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(71) Applicant: **Burnside Autocyl (Tullow) Limited**
County Carlow (IE)

(72) Inventor: **BYRNE, Patrick**
County Carlow (IE)

(74) Representative: **Weldon O'Brien Ltd.**
Shannon Lodge
Casement Road
Bandon
County Cork, P72 TN24 (IE)

(54) PISTON TRAVEL MONITORING IN HYDRAULIC RAM CYLINDERS

(57) A high-pressure hydraulic fluid ram (1) has a piston (4) mounted in a cylinder (2), and an electromagnetic wave sensor (10) mounted to detect movement of the piston in its travel within the cylinder. An electromagnetic wave barrier (30) of electrically conductive material is mounted to the piston around its circumference in a groove (33) to prevent passage of electromagnetic waves past the piston. It is alongside a pair of spaced-apart guide rings (20) and a high-pressure resilient seal (21). By blocking passage of electromagnetic waves past the piston accuracy of measurement is considerably improved without affecting normal dynamic interaction of the piston and the cylinder.

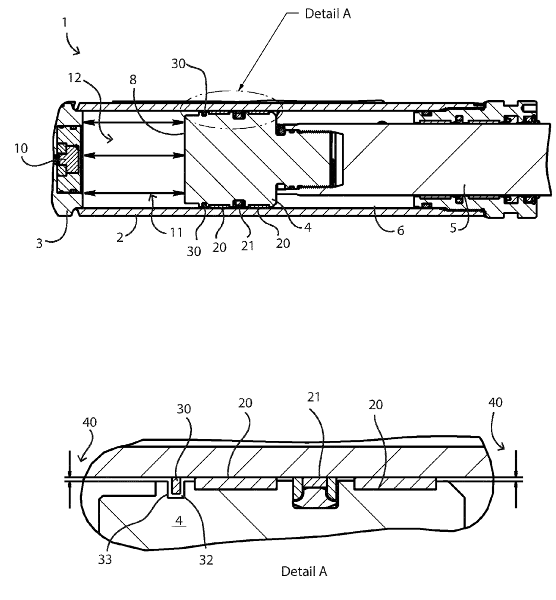

Fig.1

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Description

Introduction

[0001] The invention relates to monitoring of travel of a piston in a cylinder of a hydraulic ram.

[0002] It is known to use radiation-emitting sensors for monitoring piston travel, especially for high precision and/or high-pressure applications. For example, electromagnetic waves are suitable for measuring the linear stroke of a piston. The linear measurement of stroke can be determined within a hydraulic cylinder by sending an electromagnetic signal from an antenna/receiver that is mounted either on the full-bore side of the cylinder to reflect off the piston face or on the annular side of the cylinder to reflect off the rear of the piston. Electromagnetic waves are chosen which have high penetration abilities through many non-metallic or non-conductive substances such as hydraulic oil.

[0003] Examples of such an arrangement are described in US8362788 and US10,436,889 (Astyx).

[0004] Utilisation of the higher frequency ranges brings significant advantages in regard to signal quality and possible information generation. However, the higher the frequency the more severe the penetration past the piston becomes.

[0005] The invention is directed towards achieving more accurate piston position measurement.

Summary of the Invention

[0006] We describe a fluid ram having a piston mounted in a cylinder, an electromagnetic wave sensor mounted to detect movement of the piston in its travel within the cylinder, characterized in that, the piston comprises an electromagnetic wave barrier of electrically conductive material mounted to the piston around at least part of its circumference to prevent passage of electromagnetic waves past the piston. Preferably, the fluid is hydraulic oil.

[0007] Preferably, the barrier is of a material selected from aluminium, phosphor bronze, malleable cast iron, a metal alloy with impregnated graphite, and a conductive plastics material.

[0008] Preferably, the barrier is annular, extending fully or substantially fully around the piston, and the barrier has a natural position lightly pressing against the cylinder internal surface. Preferably, the barrier has at least one circumferential gap. Preferably, the barrier gap is at a taper angle to longitudinal, for example about 45°.

[0009] Preferably, the barrier has only one gap. Preferably, the barrier is mounted in a circumferential groove around the piston. Preferably, the barrier has a natural size providing a radial gap between the barrier and the groove base. Preferably, the radial gap between the barrier and the groove base has a radial dimension in the range of 0.5mm and 1.0mm.

[0010] Preferably, the barrier is around the piston adjacent an end of the piston closest to the sensor. Preferably, the ram further comprises a seal around the piston at a location axially separate from the barrier, and a guide ring around the piston at a location axially separate from the barrier. Preferably, the piston comprises or supports, in order in the axial direction from the sensor, the barrier, a guide ring, a seal, and a guide ring.

