United States Patent

[11] 3,550,582

[72] Inventor Jack L. Wilhelmson
Fenton, Mo.

[21] Appl. No. 627,124
[22] Filed Mar. 30, 1967
[45] Patented Dec. 29, 1970

[73] Assignee By mesne assignments to,
Hoffman-La Roche Inc.,
Nutley, N.J.,
a corporation of New Jersey

[54] **SYSTEM FOR CLOSELY MONITORING A BLOOD PRESSURE OVER AN EXTENDED PERIOD OF TIME**

3 Claims, 4 Drawing Figs.

[52] U.S. Cl. 128/2.05
[51] Int. Cl. A61b 5/02
[50] Field of Search 128/2.05

[56] **References Cited**

UNITED STATES PATENTS

2,710,001	6/1955	Freyburger	128/2.05
2,826,191	3/1958	Burns	128/2.05
3,120,846	2/1964	Fletcher	128/2.05X
3,126,886	3/1964	Karsh	128/2.05
3,137,292	6/1964	Richter	128/2.05
2,952,253	9/1960	Seligman et al.	128/2.05
3,104,661	9/1963	Halpern	128/2.05

Primary Examiner—William E. Kamm
Attorneys—Samuel L. Welt, Jon S. Saxe, Bernard S. Leon and Jacob Frank

ABSTRACT: A portable blood pressure monitor featuring plural inflation sources set at different flow rates connected to a reservoir and cuff. The Korotkoff sound sensing channel and the various valves are controlled by a timing circuit to permit rapid as well as normal pressure buildup and release.

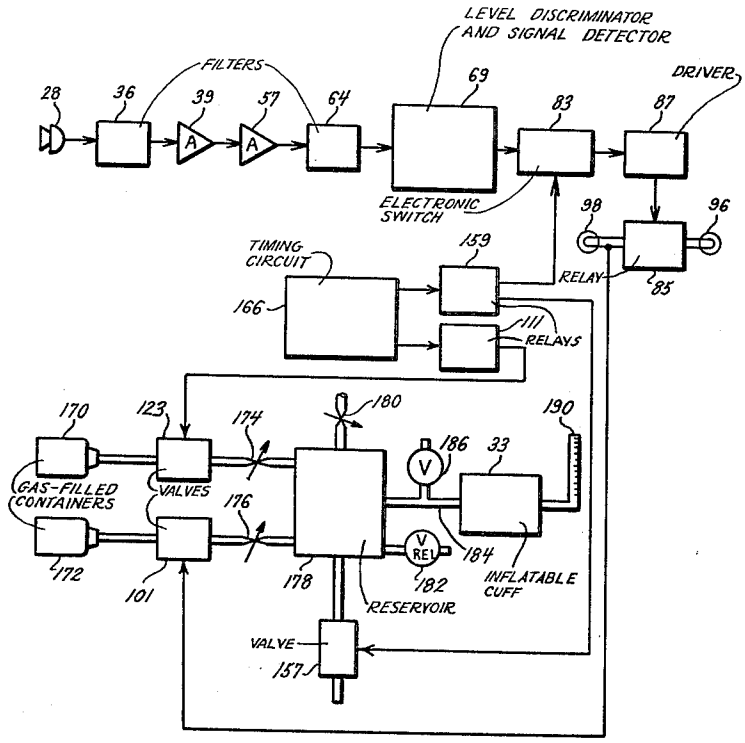


FIG. 1.

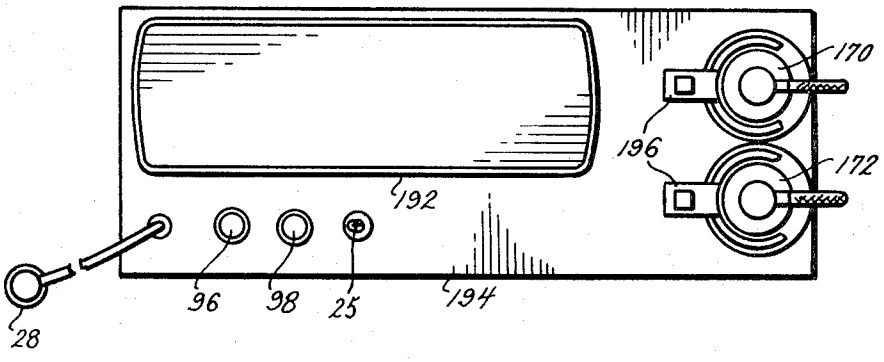

170
196
172
192
96
98
25
194
28

FIG. 3.

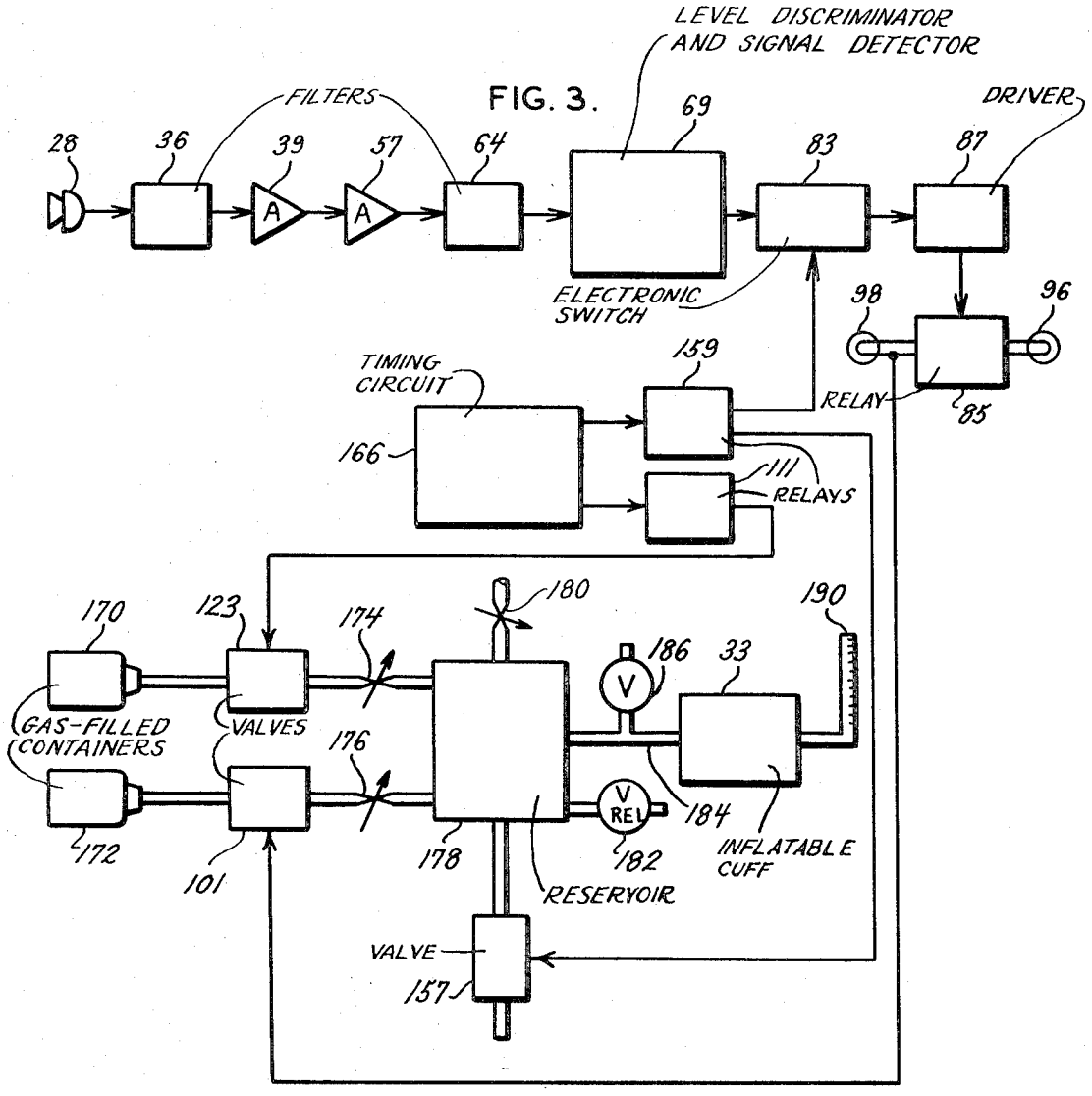
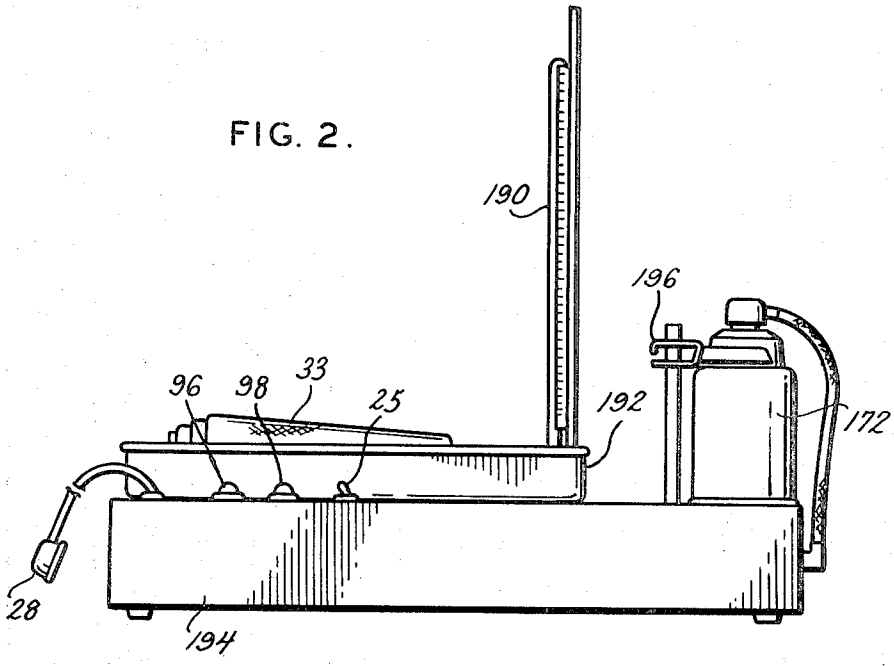

