a gain control 92 mounted on the front wall 18 of the housing 12 (FIGS. 1 and 2). The output of the amplifier 90 is connected to a motor drive circuit which is designated generally by the reference numeral 94.

The circuit 94 includes an NPN transistor 96, the base electrode 98 of which is connected to the amplifier 90 through a resistor 100. The collector electrode of the transistor 96 is connected to a lead 102 through a resistor 104. The lead 102 is connected to a positive source of potential 106, the other terminal of which is grounded. The emitter electrode of the transistor 96 is connected to a ground lead 108.

A lead 110 also connects the collector of transistor 96 to the base electrode of an NPN transistor 112, the collector electrode of which is connected to lead 102 and the emitter electrode of which is connected to the base electrode of an NPN transistor 114. The collector electrode of the transistor 114 is connected to the lead 102 and the emitter electrode is connected to the emitter electrode of a PNP transistor 116. The collector electrode of the transistor 116 is connected to ground lead 108 and the base electrode thereof is connected with the lead 110. The transistors 112 and 114 form a so-called Darlington pair and, accordingly, may be thought of as a single element which is in series with the collector emitter path of the complementary conducting transistor 116. Connected between the transistors 114 and 116 is one terminal of the motor 86 which is illustrated schematically as a winding. The other terminal of the motor 86 is connected between an NPN transistor 118 and a PNP transistor 120. The transistors 96, 112 and 114, and 116 comprise a first switch means wherein, as noted below, transistor pair 112 and 114 conduct when transistors 96 and 116 are nonconducting and vice versa. More specifically, in said first switch means, transistor 96 is a first transistor, transistor pair 114 and 112 is considered a second transistor, and transistor 116 is a third transistor.

More particularly, the collector electrode of transistor 118 is connected to the lead 102 and the emitter electrode is connected to the emitter electrode of the transistor 120. The collector electrode of transistor 120 is connected with the ground lead 108. Connected to the base electrode of the transistor 118 is the emitter electrode of an NPN transistor 122, the collector electrode of which is connected to the lead 102. The base electrode of the transistor 122 is connected to a lead 124 having one end connected to the base electrode of the transistor 120 and the other end connected to the collector electrode of an NPN transistor 126. The collector electrode of the transistor 126 is connected to the lead 102 through a resistor 128 and the emitter electrode is connected to ground lead 108. The base electrode of the transistor 126 is connected to grounded lead 108 through a resistor 130 and to the emitter electrode of the transistor 112 through a resistor 132. The transistors 118 and 122 form a so-called Darlington pair which may be considered as a single element connected in series with the collector-emitter path of the complementary conducting transistor 120. The transistors 126, 118 and 122, and 120 comprise a second switch means wherein transistor 126 is a fourth transistor, transistor pair 118 and 122 is considered a fifth transistor, and transistor 120 is a sixth transistor.

Connected to the base electrode 98 of the transistor 96 by a lead 134 is the sliding arm 136 of a potentiometer 138. One end of the potentiometer 138 is connected to a source 140 of positive potential, the other terminal of which is grounded. The other end of the potentiometer 138 is connected to a source 142 of negative potential (the other terminal of which is grounded) through a potentiometer 144 which includes a sliding arm 146 that may be moved to vary the resistance of the potentiometer 146 to obtain an initial zero point in the manner described below. The potentiometer 144 is mounted on the front wall 18 of the housing 12 and the arm 146 is controlled by a rotatable shaft having a knob 148 thereon. The potentiometers 138 and 144 and the sources 140 and 142 comprise biasing means which biases the motor to a null position, as noted below.

The arm 136 of the potentiometer comprises a brush 150 connected to and movable with the insulating block 82. The brush 150 rides along a resistive strip 152 so that the potential between the base-emitter path of the transistor 96 due to the sources 140 and 142 changes as a function of the position of the stylus 80.

Initially, without any extraneous signals applied to the transistor 96, the potentiometer 144 is adjusted so that the motor 86 causes the stylus 80 to be in a zero position which, in the present application, corresponds to a position of the stylus 80 adjacent the left-hand edge of the web 54 as taken in FIG. 1. Accordingly, as the stylus 80 is moved toward the right, the arm 136 (brush 150) similarly moves to change the amplitude of the potential applied to the base 98 by the sources 140 and 142. The potentiometer 138 and the sources 140 and 142 are designed so that the signal applied to the base 98 is always one which will return the stylus 80 to its initial position.

