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Description

This invention relates to a device for sustaining the operation of the blood vessels in the human body, at least in part in one of the limbs thereof, with more than one chamber to be positioned in contact with different zones of the body, said chambers being adapted to take up a fluid such as air under pressure and having a flexible wall for transmitting said pressure to the body, with means to subject a fluid in said chambers to a pulsating pressure.

A device of this kind is known from U.S. patent 4,029,087 and from U.S. patent 4,030,488.

It is known that the blood supply to the human limbs, in particular to the legs, gives problems particularly by ageing by weakening of skin and muscles, so that the backflow of blood towards the heart is hampered, in particular by venous valve-insufficiency or decreased muscular pumping activity.

It has thus been proposed already to obtain improvement by supporting and exerting pressure on parts of such limbs. A good possibility to this end is the exertion of a pulsating pressure thereon, i.e. of a pressure which is increased and decreased alternately.

In U.S. patent specification 4,029,087 the said chambers are subjected to a pulsating pressure from an external source, subsequent chambers being filled from a chamber closest to the extremity of the concerning limb, through throttling check valves between the chambers so that during the high pressure phase of the pulsational feed of fluid from the external source the pressure in chambers positioned more remotely from the extremity of said limb (more proximal chambers) is substantially lower than the pressure in chambers closer to said extremity (more distal chambers). Emptying of chambers during the low pressure phase of the pulsations either takes place through adjacent chambers or by connecting the chambers each separately from the others to a relief discharge. Chambers, positioned more remotely from the extremity of said human limb are filled from more distal chambers through narrow throttling connections or by check valves opening against a relatively high pressure difference, so that proximal chambers in each pulsation cycle are subjected to a much lower pressure than distal chambers. For the relief of the chambers through other chambers there are two possibilities, one being that each chamber is relieved to and through a more distal chamber, the other being relief to and through a more proximal chamber. This relief takes place through check valves, opening against a much lower pressure difference (and of course in opposite direction) than the check valves used for filling the chambers with the fluid. If each chamber is relieved to and through a more distal chamber, the pressure in the more proximal chamber may remain slightly higher than in more distal chambers, but this difference in pressure in the pulsation pressure relief phase is negligible as all the

relief check valves (flap valves) open against a pressure difference very much lower than the pressure difference for the check valves for filling.

In U.S. patent specification 4,030,488 a device of this kind is given, in which the chambers are filled and emptied in a pulsating manner independently of each other through a common supply and discharge conduit to all the chambers, a throttling passage leading from this conduit to each chamber. For more distal chambers this passage is wider than for more proximal chambers. In this way a fluid pressure is built up in each chamber, which is lower for more proximal chambers. In the pressure relief phase of each pulsation a more proximal chamber is relieved more slowly than a more distal chamber, but by the lower pressure in said more proximal chamber it rapidly reaches a pressure as low as the pressure in such a more distal chamber before the next pressure rise begins.

The invention aims at improving such devices. In this respect it has appeared that in such known devices the operation is not optimal, and moreover that this is to be attributed to the fact that, during the pressure decreasing phase of the pulsations much venous blood flows back immediately to the distal part of the limb, in particular to the lower leg of standing or sitting patients.

In view thereof the invention proposes to embody a device as given in the preamble in such a way that there are valve means in the path of a source for feeding the fluid to each one of said chambers in a relatively unthrottled flow in the raised pressure phase of the pulsations and throttling means to discharge the fluid from each one of said chambers in the decreased pressure phase of the pulsations, embodied so that the throttling means for discharge of the fluid from a more proximal chamber give substantially more throttling to this discharge flow than the throttling means for discharge from a more distal chamber.

Thereby, at least one more proximal chamber loses its pressure during the relief phase of the pulsations more slowly than at least one more distal chamber, which has a favourable influence as to avoiding such rapid back flow of venous blood.

It is possible to apply the invention with any desired number of chambers along different parts of a human leg and if desired also on an arm. The most proximal chamber may be present on part of the human torso, e.g. on breast, shoulder or hip.

For walking patients the pulsations may be generated by applying a flexible "pumping chamber" below the foot, which chamber is in fluid communication with one or more pressure chambers in contact with parts of the leg so that a fluid such as air is pumped to said pressure chambers by and from said pumping chamber when placing the foot during walking and that, when lifting the foot, this fluid flows back into said pumping chamber. This is e.g. known from British patent specification 817,521 and from European patent application 39,629.

