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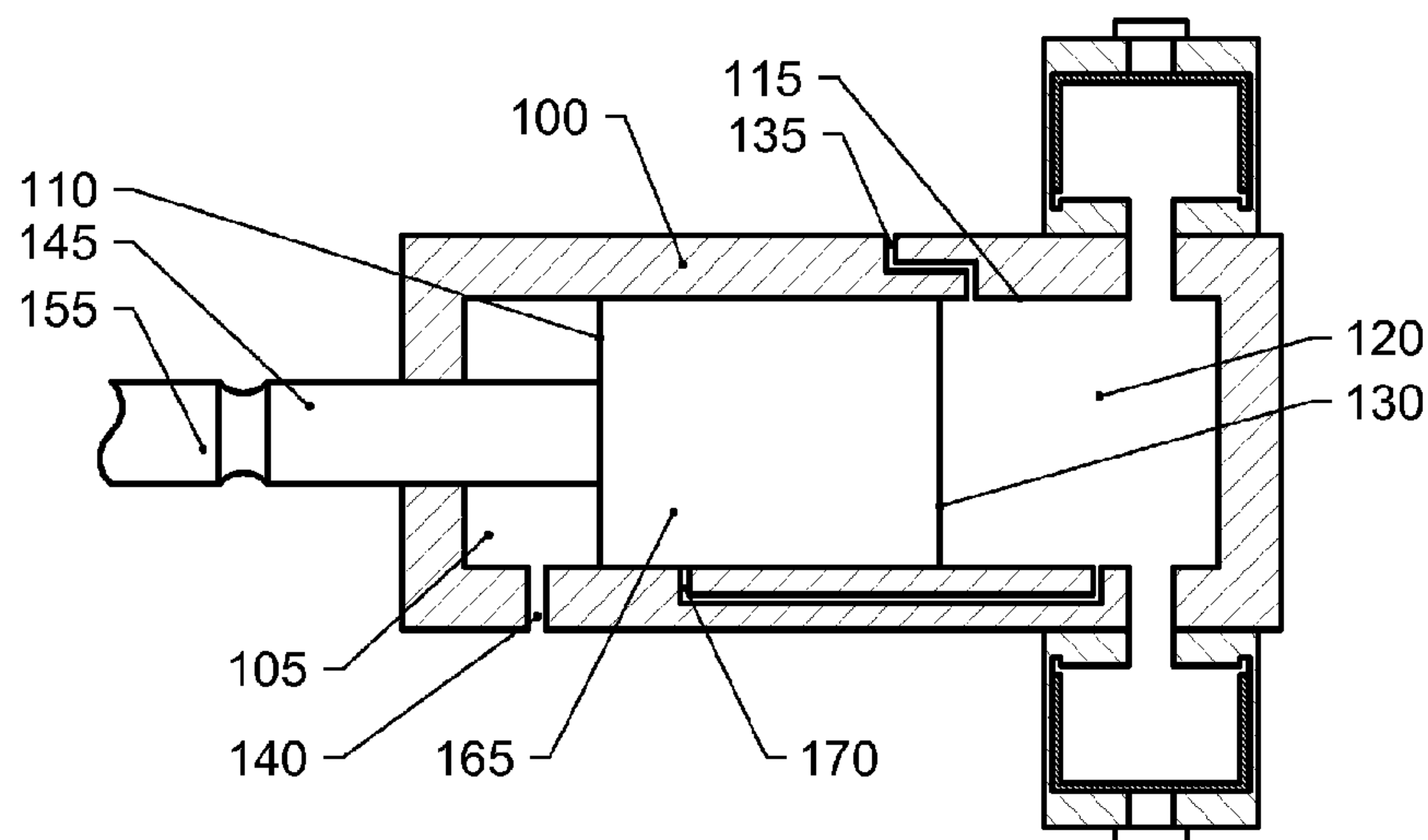
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(54) Title: HYDRAULIC IMPACT MECHANISM FOR USE IN EQUIPMENT FOR TREATING ROCK AND CONCRETE



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A hydraulic impact mechanism, of the valveless impact mechanism type, comprising a pre-charged gas accumulator connected to a working chamber in order to make possible impact mechanisms for equipment for rock drilling and hydraulic breakers that is lighter, cheaper and more sustainable from the point of view of material fatigue. Furthermore, a gas accumulator of piston type with an integral brake chamber (240, 250, 360) and a piston (220, 320) designed to fit into the said brake chamber (240, 250, 360).



