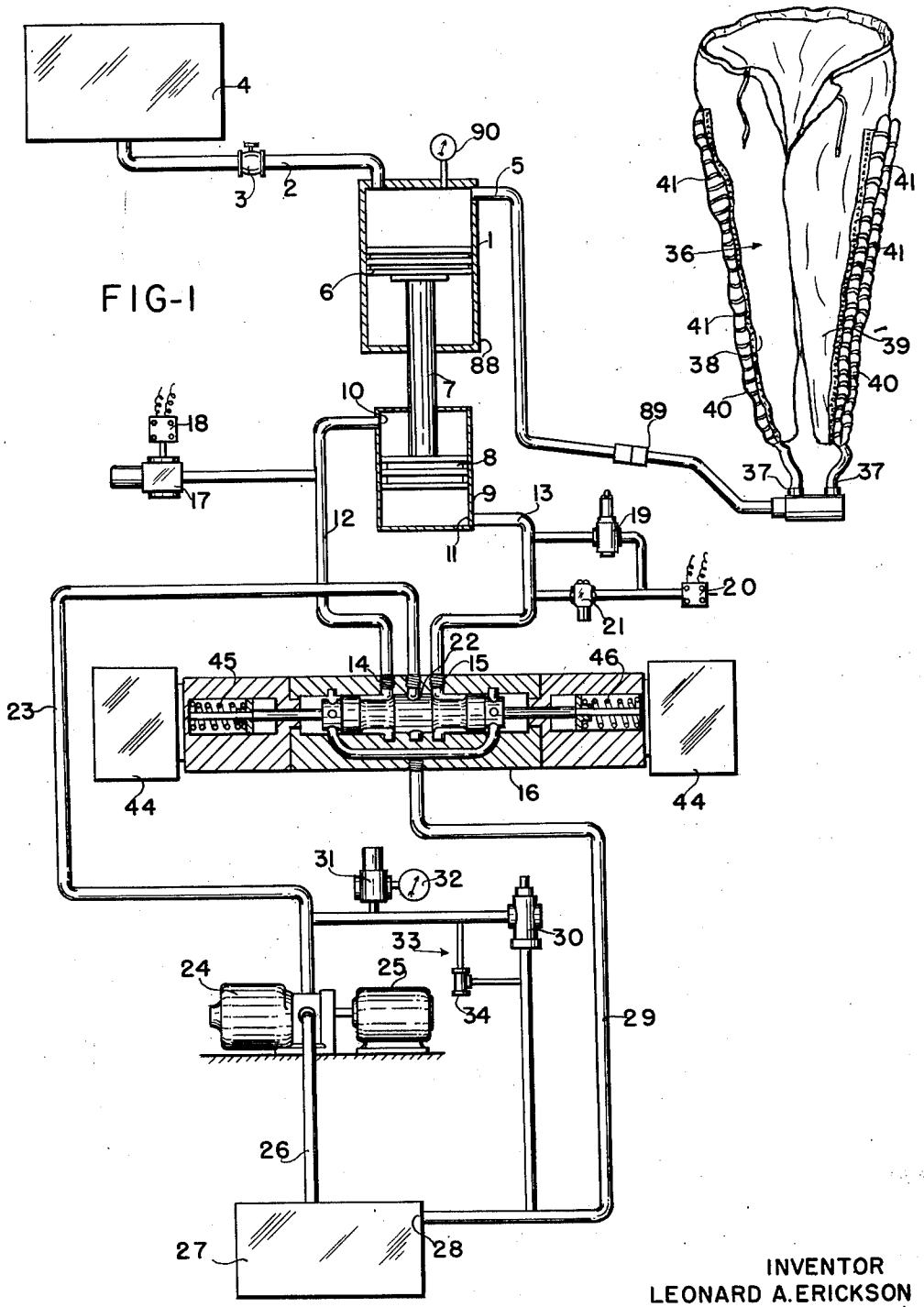
April 6, 1954 L. A. ERICKSON 2,674,231

POWER PACK FOR MASSAGE SUITS

Filed Jan. 2, 1952 3 Sheets-Sheet 1

FIG-1



INVENTOR
LEONARD A. ERICKSON
BY Toulmin & Toulmin
ATTORNEYS

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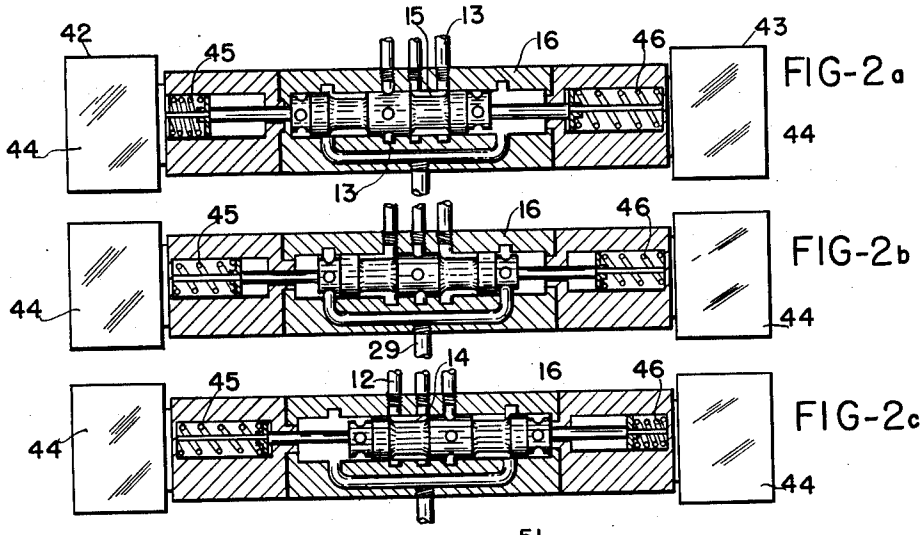
Filed Jan. 2, 1952 3 Sheets-Sheet 2



