United States Patent [19]

Hurwitz

[11] **3,771,515**

[45] **Nov. 13, 1973**

[54] **AUTOMATIC RECORDING SPHYGMOMANOMETER**

[76] Inventor: **Mathew Hurwitz,** 63 Oakland Ave., Auburndale, Mass. 02166

[22] Filed: **Sept. 2, 1971**

[21] Appl. No.: **177,405**

[52] **U.S. Cl.... 128/2.05 G,** 128/2.05 M, 128/2.05 Q

[51] **Int. Cl.** **A61b 5/02**

[58] **Field of Search** ..... 128/2.05 G, 2.05 A, 128/2.05 M, 2.05 Q, 2.05 P

[56] **References Cited**

UNITED STATES PATENTS

3,349,763	10/1967	Clements, Jr. et al.	128/2.05 M
2,980,107	4/1961	Hurley et al.	128/2.05 Q
3,444,856	5/1969	Settler et al.	128/2.05 M
3,651,798	3/1972	Egli et al.	128/205 S
3,117,570	1/1964	Halasz et al.	128/2.95 M
3,557,779	1/1971	Weinstein	128/2.05 Q
3,146,777	9/1964	Lee	128/2.05 A
3,623,478	11/1971	Saba	128/2.05 Q

Primary Examiner—Kyle L. Howell
Attorney—Nathan N. Kraus et al.

[57] **ABSTRACT**

An automatic blood pressure recording apparatus which eliminates or minimizes substantially all known sources of human error in sphygmomanometry. A unidirectional micorphone maximally sensitive to Korotkoff sounds is contained within the cuff donned by the subject. Analog signals from the microphone are amplified, and digitalized by an electronic circuit whose digital output pulses occur in synchronism with the Korotkoff sounds. Each output pulse actuates a printing stylus which produces a mark on a stationary record chart resulting in a series of marks. The stylus position is controlled by cuff pressure. Thus, the positions of the first and last marks indicate systolic and diastolic pressures.

10 Claims, 13 Drawing Figures

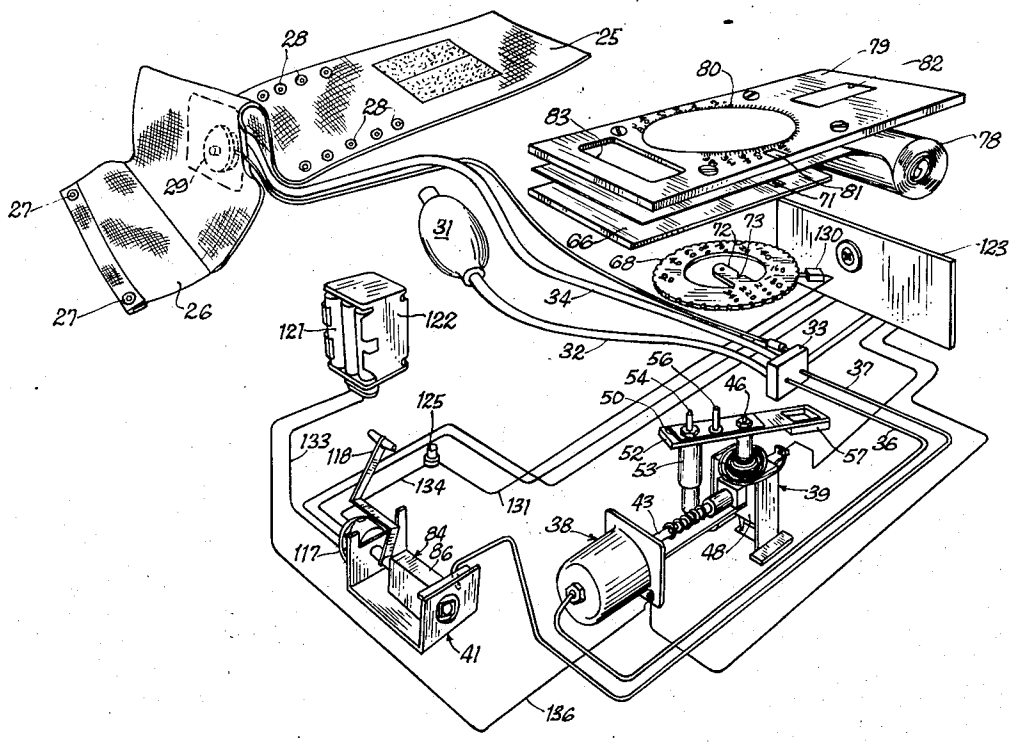


FIG. 1

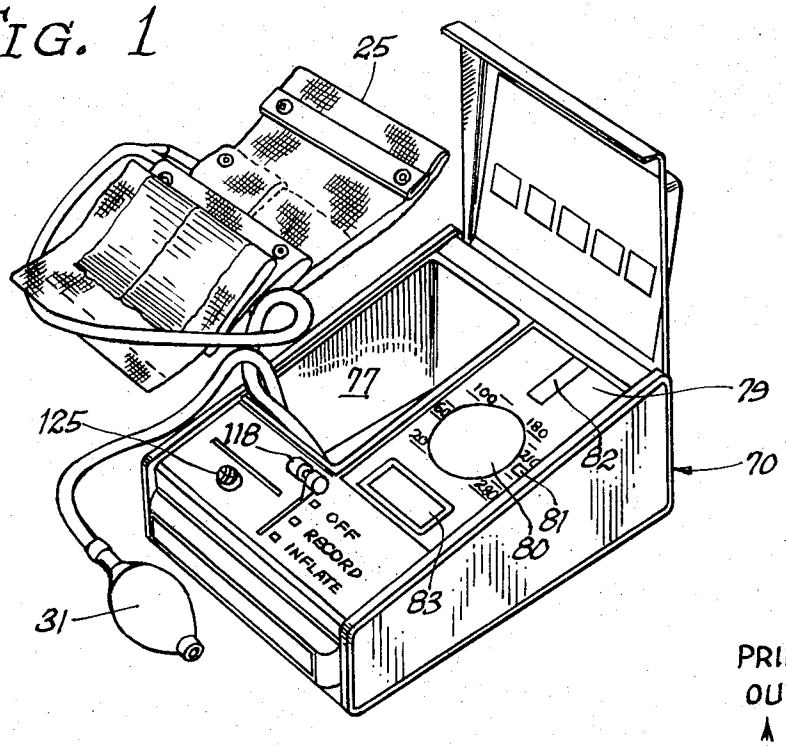
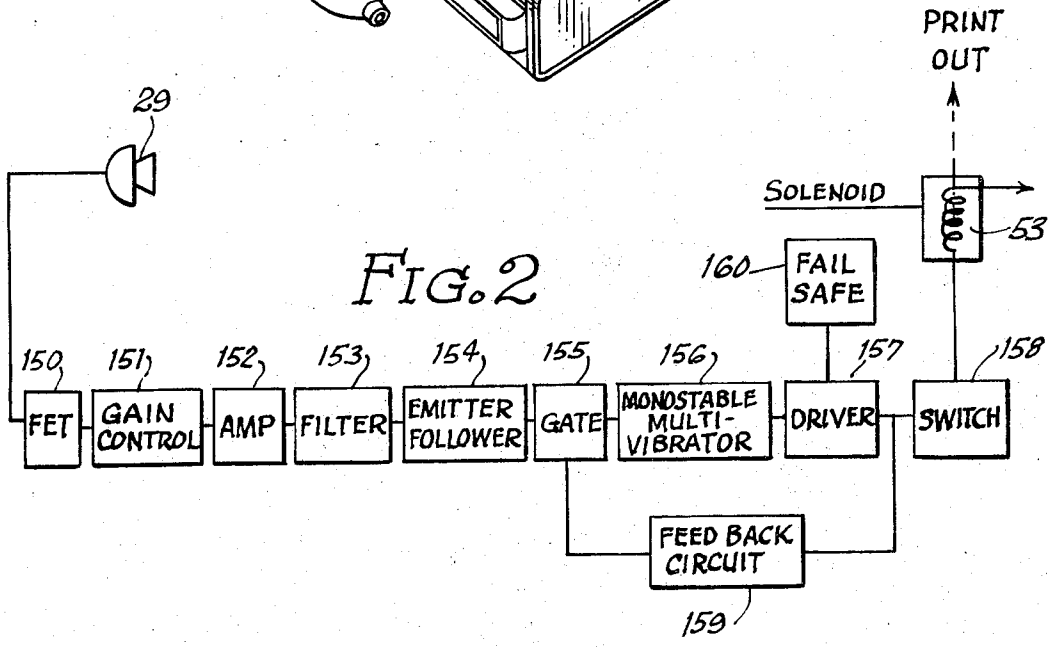