For patients who cannot walk, e.g. are bed-ridden or in a wheeled chair, such pulsations may be generated with the aid of a pump or pressure vessel and a controlled pulsation device, e.g. as disclosed in the said U.S. patent specifications 4,030,488 and 4,029,087.

The invention moreover relates to preferred embodiments of said principle.

For further explanation of the invention it is good to note that, for avoiding said rapid backflow of venous blood during the pressure relief phase it is as such not at all necessary that the pressure in the most proximal chamber is decreased at all. It should, however, be avoided that, when the pulsations are stopped, e.g. if the patient stops walking, sits or lies down immediately after walking, or when stopping or inadvertently falling out of the external source for the pulsations proximal chambers remain at the same higher pressure and thus would tend to tie up the human limb during a longer period. It is thus necessary to relieve also the more and most proximal chamber(s), but so slowly that during operation of the pulsations the pressure in said chamber(s) remains high, as indicated, while nevertheless allowing slow but sufficiently rapid decrease of said pressure in the absence of pulsations.

Throttling openings for the pressure relief may be present between the different chambers, but they may also lead directly from each chamber to the outside.

The invention will now be explained in more detail with reference to the attached drawings. Therein:

Fig. 1 is a somewhat diagrammatic vertical section through a boot, embodied as or comprising a device according to the invention;

Fig. 2 is a detail of this device at a larger scale;

Fig. 3 shows, also on a larger scale, another embodiment of the detail of Fig. 2; and

Fig. 4 gives a graph of pressure against time for a device according to Fig. 1.

The device of Fig. 1 is embodied as a boot 1, provided with a number of chambers 3, 8, 9, 10 for pressure pulsations, being permanently or easily detachably mounted in said boot. The chambers have flexible fluid-tight walls, which preferably are not elastic or only very little, such as a fabric impregnated and/or covered by a suitable flexible plastics or rubber material. In this case they are mutually connected to a unit 2. The boot may have zippers or bootlaces not shown to be easily pulled on and taken off.

In the sole part this unit has a flexible chamber 3, extending under the entire surface of the human foot sole or under the greater part thereof. A closable connecting nipple 4 serves to keep said unit filled with a fluid such as air, e.g. by the use of a simple hand or foot pump 5 easily connectable thereto and detachable therefrom, e.g. as usual for inflating air beds or rubber boats, but it is also possible to fill this unit by blowing by mouth or connection to any source of pressurized air or other gas. A meter 6 shows the filling pressure.

The nipple 4 may be connected at any point to unit 2, e.g. to one side of the sole or higher.

The chamber 3 is in open fluid connection with a chamber 8 through a flexible duct 7 extending along foot and ankle. Above chamber 8 there are two further chambers 9 and 10. To avoid hindrance to the patient and/or closing of duct 7 by the patient's foot or ankle, this duct may be embedded in a suitable material such as elastic foam plastic:

Said chambers 8 to 10 extend along the back side and along part of the sides of the lower leg. There may also be one or more chambers in contact with the upper leg and it is even possible that e.g. a hose connects the upper chamber 10 to a chamber to be applied to the patient at the height of the hip. If desired the duct 7 may be very short and chamber 8 may extend downwardly along the ankle, so that a pulsating pressure may also be exerted on the median or lateral ankle.

Within the unit 2 the chambers 8 to 10 are separated by substantially horizontal intermediary walls 11. Each wall 11 has a flow connection 12 between bordering chambers, indicated in Fig. 1 only diagrammatically by a dash. In Fig. 2 and 3 this connection 12 is shown in detail on a larger scale.

In the embodiment of Fig. 2 a valve casing 13 is mounted in an opening in each wall 11. This casing may be of metal, rather hard rubber or plastics material and it may be mounted by clamping, bonding or vulcanising or any other suitable connection method to wall 11. A valve body 14 is freely movable up and down in said casing and consists of metal, rubber or plastics material. At least one of the parts 13 and 14 is made of elastic material of such flexibility that body 14 is introduceable into casing 13. It is also possible to provide casing 13 with a separate part enclosing body 14 after introduction and mountable e.g. by screwing or screws, welding or glueing.

