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APPARATUS AND METHOD FOR ENHANCING BLOOD CIRCULATION

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3 Sheets-Sheet 1

Fig. 2.

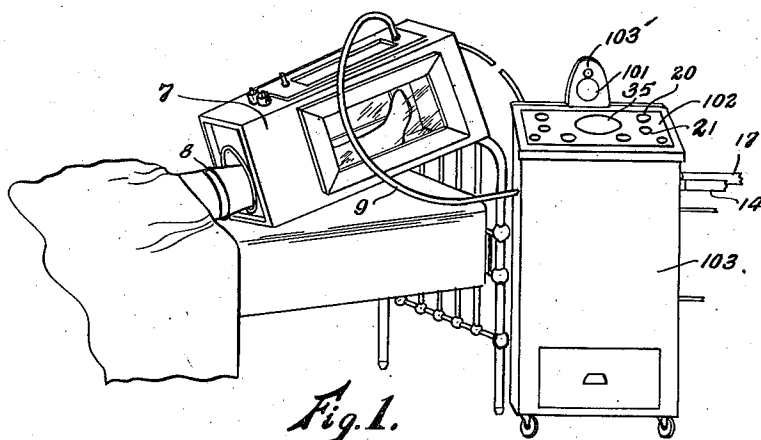
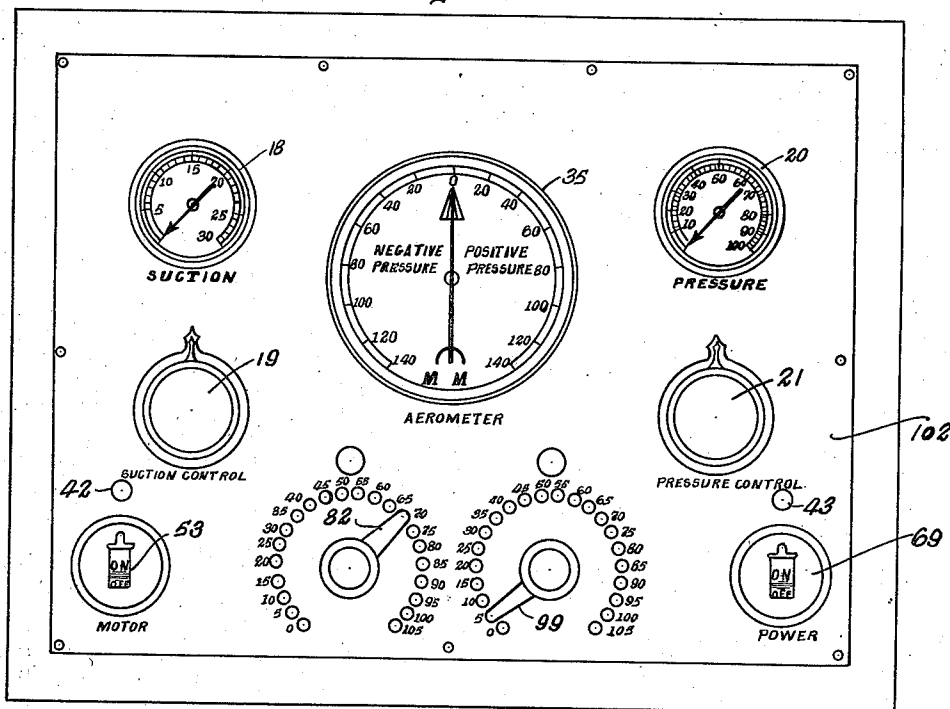


Fig. 1.