25
77
79
125
118
82
70
OFF
RECORD
INFLATE
81
80
83
31

FIG. 2


PRINT OUT
29
SOLENOID
53
160
FAIL SAFE
150
151
152
153
154
155
156
157
158
FET
GAIN CONTROL
AMP
FILTER
EMITTER FOLLOWER
GATE
MONOSTABLE MULTI-VIBRATOR
DRIVER
SWITCH
FEED BACK CIRCUIT
159

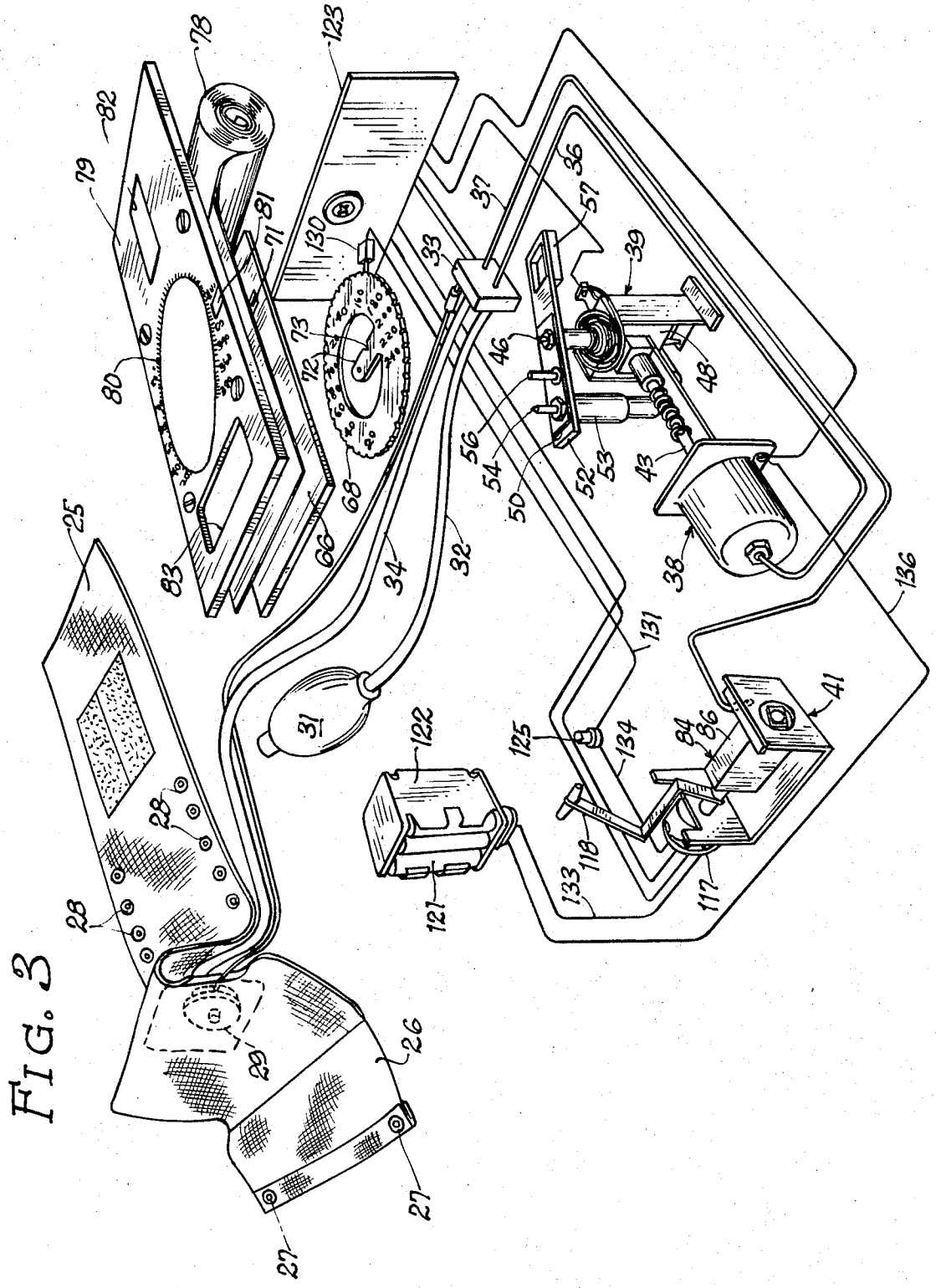

78
123
82
79
81
71
130
33
37
36
57
39
73
72
46
48
80
56
54
50
52
53
43
68
66
34
32
38
136
131
83
25
31
122
125
134
84
86
41
28
28
118
133
117
121
29
26
27
27

