(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 March 2012 (29.03.2012)

PCT

(10) International Publication Number
WO 2012/037988 A1

(51) International Patent Classification:
B64D 29/08 (2006.01)

(21) International Application Number:
PCT/EP2010/064197

(22) International Filing Date:
24 September 2010 (24.09.2010)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **SHORT BROTHERS PLC** [GB/GB]; P.O. Box 241, Airport Road, Belfast Antrim BT3 9DZ (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **STEWART, Timothy** [GB/GB]; 65B Craigadoo Road, Ballymena Antrim BT42 4RD (GB). **TWEEDIE, Alan** [GB/GB]; 56 The Belfry, Dromore Co. Down (GB). **HATRICK, Michael** [GB/GB]; 58 Seahill Road, Holywood Co., Down BT18 0DW (GB).

(74) Agent: **HOLMES, Matt**; Cawston Field IP Ltd, Davis Building, 165-189 Railway Terrace, Rugby Warwickshire, CV21 3HQ (GB).

(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, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: NACELLE WITH HINGED COWL DOORS ENABLING ACCESS TO THE ENGINE

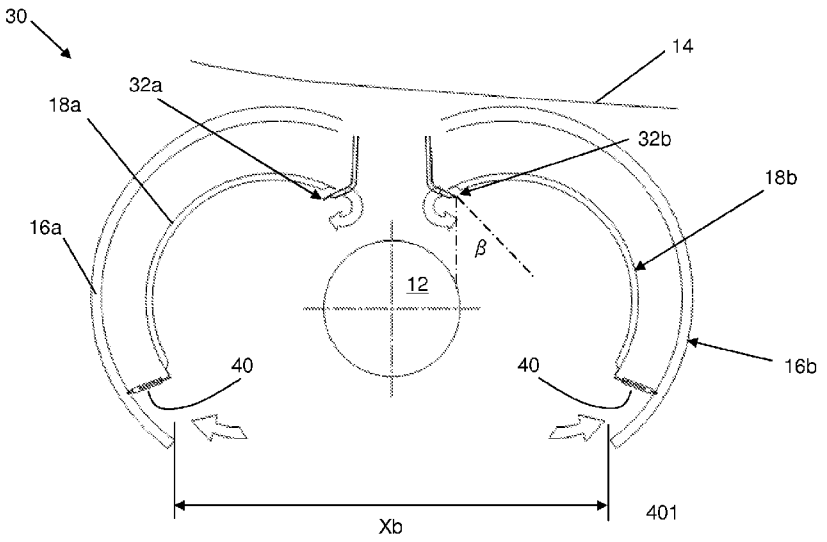


Figure 5b

(57) **Abstract**: A nacelle (30) for an engine has outer and inner cowl doors (16a, 18a) that are independently rotatable about offset hinge lines (24a, 32a). A connection device (40) is provided for selectively connecting the outer and inner cowl doors (16a, 18a) so as to cause them to open simultaneously. The inner cowl door (18a) is arranged to rotate by a greater angle than the outer cowl door (24a) so as to improve access to the engine for maintenance purposes.

WO 2012/037988 A1

NACELLE WITH HINGED COWL DOORS ENABLING ACCESS TO THE ENGINE

Field of the invention.

The present invention relates to a nacelle and particularly, but not exclusively, to a nacelle for a turbine engine such as a turbofan engine for an aircraft. Aspects of the invention relate to a nacelle, to a thrust-reverser section for a nacelle, to an engine, to an aircraft or vehicle and to a method.

Background of the invention.

Gas turbine engines, in particular so-called turbofan engines, are commonly used to provide propulsion for a wide range of modern aircraft. Such engines typically include a bypass duct through which a proportion of the air pressurized by the fan is passed and a fan nozzle for producing thrust from the fan-pressurized bypass air. The remaining air is passed through the engine core in which it is used as the working fluid to generate power for the fan.

Such engines are typically supported within a nacelle that is secured to the structure of the aircraft, for example to the fuselage or to the underside of the wing, by means of a pylon. The nacelle typically comprises an outer cowl, defining the external housing of the engine and within which the fan is disposed, and an inner cowl which houses the core of the engine, i.e. the turbine and combustion chamber stages of the engine. The inner and outer cowls are generally cylindrical in section and are aligned substantially concentrically and generally parallel with the main or thrust axis of the engine. The bypass duct is defined by the generally annular space between the radially inner and outer cowls and includes a fan nozzle at its exit.

