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APPARATUS FOR TREATMENT OF ARTERIAL CIRCULATION DISTURBANCES AND RHEUMATISM

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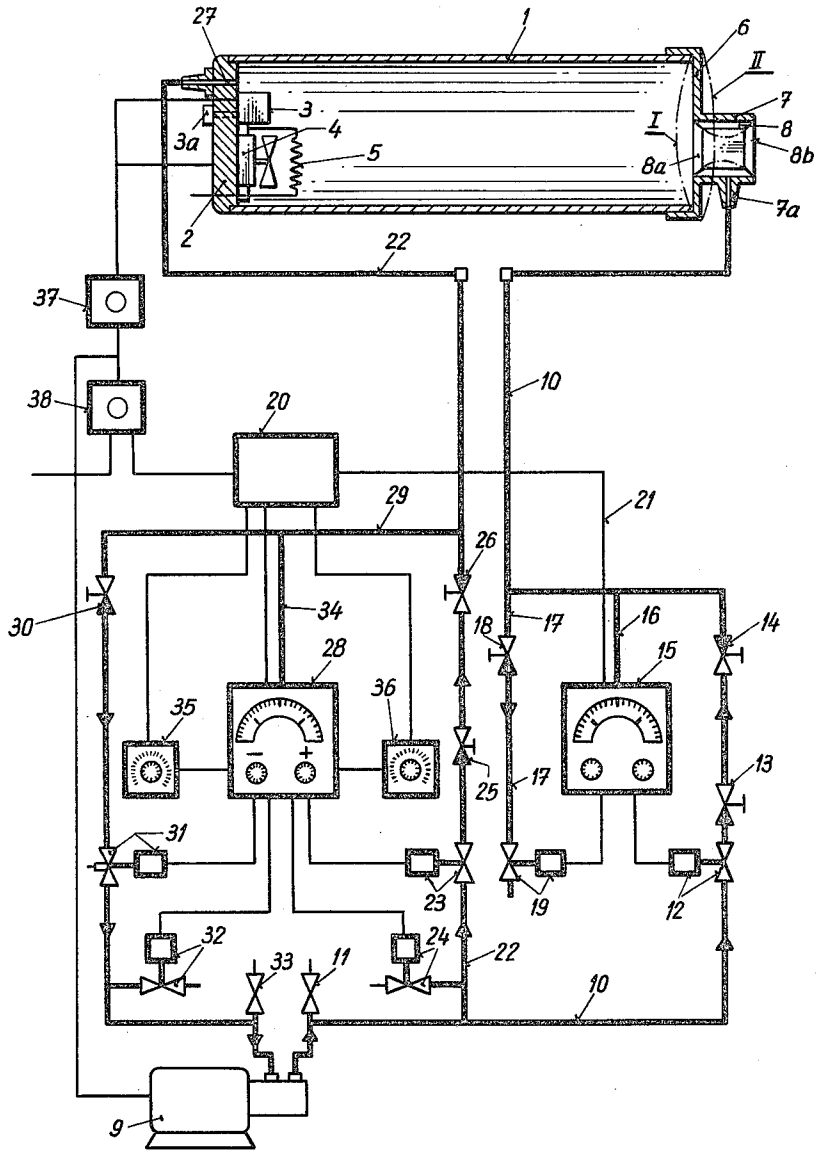

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APPARATUS FOR TREATMENT OF ARTERIAL CIRCULATION DISTURBANCES AND RHEUMATISM

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This invention relates to apparatus for the treatment of disturbances in the circulation of blood and various forms of rheumatic diseases of the upper and lower limbs of the human body.

The object of the present invention is to provide an apparatus for the treatment of disturbances in the circulation of blood and various forms of rheumatic diseases of the upper and lower limbs of the human body which apparatus has a receptacle for receiving a limb and an inflatable sleeve for airtight sealing as well as control means for the operation of a pump unit for the production of an excess pressure or reduced pressure in the receptacle.