[0011] Preferably, the barrier is shorter in the longitudinal dimension than the groove, so that it is mounted in the groove in a manner to allow a gap on both longitudinal sides of the barrier and radially inwardly of the barrier, and the relative dimensions of the barrier and the groove are such as to allow flow of pressurized fluid in the longitudinal direction through said gaps and past the barrier to a piston seal. Optionally the barrier is shorter than the groove in the longitudinal direction by a distance in the range of 0.5mm to 1.0mm.

[0012] We also describe a piston for mounting in a cylinder with an electromagnetic wave antenna sensor to detect movement of the piston in its travel within the cylinder, wherein the piston comprises an electromagnetic wave barrier of any example described herein mounted to the piston around at least part of its circumference to prevent passage of electromagnetic waves past the piston.

Additional Statements

[0013] We describe a fluid ram having a piston mounted in a cylinder, an electromagnetic wave antenna sensor mounted to detect movement of the piston in its travel within the cylinder, wherein the piston comprises an electromagnetic wave barrier mounted to the piston around at least part of its circumference to prevent passage of electromagnetic waves past the piston. The fluid is in one example hydraulic oil.

[0014] Preferably, the barrier is of an electrically conductive material, and preferably the barrier is of a material selected from aluminium, phosphor bronze, malleable cast iron, and a conductive plastics material. Preferably, the barrier is of aluminium. Preferably, the barrier is annular, extending fully or substantially fully around the piston.

[0015] Preferably, the barrier is mounted in a circumferential groove in the piston. Preferably, the barrier has a natural size providing a gap between the barrier and the groove base, allowing radial movement of the barrier within the groove. Preferably, the gap has a radial dimension in the range of 0.5mm and 1.0mm. Preferably, the barrier has a natural position lightly pressing against the cylinder internal surface. Preferably, the barrier is around the piston adjacent an end of the piston closest to the sensor.

[0016] Preferably, the ram further comprises a seal around the piston at a location axially separate from the barrier. Preferably, the ram further comprises a guide ring around the piston at a location axially separate from the barrier.

[0017] Preferably, the piston comprises, in order in the axial direction from the sensor, the barrier, a guide ring, a seal, and a guide ring. Preferably, the barrier is shorter in the longitudinal dimension than the groove, so that it is mounted in the groove in a manner to have a gap on one or both longitudinal sides of the barrier. Preferably, the relative dimensions of the barrier and the groove are such as to allow flow of pressurized fluid in the longitudinal direction past the barrier to a piston seal. Preferably, the barrier is shorter in the longitudinal direction to allow a gap on both longitudinal sides in the range of 0.5mm to 1.0mm.

[0018] We also describe a piston for mounting in a cylinder with an electromagnetic wave antenna sensor to detect movement of the piston in its travel within the cylinder, wherein the piston comprises an electromagnetic wave barrier mounted to the piston around at least part of its circumference to prevent passage of electromagnetic waves past the piston. The piston may have any or all of the piston features set out above.

Detailed Description of the Invention

[0019] The invention will be more clearly understood from the following description of some embodiments thereof, given by way of example only with reference to the accompanying drawings in which:

Fig. 1 is a cross-sectional view through the length of part of a hydraulic ram, showing the cylinder wall, piston, an electromagnetic sensor, and a radiation barrier around the piston;

Figs. 2(a), 2(b), and 2(c) are respectively a set of end, side, and perspective views of the barrier;

Fig. 3 is a view, together with an enlarged detail, similar to that of Fig. 1, of an arrangement in which the sensing is from the rear side of the piston; and

Figs. 4(a), 4(b), and 4(c) are a set of end, side, and perspective views of another electromagnetic wave barrier.

[0020] We describe various rams with a cylinder, an end cap, and a piston 4 on a piston rod. The ram has a sensor for very accurate measurement of longitudinal position of the piston face, the sensor having an electromagnetic wave transmitter and receiver in the end cap and facing the piston face. Accuracy of the measurements is excellent by ensuring that almost all radiation which is emitted is reflected back to the receiver. The radiation comprises HF electromagnetic waves. Excellent accuracy is achieved despite the fact that the piston wall does not touch the cylinder wall in operation. This gap avoids damage to the cylinder wall surface, avoids failure of the high-pressure seals between the piston and the cylinder, and allows for thermal expansion and contraction. These benefits are achieved, while also avoiding the potential problem of sensor electromagnetic waves bypassing the main reflective target (the piston), not completely dissipating behind it, and reflecting off other components.

