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Published:

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(54) Title: RECOIL REDUCTION SYSTEM

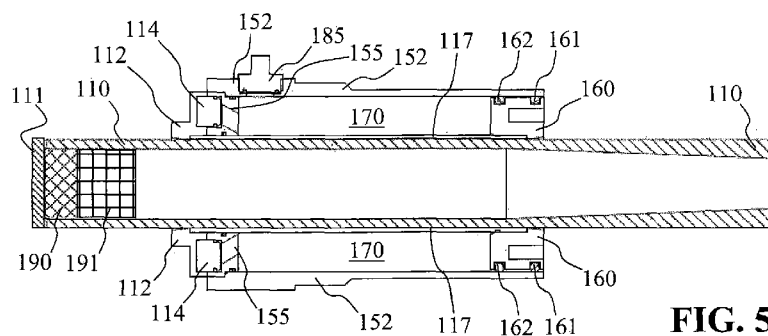


FIG. 5

(57) Abstract: There is provided a recoil reduction system (100) for a weapon having a barrel (110). The system comprises a barrel holder (152, 155), a reservoir (170) supported by the barrel holder, and a plunger portion (160) that is fixed to an outside of the barrel. The plunger portion (160) moves to reduce the volume of the reservoir as the barrel (110) slides in the barrel holder (152, 155) upon initiation of a propellant (190) in the barrel, thereby forcing fluid out of the reservoir (170) and into the external environment. There is further provided a barrelled weapon comprising the recoil reduction system (100).

RECOIL REDUCTION SYSTEM

Technical Field of the Invention

This invention relates to a recoil reduction system, and in particular to a recoil reduction system for a weapon having a barrel.

Background to the Invention

Recoil reducers are typically used to reduce the recoil forces acting on a device or person following initiation of a propellant within a barrel, the initiation driving a payload out the barrel and forcing the barrel in a direction opposite to the direction of the payload.

Known recoil reducers often seek to reduce recoil forces by smoothing the forces out over time using a damping system such as a dashpot. However, the recoil still exists and has the potential to cause damage to devices or persons supporting the barrel.

Other known recoil reducers seek to reduce recoil forces by transferring the recoil momentum to rearwardly ejected materials. The document GB 2291958 discloses the use of a counter-mass that is forced from a barrel in an opposite direction to a payload to reduce or eliminate recoil. However, the ejection of the counter-mass can present dangers to the surrounding environment, and the barrel needs to be long enough to accommodate the counter-mass as well as the payload. Furthermore, the use of such a counter-mass is wasteful of the power generated by the propellant.

It is therefore an aim of the invention to improve upon the known recoil reduction systems.

Summary of the Invention

According to a first aspect of the invention, there is provided a recoil reduction system for a weapon having a barrel, the system comprising a barrel holder, a reservoir supported by the barrel holder, and a plunger portion that is fixed to an outside of the barrel, wherein the plunger portion moves to reduce the volume of the reservoir as the barrel slides in the barrel

holder upon initiation of a propellant in the barrel, thereby forcing fluid out of the reservoir and into the external environment.

The initiation of the propellant forces a payload forwardly out of the barrel and causes the barrel to recoil backwardly and slide within the barrel holder. The plunger portion that is fixed to the barrel also moves backwardly with the barrel, reducing the volume of the reservoir supported by the barrel holder. The forcing of the fluid out of the reservoir and into the external environment by the plunger portion acts against the sliding of the barrel within the barrel holder, thereby helping to dissipate the recoil forces of the barrel upon firing by transferring momentum to the external environment which lowers the impulse transferred by the weapon to whatever/whoever is holding the weapon.

The forward direction is considered to be the direction that the payload moves in and the backward (rearward) direction is considered to be the direction in which the barrel recoils. The fluid may be a liquid such as water to avoid contamination of the external environment. Preferably, the fluid is directed into the external environment substantially in the backward direction, so that backward momentum of the barrel is transferred away from the barrel as backward momentum of the fluid.

Since the reservoir is supported by the barrel holder, the whole length of the barrel itself can be dedicated to the firing of the payload, allowing for a shorter barrel length compared to known countermass recoil reduction systems such as the above-described GB 2291958. Furthermore, the propellant may expand between the payload and an end of the barrel upon initiation, meaning that the whole weight of the barrel is used to help drive the payload forwards. This makes more efficient use of the propellant since the barrel is typically heavier than a countermass, and so results in higher forces upon the payload for a given quantity of propellant. The payload may be a solid or a liquid, for example water.

The plunger portion may be fixed to the barrel by connecting it to a barrel of an existing weapon in the case of retrofitting the recoil reduction system to the existing weapon, or the plunger portion may be fixed to the barrel when manufacturing the weapon in the first place, for example by integrally forming the plunger portion and the barrel together. Retrofitting may be performed by simply fixing the plunger portion to an outside of the barrel and

The plunger portion is preferably fixed in position relative to the barrel so that they move together as one part during initiation. Initiation may for example comprise firing and/or ignition of the propellant.

The barrel holder may comprise a ring portion connected to a shell, wherein the ring portion is configured to support the barrel within the ring portion, and wherein the shell is configured to extend around a length portion of the barrel. Making the shell extend all around the barrel along a portion of the length of the barrel helps to support the barrel within the shell.

