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(54) SELF-CONTAINED PERFUSION DEVICE

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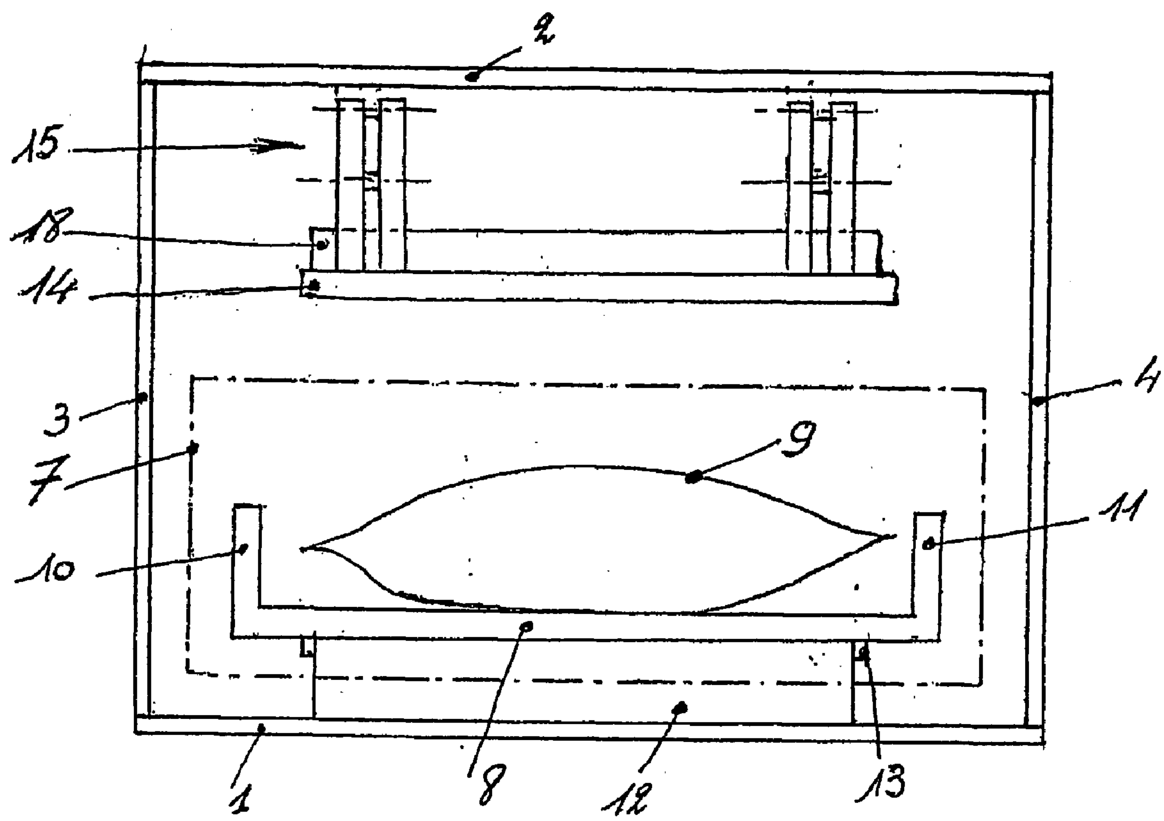
(57) **ABSTRACT**

The invention concerns a self-contained perfusion device comprising means for fixing an infusion bag under pressure between a fixed plate and a mobile plate driven by an elastic mechanism, the lower plate **(8)** is fixed in the vertical direction, while the upper plate **(14)** is mobile in the vertical direction under the action of the elastic mechanism **(15)**. At least one opening **(7)** is provided in at least a side wall **(5)** of the device for inserting an infusion bag **(9)** between the two plates **(8, 14)**. The elastic mechanism **(15)** is provided with independent means for controlling and locking the plates **(8, 14)**, and means **(24, 25)** are provided for unlocking the elastic mechanism **(15)** after the infusion bag **(9)** has been loaded. The lower plate **(8)** can be horizontally mobile like a slide. Means are further provided for controlling the emptying of the bag during perfusion.