FIG. 3

FIG. 4

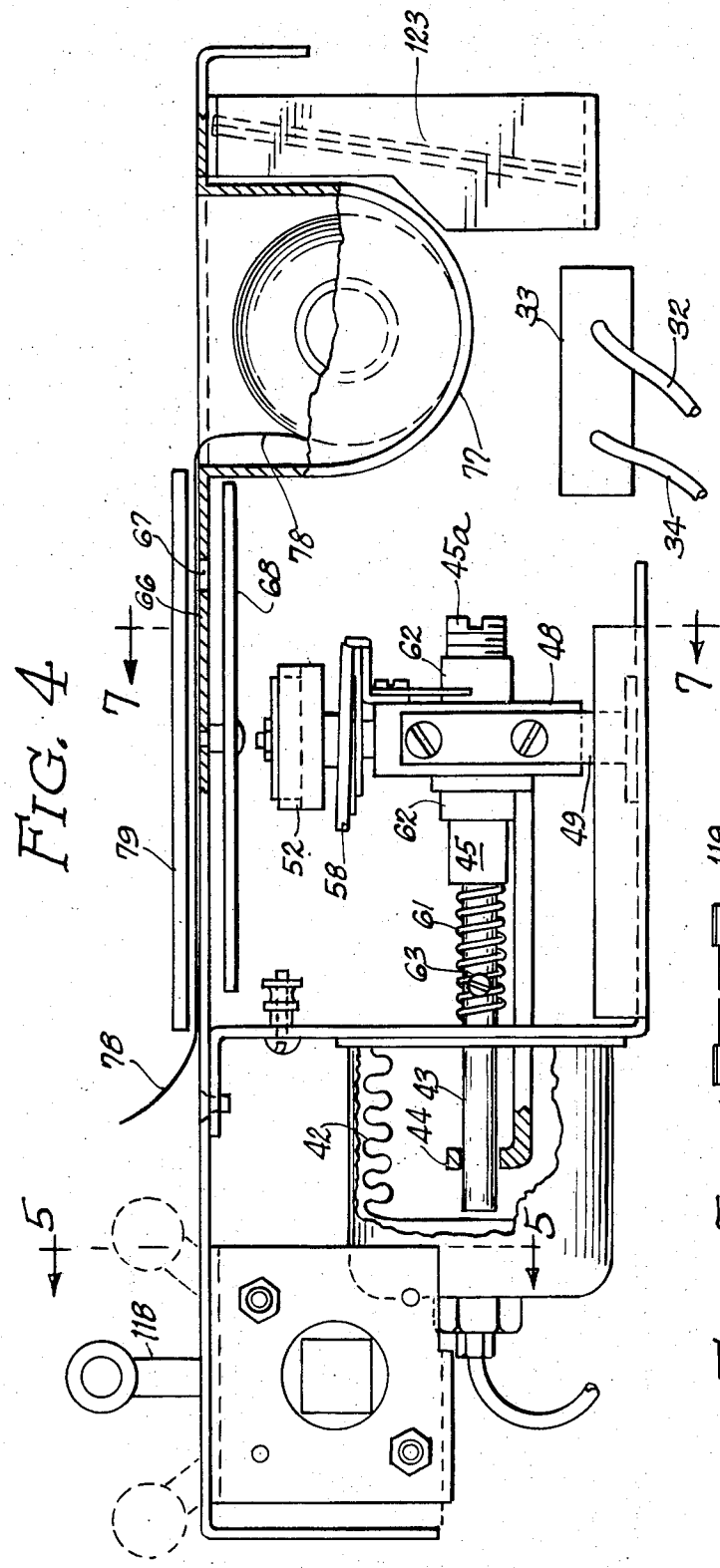


FIG. 6

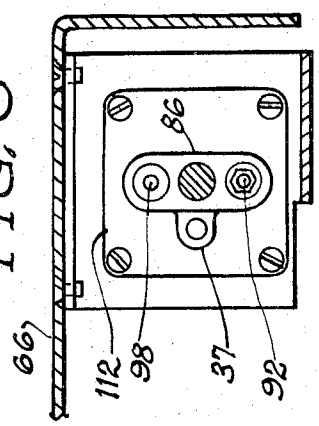


FIG. 5

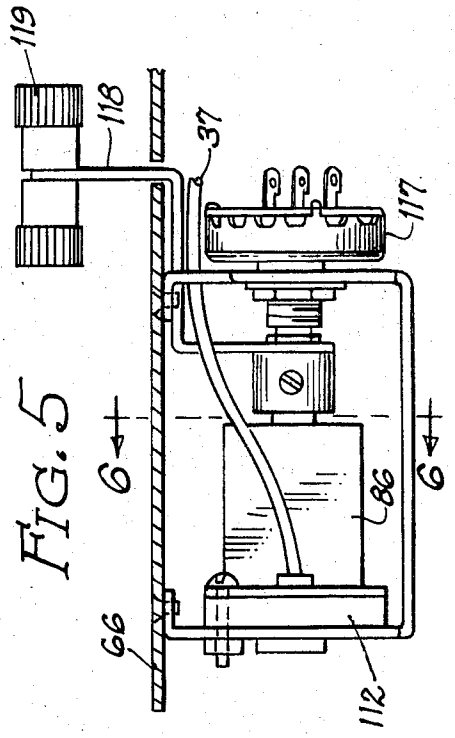


FIG. 7

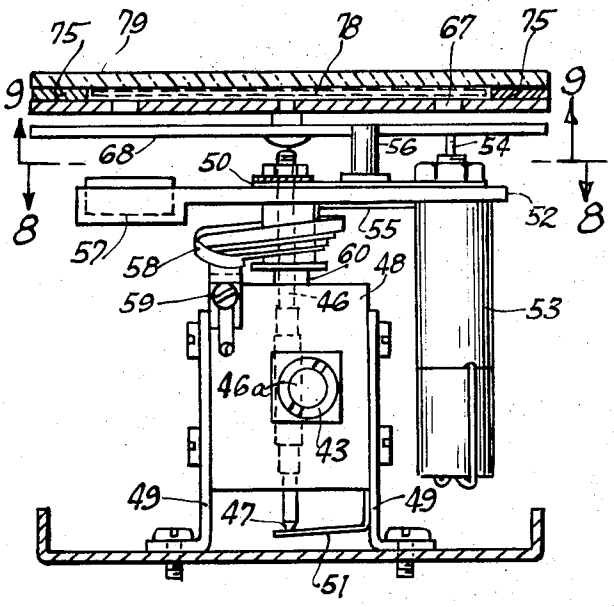


FIG. 8

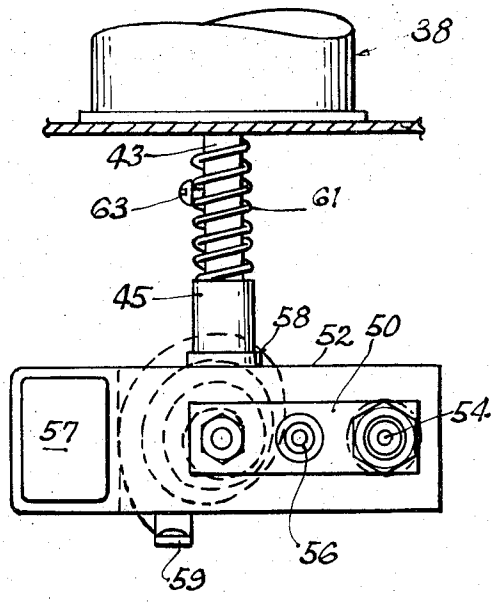
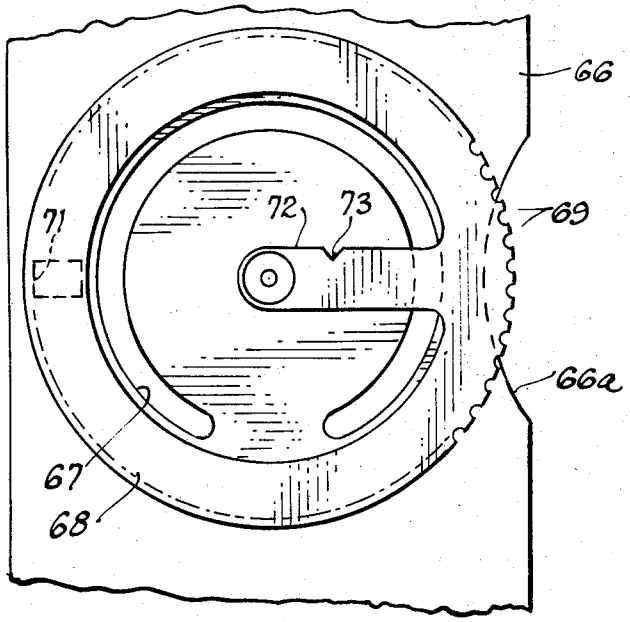


FIG. 9



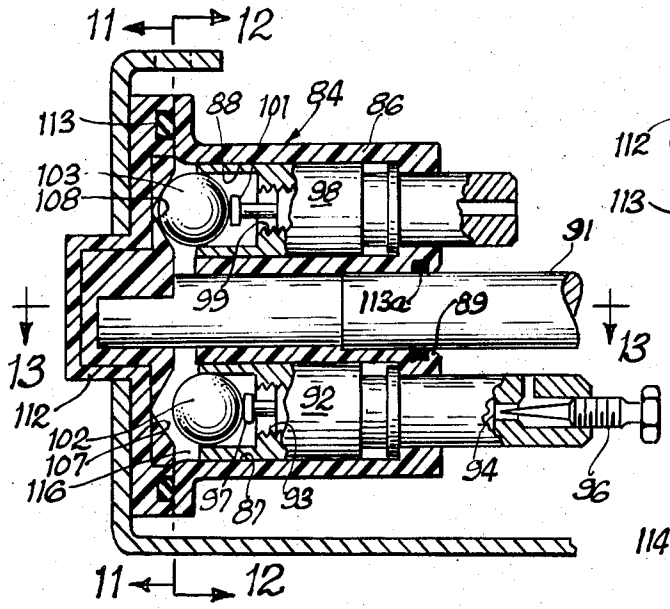


FIG. 10

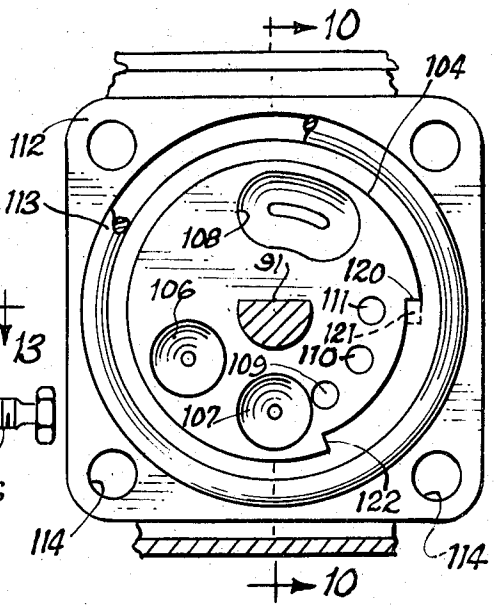


FIG. 11

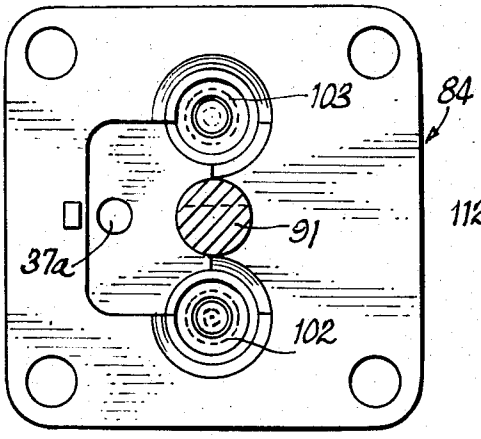


FIG. 12

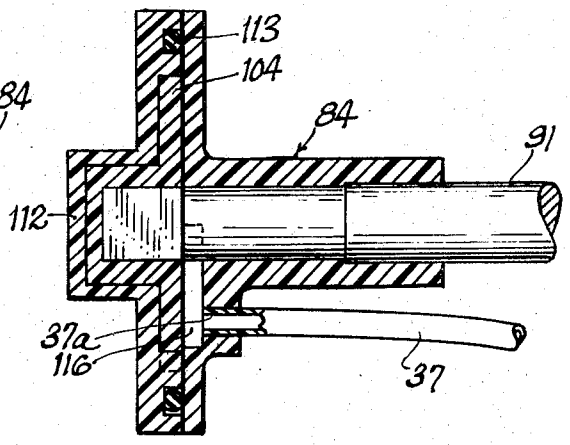


FIG. 13

AUTOMATIC RECORDING SPHYGMOMANOMETER

BACKGROUND OF THE INVENTION

This invention relates to an indirect, automatic, blood pressure recording apparatus which is accurate, simple to use, low in cost, and which eliminates or greatly reduces substantially all of the known sources of sphygmomanometer error due to operator technique and observer skill, acuity, and bias. It is based upon the universally accepted Riva-Rocci/Korotkoff technique familiar to all practitioners skilled in the art.

The Riva-Rocci/Korotkoff technique for the indirect measurement of blood pressure, as standardized by the American Heart Association, is practiced with an instrument known as the sphygmomanometer.

This instrument consists of an inflatable rubber bladder within a non-stretchable fabric cuff, an inflating bulb with a venting valve, a pressure meter (either a mercury column or aneroid gauge) to register the pressure within the rubber bladder, and a stethescope with which the operator listens to characteristic sounds which come from the artery during the course of the measurement. The sounds are known as Korotkoff sounds, named for the Russian scientist who discovered them in 1905. The method of listening for Korotkoff sounds is universally accepted as providing an accurate indication of the systolic and diastolic blood pressure for most people.