Furthermore, the plunger portion of the barrel may support the shell around the barrel. Then, the ring portion and the plunger portion may act together to stabilise the barrel within the barrel holder. The plunger portion may be formed separately from the barrel and then connected to the barrel, or may be formed integrally with the barrel.

Advantageously, an external wall of the reservoir may be formed by an inside surface of the shell, so that no separate container for the reservoir is required.

The reservoir may also be formed between the ring portion and the plunger portion, the distance between the ring portion and the plunger portion reducing upon initiation to reduce the volume of the reservoir, since the plunger portion moves with the barrel and the ring portion moves with the shell. Optionally, the plunger portion may form a forward wall of the reservoir, the ring portion may form a rearward wall of the reservoir, and the ring portion may comprise exit holes for exiting fluid from the reservoir when the barrel slides in the barrel holder upon initiation of a propellant in the barrel. Alternatively, exit holes may for example be provided in the shell. The exit holes may be configured to direct fluid in a substantially backward direction upon the propellant being initiated and forcing a payload out of the barrel in a forward direction, so that the backward momentum of the barrel is transferred to backward momentum of the fluid.

The exit holes may act in the manner of a dashpot, helping to damp the recoil of the barrel. Specifically, a high initial peak force applied to the reservoir fluid by the plunger portion upon initiation may be smoothed out in time to lower the peak force transferred to the ring

through the fluid to the ring portion will also be reduced as momentum will be transferred to the external environment by the fluid exiting the holes.

Advantageously, the recoil reduction system may further comprise a plug portion attached to the barrel, the plug portion configured to plug the exit holes when the barrel is in an initial position prior to initiation. The ring portion may be between the plug portion and the plunger portion, so that the backward movement of the barrel upon initiation automatically pulls the plug portion away from the ring portion, thereby unplugging the exit holes in the ring portion and allowing the fluid to exit through the holes under force applied by the plunger portion. The stiction between the plug portion and the ring portion may help hold the barrel in place within the barrel holder prior to ignition. The plug portion may be connected to the barrel, or may be integrally formed with the barrel.

The plug portion may be formed in the shape of a ring around the barrel, to correspond to the ring portion of the shell.

The plug portion may comprise multiple plug protrusions, each plug protrusion for plugging a corresponding exit hole of the ring portion. The combined stiction of the multiple plug protrusions in the corresponding exits holes may help improve the holding of the barrel in place within the barrel holder prior to ignition.

The plug portion may comprise a circular protrusion around a central axis of the plug portion, the circular protrusion being shaped to plug into a corresponding circular depression around a central axis of the ring portion, the exit holes being formed through the ring at a base of the circular depression. Then, the manufacture of the plug portion may be greatly simplified by forming one circular protrusion instead of the multiple protrusions. Or, the multiple plug protrusions may be provided on the circular protrusion to provide enhanced sealing.

The exit holes may be angled away from a longitudinal axis of the barrel to direct fluid past the plug portion during firing, thereby avoiding fluid from impacting against the plug portion and pushing the plug portion (and therefore the barrel) backwards.

The exit holes preferably direct fluid in a rearward direction upon firing of a payload in a

away from the barrel. The fluid is preferably a liquid. Since liquids are typically denser than gases, the use of a liquid typically transfers more momentum away from the barrel than a gas would for a given size and number of exit holes. One convenient and non-toxic liquid which could be used is water.

Preferably, the exit holes in the ring portion are evenly spaced around the ring portion so the total momentum imparted on the barrel by the fluid is in the forward direction, opposite to the movement of the barrel in the backward direction. Then, any transverse forces acting upon the barrel which could alter the longitudinal direction of the barrel and/ or damage any person/device holding the barrel are minimised. The plug portion helps plug the exit holes and prevent fluid from leaving the reservoir via the exit holes until firing.

Other means for keeping the fluid within the reservoir until firing may also (or alternatively) be used, for example a membrane over various holes in the reservoir, the membrane breaking open when the fluid pressure raises upon firing. Another possibility would be to provide holes in the reservoir positioned above an initial level of the fluid in the reservoir.

An internal wall of the reservoir may be formed by an outside surface of the barrel, or the internal wall may be formed by a sealing layer that is fitted on the outside surface of the barrel, for example if the outside surface of the barrel is insufficiently smooth to provide a good seal between the ring portion and the outside surface of the barrel. A good seal helps prevent the fluid from leaking out of the reservoir prior to initiation of the propellant. Preferably, the sealing layer extends substantially all of the way between the plug portion and the plunger portion.

The use of a sealing layer may be particularly advantageous during retrofitting as the length of the sealing layer can be used to define how far apart the plug portion and the plunger portion should be fixed relative to one another on the barrel. The plug portion, sealing layer, and plunger portion may be formed as one piece to aid retrofitting, either by integrally forming them together, or by fixing them together prior to the retrofitting.

The barrel may be cylindrical with a closed end and an open end opposite the closed end, so that the closed end provides confinement for the propellant between the closed end and the

The shell may also be cylindrical with the plunger portion and the ring portion holding the barrel with a central axis of the shell aligned with a central axis of the barrel. Then, when the internal wall of the reservoir is formed by an outside of a circular barrel, or is formed by a sealing layer in the form of a circular sleeve, the radial depth of fluid within the reservoir is substantially the same all around the barrel so that the fluid pressure during firing does not tend to force the barrel transversely relative to the shell.

