March 29, 1949. S. HENDERSON 2,465,685

HEATING CHAMBER FOR THERMOTIC PUMPS OR THE LIKE

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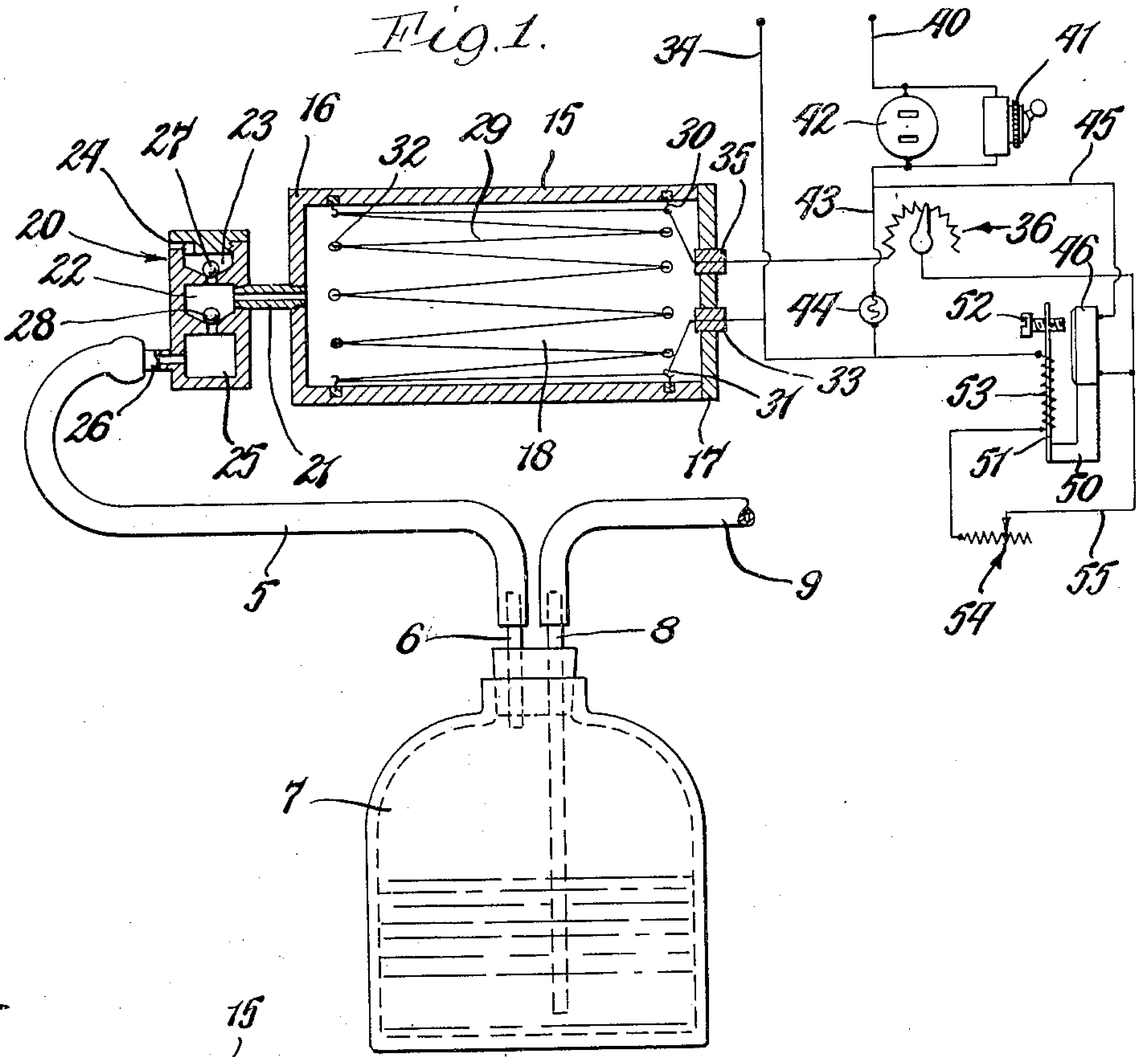
Fig.1.