For the treatment of arterial circulation disturbances and rheumatism, apparatus is known having a glass cylinder for receiving the limb to be treated. The airtight sealing of the glass cylinder is effected by means of rubber sheaths and rubber bandages. Connected to the glass cylinder is a vacuum pump to be operated by hand for producing a reduced pressure which results in a widening of the vessels of the limb inserted in the cylinder whereby a hyperaemia is released. The suction produced results in a firm pressing of the rubber sheath onto the limb and thereby prevents the venous return flow.

For determining the duration of the reduced pressure of air in the cylinder a valve is provided which according to the hyperaemia reaction is held closed for several minutes. By the opening of the valve the rarefaction of the air in the cylinder is terminated whereby the construction is relaxed and the venous return flow is restored.

By means of the use of inflatable sleeves and an electronic control in conjunction with the known apparatus it has become possible to subject the limbs to be treated also to an excess pressure whereby the indication area is enlarged. It has been proved however, that the inflatable sleeves, according to the type of treatment to be effected, for example, alternating excess and under pressure phases, effect an extraordinarily considerable construction of the limb and thus prevent a premature venous return flow whereby the exposure of the limb to great rarefaction of air leads to great pain. One therefore can no longer obtain with a very full sleeve the widening of the vessels exclusively by the rarefaction of air but only by a venous congestion by constriction.

The object of the invention is to provide a fundamental improvement of the known apparatus in the sense that the inflatable sleeve can be filled and emptied automatically in proportion to the pressure ratio in the cylinder in order to extend the field of use of the apparatus and to facilitate the maintaining of the circulation of the blood so that the venous return flow can also take place during the phase of the rarefaction of air in that the rarefaction of air brings about a widening of the blood and lymph vessels. This widening results in an increased quantity of blood and lymph in the limb to be treated whereby the feeding of the tissue is increased or when there is a deficiency it is reestablished as far as possible.

The apparatus according to the present invention is

characterised in that one end of the receptacle is closed by means of a wall carrying an air supply connection, a thermostat, a blower and a heating and cooling device while the other end of the container has a removable airtight lid with a sleeve connection with an air supply and an inflatable sleeve connected to the inner wall of this connection and that means are provided which control the pressure and the temperature within the receptacle and the pressure within the inflatable sleeve automatically according to a variable program whereby upon an excess pressure occurring in the receptacle the sleeve fills such that it excludes a leakage of the excess pressure from the receptacle and with an intended reduction in pressure does not prevent the return flow of blood in the venous system.

The above stated and further objects of the invention will be apparent from the following description of one embodiment of the apparatus which is shown diagrammatically in the accompanying drawing and in conjunction with the various control means.

The apparatus comprises a receptacle **1** adapted to receive the limb to be treated which container is closed airtight at one end by a wall **2**. On the inside of the wall **2** are fixed a thermostat **3** for the regulation of the temperature inside the receptacle **1** and a blower **4** with heating and cooling coil **5**. The other end of the container **1** is capable of being closed by means of a lid **6** on which is located a connection piece **7** for the application of an inflatable sleeve **8**. The sleeve **8** is made of a thin rubber tube the edges **8***a* and **8***b* of which are fixed to the inner wall of the connection piece **7**. The connection piece **7** has a bore which has a connection with an air connection **7***a* through which compressed air for the inflation of the sleeve can be let in or let out in order that the latter after the insertion of the limb to be treated always remains in contact with the latter in an airtight manner. The lid **6** and its sleeve connection **7** are preferably made of thicker rubber so that the lid upon reduced pressure in the receptacle takes up the position I shown in dot and dash lines in the drawing. While upon excess pressure in the receptacle it is adjusted to a position II.

