

Measuring and Reading the Size of a Parameter of a Remotely Positioned Device

TECHNICAL FIELD

A sensor-reader combination, measuring the size of a parameter of a device,

- 5 the combination comprising a measuring space, in which the size of said parameter is to be measured, said sensor is remotely positioned from said space, and said sensor is closely positioned to the reader, said space and said measuring space are communicating during a part of the time in which the size of said physics parameter is to be measured.

10 BACKGROUND OF THE INVENTION

- This invention was initiated with solutions for the problem of optimizing ergonomically the reading of a parameter such as pressure or temperature of a tyre by manual operation of a piston chamber combination, e.g. a floor pump. Current pressure gauges are positioned so far away from the user, that she or he needs to have a telescope or binoculars to enable a normal reading. As no user will use such view enhancers, many pressure gauges are being equipped with a manually rotatable pointer of a color, different from the pointer of the pressure gauge. The first mentioned pointer is pointing at the desired end pressure, and is set before the pumping session. Thereafter it is easier to assess on a distance of the difference in position of both pointers. The problem is, that end pressures of tyres normally differ from each other, and that the pointer needs to be set, mostly every time before starting the pumping. This is uncomfortable.

- The reason for all this, is that the pressure of a tyre in most current pumps is measured pneumatically in the hose of the pump. This prohibits the transmittal of the pneumatic information from the hose of the pump to another part of the piston-chamber combination, normally the chamber, closest to the user of the pump, due to the fact that there is a check valve between the pump cylinder and the hose, at least in high pressure pumps.

- 25 A common used solution is using a wireless (= by means of electromagnetic waves) transmission for this transmittal. It normally however means the use of electronic parts, and specifically batteries or another electric source. This is expensive, resources demanding and change of batteries is uneasy to handle by a common user.

OBJECT OF THE INVENTION

The object is to provide solutions for measuring a parameter, in the case that the device

of which said parameter needs to be measured and said sensor are on a (differing) distance from each other.

SUMMARY OF THE INVENTION

5 In the first aspect, the invention relates to a sensor-reader combination, wherein the size of said parameter is being simulated during the time no communication takes place between said device and said measuring space.

Specifically for piston-chamber combinations, such as innovative tyre inflation pumps, where the cross sectional area's of the chamber are differing during the stroke is the size of the
10 operating force of these pumps not anymore representing the size of the pressure in the tyre, and it is necessary to have a reliable and non-expensive pressure reading of the tyre pressure in a gauge, nearby the user during the pump stroke, e.g. nearby the handle on top of the piston rod in case of a floor pump

Obvious solutions for the transmittal of the information of a size of a parameter between parts of
15 the combination moving relatively to each other is e.g. by an elastic wire of which each end may be connected to each part. In a pump with high pressures, will the life time of such wire being negatively affected by the harsh climate of the inside of the pump, and if not, the solution would be expensive.

Another obvious solution would be to use contacts which glide over each other during the
20 stroke, where e.g. a contact rail would be connected to one of the moving parts, while a contact (flexible strip, or a springforce operated contact) would slide on said rail, and be connected to the other part. Not a very reliable solution in a harsh climate inside a pump. And, used in a floor pump, this would possibly prohibit the handle to rotate enough for being comfortable to pump with. This solution would be expensive as well, and not very reliable.

25 An obvious wireless solution is to measure e.g. the pressure in the hose of a pump, and transmit the information wireless to a receiver on the piston rod, and have a reading on a gauge on top of a handle which is operated by the user. Even this solution seems to be reliable, this solution is expensive, only already by having an electrical source on two different places.

Better solutions must be provided.

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The key to this invention is the fact that the space of the tyre to be inflated, is in direct contact with the space in the pump under the piston, during overpressure or just before balance of pressure of the pump in relation to the pressure in the tyre. That means that the size of the

pressure / temperature in the tyre may be readable by measuring said parameter in the space under the piston of the pump, and in case of a high pressure pump, before the check valve, which is normally positioned between said space under the piston and the hose, which connects the pump to the valve connector, which is mounted on the tyre valve. Said space is called the measuring space. The measuring space is a part of the chamber and is surrounding the bottom part of the piston rod, and thereby it may be possible to communicate by a channel (pneumatically) or by wires (electrically) between the sensor (a pressurized spring in a manometer, or a transducer mounted on said piston rod end or mounted on a printboard and connected by a channel to the measuring space) through said piston rod to the reader on top of the piston rod (manometer or an electric volt/current meter or an electronic display, respectively). Said channel is ending at said piston rod end.

In the second aspect, the invention relates to a sensor-reader combination wherein said measuring space is communicating during a part of the operation with said device.

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In case of current pumps for tyre inflation, measuring of the pressure of the tyre is done in the hose of the pump. This hose is at one end connected to the chamber through a check valve, and at the other end connected to a valve connector. The check valve limits the size of the dead space of the piston pump. In current low pressure pumps is no check valve present, and no pressure measuring is normally used.

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The pressure in the hose may than be representative for the pressure in the tyre, because the tyre valve closes when there is pressure equivalency between the space in the hose, and the space of the tyre. This happens in current pumps, when the piston has reached its end point after a pump stroke, and is starting to return, thus when the overpressure in the chamber drops. The reason is, that the check valve between the cylinder (chamber) and the hose is closing as well at this point of time.

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The pressure in the measuring space of the chamber, between the piston and said check valve, may than also be representative for the tyre pressure as well, when the piston is about to return for a new stroke – it is measuring then the maximum size of the pressure for the last stroke. This opens a solution where the tyre pressure / temperature may be measured at the end of the piston (rod) which is adjacent the space between the piston and a check valve. Thus may a sensor (measuring means) and a reading means be placed on one of the parts, e.g. on the piston (rod) in a piston pump e.g. for tyre inflation. The sensor may be positioned on the piston rod, and best at

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the top of the piston rod, in order to enable a surface for the guiding means of the piston rod. It may then be possible to have a reading on a gauge which is positioned on top of the handle of the piston rod – thus closest to the user, and readable during operation.