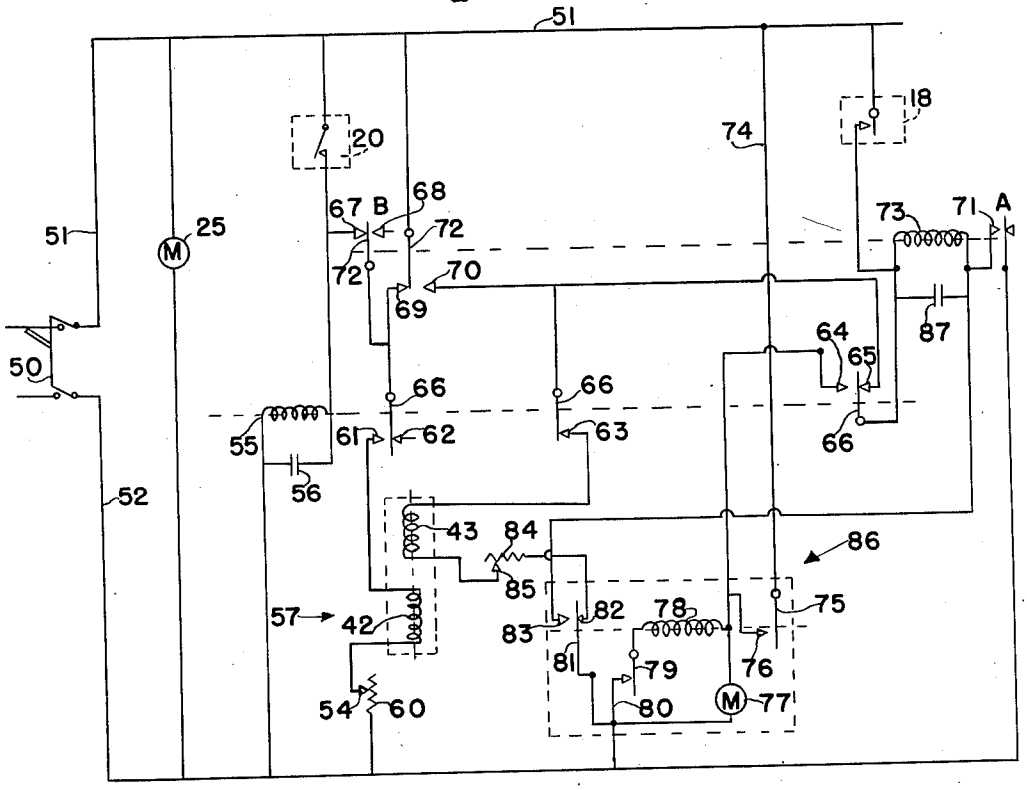


FIG-3

INVENTOR
LEONARD A. ERICKSON
BY Toulmin & Toulmin
ATTORNEYS

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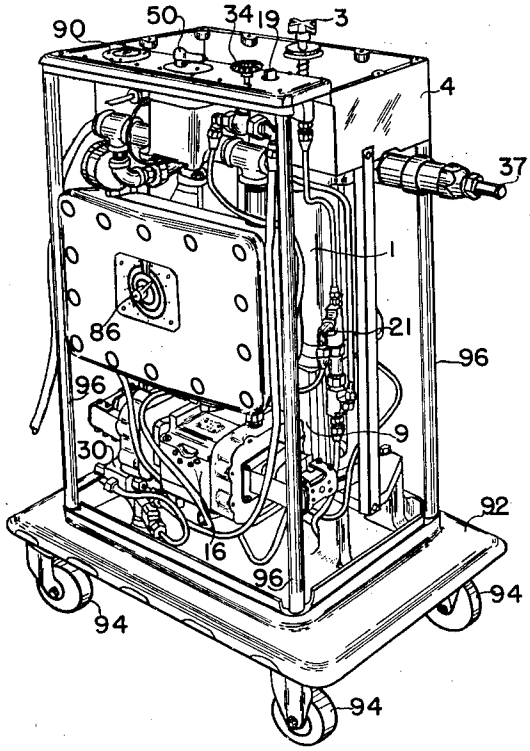


FIG-5

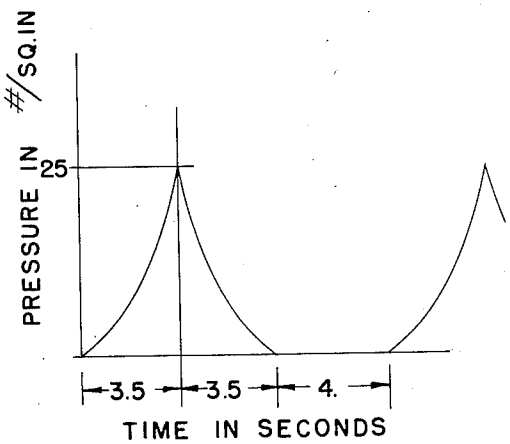
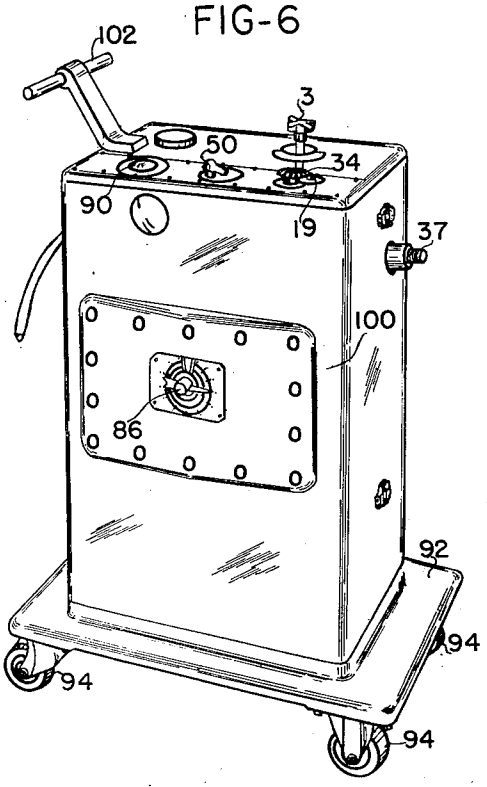


FIG-4

FIG-6



INVENTOR
LEONARD A. ERICKSON
BY Toulmin & Toulmin
ATTORNEYS

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2,674,231

POWER PACK FOR MASSAGE SUITS

Leonard A. Erickson, Dayton, Ohio, assignor to The Commonwealth Engineering Company of Ohio, Dayton, Ohio, a corporation of Ohio

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4 Claims. (Cl. 121—38)

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This invention relates to means and methods for repetitively exerting momentary peak pressures on expansible receivers. More particularly the invention relates to means and methods of exerting momentary peak fluid pressures on a receiver of a massage suit.