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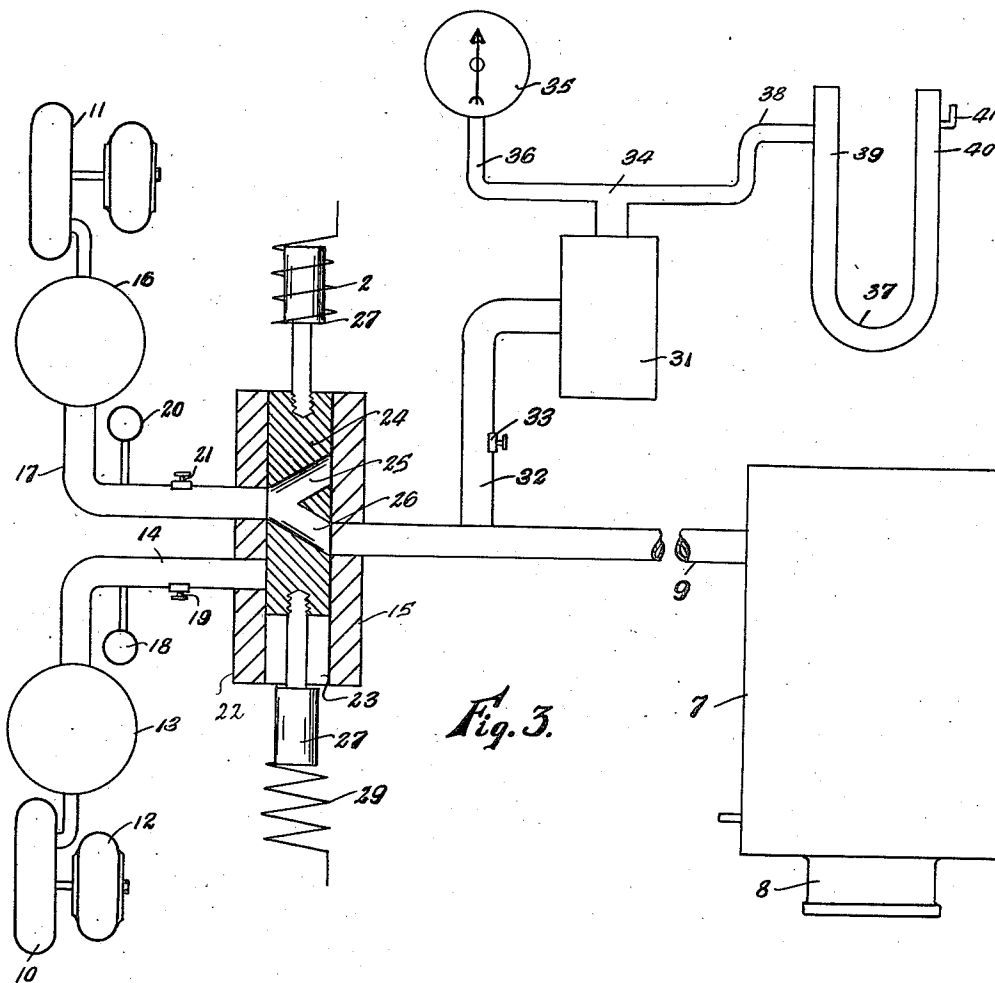


Fig. 3.

