



(51) International Patent Classification:

F16L 9/18 (2006.01) F16L 11/20 (2006.01)
F02M 37/00 (2006.01) F16L 55/027 (2006.01)
F02M 55/04 (2006.01) F16L 55/04 (2006.01)
F16C 7/00 (2006.01)

(21) International Application Number:

PCT/EP2023/066851

(22) International Filing Date:

21 June 2023 (21.06.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: WÄRTSILÄ FINLAND OY [FI/FI]; Järvikatu 2-4, 65100 Vaasa (FI).

(72) Inventors: VUOHIJOKI, Antti; c/o Wärtsilä Finland Oy, Järvikatu 2 - 4, 65100 Vaasa (FI). HÖGHOLM, Daniel Lars-Bertel; c/o Wärtsilä Finland Oy, Järvikatu 2 - 4, 65100 Vaasa (FI).

(74) Agent: GENIP OY; Heikinkatu 7, 48100 Kotka (FI).

(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, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, 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, ME, 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).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

(54) Title: A DOUBLE-WALL PIPE FOR TRANSFERRING HIGH-PRESSURE FUEL AND A FUEL SYSTEM OF AN INTERNAL COMBUSTION PISTON ENGINE

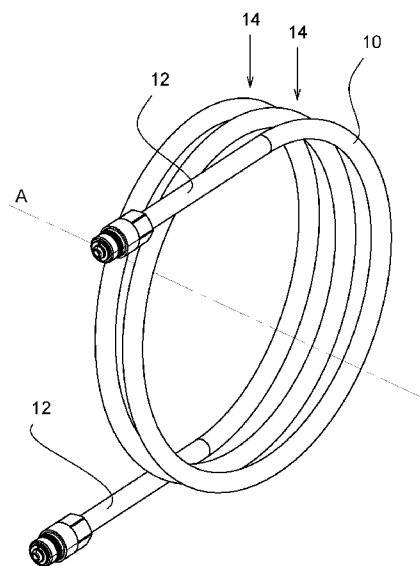


Fig. 1

(57) Abstract: Invention relates to a double-wall pipe (10) for transferring high-pressure fuel, comprising a first pipe (402) forming a fluid flow channel (404) inside the first pipe and a second pipe (406) arranged coaxially around the first pipe, wherein the double-wall pipe (10) comprises at least two loops of the double-wall pipe (10) around an axis, and the double-wall pipe (10) comprise a variable pitch.

Published:

- *with international search report (Art. 21(3))*
- *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

A double-wall pipe for transferring high-pressure fuel and a fuel system of an internal combustion piston engine

Technical field

5 [001] The present invention relates to a double-wall pipe for transferring high-pressure fuel, comprising a first pipe forming a fluid flow channel inside the first pipe and a second pipe arranged coaxially around the first pipe according to the preamble of claim 1.

10 [002] The present invention relates to a fuel system of an internal combustion piston engine according to the preamble of the second independent claim.

Background art

[003] Combustion of fuel in internal combustion engines requires high injection pressure of the fuel in order to achieve efficient combustion which results in low
15 emissions. Therefore, the fuel needs to be supplied at high pressure, which set high demands to the fuel delivery pipes. The engine, when in operation, tends to vibrate, and also the fuel which is flowing in the fuel delivery pipe is subject to pressure pulsation. Vibrations at relatively high frequency range are prevailing due to typical engine behaviour. This in turn poses a risk for fuel delivery pipe
20 vibration. Vibration is harmful because over time that will increase fatigue of the pipe material as well. Another problem is oscillation at relatively low frequency due to nature of ship movement in rough seas, when the engine is installed in a marine vessel.

[004] There is an increasing need for large internal combustion engines, such
25 as ship and power plant engines, that can be operated using other types of fuel than conventional liquid fuels, such as light fuel oil or heavy fuel oil. Alternative fuels can be either liquid fuels, such as methanol or ammonia, or gaseous fuels, such as natural gas or hydrogen.

[005] The use of alternative fuels helps reducing carbon dioxide and other emissions of the engines. However, the use of alternative fuels also poses many challenges. For instance, leakages of gaseous fuels pose a much more serious safety risk than leakages of liquid fuels with high flash point. Also, some fuels, such as methanol, can be more toxic than conventional fuels, such as light fuel oil.

[006] In many cases, the use of alternative fuels causes a need for extra safety measures. A common safety measure to address both the risk of fires and vapour poisoning is to use double-walled pipes for conveying fuel and contain the high-pressure supply unit inside a dedicated and ventilated room or compartment.

10 This way a high-pressure fuel supply device becomes too bulky to be placed on the engine, but instead it needs to be placed externally from engine. By the nature of engine movement in sea-sailing vessels, development of a fuel pipe that complies with safety standards in addition to being able to withstand relative motion between engine and external high-pressure fuel system connection points is

15 needed.

[007] Winding a pipe into a spiral is known as such for example from publication US 10157690B2, in which a pipe is provided with spiral sections for obtaining possibility to expand length and direction of the pipe by such spiral sections.

[008] EP2878804A1 discloses a fluid damper comprising a tubular member within which flows the fluid. The tubular member is shaped to be flexible and to provide a degree of freedom amortizing hydraulic waves propagating in said tubular member. The shape of the tubular member can be a coil spring, or a serpentine made of a series of U-shaped section or V, or square, or sinusoid or other or any combination of said shapes.