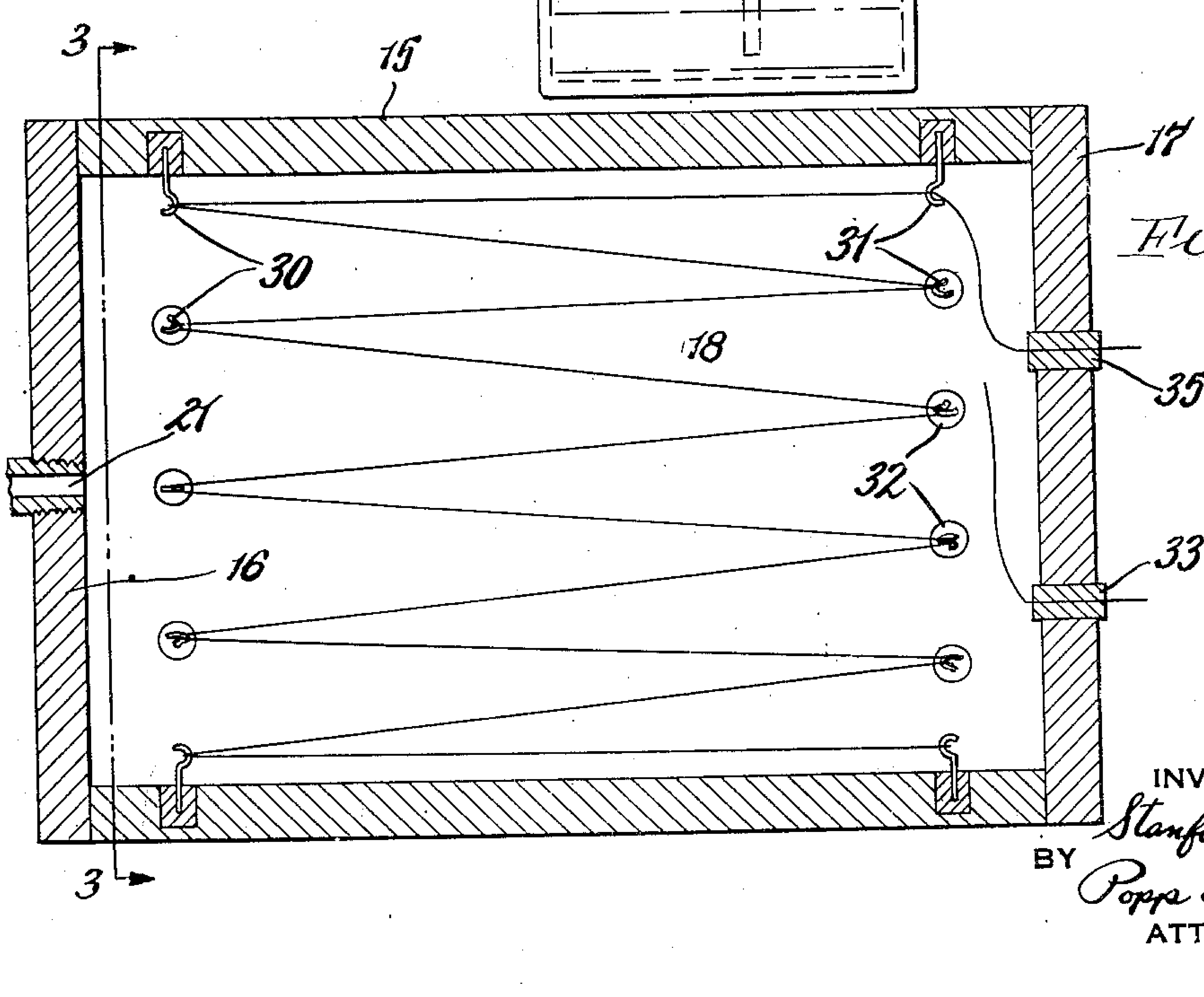


Fig.2.