Associated with the apparatus is a regulatable pressure and vacuum pump **9** the pressure side of which is connected via an air pipe **10** to the inflatable sleeve **8**. The pipe **10** has an excess pressure valve **11** and comprises also a relay-operated valve **12**, a non-return valve **13** connected to the latter and a manually adjustable throttle valve **14**. For the control of the relay-operated valve **12** there is provided a pressure regulator **15** with adjustable minimum and maximum pressure which is connected by means of a tube piece **16** to the pipe **10** such that the air pressure behind the throttle valve **14** and thus that in the inflatable sleeve **8** is effective. A further branch **17** with a throttle valve **18** and a relay-operated valve **19** is connected to the branch of the pipe **10** which lies between the inflatable sleeve **8** and the throttle valve **14**. The relay-operated valve **19** is likewise controlled by the pressure regulator **15** which in its turn is connected electrically via a wire **21** to a constant voltage source **20**.

In front of the relay-operated valve **12**, a further air pipe **22** branches off from the air pipe **10** and from which a branch is provided via a relay-operated valve **24**. From the relay-operated valve **23** the air pipe **22** leads via a non-return valve **25** and a throttle valve **26** to a connection piece **27** on the wall **2** of the receptacle **1**. The connection piece makes the connection of the air pipe **22** to the inside of the receptacle **1**. For the control of the relay-operated valves **23** and **24** a further pressure regulator **28** with adjustable minimum and

maximum pressure is used. The two pressure regulators 15 and 28 may as a contact manometer have or be in the form of a photocell control. The portion of the air pipe 22 lying between the throttle valve 26 and the connection piece 27 has a connection via a pipe 29 with a throttle valve 30 and a relay-operated valve 31 with the pressure and vacuum pump 9 to which pipe a relay-operated valve 32 and an excess pressure valve 33 as well as a branch 34 leading to the pressure regulator 28 are connected. The control of the relay-operated valves 31 and 32 is affected by means of the pressure regulator 28 which is connected to the constant voltage source 20. There are also present a time relay 35 for the regulation of the reduced pressure phases and a time relay 36 for the control of the excess pressure phases in the receptacle 1. Both time relays 35, 36 are connected to the pressure regulator 28 and to the constant voltage source 20.

The connection of the apparatus to the mains is effected via an on and off switch 38 to which are connected the constant voltage 20 and the pressure and vacuum pump 9 as well as a heating and cooling unit which latter for its part is connected to the heating and cooling coil 5 and to the thermostat 3. The thermostat 3 is adjustable by means of a rotary knob 3*a* mounted on the outside of the wall 2 to give the temperature desired at the time.

The manner of operation of the apparatus is described as follows in the treatment of a dry gangrene. For this treatment it is necessary to subject the limb to an excess pressure as well as a reduced pressure, to heat the inside of the receptacle 1 to 35° C. but upon pain occurring to cool to 10° C. As treatment values are provided:

Excess pressure	0.05 atmosphere.
Maintaining constant stabilization	30 seconds.
Reduced pressure	0.15 atmosphere.
Maintaining constant stabilization	45 seconds.
Sleeve pressure:	
Maximum value	0.08 atmosphere.
Minimum value	0.01 atmosphere.
Temperature:	
Without pain	35° C.
With pain	10° C.

The sleeve 8 fitting the limb to be treated is fixed to the sleeve connection piece 7 and the limb is introduced through the opening of the sleeve into the container 1. The pressure regulator 28 is then adjusted to the desired excess and reduced pressure values in the receptacle 1, the pressure regulator 15 to the maximum and minimum values of the sleeve pressure, the time relay 35 to the stabilization value of the reduced pressure, the time relay 36 to the stabilization value of the excess pressure and the thermostat 3 to the temperature in the receptacle.

After the switching on of the switch 38 the blower 4 begins to run and the heating coil 5 produces heat until the temperature set on the thermostat 3 is attained whereupon the heating device is automatically switched off. In the case where instead of the heating a cooling is to be effected the heating coil 5 is to be replaced by a cooling coil. In this case the switching off of the blower 4 is effected as soon as the temperature set on the thermostat is reached.