[0021] This is achieved by the ram having a barrier between the piston and the cylinder wall, alongside pressure seals and guide rings. Advantageously the barrier does not affect operation of conventional components which extend around the piston, such as seals and guide rings/sleeves. Referring to Figs. 1 and 2 a ram 1 has a cylinder 2 and an end cap or head 3. A piston 4 is on a piston rod 5. This provides an annular space 6 around the rod 5 and behind the piston 4, and there is a space 12 in front of the piston face 8. A distance sensor is in this example an electromagnetic transceiver antenna 10 is mounted in the cylinder head 3, arranged to direct HF electromagnetic waves towards the piston 4 face 8. The antenna 10 comprises a metallic core, surrounded by an insulating plastics housing, and fitted with high pressure hydraulic seals. There is an annular electromagnetic wave barrier 30 around the piston 4, in the gap between the piston and the cylinder internal wall. In the example shown, the dimensions of the cylinder and the piston are 95mm bore cylinder with 70mm rod.

[0022] The antenna 10 emits HF electromagnetic waves in the direction of the piston 4, the waves are then reflected back in the opposite direction by the piston 4 and the barrier 30.

[0023] In more detail, the piston has front and rear guide rings 20 of type C10 phenolic resin size 95mm outer diameter x 89mm inner diameter x 20mm wide, which assist accurate travel on-axis. Between the guide rings 20 in the axial direction there is a high-pressure seal 21 of type Hallite 735™ (95mm outer diameter x 80mm inner diameter x 11mm wide).

[0024] The barrier 30 is mounted in an annular groove 33 around the piston 4. The barrier 30 is configured with an excess internal diameter so that a small gap 32 exists between the barrier's internal radially inwardly facing surface and the piston.

[0025] The seal 21 is a main pressure seal, which has the function of creating a hydraulic seal around the piston. It is of a material other than metal as it is in direct contact with the cylinder 2 inner surface and must not damage it and must not leak oil. The seal 21 may be of rubber, polyurethane, or PTFE for example as is known in the art.

[0026] In this example there are two guide rings 20, however in other examples there may be only one. The function of the guide rings is to ensure that the (metal) piston 4 does touch the inner surface of the cylinder 2. They resist all side loads that are induced into the piston 4 from external forces, under both low and high temperatures. The material of each guide ring 20 is such that it does not scratch or score the cylinder 2 surface, and they may for example be plastics or phenolic based materials, also as is known in the art.

[0027] The material of the barrier 30 is preferably a good electrical conductor. Examples are aluminium, phosphor bronze, malleable cast iron, a conductive plastics material, or a combination of any of these. Other suitable materials are Grey Cast Iron, also known as Flake Graphite Iron. In this example there is impregnated graphite to assist sliding with reduced friction against the cylinder bore. The impregnated graphite is considered to provide self-lubrication of the barrier. Aluminium is particularly preferred because of its mechanical and conductive properties. The configuration and material of the barrier is such that it will not damage the inner surface of the cylinder, and will substantially block electromagnetic waves without affecting operation of the high-pressure seal 21 and the guide rings 20. In this example the barrier 30 is of GD250/EN-GJL-250 to DIN EN 1561 (Grey cast Iron) material with a tensile strength of 250 to 350 N/mm2. In general, another preferred material is an iron alloy with impregnated graphite, one example being Flake Graphite Iron.

[0028] The enlarged detail in Fig. 1, Detail A, shows an annular gap 40 between the piston 4 and the inside surface of the cylinder 2. It is this gap which would allow the microwaves 11 to travel through the space 12 and past the piston 4, but instead they are blocked, or at least reduced to an acceptable level, by the barrier 30.

[0029] The barrier 30 is shown in more detail in Fig. 2. In this case the dimensions of the barrier 30 are 95mm diameter x 3mm wide x 4mm deep (radial dimension). The barrier is in the form of a ring which is not closed, having a circumferential gap 31 at a taper angle to longitudinal. The gap is in this example 1.5mm in width. The barrier 30 has a natural shape as illustrated with the gap 31 present. This outside diameter is very slightly larger than that of the cylinder bore, providing for a very small bias radially outwardly against the cylinder bore. If there are distortions arising from, for example, temperature changes, then the barrier 30 can contract slightly by closing the gap 31. It is even possible for the outside diameter to reduce very slightly beyond closing the gap, by sliding motion of the ends upon closing the gap 31. Due to the taper, these faces slide relative to each other to further reduce the outside diameter if required due to ram distortions. Another benefit of the taper direction of the gap is that there is always a barrier presented to electromagnetic waves in the axial direction.

