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Hrdina

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[54] **METHOD AND ARRANGEMENT FOR SEGMENTATION OF A STREAM OF A LIQUID MEDIUM CONVEYED BY A PERISTALTIC PUMP**

[75] Inventor: **Jiří Hrdina,** Prague, Czechoslovakia

[73] Assignee: **Ceskoslovenska akademie ved,** Prague, Czechoslovakia

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[30] **Foreign Application Priority Data**

Feb. 22, 1971 Czechoslovakia 1309/71

[52] **U.S. Cl.**..... **137/154,** 137/566, 417/477

[51] **Int. Cl.**..... **F02b 43/12**

[58] **Field of Search**..... 137/1, 154; 417/475, 477; 23/230 A; 73/423

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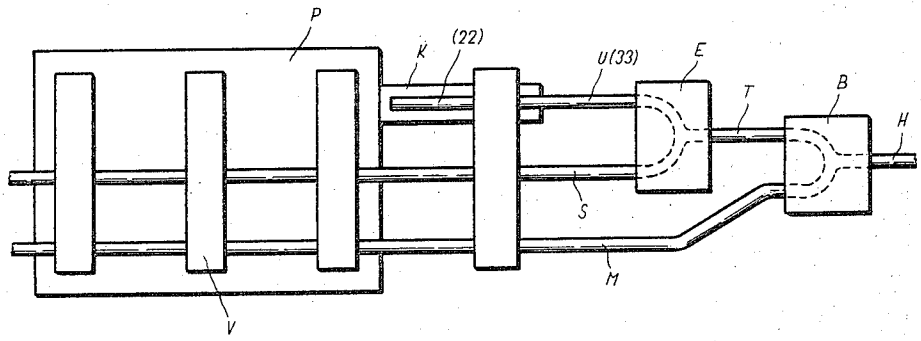
Primary Examiner—Alan Cohan

Attorney, Agent, or Firm—Murray Schaffer

[57] **ABSTRACT**

A programmed discharge of a liquid medium conveyed by a peristaltic pump and segmented by segmentation pistons of a segmentation medium introduced into the stream of this liquid medium is achieved by connection of a blinded hose filled with auxiliary medium to the tubing conveying the segmentation medium, with means for periodically compressing and releasing said blinded hose, thus periodically increasing and decreasing the pressure of the segmentation medium according to a preselected programm.