Valve body 14 has protrusions 15 such as battlements, which in the highest position of body 14 engage a shoulder 16 in casing 13 so as to allow fluid to pass through openings 17 in the battlements. Moreover this body 14 as a relatively narrow bore 18 and a conical outer surface 19 having the same cone angle as a seat 20 in casing 13. Said angle is chosen of such a high value that body 14 leaves said seat 20 upwardly easily and is not clamped thereby.

In Fig. 3 there is a small tube 21 of rubber or the like elastic material, bonded, e.g. vulcanised, sealingly in a hole in wall 11. This tube 21 is open at its lower end and closed by end wall 22 at its top. Above wall 11 it has a longitudinal (vertical) cut 23, so narrow that it is closed (gas tight) if the air pressures to both sides thereof are equal and for all pressure differences with a higher pressure at the outside of this cut. Moreover, there is a small (throttling) hole 24 penetrating the wall of tube 21 above wall 11.

The operation of this device is as follows:

After the entire unit 2 is filled by air of a

pressure somewhat higher than atmospheric, e.g. somewhat less than 40 mm Hg gauge pressure, and a human being walks on this boot 1, the chamber 8 is compressed when putting down the foot, part of the air in this chamber is pushed by duct 7 to chamber 8 and raises the pressure therein. This causes opening (lifting to the position shown) of valve body 14 (Fig. 2) or of slot 23 (Fig. 3) between chambers 8 and 9 towards chamber 9. The pressure rise in chamber 9 causes valve body 14 or slot 23 between chambers 9 and 10 to open and chambers 8, 9 and 10 thus rapidly reach about the same pressure, upon which the valves 14 or slots 23 close.

When lifting the foot the air tends to flow in the opposite direction, chamber 8 is subjected to a decrease in pressure together with chamber 3 by the increase in volume of the latter. The throttling openings 18 (Fig. 2) or 24 (Fig. 3) now form the only flow connection between chambers 8, 9 and 10, so that the pressure in chamber 9 decreases more slowly than in chamber 8 and in chamber 10 the pressure drop is even more slow. By the relatively rapid sequence of steps during walking said pressure drop in chambers 9 and 10 is not only more slow but finally also, until the next pressure rise begins, less in amount, and, for chamber 10, even if desired negligible.

The pressure changes of course depend on the relative volumes of the chambers. The chambers 8, 9 and 10 may be relatively thin in a direction perpendicular to the leg, and chamber 3 is chosen at a relatively considerable volume.

The throttling opening 18 or 24 between chambers 8 and 9 is preferably wider than the same opening between chambers 9 and 10. Thereby, chamber 9 will, during the pressure relief phase, much more rapidly fall in pressure to a pressure, considerably lower than the pressure in chamber 10, for which it is important that the pressure remains high to avoid backflow of venous blood.

Fig. 4 shows possible pressure distributions and pressure pulsations in a device according to Fig. 1. In stable, stationary condition the pressure in the entire device is e.g. somewhat less than 40 mm Hg. When the patient walks and compresses chamber 3 below his foot sole, the pressure in chamber 8 near 4b rises quickly to about the same level. As this pressure rise quickly opens (lifts) check valve body 14 of Fig. 2 or slot 23 of Fig. 3 between chambers 8 and 9, the pressure in chamber 9 also rises quickly to about the same value and thereupon opening check valve body 14 of Fig. 2 or slot 23 of Fig. 3 between chambers 9 and 10 causes chamber 10 to follow almost the same pressure rise. With the weight of the patient fully resting on this foot and fully compressed chamber 3 the pressures in the chambers 8, 9 and 10 have risen to say about 70 mm Hg.

Upon lifting this foot the pressure in chambers 3 and 8 drops rapidly, e.g. to about 20 to 25 mm Hg. As check valve 14 of Fig. 2 drops (closes) as soon as the pressures in the adjacent chambers to both sides thereof are about equal, or as slot 23 closes in this situation, the chambers 8, 9 and 10

are now only in communication by the throttling openings 18, 18' of Fig. 2 or 24 of Fig. 3. This causes the pressure in chamber 9 to decrease only gradually, e.g. to about 40 mm Hg, before the patient will again plant this foot (dashed line in Fig. 4). The pressure in chamber 10 will decrease even less (line of dots and dashes in Fig. 4), e.g. to 55 mm Hg when the next pressure rise begins. Without harm the pressure in chamber 9 may drop to lower values, e.g. by a wider throttling opening 18 or 24. The stationary pressure in the device of somewhat below 40 mm Hg is low enough to avoid undesired blood congestion.