LEVEL DISCRIMINATOR AND SIGNAL DETECTOR
FILTERS
DRIVER
28
36
39
57
64
69
83
87
A
A
ELECTRONIC SWITCH
98
96
TIMING CIRCUIT
159
RELAY
85
166
111
RELAYS
170
123
174
180
190
186
33
V
GAS-FILLED CONTAINERS
VALVES
176
V REL
184
172
101
178
182
INFLATABLE CUFF
RESERVOIR
VALVE
157

FIG. 2.


190
196
96
98
33
25
192
172
28
194

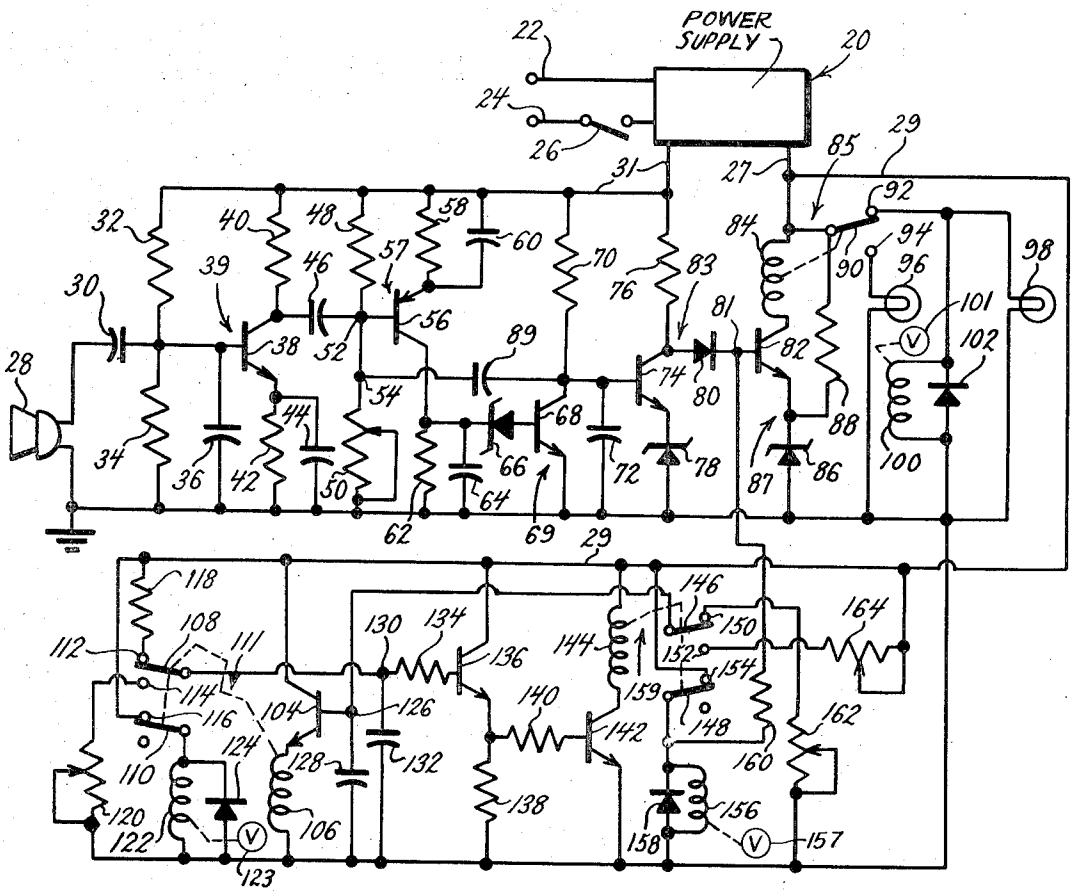

POWER SUPPLY
20
22
24
26
31
27
85
29
92
84
94
90
96
98
101
102
100
32
40
48
58
60
57
46
39
30
56
38
52
70
76
83
81
82
80
74
89
54
68
66
72
78
87
86
88
28
34
36
42
44
50
62
64
69
118
108
112
111
114
116
104
110
120
122
124
128
106
123
126
132
130
134
136
138
140
142
144
146
150
152
154
159
148
156
158
157
160
162
164

FIG. 4.

SYSTEM FOR CLOSELY MONITORING A BLOOD PRESSURE OVER AN EXTENDED PERIOD OF TIME

This invention relates to improvements in Control Systems. More particularly, this invention relates to improvements in control systems for sphygmomanometers.

It is, therefore, an object of the present invention to provide an improved control system for a sphygmomanometer.

It is frequently desirable to monitor a blood pressure of a person at frequent intervals over an extended period of time. To obtain this desirable result, an inflatable cuff can be applied to an arm of that person, a microphone can be disposed in engagement with that arm distally of that inflatable cuff, and that inflatable cuff can recurrently occlude an artery in that arm to develop Korotkoff sounds which can be sensed by that microphone. The pressure that is applied to the inflatable cuff also will be applied to a pressure-indicating instrument; and that instrument will indicate said blood pressure of that person. Because the pressure that is used in a sphygmomanometer, to compress an artery sufficiently to develop Korotkoff sounds, is great enough to halt all venous flow in the arm of that person, it is important that the sensing of said blood pressure be discontinued for finite periods of time. The present invention provides a sphygmomanometer which monitors a blood pressure of a person at frequent intervals over an extended period of time, but which protects that person by recurrently releasing all of the pressure in the inflatable cuff thereof for finite periods of time. As a result, that sphygmomanometer can monitor a blood pressure of a person over an extended period of time without any injury to that person. It is, therefore, an object of the present invention to provide a sphygmomanometer that monitors a blood pressure of a person at frequent intervals over an extended period of time, but which recurrently releases all of the pressure in the inflatable cuff thereof for finite periods of time.