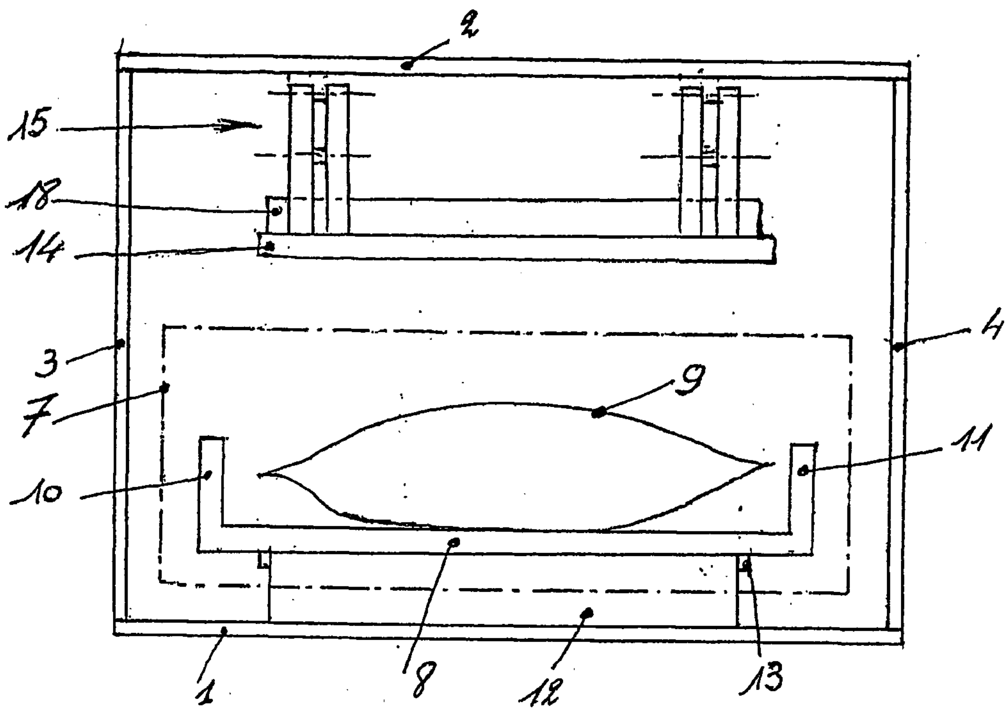

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Fig. 1

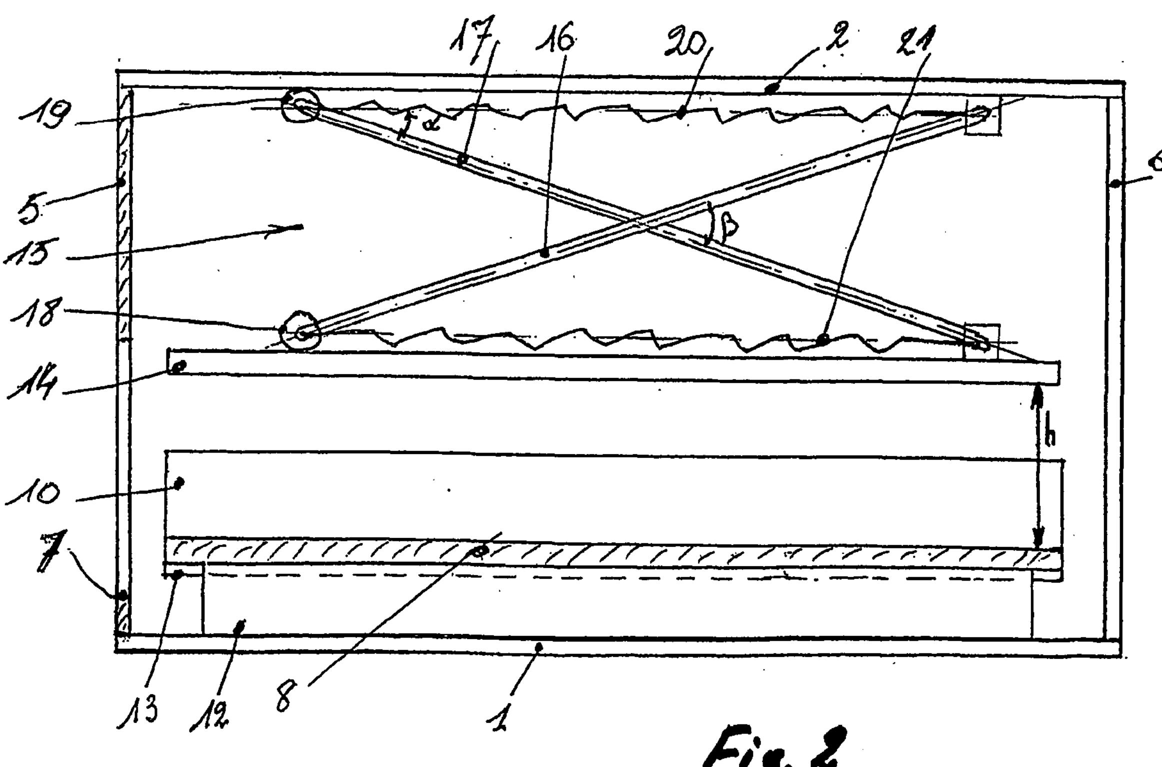
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Fig. 2