Massage suits are provided for the use of hospital patients either while recuperating from an illness or surgery, or may be utilized during an operation itself. The purpose of the suit, which is worn by the patient in a manner similar to a pair of coveralls, is to provide means to stimulate the circulation of the blood. To effect this purpose the legs of the suit are provided with bags of stretchable, flimsy material and the bags are secured by straps about the patient's leg, whereafter pressure is applied to the bag in pulses, which pulses are transmitted to the patient's leg and arteries to assist in the pumping of blood therethrough.

The pressure pulsation imparted to the blood system of the patient is required to vary slightly with the patient, both in amplitude and time of application, as a thin person may require a somewhat lower pressure and shorter pulse period than an individual having an obese extremity. Further the rate of application of pressure to the leg of the patient and the rate of withdrawal of pressure should be substantially identical.

The apparatus which delivers the liquid under pressure to the expansible bags must be of such a size and weight that it may readily be brought into a small hospital room and conveniently used therein. Further it must deliver liquid, such as water, to the bag or receiver at relatively high flow rates and pressures. Commercial apparatus capable of fulfilling this combination of requirements is not available for a unit, e. g. a pump which could meet the flow and pressure requirements is so large and unwieldy as to present difficulties in use; also a pump of proper physical size capable of attaining the required pressure does not have a sufficient flow rate and those pumps of moderate size having adequate flow rates do not meet the pressure requirements.

It is a particular object of this invention to provide apparatus which meets the above noted requirements.

It is a primary object of this invention to provide controlled means for positively exerting a momentary peak pressure on an expansible bag of stretchable material.

It is another object of this invention to provide controlled means for positively exerting a momentary peak pressure on an expansible bag or

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receiver of stretchable material which means utilize a liquid medium.

It is an important object of this invention to provide controlled means for repetitively applying a momentary peak pressure on an expansible bag or receiver of stretchable material.

It is yet another object of this invention to provide a method of repetitively applying a controlled peak pressure to an expansible bag of stretchable material.

It is a principal object of this invention to provide an electrical circuit arrangement which governs the application of the pressure in a given time sequence.

It is also an object of this invention to provide controlled means for repetitively applying a momentary peak pressure on an expansible receiver of stretchable material which means may be readily adjusted to provide particular peak pressures within a predetermined range.

Yet another object of the invention is to provide a method of obtaining a momentary peak pressure on a bag of expansible material.

These and other allied objectives of the invention are accomplished by securing to an expansible stretchable bag or receiver a hydraulic conversion unit consisting of two mechanically linked hydraulic cylinders in series and of differing diameter, the smaller double acting cylinder having the piston thereof motivated through a motor and pump combination at relatively high pressures, while the piston of the larger cylinder actuated directly by and in unison with the motion of the smaller piston delivers to the receiver a liquid at lower pressures but in considerably increased volume. This large volume delivery renders negligible the stretchable effect of the receiver and thus assures that a true momentary peak pressure will be achieved.

The application of pressure to the double acting cylinder is controlled by means of a solenoid operated, spring loaded, open center four way valve through which liquid courses in response to the action of the motor and pump combination, control of the course of the flow being effected by an electrical circuit arrangement dominating the action of the four way valve.

The electrical circuit is itself responsive to the actuation of pressure switches disposed in the hydraulic system and timing means are provided within the electrical circuit for regulating the period of fluid flow.

The invention will be more fully understood

by reference to the following detailed description and appended drawings wherein:

Figure 1 is a schematic representation of the hydraulic system including a four way valve;

Figures 2*a*, 2*b* and 2*c* illustrate the operative positions of the valve;

Figure 3 is a diagram of the electrical circuit;

Figure 4 is a curve of pressure versus time indicating the effect of operation of the structure of the invention;

Figure 5 is a perspective view of the unit of invention; and

Figure 6 is a view similar to that of Figure 5 with the casing on the unit and ready for connection to the receiver of a massage suit.

There is shown in Figure 1 a water cylinder 1 having an opening in the upper end thereof connected through line 2 having a hand valve 3 with a reservoir 4 containing water. A second opening in the upper end of cylinder 1 is connected through line 5 having a disconnect coupling 89 to the receiver 40 of the massage suit to be described more particularly hereinafter.