9 Claims, 14 Drawing Figures



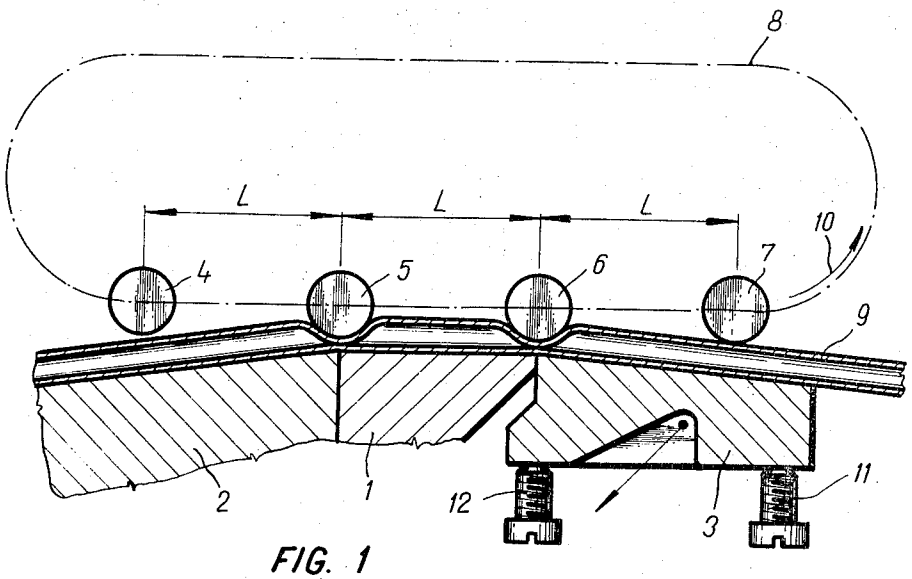


FIG. 1

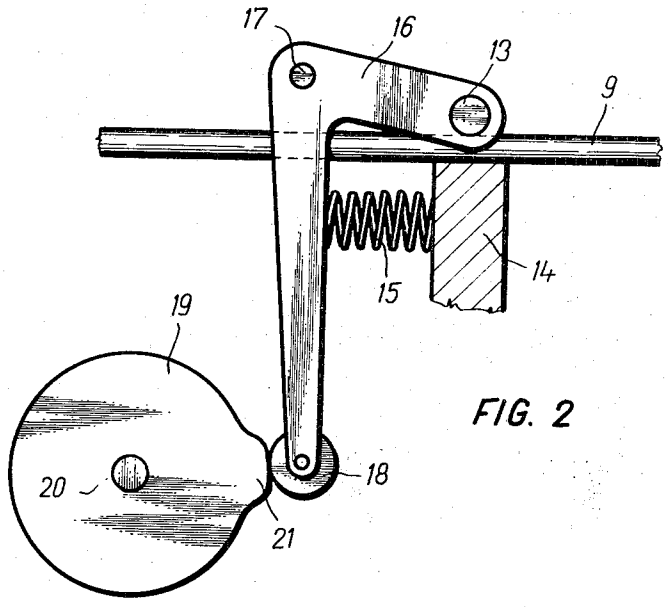


FIG. 2

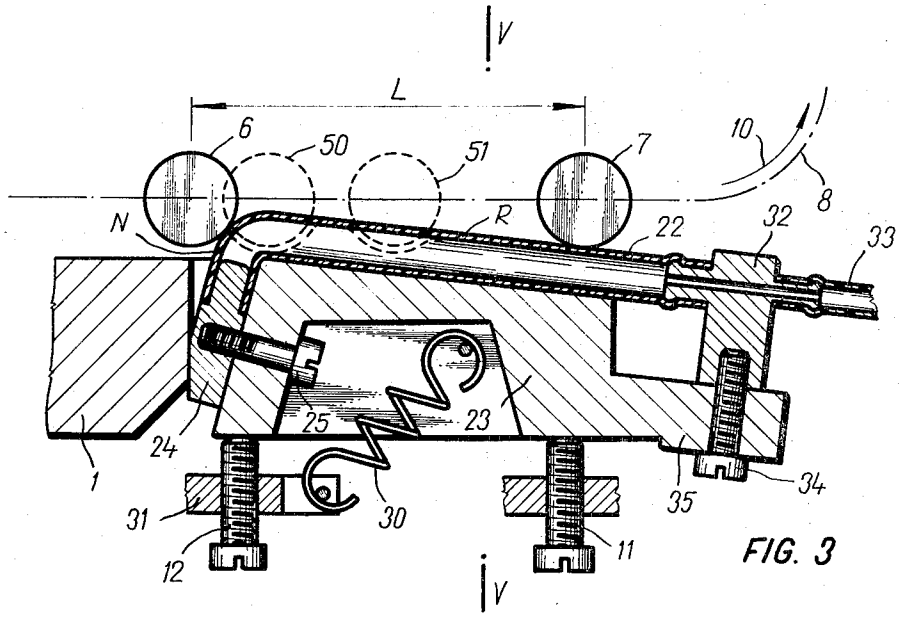

V
L
6
50
51
7
10
8
N
R
22
32
33
25
23
24
1
31
30
35
34
12
11
V

FIG. 3

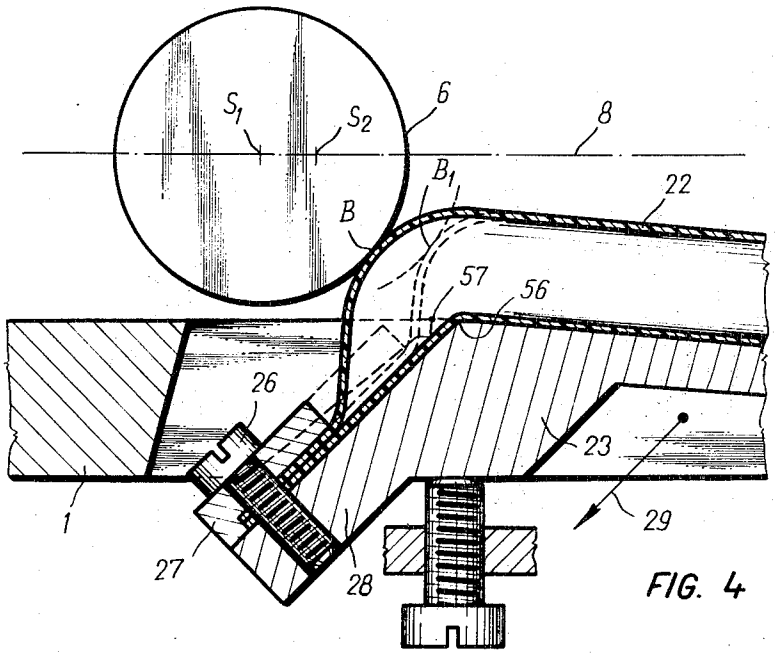

S1
S2
6
8
B1
B
22
57
56
26
23
29
1
27
28

FIG. 4

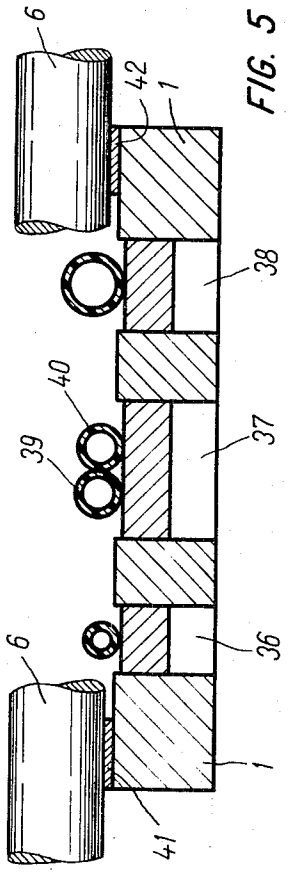


FIG. 5

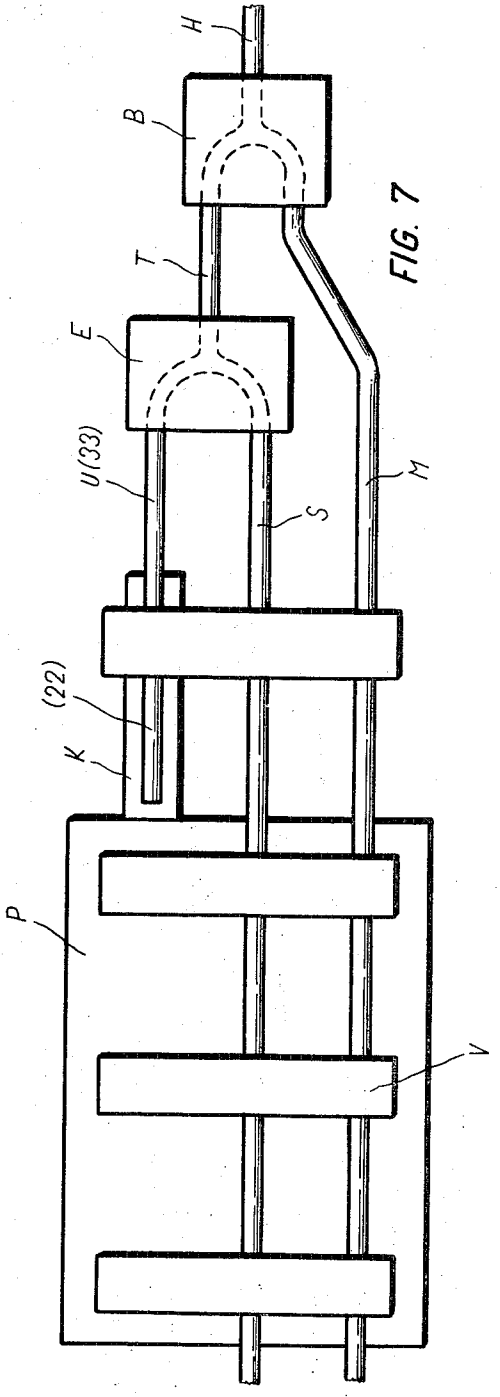


FIG. 7

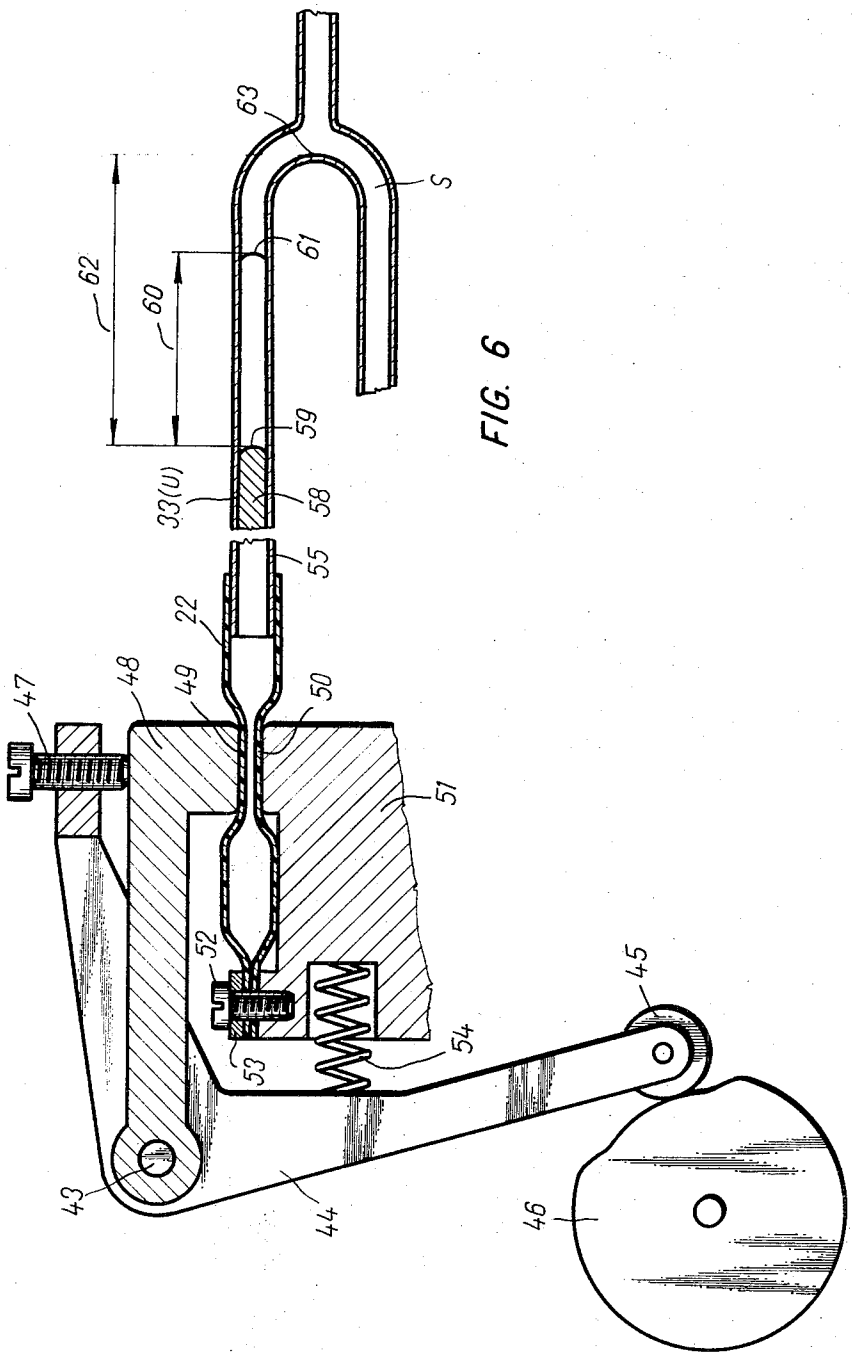


FIG. 6

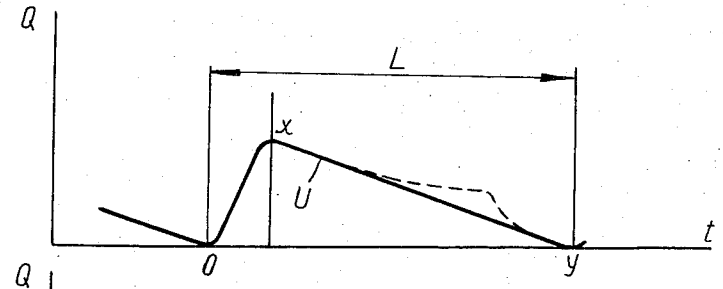


FIG. 8

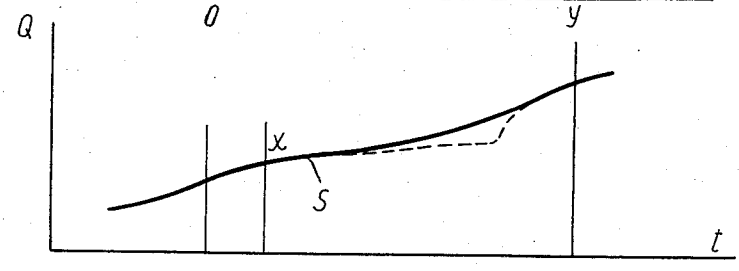


FIG. 9

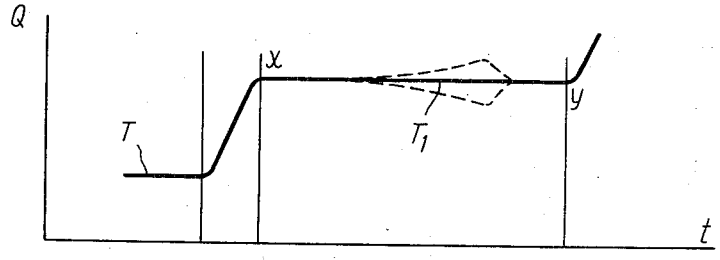


FIG. 10

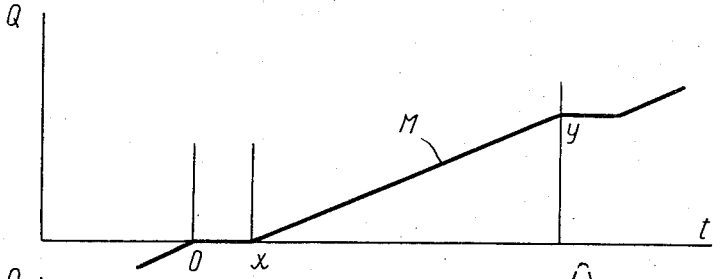


FIG. 11

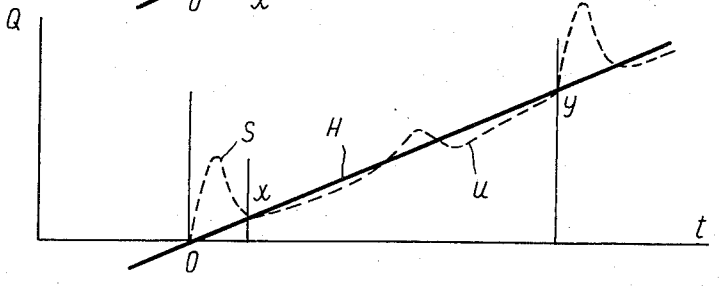


FIG. 12

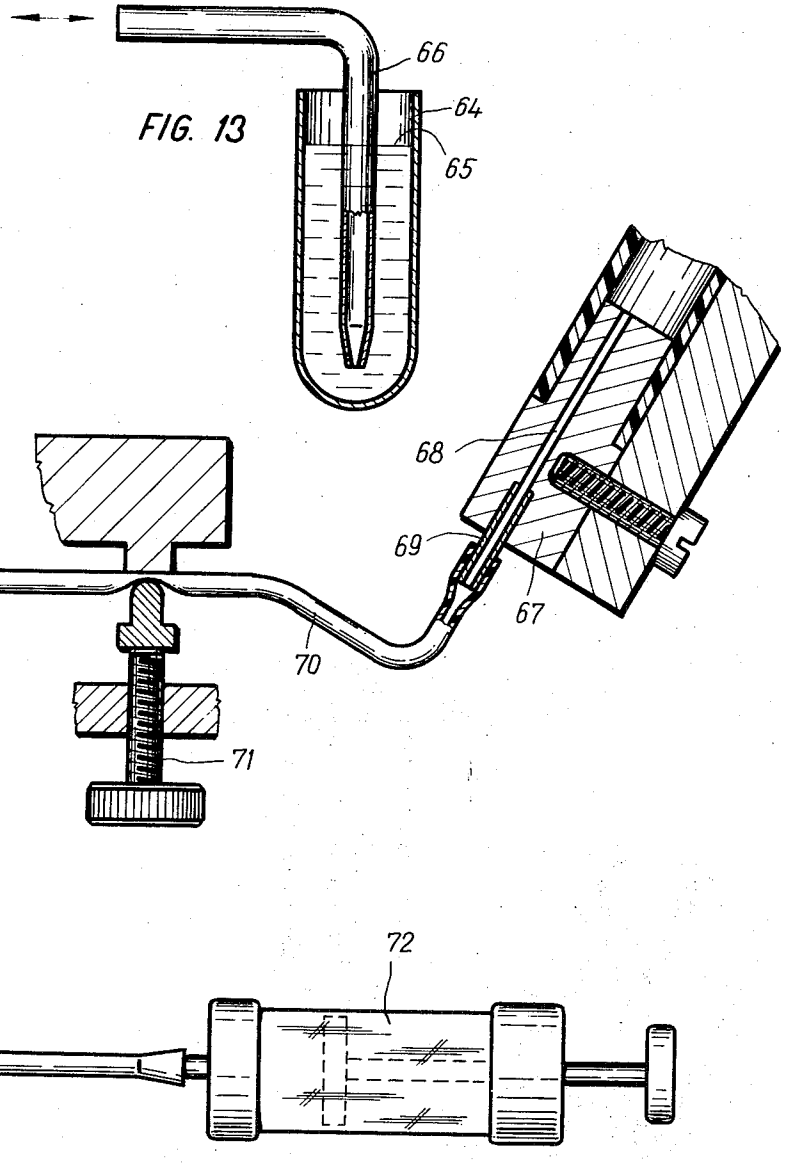


FIG. 13

FIG. 14

METHOD AND ARRANGEMENT FOR SEGMENTATION OF A STREAM OF A LIQUID MEDIUM CONVEYED BY A PERISTALTIC PUMP

BACKGROUND OF THE INVENTION

This invention relates to a method and to an arrangement for segmentation of a stream of a liquid medium conveyed by a peristaltic pump by introducing segmentation pistons into the stream of this medium. The invention relates particularly to multichannel peristaltic pumps, provided with correction means for improvement of the uniformity of delivery or of the proportionality of delivery between individual channels of a peristaltic pump, but is not limited to pumps having said means.

The invention aims at removal of the drawbacks of peristaltic pumps, particularly to the removal of the non-uniformity of the delivered stream of the medium, the speed of which varies to a high degree, sometimes even so that it achieves for short periods high negative values and further unwelcomed positive and negative accelerations. Another drawback of known pumps is the inaccuracy of the formed segmentation pistons causing not only an irregular segmentation, but sometimes even fragmentation of segmentation pistons, which segmentations are generally gas bubbles, causing great difficulties. Another drawback is the impossibility of or at least difficulty in programming the stream of media conveyed via different channels of the pump.

