

April 23, 1963

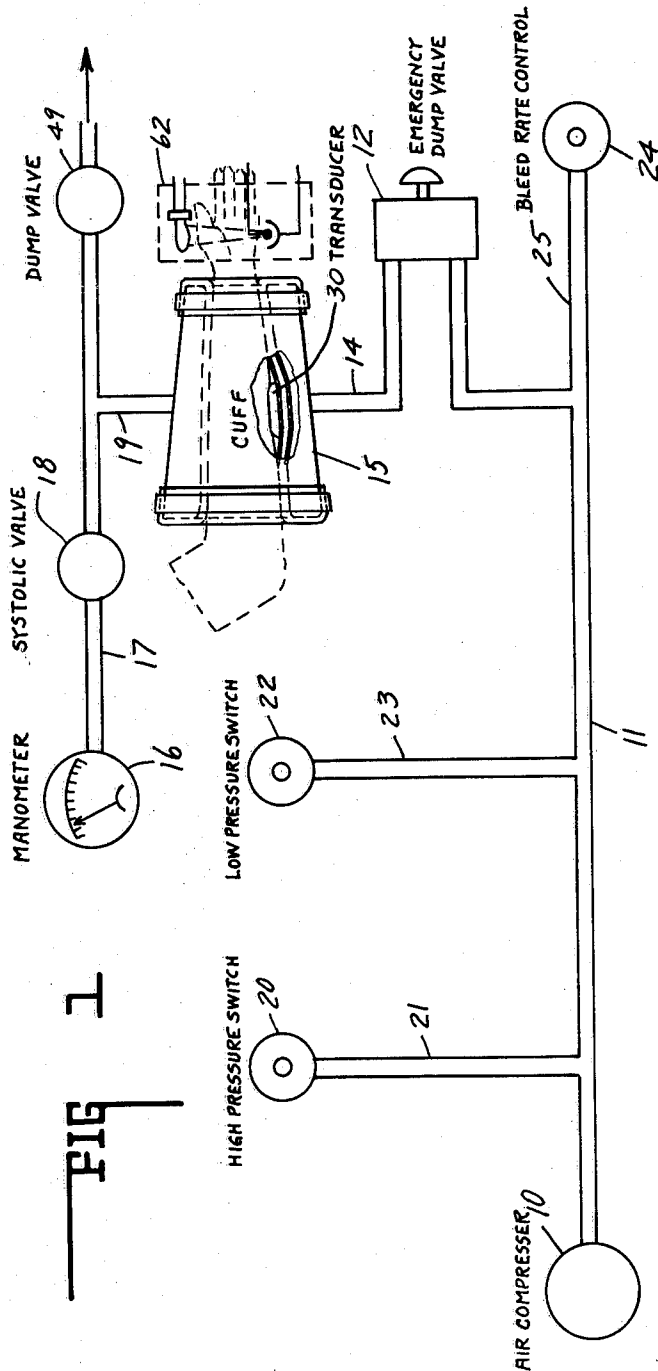
A. E. NEWLAND ETAL

3,086,513

SPHYGMOMETER APPARATUS

Filed June 1, 1959

2 Sheets-Sheet 1



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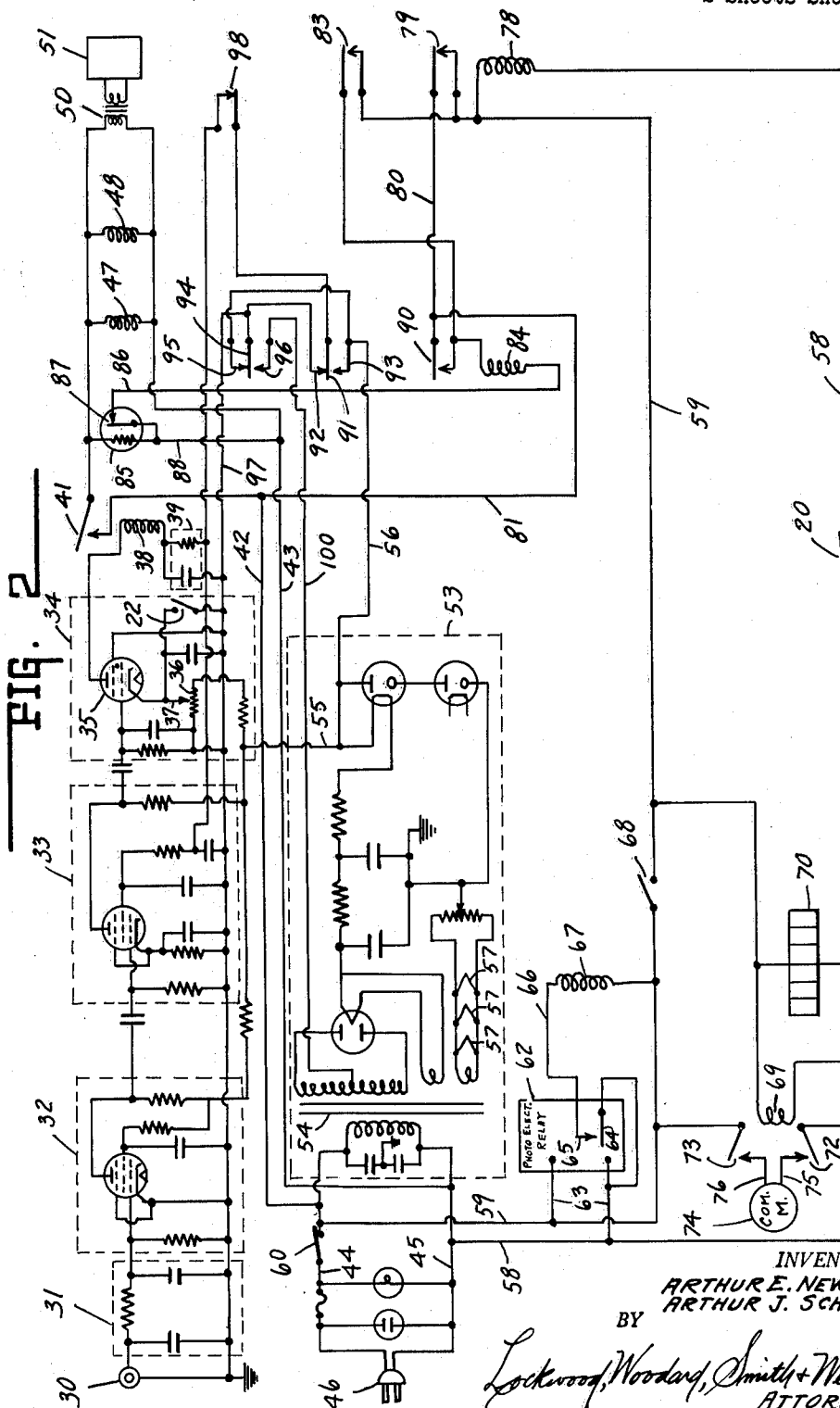
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SPHYGMOMETER APPARATUS

Arthur E. Newland, Bedford, and Arthur J. Schultz, Indianapolis, Ind., assignors, by direct and mesne assignments, of forty percent to said Newland, five percent to Mildred Pratt, Decatur, Ill.; two percent to Irvin E. Huckleberry, Salem, Ind.; twenty percent to Steven Sohacki, Gary, Ind.; five percent to Richard H. Woolery, Bedford, Ind.; three percent to Alex M. Clark, Indianapolis, Ind.; five percent to John K. Spears, Paoli, Ind.; and ten percent each to L. E. Cornwell of Indianapolis, Ind., and The Indiana National Bank of Indianapolis, executors of Paul Henry Cornwell, deceased

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This invention relates generally to a blood pressure indicator and, more particularly, to a blood pressure indicator which may be operated automatically, either in response to a manually actuated electrical switch or a coin operated electrical switch.

Our United States Letters Patent No. 2,865,365 granted December 23, 1958, discloses an electrically operated sphygmometer. The patented sphygmometer is intended to cooperate with a pneumatic system for inflating a pressure cuff operatively associated with a person's body in a manner to constrict a blood vessel. An electrical system cooperates with a pressure cuff in a manner to provide indications of systolic and diastolic pressure. The apparatus illustrated in the patent does not include auxiliary apparatus for enabling use of the sphygmometer as an automatically operable device. No controls are included in the system whereby a person can conveniently and quickly apply a pressure cuff to his body, operate an electrical switch and obtain an indication of his blood pressure.