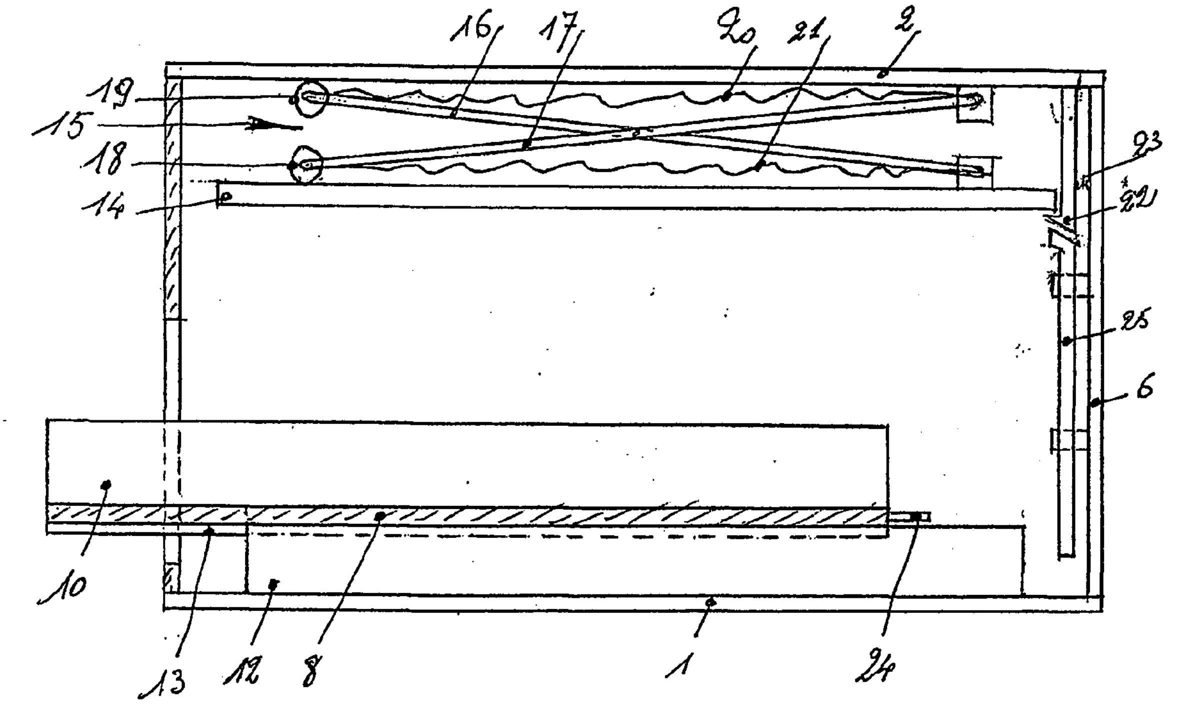

Fig. 3

SELF-CONTAINED PERFUSION DEVICE

TECHNICAL FIELD

[0001] The present invention relates to a self-contained infusion device according to the pre-characterizing part of claim 1.

PRIOR ART

[0002] It is known that infusion is a procedure permitting slow and continuous introduction of a liquid, for example a medicinal substance or blood, into an organism. This operation is currently practiced in human medicine and in veterinary medicine. It is intended to compensate for the losses of biological fluids which an organism has suffered following, for example, a surgical intervention, a road accident or any circumstance which has resulted in serious physical injuries. It is also common when the organism receiving the infusion is in a state of shock.

