

March 18, 1941.

H. A. BILLETTER

2,235,138

THERAPEUTICAL APPARATUS

Filed April 28, 1938

2 Sheets-Sheet 1

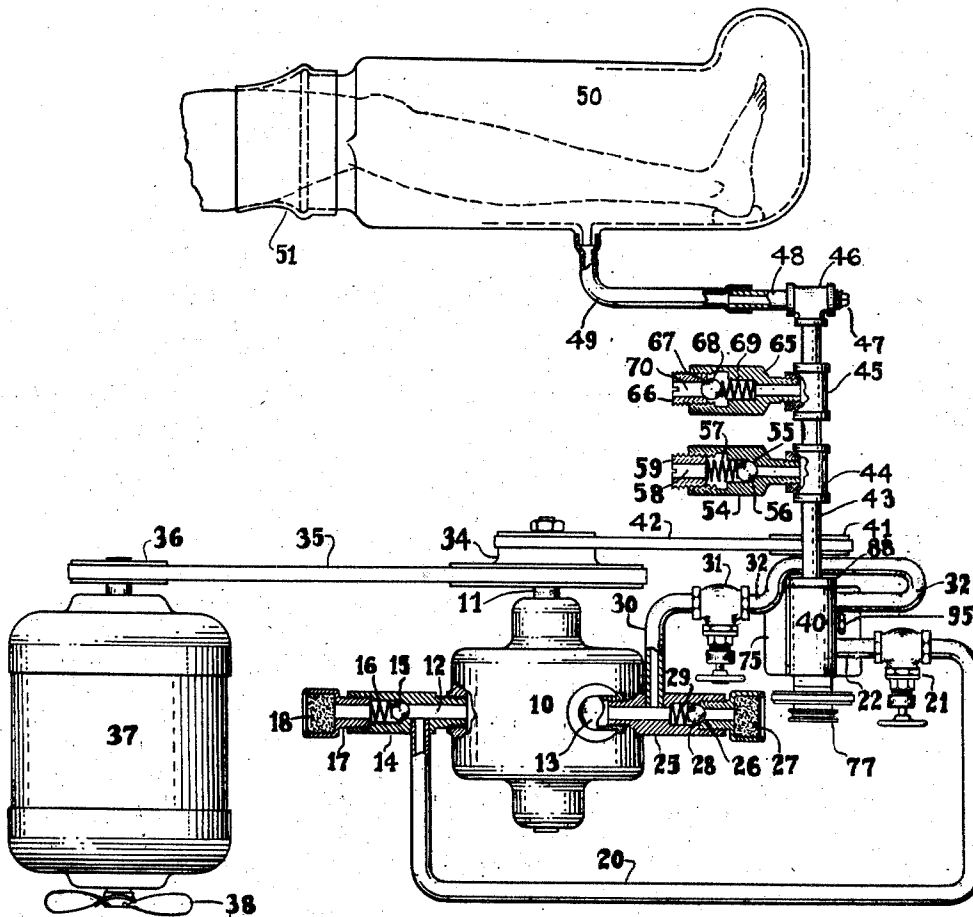


Fig 1

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2 Sheets-Sheet 2

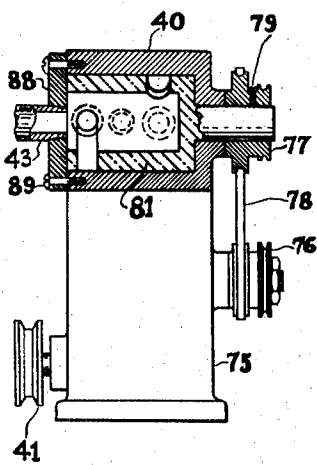


Fig. 3

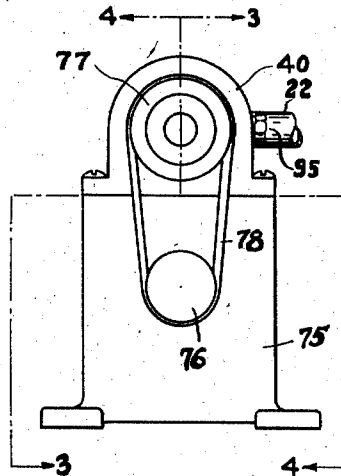


Fig. 2

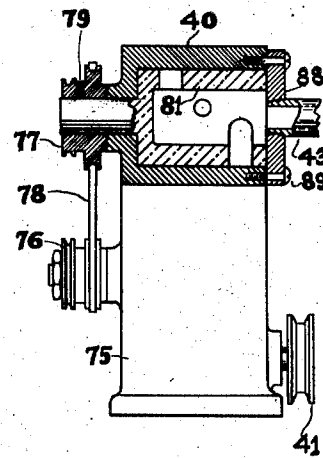


Fig. 4

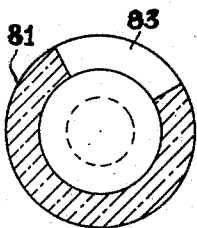


Fig. 7

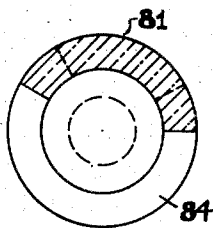


Fig. 6

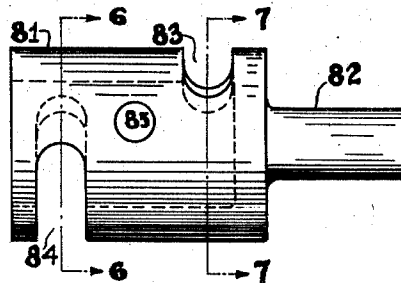


Fig. 5

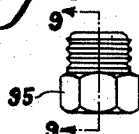


Fig. 8

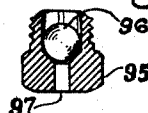


Fig. 9

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2,235,138

THERAPEUTICAL APPARATUS

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Application April 28, 1938, Serial No. 204,810

6 Claims. (Cl. 128—299)

This invention relates to an apparatus useful in the treatment of certain diseases of the circulatory system of the human body and more particularly to an apparatus for subjecting extremities of the body to cyclic variations of environmental pressure between preselected positive and negative pressure limits. In order that the treatment may attain maximum beneficial results the nature of the same is prescribed in each individual case based on the results of an examination of the patient by the attending physician. The frequency of the pressure variations as well as the limits thereof are determined for each case and it is therefore essential that the apparatus used to apply the treatment be capable of adjustment both as to frequency and pressure limits.

The method of treatment is well known and various machines have been devised to carry out the method but each of the machines for the purpose of which I am aware are deficient in a number of respects and it is, accordingly, the primary object of my invention to provide an apparatus for the purpose described which may be economically constructed, easily serviced and operated, and which possesses certain desirable operating characteristics not inherent in the devices of the prior art.

A further object of the invention is the provision of an apparatus for the purpose stated which is flexible in its adaptability and certain in operation regardless of the manner in which the apparatus is used.

Another object of the invention is the provision of an apparatus of the kind described which is reliable and quiet in operation, which attributes are attained by the exclusive use of rugged and simply designed parts and the absence of any reciprocating or intermittently moving mechanically actuated elements.