25 [009] US3245431A discloses an extensible, coiled, fluid transmission line means for transmitting actuating fluid for use, for instance, between relatively movable parts of a mechanism.

[0010] US3402743A discloses a piping used to carry fluid under pressure which has a helical section which permits oscillation along the axis of the helix as well

30 as pivotal movement in a plane perpendicular to the axis of the helix. One of the ends of the helix extends inwardly to the axis thereof and then extends outwardly

on that axis so that only simple stress is present even when the end is connected to a member which pivotally oscillates.

[0011] US8038178B2 discloses a high-pressure fuel pipe construction for an internal combustion engine, such as a direct injection engine. In order to dampen vibrations of the fluid conduit, the fluid conduit also preferably includes a loop between its ends. A dampener made of a resilient material, such as an elastomeric material, is then attached to the loop.

[0012] US7228846B2 discloses an apparatus for damping pressure pulsations and attenuating noise transmission in a fuel supply system. The apparatus includes a first end in fluid communication with a fuel supply line, a second end in fluid communication with a manifold, and a body that couples in fluid communication the first and second ends. The body includes a tube that is arranged in a helix around a central axis.

[0013] These may as such provide remedy to vibrations at least to some extent, but there is a need to improve attenuation of vibrations in fuel supply line of an internal combustion engine.

[0014] An object of the invention is to provide a double-wall pipe for transferring high-pressure fuel in which attenuation of vibration is considerably improved compared to the prior art solutions.

20

Disclosure of the Invention

[0015] Objects of the invention can be met substantially as is disclosed in the independent claims and in the other claims describing more details of different embodiments of the invention.

25 [0016] A double-wall pipe for transferring high-pressure fuel according to the invention comprises a first pipe forming a fluid flow channel inside the pipe and a second pipe arranged coaxially around the first pipe, further comprising at least two loops of the double-wall pipe around an axis, wherein the double-wall pipe comprises section with a variable pitch.

[0017] This way the double-wall pipe forms a helix which provides a double-wall pipe effectively attenuating vibrations in the double-wall pipe. When the pitch is variable, it is not constant, but it has a changing pitch between the ends of the double-wall pipe. Providing variable pitch to the coiled double-wall pipe disturbs the natural frequency phenomena by having continuously change in the pitch. Having a continuously changing pitch helps to reduce peak oscillation amplitude in double-wall pipe normally caused by component natural frequency.

[0018] According to an aspect of the invention the pitch changes in continuous manner, preferably in linear manner.

10 [0019] There is a space, substantially an annular space formed between the first pipe and the second pipe, and the pipe aggregate is therefore called as a double-wall pipe. A double-wall pipe is provided with continuously changing variable pitch coil section according to the invention is particularly advantageous for transferring high-pressure fuel to an internal combustion piston engine because it at-
15 tenuates effectively vibrations caused by natural frequencies of the engine when in operation.

[0020] According to an aspect of the invention the double-wall pipe comprises at least three sections having a first section with an average first pitch, a second section with an average second pitch and a third section with the average first
20 pitch.

[0021] According to an aspect of the invention the second section is between the first section and the third section. In other word the first and the third sections may be called end section and the second section a middle section, wherein the end sections have a shared average pitch which deviates from the middle section
25 average pitch.

[0022] According to an aspect of the invention the average second pitch is greater than the average first pitch.

[0023] According to an aspect of the invention the double-wall pipe is of a helix form and the first section, the second section and the third section are arranged
30 between a fourth section and a fifth section, which fourth section and fifth section have zero pitch.

[0024] According to an aspect of the invention the second section is between the first section and the third section, and the first section is provided with linearly increasing pitch with a first slope, the second section comprises a portion with linearly decreasing pitch with a second slope and a portion with linearly increasing pitch with a third slope, and the third section is provided with linearly decreasing pitch with a fourth slope.

[0025] Preferably, the average first pitch of the first section equals to the average third pitch third section, the average second pitch is greater than the average first pitch and the third section are arranged between a fourth section and a fifth section, which fourth section and fifth section have zero pitch.

[0026] Being a fuel feeding double-wall pipe, the double-wall pipe preferably is designed to endure a peak pressure more than 2000 bar, is designed to endure temperature more than 100 °C and/or is made of steel.

[0027] According to an aspect of the invention the loops form a constant diameter helix around a central axis.

[0028] According to an aspect of the invention double-wall pipe has a start point and an end point and a middle point, wherein the variable pitch between the middle to the start point and pitch between the middle to the end point is symmetrical.

[0029] A fuel system of an internal combustion piston engine according to the invention comprises a fuel supply device attached to a base external to the engine, the device having a first coupling for a fuel feeding double-wall pipe, and fuel admission equipment in the engine having a second coupling for a fuel feeding double-wall pipe, wherein the fuel feeding double-wall pipe is arranged between the first coupling and the second coupling and the fuel feed double-wall pipe system comprises a double-wall pipe according to the invention.

[0030] When the fuel supply device, comprising a high-pressure fuel pump unit capable of rising the fuel pressure to required fuel admission pressure, is externally to engine, for example in a ventilated and fire-proof compartment, an improved safety in fuel handling is achieved.

