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(71) Applicant: THE SECRETARY OF STATE FOR DEFENCE [GB/GB]; DSTL, Porton Down, Salisbury, Wiltshire SP4 0JQ (GB).

(72) Inventor: COOKE, Samuel, Brendan, Dixon; DSTL IP Group, G02 Building 005, DSTL Porton Down, Salisbury Wiltshire SP4 0JQ (GB).

(74) Agent: FARNSWORTH, Alastair, Graham; DIPR Formalities Section, Poplar 2#2214, MOD Abbey Wood(South), Bristol BS34 8JH (GB).

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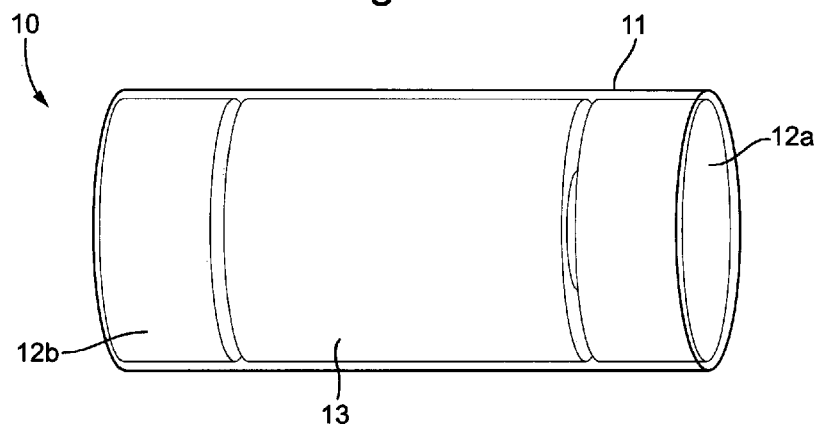
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(54) Title: RECONFIGURABLE PISTON AND METHOD OF MANUFACTURE

Fig. 1



(57) Abstract: A reconfigurable piston (10) suitable for use in a piston actuator. The reconfigurable piston (10) comprises a tubular piston rod (11) into which rod ballast (13) can be received, and retention means (optionally end plates (12a) and 12b) for securing the rod ballast (13) within the tubular piston rod (11). This allows the mass of the piston rod (11) to be varied to vary acceleration for a constant applied force, as can be required in airsoft applications. Also relates to a method of manufacture.



RECONFIGURABLE PISTON AND METHOD OF MANUFACTURE

Technical Field of the Invention

This invention relates to the field of pistons.

Background to the Invention

A piston is a mechanical component used to transfer force. It is typically configured to slide within a housing or casing such as a cylinder, and may consist solely of a piston rod, or a piston rod with an attached piston plate. A piston actuator may be used to usefully apply a force to operate a device (for instance to open and close a valve) or to move an object (for instance a projectile in an airsoft gun). The piston in a piston actuator may be driven in a linear manner by a compressed spring, compressed gas, or by the expansion of gases generated during combustion of a fuel, for example. Pistons can also be used to generate a rotary motion if implemented in a piston-crank arrangement, or can be used in suspension systems to mitigate vibrations or cushion linear motion.

The work required of a piston in a piston actuator may in the majority of applications be well defined. For instance a piston actuator may be required to open and close a valve at the same rate, cyclically, without change, until mechanical failure. However there may be occasions where the work performed by a piston needs to be altered. It may be that a valve is being opened and closed too quickly by a piston actuator, and the propulsion of the piston needs to be dampened, for instance by using a lower gas pressure, or a reduced strength spring. In some instances however the propulsion means may be inaccessible, expensive to replace, or only capable of delivering a constant propulsive force. In these cases an entirely new piston actuator may need to be installed, capable of operating with the propulsion means to deliver the required actuation effect. This can be an inefficient and expensive approach to adjusting a piston actuator system.