The chambers 9 and 10 might also have a throttling relief opening to the outside for replacing or additional to openings 18 between chambers 8, 9 and 10. During the pressure rise phase the pressure in more proximal chambers 9 and 10 will then remain lower than in chamber 8, but this may be acceptable, if only the unit 2 is not allowed to remain deflated, e.g. by making chamber 3 elastic in a sense to tend to increase in volume.

If a liquid is used instead of gas or air, it is preferable to apply elastic walls for at least part of the chambers.

It is possible to use the unit 2 without a surrounding boot, in which case it might be strapped onto the human leg.

Instead of any of the valves as shown in Figs. 2 and 3 there may be simple ball valves as check valves. Particularly in such a case the throttling opening between adjacent chambers may be provided in the separating wall 11 thereof itself, as shown by 18' in Fig. 2.

If an external source is used for the pulsations, e.g. for bedridden patients or patients in a wheeled chair, the chamber 3 may be omitted and said source may be connected to chamber 8. Particularly in that case but if desired also in all other cases, each chamber may have its own separate connection to such an external source in which case rises and falls in pressure are controlled, e.g. with the aid of a microprocessor in such a way that one or more proximal chambers during the pressure fall are less relieved or less rapidly relieved than one or more distal chambers.

For the principle of the action of the pressure rise phases of the chambers for the blood circulation the use of more than three chambers may be deemed preferable, but this is known as such. For the principle of the present invention the number of subsequent chambers is of less importance, if only the most proximal chamber satisfies the requirement of the invention about a smaller value of its pressure drop during the relief phase.

Claims

1. A device for sustaining the operation of the blood vessels in the human body, at least in part in one of the limbs thereof, with more than one chamber to be positioned in contact with different zones of the body, said chambers (8, 9, 10) being

adapted to take up a fluid such as air under pressure and having a flexible wall (2) for transmitting said pressure to the body, with means to subject a fluid in said chambers to a pulsating pressure, characterized in that there are valve means (12) in the path of a source for feeding the fluid to each one of said chambers in a relatively unthrottled flow in the pressure raise phase of the pulsations and throttling means (18, 18', 24) to discharge the fluid from each one of said chambers in the pressure relief phase of the pulsations, embodies so that the throttling means for discharge of the fluid from a more proximal chamber give substantially more throttling to this discharge flow than the throttling means for discharge from a more distal chamber.

2. A device according to claim 1, in which a flow connection (12, 17) for the fluid is provided between two or more chambers (2, 8, 9, 10), so that the pressure in one or more chambers is increased via said connection as a result of a pressure rise in another chamber, which is adapted to be positioned more distal with respect to the human limb, characterized in that said chamber(s), in which the pressure is raised through such a connection, has (have) a throttling relief opening (18) giving more resistance to the flow of fluid therethrough than said flow connection, and that means (13, 14) are provided to close said flow connection during the periodic pressure relief phase of the pulsations.

3. A device according to claim 2, in which said throttling relief (18') opening is provided between said chambers in order to allow relief of one chamber gradually towards a more distal chamber.

4. A device according to any of the preceding claims, in which a check valve (12) is provided between adjacent chambers, embodied so as to close said flow connection between said chambers in the pressure relief phase of the pulsations.

5. A device according to claim 4 together with claim 2 or claim 3, in which the check valve (12) has such a throttling opening (18, 24) in its valve body to allow passage of fluid therethrough in its closed position.

6. A device according to claim 4 in combination with claim 2 or claim 3, in which said check valve consists in an elastic hose (21) between adjacent chambers, closed at the end (22) positioned in the more proximal chamber, having a throttling opening (24) at or near said end in its wall and having a narrow slot (23) in its part extending into said more proximal chamber, which slot is closed elastically by the elastic material of the hose along its sides and opening as soon as the fluid pressure inside the hose, being the pressure in the more distal one of said adjacent chambers, is higher than the fluid pressure in the more proximal chamber.

7. A device according to any of claims 2 to 6, in which a chamber (3) is provided, adapted to be positioned below the human foot sole so that, in walking, this chamber is pressurized and substantially emptied when placing the foot and is

decreased in pressure and filled by the fluid when the foot is lifted, there being a fluid flow connection (7) between this chamber and an adjacent chamber adapted to be in contact with part of the human leg and from this latter to one or more further chambers adapted to be in contact with a more proximal part of the human body, at least the fluid connection between the two most proximal chambers having such a throttling relief opening (18, 24) and said closing means to close this connection during the periodic pressure relief phase of the pulsations.