The above and other objects and advantages of the invention will become apparent from a consideration of the drawings and the following detailed specification of one form of apparatus embodying the principles of the invention.

In the drawings:

Figure 1 is an assembled view, partly in section, of an apparatus embodying my invention;

Figure 2 is an end view of a mechanically operated valve of the apparatus of Figure 1;

Figure 3 is a sectional view of the valve of Figure 2, taken along the line 3—3 of Figure 2;

Figure 4 is a sectional view, taken along the line 4—4 of Figure 2;

Figure 5 is an enlarged view of the rotating valve part;

Figures 6 and 7 are sectional views of the valve part of Figure 5, taken along the lines 6—6 and 7—7, respectively, of Figure 5; and

Figures 8 and 9 are elevation and section views, respectively, of another valve part.

In carrying out my invention I provide a fluid pump 10, preferably of the rotary type for quietness and smoothness of operation, the pump being driven through shaft 11 on which is keyed the double pulley 34 driven by a suitable motor 37 through motor pulley 36 and belt 35. In actual construction of the machine, the pump 10, motor 37 and other moving parts are suitably mounted on a base or in a cabinet on resilient rubber cushions to lessen noise and vibration and the parts are so arranged that a current of air provided by the fan 38 on the motor shaft will cool the motor and ventilate the space containing the assembly.

Pump 10 is provided with an inlet 13 to provide suction or a source of negative pressure and an outlet 12 to provide a source of positive pressure. Pump inlet 13 is connected, through conduits 30 and 32, with a port in the side wall of the valve body 40 and pump outlet 12 is connected with another port in the valve body by means of the conduits 20 and 22. Conduit 43—48 and flexible tube 49 connect the valve body 40 with the boot 50 into which is placed an extremity, as the foot shown, of the patient being treated, the foot being sealed by a contracting rubber sleeve 51. The primary function of the valve housed within valve body 40 is to alternately connect the boot 50 with the sources of positive and negative pressures in cycles of predetermined frequencies and of preselected proportions of time allotted to positive and negative pressures. This timing valve will now be fully described.