A particular application where pistons are well utilised is in projectile launching devices, such as airsoft guns. In airsoft a spring loaded or high pressure gas driven piston can be used

to rapidly compress an air volume behind a soft projectile (an airsoft bullet). The compressed air acts upon the soft projectile to propel it from the airsoft gun. Airsoft guns are operated in accordance with strict rules and laws, particularly regarding their overall 'power'. Adherence to these laws can be compromised, intentionally or unintentionally, as a result of a 'joule creep' effect, wherein a heavier projectile can exit an airsoft gun with greater kinetic energy than a lighter projectile, despite the same spring strength or gas pressure being used. This effect can have serious consequences for the safety or legality of airsoft games.

Therefore it is an aim of the present invention to provide a reconfigurable piston that mitigates these issues.

Summary of the Invention

According to a first aspect of the invention there is provided a reconfigurable piston for use in a piston actuator, comprising a tubular piston rod into which rod ballast can be received, and retention means for securing the rod ballast within the tubular piston rod. This allows the mass of the piston rod to be adjusted without changing the overall diameter of the piston rod. Therefore in embodiments where the piston rod defines the working area of the piston, the working area is not compromised by the adjusting of the piston rod mass. In some embodiments the piston-rod may not define the working area of the piston, and in these embodiments retaining rod ballast within the piston rod allows for piston mass to be adjusted without altering the exterior surface of the piston rod (and thereby without altering the interaction of the exterior surface with airflow around the piston rod). The retention means also ensures the ballast will not exit the piston rod when the piston is being used, and allows for a variety of rod ballast types to be used (for instance granular ballast). This also ensures the ballast position can be held fixed in use, preventing the ballast from sliding and damaging the piston rod when the piston rod accelerates or decelerates in use. By providing an adjustable mass the acceleration of the piston rod can be increased or decreased for a constant applied force. This allows a piston to be tailored to a specific application, or readily adjusted between uses, with a relatively high degree of fidelity without requiring a change to the propulsion means driving the piston itself.

In preferred embodiments the retention means comprises first and second removable end plates attachable to the tubular piston rod, such that rod ballast can be held between the end plates. The end plates may provide an interference fit to the inner dimensions of the piston-rod. This provides a convenient way of securing ballast inside the tubular piston rod to prevent the ballast sliding and damaging the piston rod during use.

Preferably the end plates and tubular piston rod are threaded to cooperate, such that the end plates can be attached to the tubular piston rod to retain the rod ballast therebetween. This provides a relatively secure way of retaining ballast inside the tubular piston rod that is particularly suited to higher thrust uses of the reconfigurable piston where a higher linear acceleration may overcome other retention means.

In certain embodiments the tubular piston rod is internally threaded to receive the end plates. This allows the end plates can be screwed into the rod-body to urge against any contained ballast, to give a greater degree of control over the position of the ballast inside the piston rod. The end plates may comprise a recess or aperture into which a tool such as a screwdriver or allen key can be placed to facilitate screwing and unscrewing.

In some embodiments the threads of the tubular piston rod extend along the entirety of its length, giving a greater range of positions for securing ballast inside the piston rod.

In particular embodiments of the reconfigurable piston, rod ballast is provided received into the tubular rod-body. The rod ballast is intended to be removable and may be provided as granular ballast, solid disc masses, but more preferably is provided in the form of interlocking weights. Interlocking weights will not flow or separate and collide during use of the piston rod. Each weight may comprise a recess at a first end, and a protrusion at a second end (opposite the first end) for being received into the recess of an adjacent weight. This restricts the relative lateral movement of the weights in use. Even more preferable is that the recesses and protrusions of the interlocking weights are threaded to cooperate. This restricts longitudinal motion or separation of the weights inside the piston rod such that the weights essentially become one mass in use. The interlocking weights may in some

embodiments be conformal to the tubular rod-body such that their motion during use is further constrained.