During the actual sensing of a blood pressure of a person, the inflatable cuff of the sphygmomanometer should be inflated at a relatively low rate to prevent "over-shooting" of the pressure needed to cause Korotkoff sounds to develop; but a relatively low rate of inflation would needlessly prolong the initial pressurization of the inflatable cuff after any period wherein all of the pressure was released from that inflatable cuff. The present invention provides a control system for a sphygmomanometer which inflates the inflatable cuff of that sphygmomanometer at a relatively low rate during actual sensing of the blood pressure, but which inflates that inflatable cuff at a rapid rate during the initial pressurization of that inflatable cuff after each period wherein all pressure was released from that inflatable cuff. It is, therefore, an object of the present invention to provide a control system for a sphygmomanometer which inflates the inflatable cuff thereof at a relatively low rate during actual sensing of a blood pressure, but which inflates that inflatable cuff at a rapid rate during the initial pressurization of that inflatable cuff after each period when all pressure was released from that inflatable cuff.

The sphygmomanometer provided by the present invention pressurizes the inflatable cuff thereof until a Korotkoff sound is developed, and thus makes certain that sufficient pressure is developed within that inflatable cuff to enable that sphygmomanometer to sense a person's diastolic blood pressure. That sphygmomanometer then depressurizes the inflatable cuff thereof as long as a Korotkoff sound is being developed and for a very short length of time thereafter, and thus makes certain the pressure in that inflatable cuff falls below—but only a short distance below—the person's diastolic blood pressure. It is, therefore, an object of the present invention to provide a sphygmomanometer that pressurizes the inflatable cuff thereof until a Korotkoff sound is developed and then depressurizes that inflatable cuff as long as a Korotkoff sound is being developed and for a very short length of time thereafter.

Many sphygmomanometers utilize resilient bulbs or air compressors to supply air to the inflatable cuffs thereto to inflate those inflatable cuffs. The use of a resilient bulb to inflate the inflatable cuff of a sphygmomanometer requires the operator of that sphygmomanometer to physically develop the pressure required by that inflatable cuff, and thus prevents automatic operation of that sphygmomanometer. The use of an air compressor keeps that sphygmomanometer from being readily portable. The sphygmomanometer provided by the present invention obviates all need of a resilient bulb or of an air compressor to inflate the inflatable cuff thereof; and it does so by providing a small quantity of compressed gas to inflate that inflatable cuff. That quantity of compressed gas can be confined and held within a small space, and yet can provide recurrent pressurizations of the inflatable cuff of the sphygmomanometer for prolonged periods of time. It is, therefore, an object of the present invention to provide a sphygmomanometer which uses a small quantity of compressed gas to inflate the inflatable cuff thereof.

The compressed gas used in the sphygmomanometer provided by the present invention is a readily liquifiable gas; and such a gas is very desirable because it can safely be held and confined within a thin-walled container. Such a gas is also desirable because a large amount of it can be held and confined within a small space, and because the pressure of that gas will remain substantially constant at any given temperature. In addition, the compressed gas used in the sphygmomanometer provided by the present invention is a nonoxidizing, noninflammable gas, and thus is particularly desirable for use in operating rooms and in pressurized chambers. It is, therefore, an object of the present invention to provide a sphygmomanometer which uses a readily liquifiable, nonoxidating, noninflammable gas to pressurize the inflatable cuff thereof.

Other and further objects and advantages of the present invention should become apparent from an examination of the drawing and accompanying description.

In the drawing and accompanying description a preferred embodiment of the present invention is shown and described but it is to be understood that the drawing and accompanying description are for the purpose of illustration only and do not limit the invention and that the invention will be defined by the appended claims.

In the drawing, FIG. 1 is a plan view of one preferred embodiment of sphygmomanometer that is made in accordance with the principles and teachings of the present invention,

FIG. 2 is a side elevational view of the sphygmomanometer of FIG. 1, but it shows the lid of that sphygmomanometer in raised position,

FIG. 3 is a block diagram of the control system for the sphygmomanometer of FIGS. 1 and 2, and

FIG. 4 is a schematic diagram of that control system.

COMPONENTS OF CONTROL SYSTEM

Referring to the drawing in detail, the numeral 20 generally denotes a power supply which can have 117 volts, 60 cycle, single phase, alternating current applied to the input thereof, which can develop 24 volts DC at one output thereof, and which can develop 9 volts DC at the other output thereof. A lead 22 and a lead 24 can connect the input of that power supply to a suitable source of 117 volt, 60 cycle, single phase, alternating current; and the lead 24 has a single pole, single throw switch 26 therein. As shown particularly by FIGS. 1 and 2, that switch has a handle 25 which is readily accessible to the operator of the sphygmomanometer. A conductor 27 is connected to that output of the power supply 20 which develops 24 volts DC, and a conductor 29 is connected to the conductor 27. A conductor 31 is connected to that outlet of the power supply 20 which develops 9 volts DC.

The numeral 28 denotes a microphone which can be disposed adjacent an artery in the arm of a person; and that microphone preferably is a shielded, dynamic microphone which has an excellent low frequency response and a low impedance output. Such a microphone will provide an output signal which will be relatively free from electrical noise pickup from any adjacent strong electromagnetic fields. That

microphone will be set in register with the artery in the person's arm, and it will preferably be set so it is distal of an inflatable cuff **33** that will be wrapped around that arm. The numeral **30** denotes a capacitor which will couple the output of the microphone **28** to the base of an NPN transistor **38** and to the upper terminal of a capacitor **36**; and the lower terminal of the latter capacitor is connected to ground. The capacitor **36** will bypass to ground any signals which are due to ambient noises, voices, and the like and which have frequencies materially above 40 cycles per second.

Resistors **32** and **34** are connected in series between conductor **31** and ground, and they constitute a voltage divider which will develop a positive voltage at the base of the transistor **38**. A resistor **40** connects the collector of that transistor to the conductor **31**, and parallel-connected resistor **42** and capacitor **44** connect the emitter of that transistor to ground. The transistor **38**, resistors **32**, **34**, **40** and **42**, and capacitor **44** constitutes a class A common-emitter temperature-stablized amplifier **39**. The coupling capacitor **30** and the bypass capacitor **36** coact with the amplifier **39** to enable that amplifier to provide an excellent response to signals having frequencies close to 40 cycles per pound.

The numeral **46** denotes a capacitor which is connected to the collector of transistor **38**; and a junction **52** connects that capacitor to the base of a PNP transistor **56**. A resistor **48** is connected between the junction **52** and conductor **31**, and a junction **54** and an adjustable resistor **50** are connected between the junction **52** and ground. Parallel-connected resistor **58** and capacitor **60** are connected between the emitter of transistor **56** and conductor **31**, and a resistor **62** is connected between the collector of that transistor and ground. The resistor **48** and the adjustable resistor **50** are connected in series between conductor **31** and ground, and they constitute a voltage divider which will develop a positive voltage at the base of transistor **56**. Transistor **56**, resistors **48**, **58** and **62**, adjustable resistor **50**, and capacitor **60** constitute a class A amplifier with an adjustable bias; and that amplifier is denoted by the numeral **57**.

A capacitor **64** is connected between the collector of transistor **56** and ground, and it constitutes a low pass filter. That capacitor will filter out random noise which is generated, or picked up, by the amplifiers **39** and **57**.

The numeral **68** denotes an NPN transistor; and the emitter of that transistor is directly connected to ground. A resistor **70** connects the collector of that transistor to the conductor **31**; and a Zener diode **66** connects the collector of transistor **56** to the base of transistor **68**. That Zener diode establishes a threshold value which must be exceeded by any signals at the collector of transistor **56** before the transistor **68** can be rendered conductive. The "no signal" voltage at the cathode of that Zener diode can be adjusted by appropriate adjustment of the movable contact of the adjustable resistor **50**.