Referring more particularly to Figures 2-4 of the drawings, the timing valve is shown as comprising a cylindrically shaped housing 40, open at one end and provided at its other end with an axially extending bore for the rotatable support of the stem 82 of the cylindrically shaped valve 81. Housing 40 is conveniently supported on the casing 75, which, in the disclosed embodiment of the invention, is adapted to house a suitable speed reducing mechanism (not shown). Valve 81 is rotated within the body 40 by the stepped pulley 77 rigidly attached to the stem 82 by the set screw 79. Pulley 77 is driven by the belt 78 which in turn is driven by pulley 76 keyed to

the output shaft of the above mentioned speed reducing mechanism, the input shaft of which is driven by pulley 41 which in turn is conveniently driven from the double pulley 34 (Figure 1) by the connecting belt 42. The speed of rotation of the valve 81 may be varied by utilizing different grooves in the stepped pulleys 77 and 76 as is well understood in the art. It should also be understood that various means to vary the speed of rotation of the valve, other than that shown, may be used for the purpose with equal results. Inasmuch as the motor 37 rotates at a substantially constant speed, and a continuous mechanical driving connection exists between the motor and the valve, the valve will rotate at a uniform constant speed, the rate of which is determined by the diameter ratios between the power transmitting pulleys 36, 34 and 41, the ratio of the reduction gear housed in 75 and the selected diameter ratio between the pulleys 76 and 77, and the speed of rotation of the valve will be uniform regardless of the load imposed on the assembled machine. Thus the frequency of the pressure-suction cycle is positively maintained at the prescribed rate thereby eliminating any danger of harm to the patient due to variations in the frequency. Also the smooth, uninterrupted movement of the valve results in quiet operation of the device and freedom from mechanical breakdowns.

Valve 81 is provided with a pair of axially spaced circumferential slots 84 and 83 adapted to register with the ports in the side wall of the valve body 40 which ports are connected with the inlet and outlet, respectively, of the pump 10. The slots 83 and 84 are diametrically opposed, as shown in Figures 6 and 7, to alternately uncover the said ports thereby alternately connecting the inlet and outlet of pump 10 with the space within the valve 81. The end of the valve 81 opposite the stem 32 is open and when the valve is positioned in the body 40, this open end is substantially in the plane of the open end of the body. A cover plate 88, having the conduit 43 extending therethrough, is secured to the open end of the body 40, as by the machine screws 89, thereby providing communication between conduit 43 and the space within valve 81. The proportion of time within each cycle allotted to the pressure phase and to the vacuum phase is determined, of course, by the relative lengths of the circumferential slots 83 and 84. By lengthening slot 84 and correspondingly shortening slot 83 a greater portion of each cycle will be devoted to the suction or negative pressure phase and a lesser portion to the positive pressure phase. The features of construction of the valve described enable an adjustment of this nature to be quickly made. It is only necessary to remove cover 88 and pulley 77 to enable the valve 81 to be removed. A second valve having different relative lengths of slots may then be inserted and the pulley 77 and cover 88 replaced. This change may be accomplished in a very short time and by one not particularly skilled in mechanical work.

In order to prevent the lapse of a considerable interval of time between the termination of the negative phase and the attainment of proper pressure in the boot 50 for the positive phase, I provide a third port in the side wall of the valve body 40 axially spaced from the two ports above mentioned and in this third port I secure the member shown in Figures 8 and 9 which member consists of a body 95 having a bore 96

therethrough with tapered seat against which a check ball 96 is adapted to abut. Valve body 81 is provided with an aperture 85 axially aligned with the third bore of the valve body and positioned circumferentially between the negative phase termination end of the slot 84 and the positive phase beginning end of the slot 83. Now as the slot 84 moves past the suction port of the valve body and the port is closed the partial vacuum remains in the boot, conduits and valve, and if the pressure phase of the cycle were relied on to both bring up the pressure to atmospheric value and to the positive pressure desired for the positive phase a considerable volume of air would be required and the time allotted to the positive phase would be considerably advanced before the proper pressure is reached. Upon the closing of the suction port in the valve body the third port therein is opened by the aperture 85 in the valve 81 and air is drawn into the valve and boot past the check valve 96 to restore the pressure to atmospheric value before the beginning of the measured positive phase of the cycle.