[0031] The invention provided inter alia following general effects.

[0032] Having the high-pressure (e.g. up to 2000 bar) fuel supply device placed externally from the engine causes challenges in terms of relative motion between engine fuel supply connection and external fixing point which are now solved by the invention.

- 5 [0033] Flexible high-pressure fuel double-wall pipe according to the invention with continuous variable pitch avoids or at least minimizes natural frequencies in wide range. The double-wall pipe according to the invention does not have a distinct a single specific natural frequency but rather variable natural frequency.

- 10 [0034] In this context, unless otherwise stated specifically, the feature *double-wall pipe* means a double-wall pipe as an entity from its one end to second end, or a section of a double-wall pipe system which may include other portions of double-wall pipe system integrally or removably attached to one or both ends of the double-wall pipe. Pitch is a positive number more than zero, unless specifically stated otherwise.

- 15 [0035] The exemplary embodiments of the invention presented in this patent application are not to be interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" is used in this patent application as an open limitation that does not exclude the existence of also unrecited features. The features recited in dependent claims are mutually freely combinable unless
20 otherwise explicitly stated. The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims.

Brief Description of Drawings

- [0036] In the following, the invention will be described with reference to the accompanying exemplary, schematic drawings, in which
25 Figure 1 illustrates a double-wall pipe for transferring high-pressure fuel according to an embodiment of the invention,
Figure 2 illustrates a view of the double-wall pipe of the figure 1 seen in front,
Figure 3 illustrates a section II-III of the figure 2,
30 Figure 4 illustrates a detail 4 in the figure 3,

Figure 5 illustrates a double-wall pipe for transferring high-pressure fuel according to an embodiment of the invention,

Figure 6 illustrates a fuel system of an internal combustion piston engine and,

Figure 7 illustrates an example of a pitch in the double-wall pipe.

5

Detailed Description of Drawings

[0037] Figure 1 depicts schematically an embodiment of the invention. A double-wall pipe 10 is arranged for transferring high-pressure fuel from a source of high-pressure fuel to a fuel consumer, such as an internal combustion engine arranged to a marine vessel or a land-based power plant. As it is disclosed in the figure 1 the double-wall pipe 10 comprises here two and a half loops 14 of the double-wall pipe around an axis A. It also becomes clear that the double-wall pipe, or the loops have a pitch, which means that a helix which is formed by the looping double-wall pipe has a height or an advance of one complete loop turn, measured parallel to the axis A of the helix. The double-wall pipe 10 is provided with coupling parts 12 at its both ends for attaching the double-wall pipe to a double-wall pipe system. The coupling parts 12 are formed of straight double-wall pipe extensions. The coupling parts may comprise suitable bends to direct the end of the coupling parts to a desired direction. Figure 2 discloses a view of the double-wall pipe 10 seen in front of the double-wall pipe loops, in the direction of the axis A. The double-wall pipe 12 has an outer diameter D_o . With a reference to the figure 4, which shows a detail 4 of the figure 3, i.e. a cross section of the double-wall pipe, the double-wall pipe 10 is comprised of a first pipe 402 forming a fluid flow channel 404 inside the first pipe 402 and a second pipe 406 arranged coaxially around the first pipe 402. In a double-wall pipe 10 an inner pipe 402 for conveying the fuel and an outer pipe 406 arranged coaxially around the inner pipe 402 to form an annular leakage space between the two pipes. The leakage space collects the fuel possibly leaking from the inner pipe 402 and allows both detecting leakages and conveying the leaking fuel to a safe place, such as a tank or outdoors. In case of a leakage and/or as a safety measure prior to service, the inner pipe and the leakage space can be purged using an inert gas, such as nitrogen.

[0038] The double-wall pipe is arranged into circular loops, the centre line of the double-wall pipe 10 forming a diameter of D_L . The diameter depends on the relative movement between double-wall pipe ends, number of loops and double-wall pipe diameter. In this particular embodiment the helix diameter D_L can be defined as 20 – 35 x double-wall pipe outer diameter D_o .

[0039] Now turning to figure 3, which show a section III-III of the figure 2, one sees more clearly that the double-wall pipe 10 has a variable pitch, having sections 16.1, 16.2, 16.3. It should be noted that in the figure 3 the advance in the direction of the axis A is shown for half of a loop. The number of different sections may vary such that there are at least three sections having a first section with an average first pitch, and a second section with an average second pitch, and a third section with the average first pitch or even more than three sections. In the embodiment shown in the figures the double-wall pipe 10 comprises three sections 16.1, 16.2, 16.3 having a first section 16.1 with an average first pitch, a second section 16.2 with an average second pitch and a third section 16.2 with an average third pitch. Preferably the pitch is changing dynamically between defined pitch points in a linear manner. The second section 16.2 is between the first section 16.1 and the third section 16.3, and the average first pitch 16.1' equals to the average third pitch 16.3' in this embodiment. It can also be seen that the average second pitch 16.2' is smaller than the average first pitch 16.1' and the average third pitch 16.3'. Preferably, the double-wall pipe further comprises a fourth section 16.4 and a fifth section 16.5, at both sides of the combined double-wall pipe part comprising the first section, the second section and the third section, which has zero pitch. In other words, the first section, the second section and the third section are arranged between the fourth section and the fifth section.