Attempts have been already made to improve the accuracy of the segmented stream. One of these arrangements comprises valve means called generally a "bar". The bar acts by closing and opening periodically the hose introducing segmentation gas into the stream of a liquid medium. This arrangement, even if it represents a substantial improvement over the earlier conditions, does not meet the high demands placed on the segmentation of a stream of a medium for the most up to date analyzers, since this bar closes the passage of gas in a single place, so that the gas is compressed between the bar and between an advancing occlusion organ of the peristaltic pumps, which is generally a roller. At the moment the bar is lifted, the earlier completely occluded hose is not instantly made free, but is released only with a cetain residual degree of nonuniformity. As a result the occluded profile opens with a small irregular delay with respect to the lifting of the bar. It is therefore impossible to achieve by this method an accurate synchronization with the position of individual rollers of the peristaltic pump. A rather more imporatant drawback is the circumstance, that after opening the occluded place the accumulated gas expands with a high speed, so that it enters the stream of the liquid medium as a bubble practically shot into this liquid medium at a high initial speed. This generates high positive and negative accelerations of the liquid in the neighbourhood of the segmentation place, leading frequently even to oscillations which subsequently decrease to zero or to the pumping speed of the roller of the peristaltic pump. The duration of this phase depends on the time of opening of the hose between individual occlusions, caused by pressure of the bar.

SUMMARY OF THE INVENTION

It is an object of this invention to eliminate these drawbacks and to provide an arrangement capable of

forming segmentation pistons in a stream of a liquid medium with high regularlity and accuracy of segmentation, so that individual sections of the liquid medium between two subsequent segmentation pistons would be substantially equal.

It is another object of this invention to enable an efficient programming of delivery of the segmented medium alternately to achieve a uniform delivery which in fact is a special case of a programmed delivery.