A capacitor **72** is connected between the lower terminal of resistor **70** and ground, and it will coact with that resistor to constitute a rate circuit. In the said one preferred embodiment of sphygmomanometer, the time constant of that rate circuit is exactly three seconds. The transistor **68**, Zener diode **66**, resistor **70** and capacitor **72** constitute a level discriminator and signal detector, and that level discriminator and signal detector is denoted by the numeral **69**.

The numeral **74** denotes an NPN transistor; and the emitter of that transistor is connected to ground by a Zener diode **78**, while the collector of that transistor is connected to the conductor **31** by a resistor **76**. A diode **80** has the anode thereof connected to the collector of that transistor, and has the cathode thereof connected to the base of an NPN transistor **82** by a junction **81**. The transistor **74**, resistor **76**, Zener diode **78**, and diode **80** constitute a level-controlled electronic switch; and that level-controlled electron switch is denoted by the numeral **83**. That level-controlled electronic switch will be actuated whenever the voltage across the capacitor **72** reaches a predetermined level—and that voltage will reach that level 1 42/100 of a second after that capacitor starts to charge after it has been fully discharged. The collector of the transistor **68** is directly connected to the base of the transistor **74**; and that collector is coupled to the base of transistor **56** by a capacitor **89** and the junctions **54** and **52**. That capacitor will provide positive feedback for the transistor **56** and thereby assure full discharging of the capacitor **72**.

The emitter of the transistor **82** is connected to ground by a Zener diode **86**, while the collector of that transistor is connected to conductor **27** by the coil **84** of a relay **85**. That relay has a movable contact **90** and fixed contacts **92** whenever the relay coil **84** is deenergized, but will engage the fixed contact **94** whenever that relay coil is energized. A resistor **88** is connected in parallel with the series-connected relay coil **84** and the collector-emitter circuit of transistor **82**. That resistor and Zener diode **86** will establish a regulated voltage at the emitter of that transistor. The transistor **82** and the Zener diode **86** constitute a "driver" for the relay **85**; and that driver is generally denoted by the numeral **87**.

A lamp **96** is connected between the fixed contact **94** and ground, and that lamp preferably is an amber lamp. A lamp **98** is connected between the fixed contact **92** and ground, and that lamp preferably is a green lamp. A solenoid **100** of a normal pressurization valve **101** also is connected in parallel with the lamp **98**. A discharge diode **102** is connected in parallel with the solenoid **100**. The valve **101** will be closed whenever the solenoid **100** is deenergized, but it will be open whenever that solenoid is energized.

The numeral **104** denotes an NPN transistor which has the collector thereof connected to the conductor **29**; and the emitter of that transistor is connected to ground by the coil **106** of a relay **111**. That relay includes movable contacts **108** and **110** and fixed contacts **112**, **114** and **116**. The movable contact **108** will engage the fixed contact **112** and the movable contact **110** will engage the fixed contact **116** whenever the coil **106** is deenergized; but the movable contact **110** will move out of engagement with the fixed contact **116**, and the movable contact **108** will move out of engagement with the fixed contact **112** and into engagement with the fixed contact **114** whenever the coil **106** is energized. A resistor **118** is connected between the fixed contact **112** and the conductor **29**, and an adjustable resistor **120** is connected between the fixed contact **114** and ground. A solenoid **122** of a fast pressurization valve **123** is connected between the movable contact **110** and ground. That valve will be closed whenever the solenoid **122** is deenergized, but it will be open whenever that solenoid is energized. A discharge diode **124** is connected in parallel with the solenoid **122**.

A junction **126** and a capacitor **128** connect the base of the transistor **104** to ground. A junction **130** and a capacitor **132** connect the movable contact **108** will move out of engagement with the fixed contact **112** and into engagement with the fixed contact **112** and into engagement with the fixed contact **114** whenever the coil **106** is energized. A resistor **118** is connected between the fixed contact **112** and the conductor **29**, and an adjustable resistor **120** is connected between the fixed contact **114** and ground. A solenoid **122** of a fast pressurization valve **123** is connected between the movable contact **110** and ground. That valve will be closed whenever the solenoid **122** is deenergized, but it will be open whenever that solenoid is energized. A discharge diode **124** is connected in parallel with the solenoid **122**.

A junction **126** and a capacitor **128** connect the base of the transistor **104** to ground. A junction **130** and a capacitor **132** connect the movable contact **108** of the relay **111** to ground. A resistor **134** connects the junction **130** to the base of an NPN transistor **136**; and the collector of that transistor is connected to the conductor **29**, while the emitter of that transistor is connected to ground by a resistor **138**. The transistor **136** is connected as an emitter follower; and the emitter of that transistor is connected to the base of an NPN transistor **142** by a resistor **140**. The emitter of the latter transistor is connected directly to ground, but the collector of that transistor is connected to the conductor **29** by the coil **144** of a relay **159**. That

relay has movable contacts **146** and **148** and has fixed contacts **150**, **152** and **154**. The movable contact **146** will be in engagement with the fixed contact **150** and the movable contact **148** will be in engagement with the fixed contact **154** whenever the relay coil **144** is deenergized; but the movable contact **148** will move out of engagement with the fixed contact **154**, and the movable contact **146** will move out of engagement with the fixed contact **150** and into engagement with the fixed contact **152** whenever that relay coil is energized.

A solenoid **156** of a fast depressurization valve **157** is connected between the movable contact **148** and ground. That valve will be closed whenever the solenoid **156** is deenergized, but it will be open whenever that solenoid is energized. A discharge diode **158** is connected in parallel with the solenoid **156**. A resistor **160** and the movable and fixed contacts **148** and **154** of the relay **159** normally connect the junction **81** adjacent the base of transistor **82** to the conductor **29**.

An adjustable resistor **162** is connected between the fixed contact **150** and ground; and an adjustable resistor **164** is connected between the fixed contact **152** and the conductor **29**. The capacitors **128** and **132** and the adjustable resistors **120** and **164** constitute a fast pressurization and depressurization timing circuit; and that circuit is generally denoted by the numeral **166**.

The numeral **170** denotes a container of a readily liquifiable gas; and, while different gases could be used, Freon **114** has been found to be a very desirable liquifiable gas. That gas will develop a pressure of 36 pounds per square inch at a temperature of 25° centigrade, and it is nonoxidizing and noninflammable. That container can be quite small—being approximately 3½ inches in diameter and 7 inches high. The numeral **172** denotes a similar container of a readily liquifiable gas. As indicated particularly by FIG. **3**, the outlet of the container **170** is connectable to a reservoir **178** by the fast pressurization valve **123** and an adjustable fast pressurization orifice **174**. Also, as indicated particularly by FIG. **3**, the outlet of the container **172** is connected to the reservoir **178** by the normal pressurization valve **101** and an adjustable normal pressurization orifice **176**. That reservoir is continuously connected to the ambient atmosphere by an adjustable normal depressurization orifice **180**; and it can be connected to that atmosphere by the fast depressurization valve **157**. A safety valve **182** is connected to the reservoir **178**; and that safety valve would vent gas from that reservoir to the ambient atmosphere in the event the pressure in that reservoir were, somehow, to exceed the threshold value of that safety valve.

A conduit **184** extends between the reservoir **178** and the inflatable cuff **33**; and a manually operated venting valve **186** is connected to that conduit. Normally the valve **186** is closed, but it can be opened to vent gas to the atmosphere by the mere application of finger pressure to that valve. A manometer **190** is connected to the inflatable cuff **33**, and the level of the mercury within that manometer will indicate the blood pressure of the person.

The inflatable cuff **33**, the manometer **190**, and the housing **192** therefor are standard and usual components of a sphygmomanometer. That housing rests upon and is secured to an enclosure **194**; and that enclosure supports and encloses the reservoir **178**, the orifices **174**, **176** and **180**, the valves **101**, **123**, **157**, **182** and **186**, and most of the electrical components of the control system. As shown by FIG. **1**, the handle **25** of the switch **26** and the lamps **96** and **98** project upwardly through the enclosure **194**—to make that handle readily accessible to, and to make those lamps readily visible to, the operator of that control system. The containers **170** and **172** are releasably secured to the enclosure **194** by clamps **196**; and they are releasably connected to the valves **123** and **101**, respectively, by readily seperable pressure-tight connections of standard design.