The walls forming the reservoir may entirely consist of the outside surface of the barrel (or the sealing sleeve), the inner surface of the shell, the ring portion, and the plunger portion, so that no further components are required to form the walls of the reservoir.

The plunger portion of the barrel may comprise an O-ring that bears against the shell, and the ring portion may comprise an O-ring that bears against the sealing sleeve or against the outside of the barrel when no sealing sleeve is provided. As well as providing seals for the reservoir, the O-rings may help damp any transversely directed vibrations between the barrel and the barrel holder, and help keep the barrel running smoothly within the barrel holder.

Transverse directions are considered to be directions perpendicular to the length of the barrel.

The shell may comprise a removable filler cap for fitting in an aperture that extends through the shell and into the reservoir, to enable easy filling of the reservoir with fluid prior to initiation.

Preferably, the recoil reduction system is arranged so that its position prior to firing enables the shell to be held without any significant rotational moment needing to be countered by the holder (person or device). For example, prior to initiation the shell may extend over a point half way along the length of the barrel, and/or over a centre of mass of the combined barrel, shell, and reservoir.

The shell may comprise an attachment means at an outer surface of the shell to enable the shell to be easily attached to a mounting device, for example a remote controlled vehicle. The attachment means may for example be screw threads and/or mounting brackets.

According to a second aspect of the invention, there is provided a barrelled weapon comprising the recoil reduction system of the first aspect of the invention.

Brief Description of the Drawings

Embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Fig. 1 shows a perspective diagram of a recoil reduction system before firing according to an embodiment of the invention;

Fig. 2 shows a side diagram of the recoil reduction system of Fig. 1 before firing;

Fig. 3 shows a perspective diagram of the recoil reduction system of Fig. 1 after firing;

Fig. 4 shows a side diagram of the recoil reduction system of Fig. 1 after firing;

Fig. 5 shows a cross-sectional diagram of the recoil reduction system of Fig. 1 before firing;

Fig. 6 shows a cross-sectional diagram of the recoil reduction system of Fig. 1 after firing;

Fig. 7 shows a perspective diagram of a recoil reduction system according to an alternate embodiment of the invention; and

Fig. 8 shows another perspective diagram of the recoil reduction system of Fig. 7.

The drawings are purely illustrative and are not to scale. Same or similar reference signs denote same or similar features.

Detailed Description

The perspective diagram of Fig. 1 shows a recoil reduction system 100 according to an embodiment of the invention. Fig 2 shows a side view of the recoil reduction system 100 of Fig. 1.

The recoil reduction system 100 is shown in Figs 1 and 2 in a position prior to initiation, and comprises a barrel holder 150 that is used to hold a barrel 110 of a barrelled weapon. The barrel holder 150 may for example be held by a person or remote controlled vehicle using a mounting device such as clamps and/or brackets (not shown in Figs).

The barrel 110 has a closed end 111. A propellant located within the barrel 110 and between the closed end 111 and a payload, may be initiated to drive the payload in a forward direction out of the barrel 110. The barrel has a circular outer profile along its length, the circular outer profile being of a constant radius along a length portion of the barrel that is inside of the barrel holder 150 in the position prior to initiation of the propellant. The constant radius helps facilitate the sliding of the barrel 110 within the barrel holder 150 during initiation of the propellant.

The barrel holder 150 has a shell 152 that extends all around the longitudinal axis of the barrel 110 along the length portion of the barrel. The shell 152 encloses the length portion of the barrel 110, and supports a reservoir in between the shell 152 and the barrel 110. The reservoir may be filled with fluid by unscrewing a filler cap 180 from the shell 152 and pouring in fluid, for example water. The shell 152 forms an external wall of the reservoir.

The barrel holder also has a ring portion (not visible in Fig. 1 or 2) that is connected to the shell 152, and which supports the shell with the shell's longitudinal axis aligned with the longitudinal axis of the barrel. In the position of the recoil reduction system prior to initiation, the ring portion rests against a plug portion 112 that is fixed to the barrel 110. The plug portion 112 may be integrally formed with the barrel or may be attached to the barrel as a separate component, for example by clamping or welding to the barrel 110.

A perspective diagram and a side diagram of the recoil reduction system 100 in a position after initiation are shown in Figs. 3 and 4 respectively.

The firing of the recoil reduction system 100 has resulted in the barrel 110 recoiling backwardly to the left side of the page as viewed in Figs. 3 and 4, so that the plug portion 112 is moved away from the barrel holder 150, allowing the ring portion 155 that is connected to the shell 152 to be seen. The ring portion 155 is an annular plate having a central hole for the barrel 110 to slide back and forth through the hole. The annular plate has a plurality of exit holes 156 that allow fluid inside the reservoir to exit to the external environment during firing.

The ring portion 155 is at a rearward end of the barrel holder 150, enabling fluid in the

The plug portion 112 comprises a plurality of plug protrusions 114 that plug into respective ones of the exit holes 156 prior to firing, and prevent the fluid in the reservoir from leaking out before firing. Each plug protrusion 114 is circular and is fitted with an O-ring 115 that seals against the inner wall of the corresponding hole 156. The O-rings 115 also provide friction that helps hold the barrel 110 in position within the barrel holder 150 prior to firing.