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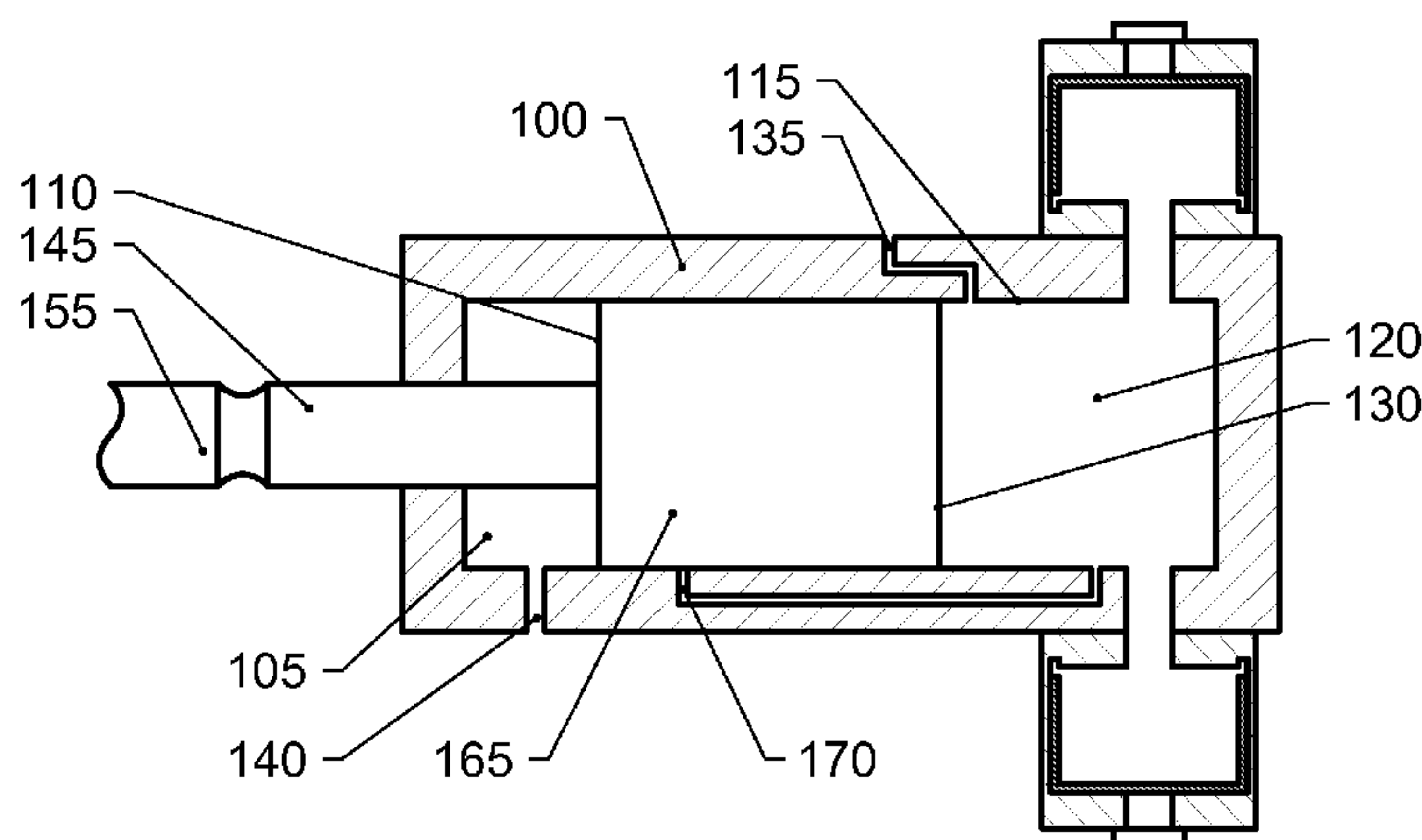
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Fig 1



(57) Abstract: A hydraulic impact mechanism, of the valveless impact mechanism type, comprising a pre-charged gas accumulator connected to a working chamber in order to make possible impact mechanisms for equipment for rock drilling and hydraulic breakers that is lighter, cheaper and more sustainable from the point of view of material fatigue. Furthermore, a gas accumulator of piston type with an integral brake chamber (240, 250, 360) and a piston (220, 320) designed to fit into the said brake chamber (240, 250, 360).

