

July 27, 1937.

K. L. TATE

2,088,044

PASSIVE VASCULAR EXERCISER

Filed June 2, 1936

3 Sheets-Sheet 1

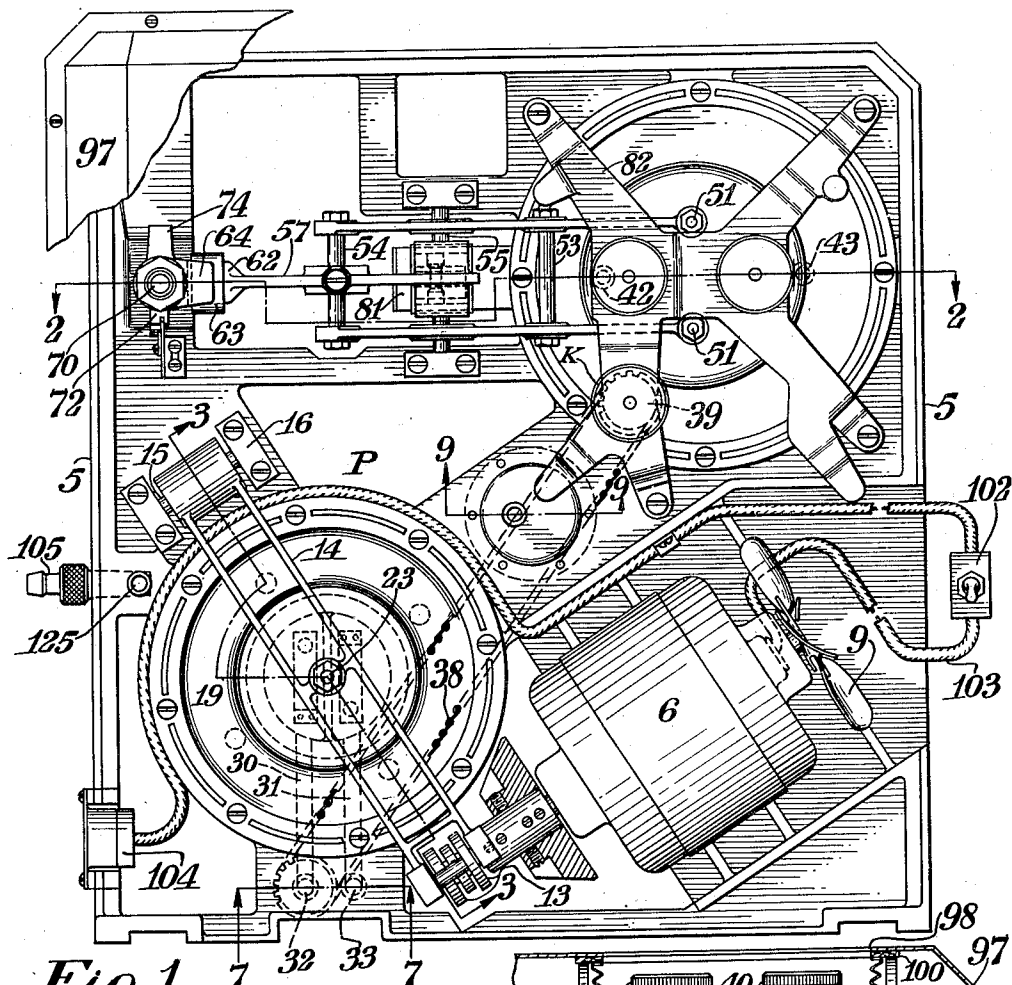


Fig. 1

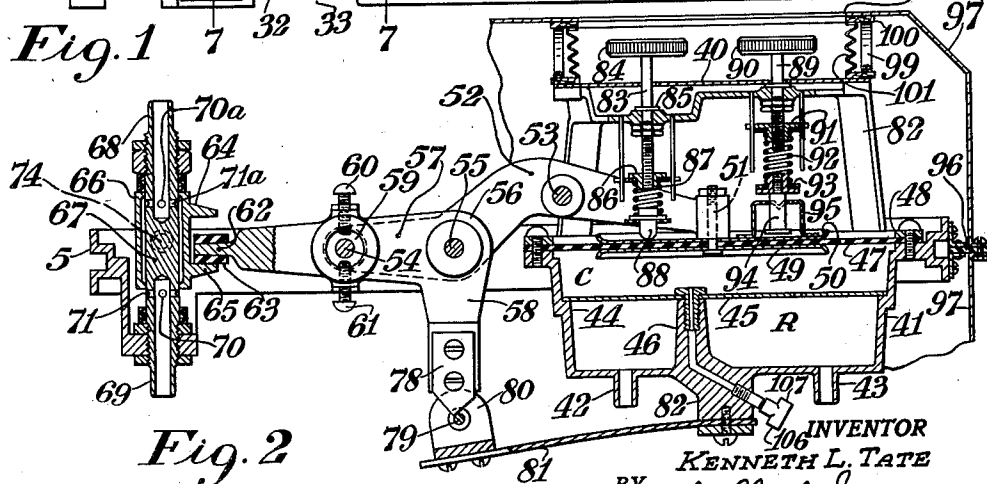


Fig. 2