Accordingly, the primary object of this invention is to provide a sphygmometer or blood pressure indicator adapted for operation in public places in a manner similar to conventional vending machines by what might be termed a "customer," having no medical skill, whereby the customer may operate the indicator to produce an indication of his own blood pressure.

Another object of this invention is to provide a coin operated blood pressure indicator device.

Still another object of this invention is to provide a coin operated blood pressure indicator device adapted automatically to measure a person's blood pressure and provide sustained indication of systolic pressure for a predetermined interval of time.

In accordance with this invention there is provided a blood pressure indicating device comprising a pneumatic system including therein a pressure cuff for application to a person's body, a manometer for indicating pressure in said cuff, and a systolic valve for isolating said manometer from the remainder of the pneumatic system, and an electrical system for controlling the operation of said pneumatic system comprising means for detecting pressure pulses in said cuff, means for amplifying said pulses, and means for detecting the occurrence of a systolic pulse and operatively associated with said systolic valve for closing said valve when systolic pressure occurs in said cuff.

The full nature of the invention will be understood from the accompanying drawings and the following description and claims.

FIG. 1 is a schematic diagram of the pneumatic pressure system as provided in accordance with this invention.

FIG. 2 is a circuit diagram illustrating the electrical circuit for controlling the pneumatic system of FIG. 1.

This invention comprises a pneumatic system having a motor driven air compressor 10 connected by a tube 11 with an emergency dump valve 12 which, in turn, is con-

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nected by means of a tube 14 to an inflatable cuff 15. An indicating manometer 16 is connected through a tube 17, a systolic valve 18 and a tube 19 with the cuff 15. For insuring that the pneumatic system will not exceed a predetermined high pressure, there is provided a high pressure limit switch 20 connected to tube 11 by means of a tube 21, and for providing a minimum pressure in the pneumatic system, a low pressure limit switch 22 is coupled to tube 11 by means of a tube 23. There is also provided a bleeding rate control device 24 connected with tube 11 by means of a tube 25.

It is intended in accordance with this invention to provide a control system wherein the inflatable cuff 15 may be inflated automatically after a person inserts his arm within the cuff and in response to a coin operated device. The system will automatically control the systolic valve 18 in such a manner that the manometer 16 will provide an indication of systolic pressure within a person's body after which the entire system will be restored to its idle condition in preparation for another cycle of operation.

Referring to FIG. 2 of the drawings there is provided a transducer 30 which may be mounted in any suitable manner in cooperation with the cuff 15 so that the transducer will be in intimate contact with the person's arm in such a position that the transducer may respond to blood flow within a vein. Transducer 30 is coupled to ground, as indicated, and also to a filter unit 31 which has a low pass characteristic for removing all sonic or audible pulses which may be generated by the transducer. Only very low frequency pulses appear in the output of the filter, and these pulses represent only the motion of a blood vessel as systolic pressure occurs therein.

The output of filter 31 is coupled to a first amplifier stage 32 which may be any conventional electron tube amplifier. The output of amplifier stage 32 is coupled in conventional manner to a second conventional amplifier stage 33. The output of this amplifier stage is coupled in conventional manner to a computer stage or electronic switch stage 34 which comprises a gas filled thyratron tube 35. There is provided in the cathode circuit of this tube an adjustable resistor 36, the purpose of which is to adjust the firing level of tube 35. Adjustment of the slider 37 to the right increases the voltage on the cathode of tube 35 in a positive direction whereby the control grid becomes relatively more negative. Conversely, adjustment of the slider to the left decreases the voltage on the cathode, making the grid relatively more positive. Thus, the level of the signal applied from amplifier stage 33 to the control grid of tube 35 may be adjusted upwardly or downwardly for determining the level of input signal which may be sufficiently positive to fire tube 35 and cause it to become conductive. Normally open low-pressure switch 22 connects the cathode of tube 35 to ground to prevent operation of tube 35 as will be described. A relay 38 is connected to the anode of tube 35 in series with a delay circuit 39 whereby tube 35 energizes relay 38 when the tube becomes conductive. The delay circuit 39 is for the purpose of preventing operation of relay 38 until after the pressure in the pneumatic system has stabilized, as will be more fully explained.