E.g. in case of pressure reading: this reading may be done by a pneumatic pressure gauge (manometer) e.g. positioned on top of the piston rod, where the gauge is connected by e.g. a channel within the piston rod to the measuring space (between the piston and the valve connector or the check valve). The same is valid when a temperature is being measured with a e.g. bimetal sensor. Experiments show that the small size of said channel and its long length is not giving rise to dynamic friction. And, that indeed the pressure / temperature in the tyre = pressure / temperature in the hose = pressure / temperature in the measuring space, when there is overpressure in the pump and when there is balance of pressure, thus when there is direct communication possible between the sensor and the device, of which the size of the parameter is to be measured. By a piston pump, it means that that happens during the pump stroke, but not during the return stroke. The measuring by the pressure sensor may also be done by an electric pressure transducer, which gives through an amplifier a signal to a digital pressure gauge or an analog pressure gauge (a volt meter or a current meter), e.g. positioned on top of the piston rod. The same is valid when the tyre temperature is being electrically monitored.

In order to make the sensor - reader combination still more profitable, the sensor may be assembled on the printboard comprising the reader, while the sensor is communicating with the measuring space through a channel.

In the third aspect, the invention relates to a sensor - reader combination, wherein:

- the size of the parameter is measured in an enclosed measuring space.

Measuring in the enclosed space is only representing the size of the parameter of the device when there is direct communication possible between the sensor and the device. When during a part of the time communication is not possible, e.g. during the return stroke of a piston pump, the size of the parameter needs to be simulated. This may be done by a sensor positioned in the measuring space. The simulation needs to be done electronically, e.g. by a chip or a computer. The position of the piston rod may be the basis for the simulation of the size of the parameter of the device. The reading may be analog or digital.

Direct measuring in the measuring space may give fluctuations of the size of the parameter, as

e.g. in a piston floor pump for tyre inflation with regard to the pressure, but also with regard to the temperature. In order to ease the simulation the pump, a conditioned measuring space may be necessary, and this may be done by a so-called enclosed measuring space.

When the value of the parameter is measured in an enclosed measuring space, it is necessary to get the fluid in, measure it and read it. Thereafter get it out again for the next measurement. E.g. in case a pressure in a tyre is measured in a floor pump, a part of the medium of the measuring space may be entered into the enclosed measuring space for enabling the measurement. This may be done by a pneumatic check valve or an electrically controlled valve. For getting the contents of the enclosed measuring space out again after the measurement, a new valve (pneumatic check valve or an electrically controlled valve) may be necessary - it may also be a channel, which is so tiny that dynamic friction (depending on its length, diameter and surface roughness, but also by a screw which has a tiny hole as well, e.g. in the case where the thread has been locked by a locking fluid) may reduce the magnitude of the flow out of the enclosed measuring space, so much that this flow does not influence so much the measurement, but only during the return path of the pump stroke, which is not very relevant for the reading. However, it is necessary to monitor the reader in order to read and remind the max. pressure of that stroke – this may be not fully convenient.

This delay may be also used for the following purpose. E.g. in case of a pressure measurement in a piston-chamber combination, it may be necessary to maintain the value of the tyre pressure of the last pump stroke done, when the piston is returning after that pump stroke, until the value of this parameter in the space adjacent the space between the piston and a check valve or valve connector has reached the maximum value of the pump stroke before, by the next pump stroke. The measured value is then representing the tyre pressure during said non-communication period. This construction functions very well in practise.

That temporary maintaining of this value may be done electronically (e.g. by the use of a condensator), by software controlling an IC, by mechatronics - the position of the piston rod in relation to the pump, controlling an IC, or just by mechanics alone: e.g. an enclosed measuring space, which may be connected by an inlet check valve to the measuring space (between the piston and the valve connector, or the space between the piston and the check valve between the combination and the hose in case of a pump for tyre inflation), and an outlet channel or an outlet channel. The inlet check valve may preferably be identical with the valve between the combination and the hose, so that opening and closing happen simultaneously.

When the requested pressure has been reached, will the movement of the piston stop, and will

the pressure in the enclosed measuring space become equal with the pressure in the measuring space, which is the pressure of the tyre. Firstly when the hose has been disconnected from the tyre valve, the pressure in the measuring space decreases to atmospheric pressure (even there is a check valve in between) when the valve connector is of a type which enables communication
5 between the atmosphere and the pump, when disconnected from the tyre valve, and will the pressure in the enclosed measuring space decrease to atmospheric pressure.

The reading of the tyre pressure in the above mentioned simulation equipment is only that pressure at the very end of the pump stroke. It is necessary to monitor the pressure during the end of each stroke, which may not be convenient. In order to allow the preservation of the
10 pressure (or temperature) during a pump return stroke, the enclosed measuring space comprises an outlet valve which may be initiated electrically, or be solely mechanical. It may be done manually, e.g. by pressing a button for closing the measuring space before the pump session, and opening up again, thereafter, by pressing said button again.

A simple automatic mechanical arrangement for a better simulating of the (tyre) pressure
15 during the return stroke may be that of an outlet valve between the enclosed measuring space and the measuring space. The valve is comprising two pistons, one at each end of the piston rod, and each piston is communicating with the enclosed measuring space and the measuring space, respectively. The diameter of the piston communicating with the enclosed measuring space is smaller than that of the piston communicating with the measuring space. This enables
20 that when the pressure in the enclosed measuring space is equal to the pressure in the measuring space – thus during pumping strokes - the valve is closed. A proper fitting of the piston rod to the housing, eg. a sliding fit, may enable that the movement of the piston rod of said valve from being closed, to become open and vice versa will be delayed. Thus, while pumping, the valve remains closed, even during the return stroke, which does not take a long
25 time – the reading shows the *current* tyre pressure. When the desired (tyre) pressure has been reached during pumping, the pump will be disconnected from the space to be inflated (tyre) and the pressure in the measuring space will drop to atmospheric pressure, said valve will open, and the pressure in the enclosed measuring space becomes equal to atmospheric pressure. It is now e.g. possible, that a manometer mounted on top of the handle of the piston
30 rod of a piston pump, is showing the current (tyre) pressure while pumping, while it is not necessary for the user to constantly monitoring the reading of said manometer, in order to obtain said information about the current (tyre) pressure.

An improvement for the valve arrangement may be that the ducts on the side of the piston rod

may be so long that the spaces behind the valves and the housing – on each side of the bearing of the piston rod, always are communicating with each other, thus irrespective the position of the piston rod in the bearing. When this would not be the case, it may be possible that one or both of the above mentioned spaces are closed in a certain position of the piston rod – a movement of the valves, would result in a higher pressure in such space, higher pressure than that of the atmosphere – this may be obstructing the movement of the piston rod, and thus of the movement of the valves.

