



(51) International Patent Classification:

F15B 21/00 (2006.01)

F04B 11/00 (2006.01)

F16L 55/04 (2006.01)

(21) International Application Number:

PCT/EP2019/063480

(22) International Filing Date:

24 May 2019 (24.05.2019)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

201811019559

24 May 2018 (24.05.2018)

IN

1811418.1

12 July 2018 (12.07.2018)

GB

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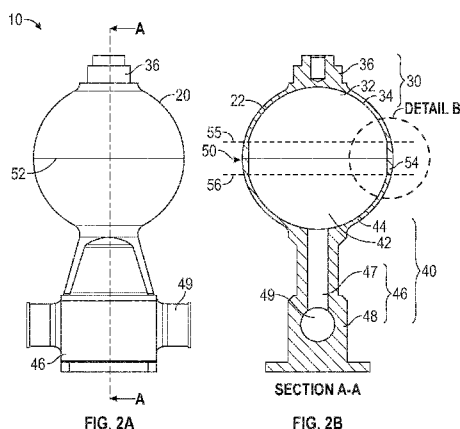
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

(54) Title: RIPPLE DAMPER



(57) Abstract: A ripple damper (10) for an aircraft hydraulic system is disclosed. The ripple damper (10) comprises a hollow, substantially spherical body (20) formed of first (34) and second (36) body portions the adjoining surfaces of which are connected at a join line (52) such that the body portions cooperatively define a substantially spherical fluid chamber (24). The body (20) further comprises a joining portion (50), the joining portion extending between first and second spaced apart parallel planes, the join line (52) being intermediate to said parallel planes. The internal diameter of the substantially spherical fluid chamber (24) is constant within the joining portion (52) such that the joining portion (52) has a locally cylindrical inner wall (54).

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Ripple Damper

5 FIELD OF INVENTION

The present invention relates to a ripple damper for an aircraft hydraulic system. In particular, the invention relates to a ripple damper for an aircraft fluid system. The invention also relates to an aircraft hydraulic system, or an aircraft fluid system, including a ripple damper and an aircraft structure including a ripple damper.

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BACKGROUND OF INVENTION

Aircraft hydraulic systems generally comprise a ripple damper in line with the fluid flow. Ripple dampers may also be known as pulsation dampers, hydraulic pressure resonance suppressors, and hydraulic attenuators. The ripple damper acts to allow the volume of the fluid system to change slightly and absorb pulses or ripples generated by a pump or other components within the system.

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A ripple damper is generally used to maintain constant fluid flow in a hydraulic system. Such ripple dampers are designed to reduce fluid pressure pulsations generated by equipment within the system, for example, aircraft hydraulic pumps. These pulsations can otherwise lead to system damage; for example, damage may result in check valve failure, tubing or hose rupture, loosened connections and cracked manifolds. In addition to the potential for system failure, hydraulic pressure pulsations can dramatically increase noise levels within the aircraft cabin. Ripple dampeners contain no moving parts and require no servicing. Ripple Dampers are designed to

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minimize the effects of hydraulic line vibration. In aircraft, such vibrations may be caused by cavitation, fluid momentum effects, and variations in pump output. Dampers may be designed around the principle of Helmholtz resonance, which describes the harmonic frequencies generated when pressure is increased in a cavity. Thus, a ripple damper creates a cavity that
5 “cancels” offending pulsations. By reducing line vibration, ripple dampers also decrease audible noise and have been found to increase component life.

The damper housing is typically spherical. The damper housing is attached to a base which includes an arrangement for connection to a hydraulic system. The spherical fluid chamber
10 defined by the housing comprises a fluid inlet on the side of the fluid chamber. A constant wall thickness is provided by the housing between the inlet and the valve. For ease of manufacture, the housing is typically formed in two generally hemispherical sections. The housing sections are attached around a circumferential join to form the chamber of the damper.

As ripple dampers are used in aircraft, they must be manufactured to precise tolerances and their
15 weight must be minimised.

There is a desire to provide an improved ripple damper design which may provide one or more of the following advantages: increased fatigue life; ease of manufacture (including, for example, simplified joining of the body portions and/or reduction in weld spatter) and relatively low
20 weight. Embodiments of the present invention seek to provide a ripple damper for an aircraft hydraulic system provide one or more of the above advantages in comparison to conventional aircraft hydraulic system ripple dampers.