Preferred embodiments of the reconfigurable piston are suitable for use in a piston actuator of a soft projectile launching device. The soft projectile launching device may be an airsoft gun and therefore the reconfigurable piston would be sized to fit an airsoft gun, and be used with the corresponding piston propulsion system (for instance spring means or high pressure gas). By being able to adjust the mass of a piston the 'joule creep' behaviour can be mitigated because the acceleration of the piston driving a projectile can be adjusted. Furthermore by allowing removable ballast to be held within the piston rod, the removable ballast is protected from any external friction effects (for instance air resistance or resistance from the gun barrel), and the overall diameter of the piston rod is maintained (maximising strength and rigidity of the piston rod, or in some embodiments maintaining the working area of the piston itself).

According to a second aspect of the invention there is provided a piston actuator comprising the reconfigurable piston of the first aspect of the invention, and spring means attached to the piston rod. By containing removable ballast inside the piston-rod, the ballast will not affect the interaction of the spring means with the exterior surface of the piston rod. Such a piston actuator can be reconfigured by the addition or removal of ballast inside the tubular piston rod, to be tailored to different applications or uses. The spring means may comprise a coiled spring. Coiled springs are relatively cheap to manufacture, and can be manufactured to have a predetermined spring strength.

According to a third aspect of the invention there is provided a method of manufacturing a piston for use in a piston actuator, comprising the steps of providing a tubular piston rod; locating a predetermined quantity of removable ballast inside the tubular piston rod; and then securing the removable ballast inside the tubular piston rod using retention means, such that a piston having a predetermined mass can be manufactured. Using this method, a piston can be configured with a high degree of fidelity without compromising the overall diameter and strength of the piston.

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:

Figure 1 illustrates in perspective view an embodiment of a reconfigurable piston;

Figure 2 illustrates in exploded perspective view the embodiment in Figure 1; and

Figure 3 illustrates in perspective view an embodiment of a piston actuator.

Detailed Description

Figure 1 shows in perspective view an embodiment of a reconfigurable piston 10 comprising a tubular piston rod 11 containing removable ballast 13. The removable ballast 13 is secured inside the piston rod 11 by end plates 12a and 12b screwed into the tubular piston rod 11 at respective ends, so as to urge against removable ballast 13. The piston 10 is formed of a hardened plastic material, with the removable ballast 13 also being formed from hardened plastic.

Figure 2 shows the embodiment in Figure 1 in exploded perspective view. Hollow tubular piston rod 11 is shown axially aligned with end plates 12a and 12b, and removable ballast 13. The removable ballast 13 is shown as interlocking weights 13a, 13b and 13c. Each interlocking weight 13 has a protrusion 14 configured to fit inside a recess (not shown) in an adjacent interlocking weight 13. The interlocking weights 13a, 13b and 13c are all sized to be conformal to an interior surface of tubular piston rod 11. The interior surface of tubular piston rod 11 is threaded to cooperate with peripheral threads of the end plates 12.

In use a plurality of interlocking weights 13 are arranged inside tubular piston rod 11. End plates 12 are screwed into the piston rod 11 so as to urge against the interlocking weights 13. The piston rod 11 is then installed with a propulsion means for propelling the piston rod 11 such as a spring, into an airsoft gun barrel at the breech end. To readjust the piston 10, the process can be exercised in reverse to remove or insert additional interlocking weights 13.

Figure 3 illustrates an embodiment of a piston actuator comprising the reconfigurable piston 10 of Figures 1 and 2, attached to a larger diameter piston plate 15. Surrounding the tubular piston rod 11 of reconfigurable piston 10 is a coiled spring 16. The coiled spring 16 is substantially conformal to the exterior surface of piston rod 11 and abuts the piston plate 15. The coiled spring 16 is shown in an uncompressed state and has a length greater than the length of the tubular piston rod 11. In use the coiled spring 16 is compressed between the piston plate 15 and a separate surface (for instance the breech face of an airsoft gun) by pushing the piston plate 15 towards the separate surface. This creates spring tension. Upon releasing the piston plate 15, the piston plate 15 with piston 10 is urging away from the separate surface with a force that can then be usefully transferred.