**Hydraulic impact mechanism for use in equipment for treating rock
and concrete**

Technical area

The present invention relates to a hydraulic impact mechanism of
5 the type known as 'gate valveless' or 'valveless', to be used in
the equipment for treating rock and concrete, and to drilling and
hammering equipment that comprises such impact mechanisms.

Furthermore, it relates to a gas accumulator and to components of
such an accumulator, for connection to a working chamber in a
10 valveless hydraulic impact mechanism.

Background

Percussion, rotation, and percussion with simultaneous rotation
variants of equipment for the treatment of rock and concrete are
available. It is well known that the impact mechanism in such
15 equipment is driven hydraulically. A hammer piston, mounted such
that it can move in a cylinder bore in a machine housing, is then
exposed to alternating pressure such that a reciprocating motion of
the hammer piston in the cylinder bore is achieved. The alternating
pressure is most often obtained through a separate switch-over
20 valve, normally of gated type and controlled by the position of the
hammer piston in the cylinder bore, couples alternately to at least
one of two drive chambers, formed between the hammer piston and the
cylinder bore, to a line in the machine housing with driving fluid,
normally hydraulic fluid, under pressure, and subsequently to a
25 drainage line for driving fluid in the machine housing. A
periodically alternating pressure arises in this manner, with a

periodicity that corresponds to the impact frequency of the impact mechanism.

The manufacture of gate valveless impact mechanisms, also known as valveless mechanisms, has also been known for more than 30 years.

5 Instead of having a separate switch-over valve, the hammer piston in valveless impact mechanisms is caused to perform also the work of the switch-over valve through its opening and closing for the supply and drainage of driving fluid under pressure during its motion in the cylinder bore in a manner that provides an alternating pressure
10 as described above, in at least one of two drive chambers separated by a drive part of the hammer piston. One condition required for this to work is that channels, arranged in the machine housing for the pressurisation and drainage of a chamber, open out into the cylinder bore such that the openings are separated in such a manner
15 that short-circuiting connection does not arise directly between supply channel and drainage channel at any position of the reciprocating motion of the piston. The connection between the supply channel and the drainage channel is normally present solely through the gap seal that is formed between the drive part and the
20 cylinder bore. If this were not the case, large losses would arise, since driving fluid would be allowed to pass directly from high-pressure pump to tank without any useful work being carried out.

In order for it to be possible for the piston to continue its motion from the moment at which a channel for the drainage of a drive
25 chamber is closed until a channel for pressurisation of the same drive chamber is opened, it is necessary that the pressure in the drive chamber is changed slowly as a consequence of a change in

volume. This can take place through the volume of at least one drive chamber being made large relative to what is normal for traditional impact mechanisms of gate valve type. It is necessary that the volume be large since the hydraulic fluid that is normally used has
5 a low compressibility. We then define the compressibility, κ , as the ratio between the relative change in volume and the change in pressure, as follows: $\kappa = (dV/V)/dP$. It is, however, more usual to use the modulus of compressibility, β , which is the inverse of the compressibility as we have defined it above, as a measure of
10 compressibility. Thus $\beta = dP/(dV/V)$. The units of measurement of the modulus of compressibility are Pascal.

The volume is to be sufficiently large that the pressure in the chamber during the change in volume that the chamber experiences during the motion of the hammer piston towards the opening of the
15 channel for pressurisation of the chamber will not be sufficiently large to reverse the motion of the piston before the channel has opened.

A valveless hydraulic impact mechanism with two drive chambers is known through US 4,282,937, where the pressure alternates in both of
20 these chambers. Both drive chambers have large effective volumes through them being in continuous connection with volumes lying close to the cylinder bore.

A valveless hydraulic impact mechanism according to another principle is known through SU 1068591 A, namely with alternating
25 pressure in the upper drive chamber and constant pressure in the lower, which is the drive chamber that lies most closely to the connection for the tool. In this case, the upper drive chamber,

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which is the one in which the pressure alternates, has a considerably larger volume than the lower drive chamber, in which the pressure is constant.

One problem with large drive chambers in which the pressure
5 continuously alternates between system pressure and return pressure, i.e. approximately atmospheric pressure, is that the machine housing itself tends to suffer from the formation of cracks as a consequence of material fatigue. In order to avoid this, designs that have thick and complex castings with
10 intermediate walls have until now been required, with a high cost and weight that follow from this.