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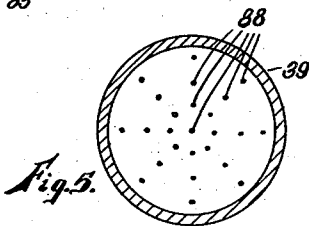
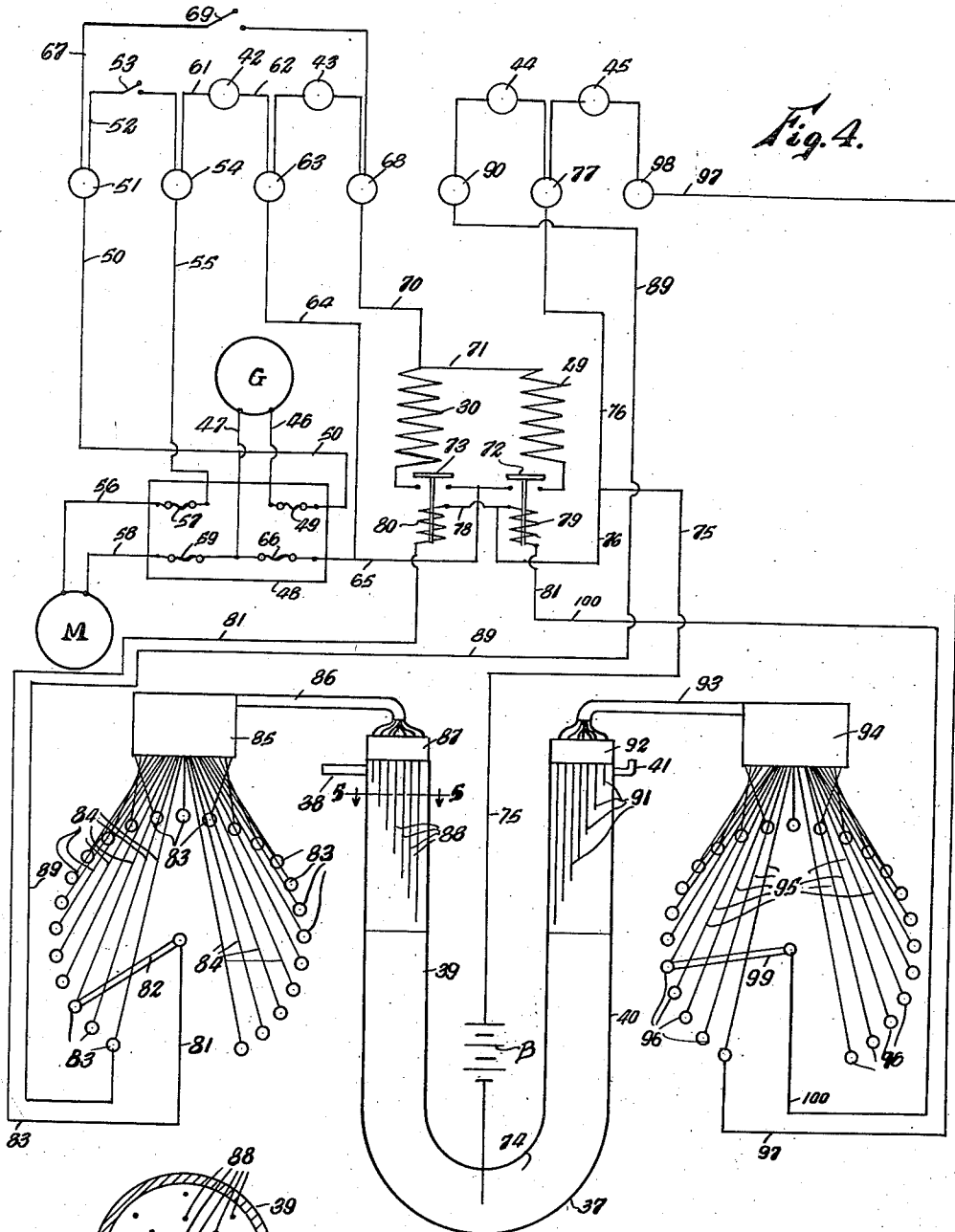
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APPARATUS AND METHOD FOR ENHANCING BLOOD CIRCULATION

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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APPARATUS AND METHOD FOR ENHANCING BLOOD CIRCULATION

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6 Claims. (Cl. 128—299)

The present invention relates to a novel method of an apparatus for treatment of disturbances of circulation of blood and lymph in the extremities and has for its object the provision of a method and means whereby the extremities affected by such disturbances may have adequate collateral circulation established therein.

These and other objects are attained by the means and method herein described and shown in the accompanying drawings, in which:

Fig. 1 is a perspective view showing an apparatus of the invention in operative use.

Fig. 2 is an enlarged view of a control panel-board associated with the apparatus.