[0003] In principle, infusion consists of the flow of a suitable liquid, contained in a flexible bag, from this bag into the receiving organism via a defined circuit also called the infusion line. This flow must take place at a constant flow rate adapted to the needs of the organism receiving it.

[0004] The traditional practice is for the bag of liquid to be maintained at a certain height above the organism in which infusion is to be performed, in such a way as to ensure a gravitational flow of the liquid. This technique can be employed fairly easily in a hospital environment or similar, where the bag can be suspended at a constant height from a bracket and can accompany the patient as he or she moves about. Outside, for example at the site of a road accident or of a natural disaster, holding the bag requires the assistance of a member of the emergency services, who is then no longer available to provide treatment proper. Moreover, the constant nature of the flow rate is far from guaranteed in these conditions.

[0005] Moreover, particularly with bags of large sizes, this method does not always guarantee a really constant flow rate during infusion, because the pressure of the liquid decreases as the bag empties. Finally, there is a not inconsiderable risk of the patient, with an inadvertent gesture, tearing out the infusion line connecting him to the suspended bag.

[0006] In an attempt to overcome these drawbacks, various infusion appliances have already been proposed which can be attached directly to the patient's body by a suitable means such as a strap or a belt clip. These appliances are referred to as self-contained, because they do not require external means for supporting the infusion bag.

[0007] In particular, European patent EP-A-0 620 747 discloses a self-contained infusion appliance which comprises means for bringing an infusion bag under pressure between two parallel compression plates. When this appliance is in its normal rest position, for example stored in a cabinet, the compression plates are basically horizontal. To facilitate the description and its understanding, reference is made here to the appliance placed in this position. During infusion, the upper plate remains fixed, and the lower plate carrying the bag can be moved upward under the action of an elastic mechanism. To load a bag into the appliance, it is necessary to lift the upper plate, which in fact constitutes a removable lid, in order to gain access to the lower plate; closing this lid provokes the arming of the elastic mechanism.

[0008] This known device has several disadvantages. The method of loading and arming it, requiring that the upper lid be opened in order to access the loading opening, means that it is not possible to stack several devices in a pile with a view to carrying out several infusions simultaneously. Moreover, closure of the lid requires the application of a considerable force which, on the one hand, is demanded of the medical personnel and, on the other hand, can damage the reliability of the lock and the rigidity of the lid. This can result in an irregularity of the pressure prevailing in the bag and, consequently, also of the flow rate of the infusion liquid. It should also be emphasized that this force is all the greater the larger the bag. For the largest bags, for example with a capacity of 3,000 ml, the force needed may exceed the physical possibilities of the medical personnel; recourse then has to be made to improvised mechanical means, often resulting in time being lost.

[0009] Furthermore, the pressure applied by this known device progressively decreases during the course of infusion, which leads to a progressive reduction in the flow rate of the liquid and often even leads to great difficulty in completely emptying the infusion bag. Finally, the size of the usable bags is limited in particular because of the force required for closing the lid. It should also be emphasized that the closure force, which is generally high, is applied directly by the lid to the infusion bag, which in turn transmits the force to the lower plate, counter to the force of the elastic mechanism, in order to arm the appliance; the bag is thus subjected to a force distinctly greater than that to which it is subjected during the infusion.

DISCLOSURE OF THE INVENTION

[0010] The invention seeks specifically to remedy these disadvantages by making available a self-contained infusion device which ensures a constant flow rate of the infusion liquid throughout the course of the infusion, which guarantees substantially complete emptying of the infusion bags, and, finally, which can be arranged in a stack, especially for simultaneous infusion of several patients or for simultaneous injection of several liquids to one and the same patient.

[0011] Here too, for the sake of clarity, the self-contained infusion device will be considered in its normal rest position.

[0012] According to the invention, a self-contained infusion device, which comprises means for bringing an infusion bag under pressure between a fixed plate and a movable plate driven by an elastic mechanism, is characterized in that the lower plate is fixed in the vertical direction, in that the upper plate is movable in the vertical direction under the action of said elastic mechanism, in that at least one opening is provided in at least one side wall of the device for the purpose of introducing an infusion bag between said two plates, in that said elastic mechanism is provided with independent means for controlling and locking said plates, and in that means are provided for unlocking said elastic mechanism after said infusion bag has been loaded.