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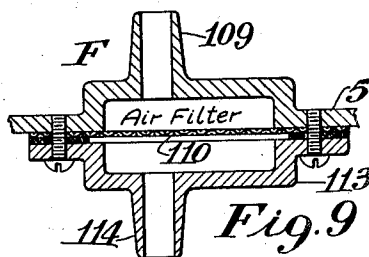
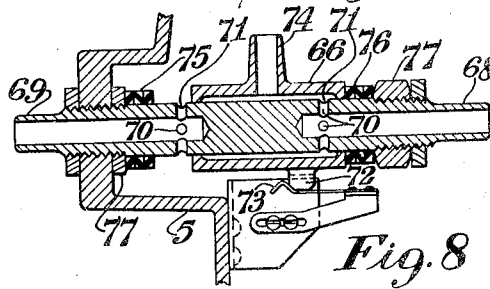
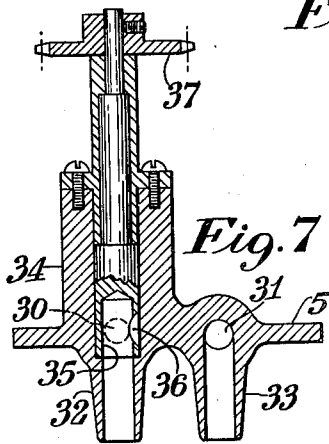
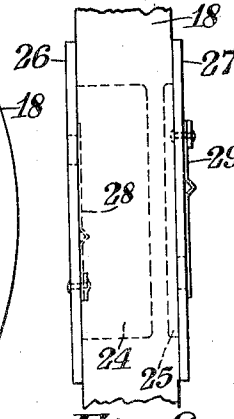
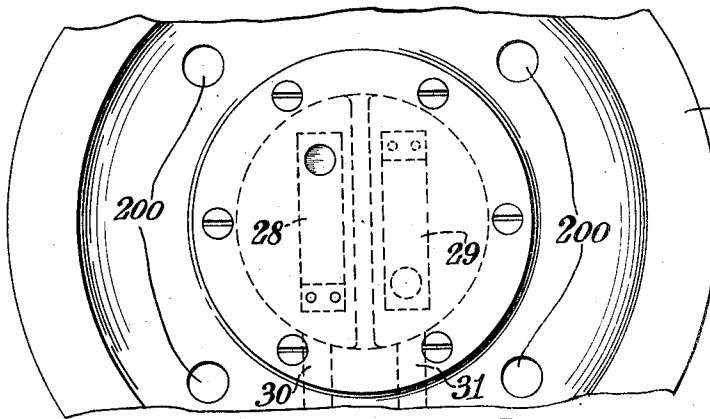