SU 1068591 reveals not only an alternative embodiment consisting of constant pressure in the lower drive chamber and alternating pressure in the upper. In addition to this, two
15 accumulators are introduced directly connected to the drive chamber with alternating pressure. The intention of this is to improve the efficiency. The problem concerning the formation of cracks in the machine housing due to material fatigue is not mentioned at all. Further, it is obvious that the membrane
20 accumulators that are described in SU 1068591 must have very limited lifetime, since the membrane will reach the bottom of the accumulators with the impact frequency. This does not constitute a design that can be used in practice.

Summary

25 Some embodiments of the present invention may provide for a design of valveless hydraulic impact mechanisms that provides

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the possibility of counteracting the problem described above, and to make possible lighter and at the same time more robust designs with respect to the formation of cracks in the machine housing itself.

- 5 It has proved to be so that a gas accumulator connected directly to a working chamber in a hydraulic impact mechanism for rock drilling or in a hydraulic breaker for demolition has a significant positive influence with respect to the risk of material fatigue and the subsequent risk of the formation of
- 10 cracks in the casing. The invention constitutes a solution of this type. In order for the gas accumulator to withstand the extremely severe conditions with pulsations of pressure between system pressure, for example 250 bar, and return pressure, for example 5 bar, and with frequencies of magnitude up to 150 Hz,
- 15 it is necessary that the elastic membrane be replaced by a solid body such as a piston mounted with reciprocating motion in a cylinder bore inside a gas accumulator.

- It is furthermore advantageous that the gas accumulator have means for braking the accumulator piston, at least before it
- 20 reaches one of its turning points. Such a means may be a brake chamber, in which the accumulator piston is allowed to run with high-precision tolerance, such as less than 0.1 mm, preferably 0.05 mm.

- Some embodiments of the invention provide a solution that may
- 25 be applied not only to impact mechanisms that have alternating pressure on only one side, but also with such that have

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alternating pressures on both sides. A gas accumulator is connected to each of the drive chambers in the latter case.

One preferred embodiment, however, constitutes an impact mechanism working with constant pressure in one chamber,
5 normally achieved through the chamber being connected during the complete stroke cycle, or at least during essentially the complete stroke cycle, to a source of constant pressure, most often directly to the source of the system pressure or the impact mechanism pressure.

- 10 Impact mechanisms of the type that is described above may be part of an integrated part of equipment for treating rock and concrete, such as rock drills and hydraulic breakers. These machines and breakers should most often be mounted during operation on a carrier that may comprise one or more of the
15 following means: means for alignment, means of positioning, and means for feeding the drill or breaker against the treated rock or concrete elements, and further, means for guiding and monitoring the treatment process. Further, means for the propulsion and guidance of the carrier itself are comprised.
20 Such a carrier may be a rock drill rig.

According to one embodiment of the present invention, there is provided a hydraulic impact mechanism for use in equipment for the treatment of rock and/or concrete comprising a machine housing with a first cylinder bore, a piston that is mounted
25 such that the piston can be displaced in the first cylinder bore such that the piston repeatedly executes a reciprocating motion relative to the machine housing during operation and in

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this way exerts impact either directly or indirectly onto a tool for the treatment of rock or concrete and that can be connected to the equipment, and where the piston includes a drive part that separates a first drive chamber and a second drive chamber formed between the piston and the machine housing and where these drive chambers are arranged such that they contain a driving medium under pressure during operation, and where furthermore the machine housing includes channels that open out into the first cylinder bore and are arranged to contain driving medium during operation and to, with the aid of the piston during its motion in the first cylinder bore, open and close into at least the second drive chamber such that at least this second drive chamber acquires periodically alternating pressure for the maintenance of the reciprocating piston motion, and that positions for the openings of the channel are axially adapted in the first cylinder bore and extent of the opening and closing of the piston parts in order to hold this second drive chamber closed for the supply or drainage of driving medium that is present in the chamber along a distance between the opening of a first channel in association with a first turning point of the piston and the opening of a second channel in association with a second turning point for the piston and that the motion of the piston along this distance takes place during compression or expansion of the volume of this drive chamber, where the magnitude of this volume has furthermore been adapted in order to obtain a slow change of pressure along the said distance, such that the hydraulic impact mechanism in this way constitutes what is

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known as a valveless hydraulic impact mechanism, wherein the said second drive chamber is designed such that the second drive chamber comprises a gas accumulator during operation, the said gas accumulator comprising a second cylinder bore with an
5 accumulator piston mounted such that the accumulator piston can be displaced in the second cylinder bore, where the said accumulator piston separates the driving medium in the second drive chamber from a gas under pressure contained in a closed compartment of the gas accumulator, and where the volume of the
10 said compartment varies with the frequency of the impact mechanism during operation as a consequence of the reciprocating motion of the accumulator piston in the second cylinder bore.