The technique for indirect measurement of blood pressure by the conventional sphygmomanometer requires an operator having good hearing and a fair measure of skill. A properly fitted cuff is wrapped snugly about the upper arm of the subject in such a manner that the bladder is centered over the brachial artery and the edge of the cuff is disposed about one inch above the anticubital space. The operator then inflates the cuff rapidly until the pressure in the cuff is sufficient to compress the arm and stop the flow of blood. The artery is now said to be occluded. The operator next places the stethescope at the anticubital space over the brachial artery just below the cuff. Initially, of course, no sounds are to be heard because the artery is occluded and no blood is flowing through the artery. The operator then opens the venting valve and adjusts it so that the pressure in the cuff falls gradually, at a rate of 2 to 3 mmHg per second. When the pressure within the cuff reaches the systolic pressure blood begins to flow through the artery and the operator hears a "tapping" sound (Phase 1 Korotkoff sound) through his stethescope. Simultaneously, he observes the reading on the pressure gauge. This pressure is the systolic blood pressure. As the pressure continues to fall, the operator will hear sounds diminish in intensity (Phase 2 Korotkoff sound) then the sounds become crisper and louder (Phase 3 Korotkoff sound), subsequently the sounds become muffled, as if an obstruction had been placed in the stethescope (Phase 4 Korotkoff sound), and finally the sounds disappear (Phase 5 Korotkoff). There is some controversy as to whether Phase 4 or 5 indicates diastolic pressure; some practitioners use Phase 4 and others use Phase 5. It is generally agreed, however, that the differences are not highly critical and good results can be obtained using either phase providing care is exercised in all other aspects of the measurement. Having noted the diastolic pressure, by whichever criterion he prefers, the operator vents the remaining pressure and may either remove the cuff or, after allowing the subject to rest for a reasonable period, usually 21/2–3minutes, he may repeat the measurements. It is well known that the accurate measurement of blood pressure, according to conventional indirect methods, demands good hearing, skill, and painstaking attention to such details as the snugness and proper fit of the cuff, the control of the vent valve, the recognition of the sometimes subtle changes in the Korotkoff sounds, and an ability to read a moving pressure gauge.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide an improved apparatus for the accurate determination of blood pressure by which the systolic and diastolic pressures are automatically sensed and recorded with a high degree of precision.

Another object of this invention is the provision of an automatic recording apparatus for the accurate determination of blood pressure which is simple to use and requires no special skill or acuity, even to the extent that a patient may measure his own blood pressure with the same accuracy as that achieved by a skilled practitioner using the same apparatus.

Still another object of this invention is the provision of an apparatus of the foregoing type which may be economically manufactured.

A further object of this invention is the provision of an apparatus which functions according to well known accepted principles and procedures, so that it should readily gain wide acceptance among physicians and other practitioners skilled in the art.

In accordance with my invention, auscultation is carried out electronically by means of a specially designed contact type microphone which is located within a pocket in the cuff. The microphone is connected to an electronic circuit which amplifies the analog signal from the microphone and interprets the signal to determine whether the sounds being detected by the microphone are of sufficient intensity to be characterized as being within the range of systolic pressure (Phase 1 Korotkoff) and diastolic pressure (Phase 4 or 5 Korotkoff). The circuit then digitalizes those amplified microphone signals which satisfy the amplitude criteria and produces digital output pulses (actually square waves) whose amplitude (voltage) and duration are constant, independent of the strength of the analog signals which gave rise to them. These pulses occur in synchronism with the heartbeats of the patient or subject under measurement, beginning with the first of the Phase 1 Korotkoff sound and terminating with the last of the Phase 4 or 5 Korotkoff sounds. The recorder includes a movable printing stylus, whose position is determined by direct pneumatico-mechanical means controlled by the pressure within the cuff. Output pulses from the electronic auscultation means are used to activate the stylus or printing means and the position of the printing means at any point during a measurement cycle is governed by the cuff pressure which is caused to slowly decrease under the control of a fixed orifice valve, at a rate of 2 to 3 mmHg/second, according to accepted practice.

A stationary record chart is positioned to cooperate with the moving stylus to produce a record which consists of a series, or train, of marks. The position of the first mark in the series denotes the pressure at which

the incipience of Phase 1 Korotkoff sounds was detected. This is the systolic blood pressure. The position of the last mark in the series denotes the pressure at which the last of the Phase 4 or 5 Korotkoff sounds was detected. This is the diastolic blood pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an apparatus, in accordance with my invention.

FIG. 2 is a block diagram illustrating the circuit logic of my invention.

FIG. 3 is a more or less exploded view illustrating the components of my invention in connected relationship.

FIG. 4 is a side elevational view showing the working components of the apparatus illustrated in FIGS. 1 and 3 mounted on a chassis.

FIG. 5 is a cross-sectional view taken substantially on line 5—5 of FIG. 4.

FIG. 6 is a cross-sectional view taken substantially on line 6—6 of FIG. 5.

FIG. 7 is a cross-sectional view taken substantially on line 7—7 of FIG. 4.

FIG. 8 is a top plan view taken substantially on line 8—8 of FIG. 7.

FIG. 9 is a bottom plan view taken substantially on line 9—9 of FIG. 7.

FIG. 10 is a cross-sectional view, on an enlarged scale, of the valve assembly taken substantially on line 10—10 of FIG. 11.

FIG. 11 is a cross-sectional view taken substantially on line 11—11 of FIG. 10.

FIG. 12 is a cross-sectional view taken substantially on line 12—12 of FIG. 10; and

FIG. 13 is a cross-sectional view taken substantially on line 13—13 of FIG. 10.

BRIEF DESCRIPTION OF A PREFERRED EMBODIMENT

The apparatus of my invention includes an inflatable compression fabric band or cuff 25 which is adapted to be wrapped or applied about a limb having an artery for the testing of blood pressure. The cuff 25 is shown and described in greater detail in my co-pending U.S. Pat. application, Ser. No. 26,283, filed Apr. 7, 1970 now U.S. Pat. No. 3,669,096, issued June 13, 1972, and briefly, comprises an elastic panel 26 attached to one end of the body portion of the cuff and provided with a pair of snap fasteners 27 which cooperate with a series of cooperating fasteners 28 disposed along the edges of the body portion, medially thereof. The cuff is intended to be formed into a closed loop, closely approximating the size of the limb, prior to being pulled thereon and is securely in proper alignment by wrapping the body portion about the loop in the usual manner. The cuff includes a pocket to receive a contact microphone 29 so disposed that its contact surface may be located over the brachial artery, in the case of an arm, when the cuff is applied thereto. The microphone is connected to an electrical circuit, hereinafter to be described. However, briefly, the circuit includes an amplifier and a gate which has a threshold so adjusted that the circuit produces output pulses only when it receives signals resulting from Korotkoff sounds of sufficient intensity to be classified within the range of Phase 1 and Phase 4 or 5 Korotkoff.