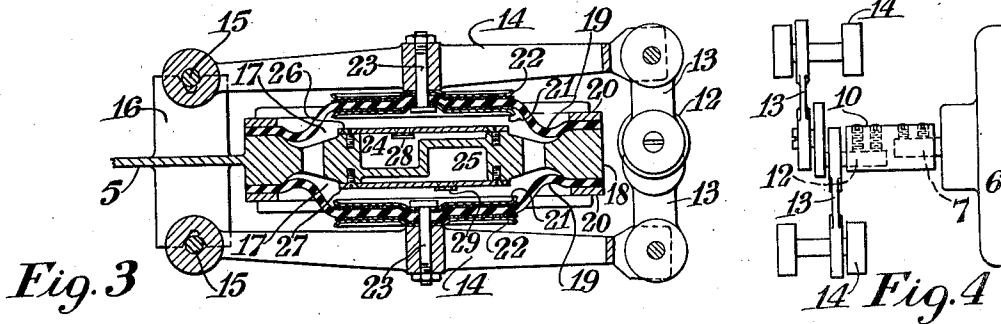
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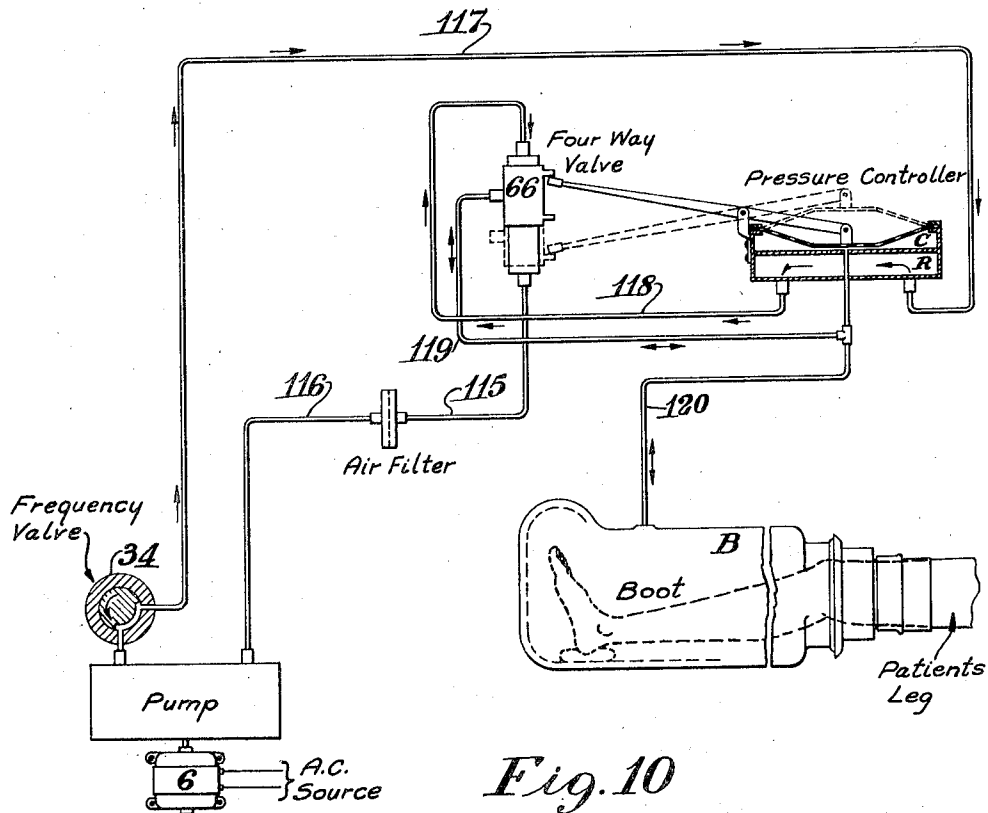
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PASSIVE VASCULAR EXERCISER