The contacts 41 of relay 38 function to close a valve operating circuit which may be connected to a source of alternating current (not shown) through lines 42 and 43, lines 44 and 45 and a conventional plug 46. This valve operating circuit includes an electromagnet coil 47 for closing systolic valve 18 and a second electromagnet coil 48, for operating a so-called dump valve 49, together with a transformer 50 which energizes a conventional electrical chime 51. Thus, when contacts 41 are closed, the systolic valve 18 is closed to trap air

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in the tube 17 and manometer 16 to provide an indication of systolic pressure. Dump valve 49 operates simultaneously to exhaust air from the cuff 15 and the remainder of the pneumatic system shown in FIG. 1. The electric chime 51 sounds simultaneously to provide the person operating the system with an audible signal indicating that he should read the manometer to determine the systolic blood pressure.

For providing direct current to the vacuum tube circuit there is provided a conventional rectifier 53 consisting of a transformer 54 connected across the power supply lines 44 and 45. Anode supply voltage is fed to the amplifier stages 32 and 33 through the line 55 while line 56 supplies anode voltage to the computer stage 34 as will be described subsequently. The heater filaments of amplifier stages 32 and 33 and computer stage 34 are indicated at 57.

For controlling the operation of the amplifier stages 32 and 33 and the computer stage 34 to provide indication of systolic blood pressure there is provided a control circuit connected across the power supply conductors 44 and 45 through the conductors 58 and 59. A manually operated emergency switch 60 is connected in series in conductor 44 so that the entire system may be disabled by deenergizing rectifier 53 and the circuits connected across conductors 58 and 59. This enables a person who becomes apprehensive or frightened at any stage of operation of the system to discontinue the operation of the system and free himself of the cuff 15.

In order to prevent false operation of the system prior to insertion of a person's hand and arm within the air cuff 15, there is provided a photoelectric relay circuit 62 having a light source and photoelectric cell connected across conductors 63. The light source directs a light beam across the path which a person's hand and arm must follow when they are inserted in the cuff whereby the system will not operate until the light beam is interrupted by the person's hand and arm. The photoelectric relay circuit 62 controls a normally open relay contact 64 connected in series with the line 58 through one of the conductors 63 and closeable with a contact 65 connected through line 66, coin return solenoid 67 to line 59. Thus interruption of the light beam operating the photoelectric relay circuit 62 closes contacts 64 and 65 energizing the coin return solenoid 67. Solenoid 67 functions in a conventional type of coin box to permit the coin to operate a coin operated switch 68 connected in line 59. If solenoid 67 is not energized, the coin is automatically returned.

Coin operated switch 68 is closed and held closed for approximately five-tenths of a second by the coin mechanism, thereby to energize a motor control relay 69 connected across the lines 58 and 59. Conventional electrical counter mechanism 70 is connected across relay 69 so that it provides a record of each operation of the system. The relay 69 includes a pair of contacts 72 and 73 connected to lines 58 and 59 respectively whereby the compressor motor 74 may be energized through the lines 75 and 76 having contacts closable with contacts 72 and 73 respectively. This causes the compressor 10 to operate and build up the air pressure within the pneumatic system shown in FIG. 1.

For maintaining operation of compressor motor 74 and starting the operation of the amplifier circuit 32, 33, 34, there is provided a starting relay 78 connected across the lines 58 and 59. Relay 78 controls normally open switching contacts 79 connected between line 59 and line 42 through conductors 80 and 81. Closure of contacts 79 connects relays 69 and 78 to conductor 42 through conductors 80 and 81, thereby to hold relays 69 and 78 energized after switch 68 opens. Relay 78 also controls normally open contacts 83 connected between line 59 and holding relay 84 which, in turn, is connected to a thermostatically controlled delay switch 85 through line 86. Switch 85 includes a switching con-

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tact 87 connected between line 86 and line 88 which couples thermostatic delay switch 85 to the power supply line 45 through line 43.