Bearing these and other objects in mind, periodical reciprocal pulses, generated by cyclically repeated oppositely acting effects of a discharged and sucked on auxiliary medium are superposed on a programmed stream of the segmentation medium, whereby the length of the discharge phase of the auxiliary medium may be advantageously a multiple of the length of the suction phase. In a preferred embodiment a blinded hose filled with an auxiliary medium, periodically compressed and released by a mechanism is provided. The length of the compressing phase is a multiple of the length of the release phase. The blinded hose is connected to the hose for introduction of the segmentation medium into the stream of the liquid medium.

DESCRIPTION OF DRAWINGS

Several examples of embodiments of the object of this invention are shown in the accompanying drawings, where FIG. 1 represents an elevation of the main parts of a known peristaltic pump, parts of which are in section, FIG. 2 is a similar view of known valve means, called generally "bar" for closing and opening a hose conveying gas, FIG. 3 is a longitudinal partly sectional view of a peristaltic pump provided with improvements according to this invention, FIG. 4 is a similar view with an alternative arrangement of the object of this invention, FIG. 5 a cross sectional view of the arrangement shown in FIG. 3, the section being taken along a plane, indicated in FIG. 3 by V—V, FIG. 6 shows in a similar view a still other embodiment of the object of this invention, FIG. 7 is a schematic layout of a peristaltic pump with its principal accessories showing the interconnection with the arrangement according to this invention, FIG. 8 an illustration of the course of a reciprocal pulse, FIG. 9 the course of delivery of the segmentation medium, FIG. 10 the resulting course of the segmentation medium, FIG. 11 the course of delivery of a liquid medium which has to be segmented, FIG. 12 the resulting course of the segmentation medium, FIG. 13 a sectional view of an arrangement for mixing a liquid, suitable for application of the object of this invention and FIG. 14 means for refilling and emptying the device from FIG. 13 in partly sectional view.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 shows the principal arrangement of a known peristaltic pump.