SUMMARY OF INVENTION

Accordingly, in one aspect of the invention, there is provided a ripple damper for an aircraft

5 hydraulic system comprising:

a hollow, substantially spherical body formed of first and second body portions the adjoining surfaces of which are connected at a join line such that the body portions cooperatively define a substantially spherical fluid chamber; wherein

the body further comprises a joining portion, the joining portion:

10 extending between first and second spaced apart parallel planes, the join line being intermediate to said parallel planes, and wherein

the internal diameter of the substantially spherical fluid chamber is constant within the joining portion such that the joining portion has a locally cylindrical inner wall.

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In accordance with a second aspect of the invention, there is provided a ripple damper for an aircraft hydraulic system comprising:

a hollow, substantially spherical body that defines a substantially spherical chamber having a first and second end;

20 a base disposed at one of the ends of the body, the base comprising:

a fluid inlet; and

a fluid pipe bracket adapted to connect the ripple damper to an aircraft hydraulic system;

wherein the body comprises a central portion extending between first and second spaced apart parallel planes and wherein the internal diameter of said central portion is constant such that a locally cylindrical inner wall is defined in said central portion.

5 In a third aspect of the invention, a ripple damper for an aircraft hydraulic system comprises:

a chamber which, in use, is in fluid communication with the fluid of the hydraulic system,

the chamber having an internal profile which is initially spherical at a first end, transitions to a cylindrical internal profile around a central portion and then transitions back to a spherical internal profile at the other end of the damper; and wherein

10 the chamber is formed of first and second body portions and the central portion includes a join between the first and second body portions.

Embodiments of the invention are particularly suitable for use in an aircraft fluid system.

15 It will be appreciated that a damper in accordance with embodiments of the invention will not have an internal chamber profile which is fully spherical as seen with existing dampers. In embodiments of the invention, it can be noted that the damper has a chamber having an internal profile (defined by the inner surface of the damper chamber) is from one end initially spherical, transitions to a cylindrical internal profile around a central portion and then transitions back to a spherical internal profile at the other end of the damper. The skilled person will appreciate that,
20 in contrast, a conventional ripple damper may follow a typical Helmholtz design having a fully spherical internal and external surface profile with a constant wall thickness.

Advantageously, the cylindrical internal surface at and adjacent to the join has been found to assist precision keyhole Electron beam. Thus, embodiments of the invention may provide a reduction in weld spatter and/or the need for subsequent manufacturing processes for removal of undesirable weld splutter. As such, embodiments of the invention may provide a reduced weight damper whilst maintaining a high fatigue life.

One of the body portions may further comprises a base disposed at an end of the body. The base may base comprising: a fluid inlet; and a fluid pipe bracket. The pipe bracket may be adapted to connect the ripple damper to an aircraft hydraulic system.

The joining portion may be generally central relative to first and second ends of the substantially spherical body. The joining portion may comprise a circumferential band extending around the middle of the spherical body.

The first and second body portions are substantially hemispherical.

The external diameter of the joining portion may be non- constant. The external surface of the body may be spherical. The external profile of the body may have a continuous spherical profile extending from the first end of the body, through the joining portion to the second end of the body.

The adjoining surfaces of the first and second body portions may be connected by means of electron beam welding.

The joining portion may extend equally above and below the join line.

The chamber may comprise a spherical internal wall outside of the joining portion.

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The fluid chamber is fed by the fluid inlet at the second end of the body. The fluid inlet may be fed by the fluid pipe.

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The cylindrical inner wall may have a height of between 15 and 25% of the internal radius of the spherical portion of the chamber.

According to a further aspect of the invention, there is provided a method of making a ripple damper as disclosed herein, wherein the body sections are assembled together and attached by means of electron beam welding.

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The base may comprise threaded holes for attachment to the aircraft structure.

A further aspect of the invention may comprise an aircraft hydraulic system may include a ripple damper as described herein.

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A yet further aspect may comprise an aircraft structure comprising a hydraulic system including a ripple damper as described herein.

