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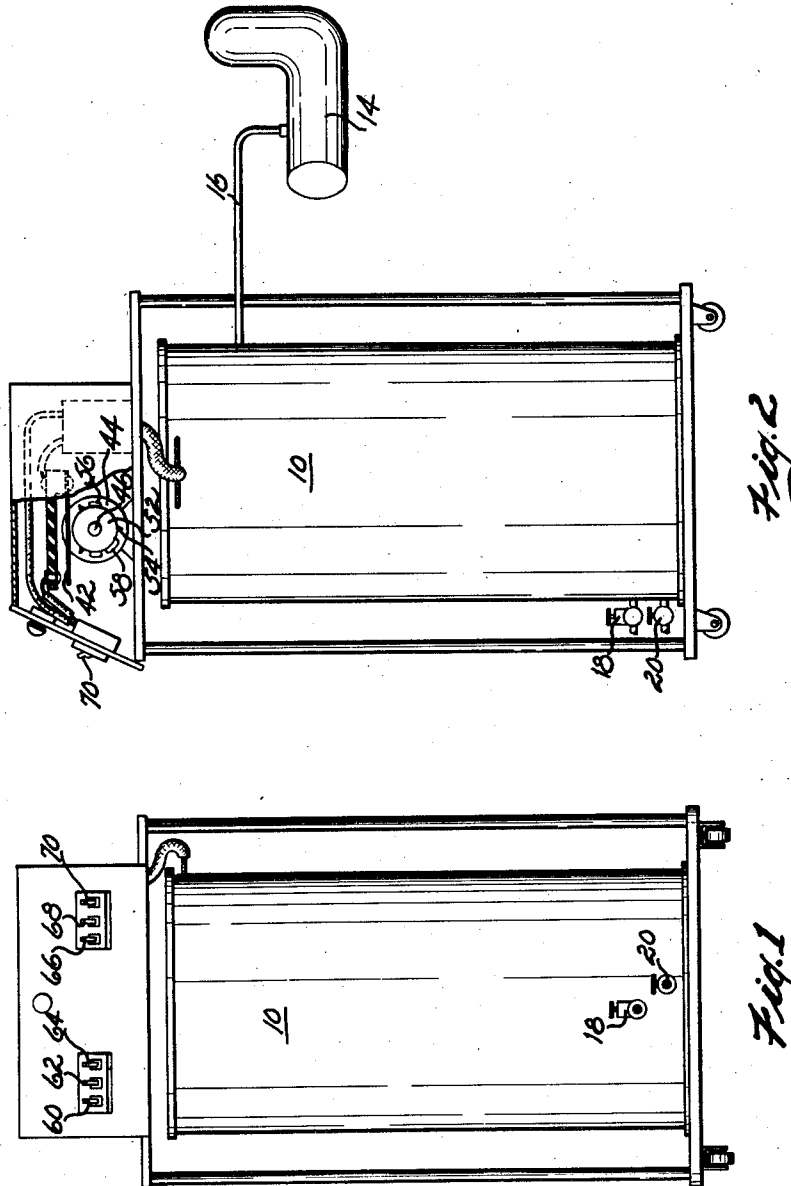
S. E. MILLER