In many turbofan engines, the outer cowl includes a thrust-reverser section located towards the rear of the nacelle. In such arrangements, the rear section of the outer cowl is moveable, for example translatable, relative to the forward section of the outer cowl so as to enable the deployment of blocking devices which cause the pressurised air from the fan to be diverted forwardly and impart a retardation force on the aircraft during braking.

In order to facilitate access to the engine by maintenance personnel, in some turbofan engines the thrust-reverser section of the cowl is divided into two halves known as C-ducts each of which is hinged to the pylon at its upper edge for rotation about a thrust-reverser hinge-line extending generally parallel to the main axis of the engine. Rotation of these C-

ducts (which effectively constitute a pair of clamshell-type outer cowl doors and are therefore hereafter termed thrust-reverser cowl doors) about the thrust-reverser hinge-line affords access to the components of the engine by maintenance operators.

In such engines, it is common for the section of the inner cowl corresponding to the thrust-reverser section also to be divided into two halves (hereafter termed core cowl doors) with each half being fixed to, or integrally formed with, the corresponding thrust-reverser cowl door. The space between the core cowl door and the corresponding thrust-reverser cowl door defines a portion of the bypass duct as described above.

In use, during inspection or maintenance of the engine, the thrust-reverser cowl doors are opened by rotation either manually or hydraulically by means of a power door opening system (PDOS). Rotation of the thrust-reverser cowl doors about the thrust-reverser hinge-line causes corresponding rotation of the core cowl doors, which are connected thereto, so as to provide access to the engine core components.

However, the applicant has recognised that, in cases where the engine is suspended by a pylon below the wing of an aircraft such that the thrust-reverser section is disposed beneath the leading edge of the wing, the amount of rotation, i.e. the degree of opening, of the thrust-reverser cowl doors is generally limited by their clearance to the lower surface of the wing. Since the inner cowl doors are fixed to the thrust-reverser cowl doors and are therefore not independently moveable relative thereto, the degree of opening of the inner cowl doors is similarly limited. Thus, overall accessibility of the engine core for maintenance purposes is restricted.

Modifying the shape or configuration of the nacelle or wing in order to improve clearance between the thrust-reverser cowl doors and the underside of the wing may result in sub-optimal aerodynamic characteristics. On the other hand, lengthening the pylon in order to increase the distance between the engine and the underside of the wing positions the engine closer to the ground, increasing the risk of damage to the engine by ingestion of debris. Finally, complete removal of the cowl doors may improve access to the engine core, but significantly increases maintenance operator time and costs.

There is therefore a need to improve the degree of access to the engine core when the inner and outer cowl doors are opened whilst obviating the inherent disadvantages of the above-mentioned solutions. It is an aim of the present invention to address this problem. Embodiments of the invention may improve maintenance access to the core of a turbofan

engine by providing a nacelle for an engine comprising independently rotatable inner and outer cowl doors which can be selectively connected to rotate about different hinge lines. Other aims and advantages of the invention will become apparent from the following description, claims and drawings.

Summary of the invention.

Aspects of the invention provide a nacelle, a thrust-reverser section for a nacelle, an engine, an aircraft and a method as claimed in the appended claims.

According to another aspect of the invention for which protection is sought, there is provided a nacelle for an engine, comprising at least one outer cowl door, at least one inner cowl door and connection means for selectively connecting the outer cowl door to the inner cowl door.

The connection means may comprise a connection device such as a rod, strut, bar or linkage.

In an embodiment, the outer and inner cowl doors are hinged to the nacelle, or to a pylon on which the nacelle is mounted, for independent rotation relative thereto.

In an embodiment, the outer cowl door is hinged for rotation about a first hinge line or axis and the inner cowl door is hinged for rotation about a second hinge line or axis, the first and second hinge lines or axes being offset from each other. The second hinge line or axis may be radially and/or laterally offset from the first hinge line or axis. Advantageously, the second hinge line or axis is disposed radially inwardly of the first hinge line or axis.

The first hinge line or axis may be substantially parallel to the second hinge line or axis. For example, in an embodiment, the first and second hinge lines or axes are substantially parallel to a central axis of the nacelle. Alternatively, the first and second hinge lines or axes may be mutually non-parallel, with only one or neither being parallel to the central axis of the nacelle.