Said valve arrangement may be used with any the type of a piston for a pump, actuator, shock absorber or motor.

The tyre pressure simulation in the enclosed measuring space during the return stroke of the piston is an example, which is quite simple. There may be other, and more complex simulations. These simulations may of course be done by a computer program or a programmed IC, which is controlling the inlet and outlet valves, while the last mentioned are valves which may be controlled electrically/electronically. This may be done in much bigger and more costly installations, which may need maintenance, than that of a floor pump for inflation purposes.

During operations may a deviation of e.g. the pressure / temperature of the device happen in relation to the reading in the enclosed measuring space.

This may e.g. be the case when there is dynamic friction in the check valve between the measuring space and the hose of a pump, due to a too big velocity of the piston during the pumping stroke. This means, that the value read is higher than the actual pressure in the tyre. It may be avoided by using a check valve having a flow possibility which is under all circumstances big enough, for both the check valve of the pump and the inlet check valve of the enclosed measuring space. Another solution is, that the bearing of the piston rod of the pump has such a fitting with the piston rod suspension or with the piston itself to the wall of the chamber, that a maximum velocity can be defined. This should than be under the velocity, which gives a certain maximum flow said check valve of the pump.

Another deviation may occur when the check valve between the pump and the hose is very different from the inlet check valve of the enclosed measuring space. However, having experienced that in experiments, the deviation was a structural one, which could be solved by an adaptation of the scale of the reader. This seems also to be necessary for the remote measurement of the tyre temperature. Still best would be to have identical check valves, both

for the pump and the enclosed measuring space.

The above mentioned examples of a floor pump for pumping tyres are are exampoles only, and the issues can also be used on other kind of devices and situations where the size of parameters have to be measured, e.g. nucleair particles.

In case of e.g. a container (envelope) piston type (claim 5) according to EP 1179140, which uses an enclosed space, the enclosed space may be preferably positioned behind the enclosed measuring space, relative to the measuring space (the space adjacent the space between the piston and a check valve valve), if an electric gauge is used.

In case of a pneumatic gauge (= manometer), the piston rod may comprising the enclosed measuring space.

A piston-chamber combination comprising an elongate chamber which is bounded by an inner chamber wall and comprising a piston means in said chamber to be sealingly movable relative to said chamber at least between first and second longitudinal positions of said chamber, said chamber having cross-sections of different cross-sectional areas at the first and second longitudinal positions of said chamber and at least substantially continuously differing cross-sectional areas at intermediate longitudinal positions between the first and second longitudinal positions thereof, the cross-sectional area at the first longitudinal position being larger than the cross-sectional area at the second longitudinal position,

said piston means being designed to adapt itself and said sealing means to said different cross-sectional areas of said chamber during the relative movements of said piston means from the first longitudinal position through said intermediate longitudinal positions to the second longitudinal position of said chamber, wherein the piston comprises an elastically deformable container comprising a deformable material. Said piston means may be comprising an enclosed space communicating with the deformable container (envelope), the enclosed space may have a constant volume. The container(or envelope) may be inflatable. This may be necessary when having a measuring channel or a wire loom inside the enclosed space, if the enclosed space is relatively small, like the situation is in a floor pump for tyre inflation. The circumpherential size of this piston type is that of the chamber.

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 sealingly movable relative to said chamber wall at least between a first longitudinal position and a second

longitudinal position of the chamber, said chamber having cross-sections of different cross-sectional areas and different 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, said piston comprising a which is elastically deformable thereby providing for different cross-sectional areas and circumferential lengths of the piston adapting the same to said different cross-sectional areas and different circumferential lengths of the chamber during the relative movements of the piston between the first and second longitudinal positions through said intermediate longitudinal positions of the chamber, wherein the piston is produced to have a production-size of the container in the stress-free and undeformed state thereof in which the circumferential length of the piston is approximately equivalent to the circumferential length of said chamber at said second longitudinal position, the container being expandable from its production size in a direction transversally with respect to the longitudinal direction of the chamber thereby providing for an expansion of the piston from the production size thereof during the relative movements of the piston from said second longitudinal position to said first longitudinal position. Said piston means may be comprising an enclosed space communicating with the deformable container (envelope), the enclosed space has a constant volume.

The enclosed space has also a constant volume when the chamber is a combination of cross-sections with and without a constant circumferential length.

The circumferential size of this piston type may be that of the chamber on its smallest circumferential size.

In case of e.g. a piston type according to claim 1 according to EP 1179140 is used, neither an enclosed space 42 (Figs. 3A-C) is necessary, nor the inflation nipple 43 (Figs. 3A-C). The enclosed space may be used then as channel 52 (Figs. 3A-C) or as inlet channel for the measuring space. The check valve 43 should than be put in a reversed position: please see Fig. 9.

The sensor - reader combination may be used in any device where a the sensor is remotely

positioned in relation to the device of which a parameter needs to be measured, such as pumps, actuators, shock absorbers or motors.

The above combinations are preferably applicable to the applications.

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Thus, the invention also relates to a pump for pumping a fluid, the pump comprising:

- a combination according to any of the above aspects,
- means for engaging the piston from a position outside the chamber,
- a fluid entrance connected to the chamber and comprising a valve means, and
- 10 - a fluid exit connected to the chamber.

The invention also relates to an actuator comprising:

- a combination according to any of the combination aspects,
- means for engaging the piston from a position outside the chamber,
- 15 - means for introducing fluid into the chamber in order to displace the piston between the first and the second longitudinal positions.

The actuator may comprise a fluid entrance connected to the chamber and comprising a valve means.

- Also, a fluid exit connected to the chamber and comprising a valve means may be
20 provided.

Additionally, the actuator may comprise means for biasing the piston toward the first or second longitudinal position.

Finally, the invention relates also to a shock absorber comprising:

- 25 - a combination according to any of the combination aspects,
- means for engaging the piston from a position outside the chamber, wherein the engaging means have an outer position where the piston is in its first longitudinal position, and an inner position where the piston is in its second longitudinal position.

- The absorber may further comprise a fluid entrance connected to the chamber and
30 comprising a valve means.