[0040] The double-wall pipe is configured to feed pressurized fuel to an engine and therefore the double-wall pipe has at least one of the following features: the double-wall pipe is designed to endure a peak pressure more than 2000 bar, the double-wall pipe is designed to endure temperature more than 100 °C, material of the double-wall pipe or the double-wall pipe section is steel.

[0041] Figure 5 illustrates a preferred embodiment of the invention where the double-wall pipe has five sections and two and a half loops 14 (shown in the

figure 3) in the helix. In the figure 5 the double-wall pipe is considered as being 100% length extending from the point 1 to the point 2, which are the start point 1 and end point 2 of the double-wall pipe 10. The straight coupling parts 12 are not considered as a part of the helix. There is also a middle point 3 in the pipe 10.

- 5 The length of the pipe between the middle 3 to the start point 1 is equal to length between the middle 3 to the end point 2.

[0042] There are two sections, the fourth section 16.4 and a fifth section 16.5, at both ends of the double-wall pipe 10 denoted with denser dotted hatch, and the first 16.1 and third 16.3 sections next to the fourth and the fifth sections 16.4, 16.5
 10 denoted with a less dense hatch. Between the first 16.1 and third 16.3 sections there is the second section 16.2 which is illustrated without hatching. Exemplary pitch transitions and values between specified helix curve points are shown in the following table, (pitch value from point to point). Here the value of 900 degrees means 2 and half loops of the helix. The pitch as function of the degree of
 15 a helix is illustrated in the figure 7, and it can be seen there that the pitch changes in continuously variable manner. More precisely in this example the pitch changes in a linear manner between the points 2 and 6, having different slopes between the points 2 and 3; 3 and 4; 4 and 5 and 5 and 6, which is a preferred embodiment of the invention.

20

Degrees	Curve length [%]	Pitch [mm/turn]
0	0	0
18	2	0
90	10	100
450	50	35
810	90	100
882	98	0
900	100	0

[0043] It can be seen that preferably distribution of variable pitch along the length of the double-wall pipe 10 between the middle to the start point and between the middle to the end point is symmetrical. Moreover, the first section 16.1 is provided with linearly increasing pitch with a first slope of the pitch, the second section 5 16.2 comprises a portion with linearly decreasing pitch (negative slope) with a second slope and a portion with linearly increasing pitch with a third slope and the third section 16.3 is provided with linearly decreasing pitch (negative slope) with a fourth slope. The fourth and fifth sections 16.4, 16.5 has a constant, zero pitch. In the figure 7 an absolute value of the first slope equals to an absolute value of the fourth slope, and an absolute value of the second slope equals to an absolute value of the third slope.

[0044] Figure 6 illustrates a fuel system 60 of an internal combustion piston engine 62. The fuel system 60 comprises a fuel supply device 64, comprising e.g. a high pressure pump, or generally a source of high pressure fuel. High pressure 15 meaning pressure suitable for use as injection pressure. The fuel supply device 64 is attached to a base 66 external to the engine. The base may be for example a hull of a marine vessel, or a support structure connected to the hull. The fuel supply device 64 is provided with a first coupling 68 for the fuel feeding double-wall pipe 10. The engine is provided with a fuel admission equipment 70 having a second coupling 72 for a fuel feeding double-wall pipe 10, wherein the fuel feed 20 double-wall pipe 10 according to the invention is arranged between the first coupling 68 and the second coupling 75.

[0045] While the invention has been described herein by way of examples in connection with what are, at present, considered to be the most preferred embodiments, it is obvious to the skilled person that, along with the technical progress, the basic idea of the invention can be implemented in many ways. The invention and its embodiments are thus not limited to the examples and samples described above but they may vary within the contents of patent claims and their legal equivalents. The details mentioned in connection with any embodiment 30 above may be used in connection with another embodiment when such combination is technically feasible.

Claims

1. A double-wall pipe (10) for transferring high-pressure fuel, comprising a first pipe (402) forming a fluid flow channel (404) inside the first pipe and a second pipe (406) arranged coaxially around the first pipe, wherein the double-wall pipe (10) comprises at least two loops of the double-wall pipe (10) around an axis, **characterized** in that the double-wall pipe (10) comprises a section with variable pitch.
2. A double-wall pipe (10) according to claim 1, **characterized** in that the double-wall pipe (10) comprises at least three sections (16.1, 16.2, 16.3) having a first section (16.1) with an average first pitch, a second section (16.2) with an average second pitch and a third section (16.2) with the average first pitch.
3. A double-wall pipe (10) according to claim 2, **characterized** in that the second section (16.2) is between the first section (16.1) and the third section (16.3).
4. A double-wall pipe (10) according to claim 3, **characterized** in that the average second pitch is greater than the average first pitch.
5. A double-wall pipe (10) according to anyone of the preceding claims, **characterized** in the that the pitch changes in continuous manner.
6. A double-wall pipe (10) according to claim 5, **characterized** in the that the pitch changes in linear manner.
7. A double-wall pipe (10) according to anyone of the preceding claims, **characterized** in that the first section (16.1), the second section (16.2) and the third section (16.3) are arranged between a fourth section (16.4) and a fifth section (16.5), which fourth section and fifth section have zero pitch.
8. A double-wall pipe (10) according to anyone of the preceding claims 1 to 5, **characterized** in that double-wall pipe (10) has a start point (1) and an end point (2) and a middle point (3), wherein the variable pitch between the middle

(3) to the start point (1) and pitch between the middle (3) to the end point (2) is symmetrical.