8. A device according to claim 7, in which the flow connection (7) between said chamber adapted to be positioned below the human foot and the most adjacent chamber is free from such closing and throttling means.

Patentansprüche

1. Vorrichtung zur Unterstützung der Tätigkeit der Blutgefäße im menschlichen Körper, wenigstens zum Teil in einem der Glieder desselben, mit mehr als einer mit mehreren verschiedenen Zonen des Körpers in Berührung zu bringenden Kammer, wobei die Kammern (8, 9, 10) dazu eingerichtet sind, ein Fluid, beispielsweise Luft, unter Druck aufzunehmen, und eine flexible Wand (2) aufweisen, um diesen Druck auf den Körper zu übertragen, mit einer Einrichtung, um ein Fluid in den Kammern einem pulsierenden Druck zu unterwerfen, dadurch gekennzeichnet, daß Ventileinrichtungen (12) in dem Weg von einer Quelle angeordnet sind, um jeder dieser Kammern das Fluid in einer relativ ungedrosselten Strömung in der Druckerhöhungsphase der Pulsationen zuzuführen, und Drosselrichtungen (18, 18', 24) angeordnet sind, um das Fluid aus jeder dieser Kammern in der Druckablassphase der Pulsationen auszulassen, die derart ausgebildet sind, daß die Drosselrichtungen für das Auslassen des Fluides aus einer näher gelegenen Kammer diese Auslaßströmung wesentlich mehr drosseln, als die Drosselrichtungen für das Auslassen aus einer entfernteren Kammer.

2. Vorrichtung nach Anspruch 1, bei der eine Strömungsverbindung (12, 17) zwischen zwei oder mehr Kammern (2, 8, 9, 10) vorgesehen ist, sodaß der Druck in einer oder mehreren Kammern über diese Verbindung als Folge eines Druckerhöhungs in einer weiteren Kammer steigt, die dazu eingerichtet ist, weiter weg in Bezug auf das menschliche Körperglied angeordnet zu werden, dadurch gekennzeichnet, daß die Kammer(n), in der (denen) der Druck über diese Verbindung steigt, eine Drosselentlastungsöffnung (18) hat (haben), die der Fluidströmung durch sie hindurch mehr Widerstand entgegengesetzt, als die Strömungsverbindung, und daß Einrichtungen (13, 14) vorgesehen sind, um die Strömungsverbindung während der periodischen Druckminderungsphase der Pulsationen zu verschließen.

3. Vorrichtung nach Anspruch 2, bei der die Drosselentlastungsöffnung (18') zwischen den

Kammern angeordnet ist, um eine Entlastung einer Kammer allmählich gegen eine mehr entfernte Kammer zu ermöglichen.

4. Vorrichtung nach einem der vorhergehenden Ansprüche, bei der ein Rückschlagventil (12) zwischen benachbarten Kammern vorgesehen ist, das so ausgebildet ist, daß es die Strömungsverbindung zwischen diesen Kammern in der Druckminderungsphase der Pulsationen verschließt.

5. Vorrichtung nach Anspruch 4 in Verbindung mit Anspruch 2 oder 3, bei der das Rückschlagventil (12) eine solche Drosselöffnung (18, 24) in seinem Ventilkörper hat, daß es den Durchgang von Fluid in seiner geschlossenen Stellung ermöglicht.

6. Vorrichtung nach Anspruch 4 in Kombination mit Anspruch 2 oder 3, bei der das Rückschlagventil aus einem elastischen Schlauch (21) zwischen benachbarten Kammern besteht, der an dem Ende (22) verschlossen ist, das in der näher gelegenen Kammer liegt, eine Drosselöffnung (24) an oder nahe diesem Ende in seiner Wand aufweist und einen engen Schlitz (23) in seinem sich in die genannte näher liegende Kammer erstreckenden Abschnitt hat, welcher Schlitz durch das elastische Material des Schlauches längs seiner Seiten elastisch verschlossen wird und sich öffnet, sobald der Druck in der entfernter liegenden der beiden benachbarten Kammern höher ist, als der Druck in der naher liegenden Kammer.