Also, the absorber may comprise a fluid exit connected to the chamber and comprising a valve means.

BRIEF DESCRIPTION OF THE DRAWINGS

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

- 5 Fig. 0L shows the combination of a pneumatic pressure / temperature gauge and a channel within the piston rod, where the measuring point is at the end of the channel, the channel communicating with in the measuring space - the lower part of the drawing has been scaled up 2:1. A scaled up detail is also shown.
- 10 Fig. 0R shows the combination of a pneumatic pressure / temperature gauge and a wire loom within the piston rod, where the measuring point is at the transducer at the end of the piston rod, the transducer communicating with the measuring space - the lower part of the drawing has been scaled up 2:1. A scaled up detail is also shown.
- 15 Fig. 1A shows the top of the piston rod of a floor pump with an inflatable piston, with an electrical gauge mounted on top of the handle, and the bottom of the piston rod with the transducer in the enclosed measuring space.
- Fig. 1B shows the bottom part of Fig 1A on a scale 2:1.
- Fig. 2A shows the top of the piston rod of a floor pump with an inflatable piston and a pneumatic gauge mounted on top of the handle, an in-between channel which ends in the enclosed measuring space.
- 20 Fig. 2B shows the bottom part of Fig 2A on a scale 2:1.
- Fig. 3A shows the top of the piston rod of a floor pump with an inflatable piston and a pneumatic gauge mounted on top of the handle, and the bottom of the piston rod comprising an enclosed measuring space.
- Fig. 3B shows the bottom part of Fig. 3A on a scale 2.5:1.
- 25 Fig. 3C shows the outlet channel of the enclosed measuring space of Fig. 3B on a scale 6: 1.
- Fig. 3D shows a detail of the outlet channel of Fig. 3C on a scale of 5:1.
- Fig. 4 shows the bottom of an advanced floor pump for e.g. tyre inflation.
- Fig. 5 shows Fig 3B where the part of Fig. 3C has been exchanged by an improved construction for the simulation.
- 30 Fig. 6A shows an improved simulation for the tyre pressure of Fig. 5 in the enclosed measuring space, where the the valve is shown closed.
- Fig. 6B shows an improved simulation of the tyre pressure of Fig. 5 in the enclosed

measuring space, where the the valve is shown open.

Fig. 7 shows the signalling of the electronic simulation when the pressure / temperature is measured in the measuring space of a floor pump.

Fig. 8A shows a section of a pneumatic gauge housing, mounted on a handle, where the enclosed space is communicating with a space outside the gauge housing, enabling an inlet for the pump, when it is not possible to have an inlet which is directly communicating with the measuring space.

Fig. 8B shows a detail of the enclosed (measuring) space of Fig. 8A.

Fig. 9 shows an improved construction of the valve arrangement of Fig. 6.

Fig. 10A shows an scaled up detail of the valve arrangement of Fig. 9, when it is closed.

Fig.10B shows an scaled up detail of the valve arrangement of Fig. 9, when it is open.

15 DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 0L shows a reading point 100 of the measured value of a pneumatic pressure gauge housing 101. Within said gauge is a mechanical manometer 102 (not shown). Said gauge housing 101 is mounted on top of a piston rod 103. The piston rod 103 is hollow with channel 104, which mounting a tube with a measuring channel 107 within tube 113, which makes communication possible between the pneumatic pressure gauge 102 and the entrance 108 of channel 108 at the bottom of the tube 107. The measuring point 108 in the housing 101, at the manometer entrance. The measuring room 111. The handle 2. The suspension 109. The spring washer 6. The bolt 7. The suspension 110 of the channel 107 in the top of the piston rod 103. The suspension 112 of the piston. The tube 113.

Fig. 0R shows a reading point 120 of the measured value of an electric pressure / temperature gauge housing 121. Said housing 121 comprises an analog/digital electric gauge 122 (not shown). Said gauge 122 is mounted on top of a piston rod 123. The piston rod 123 is hollow with channel 124, in which a wire loom 125 is mounted. Said wire loom 125 is connected with a transducer 15, which is mounted on a platform 16, which makes communication possible between said gauge 121 and the measuring point 128 at the bottom of the piston rod 123. The measuring space 130. The handle 2. The spring washer 6. The bolt 7. The suspension 129 of the channel 124 in the top of the piston rod 123. The transition 22. The suspension 131 of the piston.

Fig. 1A shows the top of a piston rod 1 with a handle 2 and an electric (pressure/temperature) gauge 3. The gauge 3 is mounted on the handle 2. The piston rod 1 has an upper space 4.1 which is serving as an enclosed space 8 for the inflatable piston, of which only the bottom part of its suspension 5 is shown. The spring washer 6. The top of a bolt 7 is shown with the bottom space 4.2 of the enclosed space 8, which is directly connected to the upper space 4.1. In the top of bolt 10 is a valve body 9 mounted, and fastened by a nut 10. The core pin 11 is shown in a closed position against the stem 12 in the valve body 9. This valve 11 is serving to keep the enclosed space 8 on the necessary pressure. On the valve body 9 is the housing 13 of the enclosed measuring space 14 mounted. The (pressure) transducer 15 is shown, mounted on a platform 16. This platform 16 allows a gentle activation of the transducer 15, as the opening is between the wall 17 of the enclosed measuring space 14 and the transducer 15. The valve 18 which connects the measuring space 14 with the measuring space 19 adjacent the outlet of the combination. The top of the hollow piston rod 1 is closed by a filler 20, which is tightly closing the necessary wire loom 21 from the pressure transducer 15 to the gauge 3. The rest of the wiring is not shown. The transition 22 prohibits the filler 20 to be burst out of the piston rod. The outlet valve of the enclosed measuring space 14 is not shown.

Fig. 1B shows the bottom part of Fig 1A on a scale 2:1.

Fig. 2A shows the top of a piston rod 31 with a handle 2 and a pneumatic pressure gauge 33. Said gauge 33 is mounted on the handle 2. The piston rod 31 has a space 34.1 which is serving as an upper part of the enclosed space 32 for an inflatable piston, of which only the bottom part of its suspension 5 is shown. The spring washer 6. The top of a bolt 7 is shown with part 34.2 which is serving as the lower part of the enclosed space 32, which is directly connected to the space 34.1. In the top of bolt 7 is a body 39 mounted, and fastened by a nut 10. On the body 39 is the housing 13 of the enclosed measuring space 14 mounted. The end 35 of the measuring channel 36 within tube 36.2 is shown which is tightly mounted in the top 37 of the piston rod 31, and connected to the pneumatic pressure gauge. The valve 18 which connects the enclosed measuring space 14 with the measuring space 38 adjacent the outlet of the combination.