The recoil reduction system 100 will now be described in more detail with reference to the cross-sectional diagrams of Figs. 5 and 6. The cross sections are taken aligned with the longitudinal axis of the barrel 110, and show the positions of the recoil reduction system before and after initiation of a propellant 190.

Before firing, as shown in Fig. 5, the propellant 190 is placed at the end 111 of the barrel 110, and a payload 191 is fitted at the opposite side of the propellant from the end 111. The reservoir 170 has an internal wall formed by a sealing sleeve 117, an external wall formed by the shell 152, a rearward wall formed by the ring portion 155, and a forward wall formed by a plunger portion 160. The reservoir 170 is filled with a fluid.

The plunger portion 160 is fixed to the barrel 110, and helps to support the shell 152 around the barrel 110, and to define the extent of the reservoir 170 that is formed between the inside surface of the shell 152, the outside surface of the barrel 110, the ring portion 155, and the plunger portion 160.

The plunger portion 160 comprises two O-rings 161 and 162, the O-rings helping to seal the interface between the plunger portion and the shell 152 and prevent fluid from leaking out of the reservoir 170. The ring portion 155 comprises an O-ring 157 (see Fig. 6), and the O-ring 157 bears against the sealing sleeve 117 that is applied to the outside surface of the barrel 110. The sealing sleeve 117 helps to provide a smooth surface against which the O-ring 157 can seal, to prevent fluid from leaking out of the reservoir 170 and provide a smooth surface over which the plunger portion can travel.

The sealing sleeve 117 is formed from a metal piece that may be treated to prevent corrosion and fits as a sleeve around the barrel. Alternatively the sealing sleeve may be made from

other materials such as polycarbonate or PTFE if the calibre of the barrel allows sufficient thickness of material to be used.

The sealing sleeve 117 helps to smooth out any imperfections in the barrel and prevent the ring portion 155 from jamming against any of these impactions during initiation of the propellant 190. In an alternate embodiment, the outside surface of the barrel 100 is sufficiently smooth to provide good sealing and the sealing sleeve 117 is omitted.

When the propellant 190 is initiated, the payload is forced forwards out of the barrel 110 in a direction D_p , and the barrel 110 is forced backwards in an opposite direction D_b . The backward movement of the barrel moves the plug portion 112 thereby unplugging the plug protrusions 114 from the ring portion holes 156, and simultaneously moves the plunger portion 160 backwards, thereby reducing the distance between the ring portion 155 and the plunger portion 160 to reduce the volume of the reservoir 170 and pressurise the fluid therein.

The pressurisation of the fluid inside the reservoir forces the fluid out through the exit holes 156 and into the external environment in a direction D_f . The force exerted on the plunger portion 160 by the fluid slows the backward movement of the barrel 110 gradually, smoothing out the peak forces exerted by the plunger portion on the ring portion. Furthermore, restricting the flow of the fluid through the exit holes 156 increases the water velocity so that momentum is transferred from the backward movement of the barrel to the external environment via the ejected fluid.

The exit holes 156 are angled slightly away from the longitudinal axis of the barrel, so that the fluid that is ejected does not significantly impact against the plug portion 112 and cause momentum to be transferred back to the barrel 110.

In an alternate embodiment shown in Fig. 7 and Fig. 8, the plug protrusions 114 are replaced by a single ring-shaped ridge protrusion 214 around the axis of the plug portion 212. The ridge protrusion 214 is shaped to fit inside a corresponding depression 256 between inner 257 and outer 258 walls of the ring portion 255. The exit holes 156 are formed through the ring portion 255 along the base of the depression 256.

Various other embodiments of the invention falling within the scope of the appended claims will also be apparent to those skilled in the art, for example the reservoir may be located in different positions relative to the barrel and barrel holder. Configurations in which the reservoir surrounds the barrel equally on all sides as in the described embodiments are preferred, to avoid the barrel and/or barrel holder from tending to rotate away from their longitudinal axes during initiation of the propellant.

CLAIMS

1. A recoil reduction system for a weapon having a barrel, the system comprising a barrel holder, a reservoir supported by the barrel holder, and a plunger portion that is fixed to an outside of the barrel, wherein the plunger portion moves to reduce the volume of the reservoir as the barrel slides in the barrel holder upon initiation of a propellant in the barrel, thereby forcing fluid out of the reservoir and into the external environment.
2. The recoil reduction system of claim 1, wherein the barrel holder comprises a ring portion connected to a shell, wherein the ring portion is configured to support the barrel within the ring portion, and wherein the shell is configured to extend around a length portion of the barrel.
3. The recoil reduction system of claim 2, wherein an external wall of the reservoir is formed by an inside surface of the shell.
4. The recoil reduction system of claim 2 or 3, wherein the plunger portion supports the shell around the barrel.
5. The recoil reduction system of claim 4, wherein the plunger portion comprises an O-ring that bears against the shell.
6. The recoil reduction system of claim 2, 3, 4, or 5, wherein the plunger portion forms a forward wall of the reservoir, wherein the ring portion forms a rearward wall of the reservoir, and wherein the ring portion comprises exit holes for exiting fluid from the reservoir when the barrel slides in the barrel holder upon initiation of a propellant in the barrel.
7. The recoil reduction system of claim 6, further comprising a plug portion that is fixed to an outside of the barrel, the plug portion configured to plug the exit holes when the barrel is in an initial position prior to initiation, the ring portion being between the plug portion and the plunger portion.