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Fig. 3.

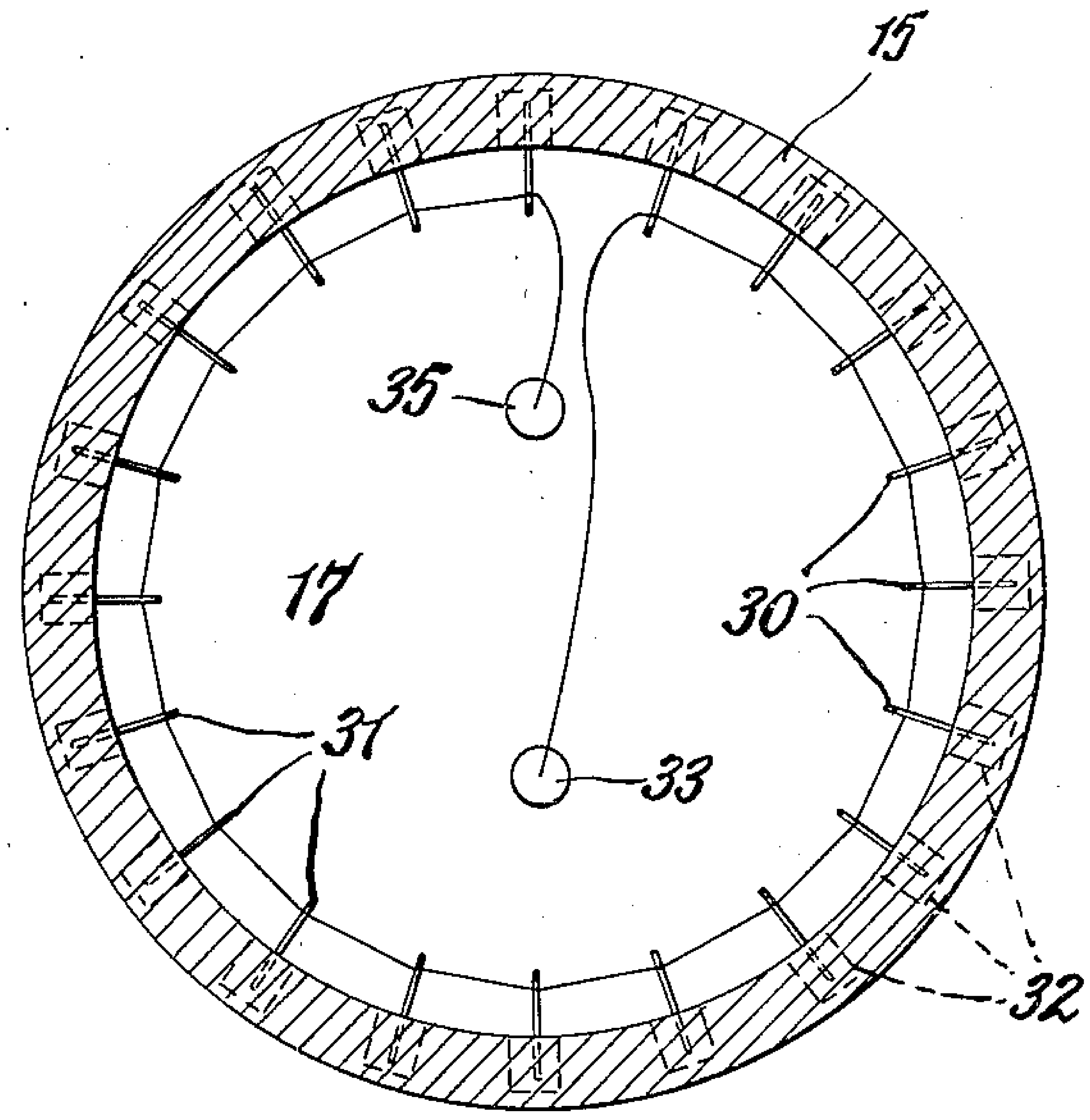
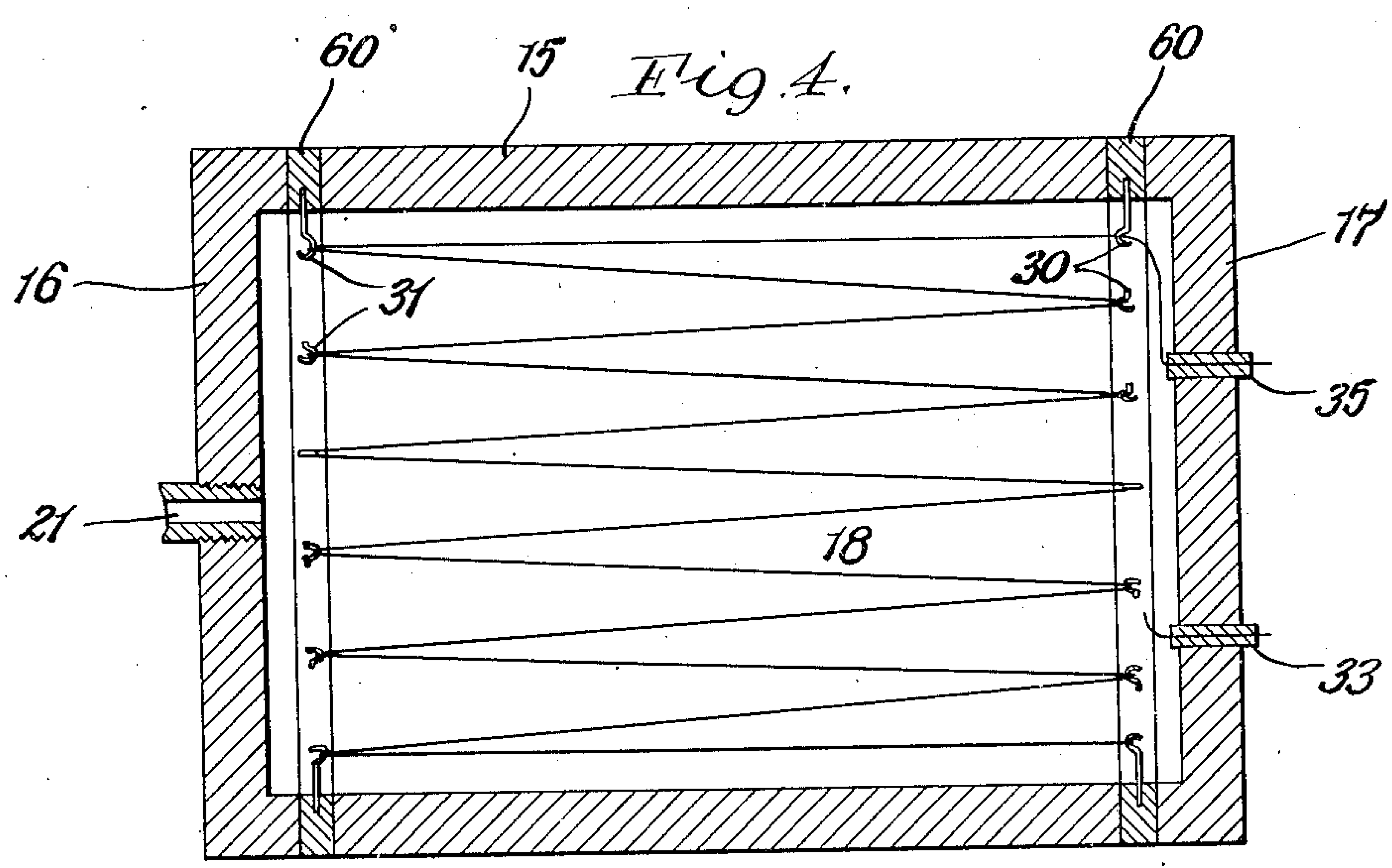


Fig. 4.