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3 Sheets-Sheet 3



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PASSIVE VASCULAR EXERCISER

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Application June 2, 1936, Serial No. 83,053

5 Claims. (Cl. 230—42)

This invention relates to passive vascular exercisers.

In the treatment of certain diseases of the peripheral circulatory system in the human extremities, it has been proposed to subject the extremity, while enclosed in a chamber or "boot" substantially sealed from the atmosphere, to environmental air pressures in the chamber varying rhythmically between predetermined positive and negative limits.

The present invention has for its purpose the production of a vascular treatment device capable of rhythmically developing positive and negative air pressures between predetermined pressure limits in such a treatment chamber. Under certain conditions the device must be portable so that it can be readily moved from one patient to another, and for this reason the device of the present invention is of reduced size and yet is capable of handling relatively large volumes of air. Since various limits of positive and negative environmental pressures may be required for the treatment of extremities of different patients, the device is readily adjustable to ensure that the exact prescribed minimum and maximum limits of pressure shall be developed thereby, without exceeding or falling short of the mentioned limits. Also, since the frequency of alternation in pressure may be changed in accordance with the requirements of the various patients, the present device is provided with adjustable frequency controlling means whereby the frequency of alternations is readily and accurately established as required.

The various features and advantages of the invention will appear from the detailed description and claims when taken with the drawings in which Fig. 1 is a front view of the device with the base thereof omitted and with the major portion of the sound-proof casing thereof broken away; Fig. 2 is a cross-sectional view thereof taken substantially on the line 2—2 of Fig. 1 looking in the direction of the arrows; Fig. 3 is a cross section of the device taken substantially on the line 3—3 of Fig. 1; Fig. 4 is an end view of the crank shaft assembly and the coupling thereof to the shaft of the motor, a fragment of which only is illustrated; Fig. 5 is a fragmentary plan view of the pump with the diaphragms thereof removed; Fig. 6 is an edge view of the structure shown in Fig. 5; Fig. 7 is a sectional view taken substantially on the line 7—7 of Fig. 1, illustrating the frequency adjusting valve; Fig. 8 is a section through the slide valve assembly; Fig. 9 is a section taken on the line 9—9 through

the air filter; and Fig. 10 is a diagrammatic showing of the device in combination with a treatment chamber or boot.

Referring especially to Fig. 1, the numeral 5 generally designates a cast aluminum vertical frame to be cushion-mounted on a base (not shown), the frame having cast therein depressions forming a part of a pump as well as a control unit and an air filter, to be described. A motor 6 is mounted on the frame so that its shaft 7 (Fig. 4) is inclined to the horizontal. One end of this shaft carries a fan 9 to circulate air about the motor in order to prevent its overheating, while the other end of the shaft is connected by a coupling 10, to a crank shaft assembly best illustrated in Figs. 3 and 4. This assembly includes a crank shaft 12 coupled to the shaft motor 7, and links 13 connecting the crank shaft to one end of each of the rocking levers 14 which are mounted at their other ends for rocking movement on spaced pivots 15, carried on extensions 16 of the frame.

The pump includes two annular chambers 17, one such chamber being located at each side of the frame. These chambers which are defined by annular ribs 18 cast in the frame, communicate with each other through the openings 200 but are otherwise closed by the circular rubber diaphragms 19 clamped at their respective edges to the annular ribs by circular clamping rings 20. A circular inner clamping plate 21 formed of metal, engages the inner surface of the center portion of each rubber diaphragm 19, and a similar outer metal clamping plate 22, of like dimensions as the first, engages the outer surface of each diaphragm. A bolt 23 passing in air-tight relation through openings in the center of the inner compressor plate, the rubber diaphragm and the outer compressor plate connects each diaphragm assembly to an intermediate portion of its adjacent rocking lever 14. It will be understood that the rocking levers 14 are connected to the crank shaft assembly in such a way that the diaphragms 19 alternately approach and recede from each other to effect the pumping action. The portion of the frame within the annular chambers is cast to have two recesses 24 and 25, which recesses are respectively closed by valve plates 26 and 27, each valve plate having an opening therein normally closed by a valve in the form of a leaf spring respectively designated 28 and 29. The valve 29 is on the outside of the valve plate 27 so that it will open when the pressure in the recess 17 is decreased to a certain value, while the other valve 28 is on the inner

surface of the valve plate 26 to open when pressure on the outside of the recess is increased to a certain amount.

The recesses 24 and 25 within the pump respectively communicate through the passageways 30 and 31 with two connection nipples 32 and 33 (Fig. 7), to which rubber tubing can be applied to connect these nipples with several parts of the machine, as will be set forth. It will be noted that the recess 24 communicates with the nipple 32 through a frequency valve 34 whereby the rate of air flow from this recess may be controlled at will to establish a desired frequency of alternation, since the pressure developed by the pump does not alternate with each impulse of the pump. The frequency valve includes a sleeve 35 having an aperture 36 in one side thereof which sleeve can be rotated in the valve body 34 to bring its aperture in alignment with the passageway 30, or partially out of alignment therewith, as desired. This sleeve is rotatable by means of a sprocket wheel 37 connected to a shaft extending from the outer end. The sprocket wheel is engaged by a chain 38 passing over a second sprocket wheel 39 mounted adjacent the control panel 40 (Fig. 2) in the case of the instrument, which second sprocket wheel is rotated by a hand-knob K, accessible at the front of the panel to adjust the frequency valve. It will be understood that instead of using this chain and sprocket wheel for adjusting the position of a frequency valve, the sprocket wheel 37 may be replaced by a hand-knob, but it is convenient to have all control knobs accessible at one panel.

