

AIR PUMP

TECHNICAL FIELD

5 A piston-chamber combination comprising an elongate chamber which is bounded by an inner chamber wall, and comprising a piston in said chamber to be engagingly movable relative to said chamber wall at least between a first position and a second position of the chamber,

said chamber having cross-sections of different cross-sectional areas and differing circumferential lengths at the first and second positions, and at least substantially continuously different cross-sectional areas and circumferential lengths at intermediate positions between the first and second positions, the cross-sectional area and circumferential length at said second position being smaller than the cross-sectional area and circumferential length at said first position, said chamber is comprising an exit valve, which is communicating with a hose, which is communicating with a valve between the other end of
15 said hose and an object to be inflated.

BACKGROUND OF THE INVENTION

This invention deals with solutions for optimal pumping conditions, for piston-chamber combinations of any kind, but specifically when the main part of the wall of the
20 chamber is not parallel to the centre axis of said chamber.

An expansion room is normally used for e.g. high pressure bicycle pumps, in order to make a kind of balance between the bigger flow rate of the pump in relation to the smaller volume of the tyre to be inflated. Said expansion room is a cavity where its inlet is communicating with the exit of the chamber of a pump, through a valve. The exit of said
25 expansion room may be directly communicating with a hose, which is connected to the valve of the object to be inflated, such as a tyre.

However, when a low pressure tyre is to be inflated, there is already a balance, because the tyre valve is opening quite early, in relation to the time it takes to finalize a pumping stroke. Thus, it is unnecessary, and when a universal bicycle pump is used, such an
30 expansion room is to be omitted.

OBJECT OF THE INVENTION

The object is to provide an optimisation of the functioning of any kind of a combination of a piston and a chamber, and in particular as a pump.

SUMMARY OF THE INVENTION

In the **first** aspect, the invention relates to a combination of a piston and a chamber, wherein:
said chamber is comprising an outlet valve, which is communicating with a hose, which is
5 communicating with an object to be inflated, which is comprising an inlet valve, the size of
the volume of said hose between said valves is variable.

Any type of chamber for a pump may be used in combination with a hose, including elongate
longitudinal chambers, with different cross-sectional area's, and differing or equal
10 circumferences between a first and second position of said chamber(s), wherein a first position
has the biggest cross-sectional area, and a second longitudinal position the smallest in a
transversal cross-section of said chamber, as disclosed e.g. in EP1179140B1.

The initial volume of a hose may be defined by the size of the cylinder (length of said cylinder
15 and radius of the cross-sectional area in a transversal cross-section) when produced, thus
unpressurized. The hose may also have various different radii between a 1st and 2nd chamber
position, as produced.

Of course may it also be possible that the hose is comprising one of both above mentioned
20 valves.

In a **second** aspect the invention relates to a combination of a piston and a chamber, wherein
the hose may change its volume by expansion.

When a pressure source, e.g. said chamber is comprising an outlet valve communicating with
a first end of said hose, and said hose is communicating with an object to be inflated at its
other end, and said inlet valve is closed, said size of the volume of said hose may increase,
when fluid is entered from said outlet valve. Depending on the type of reinforcement, as e.g.

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1. windings around the cavity of the hose, may the hose
 - not change its volume, when the angle between the tangent of a reinforcement winding and
the centre line of the hose (= so-called braid angle) is 54°44'.
 - change its length, when said angle is bigger than 54°44'.

Changing the length of a hose (in longitudinal direction), may be an innovative feature, but in practise possibly less attractive, due to its odd behaviour.

- 5 2. at least a part of the hose may comprising an inflatable container type piston, which may have a shape of a cylinder, as produced, and which may be equipped with a reinforcement which normally is used in a container type piston of which the shape is changing toward the shape of an ellipsoide, or even a sphere, thus, a changing of a radius of a transversal cross-sectional area. Such a piston is described below.

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EP 1 179140 B1 shows an inflatable container piston type, while EP 1 384 004 B1 shows that this piston type should have an unstressed production size wherein its circumference at the second longitudinal position of an elongate chamber, should have a circumference which is approximately the same as the one of the chamber, so as to avoid that the piston is jamming
15 when moving from a first to a second longitudinal position.