According to another embodiment of the present invention, there
15 is provided a rock drill comprising the hydraulic impact mechanism as described herein.

According to still another embodiment of the present invention, there is provided a hydraulic breaker comprising the impact mechanism as described herein.

20 According to yet another embodiment of the present invention, there is provided a carrier comprising a rock drill as described herein or a hydraulic breaker as described herein, further comprising one or several of the following means: means for alignment, means of positioning, and means for feeding the
25 drill or hydraulic breaker against the treated rock or concrete elements.

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According to a further embodiment of the present invention, there is provided a rock drill rig comprising the rock drill as described herein.

- According to yet a further embodiment of the present invention,
- 5 there is provided a gas accumulator housing for connection to a working chamber in a hydraulic impact mechanism as described herein, containing during operation a driving medium under pressure, whose pressure continuously pulsates between system pressure and return pressure, the said gas accumulator housing
- 10 comprising a cylinder bore for the mounting of an accumulator piston for reciprocating motion in the said cylinder bore, further comprising a brake chamber for the reception of the accumulator piston leading to braking of the accumulator piston before one of the turning points of the accumulator piston.
- 15 According to still a further embodiment of the present invention, there is provided an accumulator piston intended to be mounted in a gas accumulator housing as described herein, the accumulator piston comprising a part for penetration into the said brake chamber with a gap of magnitude less
- 20 than 0.1 mm.

According to another embodiment of the present invention, there is provided a gas accumulator comprising the gas accumulator housing as described herein and the accumulator piston as described herein.

25 **Brief description of the drawings**

FIGURE 1 shows a sketch of the principle of a hydraulic impact mechanism with alternating pressure in the chamber at the right.

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FIGURE 2 shows a gas accumulator of piston type with brake chambers at the two turning points of the accumulator piston.

FIGURE 3 shows a gas accumulator of piston type with brake chambers at the turning point of the accumulator piston on the
5 hydraulic side.

Detailed description of preferred embodiments

A number of designs of the invention are described below as

examples, with reference to the attached drawings. The protective scope of the invention is not to be considered to be limited to these embodiments: it is defined by the claims.

Figure 1 shows schematically a hydraulic impact mechanism with
5 alternating pressure on the upper side of the piston and constant pressure on its lower side, i.e. the side that is facing towards the connected tool. The first drive chamber 105 is connected to system pressure, for example 250 bar, through pressure channel 140. As Figure 1 has been drawn, the second
10 chamber 120 at the moment depicted in the drawing is connected to return pressure through the return channel 135. The force that acts upon the drive surface 110 will, in this way, drive the hammer piston to the right. This leads to the channel 135 being closed and a pressure starting to build up in the
15 chamber 120. Since the pressure is built up slowly, the piston will reach sufficiently far for the connection channel 170 to open the connection between the drive chambers 1 and 2, and the system pressure becomes prevalent in the second chamber 120. Since the drive surface 130 is greater than the drive
20 surface 110, the hammer piston will now be driven to the left. The connection channel 170 is in this way first closed, and the return channel is later opened, and the pressure in the second chamber 120 falls. A new cycle thus commences with the piston again being driven to the right by the system pressure
25 acting on the drive surface 110.

It is not now necessary that the drive chambers be large, since the compressibility arises from both of the pre-charged

gas accumulators. The dimensions of the chamber 120 are set based on space requirements for the channels and the connections to the gas accumulators. A volume that would be several litres without the gas accumulators will now become as
5 small as approximately 1 decilitre.

A working machine may have the following essential dimensions:

The diameter of the hammer piston at the drive part: 44 mm.
Diameter of the piston rod: 36 mm. Length of the drive part: 100 mm. Distance from the right edge of the return channel 135
10 at the opening in the cylinder bore to the corresponding left edge of the left opening of the connection channel 170: 93 mm.
Weight of piston: 4.5 kg. System pressure: 230 bar. And finally, the total volume of each of the accumulators: 90 cubic centimetres, with a pre-charging pressure of 190×10^5 Pa
15 for one accumulator and 15×10^5 Pa for the second.