The outer and inner cowl doors may be independently movable between closed and respective fully open positions. In one embodiment, the perpendicular distance between the cowl doors in the fully open position thereof is less than the perpendicular distance between the cowl doors in the closed position thereof. Alternatively, or in addition, the angle through which the inner cowl door rotates between the closed and fully open positions thereof may

be greater than the angle through which the outer cowl door rotates between the closed and fully open positions thereof.

In an embodiment, in the fully open position of the outer and inner cowl doors, the inner cowl door is at least partially nested within the outer cowl door. Advantageously, the connection device may be arranged to maintain the inner cowl door at least partially nested within the outer cowl door when the cowl doors are in the fully open position.

In one embodiment the connection device has a fixed length. In another embodiment, the connection device is variable in length. For example, the connection device may be extensible and movable between a first, reduced length, position and a second, extended length, position.

In an embodiment, the connection device is arranged to connect the inner cowl door to the outer cowl door such that movement of the connection device between the second position and the first position permits the inner cowl door to rotate through a greater angle than the outer cowl door. For example, the inner cowl door may move relative to the outer cowl door such that the perpendicular distance between the cowl doors reduces.

Advantageously, the connection device may be arranged for connection between the outer and inner cowl doors prior to commencement of opening, thereby to permit the outer and inner cowl doors to open simultaneously.

In an embodiment, the connection device is arranged to be selectively locked in at least one of the first and second positions. Alternatively, or in addition, the connection device may be arranged to be selectively locked in one or more positions between the first and second positions.

In an embodiment, the connection device is pivotally connectable and/or connected at each end thereof to a respective one of the inner and outer cowl doors. For example, a first end of the connection device may be connectable to one of the inner and outer cowl doors by means of a first articulation while a second end of the connection device may be connectable to the other of the inner and outer cowl doors by means of a second articulation.

In an embodiment, the first end of the connection device is fixed to one of the inner and outer cowl doors by means of the first articulation and the second end of the connection device is detachably connectable to the other of the inner and outer cowl doors by means of

an articulated attachment device. The first and/or second articulation may comprise one of a ball joint, rose joint or universal joint.

In an embodiment, when the connection device connects the inner and outer cowl doors, the arrangement effectively defines an articulated, four-bar linkage. The linkages of the four-bar linkage comprise the cowl doors, the connection device and a portion of the nacelle while the pivots of the four-bar linkage comprise the first and second hinge lines, and the articulations at either end of the connection device.

In an embodiment, the inner cowl door comprises a portion of a core cowl for at least partially surrounding a core of an engine housed in the nacelle. In an embodiment, the outer cowl door comprises a thrust-reverser portion of the nacelle.

The connection device may be movable between a stowed position and a deployed position in which the connection device connects the outer and inner cowl doors. In an embodiment, the connection device is biased towards one of the first and second positions.

The nacelle may comprise at least one of a first latch for latching the outer cowl door to a second, opposing outer cowl door in the closed position thereof and a second latch for latching the inner cowl door to a second, opposing inner cowl door in the closed position thereof.

According to a further aspect of the invention for which protection is sought, there is provided a thrust-reverser section for an engine nacelle, comprising an outer cowl door an inner cowl door and a connection device for selectively connecting the outer and inner cowl doors.

According to a still further aspect of the invention for which protection is sought, there is provided a method of accessing an engine housed in a nacelle having outer and inner cowl doors, the method comprising opening at least one outer cowl door by rotation through a first angle of rotation, opening at least one inner cowl door by rotation through a second angle of rotation, that is greater than the first angle of rotation and connecting the at least one outer cowl door to the at least one inner cowl door.

Advantageously, by rotating the inner cowl door through a greater angle than the outer cowl door, improved accessibility to the engine is provided.

The steps of the method may be carried out sequentially and in the order listed. The method may additionally comprise rotating the at least one outer cowl door and the at least one inner cowl door simultaneously.

Alternatively, the steps of the method may be carried out in a different order or may be carried out simultaneously. For example, the method may comprise connecting the at least one outer cowl door to the at least one inner cowl door and then opening the cowl doors simultaneously.

In another embodiment, the method comprises carrying out the opening and connecting steps simultaneously.

In an embodiment, opening the at least one outer cowl door comprises rotating the at least one outer cowl door about a first hinge line or axis and wherein opening the at least one inner cowl door comprises rotating the at least one inner cowl door about a second hinge line or axis, the first and second hinge lines or axes being offset from each other.