In this device it is necessary that the limits of both the positive and negative pressure phases developed by the pump be accurately maintained at any adjusted predetermined values, that is, when the pump has established the predetermined positive pressure in the boot B (Fig. 10) it is necessary that the connections from the pump to the boot be reversed so that negative pressure at a predetermined value will be established in the boot. As soon as this negative pressure limit is reached, it is necessary for the control unit to reverse the connections between the pump and the boot so that a positive pressure will be built up in the boot. The control unit of the device, for effecting this reversal of the positive and negative pressure in the boot includes a cup 41 (Fig. 2) cast into the vertical frame 5. This cup is provided with connection nipples 42 and 43 by which rubber tubes connect the pump and the boot to the cup. The side wall of this cup at an intermediate point is provided with an annular shoulder 44 against which a baffle plate 45 can be clamped in substantially air-tight relation by means of a hollow cap screw threaded into a hollow boss 46 projecting from the inner wall of the cup. The opening in this boss discharging into chamber C, communicates through a T connection having the nipples 106 and 107. It will be understood that this baffle plate and the cup define a space in the nature of a reservoir R which tends to smooth out the pulsations of positive pressure developed therein by the pump. The open end of the cup is closed by a rubber diaphragm 47 sealed to the rim of the cup by clamping screws passing through an annular plate 48 which grips the margin of the diaphragm against the marginal flange at the edge of the cup. The space between the baffle plate 45 and the diaphragm 47 provides a pressure control chamber C. The central portion of the diaphragm is engaged at each of its surfaces by

opposing metal discs 49 and 50 which are held firmly against the faces of the diaphragm, being held in this position by bolts 51 passing there-through and through the ends of the arms 52 comprising a control lever. The control lever arms 52 which are held in spaced relation by the spacer bolts 53 and 54 are mounted for rocking movement on the shaft 55 secured on the frame. There is also pivotally mounted on the shaft 55 a bell crank or cantilever lever, 56 comprising the arms 57 and 58. The arm 57 has a circular opening 59 therein to receive the spacer bolt 54 of the control lever but permits limited relative lateral movement of this bolt therein. This relative lateral movement is determined by adjustable stops in the form of set screws 60 and 61 threaded into the edge of the arm 57 and extending into the opening 59 in the path of the bolt 54. The free end of the arm 57 terminates in blade 62 covered with rubber 63 and mounted in a position to engage the lugs 64 and 65 on the sliding sleeve 66 which is movable back and forth on the body 67 of the four-way valve. This sleeve with the exception of its ends which make a sliding fit with the valve body, is slightly spaced from the body. The annular space within the sleeve communicates with an upwardly extending nipple 74 carried by the sleeve. The valve body, which is mounted on the frame, is provided at its ends with connection nipples 68 and 69, the bore of these nipples communicating with ports 70a, 71a and 70, 71 respectively in the valve body. A lug 72 carried on the underside of the sliding sleeve is engaged by a detent spring 73 carried by the frame. This lug and detent spring are so related that they retain the sleeve in its extreme right-hand position as shown in Fig. 8, or in its extreme left-hand position so that vibration of the device will not accidentally displace the sleeve. Suitable rubber washers 75 and 76 engage nuts 77 which may be adjustable on the valve body to limit the travel of the sleeve.

The arm 58 of the cantilever lever terminates in a wedge-shaped piece 78 (Fig. 2) one or the other of the tapered edges of which normally engages a cam roller 79 rotatively mounted in ears 80 carried by the free end of the cantilever spring 81. This spring at its opposite end is secured to a boss 82 on the wall of the cap 41. It will be understood that this cantilever spring, when the point of the wedge-shaped piece 78 passes over the roller 79, quickly throws the sleeve 66 of the four-way valve from one of its extreme positions to the other. It will be appreciated that this action takes place when a predetermined pressure in the chamber C actuates the control lever which, in turn, operates the cantilever lever and its wedge-shaped piece 78. The energy for operating the four-way valve is stored up in the cantilever spring 81 and no energy is taken from the control diaphragm at the trip or control points.

Since it is necessary that the exact positive and negative pressure values be adjustable within relatively wide limits, mechanism for this result is provided.