9. A double-wall pipe (10) according to claims 2, **characterized** in that the first section (16.1) is provided with linearly increasing pitch with a first slope, the
5 second section (16.2) comprises a portion with linearly decreasing pitch with a second slope and a portion with linearly increasing pitch with a third slope and the third section (16.2) is provided with linearly decreasing pitch with a fourth slope.

10. A double-wall pipe (10) according to claim 1, **characterized** in that the
10 double-wall pipe (10) is designed to endure pressure more than 2000 bar.

11. A double-wall pipe (10) according to claim 1, **characterized** in that the double-wall pipe (10) is designed to endure temperature more than 100 °C.

12. A double-wall pipe (10) according to claim 1, **characterized** in that the loops form a constant diameter helix around a central axis.

15 13. A double-wall pipe (10) according to claim 1, **characterized** in that material of the double-wall pipe (10) or the double-wall pipe (10) section is steel.

14. A fuel system of an internal combustion piston engine comprising a fuel supply device attached to a base external to the engine, the device having a first coupling for a fuel feeding double-wall pipe (10), and fuel admission equipment
20 in the engine having a second coupling for a fuel feeding double-wall pipe (10), wherein the fuel feeding double-wall pipe (10) is arranged between the first coupling and the second coupling, **characterized** in that the fuel feed double-wall pipe (10) system comprises a double-wall pipe (10) according to anyone of the preceding claims.