Whilst the invention has been described above, it extends to any inventive combination set out above, or in the following description or drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be performed in various ways, and an embodiment thereof will now be described by way of example only, reference being made to the accompanying drawings, in which:

10 Figure 1A shows a three-dimensional schematic view of the ripple damper in accordance with an embodiment in use in an aircraft hydraulic system;

 Figure 1B shows a cutaway view of the ripple damper;

 Figure 2 shows the ripple damper (A), as section view (B) across section A-A, and a detail view (C) of detail B; and

15 Figure 3 shows the ripple damper in use attached to an aircraft fluid pipe.

DETAILED DESCRIPTION OF THE DRAWINGS

Figure 1 shows the ripple damper 10 comprising a body 20 and a base 46. The ripple damper 10 is
20 formed of two body sections 30 and 40 which meet at a join line 52. Figure 2A shows a side view of the ripple damper 10 running perpendicular to the pipe of the aircraft hydraulic system. Figure 2B shows a section view (B) across line A-A, and figure 2C shows a detail view of the cylindrical profile. The ripple damper 10 is divided into a first section 30 and a second section 40. For

convenience, the terms upper and lower may be used herein to refer to parts of the damper 10; it will be appreciated that such terms are not limiting the damper to any specific orientation in use and lower merely means the parts proximal to the base 46.

5 Each of the body portions 30 and 40 define approximately half of the damper body 20 and, for example, include substantially hemispherical body portions 34 and 44. When joined together the body portions 34 and 44 cooperatively define the chamber 24 of the ripple damper 10. The chamber 24 is therefore formed of a first chamber portion 32, defined by the internal wall 22 of the body portion 34, and a second chamber portion 42, defined by the inner wall 22 of the body
10 portion 44.

The first section 30 comprises the gas chamber 32, the first body portion 34 and the tip 36. The top 35 forms the uppermost portion of the body 20. The tip 36 is diametrically opposed to the base 46. The tip 36 may include a threaded bore (or other attachment means) to provide
15 structural support for installation purposes.

The second section 40 comprises the fluid chamber 42, the second body portion 44, the base 46, the fluid inlet 47 and the fluid pipe bracket 48. The base 46 comprises a fluid inlet 47 and a fluid pipe bracket 48 adapted for connection to a pipe within the aircraft fluid system. The fluid inlet
20 47 and pipe bracket 48, are best seen in the cutaway three-dimensional view of the ripple damper 10 in Figure 1B. The base 46 may also include a number of bolt holes to allow structural support of the damper 10 for installation purposes. Thus, the damper may generally be supported at both ends in use.

The ripple damper body 20 is substantially spherical between the tip 36 and the base 46.

5 The first section 30 and the second section 40 meet at the join line 52. The join line 52 is circumferentially extending and is formed at the adjoining surfaces of the body portions 34, 44. In the illustrated embodiment the join line is centrally located between the ends of the body 20 (as such the join line is a great circle and/or may be considered to at the equator of the sphere defined by the body 20). The join between the body portions is attached by welding, particularly by means of electron beam welding.

10 The join line 52 bisects the chamber 24 such that a first chamber portion 32 is defined by the first body portion 34, and a second fluid chamber 42 is defined by the second body portion 44. It may be noted that, as shown in figure 2C, there is a distinct central/joining portion 50 of the body 20 positioned around the join line 52. The central/joining portion 50 extends above and below the
15 join line 52 between the body portions 30 and 40 from a first plane 55 to a parallel spaced apart second plane 56. The first 55 and second 56 planes bounding the central portion 50 are perpendicular to the join line 52. The diameter of the central inner wall 54 in the central portion 50 is constant such that the internal wall in the central portion is locally cylindrical. In other words, the central portion 50 has a cylindrical inner profile. The internal wall 22 of the body on
20 either side of the central portion 50 is spherical. The height of the central portion (between the planes 55 and 56) is only a small percentage of the internal radius of the chamber 24. For example, the height may be between 15 and 25% of the internal radius of the spherical portion of the chamber (for example the illustrated embodiment has a height of approximately 19% of the radius). As such, whilst the chamber 24 is not fully spherical embodiments of the invention it may

be considered to provide a substantially spherical chamber 24. For example, the chamber 24 may be sufficiently spherical to ensure that an appropriate resonance damping response is provided in use and may therefore be considered to be equivalent to a true spherical chamber for the hydraulic system.