Interposed between the pump outlet 12 and the pressure port in the valve body 40 are the pressure relief valve 14—18 and the manually controlled valve 21. As shown, the pressure relief valve consists of a body 14 having an internally threaded bore therein with an inwardly tapering shoulder forming a seat for the ball 15. Ball 15 is urged inwardly by the spring 16 the outer end of which abuts against the adjusting member 17 screw-threaded into the bore of body 40. Member 17 is provided with a passage therethrough to communicate with the bore through body 14 and is provided with an enlarged outer exposed end for the purpose of providing a grip and to serve as a container for fibrous material 18 which muffles the sound of the outmoving air. The pressure required to unseat valve 15 is determined by the pressure exerted by the spring 16 and this pressure may be varied by adjusting the position of the member 17 as will be apparent. Thus the upper limit of the pressure produced by the pump may readily be varied.

Interposed between the suction port of valve body 40 and the pump inlet 13 are the suction relief valve 25—29 and the manually operated valve 31. The suction relief valve consists of a body 25 having an internally threaded bore extending therethrough and a shoulder against which the inner end of a spring 20 is adapted to seat. A member 26 having a bore extending therethrough is threaded into the bore of body 25 and is provided on its inner end with a seat against which the spring pressed ball 28 is adapted to rest. Member 26 is formed with an enlarged outer end to provide a grip and a container for suitable filtering and noise muffling material 27. The negative pressure at which valve 28 will unseat may be varied by screwing in and out the member 26 and consequently the lower limit of negative pressure produced by the machine may be controlled.

It should be obvious from the above description that the settings of the controllable relief valves 14—18 and 25—29 determine the negative and positive pressures produced by the pump 10 and since these sources of pressures are alternately connected with the boot 50 through valve 40 the settings determine the negative and positive pressures applied to the extremity within the boot. The settings may be readily altered by rotation of the members 17 and 26 and in practice suitable pressure indicating devices are utilized 75

to indicate the pressures developed so that adjustments may be made in reference to such data.

To prevent excessive negative or positive pressures from accidentally building up in the boot, suitable pressure and suction relief valves 54—59 and 65—70, respectively, are inserted in the conduit 43 leading from the timing valve to the boot. These are conveniently supported on the pipe T's 44 and 45, respectively, and the first consists of a body 54 having a bore extending there-through with an inwardly tapering seat 55 to receive the check ball 56, the bore being internally threaded to receive the screw member 59 which is provided with a bore 58 in communication with the bore of the body 54. The outer end of screw 59 is diametrically slotted to receive a tool for turning the screw. A spring 57 is interposed between the inner end of screw 59 and the ball 56 and urges the latter against the seat 55. By adjusting the position of screw 59 the pressure at which the valve will unseat may be regulated.

The negative pressure safety valve consists of a body 65 provided with a bore in communication with the conduit 43 having a shoulder against which the inner end of a spring 69 is adapted to rest. A hollow screw member 66 having a valve seat 67 on its inner end is threaded into the body 65 and a ball 68 is interposed between the seat and the outer end of the spring 69. Excessive negative pressure in the line 43 and boot 50 will cause ball 67 to move inwardly in opposition to the outward force exerted by the spring and bring the pressure within the boot to the desired value. The pressure at which the valve 67—68 will open may be altered by adjusting the position of the screw 66 as will be well understood.

In operation, the boot 50 is connected with the machine by means of the flexible tube 49 and conduits 48, 49 and 43 and if two or more boots are used simultaneously the other boots may be connected to the connector 46 by removing plug 47, for example, and inserting a second pipe corresponding to member 48. The frequency of the cycle and the pressure phase distribution within the cycle having been determined and taken care of by the proper selection of a valve 81 and grooves of the pulleys 76 and 77, the motor 37 is energized to start the machine. The prescribed positive and negative pressure values are then attained by manipulation of the members 17 and 26 of the pressure and suction relief valves adjacent the pump or by manipulation of the valves 21 and 31 in case the members 17 and 26 have previously been adjusted for maximum positive and negative pump pressure capacity. The rotating valve 81 alternately connects the boot or boots with the inlet 13 and outlet 12 of the pump 10 in rhythmic sequence to provide the manner of treatment prescribed. When the inlet is so connected, the port in the side wall of valve body 40 is covered and conduit 20 is consequently closed. The air which is being exhausted from the boot is discharged through relief valve 14—18 as the pressure builds up in line 20. When the outlet of the pump is connected with the space within valve 81 and consequently with the boot, the suction line 30—32 is closed and air required to be taken into the pump to produce the required pressure in line 20 and the boot is taken into the pump through suction relief valve 25—29. It can thus be seen that the relief valves 14—18 and 25—29 perform two functions—regulating the pressures generated by the machine and providing an inlet and outlet for the air required for

the operation of the machine. The design and arrangement of these parts enable these complex functions to be satisfactorily accomplished by the simple, inexpensive and durable means shown.