[0030] The barrier 30 is mounted in the groove 33 such that it has its own built-in bias to remain with a diameter equal to or greater than the cylinder bore. However, the cylinder bore will vary in size due to tolerances, temperature change, and distortion among others. Therefore, the barrier 30 is able to change its outer diameter accordingly. There is a small available space 32 in the radial direction between the barrier 30 and the groove 33 to allow for this. Preferably the space is of radial dimension between 0.5mm and 1mm. This space 32 is very advantageous to allow the free movement of the barrier 30 to accommodate cylinder and piston expansion and contraction, but this feature does not allow the electromagnetic waves to pass, as they reflect off the piston 4 side walls.

[0031] Moreover, the gap 32 extends also in a preferred embodiment around one or both sides of the barrier in the longitudinal direction. This allows entry of pressurized fluid in a manner which does not allow localized build-up of pressure which might damage the barrier 30. It is most preferred to that the gap extend on both longitudinal sides, thereby allowing passage of pressurized fluid past the barrier and all of the way back to the high-pressure seal 21. This allows the seal to take the applied pressure, preventing damage to the barrier, and allowing it to perform its function of blocking electromagnetic waves. The pressurized fluid has a path to the high-pressure seal 21, but this path does not allow any significant passage of electromagnetic waves, due to the orthogonal faces of the groove 32 and the barrier 30. It is preferred that the gap on the longitudinal sides is in the range of 0.5mm and 1.0mm. For illustration purposes, the size of the gap 32 is exaggerated in Fig. 1.

[0032] Referring to Fig. 3 in another example a ram 100 has a cylinder 102, a piston 104, and a piston rod 105. Like parts are given the same reference numerals. A sensor 110 is mounted on the inner face of a gland 115, emitting electromagnetic waves towards the rear side of the piston in an annular space 106. The piston 104 has a pair of guide rings 20 and a high-pressure seal 21 similar to those of the ram 1. In this case, however, the annular barrier 30 is in a piston circumferential groove 33 around the rear end of the piston 104. In this position it performs the same function as the barrier 30 in the ram 1, and the gap 32 is present for the same purpose, in this case allowing passage of pressurized fluid to the left as viewed in this drawing.

[0033] In other examples the barrier is longer in the axial dimension, as shown in Fig. 4. In this example a barrier 200 has an axial length of 20mm, and two gaps 201 at 45°. The material of the barrier 200 is in this example is an aluminium alloy, Grade 6082T6, with a tensile strength of 250 to 300 N/mm^2.

[0034] The barrier 200 is in two pieces which interface together at the gaps 201 to make it easy to fit around the piston. In this case there isn't a spring effect toward a larger diameter to press against a cylinder bore, however because it is in two pieces the manufacturing tolerance can be very tight for optimum placement with an effect of brushing or rubbing along against the cylinder bore. In general, the arrangement of the barrier 30 (with only one gap, 31), is preferred because of the natural bias outwards. However, in the barrier 200 the gaps 201 allow movement to cater for distortion and to provide a gap between the barrier and the piston for the same purpose as the gap 32 of the barrier 30. The fact that the gaps 201 are at an angle to longitudinal, 45° in this case, means that electromagnetic waves can do not have a path in the longitudinal direction.

[0035] Any barrier, irrespective of its longitudinal length, may be manufactured as one piece with a single cut and stretched over the piston for fitting.

[0036] It is envisaged that in other examples the barrier may also perform the function of a guide ring, as the selected material already has bearing capabilities and load resisting properties, hence the selection of the high strength aluminium alloy grade 6082T6. A difference from conventional guide rings, however, is that there would be a gap under the rings for the same purpose as the gap 32, which is not ideal for a guide ring. While this combined functionality is possible, it is preferred that the barrier ring and the guide ring are separate components due to the very different nature of their functions.

[0037] It will be appreciated that the material of the blocker or barrier may be a dynamic metallic or semi-metallic or metallic-composite suitable to block electromagnetic waves emitted by the sensor. It fulfils the function of blocking low to very high frequency microwaves, thus greatly reducing the extent of echoes re-entering the measuring space from the opposite side of the cylinder. It is estimated that the improvement in sensing accuracy is about 50% to 70%.

[0038] The blocker 30/200 also fulfils all dynamic mechanical/environmental requirements to be found inside pressurised hydraulic cylinders. It operates dynamically without affecting the performance of the hydraulic cylinder. It also allows the use of high frequency microwaves in the range S-band 2-4 as against medium frequency in the range L-band 1-2 thus increasing measuring accuracy to stroke lengths of beyond 6000 mm.

[0039] It will be appreciated that the invention solves the problem of sensor signals, such as an ultrahigh frequency signal, directed towards the face of the piston will also penetrate the piston seals and enter the annular side of the cylinder. The invention prevents such a signal from being reflected by the inner wall of the gland, the cylinder rod, the cylinder wall and any other metallic features. Hence, it prevents such an errant HF from arising and hence prevents the consequent problem of such an errant signal passing back through the piston seals and creating an echo that disturbs the signal quality being received from the signal target (the piston face). It will be appreciated that this benefit is surprisingly achieved without affecting normal operation of the ram.