When relay 84 is energized through contacts 83, it closes its normally open contacts 90 thereby to establish a self-energizing circuit across lines 42 and 43 through conductors 81 and 86, contacts 87 and conductor 88. Relay 84 controls tongue 91 normally closed with a contact 92 and operable by relay 84 to close with contact 93. Relay 84 also controls tongue 94 normally closed with contact 95 and operable by relay 84 to close with contact 96.

When tongue 91 is closed with contact 92 and tongue 94 is closed with contact 95, it will be seen that the grounded line 97 is connected through normally closed contacts 98 of relay 78 thereby to ground the anode supply circuit of the thyatron tube 35 through the delay circuit 39 and the winding of relay 38. The ground line 97 is also contacted through contacts 94, 95 to line 56 and, thus, the anodes of tubes 32 and 33 are grounded through line 55, line 56, contacts 94, 95 and line 97. In this manner the amplifier circuit is prevented from operating until after maximum pressure is attained in the pneumatic system and high pressure switch 20 has been opened. After the coin is inserted in the coin mechanism the coin switch 68 closes, energizing relays 78 and 84. Relay 78 opens its contact 98. Meanwhile, relay 84 operates and locks up its own energizing circuit and closes its tongue 91 with contact 93 and its tongue 94 with contact 96. Contact 96 being connected to power supply 53 through line 100, ground is immediately applied thereto from line 97. Contact 93 being connected with line 56, closure of tongue 91 therewith connects anode voltage to the open contacts 98. Relay 78 de-energizes when switch 20 opens, thereby permitting contacts 98 to close and connect anode supply voltage to the anode of tube 35 through delay circuit 39 and relay 38. Simultaneously contact 79 opens, deenergizing relay 69 and opening the circuit of compressor motor 74.

In operation, a person desiring to obtain a measurement of his blood pressure can insert his arm within cuff 15. This action interrupts the light beam normally actuating the photoelectric relay circuit 62 whereby contacts 64 and 65 close to energize coin return solenoid 67. The person may then insert a coin return solenoid 67. switch 68. The emergency switch 60 being normally closed, closure of switch 68 energizes the motor control relay 69 closing its contacts to start the compressor motor 74. Simultaneously, the counter 70 is energized to record a cycle of operation of the system.

Then the compressor 10 is started by motor 74, air pressure builds up in the pneumatic system to a maximum of approximately 220 millimeters of mercury, at which time the high pressure limit switch 20 opens to stop compressor motor 74. In this manner the cuff 15 is inflated to a degree sufficient to stop circulation of blood in the veins and arteries of the person's arm. Also, the transducer 30 is engaged with the person's arm in firm contact therewith. The cuff may be a generally cylindrical device formed of rubber and designed in such a manner as to contract internally under air pressure and collapse the blood vessels of the person's arm to an extent that flow of blood is substantially stopped.

Meanwhile, closure of the coin switch 68 energizes the starting relay 78 which operates its contacts 79 and 83 to energize and lock up the switching relay 84. Contact 98 of relay 78 is opened thereby to prevent application of anode potential to the anode of thyatron 35. Without such anode potential, the thyatron cannot respond to electrical waves generated by the transducer in response to pulsations of air within the pneumatic system while it is being inflated by the compressor.

When limit switch 20 opens in response to maximum pressure, relay 78 is deenergized, thereby permitting all of its contacts to assume their original positions, contact

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98 closing to complete the anode potential circuit to thyatron 35. Meanwhile, relay 84 operated its tongues 91 and 94 to connect anode potential from rectifier 53 to contact 98.

The delay circuit 39 provides a slight delay in application of anode potential to thyatron 35, permitting transient pulsations within the pneumatic system to decay so that when thyatron 35 is finally energized no false operation is possible.

As the previously described functions occur, the bleed rate control valve 24 exhausts air from the pneumatic system, lowering the pressure therein at a rate of approximately 5 millimeters of mercury per second. The pressure in the pneumatic system continues to decrease until the systole occurs, or if the person is incapable of producing a systolic pulse within normal pressure range, the normally open low pressure switch 22 operates at a pressure of 105 millimeters of mercury and closes to connect the cathode of tube 35 to ground, thereby to prevent actuation thereof. When a systole occurs within the normal pressure range, there is a throbbing motion of the blood passing through all of the vessels in the person's extremity within the cuff and under the transducer and the transducer 30 generates a low motional voltage wave, corresponding to this throbbing or pulsating action, which is impressed on the grid of amplifier 32. The signal wave is amplified in amplifier stages 32 and 33 and applied to the control grid of thyatron 35. The amplified wave changes the potential on the grid to a degree sufficient to fire thyatron 35 whereby the tube conducts, causing anode current to flow through relay 38.