2,338,255

THERAPEUTIC DEVICE

Filed April 30, 1942

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

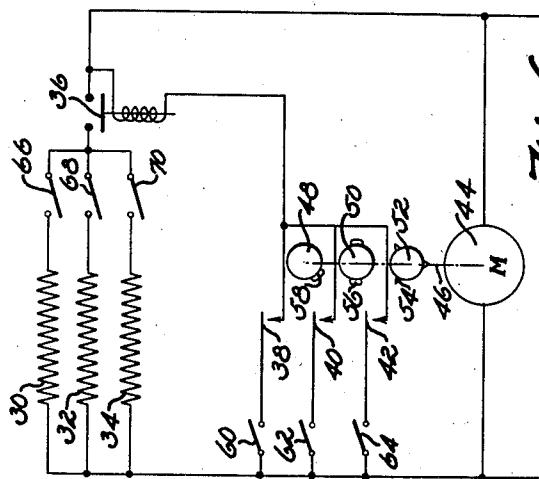


Fig. 6

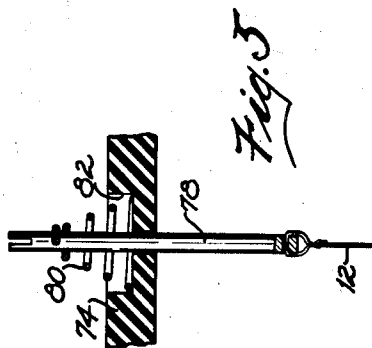


Fig. 5

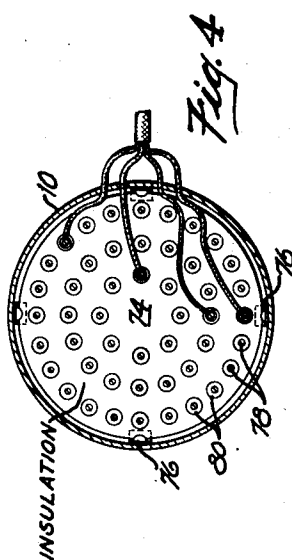


Fig. 4

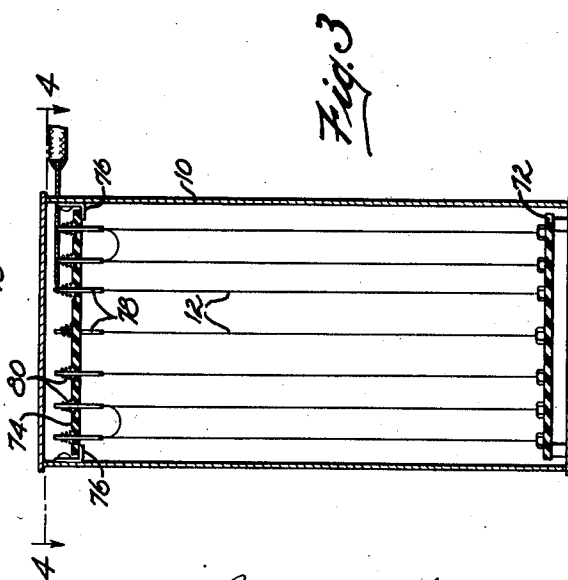


Fig. 3

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UNITED STATES PATENT OFFICE

2,338,255

THERAPEUTIC DEVICE

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Application April 30, 1942, Serial No. 441,157

5 Claims. (Cl. 128—299)

This invention relates to a therapeutic device and more particularly to a passive vascular exerciser.

There are a number of problems involved in designing a passive vascular exerciser which are not present in designing other types of systems. In the first place, passive vascular exercisers are frequently used in the treatment of gangrenous limbs which give off gas producing bacteria. Because of this fact, it is important that the apparatus be easy to sterilize or be self-sterilizing. Since oil is an ideal culture medium for the bacteria, it is apparent that the apparatus should not require the use of oil. Furthermore, since the apparatus is used on patients who are critically ill, it is also necessary that the apparatus be quiet in operation and that the changes in pressure be gradual so as not to unduly disturb the patients. Gradual changes in pressure have also been found to be the most desirable for effective treatment. Due to leaks in the gaskets, etc., and due to differences in the amount of unoccupied space in the treatment boots, the apparatus must be capable of closely controlling the pressure changes under widely varying conditions. It is an object of this invention to provide a passive vascular exerciser which overcomes the above enumerated problems.

Another object of this invention is to provide a simple, inexpensive vascular exerciser which does not require frequent adjustment.

Still another object of this invention is to provide a simple pump for cyclically changing the pressures in such a manner that the changes in pressure follow very nearly a sine wave on the vacuum side of the cycle.

Still another object of this invention is to provide an improved control arrangement for a thermal type of pump which automatically compensates for gasket leaks.