[0040] The invention is not limited to the embodiments described but may be varied in construction and detail within the scope of the claims.

Claims

1. A fluid ram (1) having a piston (4) mounted in a cylinder (2), an electromagnetic wave sensor (10, 110) mounted to detect movement of the piston in its travel within the cylinder, **characterized in that**,
   the piston comprises an electromagnetic wave barrier (30, 200) of electrically conductive material mounted to the piston around at least part of its circumference to prevent passage of electromagnetic waves past the piston.

2. A ram as claimed in claim 1, wherein the fluid is hydraulic oil.

3. A ram as claimed in claims 1 or 2, wherein the barrier is of a material selected from aluminium, phosphor bronze, malleable cast iron, a metal alloy with impregnated graphite, and a conductive plastics material.

4. A ram as claimed in any preceding claim, wherein the barrier (30, 200) is annular, extending fully or substantially fully around the piston, and the barrier has a natural position lightly pressing against the cylinder internal surface

5. A ram as claimed in claim 4, wherein the barrier (30, 200) has at least one circumferential gap (31, 201).

6. A ram as claimed in claim 5, wherein the barrier gap (31, 201) is at a taper angle to longitudinal.

7. A ram as claimed in claims 5 or 6, wherein the barrier has only one gap (31).

8. A ram as claimed in any preceding claim, wherein the barrier is mounted in a circumferential groove (33) around the piston.

9. A ram as claimed in claim 8, wherein the barrier has a natural size providing a radial gap (32) between the barrier and the groove base.

10. A ram as claimed in claim 9, wherein the radial gap (32) between the barrier and the groove base has a radial dimension in the range of 0.5mm and 1.0mm.

11. A ram as claimed in any preceding claim, wherein the barrier is around the piston adjacent an end of the piston (4) closest to the sensor (10, 110).

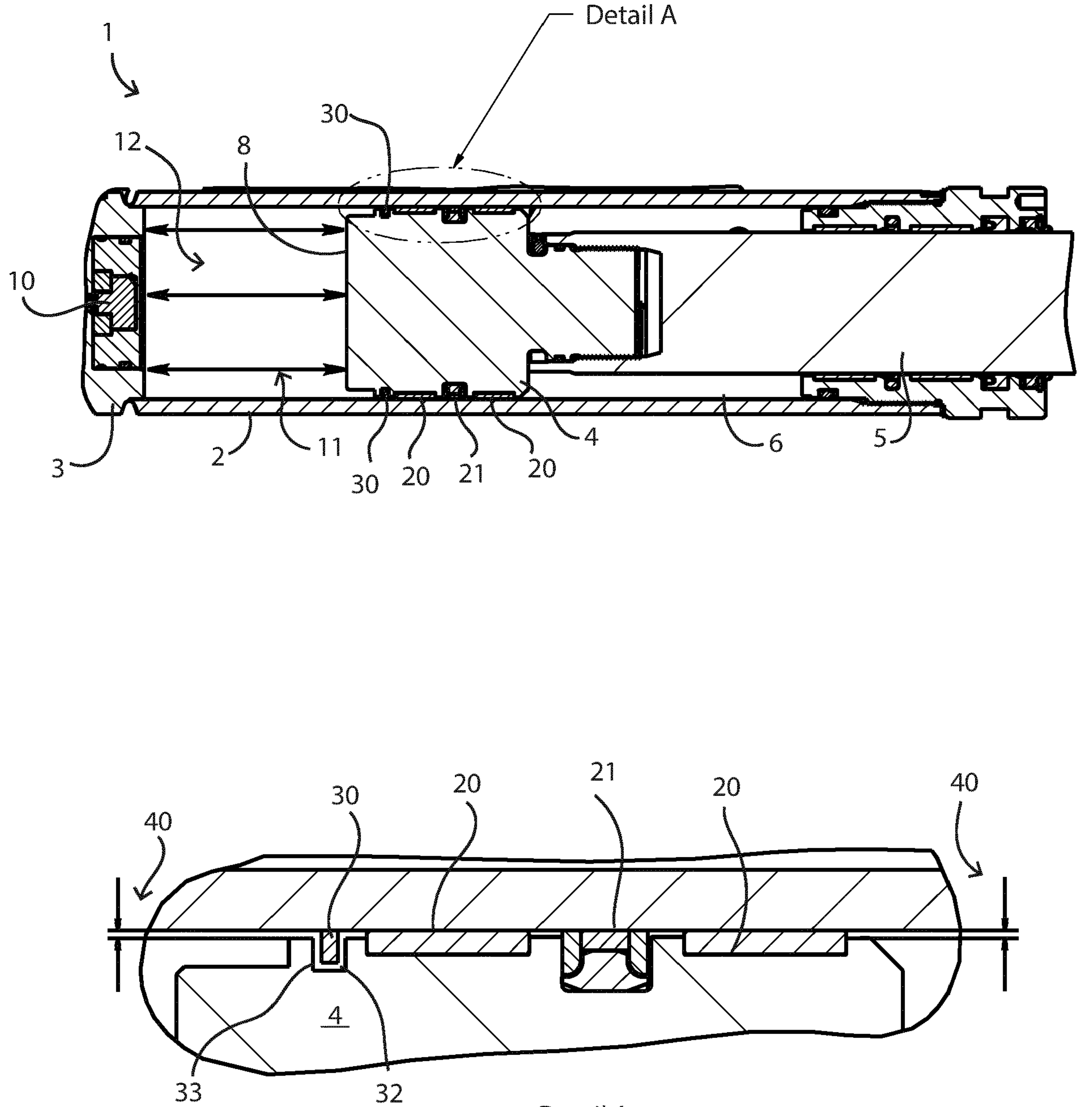
12. A ram as claimed in any preceding claim, further comprising a seal (21) around the piston at a location axially separate from the barrier, and a guide ring (20) around the piston at a location axially separate from the barrier.