[0013] According to a particular embodiment, the lower plate is movable in its plane, in the manner of a drawer, between an internal position, used for infusion and when at rest, and an external position, used for loading the bag into the device.

[0014] According to an additional characteristic, the device comprises means for unlocking said elastic mechanism which are actuated by said lower plate during its return travel to its internal position.

[0015] Means are also advantageously provided for locking the lower plate in its internal position, and also means for unlocking said lower plate with a view to permitting its movement towards its loading position.

[0016] In a manner known per se, the elastic mechanism comprises two sets of intersecting levers, in two parallel pairs, in which the levers of the same set are connected by springs, and the two sets of levers are connected by transverse shafts. The elastic mechanism thus constitutes a pantograph controlling the vertical displacement of the upper plate under the effect of the traction of the springs, which brings about a variation in the angle of opening of the pantograph. A more detailed description of this elastic mechanism and of its operation will be given below with reference to **FIGS. 2 and 3**.

[0017] In the device according to document EP-A-0 620 747, the tensioning of the springs is obtained by the closure of the lid and the transmission of the closure force to the lower plate by way of the infusion bag.

[0018] In the device according to the invention, by contrast, the tensioning of the springs, hence the priming of the device, is achieved by independent means of controlling the compression plates.

[0019] According to a particular embodiment, the control means of said elastic mechanism comprise an actual kinematic chain connecting a point of application of the priming force to the member for tensioning the springs and varying the angle of opening of the pantograph. For example, the priming force can be applied by a mechanical member such as a crank or a motor, and the member for tensioning the springs can be a gear with worm wheel and endless screw. Various suitable control members, in particular mechanical ones, but also pneumatic or hydraulic ones, are well known in the field and do not require detailed description here.

[0020] The principal advantage of these independent control means of the elastic mechanism of the compression plates is that they do not require the presence of an infusion bag and consequently do not risk damaging the latter during priming of the device.

[0021] Other particular features and advantages of the device according to the invention will be evident from the detailed description of an embodiment of the invention which is given below by way of simple example and with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] In these drawings:

[0023] **FIG. 1** shows a front view of the device according to the invention, from the direction of the loading opening;

[0024] **FIG. 2** is a side view of the device in **FIG. 1**, with the elastic mechanism in the deployed position, the upper plate in the lowered position and the lower plate in the internal position; and

[0025] **FIG. 3** is a view analogous to **FIG. 2**, but with the elastic mechanism folded up, the upper plate in the raised position and the lower plate in the external position, ready for receiving an infusion bag.

[0026] It will be appreciated that these drawings are only simplified diagrammatic representations of the device according to the invention, to no particular scale, in which only those elements essential to an understanding of the invention have been reproduced. Identical elements are designated by the same reference numbers in all the figures.

EMBODIMENT OF THE INVENTION

[0027] FIGS. **1** to **3** are diagrammatic representations of the active part of the device according to the invention. In practice, this device can be accommodated in a protective or decorative casing which is generally parallelepipedal; to simplify the drawing, only the framework formed by the supporting edges has been shown. The optional casing is basically made up of a horizontal bottom panel **1**, an upper panel **2**, side panels **3**, **4** and, possibly, a front panel **5** and rear panel **6**.

[0028] A front view of the device according to the invention has been shown in **FIG. 1**; if it is present, a front panel **5** has at least one opening **7** which in particular permits loading of the bag, withdrawal of the loading drawer which will be described below, and passage of the infusion line. The position of the optional opening **7** is symbolized by dot-and-dash lines in **FIG. 1** and can be better seen in **FIGS. 2 and 3**.

[0029] This figure shows the lower plate **8** which supports an infusion bag **9**; this lower plate **8** can be equipped with lateral shoulders **10**, **11** which in particular facilitate the correct positioning of the infusion bag. The lower plate **8** rests on a support element **12** which is fixed to the bottom panel **1** and on which it can slide horizontally via slide rails **13** or the like. The sliding movement takes place between an internal or retracted position **(FIG. 2)**, which is the working position and the rest position, and an external or extracted position **(FIG. 3)** which is the loading position.

[0030] Arranged above the lower plate **8** there is an upper plate **14** which is able to move in the vertical direction, parallel to itself, under the action of an elastic mechanism **15** known per se in the field. This mechanism and its action can better be seen in **FIGS. 2 and 3**. The upper plate **14** is fastened to the elastic mechanism **15** by means known per se and not shown here.