8. The recoil reduction system of claim 7, wherein the exit holes are angled away from a longitudinal axis of the barrel to direct fluid past the plug portion during initiation.
9. The recoil reduction system of claim 7 or 8, wherein the plug portion comprises multiple plug protrusions, each plug protrusion for plugging a corresponding exit hole of the ring portion.
10. The recoil reduction system of claim 7, 8, or 9, wherein the plug portion comprises a circular protrusion around an axis of the plug portion, the circular protrusion being shaped to plug a corresponding circular depression around an axis of the ring portion, the exit holes being formed through the ring portion at a base of the circular depression.
11. The recoil reduction system of any preceding claim, wherein the system further comprises a sealing layer that is fitted on an outside of the barrel and which forms an internal wall of the reservoir.
12. The recoil reduction system of claim 11 when appended to any one of claims 6 - 10, wherein the sealing layer extends over the outside surface of the barrel between the plug portion and the plunger portion.
13. The recoil reduction system of claim 11 or 12, wherein the sealing layer is a sealing sleeve that extends all around the barrel, and wherein the ring portion comprises an O-ring that bears against the sealing sleeve.
14. The recoil reduction system of any one of claims 2 – 14, wherein the shell comprises a filler cap that is removable to fill the reservoir with fluid.
15. A barrelled weapon comprising the recoil reduction system of any preceding claim.
16. A recoil reduction system substantially as described herein with reference to the accompanying drawings.

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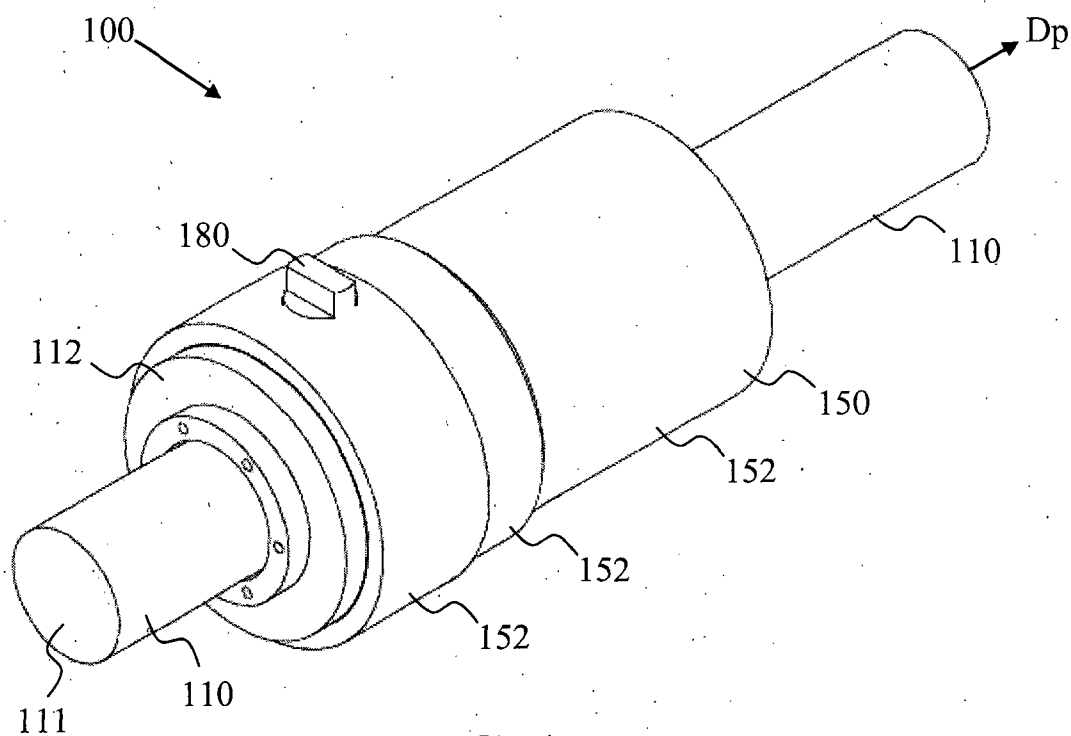