The interlocking weights may additionally be threaded to cooperate with threads on the interior surface of the tubular piston rod. The threads on the tubular piston rod may extend the length of, or partway along, the piston rod. Some embodiments may not feature threads, instead relying on an interference fit of the end plates and/or the rod ballast. The rod ballast may be granular (for instance sand or coarser material). The materials used may be metal such as steel, and the lengths and diameter of the embodiments in the figures are indicative only and not intended to be limiting.

CLAIMS

1. A reconfigurable piston for use in a piston actuator, comprising a tubular piston rod into which rod ballast can be received, and retention means for securing the rod ballast within the tubular piston rod.
2. The reconfigurable piston of claim 1, wherein the retention means comprises first and second removable end plates attachable to the tubular piston rod, such that rod ballast can be held between the end plates.
3. The reconfigurable piston of claim 2, wherein the end plates and tubular piston rod are threaded to cooperate, such that the end plates can be attached to the tubular piston rod to retain the rod ballast there between.
4. The reconfigurable piston of claim 3, wherein the tubular piston rod is internally threaded to receive the end plates.
5. The reconfigurable piston of claim 4, wherein the threads of the tubular piston rod extend along the entirety of its length.
6. The reconfigurable piston of any preceding claim, further comprising rod ballast received into the tubular rod-body.
7. The reconfigurable piston of claim 6, wherein the rod ballast comprises interlocking weights.
8. The reconfigurable piston of claim 7, wherein each of the interlocking weights comprises a recess at a first end, and a protrusion at a second end for being received into the recess of an adjacent weight.
9. The reconfigurable piston of claim 8, wherein the recesses and protrusions are threaded to cooperate.

10. The reconfigurable piston of claim 9, wherein the interlocking weights are conformal to the tubular rod-body.
11. The reconfigurable piston of any preceding claim, for use in a piston actuator of a soft projectile launching device.
12. A piston actuator comprising the reconfigurable piston of any preceding claim and spring means attached to the piston rod.
13. The piston actuator of claim 12, wherein the spring means comprises a coiled spring.
14. A method of manufacturing a piston for use in a piston actuator, comprising the steps of:
 - a) Providing a tubular piston rod;
 - b) Locating a predetermined quantity of removable ballast inside the tubular piston rod; and then
 - c) Securing the removable ballast inside the tubular piston rod using retention means, such that a piston having a predetermined mass can be manufactured.

AMENDED CLAIMS
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21 April 2020 (21.04.2020)

CLAIMS

1. A reconfigurable piston for use in a piston actuator, comprising a tubular piston rod into which rod ballast can be received, and retention means for securing the rod ballast within the tubular piston rod, wherein the retention means is arranged to be removable from the tubular piston rod such that the rod ballast can be adjusted.
2. The reconfigurable piston of claim 1, wherein the retention means comprises first and second removable end plates attachable to the tubular piston rod, such that rod ballast can be held between the end plates.
3. The reconfigurable piston of claim 2, wherein the end plates and tubular piston rod are threaded to cooperate, such that the end plates can be attached to the tubular piston rod to retain the rod ballast there between.
4. The reconfigurable piston of claim 3, wherein the tubular piston rod is internally threaded to receive the end plates.
5. The reconfigurable piston of claim 4, wherein the threads of the tubular piston rod extend along the entirety of its length.
6. The reconfigurable piston of any preceding claim, further comprising rod ballast received into the tubular rod-body.
7. The reconfigurable piston of claim 6, wherein the rod ballast comprises interlocking weights.
8. The reconfigurable piston of claim 7, wherein each of the interlocking weights comprises a recess at a first end, and a protrusion at a second end for being received into the recess of an adjacent weight.
9. The reconfigurable piston of claim 8, wherein the recesses and protrusions are threaded to cooperate.