If only one accumulator is used, the volume will be 74 cm^3 .

Pre-charging of the gas pressure of the accumulators takes place through the connection 230, 330. The connection to the hydraulic fluid in the working chamber takes place through
20 290, 390.

It is advantageous to have grooves 260, 360 for seals 370 formed in the cylinder bore 210, 310 of the accumulators.

It is advantageous to introduce a drainage channel 280, 380 between the seals in order to avoid the mixing of gas and oil.

25 Brake chambers 240, 250, 340 are designed in the accumulator

housing. The accumulator piston 220, 320 is received in these brake chambers in such a manner that the speed is reduced before the change of direction. This increases considerably the lifetime of the accumulator piston.

- 5 From the point of view of efficiency it is advantageous to have double accumulators connected, as described above. One is a high-pressure accumulator with a pre-charging pressure that is less than the system pressure, and the other is a low-pressure accumulator with a pre-charging pressure that is
- 10 greater than the return pressure, but much less than the system pressure.

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CLAIMS:

1. A hydraulic impact mechanism for use in equipment for the treatment of rock and/or concrete comprising a machine housing with a first cylinder bore, a piston that is mounted
5 such that the piston can be displaced in the first cylinder bore such that the piston repeatedly executes a reciprocating motion relative to the machine housing during operation and in this way exerts impact either directly or indirectly onto a tool for the treatment of rock or concrete and that can be
10 connected to the equipment, and where the piston includes a drive part that separates a first drive chamber and a second drive chamber formed between the piston and the machine housing and where these drive chambers are arranged such that they contain a driving medium under pressure during operation, and
15 where furthermore the machine housing includes channels that open out into the first cylinder bore and are arranged to contain driving medium during operation and to, with the aid of the piston during its motion in the first cylinder bore, open and close into at least the second drive chamber such that at
20 least this second drive chamber acquires periodically alternating pressure for the maintenance of the reciprocating piston motion, and that positions for the openings of the channel are axially adapted in the first cylinder bore and extent of the opening and closing of the piston parts in order
25 to hold this second drive chamber closed for the supply or drainage of driving medium that is present in the chamber along a distance between the opening of a first channel in association with a first turning point of the piston and the

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opening of a second channel in association with a second turning point for the piston and that the motion of the piston along this distance takes place during compression or expansion of the volume of this drive chamber, where the magnitude of this volume has furthermore been adapted in order to obtain a slow change of pressure along the said distance, such that the hydraulic impact mechanism in this way constitutes what is known as a valveless hydraulic impact mechanism, wherein the said second drive chamber is designed such that the second drive chamber comprises a gas accumulator during operation, the said gas accumulator comprising a second cylinder bore with an accumulator piston mounted such that the accumulator piston can be displaced in the second cylinder bore, where the said accumulator piston separates the driving medium in the second drive chamber from a gas under pressure contained in a closed compartment of the gas accumulator, and where the volume of the said compartment varies with the frequency of the impact mechanism during operation as a consequence of the reciprocating motion of the accumulator piston in the second cylinder bore.

2. The hydraulic impact mechanism according to claim 1, where the gas accumulator is designed with a brake chamber in order to accelerate the braking of the accumulator piston before the turning point of the accumulator piston.

25 3. The hydraulic impact mechanism according to claim 2, where the accumulator piston and the brake chambers are designed such that, when the accumulator piston enters a brake chamber, a gap of width less than 0.5 mm arises between the accumulator piston and the brake chamber, this gap constituting

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a gap seal between the brake chamber and the second drive chamber.

4. The hydraulic impact mechanism according to any one of claims 1 to 3, comprising at least two sealing elements for
5 sealing between the accumulator piston and the second cylinder bore.
5. The hydraulic impact mechanism according to claim 4 where the second cylinder bore comprises at least two grooves for the mounting of the said sealing elements.
- 10 6. The hydraulic impact mechanism according to claim 4 or 5, where the gas accumulator comprises a channel that opens out into the second cylinder bore between the two sealing elements for drainage of driving medium to a tank for driving medium.
- 15 7. A rock drill comprising the hydraulic impact mechanism according to any one of claims 1 to 6.
8. A hydraulic breaker comprising the impact mechanism according to any one of claims 1 to 6.
9. A carrier comprising the rock drill according to
20 claim 7 or the hydraulic breaker according to claim 8, further comprising one or several of the following means: means for alignment, means of positioning, and means for feeding the drill or hydraulic breaker against the treated rock or concrete elements.
- 25 10. A rock drill rig comprising the rock drill according to claim 7.