13. A ram as claimed in claim 12, wherein the piston (4, 104) comprises, in order in the axial direction from the sensor (10, 110), the barrier (30, 200), a guide ring (20), a seal (21), and a guide ring (20).

14. A ram as claimed in any of claims 8 to 13, wherein the barrier is shorter in the longitudinal dimension than the groove (33), so that it is mounted in the groove (33) in a manner to allow a gap on both longitudinal sides of the barrier and radially inwardly of

the barrier, and the relative dimensions of the barrier and the groove are such as to allow flow of pressurized fluid in the longitudinal direction through said gaps and past the barrier to a piston seal, and optionally the barrier is shorter than the groove in the longitudinal direction by a distance in the range of 0.5mm to 1.0mm.

15. A piston (4) for mounting in a cylinder (2) with an electromagnetic wave antenna sensor (10, 110) to detect movement of the piston in its travel within the cylinder, wherein the piston comprises an electromagnetic wave barrier (30, 200) mounted to the piston around at least part of its circumference to prevent passage of electromagnetic waves past the piston.



Detail A

Fig.1

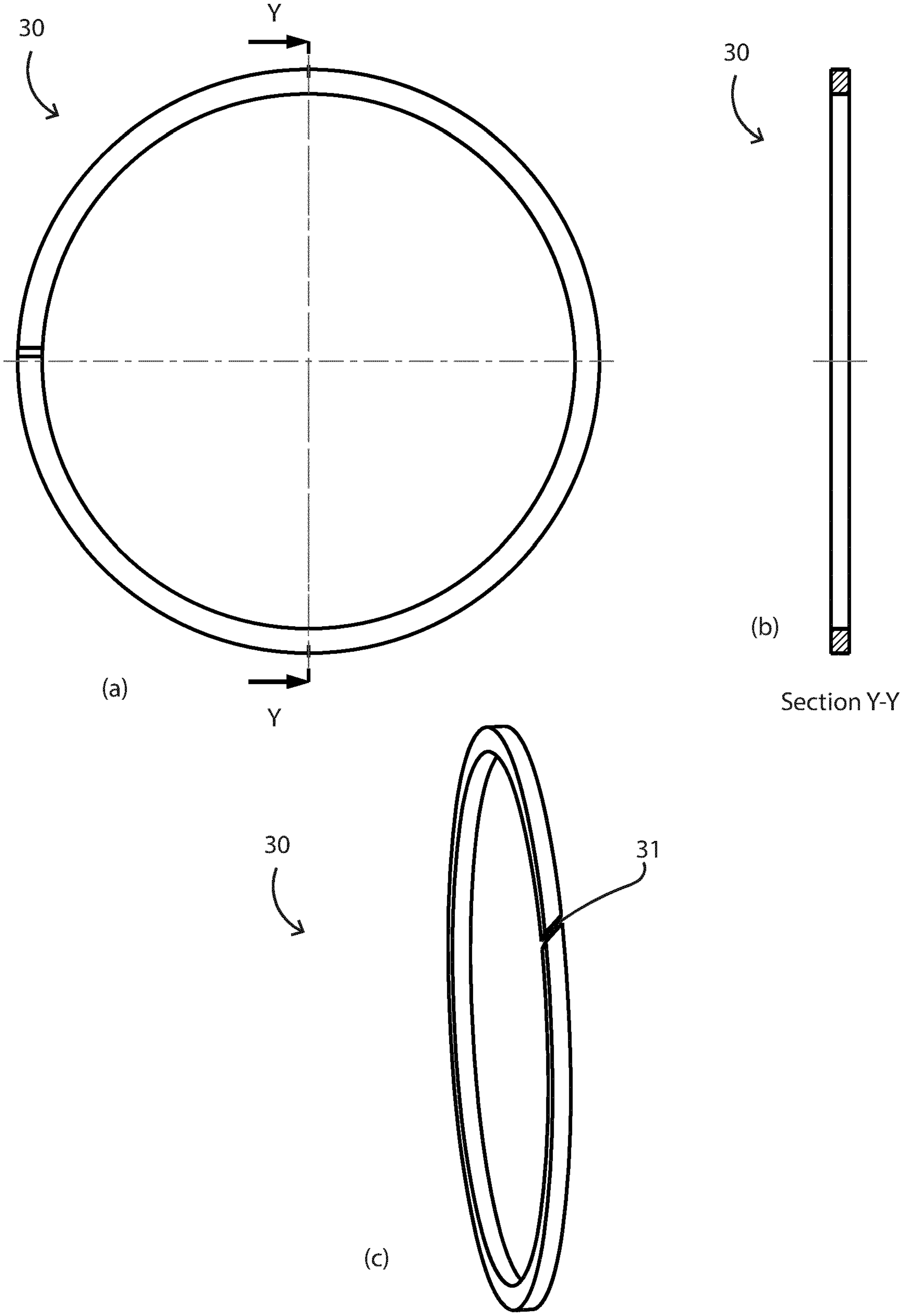
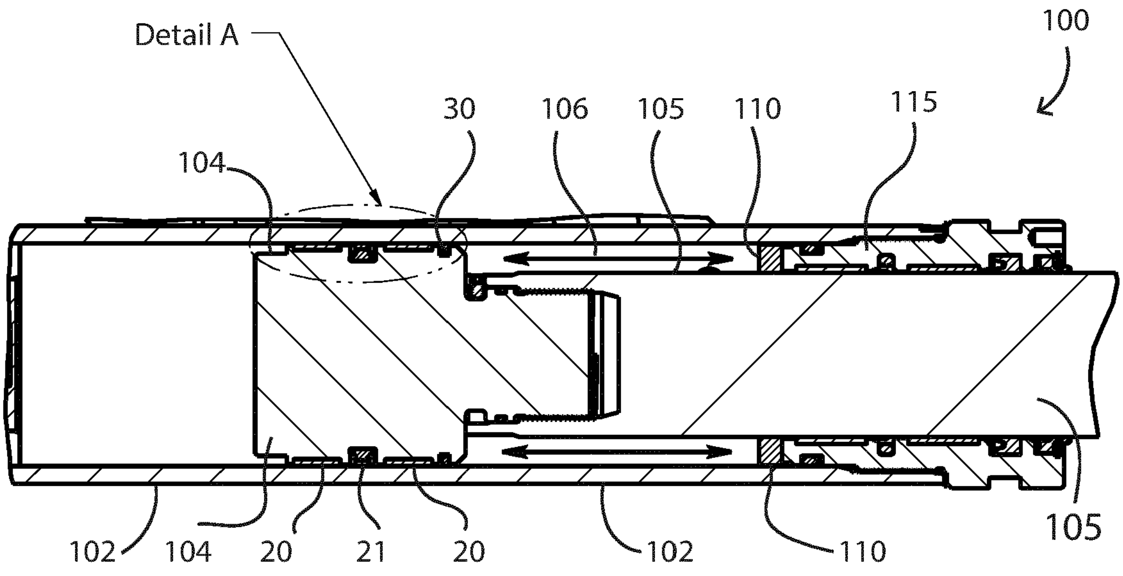
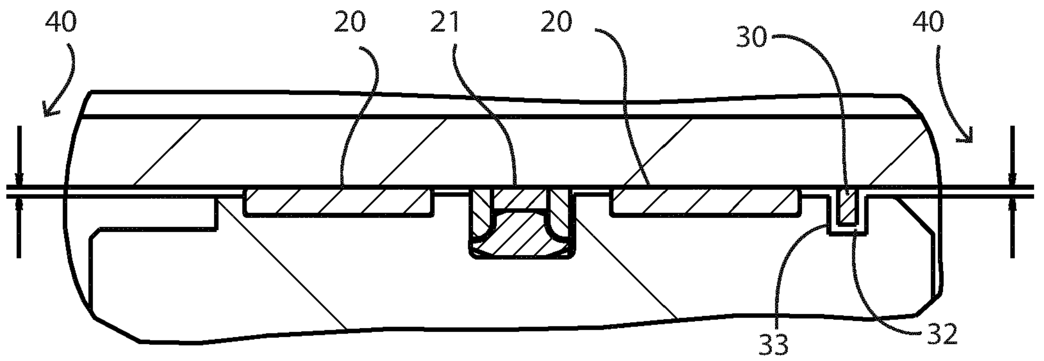