In practice, the stylus 80 is a pen which carries its own ink supply. Accordingly, as the pen moves over the web 54 it draws a graph of the action of a heart. However, this writing device is only illustrative of the many types which may be utilized and the invention is not to be thought of as being limited thereto. Thus, the web 54 may be heat responsive and the stylus 80 may be a heater which would trace out a visible path as the stylus moved over the web.

The sources 106, 140 and 142 are adapted to be connected with the electrical components described above and mounted on the board 28 through a female connector 154 mounted on the sidewall 24 and a male connector (not shown).

The operation of the apparatus 10 which is described below assumes the transducer 88 is a microphone. However, as noted above, electrode plates may be provided in place of a microphone.

The record carrier 44 is inserted into the record support 32 with the ring 76 in contact with the pulley 70, as noted above. The end of the web 54 is threaded through the slot 62 and the top wall is pivoted about the hinges 30 to the closed position. A closure member 156 on the front wall 18 maintains the housing 12 closed. The transducer 88 is placed over the heart of the person whose heart action is to be analyzed and the sources are connected to the device. The knob 148 is rotated to obtain the initial zero position of the stylus 80, and the gain control potentiometer is set for the desired gain.

The switch **78** is closed to energize the motor **68**. Accordingly, the web or roll of graph paper **54** moves past the stylus **80** and out of the housing **12**, through the slot **62**, in the manner noted above.

As the heart operates, the sounds it makes are converted to signals which are amplified by the amplifier **90** and applied to the base **98** which causes transistor **96** to conduct. Hence, the potential at the collector of transistor **96** drops thereby causing a corresponding drop at the base of transistor **112** and **114** causing these transistors to stop conducting. The potential at the emitter electrode of the transistor **112** accordingly drops, causing a similar drop in the potential at the base of transistor **126**. Hence transistor **126** ceases to conduct and the potential at its collector rises, thereby driving transistors **118** and **122** into conduction. Since the base of transistor **120** is connected to the collector of transistor **126** by lead **124**, transistor **120** is biased to cutoff. Additionally, since the base of transistor **116** is connected to the collector of transistor **96** by lead **110**, it is driven into conduction by the lowered potential thereat.

Thus, current flows through the motor **86** in a first direction, from the source **106**, through the Darlington pair **118** and **122**, the motor **86**, and the transistor **116** to ground. Accordingly, the motor **86** rotates thereby causing the stylus **80** to scribe a line on the moving web **54**. As the stylus **80** moves, the arm **136** similarly moves to apply a potential to the base **98** in opposition to the potential applied by the transducer **88**. The movement of the stylus continues until the opposing potential is equal to or slightly greater than the potential caused by the heart action. At this point transistor **96** ceases to conduct. Hence, the maximum travel of the stylus across the web **54** is proportional to the amplitude of the signal produced by the heart.

When transistor **96** stops conducting, the potential at the collector rises. Hence, the Darlington pair **112** and **114** begin to conduct and transistor **116** stops conducting. The potential at the emitter electrode of transistor **112** likewise rises, causing a corresponding rise at the base electrode of transistor **126**, which begins to conduct thereby lowering the potential at the collector. Accordingly, the transistor **120** begins to conduct whereas the transistors **122** and **118** cease to conduct. Thus, current now flows through the motor **86** in the reverse direction from the source **106**, through transistors **112**, **114**, the motor **86**, and transistor **120** to ground. Hence, the motor **86** rotates in the reverse direction to cause the stylus to move in the reverse direction, via the shaft **84** and the block **80**, back to the zero position. As the stylus **80** and, therefore, the arm **136** of the potentiometer **138**, reach the zero position, the transistor **96** ceases to conduct to drive the stylus in the opposite direction. However, movement of the stylus in the original direction causes the transistor **96** to be biased to cutoff in the absence of signals produced by the action of the heart. Accordingly, the stylus **80** will hunt about the zero position according to conventional servomechanism techniques.