OPERATION OF CONTROL SYSTEM

In using the said preferred embodiment of control system provided by the present invention, the microphone **28** can be taped to a person's arm in register with an artery within that arm; and the inflatable cuff **33** can be secured to that person's arm. Preferably, the microphone **28** will be located distally of that inflatable cuff. The leads **22** and **24** can then be connected to the source of one hundred and seventeen volts, sixty cycle, single phase alternating current, and the switch **26** can then be closed. Thereupon, current will flow from conductor **27** via the resistor **88** and the Zener diode **86** to ground; and that current flow will establish a regulated positive DC voltage at the emitter of the transistor **82**—thereby establishing a threshold at the base of that transistor. Conductor **29**, the fixed and movable contacts **154** and **148** of the relay **159**, and the resistor **160** will apply approximately 24 volts to the junction **81**; and that voltage will back-bias the diode **80**, and will cause sufficient current to flow through the base-emitter circuit of transistor **82** and Zener diode **86** to render that transistor conductive. The resulting flow of current from conductor **27** via relay coil **84**, transistor **82**, and Zener diode **86** will energize that relay coil; and, as the movable contact **90** of relay **85** moves out of engagement with fixed contact **92** and into engagement with fixed contact **94**, the lamp **98** will darken, the solenoid **100** of the normal pressurization valve **101** will become deenergized and that valve will close, and the lamp **96** will become illuminated. Current also will flow from conductor **29** via resistor **118** and the fixed and movable contacts **112** and **108** of relay **111**, junction **130**, and capacitor **132** to ground. In less than a second, the voltage across that capacitor will be large enough to force current to flow from junction **130** via resistor **134**, the base-emitter circuit of transistor **136**, and resistor **138** to ground; and that flow of current will render that transistor conductive. The resulting positive voltage at the base of transistor **142** will render that transistor conductive; and hence current will then flow from conductor **29** via relay coil **144** and transistor **142** to ground. The resulting energization of that relay coil will shift the movable contact **146** out of engagement with the fixed contact **150** and into engagement with the fixed contact **152**, and also will shift the movable contact **148** out of engagement with the fixed contact **154**. Shifting of movable contact **148** out of engagement with the fixed contact **154** will deenergize the solenoid **156** of the fast depressurization valve **157**, and will thereby permit that valve to close; and also will disconnect resistor **160** and junction **81** from the conductor **29**, and will thus remove the large voltage at the junction **81**. The reverse bias on the diode **80** will thus be removed; and, thereupon, current will flow from conductor **31** via resistor **76**, diode **80**, junction **81**, the base-emitter circuit of transistor **82**, and Zener diode **86** to ground to keep that transistor conductive. Current also will flow from conductor **29** via the fixed and movable contacts **116** and **110** of relay **111** and the solenoid **122** of the fast pressurization valve **123** to ground; and the resulting energization of that solenoid will open that valve. Thereupon, gas from the container **170** will flow through the fast pressurization valve **123**, the orifice **174**, the reservoir **178**, and the conduit **184** to the inflatable cuff **33**. As soon as the movable contact **150** of the relay **159** moves down into engagement with the fixed contact **152**, current will flow from conductor **29** via adjustable resistor **164**, fixed and movable contacts **152** and **146**, junction **126**, and capacitor **128** to ground; and that flow of current will slowly charge that capacitor.

At the instant the switch **26** was closed, current also flowed from conductor **31** via resistors **32** and **34** to ground; and the resulting positive voltage at the base of transistor **38** rendered that transistor conductive. Current also flowed from conductor **31** via resistor **48** and adjustable resistor **50**; and the resulting voltage drop across the resistor **48** made the base of transistor **56** sufficiently less positive than the emitter of that transistor to render that transistor conductive. The voltage

drop across the resistor **62** will establish a positive voltage at the cathode of Zener diode **66**; but that voltage will be less than the breakdown voltage of that Zener diode, and hence that Zener diode and the transistor **68** will remain nonconductive. Current also flowed from conductor **31** via resistor **70** and capacitor **72** to ground; and that current flow quickly charged that capacitor—the voltage at the upper terminal of that capacitor, and hence at the base of transistor **74**, rising in 1 42/100 of a second to a value which exceeded to the threshold at the base of that transistor and thus caused sufficient current to flow through the base-emitter circuit of that transistor to render that transistor conductive. The resulting low voltage at the anode of the diode **80** back-biased that diode; and, thereupon, the transistor **82** became nonconductive. The resulting deenergization of relay coil **84** permitted the movable contact **90** to move out of engagement with fixed contact **94** and into engagement with fixed contact **92**; and, thereupon, the lamp **96** darkened, the lamp **98** became illuminated, and the solenoid **100** of the normal pressurization valve **101** became energized and opened that valve. At that time, compressed gas flowed from container **170** via fast pressurization valve **123**, orifice **174**, and reservoir **178** into the inflatable cuff **33**; and compressed gas also flowed from container **172** via normal pressurization valve **101**, orifice **176** and reservoir **178** to that inflatable cuff. The conjoint flow of compressed gas from both of the containers **170** and **172** quickly increased the level of the pressure within the inflatable cuff **33**.

All of this means that as the switch **26** was closed, the fast depressurization valve **157** was permitted to close, the fast pressurization valve **123** was opened, and the normal pressurization valve **101** was permitted to close for slightly less than 1½ seconds and then was caused to open. As a result, compressed gas rapidly flowed into the inflatable cuff **33**, and the pressure within that inflatable cuff started to rise. The lamp **98** was illuminated to indicate that the pressure within that inflatable cuff was rising.

It would be desirable to permit the fast pressurization valve **123** to close after the pressure in the inflatable cuff **33** rose to 40 millimeters of mercury; and hence the movable contact of the adjustable resistor **164** is set to charge the capacitor **128** at a rate which will make the voltage at the junction **126** sufficiently positive to render the transistor **104** conductive by the time the pressure in that inflatable cuff has risen to 40 millimeters of mercury. In the said one embodiment of control system, the capacitor **128** will charge for a period of about three seconds before the transistor **104** becomes conductive; and as that transistor becomes conductive the relay coil **106** will become energized, and the movable contact **108** will move down out of engagement with fixed contact **112** and into engagement with fixed contact **114**, and the movable contact **110** will move down out of engagement with fixed contact **116**. The shifting of the movable contact **110** out of engagement with the fixed contact **116** will deenergize the solenoid **122** of the fast pressurization valve **123**, and will thereby permit that valve to close. The shifting of the movable contact **108** out of engagement with fixed contact **112** will halt the charging of capacitor **132**; and the shifting of that movable contact into engagement with fixed contact **114** and will enable that capacitor to start discharging via junction **130**, movable and fixed contacts **108** and **114**, and adjustable resistor **120** as well as via junction **130**, resistor **134**, the base-emitter circuit of transistor **136**, and resistor **138**. That capacitor will discharge for a predetermined period of time, which will be determined by the setting of the movable contact of the adjustable resistor **120**; and, in the said embodiment of control system, that predetermined period of time is about 4 minutes. The current flowing from the upper terminal of that capacitor via junction **130**, resistor **134**, the base-emitter circuit of transistor **136**, and resistor **138** will keep that transistor conductive throughout that predetermined period of time; and will thus keep the fast depressurization valve **157** closed throughout that predetermined period of time.

Compressed gas will continue to flow from container **172** through the normal pressurization valve **101** and the orifice **176** into the reservoir **178**, and thence into the inflatable cuff **33**. Consequently, the pressure within that cuff, and in the manometer **190**, will continue to increase—although at a lesser rate. As the pressure within that inflatable cuff increases, that pressure will attain a value which will enable that inflatable cuff to occlude the artery in the person's arm. As that artery is occluded, a contraction of the person's heart will cause a series of Korotkoff sounds to develop; and those sounds will be sensed by the microphone **28**.