The pressure limit adjusting mechanism includes a spider bracket 82 on which a panel 40 is carried. This spider has mounted thereon a positive pressure adjusting screw 83 which projects through the panel and terminates in a knob 84. This adjusting screw is mounted on the bracket for rotary movement only, endwise movement thereof being prevented by the washers 85 secured thereto at each surface of the bracket. 75

The screw 83 is threaded at its free end into a nut 86 which is prevented from rotary movement by pins extending from the bracket and engaging the guiding holes in the nut. A coil spring 87 has one of its ends secured to the nut 86 and its other end secured to a stud 88 which projects in a position to engage the exposed surface of the plate 50. It will be understood that as the knob 84 is turned in one direction, the screw 83 is unscrewed from the nut 86 and the spiral spring 87 will be placed under greater compression, so that greater air pressure must be exerted against the inner surface of the diaphragm 47 before the control lever will be actuated. However, when the knob 84 is turned in the opposite direction to screw the screw into the nut 84, the compression on the spiral spring 87 will be reduced and a lesser amount of positive pressure must be exerted against the diaphragm 50 to operate the control lever. The mechanism for controlling the limits of the negative pressure includes a screw 89 likewise mounted for rotary movement only in the spider 82. This screw terminates at one end in a knob 90 at the front of the panel 40 and terminates at its other end in a threaded portion screwed into the nut 91. Pins projecting from the bracket and engaging guiding holes in the nut prevent rotary movement thereof but permit the nuts to move lengthwise on the pins. One end of a spiral spring 92 is attached to the nut 91 and its other end is secured to a nut 93 secured to the end of the headed stud 94. The shank of this stud passes through an opening in a saddle 95 having its ends secured to the exposed face of the plate 50. By this arrangement when the diaphragm 47 is drawn inward, as shown in Fig. 2, in response to the increasing negative pressure or vacuum in the chamber C, the head of the stud will eventually engage the saddle 95, whereupon the tension of the spring 92 will tend to restrain movement of the diaphragm. It will be appreciated that by turning the knob 90, the screw 89 will be adjusted to vary the tension of the spiral spring 92 and therefore vary the value of the negative pressure at which the control lever and cantilever lever jointly reach the trip-over position at which the cantilever lever snaps the sleeve 66 of the four-way valve so that the negative pressure phase will be followed in the chamber by the positive pressure phase. By the present construction the pressure limits remain constant, irrespective of changes in the frequency adjustment.

It is highly desirable that dust and lint should not be driven into the boot by the pump and for this reason the frame 5 is cast with an air filter recess communicating with a nipple 109. A wire screen or other suitable air filter 110 extends across the face of the recess, being held in this position by an air filter cover 113 which clamps the filter to the frame. It will be understood that suitable gaskets are interposed between the flanges of the cover and the frame to prevent leakage through the joint therebetween. The cover 113 is provided with a nipple 114 providing an outlet from the air filter recess.

Since the device is primarily intended for use in the presence of the patient being treated, it is essential that all moving parts be covered and also that the mechanism operate with a minimum amount of noise. In order to provide a substantially sound-proof housing for the device, the frame 5 has secured about its periphery a rubber mounting gasket 96 (Fig. 2) to each surface of the free edge of which a section 97

of a divided casing, is secured. In this way the casing is cushion-mounted on the frame of the device so that any noises conducted to the frame, are not transmitted to the casing.

In order to permit access to the adjusting controls such as the knobs K, 84 and 90, an opening 98 is provided in one of the casing sections adjacent the panel 40. The edges of the panel have secured thereto leaf springs 99 which support a frame 100 in engagement with the periphery of the casing at the opening 98. A rectangular fabric or leather bellows section 101 joins the panel to the frame 100, thereby ensuring that noise will not be transmitted by air conduction through the opening 98.

A toggle switch 102 may be mounted on the panel 40, although for simplicity of disclosure it is shown on the right of Fig. 1. This toggle switch is included in one of the conductors to the motor, which conductors are enclosed in a cable 103 extending from the motor to a connecting outlet 104 on the frame and accessible through the casing.

It will be understood that the various connection nipples are joined together with rubber tubing, which has been omitted since it would complicate the showing. However, it will be understood that the pairs of nipples 32 and 43, 42 and 68, 69 and 109, 33 to 114, 74 and 106, 107 and 125, are each connected together by a section of tubing. The outlet of this device is through the connection nipple 105 to which a section of tubing is connected to a treatment chamber or boot B. The interconnection of the various parts and the operation of the unit will be understood from Fig. 10 wherein the cantilever lever and spring have been omitted since snap action of this lever is assumed, as described above.