FIG. 1

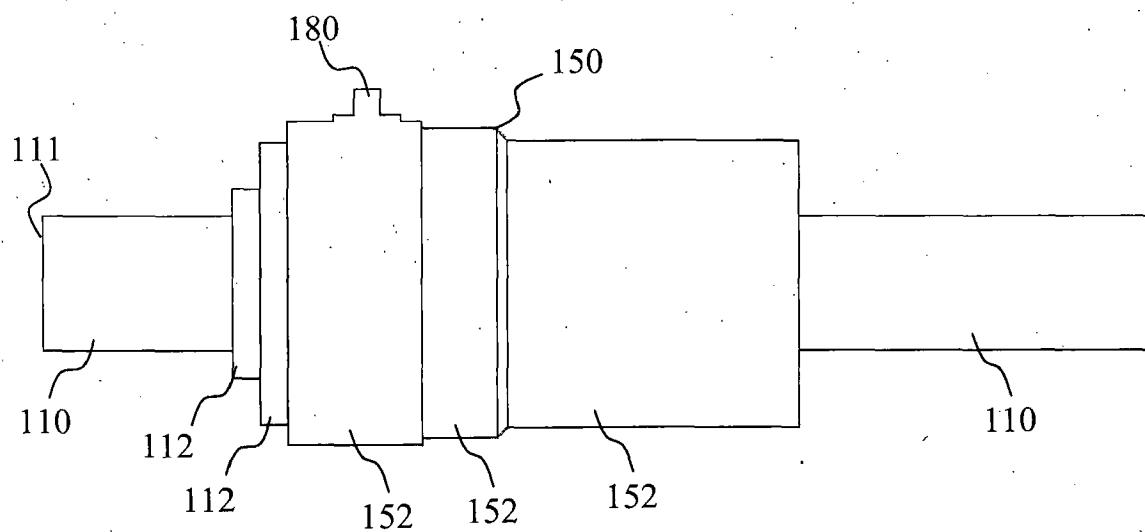


FIG. 2

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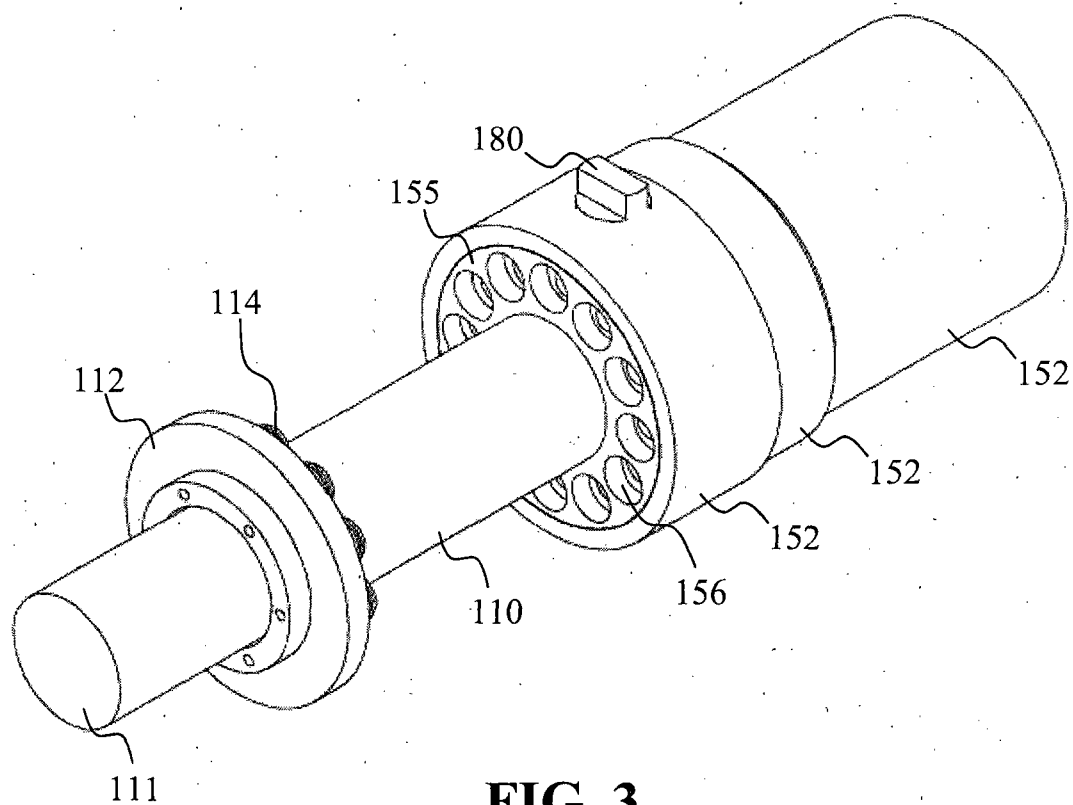