1/6

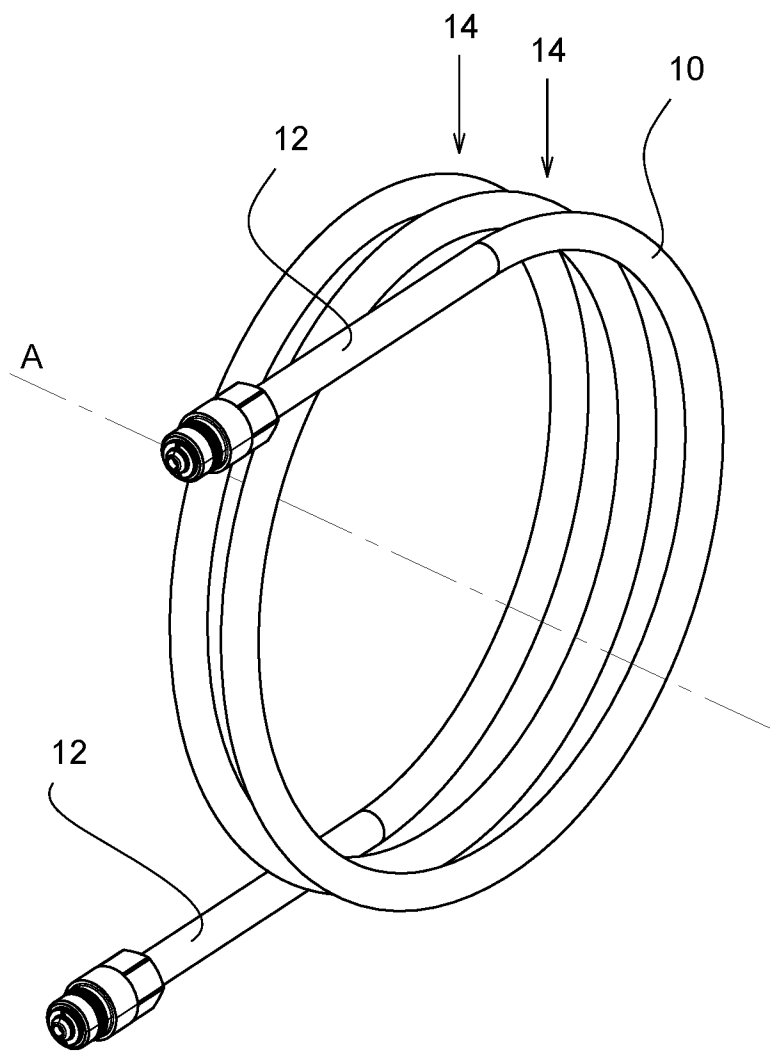


Fig. 1

2/6

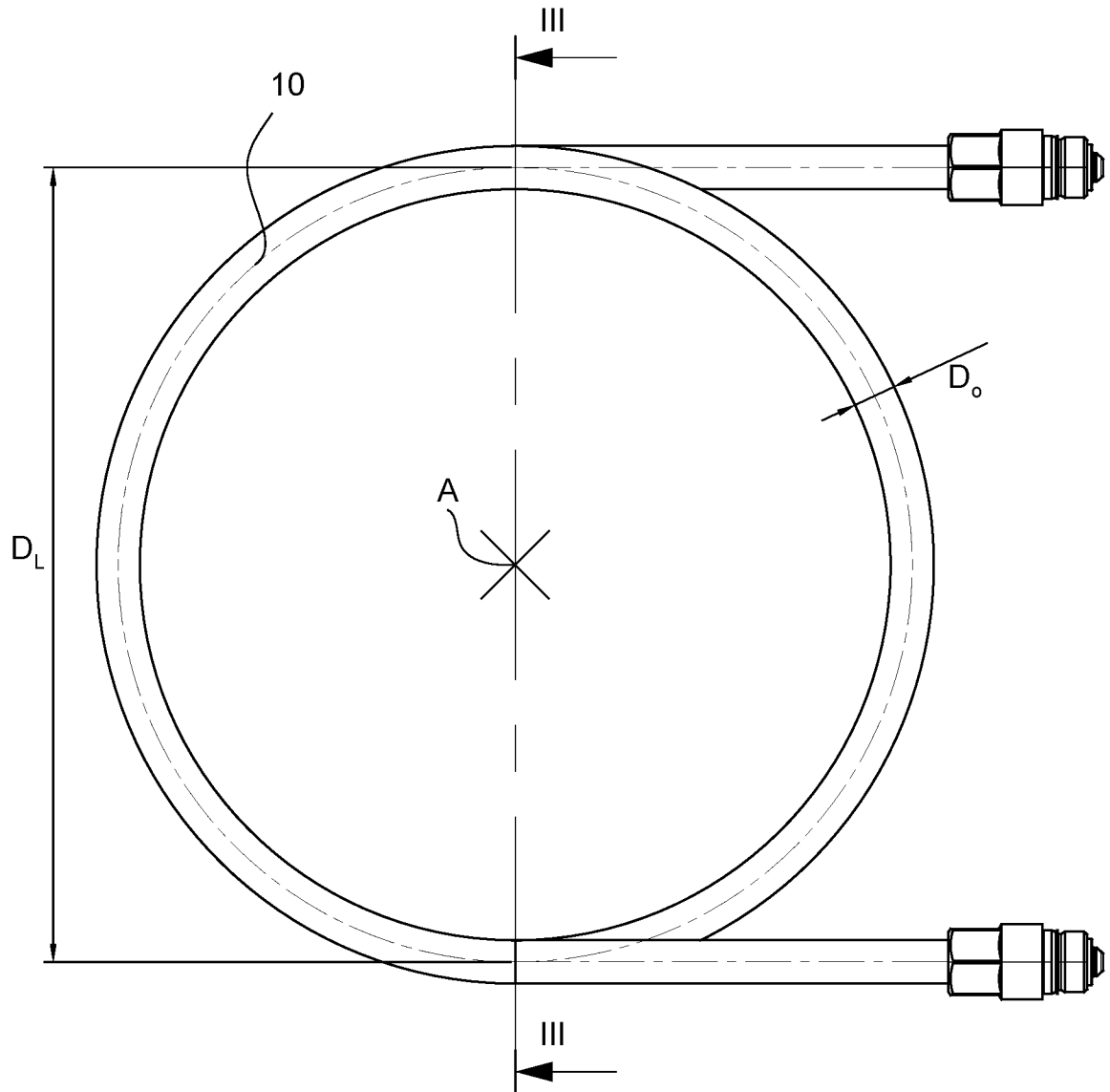
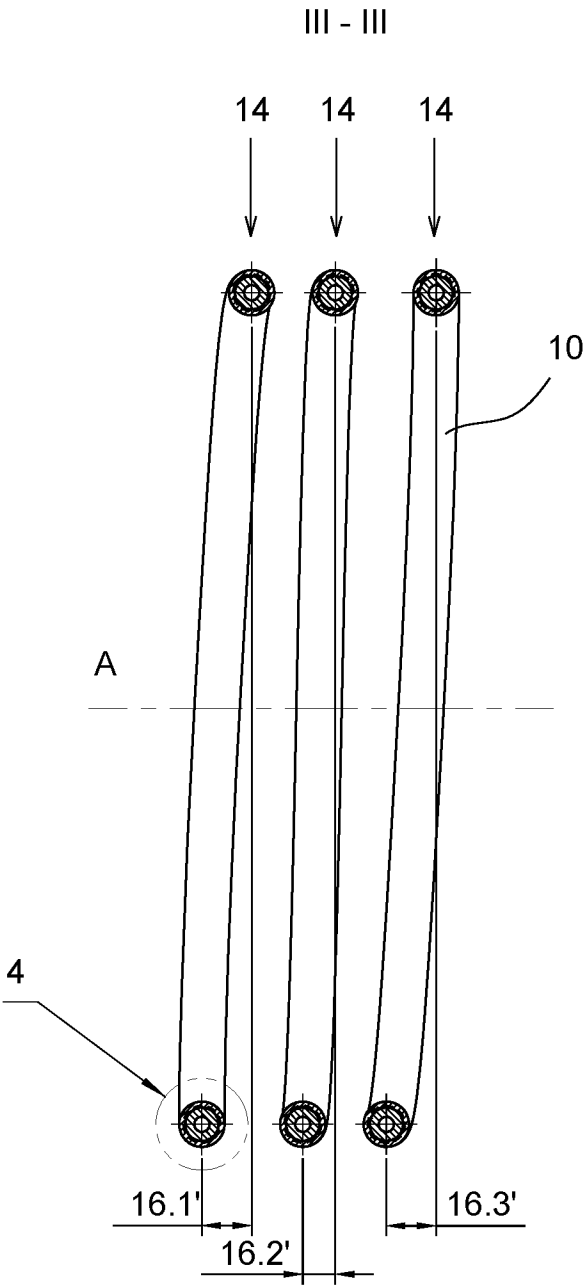