A further object of this invention is to provide an improved mechanism for controlling the frequency of the pressure cycles in a heat operated vascular exerciser.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a front elevational view of a device embodying my invention.

Fig. 2 is a side elevational view, partly diagrammatic, and with parts broken away so as

to more clearly illustrate certain features of my invention.

Fig. 3 is a vertical sectional view partly diagrammatic through the heating chamber.

Fig. 4 is a horizontal sectional view taken on line 4—4 of Fig. 3.

Fig. 5 is a fragmentary sectional view showing the manner in which the heating wires are yieldably mounted.

Fig. 6 shows the electrical circuits.

Referring now to the drawings in which I have shown a preferred embodiment of my invention, reference numeral 10 designates a metal cylinder in which a body of air is alternately heated and cooled so as to cause expansion and contraction of the air. The heating is produced by means of a large number of vertically disposed electric heating elements or wires 12. The heat generated by the heating elements 12 is dissipated through the outer walls of the main cylinder 10 during the off cycle of the heating elements. The interior of the cylinder 10 is connected with a boot element 14 through the pipe line 16.

The boot 14 is of the type which is adapted to enclose an extremity of a human body, such as an arm or a leg. Suitable gasket means, not shown, are provided for preventing the escape of air at the joint between the boot and the human extremity being treated. For purposes of illustration, I have shown a pumping unit connected to only one boot whereas in actual practice the pump is capable of handling several boots by making certain adjustments, as will be explained more fully hereinafter. The pump is also suitable for use in various types of respirators and other applications where cyclical changes in pressure are required.

The pressures maintained within the air circuit which comprises the boot 14, the pipe line 16 and the cylinder 10, are controlled by a check valve 18 and a bleeder valve 20 arranged as shown. The valve 18 is a conventional adjustable check valve which may be set to open at any predetermined pressure. The pressure at which the valve 18 is set to open depends upon a number of factors which need no discussion. Obviously, for a given set of conditions, the lower the pressure at which the valve 18 is set to open, the greater will be the suction upon cooling of the air. The valve may, for example, be set to open at a positive pressure of 10 millimeters of mercury. The valve 20 is a manually adjustable bleeder valve which may be set so as to allow a very small quantity of air to escape

from the air circuit or leak into the air circuit. The setting of the valve 20 is likewise determined by a number of factors such as the number of boots in operation and also the number of gasket leaks, etc.

By alternately heating and cooling the air within the air chamber 10, the pressure within the air circuit may be cyclically varied so as to obtain predetermined positive pressures and predetermined negative pressures. Inasmuch as the changes in pressure are the result of changes in temperature of the air in the circuit, it is apparent that no sudden changes in pressure take place. As shown in Figs. 1 and 2, the valves 13 and 20 are so arranged that only the hot sterilized air is allowed to escape from the air circuit.

As best shown in the circuit diagram of Fig. 6, the heating circuit comprises three elements, 30, 32 and 34 which are jointly controlled by a solenoid operated switch 36 which in turn is controlled by any one of a plurality of cam operated switches 38, 40 and 42. A substantially constant speed motor 44, which is preferably a synchronous motor of the type commonly used in electric clocks, is provided for operating the switches 38, 40 and 42. The motor 44 is provided with a drive shaft designated by the numeral 46 on which is mounted a series of switch operating cams 48, 50 and 52 which operate the switches 38, 40 and 42 respectively. The cam 52 is provided with three cam segments 54 whereas the cam 50 is provided with only two cam segments 56 and the cam 48 is provided with only one cam segment 58. The circumferential length of the cam segments determine the length of time that the heaters are energized per cycle. Manual switches 60, 62 and 64 are provided for selecting which cam switch is to be used for controlling the operation of the solenoid operated switch 36. It is apparent that the number of cycles per minute will be determined by which cam operated switch is placed in control of the solenoid operated switch 36. Thus the frequency of the pumping cycle may be selected so as to best suit the particular needs. It has been found practical to design the cams so as to provide a choice between one, two or three cycles per minute. The amount of heating may also be controlled by the manually operated switches 66, 68 and 70 which are placed in circuit with the heating elements 30, 32 and 34 respectively. Any one or more of the switches 66, 68 and 70 may be closed at one time depending upon the amount of heating desired.