10. The reconfigurable piston of claim 9, wherein the interlocking weights are conformal to the tubular rod-body.
11. The reconfigurable piston of any preceding claim, for use in a piston actuator of a soft projectile launching device.
12. A piston actuator comprising the reconfigurable piston of any preceding claim and spring means attached to the piston rod.
13. The piston actuator of claim 12, wherein the spring means comprises a coiled spring.
14. A method of manufacturing a piston for use in a piston actuator, comprising the steps of:
 - a) Providing a tubular piston rod;
 - b) Locating a predetermined quantity of removable ballast inside the tubular piston rod; and then
 - c) Securing the removable ballast inside the tubular piston rod using retention means, wherein the retention means is arranged to be removable from the tubular piston rod, such that a piston having a predetermined mass can be manufactured.

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Fig. 1

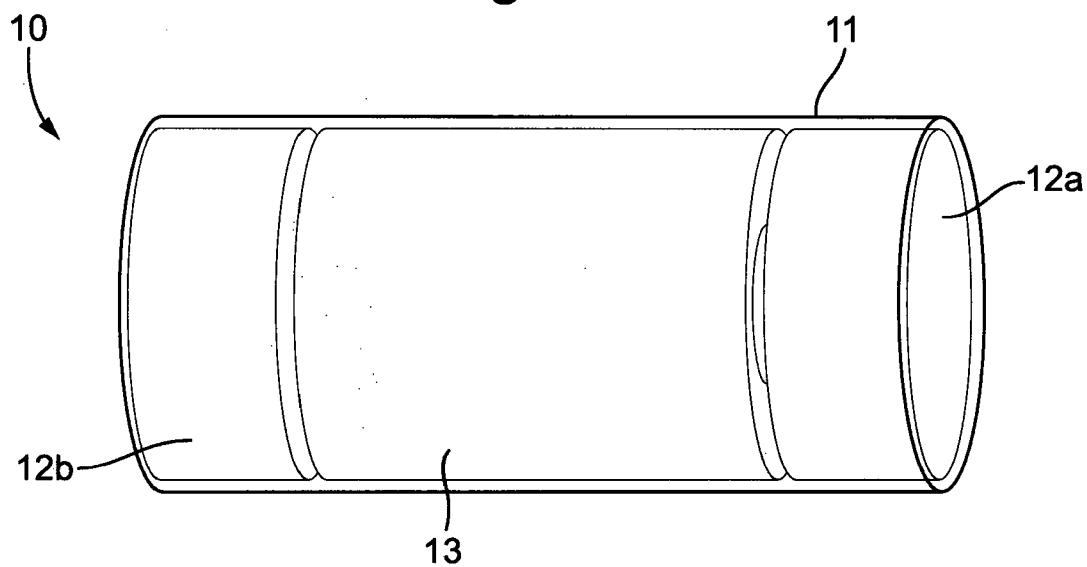
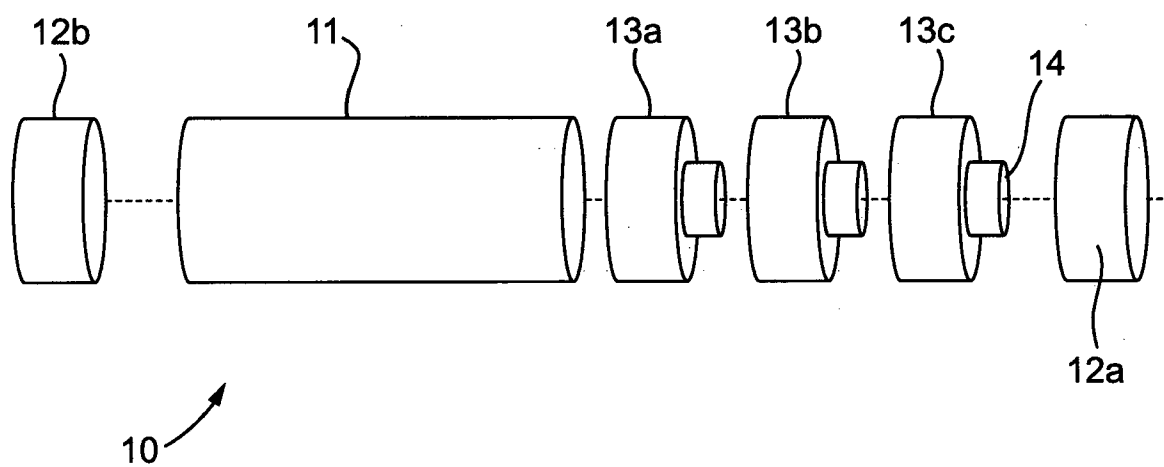
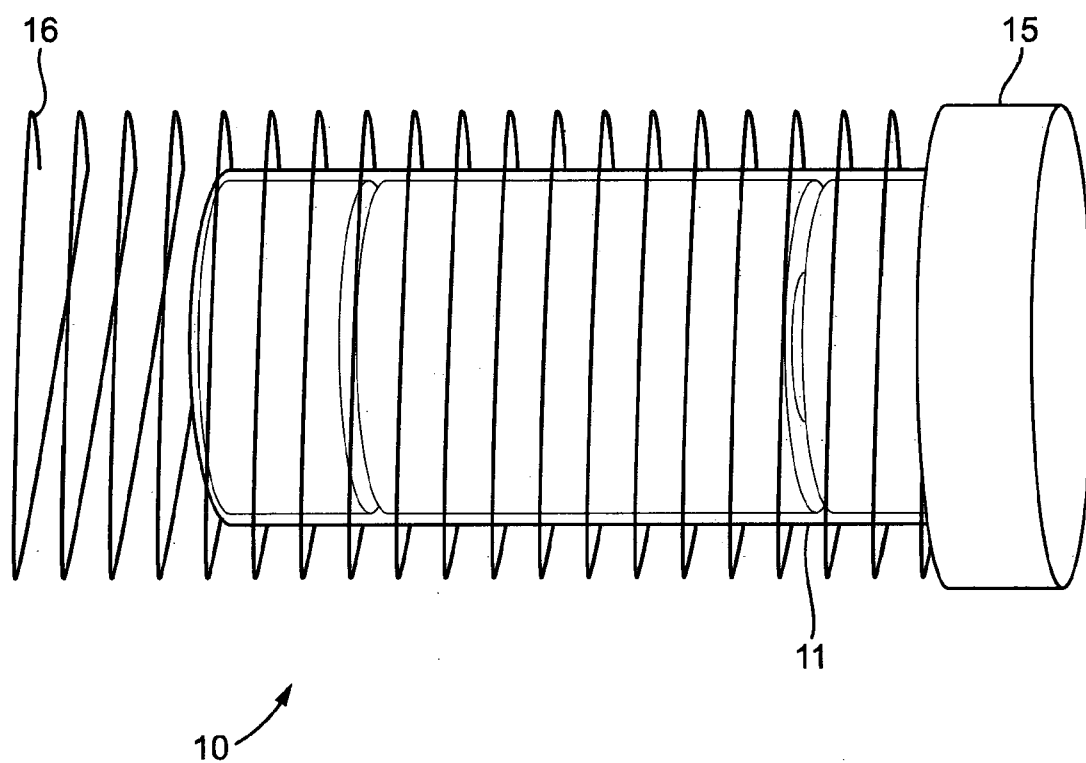


Fig. 2



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Fig. 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2019/000162

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16F9/02 F15B15/14 F16F9/32 F41B11/642
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)

F16F F16J F41B F15B F15D F42D

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2014/331855 A1 (HANSON P E JEFFREY [US]) 13 November 2014 (2014-11-13) page 3, paragraph 52; figure 4	1-4, 11-13 5-10,14
A	US 2018/208009 A1 (MCGUIRE MICHAEL E [US] ET AL) 26 July 2018 (2018-07-26) page 1, paragraph 18; figures 3,5,6	1,2,6, 11,14 3-5, 7-10,12, 13
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Kovács, Endre

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2019/000162

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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