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Figure 3 shows the ripple damper 10 in use within an aircraft hydraulic system. The ripple damper 10 is attached to a fluid pipe 60 of the system at the pipe bracket inlet 49 such that the fluid can flow into the ripple damper 10 via the pipe bracket inlet 49. The fluid chamber 42 is fed by the fluid inlet 47 which, in turn, is fed by the pipe bracket inlet 49 (which is adapted to connect to a fluid pipe in use).

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Whilst the invention has been described above with reference to preferred embodiments, it will be appreciated that various changes or modifications may be made without departing from the scope of the invention as defined in the appended claims.

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CLAIMS

1. A ripple damper for an aircraft hydraulic system comprising:

a hollow, substantially spherical body formed of first and second body portions the adjoining surfaces of which are connected at a join line such that the body portions cooperatively
5 define a substantially spherical fluid chamber; wherein

the body further comprises a joining portion, the joining portion:

extending between first and second spaced apart parallel planes, the join
line being intermediate to said parallel planes, and wherein

the internal diameter of the substantially spherical fluid chamber is constant
10 within the joining portion such that the joining portion has a locally cylindrical inner
wall.

2. A ripple damper as claimed in claim 1, wherein one of the body portions further comprises a
base disposed at an end of the body, the base comprising: a fluid inlet; and a fluid pipe bracket
15 adapted to connect the ripple damper to an aircraft hydraulic system.

3. A ripple damper as claimed in 1 or 2, wherein the joining portion is generally central relative
to first and second ends of the substantially spherical body.

20 4. A ripple damper as claimed in claim 3, wherein the first and second body portions are
substantially hemispherical.

5. A ripple damper as claimed in any preceding claim, wherein the external diameter of the joining portion is not constant.

5 6. A ripple damper as claimed in any preceding claim, wherein the external surface of the body is spherical.

7. A ripple damper as claimed in claim 6, wherein the external profile of the body has a continuous spherical profile extending from the first end of the body, through the joining portion to the second end of the body.

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8. A ripple damper as claimed in any preceding claim, wherein the adjoining surfaces of the first and second body portions are connected by means of electron beam welding.

15 9. A ripple damper as claimed in any preceding claim, wherein the joining portion extends equally above and below the join line.

10. A ripple damper as claimed in any preceding claim, wherein the chamber comprises a spherical internal wall outside of the joining portion.

20 11. A ripple damper as claimed in any preceding claim, wherein the fluid chamber is fed by the fluid inlet at the second end of the body.

12. A ripple damper as claimed in any preceding claim, wherein the fluid inlet is fed by the fluid pipe.

13. A ripple damper as claimed in any preceding claim, wherein the cylindrical inner wall has a height of between 15 and 25% of the internal radius of the spherical portion of the chamber.

14. A method of making the ripple damper of the preceding claims wherein the body sections are assembled together and attached by means of electron beam welding.

15. An aircraft hydraulic system including a ripple damper in accordance with any preceding claim.

16. An aircraft structure comprising a hydraulic system including a ripple damper in accordance with any preceding claim.

17. A ripple damper for an aircraft hydraulic system comprising:

a hollow, substantially spherical body that defines a substantially spherical chamber having a first and second end;

a base disposed at one of the ends of the body, the base comprising:

a fluid inlet; and

a fluid pipe bracket adapted to connect the ripple damper to an aircraft hydraulic system;

wherein the body comprises a central portion extending between first and second spaced apart parallel planes and wherein the internal diameter of said central portion is constant such that a locally cylindrical inner wall is defined in said central portion.

5 18. A ripple damper for an aircraft hydraulic system, the ripple damper comprising:

 a chamber which, in use is in fluid communication with the fluid of the hydraulic system,

 the chamber having an internal profile which is initially spherical at a first end, transitions to a cylindrical internal profile around a central portion and then transitions back
10 to a spherical internal profile at the other end of the damper; and wherein

 the chamber is formed of first and second body portions and the central portion includes a join between the first and second body portions.