The outlet valve of the measuring space 32 is not shown.

Fig. 2B shows the bottom part of Fig. 2A on a scale 2:1.

Fig. 3A shows the top of a piston rod 40 with a handle 2 and an electric pressure gauge 41. The gauge 41 is mounted on the handle 2. The piston rod 40 has an enclosed space 42 for keeping the piston pressurized. Said space can communicate with the piston (see e.g.

WO2000/070227 or WO2002/077457 or WO2004031583). Pressurization to a desired level of the piston is done by an external pressure source (not shown) through an inflation nipple 43, which has an built in check valve 44. The exit hole 66 of the check valve 44. The nipple 43 is positioned at the bottom of the piston rod 40, and built in the head 45 of the bolt 46. The enclosed measuring space 47 is built in a separate housing 48 in the head 45 of bolt 46. Said enclosed measuring space is connected through a check valve 49 with the measuring space 50. Said check valve 49 is built in a separate housing 51. The (vertical) channel 52 is connected to the enclosed measuring space 47 within the tube 36.2 by means of a (horizontal) channel 53, and is sealed by a sealing means 54, e.g. an O-ring, in the enclosed measuring space 47. The cap 55, which is a part of the O-ring gland. Either is the transducer 15 mounted on the bottom 56 of the tube 57, where the channel 52 is filled in with a wire loom 57 to the electric pressure gauge 41, or is the channel 52 open, and on top 58 of the channel 52, within the electric pressure gauge 41, is the transducer 15 mounted.

Fig. 3B shows the bottom part of Fig. 3A on a scale 6:1.

Fig. 3C shows a part of the enclosed measuring space (47, 43, 52) on a scale of 6:1 in relation to Fig. 3B. The outlet channel 59 in the head 45 of the bolt 46, with an screw 60, which sets the flow through the tiny channel 61 in the housing 48 of the enclosed measuring space 47. The channel 61 has a widened end 62, which suits the tapered end 63 of the screw 57. In the screw 60 is a channel 64 that connects the channel 61 with the outlet channel 59.

Fig. 3D shows a detail of Fig. 3C on a scale 5:1. The very small space 65 between the widened end 62 and the tapered end 63. Said space 65 sets the flow in channel 53.

Fig. 4 shows the bottom part 70 of an advanced floor pump for e.g. tyre inflation. The flexible manchet 71 keeps the cone formed tube 72 in place. The inflatable piston 73. On the bottom of the piston rod 74 is the embodiment of Figs. 3A-D mounted, without crew 57 arrangement (may only be necessary for prototyps). The enclosed space 42. The tube 36.2. The inlet check valve 75 The outlet check valve 76. The hose 77. The measuring space 78, 79 (inside the hose). The valve connector 80 (not shown). The space inside the valve connector 81 is also part of the measuring space (not shown).

Fig. 5 shows Fig 3B where the part of Fig. 3C has been exchanged by an improved construction for the simulation – the outlet valve arrangement. The enclosed measuring space 90.

Fig. 6A shows an outlet valve arrangement for the enclosed measuring space, situated between the enclosed measuring space 90, and the measuring space 91. This valve

arrangement is comprising an inlet channel 92 and an outlet channel 93, an inlet piston 94 and an outlet piston 95. Said inlet piston 94 has a smaller diameter of the sealing (to the wall 96 of the inlet channel 92) than that of the sealing (to the wall 97 of the outlet channel 93) of said outlet piston 95. The piston rod 98 between the inlet piston 94 and the outlet piston 95, is comprising a duct 99, which enables communication between the inlet channel 92 and outlet channel 93, when the piston rod 98 is in a certain position – in this figure: closed – no communication possible: the sealing of piston 94 is engaging the wall 96, while the piston rod has a specific fitting with the piston guidance 140 of the housing 141, which enables a certain, specified friction: e.g. a sliding fit. The spacer 142, which avoids a piston 94 and 95 to be ‘glueing’ to the housing 141. The diameter of the piston 94 is smaller than the diameter of the piston 95, in order to achieve that the outlet valve arrangement is closing when there is equal pressure in the enclosed measuring space 90 and the measuring space 91. The space 210 behind the valve 94 and the housing 141. The space 211 behind the valve 95 and the housing 141.

Fig. 6B shows the outlet valve arrangement of Fig. 6A, where communication between the enclosed measuring space 90 and measuring space 91 is possible. The flow from the enclosed measuring space 90 to the measuring space 91 is through bypass 143 between the piston 94 and the wall 144 of the inlet channel 92, through duct 99 between the piston rod 98 and the guidance 140, where the duct is now open at both ends 147 and 148, respectively, through bypass 145 between the piston 95 and the wall 146 of outlet channel 93.

During the return movement of the pistons 94 and 95, when the outlet valve arrangement is closing again, will the piston 95 closing against the wall 97, whereafter piston 94 is closing against the wall 96.

Fig. 7 shows the schematic overview of the use of electronic simulation of the pressure / temperature of a tyre in a floor pump, where said parameter are being measured in the measuring space of said pump. The floor pump 150. The piston rod 151 of the floor pump 150. The reader 152. In the top 153 is at least a positioning sensor 154 located, which is disclosing the position of the piston rod 151 in relation to the top 153 – specifically when the return stroke is ‘on’. Additionally is the speed of the piston rod 151 monitored, possibly by the said positioning sensor 154 or by a separate sensor (155). The signal(s) 156 from the sensor(s) 154 (155) is/are being transmitted to an electronic unit 157, which may comprise a Data Acquisition System and a P(ersonal)C(omputer). A signal 158 is being transmitted to the electronic/electric sensor 159.

All the above mentioned equipment may very well be assembled in the piston rod 151 and the reader 152, instead of what Fig. 7 discloses. This configuration may be used in any piston - chamber combination, besides a pump – thus, e.g. actuators, shock absorbers and actuators connected to a crankshaft. The reader may be also positioned outside the piston-chamber combination. The sensor may also be positioned elsewhere in the measuring space or enclosed measuring space than on the piston..