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HEATING CHAMBER FOR THERMOTIC PUMPS OR THE LIKE

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1 Claim. (Cl. 219—44)

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This invention relates to a heating chamber structure, and is shown as embodied in a heating chamber for a thermotic pump of the type shown in my prior Patent No. 2,346,841 granted April 18, 1944, which is actuated by the expansion and contraction of air by the application and withdrawal of heat. Such pumps have been found to be particularly useful for effecting drainage in many fields of surgery, particularly in urology and also in embalming in the removal of blood. In common with the said patented pump one of the objects of the invention is to provide such a pump which is readily designed to have a low value suction and on and off periods of short duration, thereby to effect, when used in the surgical field, a gentle drainage and a release of the flesh drawn against the catheter following each suction period so as to render the catheter operative for drainage during the next suction period. Also in common with the patented pump other objects are to provide such a pump which can be used either as a suction pump or as a pressure pump; which has accurately controlled on and off periods of uniform lengths; in which these on and off periods can be made of short duration thereby to provide a thermotic pump having high air handling capacity; which is practically noiseless in operation; in which the electrical heating elements is so designed as to rapidly heat the air and also rapidly cool when deenergized; which can be readily designed or adjusted to have any desired capacity or to develop any desired degree of pressure or suction; which has no major moving parts and which will stand up under conditions of severe and constant use without getting out of order or requiring repairs.

The pump forming the subject of the present invention is an improvement on the pump described and claimed in the said Patent No. 2,346,841. In the patented structure the fine wires of the heating element were wound on the periphery of two electric insulating disks, one disk being arranged at each end of the cylindrical housing. This mounting for the fine wires of the element was satisfactory for many uses of the pump but in endeavoring to obtain higher pressures from the pump in expanding its uses, it was found that this mounting for the resistance wires provided a limiting factor, particularly in that the disks had a relatively great mass in comparison to the

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fine wires of the element. Because of the relatively great mass of these end heads and their supporting members the air within the cylinder could not reach the higher temperature possible if the large cold mass of these disks were not present in the heating chamber. Further, the fine wires could not reach a uniform temperature since at the point of contact of these wires with the relatively large mass of the end disks heat was necessarily transmitted by conduction to the disks. By test it was found that these disks detracted from the efficiency of the pump by as much as 28% even when the disks were made as light as was mechanically feasible. Another and important undesirable effect of these supporting disks in the patented pump was due to the heat which accumulated in these disks from heat transmitted by direct contact of the fine resistance wires and by convection from the surrounding air within the chamber. Such heat developed in the supporting disks was not carried off by conduction or convection to any great extent, so that the final temperature of these disks was somewhere between the high temperature of the wire and surrounding air and the cool temperature of the heating chamber walls. This gave an affect of an undesirable secondary heating source which did not vary appreciably with the timed heating and cooling cycle of the pump. Also this retention of the heat by the supporting disks for the heating element did not allow the air within the chamber to drop to the low temperature that it did if this secondary source of heat were not present during the cooling part of the timed cycle.

Accordingly, it is a specific object of the present invention to provide a thermotic pump capable of higher pressures than were obtainable heretofore.

A further specific object of the invention is to reduce to a minimum the mass of the members within the heating chamber of the thermotic pump which serve no useful purpose other than to support the fine resistance wires.

A further specific object of the present invention is to provide a high degree of thermal conductivity between the supports for the resistance wires and the enclosing casing so as to avoid any substantial secondary heating effect by these supports.

Another specific object of the invention is to provide such a thermotic pump which can be adjusted to have a more rapid cycle through the elimination of the secondary heating and cooling effect of the supports for the fine resistance wire.