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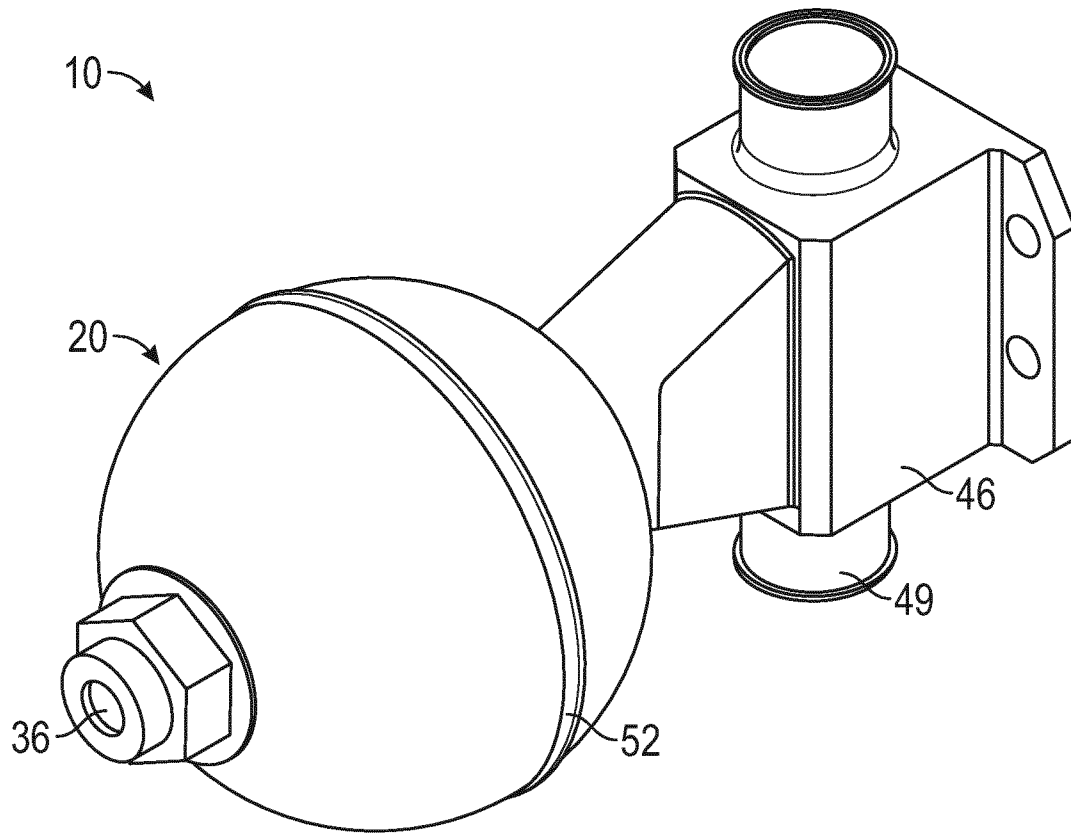