Correction extensions 2 and 3 are joined to the pump base 1. The pump mechanism consists of a system of pressure rollers 4, 5, 6, 7 guided and driven along a closed track 8 in the direction of the arrow 10 by two link chains at both sides of the pressure rollers. One or more hoses 9 are supported by the pump base 1 and by its extensions 2 and 3. The hoses 9 are occluded by the advancing pressure rollers 4, 5, 6, and 7. In order to achieve a full occlusion, it is sufficient only if at least two pressure rollers, for instance 5 and 6 are compress-

ing simultaneously the hose 9 against the planar base 1. The upper surfaces of the correction extensions 2 and 3 are shaped according to the required program of delivery of the medium. The medium passes through the hoses 9 so that there is superposed on to the uniform movement generated by a uniform rolling of a roller, for instance roller 5 along the pump base 1 the suction effect generated by the subsequently releasing occlusion. This occlusion terminates for instance just at the place where the roller 7 is shown. From this point on any movement of the roller 7 in direction of the arrow 10 has no influence on the delivery or on the back-sucking of the hose 9. The rollers are spaced at mutual distances L. The correction extension 2 is for the shown arrangement at the suction side, while the correction extension 3 is on the delivery side of the pump. A correction effect can be achieved even if the upper surfaces of the correction extensions 2 and 3 are linear but a more perfect programming, particularly a uniform delivery is achieved by suitably shaping the upper surface of the correction extension 3. This correction extension 3 can be shaped individually for each profile of the hose 9, which profiles need not be the same. In addition, the correction extension 3 can be finely adjusted by adjusting screws 11, 12.

It is possible to achieve, by a suitable shape of the upper surface of the correction extension 3 for any hose 9, an arbitrary variable programmed delivery within one cycle of operation of the pump. The programmed delivery is determined within limits by the suction effect of the pressure roller, which releases the hose 9 starting from the place of maximum occlusion (indicated by the position of roller 6) up to the last point of contact of the roller with hose 9 (indicated by the position of roller 7).

It is thus possible to segmentate by a similarly arranged pump a medium for instance for analytical or other purposes, which medium will be called in the following the "liquid medium." The stream of this liquid medium is segmentated by introduction of segmentation pistons into the stream of the liquid medium. The segmentation medium is generally gaseous, for instance air, but it can be equally a liquid. In the described arrangement of a peristaltic pump, for instance a liquid medium is conveyed in one hose 9 while in another parallel hose 9 the segmentation medium may be conveyed by means of the same mechanism of the peristaltic pump. It is obvious that a number of similar hoses 9 can be arranged side by side in a single pump. Modern peristaltic pumps have up to 28 hoses controlled by a single mechanism.

It is frequently desirable that the length of a segmentation piston, that is, the length of a bubble have only a small fraction of the length of the liquid segment in order to achieve optimum conditions for the highest accuracy of segmentation. It is of course necessary in such cases to introduce the segmentation medium into the stream of the liquid medium at accurate time intervals according to a predetermined programming. The re-solution of the program is one of the principal objects of this invention. The speed of the stream of the liquid medium changes thereby so that the segmentation medium is introduced into the liquid medium at moments, where the speed of the liquid medium is a minimum, and if possible zero. The resulting volume speed of the common stream after introduction of the segmentation medium into the liquid medium may be constant, so that the resulting segmented stream will advance behind the place of segmentation with uniform speed and without any jerks, which are present known arrangements and which are the sources of many drawbacks.

The length of a segmentation piston (of a bubble) should be, at normal temperature, about one-tenth to one-twentieth of the length of a liquid segment. The ratio of cross sections of hoses for the supply of the segmentation medium and of the segmented medium is generally in a range of 1 to 10 up to 1 to 20. It has been however found that due to very small diameter of the hose by which the segmentation medium is supplied, which for technological reasons has in addition a very wide manufacturing tolerance, it is rather difficult to obtain a sufficiently quick suction effect, generated by release of the full occlusion, in order to comply to the optimum formation of a segmented stream even if shaped correction extensions are used as indicated in FIG. 3.

A solution has been proposed to synchronize exactly the formation of segmentation pistons (bubbles) with the operation of a peristaltic pump by means of a valve, which alternately closes and opens the hose supplying air. This solution is object of the U.S. Pat. specification No. 3,306.229 and as earlier indicated is generally called "bar."

FIG. 2 shows one of known embodiments of a bar. The bar is substantially a cylindrical rod 13 which compresses the hose 9 supplying segmentation air up to a full occlusion against an anvil block 14 by pressure of a spring 15 acting on one arm of a bell crank lever 16, the other arm carrying the rod 13. The bell crank lever 16 is pivotable around the bolt 17 and its lower arm supports a roller 18 engaging with a cam 19 rotating on a shaft 20 in synchronism with the mechanism of the pump, controlling the movement of pressure rollers. The extension 21 of the cam 19 causes the roller 18 to recede, lifting thus the rod 13 at a certain predetermined moment, determined by the position of the roller of the pump. Thus the hose 9 is released for a certain interval time. The air which has been compressed in the meantime between the rod 13 and the advancing roller of the pump escapes into the part of the hose behind the rod 13 and into the tubing conveying the liquid medium.

The bar has many advantages and represents a substantial improvement over earlier arrangements. It however has still some drawbacks. An accurately segmented stream cannot be achieved by means of the bar. By the sudden release of the segmentation gas, which had collected in the course of the closing of the bar, the gas enters the liquid medium at high speed. This causes frequent irregularities leading to a fragmentation of the bubbles, so that there is a danger that bubbles are created not only at the required place for introduction of the segmenation medium, but also at other places behind the segmentation place, for instance at the junctions of individual tubings and similar places.

FIG. 3 shows schematically an advantageous arrangement according to this invention. It represents only the right part of the pump according to FIG. 1 in enlarged scale, and comprising additional elements. The pressure rollers 6, 7, advance in direction of the arrow 10 along the dot and dash line 8 and cause a deformation of the hose 22 which is supported by a correction extension 23 of the indicated shape, which is somewhat

different from the shape of the correction extension 3 in FIG. 1. The hose 22 is on its left end bent downwards and closed or blinded by a plug. This shape allows not only the closing of the left end of the hose 22 but simultaneously by means of a screw 25 enables its fixing to the correction extension 23. This correction extension 23 rests by means of the left side of said plug 24 against the pump base 1.

This arrangement of the hose 22 and of the correction extension 23 is of course only one of numerous possible arrangements taking different shapes. The substantial feature is, that the hose 22 is at its end closed by any suitable closing means and fixed so that it can not be shifted with respect to the correction extension 23 even in the course of advance of the pressure rollers 6,7.

Another possible embodiment is shown in FIG. 4 where the correction extension 23 is somewhat wider than the hose 22 and is arranged so that the blinded hose 22 passes through a recess provided both in in the correction extension 23 and in the pump base 1. The end of the hose 22 is here fixed by a screw 26 by means of a washer 27 and is simultaneously closed by pressure against the extended part 28 of the correction extension 23.

The position of the correction extension 23 can be adjusted in both the arrangement according to FIG. 3 or FIG. 4 by adjusting screws 11, 12. The correction; extension 23 is pulled the direction of the arrow 29 to the left, for instance by a spring 30 fixed with one end on the correction extension 23 and with the other end for instance on a stable unit 31 of the adjusting screw 12 or on any other stable part of the pump.

The hose 22 continuous further to right (see FIG. 3 and 4) up to the place of the periodic utilisation of the reciprocal pulses of the medium within the hose as will be described later, either freely, or as indicated in FIG. 3 by being connected by a coupling 32 to a narrower coupling hose 33. The coupling 32 can be fixed by a screw 34 to the extended right end of the correction extension 23. Thuus not only a perfect fixing of the hose 22 on the right end of the correction extension 23 is achieved, but also a more rigid transmission of the medium by means of the narrower hose 33 to the place of utilisation of the reciprocal pulses.