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The piston is expanding when moved from a second to a first longitudinal position. EP 1 384 004 B1 shows that a reinforcement for such a desired behaviour may be a layer where the reinforcement strengs are laying parallel besides each other in an unstressed production model, and these strengs are connecting the two end parts, of which one is mounted on the piston rod, while the other ican glide of the piston rod – the rubber is directly vulcanized on both ends. The reinforcemnet layer is the inner layer, while another, thicker layer than the layer with reeinforcement strengs, is protechting said reinforcement layer. Both layers are being vulcanized on each other, and at the end parts, there may be another extra layer on top of the
25 two. The function of the second layer is additionally to avoid that the reinforcement strengs are 'sticking' out of the outer layer, thereby making a sealingly contact with the wall of the chamber impossible – however, for an engagingly contact is this just fine. Hacving the second layer on top of the reinforcement layer is working fine in practise, and it has shown be possible to expand near the 330%, e.g. in a chamber of a pump (please see WO 2008/025391)
30 where the max. force on the piston rod is constant, from an ø17 mm (2nd longitudinal position) to an ø 59 mm (1st longitudinal position). With two reinforcment layers on top of each other with a very small angle for overlapping each other, and on top the above mentioned 'second' layer makes the container more strong, but expansions possible are much less 330%.

The types of rubber of the layers rubber may be different, but should be compatibel so, that

these can be vulcanized on each other, without getting lose from each other under normal working conditions.

It was observed that when the ellipsoide shaped container type piston was expanding completely to its sphere shape, the chance of breaking apart was very present – that is why the design may be changed so that the length of the piston as unstressed production model be increased, by keeping the other variables, such as the chamber design unchanged – thus, the sphere shape may not be reached and neither an expansion to 330%, only an ellipsoide which has almost become the shape of a sphere – this makes the piston reliable, even with one layer with reinforcements.

10 The shape of the container in an unstressed production state may also be that the wall of the container is not parallel with the centre axis, but parallel to the wall of the chamber because the wall of the chamber at a second longitudinal position is not parallel to the centre axis. Just the wall of the chamber is free of the wall of the container in said unstressed production state.

15 Also an inflatable sphere piston may be used as a temporary expansion vessel, and such a piston has been described in e.g. EP1179140B1 and EP 1384004B1.

In a **third** aspect, the invention relates to to a combination of a piston and a chamber,
20 wherein:

said exit is communicating with a hose, the hose is comprising a check valve.

The hose may comprise a build in check valve. This may be classic ball check valve inside a cylinder, which is mounted in the hose – the pressure of the inner wall of the hose keeps the
25 check valve in place. This may also be a hose, which is expandable on a small length, so that unstressed the channel inside the wall of the hose is closed, and while stressed is open.

In a **fourth** aspect, the invention relates to a combination of a piston and a chamber, wherein:
30 said expandable expansion chamber is expanding from a certain pre-destinated pressure inside said hose, and is imploding by decreasing pressure rates.

The expansion of e.g. a part of the hose may enable the creation of a temporary expansion vessel. Temporary, because it is only created when there is a flow from the chamber, while

the valve nearest the object to be inflated still is closed. When said hose is disconnected from the valve belonging to the valve of the object to be inflated, and there is a direct communication to the atmosphere, the internal pressure in said hose may decrease rapidly, and by that, the expanded wall of the hose may implode, resulting again in a cylinder shaped hose. And depending on e.g. the stiffness of the flexible material of the hose, and the number of layers of reinforcement, and the angle in between said layers, this temporary expansion vessel may be created firstly when a certain pressure level has been created. This is e.g. important for the efficiency of pumping with a universal bicycle pump, with which low (low pressure, relatively high volume) and high pressure tyres (high pressure, low volume) may be inflated.

And, the stroke volume of a pump with an expansion vessel, e.g. as part of the chamber at a second longitudinal position, may be less than that of a pump which is using the bottom part as part of the stroke volume, while using an expansion vessel as part of the hose.

In order to optimize the pumping speed, the hose of a bicycle pump may be expandable upon a certain pressure, so that an expansion vessel is created there. That means that the pump is pumping very efficiently at low pressures, where the hose is not creating an expansion vessel – such a pressure vessel creates more volume to the volume of the tyre alone, to be pumped. Most of the pumping is done for low pressure tyres.