FIG. 1A

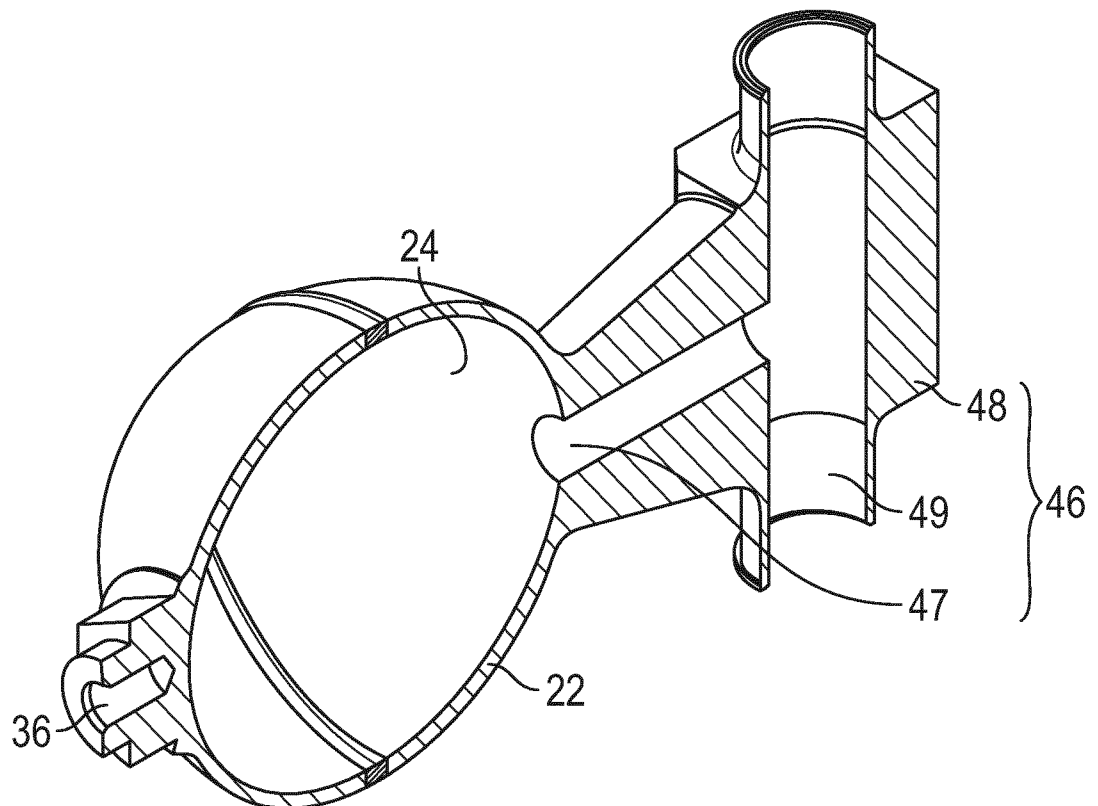


FIG. 1B

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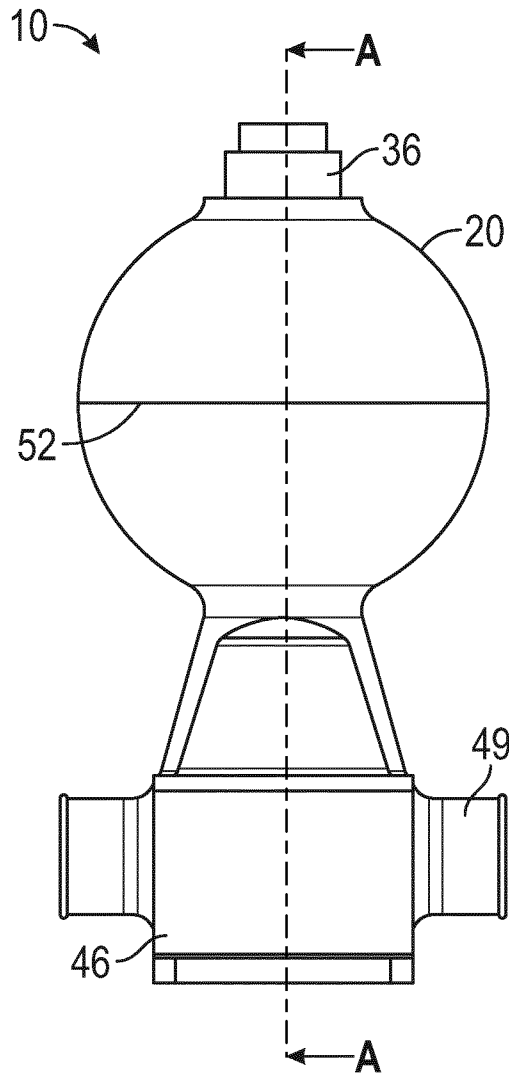