It is thus obvious that the starting parts of the hose, indicated by the letter N, which is at the place of the first contact of the hose with the occluding pressure roller 6, is in a steep direction with respect to the track of the occluding roller 6. The roller 6 is, at this place, parallel with the upper surface of the pump base 1. The hose is bent, behind this steep first part N, around the apex of the correction extension 23 and the following part R of the hose proceeds from this place so that it slowly recedes with respect to the track of the roller 6 in direction of its advance.

In FIG. 4 it is indicated in broken lines, how it is possible to reduce the length of the delivery part of the periodical delivery curve or of the back sucking of the medium from the hose 22. The hose 22 shown in broken lines is fixed by an extended washer 27 obtaining thus the shape indicated by broken lines so that the first contact of the roller 6 with the thus deformed hose is not accomplished at point B, but at point B_1. Point B_1 corresponds to the center of the roller 6 at S_2 instead of the original center S_1 of the roller 6 shown in full lines.

Thus the track, along which the delivery from the hose 22 is accomplished and therefore also the time of delivery is reduced for about the distance between S_1 and S_2.

FIG. 5 shows schematically a cross sectional view of the arrangement along a plane V—V indicated in FIG. 3. The pump base 1 has several grooves 36, 37, 38 receiving individual hoses of the pump which may have different profiles. For current designs of pump these grooves are generally of the same width and each contains a single hose. Some of these grooves however, for instance groove 38 can be wider either to enable the use of a correction extension according to FIG. 4 or to provide space for two separate or mutually cemented hoses 39, 40 as indicated for groove 37. If hoses 22 are enployed which have to serve a purpose described in the following, they may be fixed by a common screw as for instance shown in FIG. 4 by the screw 26 and their other ends, may be even connected eventually together with other hoses to a common discharge tubing as shown in the right part of FIG. 3.

The pump base 1 is provided on its right and left lateral border provided with ledges 41, 42 (FIG. 5) limiting the maximum deformation of individual hoses due to pressure of the pressure rollers. The wall thickness of hoses of different profiles is equal, so that for a correct occlusion the gap between the pressure roller and the support of the hose has to be somewhat smaller than the height of the ledge 41 or 42 increased by the depth of the groove 36, 37 or 38.

FIG. 6 shows another embodiment of this invention enabling to obtain approximately the same results as the embodiments in FIG. 3 and 4. A bell crank lever 44 is pivotably supported on a bolt 43, the lower end of one arm of this lever provided with a roller 45 engaging with a cam 46. A set screw 47 rests on the end of the other arm of lever 44, against a jaw 48 pivotably supported by the bolt 43. This jaw 48 could be also firmly connected with the bell crank lever 44. The earlier mentioned arrangement however has the advantage of being adjustable. The jaw 48 rests with its operating part 49 on the hose 22, which is supported by the active surface 50 of an anvil block 51 having a somewhat different shape from the shape of the correction extension 3. This shape, indicated in FIG. 6 enables a fixing and closing of a short hose 22 by a screw 52 by means of a washer 53. The jaw 48 need not have a planar active surface, which surface can be shaped also in some other way. A spring 54 acts on the bell crank lever 44, generating pressure of the jaw 48 against the hose 22 and compressing this hose 22.

The cam 46 rotates in synchronism with the movement of the pump mechanism and by its action the jaw 48 is released from and pressed against the hose 22. The hose 22 can also in this case be connected to a thinner hose 55 brought up to the place of utilisation of the periodic pulses, as will be described later.

FIG. 7 shows schematically the interconnection of the different elements with a peristaltic pump. The peristaltic pump P is provided with a number of pressure rollers V. Only two hoses conveying the respective media are shown in order not to complicate the drawing. A hose M is provided for the transport of the liquid medium, the stream of which should be segmented by the bubble generator B by a segmentation medium (for instance air) which is equally transported by the peristaltic pump over the hose S.

The pump is provided with the arrangement according to this invention, indicated by the letter K, where a hose U is located, corresponding to hose 22 or 33. As shown in FIG. 7, this hose is closed on the left end and terminates at its right end at place E into a hose S conveying segmentation air. From the junction place E of the hose S with hose U the tube T leads to the bubble generator B, where it meets hose M conveying the liquid. Tubing H starts from the bubble generator B, conveying the resulting segmented stream.

The described arrangement operates as follows: Let us consider the arrangement according to FIG. 7, where the alternative according to FIG. 3 is used. Two pressure rollers 6 and 7 are shown in full lines spaced from each other a distance L. According to FIG. 3 the pressure roller 6, due to its movement to the right, starts to deform the hose 22 and to squeeze out the medium contained therein into the connecting hose 33. In the following the medium contained in hose 22 is called the "auxiliary medium" although this auxiliary medium may be the same as the segmentation medium, conveyed through the hose S according to FIG. 7. The roller 7 is in FIG. 3 shown in a position, where it just finished to deform hose 22.

In order to finish any contact of the pressure roller with the hose exactly in this position (in cases, where there is some special reason, this contact may end at some other place), the position of the correction extension 23 may be adjusted by the adjusting screw 11.

Two other intermediate positions which the pressure roller 6 may subsequently occupy, prior to reaching the position indicated by the reference mark 7, are shown in broken lines in FIG. 3. In position 50 the pressure roller 6 generates, along a relatively short track, a maximum deformation of the hose 22 and thus squeezes out of this hose a maximum amount of auxiliary medium. It does not matter thereby, whether the deformed upper wall of hose 22 fully contacts the bottom wall and thus fully occludes this hose. It is generally supposed that no full occlusion takes place. These conditions can be finely adjusted by the adjusting screw 12 practically independently of the position of the adjusting screw 11 and thus also on the position, where the pressure roller in position 7 comes out of contact with hose 22. The axis of the adjusting screw 11 is therefore approximately coincident with a perpendicular line to the track of the pressure roller 7 at the place, where it leaves the hose 22.

The movements of the adjusting screw 11 similarly will not affect the maximum deformation of hose 22 if the adjusting screw is not in a position shown in FIG. 3 but somewhat shifted to the right as shown in FIG. 4 so that its axis passes through the apex 56 of the correction extension 23 and thus also through the axis of the pressure roller in a position indicated by 50. At this point the pressure roller 6 achieves the maximum deformation and thus also the maximum discharge of the auxiliary medium from the hose 22.

In order to achieve a still greater independence of the position of the maximum deformation and thus also of the discharge of the auxiliary medium, the position of the meeting place 57 between the pump base 1 and the correction extension 23 can be shifted more to the right. In this manner it would be equally along the axis of the screw 12 passing through the apex 56.