It can thus be seen that I have provided a simple and inexpensive apparatus for carrying out the treating method stated and that the objects are accomplished by the use of simply designed and rugged parts which are operable with a minimum of noise and vibration and which are unlikely to get out of order. The apparatus can be used with any number of boots to simultaneously serve a number of patients and the frequency of the cycles and the pressures produced will not vary because of the addition or removal of any of the boots since the timing and pressure regulation is not dependent in any way on the pressures existing in any of the boots. It is also possible to position part of the apparatus, as the motor and pump in a separate room leaving the pressure adjusting and timing mechanisms in the patient's room.

It should be observed that none of the air exhausted from the boots is reintroduced back into the boots and consequently the boots are well ventilated by substantially a complete change of air every cycle and if a plurality of boots on different patients are used at the same time no objectionable intermingling of the air in the various boots takes place. By placing a suitable filter in the bore 97 of member 95 (Figure 9) all air inlets to the system will be provided with filters and consequently any air coming into the boots by reason of operation of the apparatus will be filtered. The filters perform the added function of muffling the sound of the moving air.

The above specifically described embodiment of my invention should be considered as illustrative only as obviously many changes may be made therein without departing from the spirit or scope of my invention as defined in the appended claims.

Having thus fully described my invention what I claim is:

1. In an apparatus of the character described having a sealed chamber for the reception of an extremity of the human body, means to rhythmically vary the pressure within said chamber comprising means to produce positive and negative fluid pressures, means to alternately connect said positive and negative pressures with said chamber comprising a valve body having a cylindrical bore with a pair of ports in its side wall connected with said sources of positive and negative pressures, a hollow valve rotatable within said bore and being provided with circumferentially extending slots in its side wall adapted to alternately register with said ports, means to connect the space within said valve with said chamber, means to continuously rotate said valve, and means supporting said valve for quick removal from said bore whereby valves having slots of different lengths may be readily interchanged to vary the relative time allotted to said positive and negative pressures.

2. In an apparatus of the character described having a sealed chamber for the reception of an extremity of the human body, means to rhythmically vary the pressure within said chamber comprising a fluid pump for producing positive and negative fluid pressures at its outlet and inlet, respectively, a valve assembly having a first port connected with said outlet, a second port connected with said inlet, and a third port connected with said chamber, means to simultaneously

cover said first and second ports, means to alternately uncover said first and second ports whereby said ports are alternately connected with said third port and said chamber, a pressure relief valve connected with said pump outlet, and a suction relief valve connected with said pump inlet.

3. A structure according to claim 2 in which said two last mentioned means consist of a continuously moving member having closed spaces to cover said ports and open spaces to uncover said ports.

4. In an apparatus of the character described having a sealed chamber for the reception of an extremity of the human body, means to rhythmically vary the pressure within said chamber comprising sources of positive and negative fluid pressure; a valve assembly having a port connected with said source of positive pressure, a port connected with said source of negative pressure, a port connected with said chamber and a port connected with the atmosphere; said valve including means to first connect said second port with said third port, then to connect said fourth port with said third port and then to connect said first port with said third port in sequence, and means to operate said valve in predetermined time sequence.

5. In an apparatus of the character described having a pressure member adapted to be applied about a member of the human body, means to supply controlled and intermittent pressure to said member comprising a source of positive fluid pressure, means to intermittently connect said source with said member comprising a valve body having a cylindrical bore with a port in its side wall connected with said source, a hollow valve rotatable within said bore and being provided with a circumferentially extending slot in its side

wall adapted to register with said port for a length of time determined by the length of said slot and the speed of rotation of said valve, means to continuously rotate said valve at a uniform rate, means to connect the space within said valve with said member, means supporting said valve for quick removal from said bore whereby valves having slots of different lengths may be readily interchanged to vary said length of time, and an adjustable pressure relief valve in the means connecting the space within the valve with said member.

6. In an apparatus of the character described having a pressure member adapted to be applied about a member of the human body, means to supply controlled and intermittent pressure to said member comprising a source of positive fluid pressure, means to intermittently connect said source with said member comprising a valve body having a cylindrical bore with a port in its side wall connected with said source, a second port in the side wall of said body circumferentially spaced from said first mentioned port, a hollow valve rotatable within said bore and being provided with a circumferentially extending slot in its side wall adapted to alternately register with said ports for lengths of time determined by the length of said slot and the speed of rotation of said valve, means to continuously rotate said valve at a uniform rate, means to connect the space within said valve with said member, means supporting said valve for quick removal from said bore whereby valves having slots of different lengths may be readily interchanged to vary said lengths of time, and an adjustable pressure relief valve in the means connecting the space within the valve with said member.

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