Fig. 8A shows an assembly of a gauge housing – top part 183 and bottom part 84, assembled with scrues (not shown) - on a handle 185 of a floor pump of Fig. 4. The piston rod 74, which is mounted on a nipple 186, on which the handle 85 has been mounted. This is done by a spring washer 187 and a spacer 188. A nut 189 which is comprising a washer 190 is keeping the handle 185 in place. The piston rod 74 is comprising the enclosed space 42, which is permanently communicating with space 91. The tube 36.2 is comprising the enclosed measuring space 52. In order to be able to mount the pneumatic pressure gauge 92 on the tube 36.2, the tube is comprising an S-bend 94, and has on its top a nipple 93 – the nipple 93 is sealed (not shown) to the gauge housing. The pneumatic pressure gauge has been mounted in the top part 183 of the pneumatic pressure gauge housing by e.g. scrues (not shown). The centre axis 82 of the enclosed measuring space 52. The space 199 is communicating with the space 91, and is communicating with the space 195 outside the top part 183 of the gauge housing, which is the outer atmosphere, so that the measuring space 91 is communicating with the outer atmosphere when the check valve 201 is open (see Fig. 9A).

Fig. 8B shows a detail of the nipple 186. The tube 36.2, with its centre axis 82 and the enclosed measuring space 52. The space 191 is in continuation of the enclosed space 42.

Fig. 9 shows Fig. 5 where the part of Fig. 6a has been exchanged by an improved construction for the simulation – the outlet valve arrangement: Fig.10A. The enclosed measuring space 226. The inlet 198 (Fig. 8A) is communicating with the measuring space 91, through the channel 197, space 199 and channel 191, enclosed space 42 and the check valve 250. The channel 197, the space 199, channel 191 and the enclosed space 42 serves here as a feeding channel in case the inlet valve of the measuring space 91 cannot be positioned elsewhere in the boundary of the measuring space 91. The valve housing 251. The inlet 252. The stop 253 and the outlet 254. The sealing surface 255.

Fig. 10A shows an improved version of the outlet valve arrangement of Fig. 5, 6A, 6B where the ducts 221 on the piston rod 223 are longer than the ducts 99, so that at any time there is a communication possible between the spaces 220 and 221 at both sides of the duct

221, in between both pistons 94 and 95. This enables said pistons 94 and 95 to move, solely due to the difference in force between both pistons 94 and 95. The centre line 231 of the piston rod 223. The measuring space 91.

5 The outlet valve arrangement is now assembled in a separate valve housing, of which the upper part 224 has been screwed in the housing 225 of the enclosed measuring space 226, with sealing 227 in between. The bottom part 228 of the housing is screwed on the upper part 224 of the valve housing, with a seal 229 in between. The piston rod 223 can easily be assembled onto the bottom part 228 of the housing, with a special fit, e.g. a sliding fit, with the bearing 232 of the bottom part 228 of the housing. Both valve sealings 94 and 95 can be
10 assembled easily onto the piston rod 223.

Fig. 10B shows the outlet valve arrangement when there is a flow of the fluid from the enclosed measuring space 226 to the measuring space 91. When there is overpressure at the side of the enclosed measuring space 226 in relation pressure in the measuring space 230, so that the force on the piston rod 223 is bigger by the inlet piston 94 than by the outlet piston
15 95, a flow through the channel 232, the space 233, presses the piston rod 223 toward the measuring space 91, whereby the pistons 94 and 95, respectively, sealingly move against the walls 144 and 146, respectively, until the seekers 234 and 235, which have angles α and β , respectively with the centre axis 231, have been reached by the pistons 94 and 95, respectively, thereby establishing a bypass 236 and 240, respectively, so that a flow can be
20 established to space 210, through the bypass 236 to space 210, through the opening 237, the ducts 221 to the space 211 through opening 239, and through bypass 240 along the seeker 235, to space 241 and the measuring space 91.

Specifically preferred embodiments

25 A sensor - reader combination the measuring can be done by a transducer communicating with the measuring space, which can be connected with mechanical conducting devices, such as wires, to an analog electrical and/or digital gauge.

A sensor - reader combination the measuring can be done by connecting the measuring space with the inlet of the pneumatic gauge (manometer) by a measuring channel.

30 A sensor reader combination the measuring can be done by connecting the transducer to the enclosed measuring space, the transducer can be connected with mechanical conducting devices, such as wires, to an analog electrical and /or digital gauge.

A sensor reader combination the enclosed measuring space comprises an inlet and an outlet

valve which can be initiated electrically, and which can be opening and closing the valve opening from and towards the measuring space, respectively, and can be controlled by a computer.

A sensor-reader combination, measuring the size of a parameter of a device, the combination comprising a measuring space, in which the size of said parameter is to be measured, said
5 sensor is remotely positioned from said space, and said sensor is closely positioned to the reader, said device and said measuring space are communicating during a part of the time in which the size of said physics parameter is to be measured, wherein the size of said parameter can be simulated during the time no communication takes place between said space and said measuring space.

10 A sensor-reader combination wherein the parameter can be a physics parameter.

A sensor-reader combination wherein said the simulation can be done by electronic means.

A sensor-reader combination wherein said measuring space can be comprising an enclosed measuring space.

15 A sensor-reader combination wherein the sensor can be measuring said physics parameter in the enclosed space.

A sensor-reader combination wherein said enclosed measuring space is communicating with said measuring space by a valve.

20 A sensor-reader combination wherein said valve can be a check valve, opening the enclosed measuring space to the measuring space when there is overpressure in the measuring space in relation the pressure in the enclosed measuring space, so that a medium from the measuring space can enter the enclosed measuring space.

A sensor-reader combination wherein the enclosed space can be communicating with the measuring space by a small channel.

25 A sensor-reader combination wherein said channel can be comprising a screw, which is defining the flow of a medium from the enclosed measuring space to the measuring space.

A sensor-reader combination wherein said valve can be a check valve, closing the valve when there is overpressure or equal pressure in the enclosed measuring space in relation to the pressure in the measuring space, and opening the measuring space when there is overpressure in the enclosed measuring space in relation to the pressure in the measuring space, so that a
30 medium from the enclosed measuring space can enter the measuring space.