In another embodiment, the method comprises unlatching the outer cowl door and rotating it through a first angle to a partially open position, unlatching the inner cowl door and coupling a connection device between the inner cowl door and the outer cowl door, opening the inner cowl door by rotation through a second angle that is greater than the first angle and rotating the outer cowl door to a fully open position whereby the connection device couples the movement of the outer cowl door with the inner cowl door, causing the cowl doors to open simultaneously.

According to another aspect of the invention for which protection is sought, there is provided a nacelle for an engine comprising an outer cowl door, an inner cowl door at least partly overlapped by the outer cowl door and at least one link rod, wherein the inner cowl door and the outer cowl door are independently pivotable between closed and open positions, and wherein the link rod is arranged to selectively join the inner cowl door to the outer cowl door such that when the two doors are thus joined, the cowl doors may be opened simultaneously.

Advantageously, pivotally securing the inner cowl door to the nacelle independently from the outer cowl door allows the inner cowl door to open wider than would be the case if the cowl doors were integrally formed. This facilitates greater access to the engine by maintenance personnel.

In addition, the present invention provides the advantage that the link rods may selectively join the inner and outer door together, so permitting simultaneous operation of the doors where required. This provides the maintenance personnel with the option to use the doors independently if required.

5

According to yet another aspect of the invention for which protection is sought, there is provided a nacelle for an engine comprising a hinged outer cowl door at least partially overlapping a hinged inner cowl door, wherein the inner cowl door is arranged to at least partially nest or tessellate within the outer cowl door when in the open position.

10

The various aspects and embodiments of the invention greatly increases the available access provided to the engine with the cowl doors open, reducing the time and attendant cost of regular scheduled engine maintenance.

15 Within the scope of this application it is envisaged that the various aspects, embodiments, examples, features and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings may be taken independently or in any combination thereof. In particular, features described in connection with one embodiment are applicable to the other embodiment, except where there is an incompatibility of features.

20

Brief Description of the Drawings

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

25

Figure 1 shows a section through a known C-duct type engine nacelle shown with closed outer and inner cowl doors;

Figure 2 shows the engine nacelle of Figure 1 with outer and inner cowl doors in a fully open
30 position;

Figure 3a shows a section through a form of engine nacelle embodying the present invention with closed outer and inner cowl doors;

35 Figure 3b illustrates the inner cowl doors of the nacelle of Figure 3a in a perspective view;

Figure 4a illustrates a first opening step for the nacelle of Figure 3a in which the outer cowl doors are opened to a first position and the inner cowl doors remain closed;

Figure 4b illustrates a second opening step for the nacelle of Figure 3a in which connecting devices are deployed to join the inner and outer cowl doors;

Figure 5a illustrates a third opening step for the nacelle of Figure 3a in which the inner cowl doors are opened independently of the outer cowl doors;

Figure 5b illustrates a fourth opening step for the nacelle of Figure 3a in which the inner and outer cowls are rotated simultaneously to a fully open position;

Figure 6 shows a comparison between the nacelle of Figure 1 and the nacelle of Figure 3a in the fully open position;

Figure 7 shows a view of the section A-A in Figure 6;

Figure 8 shows a view of the section B-B in Figure 6;

Figure 9a illustrates a first closing step for the nacelle of Figure 3a in which the inner and outer cowl doors are rotated simultaneously towards a partially open position;

Figure 9b illustrates a second closing step for the nacelle of Figure 3a in which the inner cowl door are closed independently of the outer cowl doors;

Figure 10a illustrates a third closing step for the nacelle of Figure 3a in which the connecting devices are detached from the outer cowl doors and stowed;

Figure 10b illustrates a fourth closing step for the nacelle of Figure 3a in which the outer cowl doors are closed whilst the inner cowl doors remain stationary;

Figure 11 illustrates the trajectory taken by the connecting device during opening of the cowl doors; and

Figures 12a and 12b illustrate the increase in available access to the engine afforded by the relative movement between the inner and outer cowl doors during opening.

Detailed Description

As far as possible, in the following description, like reference numerals indicate like parts.

Figures 1 and 2 show section views through a C-duct type thrust-reverser section of a known form of engine nacelle 10.

Referring firstly to Figure 1, the nacelle 10 houses a turbofan engine consisting of a ducted fan (not shown) and an engine core shown schematically at 12. The engine core 12 is mounted within the nacelle 10 substantially coaxially with the fan and includes, for example, a multistage turbine arrangement, a combustion chamber and an exhaust nozzle, none of which are illustrated. In the illustrated example, the nacelle 10 is mounted to the underside of the wing 14 of an aircraft by means of a pylon (not shown).