FIG. 8, 9, 10, 11, 12 are diagrams showing the time course of the movement of different media in different hoses. In FIG. 8 the full curve shows the time course of the amount Q of the auxiliary medium, which is squeezed from hose 22 in dependence on time t. The curve starts from a zero value 0 at the moment where the pressure roller 6 starts to deform hose 22, whereas the pressure roller 7 has just left hose 22, as indicated in FIG. 3. In the course of the movement of the pressure roller 6 to the right the deformation of hose 22 starts and thus also the discharge of the auxiliary medium, as indicated by the steep part U of the curve between points 0 and X in FIG. 8. This curve is initially concave, because the hose 22 has a circular cross section. The first part of the deformation starts therefore with zero speed. It increases and reaches a maximum at the apex X which corresponds to position 50 in FIG. 3. From this place on, the pressure roller 6, subsequently releases the hose 22 until all deformation ceases. This latter point corresponds to the position of the pressure roller indicated by 7. At this place the curve U drops again to zero. This course is periodically repeated.

It is also possible to consider the movement dependent on the angular deviation of the mechanisms, of the common driving motor or similar device. This holds of course true if we suppose that for instance the hysteresis lag behind the static case. This case, which proceeds at infinitely small speed, can be neglected. The curve U again has between its maximum X and its minimum Y a somewhat concave course as indicated in FIG. 7 by the full line, assuming the active upper surface of the correction extension is planar. This surface can have any shape, resulting of course that within limits not surpassing the maximum deformation of the hose, a different course of the curve U is obtained, as for instance the course indicated by broken lines both in FIG. 9 and 8. The courses of both curves can also be chosen so that the resulting curve of the combined discharge from both hoses will have the course indicated in FIG. 10 by the full line, with horizontal parts T_t. This can be achieved by the combination of both discharges according to FIG. 9 and 8, either of the discharges corresponding to full or to broken lines. The deviations of the curve shown in FIG. 8 are of course for these condition too large and they should be reduced to one half.

From the above it follows, that the auxiliary medium is first squeezed from hose 22 into the connecting hose 33 and further to place E of FIG. 7, that is to the meeting place with the hose S conveying the segmentation medium. In the following operation phase the auxiliary medium is again sucked back into the hose 22. It is obvious from the course of the curve U that the discharge phase between points 0 and x is many times shorter than the suction phase between points x and y.

The full curve S in FIG. 9 shows the time course of the amount of the segmentation medium passing through hose S according to FIG. 7. The segmentation medium can be discharged over a channel of the multichannel peristaltic pump or it can be represented as a sum of amounts of the medium, discharged from several hoses of the pump. In FIG. 9 we assume that the discharge from these hoses is corrected and is approximately uniform as indicated by the full line. There can be of course another course as shown in FIG. 9 by a broken line.

In FIG. 10 the curve T shows the course of the volume discharge after the stream of the auxiliary medium from hose U has joined the stream of the segmentation

medium from hose S. The curve T_1 in FIG. 10 shows that the discharge pulse of the curve U is superposed to the corresponding part of the curve S so that, in the tubing T, a steep increase is produced within the phase indicated between 0 and *x*. From point *x* to point *y* the descending part of the curve U (that is the part relating to suction of the auxiliary medium back into hose 22) is superposed to the corresponding part of the curve S so that the resulting course of both these streams, that is of the stream of the auxiliary medium and of the segmentation medium in tube 1 is shown by the horizontal part of the curve marked with T_1. That means, that in the phase between points *x* and *y* the segmentation medium in tube T does not move at all. The further movement starts again at *y*, where the following discharge pulse of the curve U is superposed to the corresponding part of curve S as has been already described. The curve 1 shows therefore the time course of the amount of the segmentation medium in tube 1.

FIG. 11 shows the course of the amount of the liquid medium streaming through the hose M. Let us suppose that the stream of this medium is programmed so that a delay is caused from point 0 to point *x*, that is that the stream of the medium has within this time interval a zero speed. Thus it would again advance from point *x* to point *y* at a uniform speed, whereafter another delay takes place.

The stream of the liquid medium from hose M joins the stream of the segmentation stream from hose 1 in the bubble generator B (see FIG. 7). From the shown curves it is obvious, that by superposition of the course of the curves M and T_1 we obtain course H which is practically linear. This means that the resulting segmented stream in the tube H will be quite uniform. It is obvious that this substantially uniform movement of the segmented stream has great advantages over a stream advancing non-uniformly or intermittently or even with ocassional negative speed as is the case for known peristaltic pumps.

Optimum conditions for a most accurate segmented and uniformly advancing stream are thus created according to this invention. The rather unfavourable cases are eliminated, where the segmentation medium is introduced into the stream of the liquid medium, which itself does not move with uniform speed, sometimes intermittently or even with temporary negative speeds, so that the individual bubbles are separated irregularly due to oppositely acting capillary hydrodynamic forces. The competition of both these forces determines the moment of separation of the segmentation bubble. The uniformity of such a segmentation in known arrangements is however rather questionable.

It is of course possible to modify the described arrangements in different ways without departing from this invention. The auxiliary medium in the hose 22 need not be the same as the segmentation medium, although this case will be most frequent. Since the segmentation medium generally used is air, and it is therefore most convenient to use as the auxiliary medium air. It is however possible to use a liquid as auxiliary medium, which case is schematically indicated in FIG. 6. It is then necessary to prevent penetration of this auxiliary liquid in the course of discharge from the hose 22 into the tubing conveying the segmentation medium. The liquid auxiliary medium would here contact the gaseous segmentation medium in a meniscus 59, forming the boundary of both these media. It is important that the discharge track 60 along which the meniscus 59 advances from its starting position when the hose 22 is compressed, up to the extreme discharge position 61 should be less than the distance 62 from the starting position of the meniscus 59 to the place 63, where the hose 33 meets the tubing S conveying the segmentation medium. It is obvious that also in case a liquid auxiliary medium 58 is used this medium performs only a return movement in the hoses 22 and 33 and thus generates the required pulses.

The jaw 48 need not have a planar active part 49 in the arrangement according to FIG. 6, this part can be shaped differently and the profile may be according to a curve of the required shape. It is also possible that it be cylindrical similarly as the rod 13 of the known bar. The known bar has of course nothing common with the arrangement according to FIG. 6 as the above description clearly shows, for the bar serves only to produce a full occlusion of the hose, whereas the arrangement according to FIG. 6 to generates periodic pulses in a blinded hose 22 which pulses are transmitted to the segmentation medium.

The arrangement according to this invention can be also used for generation of a non-uniform stream of a segmented medium. The medium need not have a uniform speed as has been supposed for the embodiment described in connection with FIGS. 8 to 12 but may be programmed arbitrarily. The required course of the resulting segmented medium is thereby achieved by superposing a partial programmed course of periodical discharge and suction of the auxiliary medium in hose 22 to a programmed gradual discharge of the segmentation medium in the tubing S (FIG. 7). This combined discharge course is superposed to the programmed gradual discharge of the liquid medium, passing through tubing M. It is substantially the same operation as described with reference to FIG. 8 to 12 with the difference that the result should not be a uniform, but a differently programmed stream. The individual partial programming is obtained by a suitable shape and inclination of the correction extensions 3 and 23 controlling the passage of the media through hoses 9 and 22.

Although the arrangement has been described in connection with pressure rollers of a peristaltic pump, it is obvious that any other mechanism which produces the required course of the pulses can be used for this purpose instead of said rollers.