The capacitor **30** will couple the signals corresponding to the first of those Korotkoff sounds to the base of transistor **38**; and that capacitor will coact with the resistor **34** to attenuate signals appreciably below forty cycles per second. The capacitor **36** will coact with the resistor **34** and with the input impedance of the transistor **38** to attenuate signals appreciably above forty cycles per second. The transistor **38** will amplify the signals corresponding to the first of the Korotkoff sounds; and the resulting amplified and inverted signals will appear at the collector of transistor **38**. Those amplified and inverted signals will be coupled to the base of transistor **56** by capacitor **46** and junction **52**; and they will render that transistor more conductive. The resulting increased voltage across the resistor **62** will enable the voltage at the cathode of the Zener diode **66** to exceed the breakdown voltage of that Zener diode; and, thereupon, current will flow from conductor **31** via resistor **58**, the emitter-collector circuit of transistor **56**, Zener diode **66**, and the base-emitter circuit of transistor **68** to ground. That flow of current will render the latter transistor conductive; and the voltage at the collector of that latter transistor will tend to fall to ground potential. The capacitors **72** and **89** will discharge through the transistor **68**, and the ensuing voltage drop across the latter capacitor will make the base of transistor **56** even more negative. The latter transistor will become even more conductive, and will further increase the positive voltage at the base of transistor **68**. The resulting regenerative action between the transistors **68** and **56** will drive the former transistor into saturation; and that transistor will promptly—in less than one-tenth of a second—discharge the capacitor **72**. While that capacitor is discharging, it will tend to make the left-hand terminal of capacitor **89** more negative than the right-hand terminal of that capacitor, and thus will tend to keep the transistor **56** more conductive. While the capacitor **72** is still discharging, the voltage at the base of transistor **74** will fall sufficiently toward ground potential to drop below the threshold which the Zener diode **78** establishes at that base; and, thereupon, that transistor will become nonconductive. As that transistor becomes nonconductive, a positive-going voltage will develop at the collector thereof, and thus at the anode of diode **80**; and that voltage will forward-bias that diode and thus permit current to flow from conductor **31** via resistor **76**, diode **80**, junction **81**, the base-emitter circuit of transistor **82**, and Zener diode **86** to ground; and, thereupon, the latter transistor will become conductive. The consequent flow of current from conductor **27** via relay coil **84**, transistor **82** and Zener diode **86** will again energize that relay coil and will again cause the movable contact **90** to move out of engagement with the fixed contact **92** and into engagement with the fixed contact **94**. As that movable contact moves out of engagement with the fixed contact **92**, it will darken the lamp **98** and it also will deenergize the solenoid **100** of the normal pressurization valve **101**. Immediately, that valve will close; and no further compressed gas will be introduced into the inflatable cuff **33**. Gas will continue to vent from that inflatable cuff through the normal depressurization orifice **180**; and hence the pressure in that inflatable cuff, and in the manometer **190**, will slowly decrease. The lamp **96** will be illuminated as the movable contact **90** moves into engagement with the fixed contact **94**; and that lamp will indicate to the operator of the sphygmomanometer that the pressure in the inflatable cuff **33** is decreasing.

All of this means that the compressed gas from the container 172 increased the pressure within the inflatable cuff 33 from 40 millimeters of mercury to whatever pressure was needed to enable that inflatable cuff to occlude the artery in the person's arm. As that artery was occluded, a contraction of the person's heart caused a series of Korotkoff sounds to develop; and the first of those Korotkoff sounds caused the transistor 82 to become conductive, and thereby terminated the pressurization of the inflatable cuff 33 and initiated the depressurization of the inflatable cuff.

As the capacitor 72 becomes substantially completely discharged, the voltage at the right-hand terminal of the capacitor 89 will no longer be more positive than the voltage at the left-hand terminal of that capacitor; and, consequently, the conductivity of the transistor 56 will fall to its normal level. The resulting decrease in voltage drop across the resistor 62 will permit the transistor 68 to become nonconductive once again; and at such time the capacitor 72 will again start charging. However, the second of the Korotkoff sounds caused by the contraction of the person's heart will again render the transistor 68 conductive, and thus again discharge the capacitor 72. As that capacitor discharges, it will again coact with the capacitor 89 to make the transistor 56 more conductive; and the ensuing regenerative action between the transistors 56 and 68 will again drive the latter transistor into saturation, and will again discharge the capacitor 72. Thereupon, the transistor 68 will again become nonconductive, and the capacitor 72 will again start to charge. The succeeding Korotkoff sounds caused by the said contraction of the person's heart will cause further discharging of the capacitor 72, and will thus keep the voltage across that capacitor from increasing sufficiently to exceed the threshold which the Zener diode 86 establishes at the base of transistor 74. As a result that transistor will remain nonconductive. The overall result is that as long as the microphone 28 senses any of the Korotkoff sounds caused by the said contraction of the person's heart, the transistor 74 will remain nonconductive and the transistor 82 will keep the relay coil 84 energized—and the pressure in the inflatable cuff 33 will continue to fall at a slow rate.

If the microphone 28 fails to sense any Korotkoff sounds for 1 42/100 of a second, the resulting uninterrupted charging of the capacitor 72 will make the voltage across that capacitor great enough to exceed the threshold which the Zener diode 78 establishes at the base of transistor 74; and, thereupon, that transistor will become conductive. As that transistor becomes conductive, it will back-bias the diode 80 and thus keep further current from flowing from conductor 31 via resistor 76, diode 80, junction 81, the base-emitter circuit of transistor 82, and Zener diode 84 to ground. Thereupon, the latter transistor will become nonconductive, the relay coil 84 will become deenergized, and the lamp 96 will become dark while the lamp 98 will become illuminated and the solenoid 100 will become reenergized.

This means that the depressurization of inflatable cuff 33 began as the first Korotkoff sound, of a series of Korotkoff sounds, was heard, that such depressurization was continued throughout the duration of that series of Korotkoff sounds, and that such depressurization was concluded 1 42/100 of a second after the last Korotkoff sounds, of that series of Korotkoff sounds, was sensed by microphone 28. In continuing the depressurization of inflatable cuff 33 for just less than 1½seconds after each Korotkoff sound is sensed by the microphone 28, the control system of the sphygmomanometer provided by the present invention provides sufficient time for a further Korotkoff sound, of the series of Korotkoff sounds, to cause a further discharging of the capacitor 72; and thus causes the depressurization of that inflatable cuff to continue throughout the duration of that series of Korotkoff sounds. In continuing the depressurization of the inflatable cuff 33 throughout the duration of that series of Korotkoff sounds that control system makes certain that the pressure in that inflatable cuff does fall below the level of the person's diastolic blood pressure, and that repressurization of that inflatable cuff can not be initiated until the pressure in that inflatable cuff has so fallen. As a result, that control system prevents premature repressurization of that inflatable cuff.

As the transistor 82 becomes nonconductive and causes the relay 85 to reenergize the solenoid 100 of the normal pressurization valve 101, that valve will open; and further compressed gas will be introduced into the inflatable cuff 33 to repressurize that inflatable cuff. The repressurization of the inflatable cuff 33 will continue until the pressure in that inflatable cuff again occludes the artery in the person's arm, and causes a second group of Kortkoff sounds to develop. As the first Korotkoff sound of that second group of Korotkoff sounds is sensed by the microphone 28, the transistor 56 will again be rendered more conductive, and will again render the transistor 68 conductive. The ensuing discharging of capacitor 72 will again render the transistor 74 nonconductive; and a further depressurization of the inflatable cuff 33 will be initiated. That depressurization will continue as long as any Korokoff sound of that second group of Korotkoff sounds is sensed by the microphone 28; and that depressurization will continue for 1 42/100 of a second thereafter. When that microphone fails, for a period of 1 42/100 of a second, to sense a Korotkoff sound, the transistor 74 will again become conductive—and the second depressurization of the inflatable cuff 33 will end and a further repressurization of that inflatable cuff will begin.