A sensor-reader combination wherein the opening of said valve can be delayed by a special fitting of the piston rod with the housing.

A sensor-reader combination wherein the flow of the check valve between the pump and the hose of a pump is big enough to avoid dynamic friction.

A sensor-reader combination wherein the flow of the check valve between the measuring space and the enclosed measuring space of a pump can be big enough to avoid dynamic friction.

A sensor-reader combination the bearing of the piston rod of a piston pump can have such a fitting that the piston rod has a maximum velocity.

A sensor-reader combination wherein the manometer, reading and sensing the tyre pressure of a tyre in a pump is positioned on top of the assembly, can comprising the enclosed measuring space.

A piston-chamber combination comprising an elongate chamber which is bounded by an inner chamber wall and comprising a piston means in said chamber to be sealingly movable relative to said chamber at least between first and second longitudinal positions of said chamber, said chamber having cross-sections of different cross-sectional areas at the first and second longitudinal positions of said chamber and at least substantially continuously differing cross-sectional areas at intermediate longitudinal positions between the first and second longitudinal positions thereof, the cross-sectional area at the first longitudinal position being larger than the cross-sectional area at the second longitudinal position, said piston means being designed to adapt itself and said sealing means to said different cross-sectional areas of said chamber during the relative movements of said piston means from the first longitudinal position through said intermediate longitudinal positions to the second longitudinal position of said chamber, the piston means comprises an elastically deformable container (envelope), comprising a deformable material, the piston means, comprising an enclosed space communicating with the deformable container (envelope), wherein the enclosed space (4.1, 4.2, 8, 34.1, 34.2, 42) can have a constant volume.

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 sealingly movable relative to said chamber wall at least between a first longitudinal position and a second longitudinal position of the chamber, said chamber having cross-sections of different cross-sectional areas and different 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, said piston comprising a which is elastically deformable thereby providing for different cross-sectional areas and circumferential lengths of the piston adapting the same to said different cross-sectional areas and different circumferential lengths of the chamber during the relative movements of the piston between the first and second longitudinal positions through said intermediate longitudinal positions of the chamber, wherein the piston is produced to have a production-size of the container (envelope) in the stress-free and undeformed state thereof in which the circumferential length of the piston is approximately equivalent to the circumferential length of said chamber at said second longitudinal position, the container being expandable from its production size in a direction transversally with respect to the longitudinal direction of the chamber thereby providing for an expansion of the piston from the production size thereof during the relative movements of the piston from said second longitudinal position to said first longitudinal position, the piston means comprising an enclosed space communicating with the deformable container (envelope), wherein the enclosed space can have a constant volume.

A piston chamber combination wherein the chamber can comprise cross-sections with and without a constant circumferential length.

A piston-chamber combination additionally comprising a sensor reader combination, wherein the piston rod can comprising an enclosed measuring space.

A pump for pumping a fluid wherein the pump can comprising:

- a combination according to earlier described preferred embodiments,
- means for engaging the piston from a position outside the chamber,
- a fluid entrance can be connected to the chamber and comprising a valve means, and
- a fluid exit can be connected to the chamber.

A pump wherein the engaging means can have an outer position where the piston is at the first longitudinal position of the chamber, and an inner position where the piston is at the second longitudinal position of the chamber.

A pump wherein the engaging means can have an outer position where the piston is at the second longitudinal position of the chamber, and an inner position where the piston is at the first longitudinal position of the chamber.

A shock absorber can comprising:

- a combination according to earlier described preferred embodiments,
- means for engaging the piston from a position outside the chamber, wherein the

engaging means can have an outer position where the piston is at the first longitudinal position of the chamber, and an inner position where the piston is at the second longitudinal position.

5 A shock absorber wherein further can comprising a fluid entrance connected to the chamber and comprising a valve means.

A shock absorber further comprising a fluid exit which can be connected to the chamber and comprising a valve means.

10 A shock absorber wherein the chamber and the piston form an at least substantially sealed cavity can comprising a fluid, the fluid can be compressed when the piston moves from the first to the second longitudinal positions of the chamber.

A shock absorber further comprising means for biasing the piston toward the first longitudinal position of the chamber.

An actuator comprising:

- a combination according to any of the earlier described preferred embodiments,
- 15 - means for engaging the piston from a position outside the chamber,
- means for introducing fluid into the chamber in order to displace the piston between the first and the second longitudinal positions of the chamber.

An actuator further comprising a fluid entrance which can be connected to the chamber and can comprising a valve means.

20 An actuator which further can comprising a fluid exit connected to the chamber and can comprising a valve means.

An actuator which further can comprising means for biasing the piston toward the first or second longitudinal position of the chamber.

25 An actuator wherein the introducing means can comprising means for introducing pressurised fluid into the chamber.

An actuator wherein the introducing means can be adapted to introduce a combustible fluid, such as gasoline or diesel, into the chamber, and wherein the actuator further comprises means for combusting the combustible fluid.

30 An actuator wherein the introducing means can be adapted to introduce compressed fluid, such as air, into the chamber.

An actuator further comprising a crank adapted to translate the translation of the piston into a rotation of the crank.

Claims

1. A Piston-chamber combination in which the piston (73) can move in the chamber (72), forms a boundary of a measuring space (19,38,50,78,79,111,130) containing a fluid on one side of the piston (73) and is provided with a piston rod (1,31,40,74,103,123) extending on the other side, the piston-chamber combination being provided with a sensor-reader combination with a sensor (15) for measuring a parameter of the measuring space 19,38,50,78,79,111,130) the reader (3,33,41,122) for displaying the value of the parameter is positioned outside the chamber (72) and that the piston rod (1,31,40,74,103,123) contains a channel (47,52,53) which is used to provide communication of the value of the parameter between the measuring space (19,38,50,78,79,111,130) and the reader (3,33,41,122), the sensor measures inside an enclosed measuring space (14,47,52,53) which has a connection with the measuring space (19,38,50,78,79,111, 130), the connection being provided with a check valve (49) which opens in case the pressure in the measuring space (19,38,50,78,79,111,130) is higher than the pressure in the enclosed measuring space (14,47,52,53,90),
- characterized by the fact that**
- the enclosed measuring space (14,47,52,53,90) is additionally connected to the measuring space (19,38,50,78,79,91,111,130), the connection being provided with a valve (94,95,98), said valve is moving solely by the forces on said valve (94,95,98), opening and closing said connection.
2. A piston-chamber combination according to claim 1, **characterized by the act that** said valve (94,95,98) is comprising a piston rod with a piston (94) closest to the enclosed measuring space (14,47,52,53,90) and a piston (95) closest to the measuring space (19,38,50,78,79,91,111,130), said piston rod is moving between a position where the pistons (94,95) are in sealing contact with the housing (224,228), and a position where said pistons (94,95) are not in contact with said housing.
3. A piston-chamber combination according to claim 2, **characterized by the fact that** the diameter of the piston (94) closest to the enclosed space (90) is smaller than the diameter of the piston (95) which is closest to the measuring space (91).