After the examiner has obtained a graphic record of the operation of the heart, he can remove the recorded portion from the remainder of the web **54** to obtain a permanent record of the heart action for analysis and the like.

Accordingly, a cardiographic apparatus has been described which is simple in operation, produces accurate results and is compact in size so that it easily may be carried by a physician.

While a preferred embodiment of the invention has been shown and described it is obvious that numerous omissions, changes and additions may be made in such embodiment without departing from the spirit and scope of the present invention. For example, more than one input may be provided which are adapted to be connected to different portions of the body and inputs in general. Accordingly, a different stylus and drive circuitry would be provided for each input so that each input causes a record to be made on the same graph.

What I claim is:

1. A cardiographic device including transducer means for converting the heart action into electric signals representative of such heart action; a stylus; record means operatively associated with said stylus for producing a record of the travel of said stylus across said record means; bidirectional motor means connected to said stylus for moving said stylus in first and second directions across said record means; and circuit means responsive to the amplitude of said electric signals for moving said motor means through a distance proportional to the amplitudes of said electric signals; said circuit means including first switch means connected to said transducer means and being operable from a first to a second state in response to said electric signals from said transducer means to provide for the flow of current through said motor means in a first direction corresponding to movement of the stylus in said first direction, and second switch means connected to said first switch means and being operable from a first to a second state in response to the movement of said first switch means to the first state to provide for the flow of current through said motor means in the opposite direction corresponding to movement of the stylus in said second direction.

2. A cardiographic device as in claim **1**, in which said motor means includes a threaded shaft, a motor drivingly connected with said shaft whereby said motor is adapted to rotate said shaft in opposite directions in accordance with the direction of current flow through said motor, said stylus includes means threadedly engaging said shaft whereby the rotational motion of said shaft is converted to a linear motion of said stylus.

3. A cardiographic device as in claim **1**, in which said record means includes a web of graph paper positioned adjacent said stylus, and selectively operable driving means for moving said web relative to said stylus.

4. A cardiographic device as in claim **1**, and biasing means connected to said circuit means for biasing said motor means to a null position corresponding to a preselected position of said stylus.

5. A cardiographic device as in claim **4**, in which said biasing means includes a potentiometer having an arm connected to said stylus and movable therewith, opposite polarity sources of energy connected to each end of said potentiometer, whereby movement of said stylus causes said potentiometer arm to move toward one of said sources of energy to cause movement of said first switch means to said second state.

6. A cardiographic device including transducer means for converting the heart action into electric signals representative of such heart action; a stylus; record means operatively associated with said stylus for producing a record of the travel of said stylus across said record means; bidirectional motor means connected to said stylus for moving said stylus in first and second directions across said record means; and circuit means responsive to the amplitude of said electric signals for moving said motor means through a distance proportional to the amplitudes of said electric signals; said circuit means including first switch means operable from a first to a second state in response to said electric signals to provide for the flow of current through said motor means in a first direction corresponding to movement of the stylus in said first direction, and second switch means operable from a first to a second state in response to the movement of said first switch means to the first state to provide for the flow of current through said motor means in the opposite direction corresponding to movement of the stylus in said second direction, said first switch means including a first normally nonconducting, a second normally conducting and a third normally nonconducting transistor having an opposite conductivity from said first and second transistors; said second and third transistors being connected in series and to said first transistor whereby said second transistor is nonconducting and said third transistor conducts when said first transistor is conducting; said second switch means including a fourth normally conducting, a fifth normally nonconducting and a sixth normally conducting transistor, said sixth transistor having said opposite conductivity; said fifth and sixth transistors being connected in series and to said fourth transistor whereby said fifth transistor is conducting and said sixth transistor is nonconducting when said fourth transistor is nonconducting; lead means connect-

ing said second and fourth transistors and said fourth transistor being responsive to said second transistor whereby said fourth transistor is rendered conductive when said second transistor conducts, and said motor being connected between the second and third transistors at one end and the fifth and sixth transistors at the other end.

7. A cardiographic apparatus as in claim 6, and biasing means for normally biasing said first transistor so that it hunts about the conduction-nonconduction point.