In a **fifth** aspect, the invention relates to a combination of a piston and a chamber, wherein: said expandable expansion vessel or chamber is comprising an stopper for maximizing the expansion of the wall of said hose.

The expansion of the hose may be limited by a reinforcement of the hose, and the expansion may be done only on a part of the hose. Additionally, there may be a stopper, e.g. a metal wire, positioned in the channel of said hose, said wire has been vulcanized to two parts of the wall inside said piston, there where the radius in a transversal cross-section is biggest – when a maximum expansion has been reached, may the wire be a straight line.

Said hose may be used besides in pumps, additionally in actuators, shock absorbers and motors.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, preferred embodiments of the invention will be described with reference to the drawings wherein:

Fig. 1 shows a longitudinal cross-section of a conical shaped elongate chamber showing an expansion chamber as continuation of said chamber.

Fig. 1.1 shows a scaled up detail of Fig. 1.

Fig. 2 shows an inflatable container type piston at an ultimate second chamber position where the inner wall of the chamber shown in Fig. 1 is parallel to the centre axis.

Fig. 3 shows an elongate chamber with a foam piston type (schematically drawn) with a nipple as exit, which is connected to a hose.

Fig. 4 shows the chamber of Fig. 3, which has additionally a part in between the the chamber and the exit – an inflatable piston as a part of the hose is shown as expansion chamber.

Fig. 4.1 shows a scaled up detail of Fig. 4.

Fig. 5 shows the container type piston at the begin and end of a stroke, in a chamber

where the force on the piston rod is constant.

Fig. 6 shows a longitudinal view and cross-sections of the ends of a container type piston, as produced.

Fig. 6.1 shows the details of the top end of the container type piston of Fig. 6.

Fig. 6.2 shows the details of the bottom end of the container type piston of Fig. 6.

DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 shows a bottom part of a chamber of an advanced bicycle floor pump, where additionally the bottom part of the chamber is shown. A flexible manchet 42 assembles the chamber 1 on the foot 41. The hose 43, which is connected to the exit 44 of the pressure expansion vessel 49 – this exit is without a check valve. The (schematically drawn) piston 45 is comprising a piston rod 46. At the bottom of the piston rod is a check valve 47 positioned, which is communicating with the external atmosphere (48), and is opening towards the chamber 1, so as to fill the chamber 1 when the piston 45 is moving from a second longitudinal position to a first longitudinal position. An expansion pressure vessel 49 with a

chamber 56 is shown, comprising an inlet check valve 50, when open, the chamber 1 is communicating with the hose 43, through an exit 44. The cross-section of the external wall 51 of the expansion pressure vessel 49, with an inner wall 52. The expansion pressure vessel 49 is assembled between a top end 53 and a bottom end 54 of said vessel 49. The top end 57 of the expansion pressure vessel 49 is sealed to the wall of the chamber 1 by an O-ring 55, while the top end 57 and the bottom end 54 are sealed to the wall 52 of the expansion pressure vessel 49 by gas sealing thread 58 and 59 respectively.

This is a preferred embodiment for very high pressures (e.g. 16 Bar), and when the piston has difficulties in sealing to the inner chamber wall at second longitudinal positions. This construction avoids the sealing on the transition from a longitudinal cross-sectional section with a convex wall to a longitudinal cross-section section with a concave wall.

Fig. 1.1 shows a scaled up detail of Fig. 1. Please refer to the description of Fig. 1 for the description of Fig. 1.1

Fig. 2 shows the foot 70 of an advanced floor pump for e.g. tyre inflation, wherein the chamber of Fig.3 has been used. The flexible manchet 71 keeps the cone formed chamber 80 of Fig. 3 in place. The inside wall 81 of the chamber 80 is parallel to the centre axis 85 of the chamber 80 – the outside wall 72 at the position of the inside wall 81 is not parallel to the centre axis 85 of the chamber 80. The inflatable piston 73. The enclosed space 66. The tube 65. The inlet check valve 75. The outlet check valve 76. The hose 77. The measuring space 78, 79 (inside the hose). The valve connector 67 (not shown). The space 68 inside the valve connector 67 is also part of the measuring space (not shown).