FIG. 2A

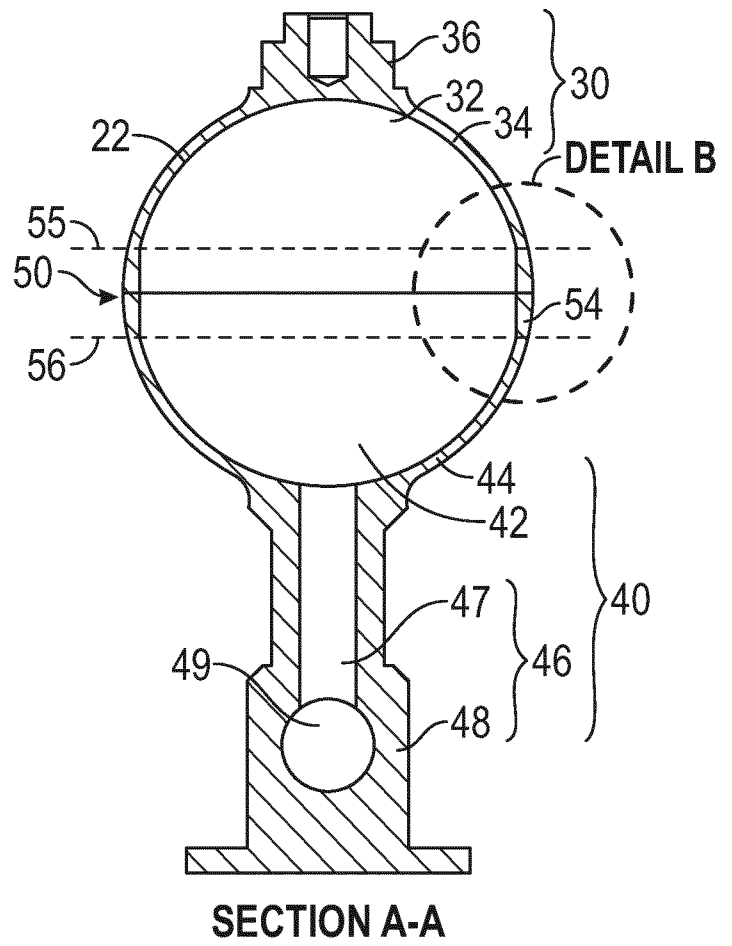
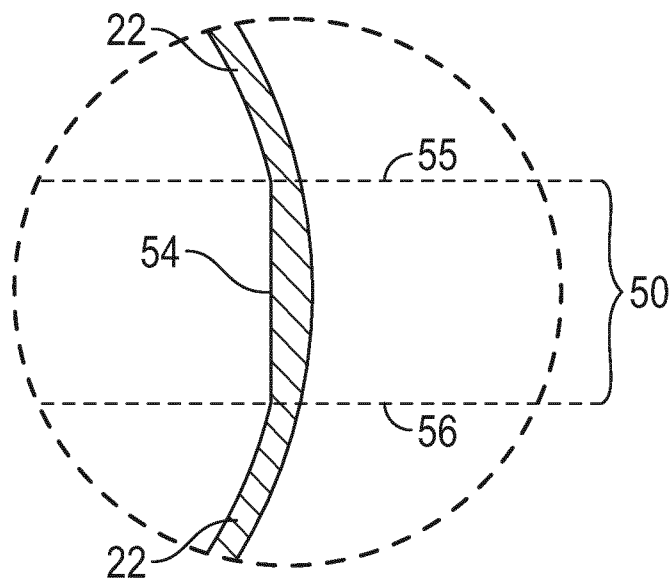