For the automatic regulation of the pressure ratios between the pressure within the sleeve 8 and that in the receptacle 1, the throttle valves 30, 26, 18 and 14 are used whereby care should be taken that the throttle effect by the throttle valve 30 must be smaller than that of the throttle valve 18 and that the throttle effect of the throttle valve 26 must be greater than the throttle effect of the throttle valve 14. The non-return valves 13 and 25 prevent an equalization of pressure between the sleeve 8 and the casing 1. This measure is necessary because the sleeve 8 at the beginning has to take a larger quantity

of air than the casing 1 in order that a satisfactory application of the sleeve to the limb is ensured. In this way the necessary sealing of the casing is first effected which only then makes an increase of pressure within the casing possible.

When the maximum value of the sleeve pressure is attained the relay-operated valve 12 closes. In setting this maximum value on the pressure regulator 15 care is to be taken that the increase in pressure in the receptacle 1 results in an increase of pressure in the sleeve 8 readable on the pressure regulator. This pressure effect coming from outside must be added to the pressure existing in the sleeve 8 itself whereby the maximum value of the sleeve pressure to be set at the beginning turns out to be higher than the pressure in the receptacle 1. Experiments which have been carried out resulted in a difference of about 0.03 atmosphere. If therefore the pressure present in the receptacle 1 is to be 0.05 atmosphere then the maximum value of the sleeve pressure must be adjusted in the first place to 0.08 atmosphere with the result that the relay-operated valve 12 only closes when in the receptacle 1 the pressure of +5 (0.05) is actually reached.

The minimum value of the sleeve pressure depends on the disease to be treated as there are cases in which a certain constriction proves to be favorable. Thus the zero value of the pressure regulator 15 corresponds to the pressure which is necessary in order to press the sleeve 8 onto the limb such that it contacts the skin. This pressure suffices to prevent a flowing in of air at the commence of the rarefaction of air in the receptacle 1. If one wishes therefore to bring about a certain constriction one must increase the minimum value of the sleeve pressure whereby at the commencement of the reduced pressure a certain pressure remains in the sleeve 8 which places the sleeve firmly into contact with the limb so that during the phase of the rarefaction of air a constriction and thereby a stronger or weaker prevention of the venous return flow is brought about.

Due to the weaker throttling at the throttle valve 30 in proportion to the throttling at the throttle valve 18 the pressure in the casing 1 dissipates more rapidly than in the sleeve 8 and the reduced pressure in the receptacle already begins before the sleeve pressure has reached the set minimum value. The reduced pressure in the receptacle 1 effects a continuously stronger suction of the sleeve on the limb. As the limb however offers a resistance the same is expressed by a measurable increase of pressure in the sleeve 8. This increase of pressure may be drawn off by opening of the relay-operated valve 19. If therefore the minimum valve of the sleeve pressure is set such that it is under the value necessary for adopting the sleeve at "0" pressure onto the limb so that it contacts the skin (zero value of the sleeve pressure) then one causes thereby the sleeve 8 during the reduced pressure phase of the treatment to give the pressure which is necessary or would be necessary to produce a reduced pressure in the receptacle 1. This prevents to a great extent a constriction of the limb by the sleeve 8 so that the venous return flow can also be maintained even during a greatly reduced pressure. At "0" pressure the atmospheric outer pressure applies which exists also in the inside of the receptacle before the switching on of the apparatus.