Fig. 3 is a schematic lay-out diagram of the pressure system embodied in an apparatus of the invention.

Fig. 4 is a wiring diagram showing the electrical automatic and control circuits for the apparatus of the invention.

Fig. 5 is a view taken on line 5—5 of Fig. 4.

Arteriosclerosis as well as other forms of obliterative arterial and lymphatic disturbances in the extremities of the human body have not yielded appreciably to treatment heretofore. These latter mentioned cases are numerous, however, and are the cause of much suffering. The particular details of the diseases and of the attendant or subsequent circulatory disturbances in the extremities are to be found in scientific publications and for the purposes of this disclosure require no detailed explanation. It has been found that if sufficient collateral circulation is induced in the parts affected by manipulative methods without material injury thereto, the amplified collateral circulation becomes sustained and frequently effects permanent relief of the distressing symptoms and results in normal use of the parts.

The method whereby this manipulative treatment is applied with a minimum of danger as hereinafter described is intended for use only by or under the supervision of competent physicians whose diagnosis and knowledge of the nature of the various types of peripheral vascular disturbances will enable them to determine when and to what extent the treatment shall be used.

It is pointed out that in the cycle of treatment, the positive pressure limit should be very slight, that is, of the order of plus twenty millimetres of mercury, whereas the negative pressure limit should be of the order of seventy to eighty millimetres of mercury so that the pressure applied to the extremity is predominantly in the negative phase. The importance of having the pressure

predominantly in the negative phase will be appreciated from the following explanation:

The present character of the pressure curve used for passive vascular exercises, which consists of the gradual rise and fall, in cyclic sequence, of the air pressure about an extremity with the pressure predominantly in the phase below the existing atmospheric pressure, was arrived at after many thousand hours of clinical experience and experimental studies. During the experimental studies, the arteries were actually observed and the various types of alternations of environmental pressure were used to see which would bring about the greatest increase in circulation with the least damage to the delicate lining of the smaller blood vessels. When applicant applied the alternation of environmental pressure to people with diseased arteries, he found that the use of positive pressure caused a compression of the hardened arteries and this compression usually gave rise to small cracks in the inner lining of the blood vessels. These cracks permitted the tissue fluids to come in contact with the circulating blood, with the result that at the point of damage of the inner lining of the arteries the blood would clot instead of remaining fluid. This blood clot would then propagate due to the fact that it extended directly into the lumen of the vessel, and then caused a rapid extension of the clot or thrombosis throughout the length of the vessel.

It was likewise shown in the study of people with diseased arteries that the actual increase in the flow of blood, took place only during the negative phase of the cycle. Therefore, combining these two observations, one will see that it is extremely important that diseased arteries suffer no compression during the entire cycle and since pressure of more than forty millimetres of mercury above atmospheric pressure definitely compress these vessels, experience has shown that it is extremely hazardous to use a cycle which often precipitates secondary thrombosis.

Applicant's invention is based on his discovery that any substantial positive pressure on the arteries is fraught with danger of the most serious nature. He has devised a method which eliminates this danger.

In its broadest aspects the method of the invention consists in alternation of negative and positive pressures applied rhythmically and at regular intervals to the affected extremities. More specifically and by way of example, the affected extremity is placed in a sealed treatment boot or chamber in which negative pressure is

slowly allowed to reach a desired selected level of about seventy to eighty millimeters of mercury during a time period of several seconds more or less, after which the negative pressure is normalized and a positive pressure is built up until a desired level of about twenty millimeters of mercury positive pressure is reached. The intervals between peak negative pressure and peak positive pressure should be regular and rhythmic and this alternation should continue for a suitable treatment period of about twenty minutes. The frequency and duration of treatments as well as the degrees of negative and positive pressures and the rate of alternation are subject to change according to the condition of the parts treated as diagnosed by the physician. Such treatment, continued under the direction of the competent physician effects permanently beneficial results in many cases.