FIG. 3

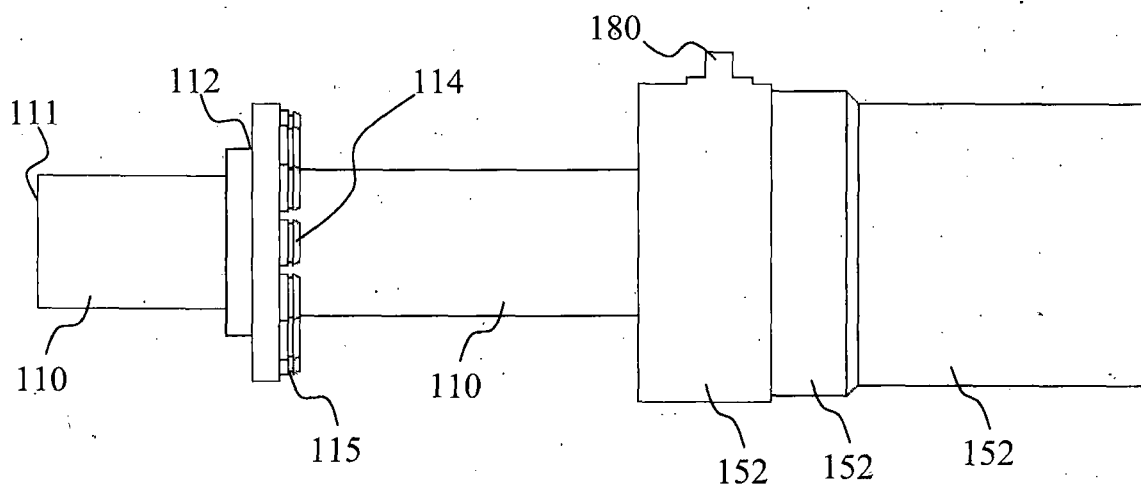


FIG. 4

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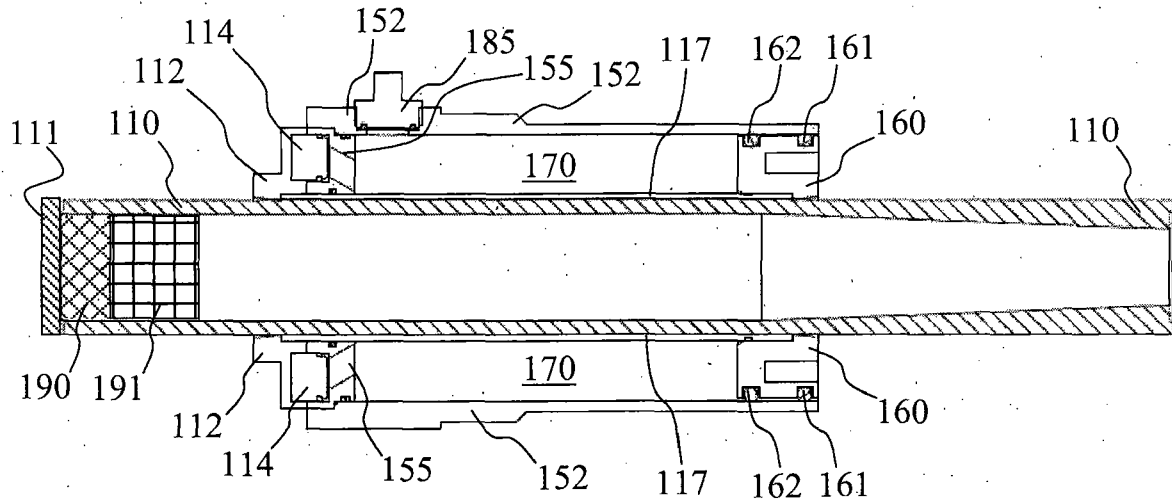