4. A piston-chamber combination according to claim 2 or 3, **characterized by the fact that** the piston rod (98) has a special fit with the adjacent bearing (232) of said housing (224,28), which is slowing down the movement of the piston rod (98) in the bearing (232)
- 5 5. A piston-chamber combination according to claim 4, **characterized by the fact that** the fit is a sliding fit.
6. A piston-chamber combination according to claim 2 , **characterized by the fact that** the piston rod (98) is comprising a duct (221), enabling communication between the
10 enclosed measuring space (90) and the measuring space (91).
7. A piston-chamber combination according to claim 6 , **characterized by the fact that** said duct (221) is enabling communication between both pistons (94,95).
- 15 8. A piston-chamber combination according to claim 7, **characterized by the fact that** said communication is continuous, and independent of the position of the piston rod (223) in the housing.
9. A piston-chamber combination according to claim 7, **characterized by the fact**
20 **that** said communication is non-continuous, and depends on the position of the piston rod,
- opened when the pistons (94,95) are not sealingly connected to the housing,
- not opened when a piston (94,95) are sealingly connected to the housing.
10. A piston-chamber combination according to claim 1, **characterized by the fact**
25 **that** the communication is effected by means of an electric signal or by means of the fluid present in the measuring space (19,38,50,78,79,111,130).
11. A Piston-chamber combination according to claims 1-10, **characterized in that** the piston-chamber combination is part of a pump.
- 30 12 A Piston-chamber combination according to claim 11, **characterized in that** the pump is a pump for inflating a tyre.

13. A Piston-chamber combination according to any of the previous claims, **characterized in that** the parameter is pressure.

5 14. A Piston-chamber combination according to claims 1-12, **characterized in that** the parameter is temperature.

15. A Piston-chamber combination according to any of the previous claims, **characterized in that** the sensor (15) is located on or in the piston (73) or piston rod (1,31,40,74,103,123).

10 16. A Piston-chamber combination according to any of the previous claims, **characterized in that** the piston rod (1, 31,40,74,103,123) is formed by a hollow tube connected to the measuring space (19,38,50,78,79,111,130) and that the sensor (15) is located in the hollow tube or at an extremity thereof.

15 17. A Piston-chamber combination according to any of the claims 1-16 , **characterized in that** the piston is an inflatable piston (73), the piston rod (1,31,40,74,103,123) is a hollow tube, the space (42) inside the piston rod (1,31,40,74,103,123) is in communication with the space inside the inflatable piston (73) and in that lengthwise inside the hollow piston rod (1,31,40,74,103,123) a second hollow tube (36) is provided through which the
20 communication takes place.

18. A Piston-chamber combination according to claim 17 , **characterized in that** the measuring space (78) is provided with a fluid inlet provided with a check valve (75).

25 19. A Piston-chamber combination according to any of the claims 1-16, **characterized in that** the piston is a non-inflatable piston (73), the piston rod (1,31,40,74,103,123) is a hollow tube, the space (42) inside the piston rod (1,31,40,74,103,123) is in communication with the atmosphere through an inlet (198) in the housing (183) of the reader, and through a check valve (250) with the measuring space ((19,38,50,78,79,111,130) and in that
30 lengthwise inside the hollow piston rod (1,31,40,74,103,123) a second hollow tube (36) is provided through which the communication takes place.

20. A Piston-chamber combination according to any of the previous claims, **characterized**

in that the measuring space (78) is provided with a fluid outlet provided with a check valve (76).

21. A Piston-chamber combination according to any of the previous claims, **characterized**
5 in that the reader (3,33,41,122) is placed at or near an extremity of the piston rod (1,31,40,103,123).

22. A Piston-chamber combination according to any of the previous claims **characterized in**
that the piston-chamber combination is provided with a handle (2) at the extremity of the
10 piston rod (1,31,40,103,123) not connected to the piston (73), and that the reader ((3,33,41,122)) is built into said handle (2) or connected to it.

23. . A Piston-chamber combination in which the piston (73) can move in the chamber (72),
forms a boundary of a measuring space (19,38,50,78,79,111,130) containing a fluid on one
15 side of the piston (73) and is provided with a piston rod (1,31,40,74,103,123,155)
extending on the other side, the piston-chamber combination being provided with a sensor-
reader combination with a sensor (15) for measuring a parameter of the measuring space
19,38,50, 78,79,111,130) the reader (152) for displaying the value of the parameter is
positioned outside the chamber (150) and that the piston rod (1,31,40,74,103,123,155)
20 contains a channel (47,52,53) which is used to provide communication of the value of the
parameter between the measuring space (19,38,50,78,79,111,130) and the reader (152),
the sensor measures inside an enclosed measuring space (14,47,52,53) which has a
connection with the measuring space (19,38,50,78,79,111, 130), the connection being
provided with a check valve (49) which opens in case the pressure in the measuring space
25 (19,38,50,78,79,111,130) is higher than the pressure in the enclosed measuring space
(14,47,52,53,90),

characterized by the fact that

the enclosed measuring space (14,47,52,53,90) is additionally connected to the measuring
space (19,38,50,78,79,91,111,130), the connection being provided with a valve, said valve
30 is controlled by a computer, opening and closing said connection, on the basis of the input
to the computer by a sensor (154,155).

24. A Piston-chamber combination according to claim 23, **characterized by the fact that**

the computer is monitoring the position of the piston rod (1,31,40,74,103,123,155) in relation to the top of the chamber.

25. A Piston-chamber combination according to claim 23, **characterized by the fact that**

5 the computer is monitoring the velocity of the piston rod (1,31,40,74,103,123,155) in relation to the top of the chamber.

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