In order that the patients under the care of the physician may be treated exactly as prescribed, apparatus is provided whereby the automatic positive and negative pressure alternations are attained within the suitably designed boot or chamber in which the extremity is placed. The apparatus further comprises, in conjunction with means to effect suction or negative pressure and means to effect positive pressure in the boot, means to independently regulate the positive and negative pressures from five millimeters of mercury to one hundred twenty (120) millimeters of mercury and also means to independently regulate the rates of pressure flow to and from the boot so that the time intervals for attaining the desired peak of positive and negative pressures may be regulated with extreme accuracy. Means are provided to automatically carry on the pressure alternations at a selected rate and degree after being adjusted thereto so that the physician who is thoroughly conversant with the condition of the extremities of the patient to be treated can prescribe the details of treatment for the patient and have the actual treatment of the patient carried on under the care of a trained and careful assistant.

The apparatus of the invention consists essentially in a treatment chamber or treatment boot 7, the particular construction of which is subject to variation in shape and size as well as in materials, it being essential only that the chamber shall be air-tight or substantially so, and of sufficient strength to withstand the effects of increased and reduced interior pressures. The extremity, either the forearm or lower leg of the patient, is inserted in the treatment boot or chamber through a flexible resilient tube or cuff 8 which is connected with, and in part forms one wall of the chamber 7. With the extremity in place within the chamber and surrounded by the cuff, the pressure interiorly of the chamber may be varied in accordance with the teachings previously explained to beneficially act upon the extremity for initiating and inducing the continued amplification of collateral circulation in the extremity treated. A conduit 9 serves to direct a positive air pressure flow into, or a negative air pressure flow from the chamber and the positive and negative pressures may be produced by any suitable agency such as a vacuum pump 10 and a compressor 11 which are alternately connectible with the conduit 9. A manometer is considered essential and desirable in any embodiment of the apparatus as are control valves which serve to regulate the rate at which pressure air is introduced and air is withdrawn from

the treatment chamber by the respective instrumentalities 10 and 11.

The apparatus, in its preferred form also includes means whereby the attainment of predetermined or desired negative and positive pressures in the treatment chamber automatically shuts off further increase of such positive or negative pressures and provides for the reduction thereof to atmospheric pressure or beyond. Such automatic apparatus enables the skilled and competent physician to prescribe treatment and to have it actually administered by a skilled and trained assistant, or it enables the physician to personally arrange for the treatment, but leaves him free of the necessity for constant attendance on the patient during the treatment period.

Such desirable automatic adjusting and alternation actuating means are illustrated diagrammatically and schematically in Figs. 3 and 4, wherein the vacuum pump 10, suitably driven as by motor 12 may be set into operation to continuously evacuate air from tank 13 which communicates through pipe 14 with a suitable alternating valve indicated generally at 15. The compressor 11 discharges into pressure tank 16 which communicates by way of pipe 17 with the alternating valve 15. In establishments such as hospitals and the like wherein a piped source of compressed air is available, such source may be employed in lieu of an individual compressor for the apparatus. For apparatus of a portable or semi-portable nature, it is desirable to have the entire operating mechanism self-contained in a cabinet as shown in Fig. 1, and any suitable known means for effecting an ample rate of evacuation and a suitable pressure may be employed, combined vacuum and pressure pumps such as are available in the markets being usable for the purpose. Interposed in the line 14 between tank 13 and alternating valve 15, is a suction gauge 18 and a manually adjustable suction control valve 19, the latter being of any suitable needle valve type. In the line 17 between pressure tank 16 and the alternating valve 15 is a pressure gauge 20 and a needle valve 21 for adjusting the rate of pressure air flow from the tank to the valve. The alternating valve 15 may be of any suitable construction; for example, as shown in the drawings wherein the block 22 has a cylindrical bore 23 extending therethrough, and the pipes 14 and 17 communicate with this bore intermediate its ends. Diametrically opposite and longitudinally intermediate the points of communication of pipes 14 and 17 is the terminus of conduit 9 which communicates with the treatment chamber 7, as aforesaid. A piston 24 is reciprocable in the bore 23 and has a pair of diagonally transverse bores 25 and 26 which communicate at one side thereof and which are adapted, upon reciprocation of the piston, for alternate registry with the terminal ends of pipes 14 and 17, the bore 26 thus communicating pressure air flow from tank 16 through conduit 9 to the chamber 7 while bore 25 is sealed by the wall of bore 23. Upon proper longitudinal movement of piston 24, the bore 25 establishes communication between pipe 14 and conduit 9 for evacuating air from chamber 7 to establish sub-atmospheric pressure therein. The means for reciprocating valve 24 are in the present embodiment, electro-magnetic. Armatures 27 and 28 are connected respectively to the opposite ends of the valve and are subject to the action of suction coils or solenoids 29 and 30 respectively.