If in the treatment set forth of a dry gangrene the relay-operated valves 31, 24 and 19 are closed and the relay-operated valves 32, 23 and 12 open then the sleeve 8 and the receptacle 1 fill with compressed air. If the set maximum values are reached then the relay-operated valves 31, 23, 19 and 12 close while the relay-operated valves 32 and 24 open. The time relay 36 effects the stabilization of these positions during the set period. After expiration of this period the relay-operated valves 32, 23 and 12 close while the relay-operated valves 31, 24 and 19 open. The sleeve 8 and the receptacle 1 can

now empty. If the minimum value of the sleeve pressure set is reached, the relay-operated valves 32, 23, 19 and 12 are closed and the relay-operated valves 31 and 24 are opened so that in the receptacle 1 a pressure reduction is brought-about. If the maximum value of air rarefaction set is reached then the relay-operated valves 31, 23, 19 and 12 are closed while the relay-operated valves 32 and 24 are opened. The time relay 28 effects the stabilization of this position during the set period after expiration of which the relay-operated valves 31, 23, 19 and 12 close and the relay-operated valves 32 and 23 open with the result that the receptacle 1 receives compressed air and the air rarefaction disappears. If the set minimum value of the sleeve pressure is reached, the relay-operated valves 31, 24 and 19 close and the relay-operated valves 32, 23 and 12 open which position corresponds to the above mentioned starting position.

The treatment phases described run according to the duration of treatment for 20 minutes to 15 hours returning always to the sequence set forth and thus effect the therapy. In consequence of the automatic sequence special supervision is not necessary.

For reasons of safety for the pressure regulators 28 and 15 the excess pressure valves 33 and 11 are provided as well as the member 20 ensuring the constant voltage. There are also safety devices, not shown, present in the individual circuits.

I claim:

1. Apparatus for the treatment of disturbances in the circulation of the blood and various forms of rheumatic diseases of the upper and lower limbs of the human body comprising a hollow receptacle having an opening, a closure member mounted on said receptacle across said opening and having a tubular extension with said closure member and tubular extension being formed of a semi-rigid material, an inflatable sleeve fixedly mounted within said tubular extension and being capable of having the limb to be treated extending therethrough into said receptacle, means for heating and cooling the interior of said receptacle, a source of compressed air connected to said receptacle and said sleeve, relay operated valves for controlling the pressure in said sleeve in proportion to the pressure inside said receptacle interconnected between said source of compressed air and said sleeve and receptacle and means for regulating said valve relays and said heating and cooling means according to a variable program of treatment for the limb.

2. Apparatus for the treatment of disturbances in the circulation of blood and various forms of rheumatic diseases of the upper and lower limbs of the human body comprising an elongated hollow receptacle having an open end, a lid for closing said receptacle open end and having a tubular extension for receiving the limb to be treated extending therethrough into said receptacle, said lid and its extension being formed of a semi-rigid material, an inflatable sleeve fixedly mounted in said lid extension, means for heating and cooling the interior of said receptacle, a pressure and vacuum pump, air conveying means connecting said pump to said receptacle and said sleeve and automatic means for controlling the flow of air through said air conveying means and the temperature provided by said heating and cooling means as desired.

3. Apparatus as claimed in claim 2 wherein said air conveying means consists of a pair of pipes with one pipe connected to said receptacle and the other to said sleeve and including a pair of individually regulatable throttle valves each interconnected in one of said pipes being adjustable for permitting a greater quantity of air to flow into said sleeve than into said receptacle and a greater quantity of air to flow out of said receptacle than out of said sleeve.

4. Apparatus as claimed in claim 2 wherein said air conveying means consists of a pair of pipes with one pipe connected to said receptacle and the other pipe to said sleeve and including a pair of individually regulatable throttle valves each interconnected in one of said pipes and a non-return valve interconnected in said pipe connected to said sleeve for preventing equalization of pressure between said sleeve and said receptacle.

5. Apparatus as claimed in claim 2 including a pressure regulator in fluid circulation with said sleeve.

6. Apparatus as claimed in claim 2 including a pressure regulator in fluid circulation with said receptacle.

References Cited by the Examiner

UNITED STATES PATENTS

1,110,494	9/1914	Kellogg	128—402 X
2,655,145	10/1953	Heger	128—24.1

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