[0031] As can be clearly seen in **FIG. 2**, the elastic mechanism **15** is made up of two sets of intersecting levers **16**, **17** which are articulated on one another at their centre and together define a vertical plane. At one of its ends, for example towards the rear of the device, the lever **16** of each set is articulated on the upper frame of the device; similarly, the lever **17** of each set can be articulated via its rear end on the upper plate **14**. At their other end, the two levers **16** are joined to one another via a transverse shaft **18** which for example rolls in slide rails provided on the upper plate **14**; likewise, the other ends of the two levers **17** are joined to one another via a transverse shaft **19** which rolls on the upper frame. Moreover, traction springs **20**, **21** are stretched, respectively, between the upper ends and between the lower ends of the intersecting levers **16**, **17** of each set.

[0032] Control means, known per se and not shown here, such as a crank activating a worm wheel and an endless screw, make it possible to vary the angle of opening β of the intersecting levers of each set and, consequently, the tension in the springs **20, 21** of the two sets and the vertical position of the upper plate **14**. The point of application of the priming force on these control means is preferably situated in the front face **5** of the device so as to facilitate access thereto and to limit the lateral size of the device.

[**0033**] As will also be appreciated from **FIG. 1**, each set of intersecting levers **16, 17** is in fact made up of a pair of intersecting levers arranged on either side of the respective articulation bearings of the levers to the upper panel **2** and possibly to the upper plate **4**. This arrangement avoids the introduction of parasitic bending moments in the levers upon control of the movement of the elastic mechanism **15** and of the upper plate **14**.

[**0034**] Finally, **FIG. 3** shows an example of a system for locking and unlocking the elastic mechanism **15**. An elastic hook **22**, pushed into place by a compression spring **23**, locks the elastic mechanism **15** in the raised position. The lower plate **8** is shown here in the loading position. It has a rod **24** protruding from the rear of the lower plate **8**. Arranged on the rear panel **6** there is an elastic blade **25** which, on deforming, can activate the hook **23** counter to the force of the spring **23**. This rod **24** can for example slide through the lower plate **8**.

[**0035**] According to an additional characteristic, the device comprises means for monitoring the degree of emptying of the bag during the infusion. These means can consist, for example, of a graduated window permitting monitoring of the variation in the distance h, or a member permitting monitoring of the angular position of the elastic mechanism **15**. When the device comprises a casing, such a window is advantageously situated in the front panel **5** of the casing.

[**0036**] According to the invention, the elastic mechanism **15** and the springs **20, 21** are advantageously made of a material resistant to corrosion, for example stainless steel. The device can thus be used without problem in humid or polluted atmospheres.

[**0037**] The device according to the invention is operated in the following way:

[**0038**] The elastic mechanism **15** is first brought to the raised position by a suitable control means. The effect of this movement is to disengage the lower plate **8**, close the angle β formed by the intersecting levers **16, 17** and tension the springs **20, 21**. The elastic mechanism **15** is locked in the raised position by the hook **22**. The lower plate **8** is then moved into the loading position (**FIG. 3**) and an infusion bag **9** is placed on it. The lower plate **8** is pushed back into the working position. With the aid of the rod **24** and the elastic blade **25**, the elastic mechanism **15** is unlocked, and said elastic mechanism **15** applies the upper plate **14** onto the bag **9** under the effect of the traction force exerted by the springs **20, 21**. The angle β of the intersecting levers **16, 17** opens. The upper plate **14** thus exerts a pressure on the infusion bag **9**, and this causes the expulsion of the infusion liquid from the bag towards the infusion line (not shown here).

[**0039**] It is important, however, that this expulsion takes place under perfectly controlled conditions so that the flow rate of the liquid expelled remains as constant as possible throughout the period of infusion.

[**0040**] To this end, and also in a manner known per se, the infusion line is equipped with means for regulating the flow rate of liquid, and a device for measuring this flow rate. It is thus possible to adapt the infusion rate to each particular case and to monitor the constancy of this flow rate.

[**0041**] In concrete terms, the constancy of the infusion rate is governed by the constancy of the pressure generated within the liquid contained in the bag. This pressure is itself determined by the ratio between the pressure force F_P exerted by the plates and the contact surface S between these plates and the infusion bag.