Fig.2





Detail A

Fig.3

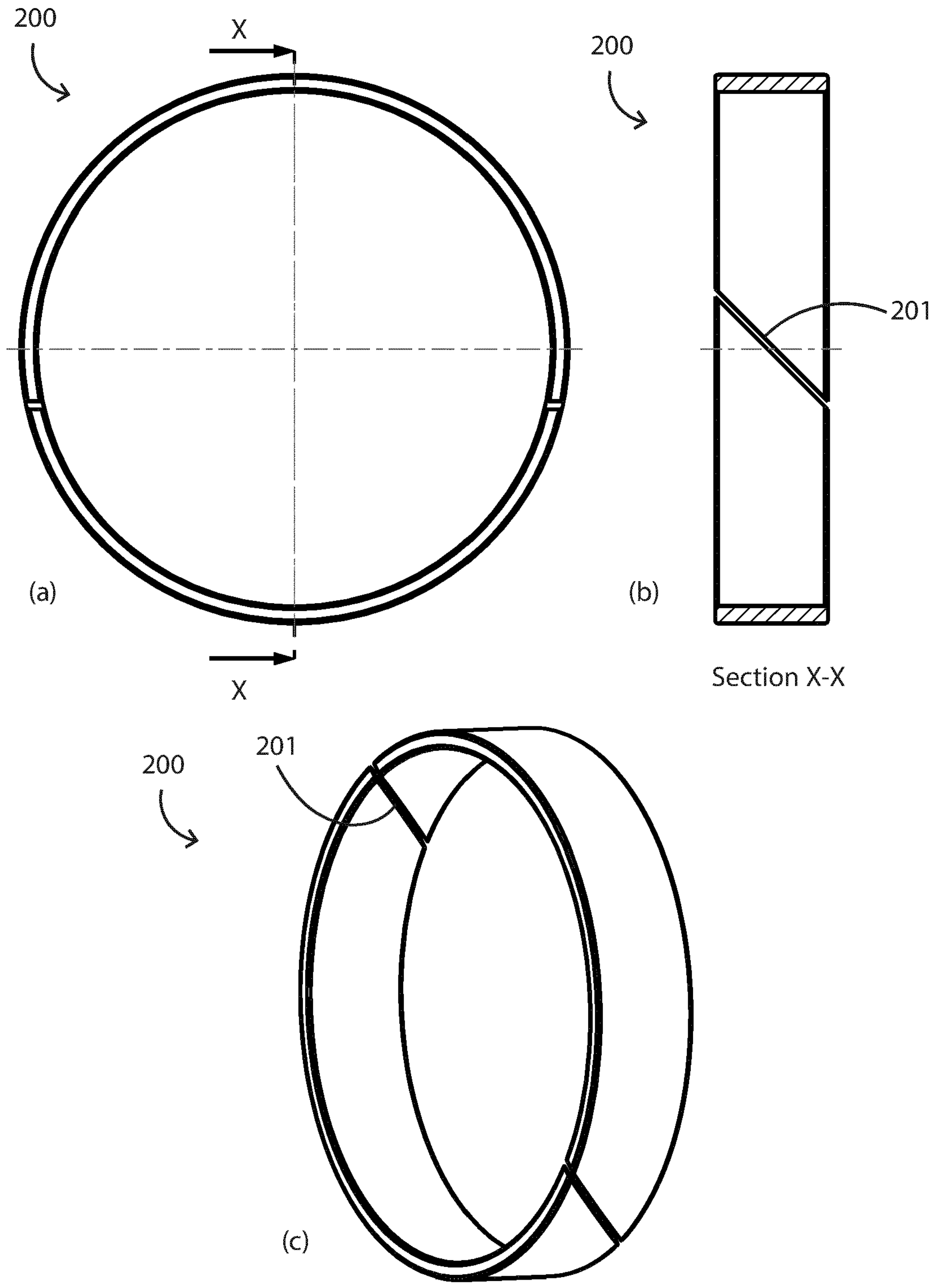


Fig.4

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 1189

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The present search report has been drawn up for all claims

3

Place of search	Date of completion of the search	Examiner
Munich	8 October 2021	Deligiannidis, N

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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