It should thus be clear that the control system for sphygmomanometer provided by the present invention will recurrently raise the pressure in the inflatable cuff 33 to a value slightly above the person's diastolic blood pressure and will then permit that pressure to fall to a value slightly below that person's diastolic blood pressure. The total change in pressure within that inflatable cuff, and hence in the manometer 190, will be the equivalent of just a few millimeters of mercury; and, consequently, that manometer will provide a substantially steady pressure level indication. Such a pressure level indication will enable the operator of the sphygmomanometer to readily determine the person's diastolic blood pressure.

The discharging of the capacitor 132, which began when the coil 106 of relay 111 became energized and moved the movable contact 108 down into engagement with the fixed contact 114, will continue throughout the recurring pressurizations and depressurizations of the inflatable cuff 33. Specifically, current will flow from the upper terminal of capacitor 132 via junction 130, resistor 134, the base-emitter circuit of transistor 136, and resistor 138 to the lower terminal of that capacitor, and also from the upper terminal of that capacitor via junction 130, movable and fixed contacts 108 and 114, and adjustable resistor 120 to the lower terminal of that capacitor. After about 4 minutes, the voltage across the capacitor 132 will decrease to the point where the current flowing through the base-emitter circuit of transistor 136 will be too small to keep that transistor conductive; and, thereupon, that transistor will become nonconductive. The resulting negative-going voltage at the emitter thereof will render the transistor 142 nonconductive, and will thus deenergize the 144 of relay 159. The movable contact 146 of that relay will then move up out of engagement with fixed contact 152 and into engagement with fixed contact 150, and the movable contact 148 will move up into engagement with fixed contact 154. Thereupon, the fixed and movable contacts 154 and 148 of relay 159 and the resistor 160 will again connect conductor 29 to the junction 81; and the resulting application of about 24 volts to that junction will again back-bias the diode 80 and will again render the transistor 82 conductive. The ensuing energization of relay coil 84 will again illuminate lamp 96, darken lamp 98, and deenergize solenoid 100 of the normal pressurization valve 101—with consequent cessation of the pressurization of the inflatable cuff 33.

As the movable contact 148 of the relay 159 moved into engagement with fixed contact 154, current began to flow from conductor 29 via fixed and movable contacts 154 and 148 and solenoid 156 of the rapid depressurization valve 157 to

ground; and the resulting opening of that valve quickly depressurized the inflatable cuff **33** and the reservoir **178**. That depressurization is desirable, because it will substantially completely relieve the pressure on the person's arm; and that relief of pressure is important in minimizing discomfort of that person and in protecting that person's arm from injury. Moreover, that relief of pressure is important, because it will keep the diastolic blood pressure of that person from shifting—as it could do if the blood pressure of that person was being sensed continuously.

As the movable contact **146** of relay **159** moved back up into engagement with the fixed contact **150**, the capacitor **128** tended to discharge via movable and fixed contacts **146** and **150** and adjustable resistor **162**, and also via the base-emitter circuit of transistor **104** and relay coil **106**. The resulting flow of current through that base-emitter circuit will keep that transistor conductive, and thus will enable that transistor to keep that relay coil energized. That relay coil will be kept energized for a predetermined length of time; and, in the said preferred embodiment of sphygmomanometer provided by the present invention, that relay coil will be kept energized for one minute. As a result, the normal and fast pressurization valves **101** and **123** will remain closed, and the fast depressurization valve **157** will remain open, for one minute. The pressure within the inflatable cuff **33** will fall to the ambient level, and substantially no pressure will be applied to the person's arm for that period of time.

At the end of that one minute, the voltage across the capacitor **128** will decrease sufficiently to permit the transistor **104** to become nonconductive; and, as that transistor becomes nonconductive, the relay coil **106** will become deenergized and the movable contacts **108** and **110** will move back up into their normal positions. Current will immediately flow from conductor **29** via resistor **118**, fixed and movable contacts **112** and **108**, junction **130** and capacitor **132** to ground; and, in less than one second, transistor **136** will become conductive and will render transistor **142** conductive—with a consequent energization of coil **144** of relay **159**. Thereupon, movable contact **148** will again move downwardly, and movable contact **146** will again move out of engagement with the fixed contact **150** and into engagement with the fixed contact **152**. Shifting of movable contact **148** out of engagement with the fixed contact **154** will deenergize the solenoid **156** of the fast depressurization valve **157**, and will thereby permit that valve to close once again; and also will disconnect resistor **160** and junction **81** from the conductor **29**, and will thus again remove the large voltage at the junction **81**. Current also will flow from conductor **29** via the fixed and movable contacts **116** and **110** of relay **111** and the solenoid **122** of the fast pressurization valve **123** to ground; and the resulting energization of that solenoid will again open that valve. Thereupon, gas from the container **170** will again flow through the fast pressurization valve **123**, the orifice **174**, the reservoir **178**, and the conduit **184** to the inflatable cuff **33**. As soon as the movable contact **150** of relay **159** moves down into engagement with the fixed contact **152**, current will again flow from conductor **29** via adjustable resistor **164**, fixed and movable contacts **152** and **146**, junction **126**, and capacitor **128** to ground; and that flow of current will slowly charge that capacitor. Because the pressure within the inflatable cuff **33** will be too low to enable that inflatable cuff to occlude the person' s artery, no Korotkoff sounds will be present; and hence the capacitor **72** will be charged and the transistor **74** will be conductive. The diode **80** will be back-biased and hence the transistor **82** will be nonconductive; and, as a result, the relay **85** will illuminate the lamp **98** and will energize the solenoid **100** of the normal pressurization valve **101**.

The overall result is that at the end of the four minute pressure relief period, the fast depressurization valve **157** will again reclose, the fast pressurization and the normal pressurization valves **123** and **101** will again reopen, and the inflatable cuff **33** will again be pressurized at a rapid rate. After about three seconds, the transistor **104** will again become conductive, and will again energize the coil **106** of relay **111**. The ensuing shifting of movable contacts **108** and **110** downwardly will again deenergize the solenoid **122** of the fast pressurization valve **123**, and will again limit further pressurization of the inflatable cuff **33** to the normal pressurization rate. The shifting of the movable contact **108** down into engagement with the fixed contact **114** will again start the four minute discharging period of the capacitor **132**.

Thereafter, throughout that one minute period, the sphygmomanometer provided by the present invention will successively increase and pressure within the inflatable cuff **33** to cause Korotkoff sounds to develop, will decrease that pressure until those Korotkoff sounds disappear, and will then continue to decrease that pressure for 1 42/100 of a second thereafter. The pressure in that inflatable cuff, and hence in the manometer **190**, will hover closely around the person's diastolic blood pressure; and that blood pressure can be easily read by the operator of the sphygmomanometer. Each four minute pressure-sensing period will be succeeded by a one minute pressure relief period; and hence generally continuous sensing of the person's diastolic blood pressure can be provided without undue discomfort for that person.

In the event a person's diastolic blood pressure is less than forty millimeters of mercury, Korotkoff sounds can render the transistor **68** conductive, and can thus cause the relay **85** to deenergize the solenoid **100** of the normal pressurization valve **101** prior to the time the capacitor **128** is charged sufficiently to render the transistor **104** conductive. This means that the fast pressurization cycle will be initiated while both the fast pressurization and normal pressurization valves **123** and **101** are open but will be terminated while only that fast pressurization valve is supplying compressed gas to the inflatable cuff **33**. Further, it means that as soon as the fast pressurization valve **123** is closed, as the transistor **104** becomes conductive and deenergizes the relay coil **106**, the depressurization of that inflatable cuff will start. Thereafter, the pressure in that inflatable cuff will fall until no further Korotkoff sounds are heard, and will continue to fall for 1 42/100 of a second thereafter; and then the normal pressurization solenoid **100** will again be energized.