A piston 6 closely engaging the walls of the cylinder has a shaft 7 secured thereto which passes through the lower end wall of cylinder 1 and has secured to the other end thereof a piston 8 of smaller diameter than that of piston 6. Piston 8 is enclosed in cylinder 9 which is provided with ports 10 and 11 from which lines 12 and 13 extend to openings 14 and 15, respectively, in a four way valve 16. Secured in line 12 between the cylinder 9 and the valve 16 is a pulsation dampener 17 and a pressure switch 18. Bypassing line 13 between cylinder 9 and valve 16 is the combination of a variable set relief valve 19, a pressure switch 20 and a check valve 21. The check valve 21 prevents direct fluid flow to pressure switch 20 and permits a pressure rise in the line between the elements 21 and 20. The four way valve 16 has opening 22 which is connected to line 23 and the other end of this line 23 is provided with a pump 24 driven by a motor 25. The inlet line 26 of the pump 24 is connected with an oil reservoir 27 which reservoir has an opening 28 which is connected directly to the valve 16 through line 29. Connected between line 29 and line 23 is a relief valve 30 having associated therewith a pulsation dampener 31 and a pressure gauge 32 of about 600 p. s. i. capacity. A bypass line indicated generally at 33 and having a needle valve 34 bypasses the relief valve 30. This relief valve is adapted to be set at about 300# p. s. i.

This hydraulic unit as described is connected through means of the port in the wall of cylinder 1 through line 5 to the massage suit 36 by couplings on the suit indicated at 37. The suit 36 is provided with legs 38, 39 and a receiver 40 of stretchable material may be seen secured to each of the legs. Lacings 41 are provided to secure the receiver 40 tightly to the leg of the patient.

As more clearly shown in Figures 2*a*, 2*b* and 2*c* the four way valve 16 is a spool valve provided with solenoids 42 and 43 positioned in housing 44 which also contains spring elements 45 and 46.

In Figure 2*a* the valve is shown positioned to pass oil from the pump through opening 15 and line 13 to the lower side of cylinder 9.

As shown in Figure 2*b* the spool is centrally positioned and oil flows from the pump 24 directly back to the reservoir 27 through line 29.

As shown in Figure 2*c* the spool is positioned to pass oil through opening 14 and line 12 to the upper side of the cylinder 9.

The action of valve 16 is controlled by the spring elements 45, 46 which tend to force the valve to the central, open center position and the solenoids 42, 43 which occasion movement of the spool to the left or right position under the influence of power derived from the electrical circuit.

Figure 3 is a schematic diagram of the electrical circuit arrangement. It will be noted at the left of the diagram there is positioned a power switch 50 fed from a source (not shown) to pass current through lines 51 and 52. A motor 25 is connected across the line as in the combination of pressure switch 20 and coil 55. A condenser 56 is connected across the coil 55 for purposes to be described hereinafter.

At 57 the four way valve is schematically represented, the solenoids being indicated at 42 and 43 numbered as heretofore. The exhaust solenoid 42 has one end thereof connected to the power line element 52 through contact 54 of variable resistor 60, and the other end thereof to open contact 61, which contact 61 is one of three in a relay system noted generally by the numeral 66, indicated by the adjacent dotted line, and operative upon energization of coil 55. The filling solenoid 43 has one end thereof connected to contact 63 and switch or switch arm 66 and the other end of solenoid 43 is connected to one side 52 of the power line through resistor 84, contact 85 and contact 82. Contact 82 is a member of a second relay system indicated by the dotted line extending through coil 78 and operative upon energization of the said coil.

Contacts 62, 63 and 65 are normally closed and are ganged together on relay 66 for actuation through the coil 55, which relay in the actuated position closes on contacts 61 and 64. Similarly ganged switch arrangement 72 or relay system indicated by the dotted line adjacent thereto is normally closed on contacts 67 and 69 and when actuated by coil 73 closes on contacts 68 and 70 and also closes switch 71.

A timer arrangement indicated generally at 86 consists of timer motor 77, contact 76, switch 75, coil 78, a switch 79 and a mechanical timer contact 80, and contact 83.

Before the start of operation water is bled in sufficient quantity into the top of cylinder 1 and valve 3 (Figures 1 and 5) is then closed. The amount of water is not critical as long as it is sufficient in amount to fill the receiver and the top of the cylinder under pressure conditions.