The arrangement according to this invention can be also used for other purposes, such as for arrangements, where multichannel peristaltic pumps with or without a bar proved to be advantageous at laboratorium equipments. These known pumps can be easily adapted by adding the arrangement according to this invention and thus improve their performance or adjust them for other purposes as will be described later.

It is obvious from the foregoing, that optimum effects may be achieved with the arrangement according to this invention, which removes to a high degree some major drawbacks of peristaltic pumps. Peristaltic pumps have met recently with objections, since it looked that these drawbacks would be major factors in the future and would limit the further development of devices using these pumps. Furthermore, it was not contemplated that their advantages would not in the future surpass their disadvantages, which have been considered to be irremovable. According to this invention these drawbacks have been to a large extent elimi-

nated and thus the use of peristaltic pumps, even for the most up to date analyzers, is enabled.

Everything what has been said and shown for peristaltic pumps having pressure rollers guided by link chains as occlusion organs holds true for practically all kinds of peristaltic pumps. This concerns particularly frequently used pumps, where the hoses are supported by at least partly circular tracks. The arrangement according to this invention can be aslo used for achievement of similar useful effects in combination with non peristaltic pumps, even with piston pumps.

The method and arrangement according to this invention can be also applied for other purposes without a pump, for instance for mixing of liquids. A similar arrangement is indicated schematically in FIG. 13. A vessel 64 having for instance the shape of a test tube contains some liquid 65 which has to be stirred. A tube 66 is connected for instance to a hose 33 as in FIG. 3 or to a discharge tube of any of the described arrangements. The tube 66 terminates with its narrowed discharge cross section below the level of the liquid 65. In operation, the liquid 65 is sucked on into the tube in the course of the suction phase in the hose 22, whereafter it is discharged back into the vessel 64 with high discharge speed in the course of the short and vehement discharge phase, causing an efficient mixing of the liquid. If a liquid acting as auxiliary medium is in the tube 66 or in its end part care should be taken that this auxiliary medium does not enter via the tube 66 the vessel 64, that is its meniscus must not come close to the end of tube 66. It is thus possible to achieve a mixture of the liquid 65 without contact with the gas, where the bubbling through the liquid could be troublesome.

A similar arrangement is frequently necessary for mixing of samples, particularly of samples which have a tendency to sediment, for instance blood corpuscles. This task is now generally performed by means of vibrators or by bubbling through of a gas. A multichannel peristaltic pump generally is available at automatic devices operating in different laboratories, particularly in laboratories working with biological material. The application of the arrangement according to this invention for similar automatic devices presents no particular difficulties for adaptation.

The tube 66 shown in FIG. 13 which is for the sake of simplicity drawn as a simple tube for mixing, can be combined with a known needle or tube for sucking on a sample from the vessel 64 for the proper automatic analytic processing, using eventually known methods, by means of which the sucking on is achieved so that the segmentation is created very close to the lower end of tube 66.

These possibilities and other possible useful combinations of the method and arrangement according to this invention with known and currently used methods and arrangements are rather numerous and their application will offer no difficulties to those familiar with these branches they will be therefore neither described nor shown on drawings.

It is however advantageous, if the content of the vessel 64 in FIG. 13 can be refilled with the liquid so that the vessel 64 is not closed as indicated in FIG. 13 but for instance as shown in FIG. 14. This is no strict condition but an advantage, having its significance in practical operation as the filling of this "sack" in a closed condition is somewhat more difficult.

According to the embodiment in FIG. 14 the bottom of this "sack" is made so that its blinding plug 67 has the indicated shape, having a communication opening 68, into which a needle 69 is terminating, tightly fixed in the plug 67. A resilient hose 70 is connected to this needle 69, which is on a place suitable for manual operation closed by any kind of pressure device, symbolically indicated by a screw 71. The hose 70 proceeds further and its free end can be slipped either directly or via an injection needle to an injection syringe 72 filled with a suitable liquid, generally water.

After the closing screw 71 has been loosened, the liquid content of the syringe 72 can be pressed via the thin hose 70, the needle 69 and the opening 68 into the proper space of the "sack" of any shape. It is understood that after filling and tightening of the closing screw 71 the liquid content remains unchanged and may be eventually completed or replaced by some other liquid after prior emptying by repeated filling of the injection syringe 72 with air. Thereafter the "sack" can be refilled with another liquid. Thus it is possible to regulate or to complete the content not only of the "sack" but also of the hoses connected thereto. It is sometimes advantageous, for the liquid content which is periodically discharged and again sucked on by the proper "sack" reach close to the junction place with the constantly streaming medium to be segmented, as for instance shown in FIG. 7, whereby the periodically by the "sack" sucked on and discharged liquid content may reach up to the hose 33 and into the neighbourhood of its junction with hose S of the block F. If for any reason the liquid from the "sack" would reach beyond the junction place of both channels in block E, the surplus of the liquid would be automatically taken along over the tube T to the segmentation placed in the bubble generator B.

I claim:

1. A system for the segmentation of a stream of a liquid medium conveyed by a peristaltic pump, through the introduction of segmenting pistons of a segmentation medium into the stream of said liquid medium comprising

a peristaltic pump having a base supporting flexible hoses conveying the respective medium and

occlusion organs adapted to perform a relative movement with respect to said base causing, by successive compression of said flexible hoses, a movement of these media in said flexible hoses

a first of said flexible hoses containing a liquid medium to be segmented

a second of said flexible hoses containing a segmentation medium,

both said streams of these media meeting at a segmentation place,

a third of said flexible hoses blinded at one end and containing an auxiliary medium connected to the second hose conveying the segmentation medium, and

means for periodically generating a compression and release of said third flexible hose.

2. The system as set forth in claim 1, wherein the release phase of said third flexible blinded hose is a multiple of its compression phase.

3. The system as set forth in claim 1, wherein the third blinded hose is supported by a correction extension of said pump base so as to be in the track of the occluding organs of the peristaltic pump, the part of

said third blinded hose near the blinded and being steeply inclined with respect to the track of the occluding organs, the following part of said third blinded hose gradually receding from said track in the direction of movement of the occluding organs, and the surface of the correction extension supporting the blinded hose being curved near the pump base.

4. The system as set forth in claim 3, wherein the correction extension is provided with means for adjustment of its position with respect to the track of the occluding organs.

5. The system as set forth in claim 4, wherein one of said means for adjustment comprising an adjusting screw situated close to the pump base the axis of said adjusting screw passing through the apex of the curved surface of the correction extension.

6. The system as set forth in claim 1, wherein the blinded hose is connected to the tubing conveying the segmentation medium via a connecting hose of a smaller diameter and higher rigidity than the blinded hose.

7. The system as set forth in claim 1, wherein the means for compressing and releasing the blinded hose comprises a pressure jaw controlled by a cam mechanism.

8. The system as set forth in claim 1, including a tube adapted to be connected with the open end of the blinded hose, a container filled with a liquid to be mixed, the end of said tube terminating below the surface of this liquid.

9. The system as set forth in claim 8, wherein said container is connected by a flexible hose with means for emptying and refilling this container and with means for closing and opening said flexible hose.

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