The cuff 25 is inflated by an inflation bulb 31 connected by a flexible conduit 32 to a manifold 33. The cuff is connected to one side of said manifold by a flexible conduit 34 and to the opposite side of said manifold are connected two flexible conduits 36 and 37, conduit 36 leading to a bellows assembly 38 constituting part of a recording mechanism, indicated generally by the numeral 39 and hereinafter to be more fully described. The conduit 37 is connected to a valve switch assembly, indicated generally by the numeral 41 and hereinafter to be more fully described. The valve of the assembly 41 affords means for the controlled venting of air pressure from within the cuff 25.

The recorder mechanism (FIG. 3), indicated generally by the numeral 39, comprises a low cost hydroformed metal bellows 42, (FIG. 4) the head of which is arranged to engage against one end of a shaft 43 supported for axial movement in an arm 44 and a nylon sleeve 45 positioned axially by a threaded adjustable jam nut 45a having a slotted end. The round shaft 43 has machined on it an intermediate gear rack portion, (shown end-on in FIG. 7), which meshes with a pinion 46*a*, machined onto the vertical shaft 46 (FIG. 7). The shaft is journaled for rotation in an insulating block 48 having integral hollow threaded bosses 62, 62 in which the sleeve 45 and nut 45*a* are received, the block being supported on a pair of bracket members 49. The lower end of the shaft 46 is machined to a conical shape 47 (FIG. 7) which is engaged by a resilient electrical contact arm 51 secured to one of the brackets 49. A rotor arm 52 formed of insulating material is mounted on the upper end of shaft 46 and is secured thereto for rotation therewith. Supported at one end of the rotor arm 52 is a push type solenoid 53 having a plunger, the upper end of which is typically machined to a frusto-conical or spherical point to enable it to make visible impressions on a stationary pressure-sensitive record tape, as will be hereinafter explained. It will, of course, be understood that other suitable stylus means and record media may be employed in place of the solenoid arrangement hereinabove described. For example, an electro-magnetically actuated ink pen may conveniently be used for recording on a paper tape of the type used in conventional adding machines or a blinking light may be used to record on photosensitive record paper. The opposite end of the rotor arm 52 is provided with a shallow depression to receive a counter-weight 57. The rotor arm 52 carries an upstanding stop pin 56 which constitutes an abutment member for engaging an adjustable dial/stop, hereinafter to be described. A metal strap 50 lying on the top surface of rotor arm 52 is in contact with one terminal of solenoid 53 and pin 56 and provides a ground conductor through shaft 46. The other terminal of solenoid 53 is connected through a section of conductive tape 55 attached to the underside of rotor arm 52, to a conductor in the form of a hair spring 58, the inner end of which is attached to an insulating sleeve 60 circumposed about shaft 46. The hair spring thus serves both as an electrical conductor and as an anti-backlash spring for the rack and pinion. The outer end of spring 58 is connected to a lug 59 mounted on block 48. A compression spring 61 is circumposed about shaft 43 and one end of the spring abuts sleeve 45 which is supported in threaded hollow bosses 62 integral with block 48. The sleeve 45 is axially adjustable by means of a screw driver inserted in the slot of jam nut 45*a*. The shaft 43 is drilled laterally and threaded to receive a screw 63, the head of which is arranged to engage two adjacent

coils of the spring **61** thereby to fix the spring in a position of adjustment. It will be apparent that the spring rate of spring **61** may be adjusted for purposes of calibration by increasing or decreasing the number of active coils between the end of sleeve **45** and screw **63.** The spring **61** serves to urge the shaft **43** to the left, as viewed in FIG. **4,** to maintain the left hand of the shaft **43** in engagement with the head of the bellows **42.** Thus the spring **61** normally urges the rotor arm **52** in a counter-clockwise direction, as viewed in FIG. **3,** to assume a normal non-operative position.

The housing of the apparatus is shaped substantially as illustrated in FIG. **1** and includes a top panel **66** (best seen in FIGS. **3, 7,** and **9**) having an arcuately formed opening **67** concentric with the axis of shaft **46.** As shown in FIG. **7** the opening **67** is in registration with the path of travel of the plunger **54** as it revolves about the axis of shaft **46.** It will be understood that when the solenoid **53** is energized the point of plunger **54** will pass through the arcuate slot **67** and impinge on a tape **78** lying on the surface of the panel **66.**

A dial/stop **68,** shaped substantially as illustrated in FIGS. **3** and **9,** is mounted for rotation below the panel **66** coaxially with shaft **46.** The dial/stop is provided on its periphery with a series of uniformly spaced notches **69** and carries a series of numerals or indicia on its upper face which are visible through a window opening **71** provided in the panel **66.** The dial/stop **68** is supported by an integral arm **72** which is notched along one edge, as at **73,** to engage the stop pin **56,** as will be hereinafter explained.

A portion of panel **66** is cut away, as at **66a** (FIG. **9**) to expose an edge portion of dial/stop **68** so that it may be rotated, as with a finger, to position the arm **72** in a desired angular disposition to provide a stop for pin **56.** It will be understood that the indicia on the dial/stop **68** is related to the position of arm **72** so that a particular indicium visible through the window **71** will indicate a particular cuff inflation pressure value.

A spring biased metal detent **130** (FIG. **3**) supported in an insulated case suitably mounted in the housing **70** is arranged to contact the periphery of dial/stop **68** and to engage one of the notches **69** to releasably retain the dial/stop **68** in a position of adjustment. The detent element is electrically connected to signal lamp **125** by conductor **131.**

Referring to FIG. **4,** the housing **70** includes a well **77** to receive a supply roll of a suitable pressure-sensitive record paper **78** on which the measurements are recorded. The record paper is adapted to be manually drawn over the panel **66** between edge guides **75** (FIG. **7**). A transparent plate **79** bearing dial indicia in units of pressure is superposed over the panel **66** resting on the guides **75** so as to accommodate the record paper **78** in the space therebetween. The plate **79** has a circular transparent window **80** (FIGS. **1** and **3**) superposed over the arcuate slot **67.** In addition, plate **79** is provided with a transparent window **81** in registration with the opening **71** (FIG. **3**) and also includes an additional window **82** in registration with the well **77** so as to afford to the operator a view of the record paper supply roll **78.** In addition, an aperture **83** exposes a portion of the record paper **78** so that pertinent information concerning a particular blood pressure measurement may be written on to the tape by the operator, as with a pen or pencil.