The operation of the device is then initiated by closing power switch 50 which causes motor 25 to operate and oil to flow from reservoir 27. With the closing of switch 50, electric current flows through line 51, contacts 67, 69 and coil 55 to the other side 52 of the power line. The current flowing in coil 55 causes the ganged switch arrangement 66 to open contacts 62, 63 and 65 and close contacts 61 and 64 thereby completing the circuit having contact 69, contact 61, solenoid 42 and variable resistor 60 and the power line elements 51, 52.

Operation of solenoid 42 moves the spool of valve 16 leftwardly from the position shown in Figure 2*b* to that shown in Figure 2*c* and oil accordingly passes through line 12 to the upper end of cylinder 9 forcing the mechanically locked pistons 8 and 6 downwardly. When the pressure in line 12 and cylinder 9 reaches that at which pressure switch 18 is triggered, for example 275#, this switch closes, completing electrical

circuits between power line elements 51, 52 through contact 64 and motor 77 and also through coil 78, switch 79 and contact 80.

Current flowing through coil 78 will cause contact 76 to close with switch arm 75 connecting motor 77 directly across the line and switch 81 also changes position causing a circuit to be completed between line element 51, pressure switch 18, coil 73, contact 83 and line element 52.

Current coursing through coil 73 causes the ganged switch arrangement 72 having contacts 68, 70 and 71 to be actuated thereby closing these contacts and opening the circuit at 67 and 69 which opens the line to the coil 55 and which causes contacts 62, 63 and 64 to resume their normal positions as shown in Figure 3. Meanwhile current coursing through coil 78 will maintain contact 82 open and hence solenoid 43 open, but when the timing motor has attained the predetermined setting switch 80 will be opened mechanically causing the field across coil 78 to fall thereby closing contact 82. This would also cause the field across coil 73 to fall and accordingly holding contact 71 is provided to prevent this occurrence at this time.

With the above operation the circuit of the filling solenoid 43 is now completed across the line through contacts 63, 65 and pressure switch 18 on one side and variable resistor 84 and contact 82 on the other side of the solenoid.

Actuation of solenoid 43 causes the spool of valve 16 to move to its Figure 2a position and oil accordingly flows to the bottom side of cylinder 9 causing pistons 8 and 6 to rise. Thereby water is forced through line 5 to the expansible bag 1 of stretchable material and pressure is exerted on the leg of the patient. However as the pressure on switch 18 begins to fall this switch opens and the circuit through solenoid 43 is completed across the line through contacts 70, 63, resistor 84 and contacts 82. This circuit was of course as to 63 completed upon the original actuation of coil 73.

When the pressure in oil line 13 has exceeded the relief valve setting and the oil exerts the tripping pressure, about 70# for pressure switch 20, this switch closes completing the circuit across the power line through coil 55 and thereby again changing the position of the relay system 66 carrying contacts 62, 63 and 64.

This causes an open contact at 65 thus breaking the circuit which had existed through contact 70, contact 65, coil 73 and switch 71 and effectively clears the circuit for another cycle of operation. Thus the exhaust solenoid 42 is then again energized from the power line through contacts 61 and 54 on resistor 60 and the operation is automatically repeated.

Condenser 58 across coil 55 and condenser 87 across coil 73 are each provided to supply current to the coils as the fields thereacross change. This prevents the spool of the valve 16 from moving too rapidly across the valve body and prevents clicking sounds emanating therefrom which might be distracting in a hospital or surgery room.

Relief valve 19 is primarily a safety feature and in conjunction with check valve 21 which is normally set to be actuated at about 5# differential pressure and operates to protect the oil system from overload.

The pulse dampeners 17 and 31 of conventional construction serve to insure that the switches 18, 20 will not be affected by surge pressures in the lines.

Needle valve 34 is set with relation to variable set relief valve 19 and operates to bypass in large measure the oil flow around relief valve 30 which is normally set at about 300#. Thus this valve controls the amount of oil recycled and hence the speed of operation of the piston 8.

With the hydraulic system shown, piston 6 having a diameter of about 6'' and piston 8 a diameter of about 2'', the diameter of the connecting piston rod 7 being about 1⅜'' flow of water to the expansible receiver to attain a pressure of about 25# per square inch is accomplished with an oil pressure of about 225 p. s. i. on the lower face of piston 8 in about 3½ seconds. The volume of each bag is then about 152 cubic inches.