Briefly, the operation of the device is as follows: The starting of the device is effected by closing the toggle switch 102 in the electrical conductors which connect the motor 6, to a commercial source of current. The motor then starts to rotate and drives the crank shaft assembly so that the rocking levers 14 alternately approach and recede from each other, causing the diaphragms likewise to approach and recede from each other. When the diaphragms recede from each other, air will be drawn into the pump. This air is drawn from the atmosphere through the ports 70 and 71 adjacent to nipple 69 in the valve body 67, connection nipple 69 of the four-way valve to the rubber tube or conduit 115 through the air filter F, through the section of the rubber tube 116, passageway 31, valve recess 25, valve 29 into the space between the diaphragms of the pump. As these diaphragms approach each other, the air therebetween is prevented by the valve 29 from being forced out through the passageway 31. However, this air is forced through the valve 28 into the valve recess 24 and thence through the passageway 30 and through the frequency valve 34. From the frequency valve this air is forced through the section of rubber tubing 117 into the reservoir R of the control unit, where the pulsations of the air supply are smoothed out owing to the relatively large air capacity. From this reservoir the compressed air is supplied to the section 118 of rubber tubing to the nipple 68 of the four-way valve, thence through the other ports 70a and 71a into the space within the sliding sleeve 66 to the nipple 74. From this point compressed air is forced through the tube section 119 through

the nipples 106 and 107 of the T connection and thence through the rubber tubing 120 into the treatment boot B.

It will be understood that air passing through the T connection also flows through the hollow boss 46 into the control chamber C, and when the pressure in this chamber reaches a predetermined point, the control lever and the cantilever lever actuate the sliding sleeve 66 of the four-way valve to reverse its position. Under these conditions when the diaphragms on the pump recede from each other, air is withdrawn from the boot through the rubber tubes 120, 119. The control diaphragm 47 forming one side of the chamber C receives pressure from the boot and therefore measures the pressure in the boot, except for a negligibly small pressure drop in the tubing.

I claim:

1. In a device of the character described, an outlet conduit, an air pump comprising a rigid wall having recesses formed in the opposite sides thereof, a diaphragm closing each of said recesses, means for causing said diaphragms to approach and to recede from each other alternately, a valve chamber having an output valve therefor and a second valve chamber having an input valve therefor, said valve chambers being mounted in the space between said diaphragms, an output conduit connected to said first chamber, an input conduit connected to said second chamber, means including connections and valve mechanism for alternately connecting said outlet conduit to said input conduit and to said output conduit when positive and negative pressures are developed at said outlet conduit, and pressure limiting means responsive to said positive and negative pressures in a portion of said connections for operating said valve mechanism.

2. In a device of the character described, an outlet conduit, an air pump having an input conduit and an output conduit, means including valve mechanism for connecting said outlet conduit respectively to said input conduit and to said output conduit, whereby positive and negative pressures are developed at said outlet conduit, and pressure limiting means for operating said valve, said pressure limiting means including a chamber having a flexible diaphragm wall actu-

ated by predetermined positive and negative values of pressure corresponding to pressures at said outlet conduit.

3. In a device of the character described, an outlet conduit, an air pump having an input conduit and an output conduit, means including valve mechanism for alternately connecting said outlet conduit respectively to said input conduit and to said output conduit, whereby positive and negative pressures are alternately developed by said pump at said outlet conduit, a chamber connected to said outlet conduit, said chamber having a flexible diaphragm wall, and valve operating means having a trigger action, said valve operating means being actuated by the movement of said diaphragm in response to predetermined positive and negative values of pressure.

4. In a device of the character described, an outlet conduit, an air pump having an input conduit and an output conduit, means including valve mechanism for alternately connecting said outlet conduit respectively to said input conduit and to said output conduit, whereby positive and negative pressures are alternately developed by said pump at said outlet conduit, a chamber connected to said outlet conduit, said chamber having a flexible diaphragm wall, valve operating means having a trigger action, said valve operating means being actuated by the movement of said diaphragm in response to predetermined positive and negative values of pressure, and means for applying adjustable resistances to the inward and outward movement of said diaphragm.

5. In a device of the character described, an outlet conduit, an air pump having an input conduit and an output conduit, means including valve mechanism for alternately connecting said outlet conduit respectively to said input conduit and to said output conduit, whereby positive and negative pressures are alternately developed by said pump at said outlet conduit, a chamber connected to said outlet conduit, said chamber having a flexible diaphragm wall, a lever for moving said valve back and forth, a spring arranged to bias said lever in either of two positions, an arm for moving said lever to either of its two positions, said arm being actuated by said diaphragm.

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