FIG. 5

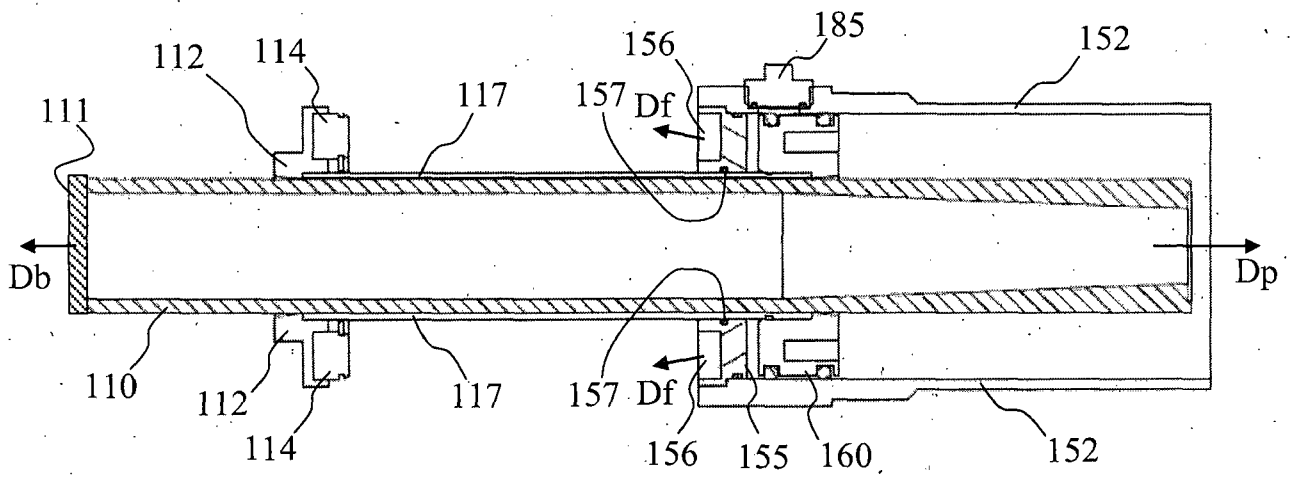


FIG. 6

4/4

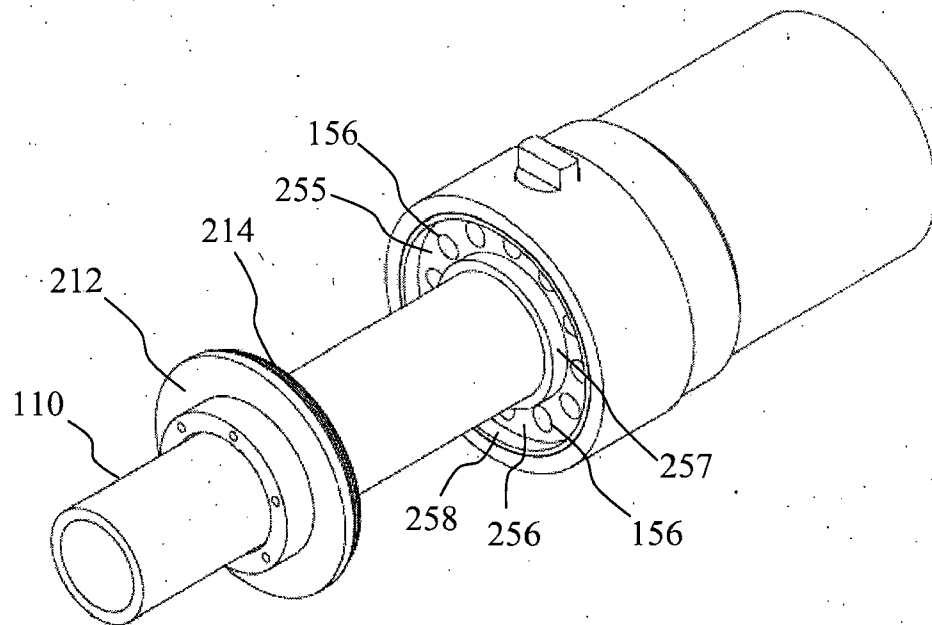


FIG. 7

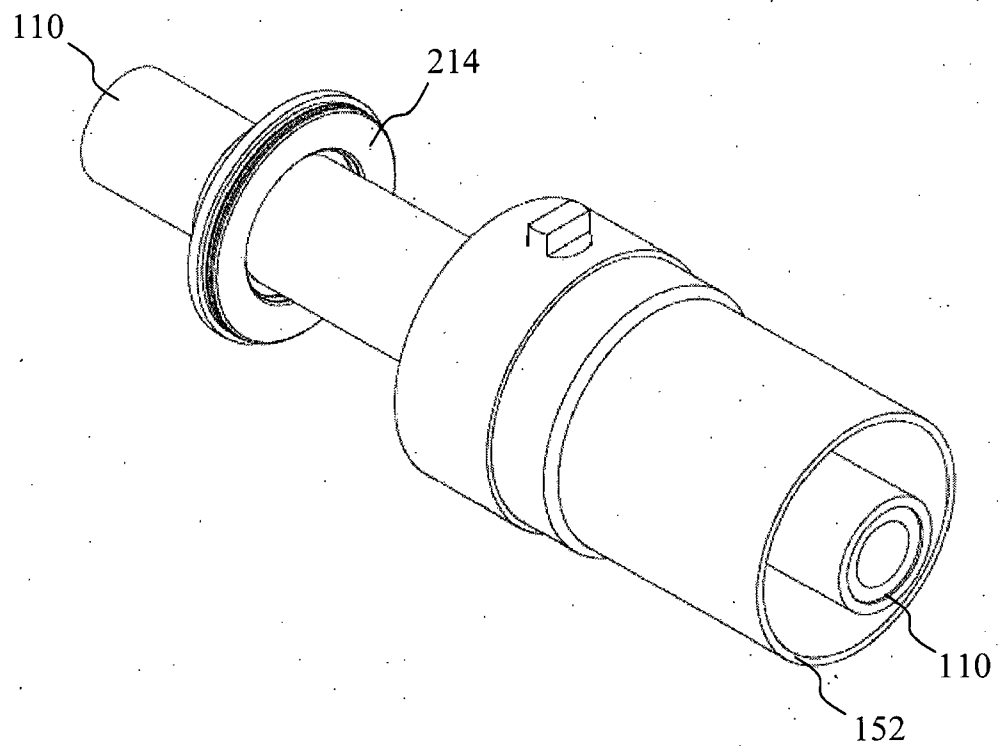


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/000292

A. CLASSIFICATION OF SUBJECT MATTER
INV. F41A1/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F41A

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/282057 A1 (RAPP JOHN [US] ET AL RAPP JOHN W [US] ET AL) 11 November 2010 (2010-11-11)	1,15
Y	figures 16,17 paragraph [0123] - paragraph [0135] -----	2-5
Y	US 5 491 917 A (DILHAN DENIS [FR] ET AL) 20 February 1996 (1996-02-20) abstract; figures 3,4 column 2, line 39 - line 63 -----	2-5
A	GB 2 291 958 A (ROYAL ORDNANCE PLC [GB]) 7 February 1996 (1996-02-07) cited in the application abstract; figures 1,3,4 ----- -/--	1

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

3 October 2013

Date of mailing of the international search report

14/10/2013

Name and mailing address of the ISA/

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Schwingel, Dirk

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2013/000292

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2007 005939 A1 (CONTRAVES AG [CH]) 7 August 2008 (2008-08-07) abstract; figures 1,3 paragraph [0024] -----	1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2013/000292

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 16
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 16

Claim 16 contains merely a reference to the description and the drawings. According to Rule 6.2(a) PCT, claims should not contain such references. Since the claim does not contain any technical features and said reference to the description and the drawings leaves the reader in doubt as to its meaning, claim 16 is unclear (Article 6 PCT). A meaningful search has not been possible for this claim.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2013/000292

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