As may be seen from Figure 4 the unit may be conveniently set to allow the pressure to rise from about zero to about 25# per square inch in about 3½ seconds and the pressure fall may likewise have the same time period. Pulsations may occur at convenient intervals of about 4 seconds and this interval is determined by a pre-set of motor 77 (Figure 3).

Motor 77 is first actuated upon the closing of switch 18 as noted hereinbefore, when the pressure on the upper side of piston 8 has reached the switch 18 setting. Motor 77 will continue to operate as long as coil 78 is energized since contact 76 which is a portion of the relay will be closed and place motor 77 directly across the power line. Upon the opening of switch 80 mechanically at the end of the predetermined time period, 4 seconds in the present instance (Figure 4), the coil across coil 78 falls opening switch 76 and stopping the timing motor, switch 80 then returning to position. Prior to the opening of switch 80 switch 18 has been opened due to the fall of pressure in the portion of cylinder 9 above piston 8 as the oil moves back through valve 16. It will be noted however that the circuit of the filling solenoid 43 cannot be completed until coil 78 is de-energized and contact 82 is closed on switch 81 and that switch 80 is spring loaded to return to contact position upon the de-energizing of coil 78. By the above means smooth operation of the system, as shown by Figure 4, is assured.

The time of reversal (see Figure 4) is approximately the same, much of the water being drawn from the expansible receiver as piston 6 moves downwardly forcing air through the opening 88 to the atmosphere. The downward travel of the piston is accomplished at higher pressure than the upward motion to offset the effect of decreased area due to rod 7.

It will thus be seen that the method of invention provides for the attainment of relatively high flow rates from cylinder 1 derived from high pressures in cylinder 9 thus permitting the attainment of an operation cycle as shown in Figure 4.

It should also be noted that in normal operation the receiver of a massage suit will be positioned at a higher elevation than the unit of invention and gravity will then assist the flow of water from the receiver to return the pressure on the same to substantially atmospheric. Under this condition a portion of the water may remain in the receiver and the operation is facilitated thereby.

As may be clearly seen from Figures 5 and 6 the unit of invention is an extremely compact and versatile arrangement having all control elements readily available to an operator. Thus valve 3, speed control 34, adjustable relief valve 19, water pressure gauge 90, coupler 37, and timer control 86 (see also Figure 3) are conveniently

positioned. A platform 92 having wheels 94 supports the unit and renders it easily movable when pressure is exerted on handle 102 (Figure 6). Casing 100 eliminates substantially all pockets or corners which might collect dust and dirt thus assisting in a particularly clean unit. The weight of the unit is only about 275 pounds and the overall height about 3 feet.

It will be understood that this invention is susceptible to modification in order to adopt it to different usages and conditions and, accordingly it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

I claim:

1. In a liquid flow system an electric circuit for controlling the cyclic operation of a unit having an open center spring loaded four way valve and a pressure cylinder into the opposite ends of which streams of flowing liquid are directed alternately for exerting a pressure on opposing faces of the piston of the cylinder, and which unit has a pressure switch reactive with each said stream, the combination comprising electric circuit power means including a power line, first and second solenoids for control of the valve, a first coil having an associated relay and connected across said power line of said power means, the said first coil being operative upon actuation thereof to control a first solenoid and the flow of one of said streams from said valve, a second coil and associated relay operative upon actuation of one of said pressure switches to de-energize said first coil and thereby center said spring loaded valve, a third coil and associated relay operative upon actuation of said second coil to maintain said valve in open center position, a timing motor having mechanical means operable to de-energize said third coil, and circuit means including said second solenoid operable upon the de-energizing of said third coil to control the flow of the other of said streams from said valve.

2. A system as in claim 1 in which the second coil and its associated relay are maintained in circuit upon deenergization of the actuating pressure switch, the relay associated with the first coil, which coil is itself deenergized, functioning to maintain the said second coil and relay in circut.

3. A system as in claim 1 in which the second coil and its associated relay are deenergized upon a rise of pressure in the other of said streams, said deenergization taking place by actuation of the pressure switch associated with the other of said streams and the simultaneous energization of said first coil.

4. A system as in claim 1 in which the pressure switch reactive with the other of said streams is actuable upon rise of pressure in said stream and is energized with the first coil and relay associated with the said first coil.

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