The housing **70** includes a well **77** for storing the cuff **25** when not in service. A signal lamp **125** is mounted on panel **66** for indicating when the cuff has been inflated to a pressure pre-set by dial **68.**

The valve and switch assembly, indicated generally by the numeral **41,** is shown more particularly in FIGS. **5, 6** and **10** through **13** inclusive.

The valve, indicated generally by the numeral **84,** includes a body **86,** shaped substantially as shown, and having two cylindrical bores **87** and **88** respectively, and an intermediate bore **89** in which is journaled an operating shaft **91.** An opening **37*a*** is provided in the flange of the body **86** to receive one end of conduit **37.** Received in the bore **87** is a valve element **92** having a longitudinally extending passage **93** communicating with a vent aperture **94** controlled by a needle valve **96.** The passage **93** is threaded for a portion of its length to accommodate a conventional tire valve core **97.** Received in the bore **88** is a valve element **98** which includes a threaded longitudinally extending passage **99** in which is received a conventional tire valve core **101.** The passage **99** extends through the element **98** and vents directly to the atmosphere. Each of the valve elements **92** and **98** has an enlarged chamber in which are received the balls **102** and **103,** respectively. The valve **84** includes a rotor element **104** which is keyed to shaft **91** for rotation therewith. The rotor element includes two circular recesses **106** and **107** respectively, and an arcuately shaped recess **108.** Additionally, the rotor element is provided with three apertures **109, 110** and **111** which insure a free flow of air from opening **37*a*** to valve chamber **116** within the valve body. It will be noted that the centers of each of the recesses and apertures are located on a circle, the center of which coincides with the axis of shaft **91.** A cover member **112** shaped to receive the rotor element **104** and having an annular groove to accommodate a sealing O-ring **113** is secured to the valve body **84,** as with screws **114.** O-ring **113*a*** effects a seal between shaft **91** and bore **89.**

The opposite end of shaft **91** is connected to a rotary switch **117** which is in circuit with the electrical components, hereinafter to be described. An actuating lever **118** fixed to the shaft **91** extends through a slot in the panel **66** and terminates in a knob **119** which may be readily engaged by the operator. It is noted that the valve **86** and switch **117** are connected for synchronous operation, as will be hereinafter explained.

Power to operate the apparatus is derived from a plurality of dry cell batteries **121** (9 volts) contained in a suitable housing **122.**

A circuit board **123,** preferably positioned at the rear of the housing of the apparatus, carries substantially all of the electrical components shown in the block diagram illustrated in FIG. **2.** Said components and their functions are well known in the art and will be described hereinafter, briefly, in relation to their functions in the operation of the apparatus of my invention.

OPERATION

The cuff is applied to the subject's limb and the operator moves the control lever **118** to its initial position corresponding to inflate position, as indicated by a legend on panel **66.** Prior to inflating the cuff **25,** the operator rotates the dial/stop **68** to a point where the indicia visible through the openings **71** and **81** should indicate a pressure approximately 30 mmHg higher than the anticipated systolic pressure. It will be understood that

the arm **72** of dial/stop **68** thereby has been rotated to a specific angular position related to the pressure indicated.

In inflate position, the valve rotor element **104** is disposed in the position illustrated in FIG. **11**, with shoulder **120** abutting stop **121** of the body **86**. Ball **103** is disposed in recess **108** and ball **102** is disposed in recess **107**. Neither of the valve cores **97** or **101** now is engaged by a respective ball hence, both valves are closed to venting of any air. Air may pass freely from bulb **31**, through manifold **33**, to cuff **25**, valve **86** and bellows **42**.

As cuff **25** is inflated, air pressure entering bellows **42** effects rotation of shaft **46** and rotor arm **52** to the point where pin **56** engages in notch **73** thereby closing an electrical circuit to energize signal lamp **125** which indicates to the operator that the pressure in the cuff is high enough to occlude the artery and that he may now begin the recording cycle. The lamp **125** is energized by current which flows from batteries **121** through conductor **133**, switch **117**, conductor **134**, lamp **125**, conductor **131**, detent **130**, dial **68**, arm **72**, pin **56**, strap **50**, shaft **46**, arm **51** to a ground connected by conductor **136** to the other battery terminal.

The operator now moves the lever **118** to record position which conditions the switch **117** to extinguish the signal lamp **125** and simultaneously to switch the circuit output to solenoid **53**. Correspondingly, the ball **102** is now caused to be cammed out of the conical recess **107** and to rest on the surface intermediate the recesses **106** and **107**, thereby engaging valve core **97** and venting the system through vent aperture **94**. The rate of fall of cuff pressure is not constant but is roughly proportional to cuff pressure. Nevertheless, it is possible to adjust the needle **96** so that the cuff pressure falls at a rate between 1.5 to 3.5 mmHg/sec over that portion of the pressure range (170 to 70 mmHg) where most adult blood pressures lie. This rate deviates by an acceptable margin from the vent rate range of 2–3 mmHg recommended by the American Heart Association. Ball **103** remains in recess **108** out of engagement with valve core **101** which remains closed.

As the pressure in the cuff diminishes a point is reached wherein Korotkoff sounds are detected by the microphone. The microphone transduces these sounds to voltage waves which are fed into the circuit which amplifies the analog signal from the microphone and interprets the signal to determine whether the sounds being detected by the microphone are of sufficient intensity to be classified in the range of systolic and diastolic pressures. When the first Phase I Korotkoff sound is detected which satisfies the amplitude criterion of the circuit, the circuit produces a digital output pulse, preferably a square wave, which causes the solenoid **53** to be energized thereby activating the plunger **54** to produce a dot on the pressure sensitive record paper **78**. These output pulses whose amplitude and duration are constant occur in synchronism with the heart beats of the subject, one dot for each heart beat, until Phase IV or V Korotkoff is reached, at which point the amplified microphone signal is no longer of sufficient amplitude to trigger the gate and thus to produce the pulse required to energize the solenoid **53**. As a result, the signals to the solenoid **53** cease and the solenoid can no longer print dots on the record paper **78**. It will be understood that the position of the solenoid **53** at each instant during a measurement cycle is governed by cuff pressure so that the angular position of the rotor member **52** and solenoid **53** will vary in accordance with such pressure. Thus, the record produced on the tape **78** comprises a series of dots arranged in an arc, with the position of the first dot in the series denoting the pressure at which the Phase I Korotkoff sound was detected, (systolic blood pressure) and the position of the last dot in the series denoting the pressure at which the last of the Phase IV or V Korotkoff sounds was detected, (diastolic blood pressure).

In the final step, the lever **118** is moved to the off position wherein shoulder **122** abuts stop **121**. The switch **117** is conditioned to open the circuit to the batteries **121**. The valve rotor **104** is positioned so that the ball **103** is cammed out of the recess **108** to come to rest on the flat surface of the rotor element wherein it engages the valve core **101** to open the passage **99** and rapidly vent the air from the system to the atmosphere. Ball **102** is received in recess **106**, closing valve core **97**.