In the accompanying drawings:

Fig. 1 is a diagrammatic representation of a thermotic pump embodying the present invention and the circuit therefor, the pump being shown as used in conjunction with a conventional suction bottle for effecting drainage in surgery.

Fig. 2 is an enlarged view, similar to Fig. 1, of the working chamber of the pump and showing the manner in which the fine resistance heating element is supported therein in accordance with the present invention.

Fig. 3 is a transverse section, taken on line 3—3, Fig. 2.

Fig. 4 is a view similar to Fig. 2 and showing a modified form of the invention.

The form of the invention shown in Figs. 1–3 is shown as adapted for use for surgical drainage and is shown as connected by a suction tube 5 with the short stem 6 of a conventional suction bottle 7, the long stem 8 of which is connected by a tube 9 with the catheter (not shown). The liquid drawn through the suction line 9 from the wound or cavity being drained is trapped in the suction bottle 7.

The thermotic pump is shown as including a cylinder 15 having end heads 16 and 17 forming a cylindrical working chamber 18. This cylinder and its end heads are preferably made of aluminum so as to be light in weight and so as to readily dissipate the heat generated in its working chamber. However, it is not essential that this cylinder be made of metal and it could be made of glass, plastic, or any other material.

The cylinder 15 is shown as connected with a valve housing 20 by a tube 21, this valve housing being conventionally illustrated as having a central chamber 22 in communication with the working chamber 18 of the cylinder 15 through the tube 21, an upper exhaust chamber 23 having an exhaust port 24 leading to the atmosphere and a lower suction chamber 25 having a nipple connection 26 with the suction tube 5 leading to the suction bottle 7. An upwardly opening exhaust check valve 27 is conventionally shown as controlling the escape of air from the chamber 22 into the exhaust chamber 23 and an upwardly opening check valve 28 is conventionally shown as controlling the flow of air from the suction chamber 25 into the chamber 22.

With the apparatus as above described, it will be seen that upon heating the air in the working chamber 18, this air will be expanded and forced out through the tube 21, chamber 22, exhaust check valve 27, exhaust chamber 23 and through the exhaust port 24 to the atmosphere. Upon then allowing the air in the working chamber 18 to cool, its contraction on cooling will draw air from the suction bottle 7, through suction tube 5, nipple 26, and suction chamber 25 past the suction check valve 28 and through the chamber 22 and tube 21 into the working chamber 18 of the cylinder 15. Alternate suction and pressure producing periods are thereby provided, the pump being capable of being employed either as a suction or a pressure pump.

The dissipation of the heat from the air in the working chamber 18 is effected by conduction through the walls of the cylinder 15 and the heating of the air in the working chamber is effected by a fine resistance heating wire or filament 29 which extends lengthwise of the working chamber 18 and is looped back and forth between its opposite ends in close proximity to the wall of the cylinder 15.

The principal feature of the present invention resides in the means for supporting the resistance heating wire or filament 29 within the working chamber 18. The supports 30 for the successive loops of the heating element are made of small mass and are made a part of the heating chamber walls. These supports are shown as being made of wire having hook-shaped ends projecting into the working chamber in position to permit the resistance wire 29 to be looped thereon and having their stems embedded in inserts 32 cast or inserted in the cylinder 15. These inserts 32 are preferably made of an electrical insulating material so as to insulate the wire supports 30 and heating element 29 from the cylinder 15. These inserts 32 are also preferably made of a good heat conducting material, such as of glass, ceramic or a suitable plastic, so that the heat applied to the metal supports 30 by contact with the heating element 29 is freely conducted to the cylinder wall 15 for ready dissipation. The wire supports 30 are preferably made of a springy material so that a slight tension is maintained on the loops of the heating element 29. By this means these supports 30 tend to take up any slack which may develop in the heating element 29 due to expansion by heat.