FIG. 2B



DETAIL B

FIG. 2C

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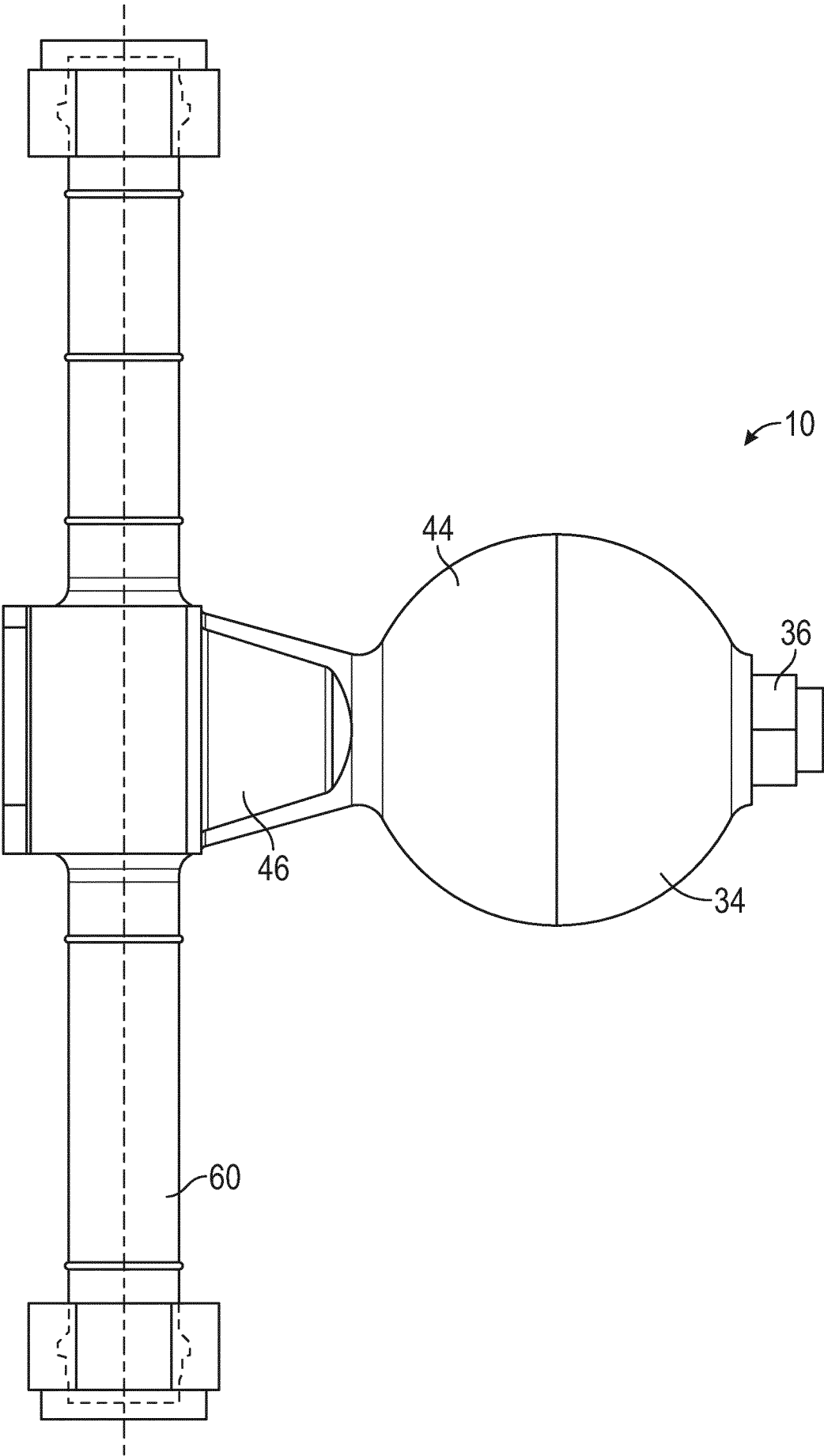


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/063480

A. CLASSIFICATION OF SUBJECT MATTER

INV. F15B21/00 F16L55/04 F04B11/00
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)

F15B F16L F04B

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.
X	DE 15 25 730 A1 (LANGEN & CO) 8 January 1970 (1970-01-08) figure 1 -----	1-4,8-18
X	US 4 117 866 A (BOHM GERHARD ET AL) 3 October 1978 (1978-10-03) figure 1 -----	1-4,8-18
X	US 3 146 796 A (EVERETT WILHEM S) 1 September 1964 (1964-09-01) figure 4 -----	1-18
X	DE 102 17 080 C1 (HYDAC TECHNOLOGY GMBH [DE]) 7 August 2003 (2003-08-07) figure 1 -----	1-4,8-18
A	DE 32 09 296 A1 (BALCKE DUERR AG [DE]) 29 September 1983 (1983-09-29) the whole document -----	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

11 September 2019

Date of mailing of the international search report

23/09/2019

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/063480

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 1525730	A1	08-01-1970	NONE
US 4117866	A	03-10-1978	DE 2356796 A1 15-05-1975 FR 2250925 A1 06-06-1975 JP S5080243 A 30-06-1975 US 4117866 A 03-10-1978
US 3146796	A	01-09-1964	NONE
DE 10217080	C1	07-08-2003	NONE
DE 3209296	A1	29-09-1983	NONE