In order to closely associate all metering devices and controls for the apparatus, so that the

conditions and rates of change of pressure in the treatment chamber can be observed and controlled at a point remote therefrom, i. e., as at a control and instrument board which may be associated with the housing cabinet for the apparatus, a balancing tank 31 is connected by pipe 32 with conduit 9 and a needle valve 33 is interposed in the pipe 32 to enable the regulation of the flow of pressure air to and from balancing tank 31 to be proportioned to the rates of flow to and from the treatment chamber 7. From balancing tank 31 extends a communicating tubular T connection 34, to one side of which is connected a dial type manometer 35 by pipe 36, and to the other side of which is connected a mercury U tube 37, the connection being made through pipe 38 which connects with the arm 39 of the U tube. The arm 40 of the mercury U tube is vented to the atmosphere as at 41.

As will be appreciated from an inspection of Fig. 4 in conjunction with the hereinafter described electrical circuits, the mercury U tube 37 is sealed at least at the top of arm 39. Referring now to the diagrammatic showing in Fig. 4, the means whereby automatic alternation and the adjustment of positive and negative pressures is attained, the solenoids 29 and 30, the motor or motors M and the signal lights 42 and 43 are all preferably energized from an ordinary source of house current. The relays controlling energization of the solenoids and of the signal lights 44 and 45 are preferably under the control of a low voltage circuit, e. g., a battery circuit.

Current source G, selected according to the designed electrical rating of the machine, connects through lines 46 and 47 with fuse panel 48 where line 46 connects through fuse 49 with conductor 50. The current passes to binding post 51, through line 52 which has a motor control switch 53 in it and thence to binding post 54 and back to fuse panel 48 through line 55. The motor M has the lead 56 thereof connected to line 55 through fuse 57 and the lead 58 connected through fuse 59 to supply line 47. A signal light 42 is shunted around this motor circuit through binding post 54, line 61—62 to binding post 63 and thence through lines 64 and 65 and fuse 66 to supply line 47. The motor M corresponds to motor 12 of Fig. 3 where the vacuum pump would be normally inoperative when the apparatus is not in use but the pressure pump 11 offers constant pressure supply for other non-related purposes. Obviously a double service motor or two motors may be used in the circuit described under other constructions.

The valve actuating solenoids are included in the so-termed power circuit comprising a line 67 which connects binding post 51 and binding post 68 with a power switch 69 interposed, thence through line 70 to a branch line 71 which connects with an end of each of the solenoids 29 and 30. At the opposite ends of said solenoids are switches 72 and 73 which are relay-actuated, and that alternately connect their respective solenoids to line 65. A signal light 43 for the power circuit just described is connected between binding posts 68 and 63 and is energized so long as power switch 69 is closed.