After a measurement has been taken and recorded, as above described, the series of dots on the record paper is interpreted with reference to the dial indicia carried on the transparent plate **79** and the reading may be written directly on the record paper preferably in the area provided by the aperture **83**. The record paper may then be advanced manually and the portion bearing the record torn off and saved for future reference. Since the transparent plate is part of the apparatus, the record paper need not be printed with a scale, nor need it be carefully oriented or positioned for rethreading. Thus, the usual costly paper transport mechanism required in many types of data recording apparatus is eliminated.

In the operation of the circuit embodied in my invention the signal developed in the microphone **29** by the subject's Korotkoff sounds is applied to a field effect transistor **150** operated in a source follower mode. The signal passes through a gain control **151** into the amplifier **152** which increases the amplitude of the signal to a level suitable for usage in the remainder of the circuitry. The output from the amplifier is applied to a band pass filter **153** which allows only frequencies between predetermined limits to pass and which provides some additional amplification to the signal which is then applied to the emitter follower **154** which produces a low impedance output which follows the input signal. This output is applied to a gate **155** which discriminates the signals in accordance with their amplitude. Only a signal of sufficient amplitude can cause the gate to emit an output signal. The output signal from the gate **155** triggers a monostable multivibrator **156** to generate a square wave which is applied to the driver **157**, the output of which actuates switch **158** which controls the circuit to solenoid **53**. A feedback circuit **159** in parallel with the gate, multivibrator and driver, locks out random noise signals so that they will not produce signals to actuate the switch **158**. A failsafe circuit **160** associated with the driver **157** senses low battery voltage and inhibits the driver **157** from actuating the switch **158** when the battery voltage is below 5.8 volts to prevent the solenoid **53** from pulsing under such conditions wherein it might otherwise record a measurement erroneously.

It is to be understood that my invention anticipates other forms than the preferred embodiment described. For example, the stylus may be translated linearly rather than being moved through an arc. The resulting

embodiment produces a record consisting of a linear train of marks on the record medium which are then interpreted against a linear scale rather than the circular dial described.

It should also be clear that although the record medium in my preferred embodiment bears no scale (interpretation being expedited by the stationary dial on the instrument itself), my invention anticipates embodiments in which the record medium carries a pressure scale imprinted thereon so that interpretation may be made both by reference to the dial on the instrument and by the scale imprinted on said record medium.

Various changes coming within the spirit of my invention may suggest themselves to those skilled in the art; hence, I do not wish to be limited to the specific embodiments shown and described or uses mentioned, but intend the same to be merely exemplary, the scope of my invention being limited only by the appended claims.

I claim:

1. An apparatus for measuring and recording blood pressure comprising:

a. an inflatable cuff adapted to be applied to the upper third of a limb and having inflating means for inflating said cuff for selectively occluding the flow of blood to the limb;

b. a microphone positioned within said cuff capable of detecting Korotkoff sounds occurring within the limb as the pressure in said cuff is reduced;

c. electronic circuit means mounted in a housing and connected electrically to said microphone for amplifying and discriminating the signals emanating from said microphone for emitting a digital output signal for each Korotkoff sound;

d. a recording device having a stationary record medium and stylus means which is operable therewith, said recording device being electrically connected to said circuit means, and said stylus means being operable upon actuation by the digital pulses emanating from said circuit means for imprinting a single mark on said stationary record medium for each Korotkoff sound;

means mechanically coupled with said stylus means for moving e. stylus means relative to said record medium in synchronism with falling cuff pressure such that the position of said stylus means is specifically determined by the pressure in said cuff;

f. an adjustable indicating means for indicating inflation of said cuff to a pre-determined pressure above the anticipated systolic blood pressure, said adjustable indicating means being mounted in said housing and connected to said means for moving said stylus means;

g. multi-position pneumatic bleed valve means selectively conditionable in a ontrolled-slow-leak mode for venting of said cuff during the measurement, in a gross venting mode for releasing the pressure from said cuff when the measurement is completed, and in a sealed mode during inflation of said cuff, said valve means being mounted in said housing and connected pneumatically to said cuff;

h. multi-position electrical switch means selectively conditionable in a first mode for actuating said indicating means to indicate when the predetermined cuff inflation pressure has been attained while preventing said stylus means from being actuated, in a second mode to deactivate the said indicating means, and to permit said stylus means to imprint a record of said medium, and a third mode to deactivate said circuit means and said indicating means to disconnect all electrical functions, said switch means being mounted in said housing and connected to said circuit means and to said indicating means; and

i. a stationary dial graduated in units of pressure mounted adjacent said record medium to permit interpretation of the marks recorded on said record medium.

2. The invention as defined in claim **1** in which said stylus means comprises a solenoid having a plunger stylus arranged to produce visible marks on said record medium.

3. The invention as defined in claim **1** in which said means for moving said stylus means comprises pneumatico-mechanical means in pneumatic communication with said cuff.

4. The invention as defined in claim **1** in which said circuit means is adapted to digitalize only those microphone signals which are within a predetermined range of amplitudes which includes the amplitudes of Korotkoff sounds.

5. An apparatus for measuring blood pressure as defined in claim **1** comprising,

a. a rotatable vertical shaft journaled in said housing; and

b. a rotor arm supported on said shaft;

c. said stylus means comprising a solenoid having a plunger stylus arranged to make impressions on said record medium and supported on said rotor arm;

d. said means for moving said stylus means comprising bellows connected by a conduit to said cuff and operable in response to variations of pressure in said cuff, and

e. means operatively connected to said shaft and being engaged with said bellows for effecting rotation of said shaft;

f. whereby movement of said bellows will effect rotation of said shaft to move said solenoid in synchronism with the variations in said cuff pressure

6. The invention as defined in claim **5** including moveable abutment means mounted adjacent said rotor arm and arranged to be selectively positioned within the range of movement of said rotor arm in relation to different predetermined pressures, and stop means carried on said rotor arm and engagable with said abutment means for limiting the movement of said rotor arm, said indicating means being operable upon contact of said stop means with said abutment means to indicate when a predetermined cuff inflation pressure has been reached.

7. The invention as defined in claim **5** wherein said indicating means for indicating when a predetermined cuff pressure has been reached includes a lamp.

8. The invention as defined in claim **1** in which said stationary record medium is pressure sensitive paper.

9. The invention as defined in claim **5** including spring means mounted adjacent said bellows and said means for effecting rotation of said shaft for acting against the movement of said bellows and including means for adjusting the spring rate of said spring means.

10. The invention as defined in claim **1** wherein said multi-position switch means is operable to control the operation of said circuit means, and is connected to said multi-position pneumatic bleed valve means to permit the use of a single actuator to control both means and thereby control the electrical and pneumatic functions of the apparatus.

* * * * *