CONCLUSION

The discharge diode **102** will constitute a low impedance path for the energy within the solenoid **100**, and thus will quickly dissipate that energy whenever the coil **84** of relay **85** is energized. Similarly, the discharge diodes **124** and **158** will constitute low impedance paths, respectively, for the energy within the solenoids **122** and **156**, and thus will quickly dissipate that energy whenever the coils **106** and **144** of relays **111** and **159** are energized.

The containers **170** and **172** are small in size, but they are able to hold and confine very large amounts of gas; because that gas is readily liquifiable at room temperatures. Thus, each of those containers is able to hold and confine sufficient gas to pressurize the inflatable cuff **33** for 24 hours of blood pressure monitoring. If desired, a single, larger container of compressed gas could be substituted for the containers **170** and **172**.

During the operation of the sphygmomanometer provided by the present invention, ambient noises may be able to cause the microphone **28** to supply signals to the base of transistor **68** which will render that transistor conductive. That transistor and the transistor **56** will provide the regenerative action which will cause prompt discharging of the capacitor **72**; and the transistor **74** will become nonconductive and will render the transistor **82** conductive—with a consequent energization of the relay coil **84** and a consequent deenergization of the solenoid **100** of the fast pressurization valve **101**. However, if no further signals are received from the microphone **28** which could again render the transistor **68** conductive, the capacitor **72** will recharge and will again render the transistor **74** conductive—with a consequent rendering of transistor **82**

nonconductive, a consequent deenergization of relay coil **84**, and a consequent reenergization of solenoid **100**. This means that while a noise which could cause the microphone **28** to render the transistor **68** conductive would deenergize the solenoid **100** of the fast pressurization valve **101**, that deenergization of that solenoid would be short-lived and that solenoid would quickly become energized again and would again open the fast pressurization valve **101**. Only where the transistor **68** is repeatedly rendered conductive over a short period of time, as when a group of Korotkoff sounds is developed, will the solenoid **100** of the fast pressurization valve **101** be kept deenergized beyond 1 42/100 of a second during the 4 minute pressure-sensing period of the sphygmomanometer.

The pressure-sensing period can be made longer or shorter than four minutes by adjusting the position of the movable contact of adjustable resistor **120**. That period can be made as short as 30 seconds or as long as 10 minutes. The fast pressurization period can be made longer or shorter than three seconds by adjusting the position of the movable contact of adjustable resistor **164**. However, where that period is lengthened it will usually be desirable to make the orifice **174** smaller; and where that period is shortened it will usually be desirable to make that orifice longer. The pressure relief period can be made longer or shorter than one minute by adjusting the position of the movable contact of adjustable resistor **162**. That period can be made as short as 10 seconds or as long as 10 minutes. By changing the size of the orifice **180**, it is possible to change the normal pressurization rate and the normal depressurization rate. Preferably that orifice will be dimensioned to provide a normal pressurization rate of 2 millimeters of mercury per second and a normal depressurization rate of 2 millimeters of mercury per second. Such rates facilitate precise and accurate sensing of a person's diastolic blood pressure.

If it ever became desirable to manually release the pressure within the inflatable cuff **33**, as when the switch **26** was opened while the inflatable cuff **33** was pressurized, the operator of the sphygmomanometer need only actuate the manually-released valve **186**. Thereupon, the compressed gas within that inflatable cuff and within the reservoir **178** would vent to the atmosphere.

If desired, a piezoelectric transducer, an infrasonic capacitive pickup or transducer, or some other form of pickup or transducer which could effectively sense Korotkoff sounds could be substituted for the microphone **28**. However, that microphone has been found to be very useful.

In any control system that utilizes Korotkoff sounds in the monitoring of blood pressure, extraneously developed sounds in the audio frequency range can constitute a problem. Some control systems attempt to meet that problem by using elaborate and complex filters to remove or attenuate signals generated by unwanted sounds; but elaborate and complex filters are expensive, and even the most elaborate and complex filters can not reject all signals generated by unwanted sounds having frequencies close to the frequencies of signals generated by Korotkoff sounds. The control system provided by the present invention effectively meets that problem by using the capacitors **30** and **36** and the resistor **34** to attenuate the signals generated by most unwanted sounds, by keeping the effect which the rest of those signals have upon the level discriminator and signal detector **69** from materially affecting the monitoring of a person's blood pressure, and by providing a short recovery time for that level discriminator and signal detector specifically, the capacitors **30** and **36** and the resistor **34** will attenuate all signals which have frequencies appreciably above and appreciably below 40 cycles per second; and thus will permit only a very limited number of signals generated by unwanted sounds to reach the level discriminator and signal detector **69**. Those signals will cause that level discriminator and signal detector to discharge the capacitor **72**, and will thereby cause the level-controlled electronic switch **83** to render the transistor **82** and the relay **84** conductive—with a consequent deenergizaton of the solenoid **100** of the normal pressurization valve **101**. However, such deenergization will merely delay the pressurization of the inflatable cuff **33** and will not provide an incorrect or aberrated level for the mecury in the manometer **190**, and will not provide any other undesirable result. Furthermore, the level discriminator and signal detector **69** has a recovery time of less than one and six-tenths seconds; and hence the effect produced by a signal generated by an unwanted sound can go virtually unnoticed, insofar as any significant effect that it might have upon the monitoring of a person's diastolic blood pressure is concerned. Moreover, any signal which is applied to the level discriminator and signal detector **69** while the capacitor **72** is discharging will have no effect at all. The recovery time provided for that level discriminator and signal detector is longer than the time intervals between the heart beats of most persons—and thus is long enough to prevent repressurization of the inflatable cuff **33** between the termination of the Korotkoff sounds due to one heart beat and the initiation of further Korotkoff sounds due to the next-succeeding heart beat—but is short enough to keep the pressure in the inflatable cuff **33** from dropping unduly if a signal corresponding to an unwanted sound reaches that level discriminator and signal detector. The overall result is that the control system provided by the present invention minimizes the effect which unwanted sounds can have upon it, and yet does not require an elaborate or complex filter.

Whereas the drawing and accompanying description have shown and described a preferred embodiment of the present invention, it should be apparent to those skilled in the art that various changes may be made in the form of the invention without affecting the scope thereof.

I claim:

1. In a control system for sensing a blood pressure which has a transducer to develop signals in response to the interaction of arterial pressure and cuff pressure, an inflatable cuff that can be applied to the body of a person, a source of gas for said inflatable cuff, a valve connected to said source of gas and to said inflatable cuff to selectively permit gas to pass to said inflatable cuff, and pressure relief means connected to said inflatable cuff to vent gas and thereby permit the pressure on the gas in said inflatable cuff to decrease, the improvement which comprises means coupled from said transducer and tending to hold said valve in cuff-pressurizing position until said transducer senses said signals, and thereby make certain that the pressure in said inflatable cuff will rise to a value at least as great as the diastolic blood pressure of said person, said means thereafter responding to the sensing of said signals by said transducer to cause said valve to shift to cuff-depressurizing position and said means includes a timer resettable each time the transducer senses successive ones of said signals in each blood pressure measurement cycle to maintain said valve in said cuff-depressurizing position, and said means subsequently continuing to maintain said valve in cuff-depressurizing position for a short predetermined length of time after said transducer senses the last of said successive ones of said signals thereby making certain that the pressure in said inflatable cuff will fall below the diastolic blood pressure of said person.

2. In a control system for sensing a blood pressure according to claim **1** whereby, said predetermined length of time is longer than the time interval between one of said signals which is effectively sensed by said transducer and is due to a given heartbeat of said person and one of said signals which is effectively sensed by said transducer and is due to the next-succeeding heartbeat of said person.

3. In a control system for sensing a blood pressure according to claim **2** wherein said timer comprises a capacitor, a charging circuit therefor, and a discharging circuit therefor, said changing circuit for said capacitor having means therein tending to charge said capacitor at least over a period equal to said short predetermined length of time whenever said transducer is not effectively sensing said signals, said discharging circuit for said capacitor having means therein tending to discharge said capacitor whenever said transducer effectively senses one of said signals, said discharging circuit for said capacitor being regenerative to provide rapid, substantially complete discharging of said capacitor.