While it is contemplated that switches 72 and 73 may be of the manually operable type, the preferred form of apparatus as illustrated provides for the automatic actuation thereof by pressure responsive switching means. This means includes a suitable source of current of low voltage such as a battery B, one terminal of

which is electrically connected with the body of mercury 74 in the U tube 37. The other terminal of said battery connects, through lines 75 and 76 to binding post 77, and also to the branch line 78 which connects to an end of each of the relay coils 79 and 80. From the opposite end of coil 80 a conductor line 81 connects with the selector arm 82 which is manually rotatable to contact with selector contacts 83 which are independently connected by means of wires 84, connector block 85, multiple wire cable 86 and terminal block 87, to the several depending dip contacts 88 of graduated length in the arm 39 of the mercury U tube. The longest of the dip contacts connects with the first contact 83 of the series, from which contact, wire 89 passes to connect with binding post 90. A signal light 44 of suitable color, e. g., red, is connected in series with binding posts 90 and 77.

The arm 40 of the mercury U tube is provided with a series of dip contacts 91, corresponding to dip contacts 88, and connected through terminal block 92, cable 93, connector block 94 and wires 95 to the respective selector contacts 96. The first contact 96 of this series connects through wire 97 to binding post 98. Signal light 45 is connected in series between binding posts 98 and 77. The remaining contacts 96 connect successively to successively shorter dip contacts 91. Selector arm 99 completes a circuit from any given contact 96, through wire 100 to the relay 79. From the foregoing it will be noted that with substantially atmospheric pressure in the sealed upper portion of arm 39, the level of mercury in both arms of the U tube will be below the longest dip contacts 88 and 91 and the relays 79 and 80 and signal lights 44 and 45 will be deenergized.

In operation, assuming that switches 53 and 69 have been closed and the piston 24 is in the position shown in Fig. 3, the pressure from supply tank 16 will direct a flow of pressure air through pipe 17, regulator valve 21, alternating valve 15, through pipe 38 into arm 39 of U tube 37, thus gradually forcing the level of mercury down in arm 39 and raising the mercury level in arm 40. When the mercury column reaches the longest dip contact 91 a circuit is completed through the mercury 74, the battery B, line 75, line 76, signal light 45, line 97 to the first contact 96 and from thence through the associated wire 95, cable 93 back to the dip contact 91. This apprises the operator of the fact that positive pressure is being built up in treatment chamber 7. The dial manometer 35 indicates the amount of pressure in chamber 7 and balance tank 31 as previously explained, and the rate of rise is easily adjusted by manipulation of needle valve 21 especially with the aid of clock 101 that is conveniently provided adjacent the instrument and control panel 102. The dip contacts in this embodiment are so graduated in length as to afford contact with a successive contact with every pressure increase of 5 m. m. of mercury. With the arm 99 set on a given contact 96, the pressure will continue to rise until the rising column of mercury reaches the associated dip contact 91 when a circuit is established through the mercury column, the said dip contact, selector contact 96 and arm 99, thence by way of wire 100 through relay 79, returning through branch 78, wire 76, wire 75 and the battery. Switch 72 is closed by actuation of the relay so that coil 29 is now energized in its circuit from the source of supply G and wires 50 and 65. Valve 24 is shifted magnetically by coil 75

29 and shuts off the positive pressure flow from pipe 17 and opens up communication between pipe 9 and pipe 14 so that suction, regulated by needle valve 19, causes a reduction of the positive pressure at the desired rate down to atmospheric pressure and continues to set up a progressively increasing negative pressure causing the mercury column in arm 39 to rise. During the fall of positive pressure the relay 79 was first deenergized and then, just before atmospheric pressure was attained the signal light 45 was extinguished. Thereafter with the rise of mercury in the arm 39, the signal light 44 is energized, and finally upon reaching of a negative pressure according to the setting of selector arm 82, the relay 80 is energized to close the power circuit at switch 73 and cause shifting of valve 24 back to its original position due to the energization of solenoid 30. This automatic alternation continues rhythmically and regularly according to the setting of the several selectors and regulator valves to continuously vary the pressure in the treatment boot or chamber until the apparatus is stopped by opening power switch 69.