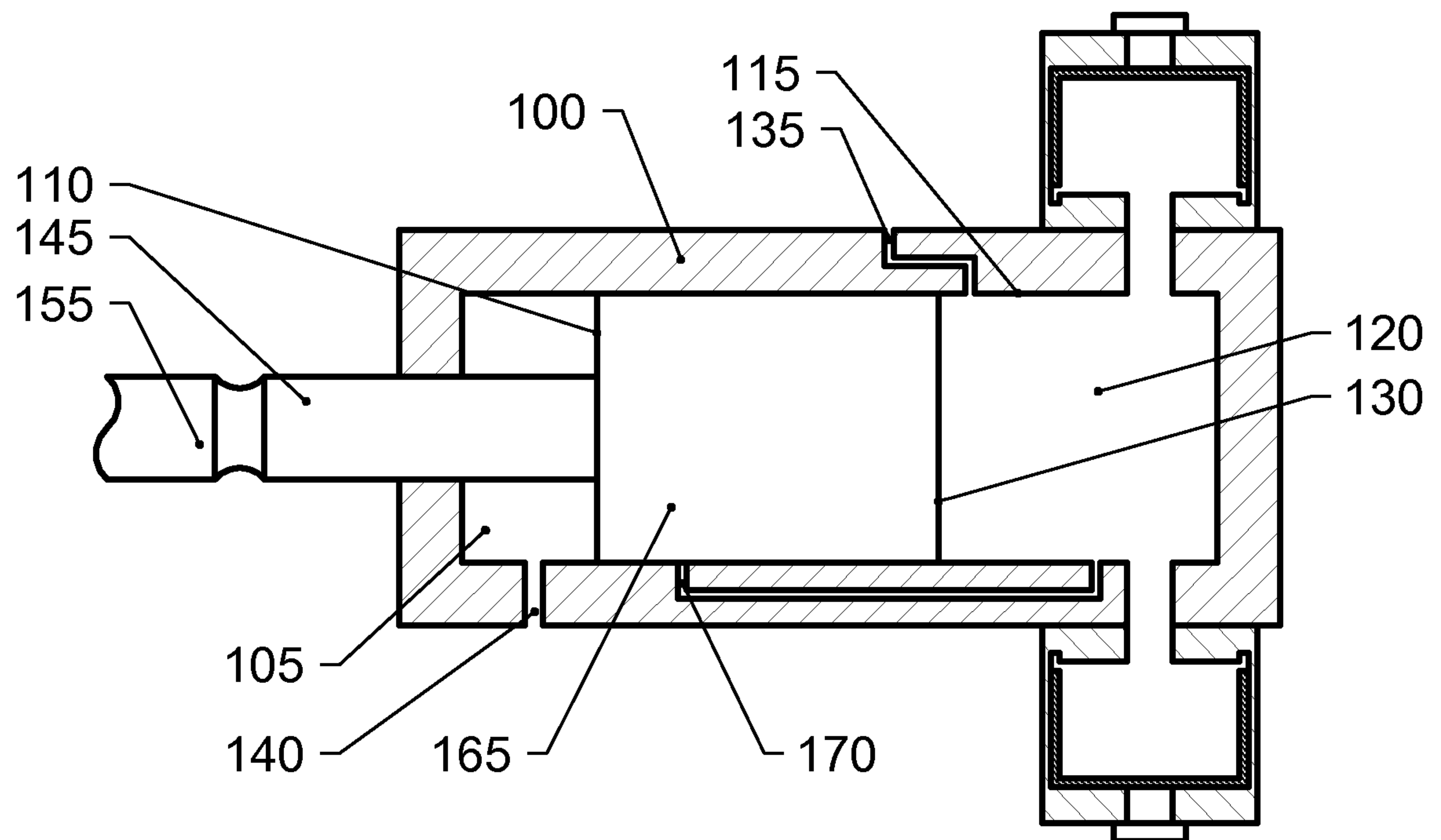
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11. A gas accumulator housing for connection to a working chamber in a hydraulic impact mechanism according to claim 1, containing during operation a driving medium under pressure, whose pressure continuously pulsates between system pressure and return pressure, the said gas accumulator housing comprising a cylinder bore for the mounting of an accumulator piston for reciprocating motion in the said cylinder bore, further comprising a brake chamber for the reception of the accumulator piston leading to braking of the accumulator piston before one of the turning points of the accumulator piston.
12. An accumulator piston intended to be mounted in a gas accumulator housing according to claim 11, the accumulator piston comprising a part for penetration into the said brake chamber with a gap of magnitude less than 0.1 mm.
13. A gas accumulator comprising the gas accumulator housing according to claim 11 and the accumulator piston according to claim 12.