Fig. 3 shows chamber 100, which is a 10 Bar overpressure chamber of the chamber 1 of Fig.1. It's second longitudinal positions end with a common border 27. This bottom of this chamber is screwed on a bottom part 101 which is corresponding the longitudinal cross-sectional section 30 of Fig.1. The thread connecting both parts of the chamber is gas thread 102, which makes a gas tight connection. In the bottom 103 of chamber part 100 is an exit 104, in which a hose nipple 105 has been screwed. The chamber part 100 is comprising a piston 106, which has been schematically drawn. The piston 106 is comprising a hollow piston rod 107, which is comprising a check valve 108, which opens the space 109 between the piston and the bottom 103, and thereby let air in from the atmosphere (48) into said space 109. On the hose nipple 105 is a hose 110 assembled with a hose clamp 111. The hose is at its other end connected to e.g. a valve connector 67. The hole 112 in hose 110.

Fig. 3.1 shows a scaled up detail of Fig. 3. Please refer to the description of Fig. 1 for the description of Fig. 3.1.

Fig. 4 shows a chamber 80. Within said chamber 80 is an inflatable piston 73, which has been shown in Fig. 2, and which is tightening against a straight wall 81, which is parallel the centre axis 85. Here is also aa construction where the chamber 80 has been updivided in two parts 115 and 116. The bottom 117 of chamber part 115 has an exit 104, in which a hose nipple 105 has been screwed. On the hose nipple 105 is a hose 118 assembled with a hose clamp 119. The hose 118 is at it's other end connected to e.g. a valve connector 67. Without internal pressure has the hose 118 no hollow channel 120, due to the reinforcement (not shown) of the wall 120 of the hose 118 – with internal pressure will there be a channel 121. Further down the hose 118 to side of the valve connector 67, there is an expandable chamber 123, with a wall 124, comprising reinforcements 125. Said reinforcements 125 are comprising e.g. more than one layer of e.g. unstretchable reinforment lanes, with a very small angle of overlapping each other. This results in that the expansion chamber 123 only will expand, when there is a high pressure rate inside the expansion chamber 123 – this makes inflating efficient, as otherwise the volume of the expansion chamber also has to be inflated, every time a e.g. a tyre has to be inflated –this is unnessary for low presseure tyres (e.g. up to 4.5 bar). The metal wire 126, which is limiting the expansion of the inflatable container piston (as expansion chamber). There may be used nipples 127 and 128 (not shown) for connecting said piston 123 to the hose .

Fig. 4.1 shows a scaled up detail of Fig. 4. Please refer to the description of Fig. 4 for the description of Fig. 4.1.

Fig. 5 shows the enlarged container type piston 1400, in a chamber 1401, which has a centre axis 1402, at the start and end of a stroke. The chamber is of a type where the maximum force on the piston rod is approx. even during the stroke. said chamber comprising an inner convex shaped wall near a first longitudinal position, said wall is updivided by longitudinal cross-sectional sections creating a common border, a distance between two following common borders defines a heigth of an inner wall of said longitudinal cross-sectional sections, said heigths are decreasing from a first longitudinal position to a second longitudinal position the transversal length of the cross-sectional common borders is determined by the maximum work force, which is chosen at least constant for said common borders near a second longitudinal position, said chamber may comprising an inner wall which is parallel to the centre axis of said chamber at a second longitudinal position. The shape of the piston at a second longitudinal position is that of a 'starting' ellipsoïde 1403 after having been pressurized from a non stressed production model, where the shape is approximately cylinder like shaped (see Figs. 3 and 5). The shape of the piston near a first longitudinal

position is an ultimate ellipsoïde 1404, which is almost a sphere 1405 (dashed). In between has the piston 1400 the shape of an ellipsoïde. The details of an ellipsoïde instead of a sphere at a first longitudinal position are identical with these of a sphere.