The alternating valve, relays, balancing tank, and mercury tube are preferably housed in cabinet 103 but other parts may also be installed therein.

The clock 101 is preferably of the electric chronometer type with a variable time interval alarm 103 of any approved type associated therewith so that the prescribed duration of treatment may be given with accuracy.

It will be understood that the form of electrically operated pressure selector may be subject to alteration in form and design. Other details of construction are likewise subject to modification within the scope of the appended claims.

What is claimed is:

1. In a device of the class described, the combination of a treatment boot adapted to receive a human extremity only, in isolated relation to atmospheric pressure, air suction means, air pressure means, means including a control valve slidable to effect alternately communication between the boot and the respective pressure and suction means, and electromagnet means including a mercury type switch responsive to the pressure in said boot and communicating with the boot to automatically control the sudden shifting of the valve.

2. In a device of the class described, the combination of a treatment chamber adapted to receive a human extremity only, in isolated relation to atmospheric pressure, a positive pressure fluid source, a negative pressure fluid source, means including a conduit and an electrically operated valve mechanism for effecting communication between said chamber and either of said sources, a pressure fluid actuated electrical switching means communicating with said conduit and responsive to predetermined limiting positive and negative pressures therein, and an operating circuit for said valve mechanism completed by said switching means.

3. In a device of the class described, the combination of a treatment chamber adapted to receive a human extremity only, in isolated relation to atmospheric pressure, a positive pressure fluid source, a negative pressure fluid source, means including a conduit and valve mechanism for effecting communication between said chamber and either of said sources, a pressure-actuated device for operating said valve mechanism, said device communicating with said conduit and responsive to predetermined limiting positive and negative pressures therein, and a damping or balancing chamber through which said pressures are communicated to said device.

4. In a device of the class described, the combination of a treatment chamber adapted to receive a human extremity only, in isolated relation to atmospheric pressure, a positive pressure fluid source, a negative pressure fluid source, means including a main conduit and a valve for effecting communication between said chamber and either of said sources, a pressure-actuated device for operating said valve, said device being responsive to predetermined limiting positive and negative pressures, a branch conduit communicating with said device and with said main conduit, and a damping or balancing chamber in said branch conduit between said main conduit and said device.

5. In a device of the class described, the combination of a treatment chamber adapted to receive a human extremity only, in isolated relation to atmospheric pressure, a positive pressure fluid source, a negative pressure fluid source, means including a conduit and electrically operated valve mechanism for effecting communication between said chamber and either of said sources, a pressure fluid actuated control unit comprising a U-tube containing an electrically conducting liquid and having one of its ends communicating with said conduit, a set of electrical contacts of different lengths projecting into each arm of said tube, a switch individual to each set of contacts and adjustable to render any selected contact of a set effective, and circuits controlling the reversal of said valve mechanism, said circuits being respectively completed through said liquid and the effective contact of said sets as said liquid respectively engages said effective contacts in response to the pressure conditions in said conduit.

6. A method of operating a passive vascular exerciser to enhance the blood circulation in an extremity of a human body, said exerciser including a chamber in which the extremity can be inserted and substantially sealed from atmospheric pressure, which method comprises applying rhythmically and at regular intervals a variation of environmental pressure in said chamber in a fixed cycle, in which negative pressure is caused to reach slowly a desired selected level of about seventy to eighty millimetres of mercury below atmospheric pressure after which the negative pressure is neutralized and a positive pressure is built up in the chamber to a desired level of the order of twenty millimetres of mercury.

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CERTIFICATE OF CORRECTION.

Patent No. 2,055,128.

September 22, 1936.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, first column, line 49, claim 1, for "electromagnet" read electromagnetic; and in the drawings, sheets 1, 2 and 3, strike out the name "Mont R. Reid", and for the word "Inventors" read Inventor; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 8th day of December, A. D. 1936.

Henry Van Arsdale

(Seal)

Acting Commissioner of Patents.