7. Vorrichtung nach einem der Ansprüche 2 bis 6, bei der eine Kammer (3) vorgesehen ist, die dazu eingerichtet ist, unter der menschlichen Fußsohle angeordnet zu werden sodaß beim Laufen diese Kammer unter Druck gesetzt und im wesentlichen entleert wird, wenn mit dem Fuß aufgetreten wird, und im Druck vermindert und mit dem Fluid gefüllt wird, wenn der Fuß gehoben wird, wobei eine Strömungsverbindung (7) zwischen dieser Kammer und einer benachbarten Kammer vorhanden ist, die dazu eingerichtet ist, mit einem Teil des menschlichen Beins in Berührung zu sein, und von dieser letztgenannten zu einer oder mehreren weiteren Kammern, die dazu eingerichtet sind, mit einem näher liegenden Teil des menschlichen Körpers in Berührung zu sein, wobei wenigstens die Fluidverbindung zwischen den zwei am nächsten liegenden Kammern eine solche Drosselentlastungsöffnung (18, 24) und die Verschließeinrichtung zum Verschließen dieser Verbindung während der periodischen Druckminderungsphase der Pulsationen aufweist.

8. Vorrichtung nach Anspruch 7, bei der die Strömungsverbindung (7) zwischen der unter dem menschlichen Fuß anzuordnenden Kammer und der nächst benachbarten Kammer frei von solchen Verschließ- und Drosseleinrichtungen ist.

Revendications

1. Un dispositif pour assister le fonctionnement des vaisseaux sanguins dans le corps humain, du moins en partie dans un de ses membres, com-

portant plus d'une chambre destinée à être en contact avec différentes zones du corps, lesdites chambres (8, 9, 10) étant prévues pour recevoir un fluide tel que de l'air sous pression et possédant une paroi flexible (2) pour la transmission de ladite pression au corps, un moyen pour soumettre un fluide dans lesdites chambres à une pression pulsatoire, caractérisé en ce qu'il est prévu un dispositif à soupape (12) sur le trajet d'une source d'alimentation en fluide à chacune desdites chambres avec un écoulement relativement non étranglé au cours de la phase de montée en pression des pulsations et des dispositifs d'étranglement (18, 18', 24) pour le refoulement du fluide à partir de chacune desdites chambres au cours de la phase de décompression des pulsations, l'ensemble étant réalisé de telle manière que les dispositifs d'étranglement pour le dégagement du fluide à partir d'une chambre plus rapprochée produisent une diminution sensiblement plus prononcée de ce courant de dégagement que les dispositifs d'étranglement pour le refoulement à partir d'une chambre plus éloignée.

2. Dispositif selon la revendication 1, dans lequel il est prévu une jonction d'écoulement (12, 17) pour le fluide entre deux ou davantage de chambres (2, 8, 9, 10) de manière que la pression dans une ou plusieurs chambres croisse par ladite jonction par suite d'une élévation de pression dans une autre chambre, qui est destinée à être placée à l'endroit plus éloigné par rapport au membre, caractérisé en ce que la ou les chambres dans lesquelles la pression s'élève grâce à cette jonction possèdent un orifice de dégagement à étranglement (18) offrant plus de résistance au courant de fluide à travers celui-ci que ladite jonction d'écoulement et qu'il est prévu des moyens (13, 14) pour obturer ladite jonction d'écoulement au cours de la phase de décompression périodique des pulsations.

3. Dispositif selon la revendication 2, dans lequel ledit orifice de dégagement à étranglement (18') est prévu entre lesdites chambres pour permettre le dégagement progressif d'une chambre vers une chambre plus éloignée.

4. Dispositif selon l'une des revendications précédentes, dans lequel il est prévu un clapet de retenue (12) entre des chambres adjacentes réalisé de manière à obturer ladite jonction d'écoulement entre lesdites chambres pendant la phase de décompression des pulsations.

5. Dispositif selon la revendication 4 en combinaison avec la revendication 2 ou 3, dans lequel le clapet de retenue (12) possède un orifice d'étranglement (18, 24) dans le corps de clapet pour permettre le passage du fluide dans sa position fermée.