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Fig 1



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Fig 2

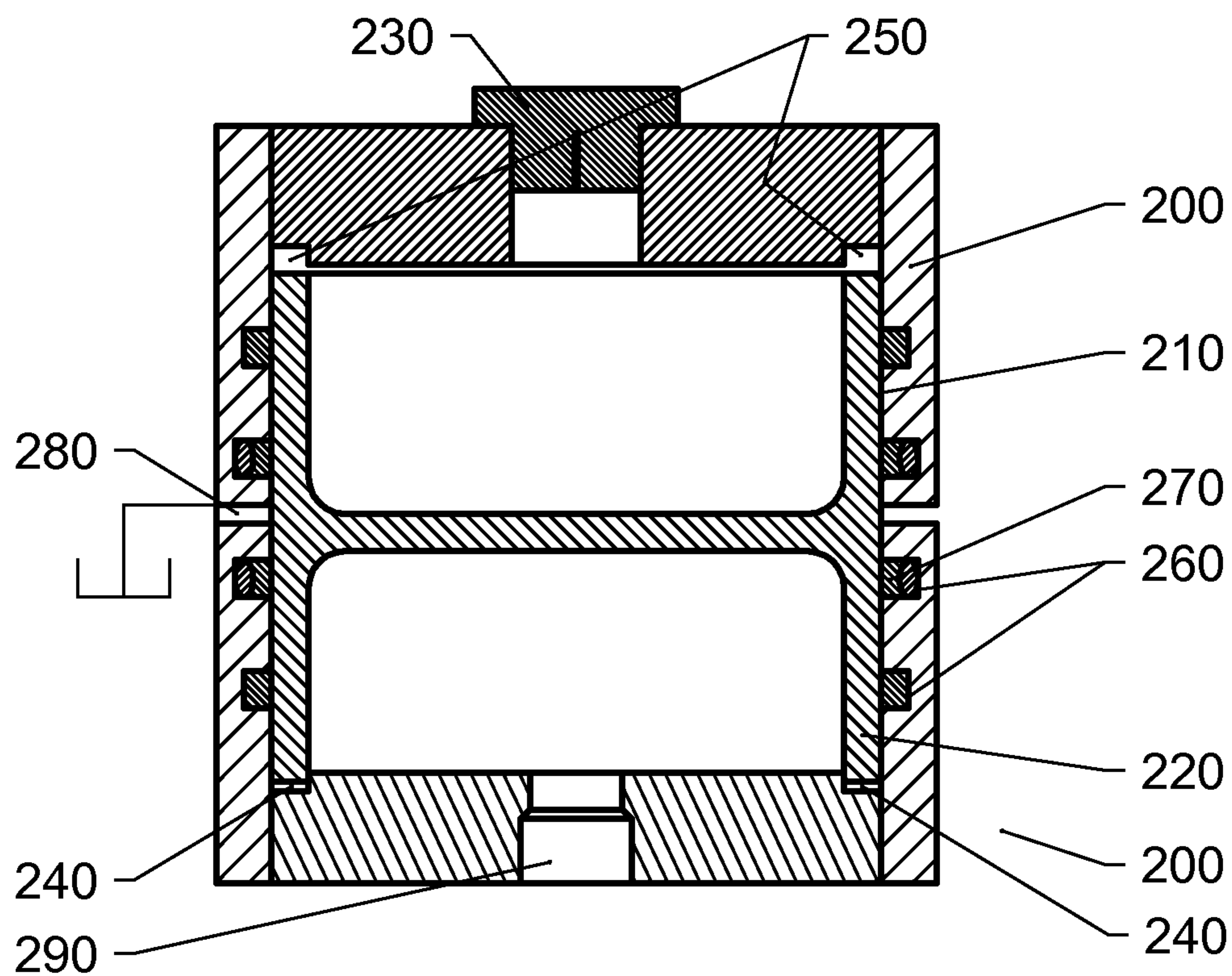


Fig 3