As with the said patented thermotic pump, one terminal of the resistance heating wire or filament 29 can extend through an insulator 33 in the end head 17 to one side 34 of a main power line which supplies power at, say, 110 volts, and and the other terminal of the resistance heating wire or filament 29 is shown as extending through a similar insulator 35 to the slide wire resistance of a rheostat 36. The resistance heating wire or filament 29 should be as fine as possible and should be spread along the entire inner face of the cylindrical working chamber in close proximity thereto. To this end the resistance heating wire or filament 29 is preferably in the order of .002 inch in diameter. By using such fine and widely distributed wire or filament 29 as the heating element, the element heats and cools rapidly thereby to provide shorter cycles and pump more air in a given period of time; a greater current can be passed through the filament without danger of burning it out because of the short period of energization required; because of this increased capacity higher positive or negative pressures can be developed by the pump; and thermal lag is reduced because of the high rate of heat transfer between the resistance heating wire or filament 29 and the surrounding air in the working chamber 18.

The other side 40 of the main power line is shown as connected through a line switch 41 and plug socket 42 to a line 43 connecting a pilot light 44 across the main power line and to a line 45 connected with a microswitch or snap action switch 46. The plug socket 42 is for the reception of the plug of an extension switch (not shown) so that the pump can be turned on and off from a remote point. When either this extension switch or the line switch 41 is closed, the pilot light 44 is, of course, illuminated to indicate that fact. The microswitch is carried by a fixed bracket or frame 50 to which is also fixed one end of a bimetallic arm 51 on the free end of which is arranged an adjusting screw 52 in position to engage the operating button of the microswitch 46. This bimetallic arm is surrounded by a resistance wire 53, one terminal of which is connected directly with the side 34 of the main power line and the other terminal of which can be connected through an adjustable resistor 54 with a line 55 leading to the rheostat 36 and to the other terminal of the microswitch 46.

In the operation of the form of the invention illustrated in Figs. 1–3, when the line switch 41, or the extension switch (not shown) connected with the plug socket 42, is closed, current flows from the side 40 of the main power line through the line 43 and pilot light 44 to the other side 34 of the main power line, and also flows through the line 45, closed microswitch 46, line 55, rheostat 36, resistance heating wire or filament 29 to the other side 34 of the main power line. At the same time, current from the closed microswitch 46 passes from line 55 through the adjustable resistor 54, and through resistance wire 53 surrounding the bimetallic arm 51 to the other side 34 of the main power line.

The energization of the resistance heating wire or filament 29 causes this fine, widely spread wire to rapidly heat the air confined in the cylindrical heating chamber 18, this expanding the air and causing it to discharge through the tube 21, chamber 22 of the valve housing 20 and past the exhaust check valve 27, exhaust chamber 23 and exhaust port 24 to the atmosphere. During this energization of the resistance heating wire or filament 29, the resistance wire 53 surrounding the bimetallic arm 51 is also heated thereby causing the bimetallic arm to flex and engage its screw 52 with the button of the microswitch 46 and open this switch. The opening of the microswitch 46 breaks the circuit through the resistance heating wire or filament 29 and hence this resistance heating wire or filament and the surrounding air begins to cool, the heat being conducted through the walls of the cylinder 15. This cooling of the air in the working chamber 18 causes it to contract, thereby to draw air from the suction bottle 7 through suction tube 5, nipple 26 and suction chamber 25 and past suction check valve 28, chamber 22 and tube 21 into the working chamber 18.

When the resistance wire 53 surrounding the bimetallic arm 51 again cools, the bimetallic arm 51 flexes to close the microswitch 46 whereby the cycle of operations is again repeated.

When it is desired to vary the pressure, either positive or negative, developed by the pump, this is readily done by adjusting the rheostat 36 to cut more or less resistance into the main circuit. Less resistance through the rheostat 36 results in heating of the resistance heating wire or filament 29 to a higher temperature and hence in a more complete expansion of the air in the working chamber 18 with the development of a greater negative or positive pressure in the inlet and outlet parts, respectively, of the valve housing 20.