6. Dispositif selon la revendication 4 en combinaison avec la revendication 2 ou 3, dans lequel ledit clapet de retenue consiste en un tuyau élastique (21) entre des chambres adjacentes, fermé à l'extrémité (22) placée dans la chambre la plus rapprochée, possédant dans sa paroi un orifice d'étranglement (24) à ou près de ladite extrémité et une fente étroite (23) dans la partie

s'engageant dans ladite chambre plus rapprochée, laquelle fente se ferme élastiquement grâce au matériau élastique du tuyau le long de ses côtés et s'ouvre dès que la pression du fluide à l'intérieur du tuyau, qui est la pression dans l'une des chambres adjacentes plus éloignée, est supérieure à la pression du fluide dans la chambre plus rapprochée.

7. Dispositif selon l'une des revendications 2 à 6, dans lequel il est prévu une chambre (3) destinée à être placée sous la plante du pied humain de manière que, lors de la marche, cette chambre soit mise sous pression et pratiquement vidée lorsqu'on pose le pied et décompressée et remplie par le fluide lorsqu'on lève le pied, une jonction d'écoulement pour le fluide (7) étant prévue entre cette chambre et une chambre adja-

cente destinée à être en contact avec une partie de la jambe et, à partir de cette dernière, avec une ou plusieurs autres chambres prévues pour être en contact avec une partie plus rapprochée du corps humain, la jonction pour fluide au moins entre les deux chambres les plus rapprochées possédant un tel orifice de dégagement à étranglement (18, 24) et un moyen d'obturation pour fermer cette jonction pendant la phase de décompression périodique des pulsations.

8. Dispositif selon la revendication 7, dans lequel la jonction d'écoulement (7) entre ladite chambre destinée à être placée sous le pied humain et la chambre la plus proche est dépourvue de tels moyens d'obturation et d'étranglement.

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fig-1

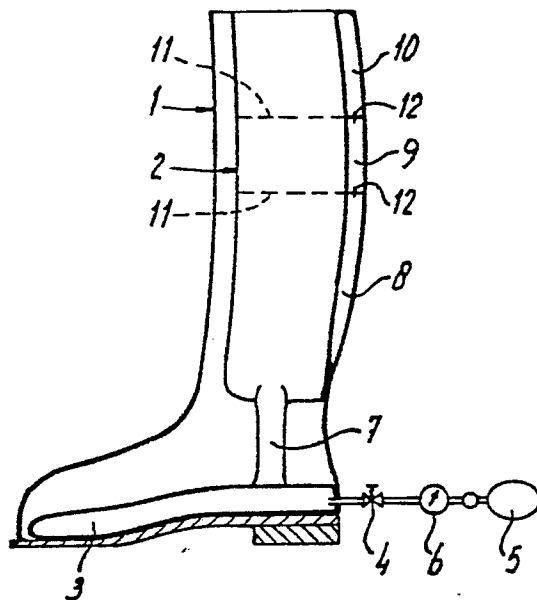


fig-2

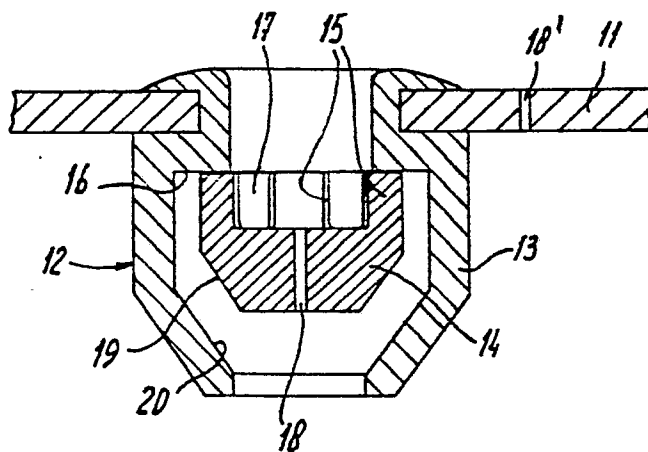


fig-3

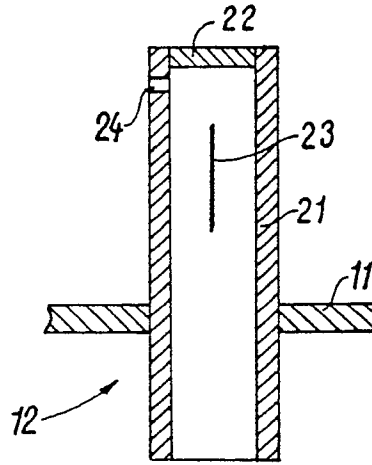


fig-4