Fig. 6 shows an unstressed produced container type piston 1400, which, stressed may have the shape of an ellipsoïde or a sphere. At the bottom of the figure the non-movable cap 1420, with a gland 1421 for a O-ring(not shown), which tightens on the piston rod (not shown). A recess 1422 which is more or less a gland for an O-ring (not shown), which tightens the bottom of the piston 1400 on a bolt (not shown) which locks the bottom of the piston rod (not shown), through the hole 1432. On top of the figure the movable cap 1423, which is movable on the piston rod (not shown). The gland 1424 for an O-ring (not shown), which makes the piston tight in the top of said piston 1400. Both caps 1420 and 1423 having a recess 1425 and 1426, respectively, which is used to vulcanize the flexible wall 1427 of the container piston 1400 on said cabs 1420 and 1423, respectively. Said wall 1427 is shown in the figure with two layers: a reinforced layer 1428 and a layer which functions as a cover 1429 for the reinforced layer 1428. The dashed lines show a possible third layer 1430 and 1431, on top of the other layers 1428 and 1429, respectively, which is only present on the position where said two layers 1428 and 1429, respectively have been vulcanized on the cabs 1420 and 1423. The centre axis 1433. The wall 1427 of the piston 1400 is approximately parallel with the centre axis 1433. The reinforcement strengs 1440 lie in a parallel pattern, parallel to the centre axis 1433. The reinforcement pattern 1441 when there are two layers. Please note the small angle between the reinforcement strengs 1440 and 1441.

Fig. 6.1 and Fig. 6.2 show both cabs 1420 and 1423 scaled up, respectively of Fig. 6. At the outer side the rounded off transition 1434 and 1435, respectively, from the flexible wall 1427 to the portions of said wall 1427 which has been vulcanized on the portions 1425 and 1426 of said cabs 1420 and 1423, respectively. At the inner sides of the flexible wall 1427, just before said flexible wall 1427 meet the portions 1425 and 1426 of said cabs 1420 and 1423, respectively is a rounded off transition 1436 and 1437. These transitions 1436 and 1437 provide a stable transition of the wall, when the piston is being stressed by inflation.

CLAIMS

1. A piston-chamber combination comprising an elongate chamber which is
5 bounded by an inner chamber wall, and comprising a piston in said chamber to be
engagingly movable relative to said chamber wall at least between a first position and a
second position of the chamber,

10 said chamber having cross-sections of different cross-sectional areas and differing
circumferential lengths at the first and second longitudinal positions, and at least
substantially continuously different cross-sectional areas and circumferential lengths at
intermediate longitudinal positions between the first and second longitudinal positions, the
cross-sectional area and circumferential length at said second longitudinal position being
smaller than the cross-sectional area and circumferential length at said first longitudinal
position,

15 said chamber is comprising an exit valve, which is communicating with a hose,
which is communicating with a valve between the other end of said hose and an object to be
inflated,

characterized by the fact that

the size of the volume of said hose between said valves is variable .

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2. A piston-chamber combination comprising an elongate chamber which is
bounded by an inner chamber wall, and comprising a piston in said chamber to be
engagingly movable relative to said chamber wall at least between a first longitudinal
position and a second longitudinal position of the chamber,

25 said chamber having cross-sections of different cross-sectional areas and equal
circumferential lengths at the first and second longitudinal positions, and at least
substantially continuously different cross-sectional areas and equal circumferential lengths at
intermediate longitudinal positions between the first and second longitudinal positions, the
cross-sectional area at said second longitudinal position being smaller than the cross-
30 sectional area at said first longitudinal position,

said chamber is comprising an exit valve, which is communicating with a hose,
which is communicating with a valve between the other end of said hose and an object to be
inflated,

characterized by the fact that

the the size of the volume of said hose between said valves is variable.

3. A piston-chamber combination according to claim 1 or 2, wherein said piston is sealingly movable relatively to said chamber wall.

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4. A piston-chamber combination according to claims 1 – 5, wherein said hose is expandable.

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5. A piston-chamber combination according to claim 6, wherein the expansion is in the longitudinal direction of said hose.

6. A piston-chamber combination according to claim 6, wherein the expansion is in a transversal direction of said hose.

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7. A piston-chamber combination according to claim 5 and/or claim 6, further comprising an inflatable flexible piston, said piston is expanding when said hose is being pressurized.

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8. A piston-chamber combination according to claims 5 - 7, wherein the expansion initiates from a certain pre-destinated pressure inside said hose, and is imploding by a decreasing pressure rate.

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9. A piston-chamber combination according to claims 5 - 7, further comprising means for limiting the expansion, wherein said expandable expansion chamber is comprising a stopper.

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