When it is desired to vary the volume of air handled by the pump, this is readily done by adjusting either the adjusting screw 52 of the bimetallic arm 51 or the adjustable resistance 54. Backing away the adjusting screw 52 requires the bimetallic arm to be heated to a higher temperature before it opens the microswitch 46 but due to its elevated temperature it will cool more rapidly. This more rapid cooling shortens the time of the complete cycle and for a succession of cycles results in a greater volume of air handled by the pump. Slow or fast timing of the

operation of the thermostatically controlled microswitch 46 can also obviously be obtained by adjustment of the adjustable resistor 54. It will therefore be seen that either the adjusting screw 52 or the adjustable resistor 54 can be employed for this purpose, both being shown by way of illustration.

It is desirable that the temperature of the pump cylinder 15 be maintained as low as possible and that the pump be capable of adjustment to reduce the on and off periods to as short a time as possible. Thus, by reducing the time necessary to reach maximum air pressure in the working chamber 18 and by reducing the time necessary to cool this air, an increased amount of air is handled and the size of pump to handle a given amount of air can be reduced. This rapid timing of the pump is in large measure achieved by the fineness and spacing of the resistance heating wires or filaments 29. The transfer of heat from a heavy wire to air would be greater than a thin wire due to the greater surface area thereof, but because of the specific heat of the material in the wire there is a time element involved, the timing being slower both in heating and cooling when using a heavy wire. Also the fine wires heat up more rapidly both because of the greater resistance provided by the fine wires and because of the fact that more current can be carried without danger of their burning out because of the fact that these wires are energized for a shorter time. This also permits the wires 29 to be carried to a higher temperature thereby to increase the positive or negative pressures being developed by the pump.

This rapid timing of the pump is also due to the form and mounting of the supports 30 upon which the resistance filament 29 is looped. These supports 30 and the mountings therefor further serve to permit higher pressures to be developed by the pump. Thus, these supports 30 are of small mass and hence are rapidly heated to follow the heating cycle of the pump. Further, since they are mounted directly on the casing or cylinder 15 there is a rapid transfer of the heat from these supports to the cylinder wall during the cooling cycle of the pump so that these supports do not provide a secondary heat source of any substantial value within the working chamber 18. Accordingly a pump having the supports 30 for the resistance, in accordance with the present invention, can develop higher pressures and can operate more rapidly than thermotic pumps heretofore in use.

It will be seen that the supports 30 for the heating resistance element can be made of many materials and can be secured to the wall of the working chamber 18 in a number of different ways in carrying out the present invention. For example, as shown in Fig. 4, these supports 30 can be cast or inserted in a pair of rings 60 which can be held between the end heads 16 and 17 of the cylinder 15. As with the embodiment of the invention shown in Figs. 1–3 if the supports 30 are in the form of metal wires the rings 60 would be made of a good thermal conductive electrical insulating material and the supports 30 are preferably made springy so as to take up any slack which may develop in the heating element 29.

From the foregoing it will be seen that the present invention provides a pump which is noiseless; free from major moving parts; is reliable in operation; is not likely to get out of order; can be designed to have high capacity and in particular can be designed to develop higher pressures, either positive or negative than has heretofore been possible with thermotic pumps of this character.

I claim as my invention:

In an electrical heating unit, a cylindrical enclosed container having a relatively thick metal wall through which substantially all of the heat developed within said container is dissipated, an annular ring of heat conductive electrical insulating material inserted in each end of the cylindrical part of said wall and communicating with the interior thereof, an annular series of spaced small metal supporting members secured directly to each of said rings and projecting radially inwardly therefrom and a relatively fine electrical resistance heating filament looped back and forth on said small metal supporting members and in closely spaced relation to the cylindrical part of said wall.

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