Inasmuch as the heating elements tend to expand and contract in response to changes in the temperature thereof, it is desirable to provide some means for maintaining the proper tension on the heating elements at all times. As shown in Fig. 3, the lower ends of the heating elements are held in place by a stationary plate of insulation 72 carried by the bottom wall of the cylinder 10. The upper ends of the wires 12 are resiliently supported by the insulating plate 74 supported on the lugs 76 carried by the cylinder 10. The upper ends of the wires are fastened to slidable pins such as the pin 78 shown in Fig. 5. Each pin 78 projects through the insulating member 74 and is biased upwardly by means of a spring 80 constructed and arranged as shown in Fig. 5. The upper end of each spring 80 is secured to the pin 78 and the lower end rests with the recess 82 provided in the insulating member 74. Thus, as the heating element contracts the spring 80 is compressed, whereas ex-

pansion of the heating element allows the spring 80 to expand and pull the pin 78 upwardly. A large number of wires are required and, for purposes of illustration, I have shown them connected into three parallel heating circuits, as shown in Fig. 6.

The capacity and efficiency of the pumping element are greatly influenced by the proportions of the air heating chamber and the arrangement of the heating elements. I have found that a heating chamber having a diameter equal to half the height of the chamber is very efficient. In the particular arrangement shown in the drawings (see Fig. 4), I have provided forty-eight uniformly disposed heating wires which, under normal operating conditions, heat the air several hundred degrees Fahrenheit. The maximum temperature of the air will, of course, depend in part upon the number of heating elements energized. No special cooling means is required for cooling the air in the cylinder 10 for those types of systems in which only a few pressure cycles per minute are required. When more frequent cycling is required, the rate of cooling may be increased by providing a fan (not shown) for circulating air in thermal exchange with the outer walls of the cylinder 10 or by providing any other suitable means for increasing the rate at which the heat is dissipated from the air in the cylinder 10. Extensive tests have shown that very effective results may be produced by regulating the heating so as to cause the pressure to vary between 5 millimeters of mercury and -60 millimeters of mercury at the rate of two cycles per minute.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In combination, a treatment chamber adapted to receive a portion of a human body, a fluid chamber having means for alternately heating and cooling an expansible fluid so as to cause expansion and contraction of said fluid, means whereby changes in pressure of said expansible fluid produces a substantially corresponding change in pressure in said treatment chamber, clock means for controlling the alternate heating and cooling of said expansible fluid, and an open vent for said fluid chamber communicating with the outside atmosphere.

2. In a pressure varying system, a treatment chamber adapted to receive a portion of a human body, means for alternately heating and cooling an expansible fluid, fluid flow connections between said last named means and said pressure chamber, an adjustable bleeder port between the interior of said fluid flow connections with the outside atmosphere, and a check valve connecting the interior of said fluid flow connections with the outside atmosphere, said check valve being adapted to purge fluid from said system when the pressure in said system exceeds a predetermined value.

3. In combination, a treatment chamber adapted to receive a portion of a human body, a fluid chamber having means for alternately heating and cooling an expansible fluid so as to cause expansion and contraction of said fluid, means whereby changes in pressure of said expansible fluid produces a substantially corresponding change in pressure in said treatment chamber,

and clock means for controlling the alternate heating and cooling of said expansible fluid.

4. In a device of the class described, a combination of a treatment chamber adapted to receive a portion of a human body in isolated relation to atmospheric pressure, means for alternately heating and cooling a body of air so as to produce pressure variations in said body of air, said last named means being connected in pressure translating relationship to said treatment chamber, 10 and means independent of changes in pressure in

said treatment chamber for controlling the heating of said air.

5. In combination, an elongated heating element, insulating means supporting said heating element, means maintaining tension on said elongated heating means comprising a spring element having one end resting in a recess in said insulating means and the other end connected to said elongated heating element.

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