At this point sufficient current flows through relay 38 to cause contact 41 to close, applying voltage from lines 42 and 43 to the systolic valve control winding 47 and the dump valve control winding 48. The systolic valve 18 is closed isolating the manometer 16. As the pressure decreased in the pneumatic system, the reading on the manometer also decreased so that closure of valve 18 stops the needle of the manometer at the point indicating the systolic pressure of the person. At the time that the systolic valve is closed, transformer 50 is energized to actuate the electrical chime 51 which serves to notify the person that he should read the systolic pressure indicated by the manometer.

The manometer reading is maintained for approximately 20 seconds at which time the thermal delay relay 85 will have opened its contacts 87 deenergizing relay 84 and restoring the entire system to its idle condition.

From the foregoing description it will be readily apparent that this invention provides a coin operated means of indicating blood pressure wherein completely adequate safeguards are provided for preventing false indications of blood pressure and any discomfort to the person operating the device. The photoelectric detection device 62 prevents operation of the indicating system until the person's arm is in proper position within the cuff. The system includes means 60 for allowing the person to release himself at any time should he become uncomfortable or fearful. Also false indications of blood pressure are prevented by delay circuit 39 prior to stabilization of the pneumatic system. In addition, maximum and minimum pressures are established within the pneumatic system by high pressure limit switch 20 and low pressure switch 22, respectively so that there can be no excessive and uncomfortable pressure on the person's arm and so that excessively low pressures will not create false indications.

The invention claimed is:

1. A systolic pressure measuring system comprising in

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combination a pneumatic system for providing an indication of a person's systolic pressure and a coin operated electrical control system for initiating operation of said pneumatic system and terminating a cycle of operation of said pneumatic system when systolic pressure has been indicated, said pneumatic system comprising an inflatable cuff for receiving a person's arm and applying pressure thereto for stopping circulation of blood therein, a transducer associated with said cuff for pressure contact with the person's arm, an air compressor, a manometer, an electrically operable valve between said compressor and said manometer operable to isolate said manometer from said compressor, and a bleeder valve adapted to reduce pressure in said pneumatic system at a controlled rate, said coin operated control system comprising an amplifier coupled to said transducer for producing an electrical wave as a function of the person's systolic blood pressure, switch means coupled to said amplifier and said valve and responsive to said wave for operating said valve to isolate said manometer when pressure equal to the person's systolic pressure occurs, coin operated switch means in said control system for initiating operation of said pneumatic system and switch means coupled to said pneumatic system and said amplifier and responsive to a predetermined pressure in said pneumatic system for initiating operation of said amplifier.

2. The systolic pressure measuring system of claim 1 in which said control system includes means coupled to said amplifier for delaying operation of said wave producing means until pressure has been stabilized in said pneumatic system.

3. The systolic pressure measuring system of claim 1 in which said control system includes relay switching means coupled to said amplifier for deenergizing said wave producing means while said pressure applying means is initially operating and thereafter energizing said wave producing means.

4. The systolic pressure measuring system of claim 1 in which said control system includes switch means for maintaining operation of said pressure indicating means for a predetermined period of time and thereafter terminating operation of said pressure indicating means and restoring said control system and said pneumatic system to idle condition.

5. The systolic pressure measuring system of claim 1 in which said control system includes photoelectric means adjacent said cuff for detecting the presence of the person's arm, in said pressure applying means and conditioning said coin operated switch means for actuation by a coin.

6. The systolic pressure measuring system of claim 1 in which said pneumatic system includes a high pressure limit switch operable at a predetermined maximum pressure within said pneumatic system, and said control system includes means responsive to said high pressure limit switch for terminating inflation of said pneumatic system when said maximum pressure is attained, and means coupled to said amplifier for normally deenergizing said wave producing means and operable by said high pressure limit switch for energizing said wave producing means after said maximum pressure is attained in said pneumatic system.

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