Fig. 2

Fig. 3



4/6

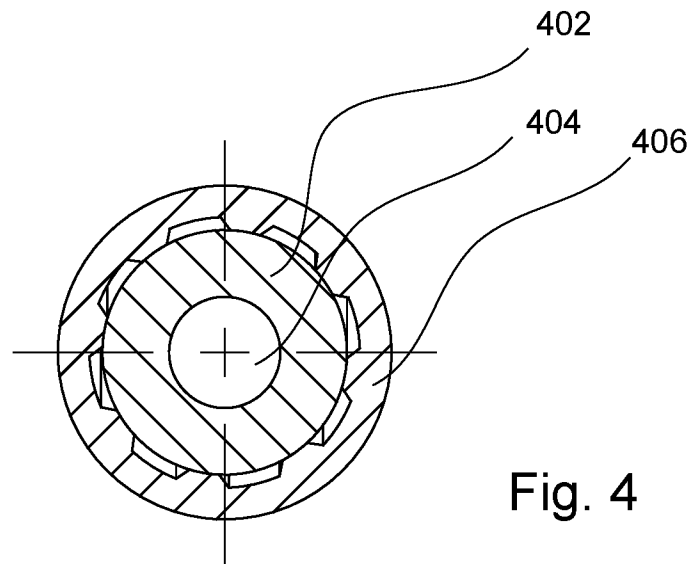


Fig. 4

5/6

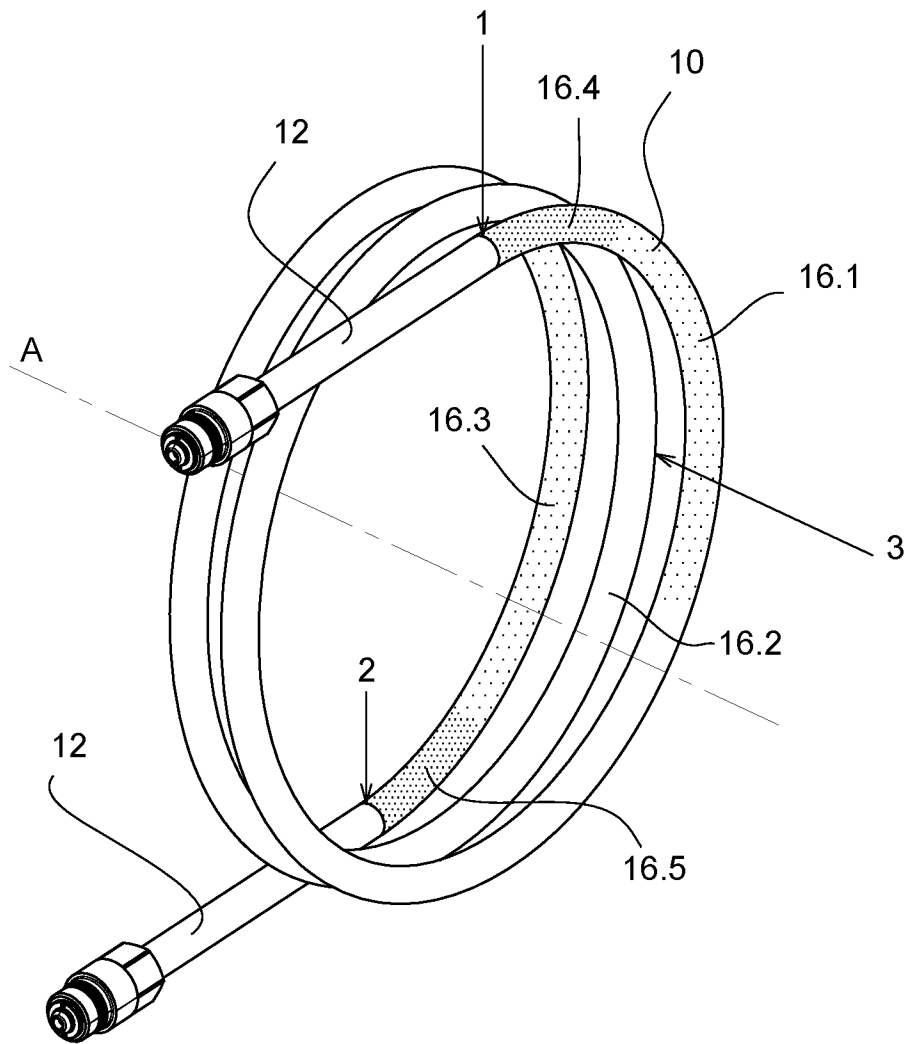


Fig. 5

6/6

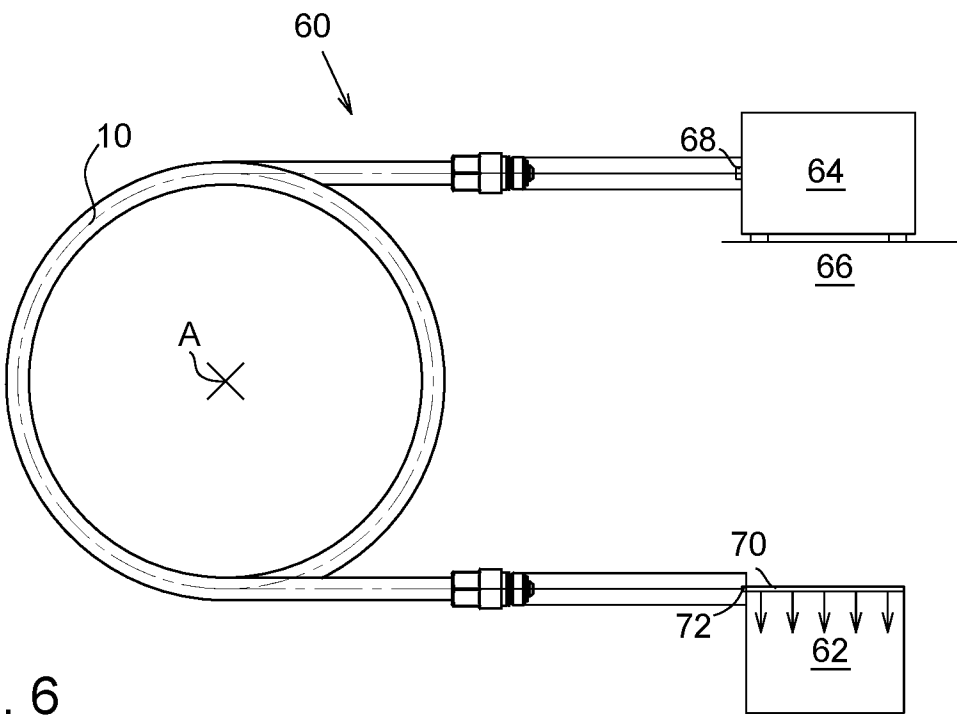


Fig. 6

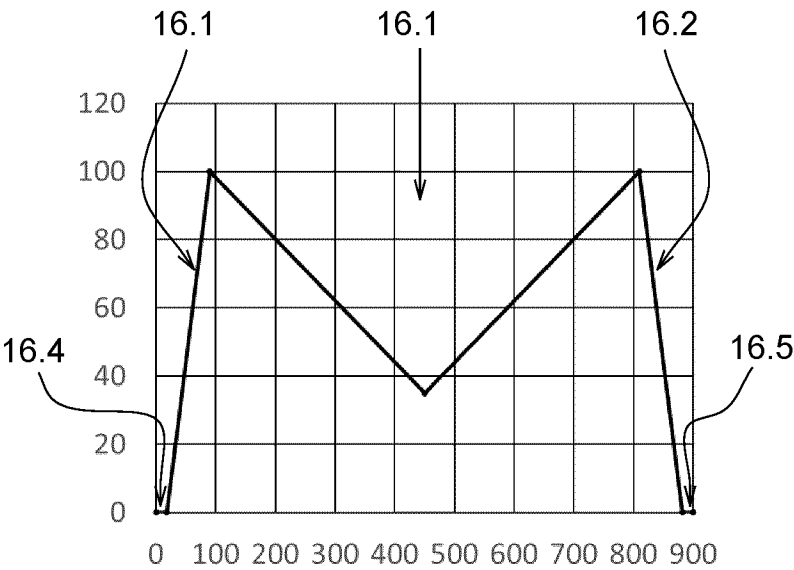


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/066851

A. CLASSIFICATION OF SUBJECT MATTER INV. F16L9/18 F02M37/00 F02M55/04 F16C7/00 F16L11/20 F16L55/027 F16L55/04 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) F16L F16C F02M 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 3 245 431 A (COE JAMES H) 12 April 1966 (1966-04-12) cited in the application	1-13
Y	the whole document -----	14
X	CN 209 575 777 U (SAMSON AG) 5 November 2019 (2019-11-05) figures 5a, 5b claims 1, 6 -----	1-6, 10-13
Y	EP 2 878 804 A1 (DELPHI INT OPERATIONS LUX SRL [LU]) 3 June 2015 (2015-06-03) cited in the application	14
A	the whole document -----	1
Y	US 7 228 846 B2 (SIEMENS VDO AUTOMOTIVE CORP [US]) 12 June 2007 (2007-06-12) cited in the application	14
A	the whole document -----	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 7 December 2023		Date of mailing of the international search report 19/12/2023
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Prieto Sanz, M

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2023/066851

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 3245431	A	12-04-1966	NONE	

CN 209575777	U	05-11-2019	CN 209575777 U	05-11-2019
			DE 102015005611 A1	03-11-2016
			EP 3289262 A1	07-03-2018
			EP 3693645 A1	12-08-2020
			US 2018283580 A1	04-10-2018
			WO 2016174107 A1	03-11-2016

EP 2878804	A1	03-06-2015	NONE	

US 7228846	B2	12-06-2007	US 2003070723 A1	17-04-2003
			US 2004216803 A1	04-11-2004