[**0042**] Trials carried out using infusion bags of a current type showed that the contact surface increased linearly as a function of the volume infused, that is to say as a function of the decrease in the distance h between the lower plate **8** and upper plate **14**.

[**0043**] Moreover, the pressure force depends both on the restoring force F_R of the springs and on the angle α formed by the axis of the levers and the axis of the springs, by the equation

$$F_P = k * F_R * tg\ \alpha$$

[**0044**] where

[**0045**] k is a factor of proportionality characteristic of the device;

[**0046**] F_R is the restoring force of the springs **20, 21**;

[**0047**] tg α reflects the influence of the inclination of the levers relative to the line of action of the springs.

[**0048**] The restoring force F_R is in turn a linear function of the stiffness of the spring and of its elongation; it decreases linearly as a function of the decrease in the elongation of the spring and consequently also as a function of the decrease in the distance h, hence as a function of the volume infused.

[**0049**] By contrast, tg α increases practically linearly as a function of the decrease in the distance h, hence as a function of the volume infused, for an angle α of between 0° and approximately 35°. It should be noted that, as a result of the symmetry of the mechanism **15**, we have $\beta = 2\alpha$.

[**0050**] It appears then that, overall, the pressure force depends linearly on the variation in the distance h, via a factor of proportionality dependent in turn on the stiffness of the springs and the dimensioning of the pantograph.

[**0051**] According to the invention, the springs have a stiffness which, combined with a suitable dimensioning of the pantograph, leads to an increase in the pressure force F_P as a function of the decrease in the distance h, at least substantially equal to the increase in the contact surface S also as a function of the decrease in this distance h.

[**0052**] In this regard, the size of the device according to the invention, and consequently the geometry of the pantograph, is adapted to the size of the bags which it receives; the corresponding springs in each case have a stiffness, that is to say a diameter of the wire and a number and a diameter of spirals, determined in such a way as to ensure the pressure force required as a function of the size of the bag.

[0053] It is not possible to indicate a precise relationship between these elements, and the springs have to be dimensioned experimentally for each size of bag.

[0054] The invention is not limited to the illustrative embodiment which has just been described and illustrated. Various modifications can be made to it by the skilled person, in particular as regards the means of control of the elastic mechanism and the means for monitoring the degree of emptying of the bags.

1. Self-contained infusion device which comprises means for bringing an infusion bag under pressure between a fixed plate and a movable plate driven by an elastic mechanism, characterized in that the lower plate **(8)** is fixed in the vertical direction, in that the upper plate **(14)** is movable in the vertical direction under the action of said elastic mechanism **(15)**, in that at least one opening **(7)** is provided in at least one side wall **(5)** of the device for the purpose of introducing an infusion bag **(9)** between said two plates **(8, 14)**, in that said elastic mechanism **(15)** is provided with independent means for controlling and locking said plates **(8, 14)**, and in that means **(24, 25)** are provided for unlocking said elastic mechanism **(15)** after said infusion bag has been loaded.

2. Device according to claim 1, characterized in that said lower plate **(8)** is movable in its plane, in the manner of a drawer, between an internal working and rest position and an external loading position.

3. Device according to either one of claims **1** and **2**, characterized in that said unlocking means are actuated by said lower plate **(8)** during its return travel towards its internal position.

4. Device according to any one of the preceding claims, characterized in that the means for controlling said elastic mechanism **(15)** comprise a kinematic chain connecting a point of application of the priming force to a member for tensioning the springs.

5. Device according to any one of the preceding claims, characterized in that it comprises means for monitoring the degree of emptying of the bag during the infusion.

6. Device according to claim 5, characterized in that said monitoring means comprise at least one graduated window, optionally arranged in a vertical panel **(5)** of the device and extending by a height at least equal to the maximum distance h.

7. Device according to any one of the preceding claims, characterized in that the springs **(20, 21)** have a stiffness which, combined with suitable dimensioning of the elastic mechanism **(15)**, leads to an increase in the pressure force F_P as a function of the decrease in the distance h, at least substantially equal to the increase in the contact surface S, also as a function of the decrease in this distance h.

8. Device according to claim 7, characterized in that the springs **(20, 21)** have a wire diameter and/or a number of spirals and/or a diameter of the spirals which are determined in such a way as to ensure the pressure force required as a function of the size of the bag.

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