The thrust-reverser section of the nacelle 10 includes an outer cowl, comprising a pair of semicircular or C-shaped thrust-reverser cowl doors 16a, 16b, and an inner or core cowl, comprising a correspondingly-shaped pair of core cowl doors 18a, 18b which have a smaller radius than the thrust-reverser cowl doors 16a, 16b and which house a rearward portion of the engine core.

The left hand core cowl door 18a is fixed to, or integral with, the left hand thrust-reverser cowl door 16a and is joined to upper and lower portions thereof by integral upper and lower bifurcations 20a, 22a. Similarly, the right hand core cowl door 18b is fixed to, or integral with, the right hand thrust-reverser cowl door 16b and is joined to upper and lower portions thereof by integral upper and lower bifurcations 20b, 22b. The spaces 11 defined between the each thrust-reverser cowl door 16a, 16b and the corresponding core cowl door 18a, 18b together form an annular channel forming part of the bypass duct for the nacelle 10.

The left hand pair of doors, comprising the left hand thrust-reverser cowl door 16a and the left hand core cowl door 18a joined thereto, is hinged or otherwise pivotally connected at its upper edge to an upper part of the nacelle 10, or to the pylon (not shown), for rotation about a common left-hand thrust-reverser hinge line 24a. Likewise, the right hand pair of doors, comprising the right hand thrust-reverser cowl door 16b and the right hand core cowl door 18b joined thereto, is hinged or otherwise pivotally connected at its upper edge to the upper part of the nacelle 10, or to the pylon (not shown), for rotation about a common right-hand thrust-reverser hinge line 24b.

The left and right hand pairs of doors 16a, 18a, 16b, 18b are coupled at their lower interface 26 by a latch (not shown) which, when released, allows each pair of doors to be independently rotated upwardly about the respective thrust-reverser hinge line 24a, 24b so as to permit access to the engine core for maintenance purposes, as illustrated in Figure 2.

The applicant has, however, recognised a disadvantage of the type of arrangement shown in Figures 1 and 2. In particular, in a case where the engine is mounted beneath the wing 14 of an aircraft, the available clearance between the nacelle 10 and the lower surface of the wing 14 limits the angle by which the thrust-reverser doors 16a, 16b can be rotated without contacting the wing 14.

This condition is best shown in Figure 2, which illustrates the maximum angle of rotation α of the thrust-reverser doors 16a, 16b that can be achieved at the fully open position without direct contact occurring between the outer surface of the doors and the lower surface of the wing 14. In practice, due to the dihedral angle of the wing's lower surface and the curvature of the thrust-reverser cowl doors 16a, 16b, the maximum angle of rotation α of the cowl doors may be limited to less than 30° in order to maintain a predetermined minimum clearance CL between the door and the wing when in the fully open position.

Since the core cowl doors 18a, 18b are fixed to the thrust-reverser cowl doors 16a, 16b, there is no relative movement therebetween and their angle of rotation is thus similarly restricted. That is to say, the degree of opening of the core cowl doors 18a, 18b is limited to the maximum angle of rotation α of the thrust-reverser cowl doors 16a, 16b.

Furthermore, since the core cowl doors 18a, 18b are of smaller radius than the thrust-reverser cowl doors 16a, 16b, their maximum angle of rotation directly determines the accessibility afforded to maintenance personnel to the engine core 12 when the cowl doors are in the fully open position. In Figure 2, this accessibility is represented by the opening dimension Xa.

Referring next to Figure 3, the thrust-reverser section of a nacelle embodying one form of the invention is shown, in cross-section, generally at 30. The present invention has been conceived to address the above-mentioned problems associated with the type of nacelle described with reference to Figures 1 and 2, and to improve the accessibility to the engine core 12 during maintenance.

As with the nacelle shown in Figure 1, the thrust-reverser section of the nacelle 30 includes an outer cowl, comprising a pair of semicircular or C-shaped thrust-reverser cowl doors 16a, 16b, and an inner or core cowl, comprising a correspondingly-shaped pair of core cowl doors 18a, 18b which have a smaller radius than the thrust-reverser cowl doors 16a, 16b and which house a rearward portion of the engine core 12.

The left and right hand thrust-reverser cowl doors 16a, 16b are each hinged or otherwise pivotally connected at their respective upper edges to a supporting body such as an upper part of the nacelle 30 or to the pylon (not shown) for rotation about a respective thrust-reverser hinge line 24a, 24b. Independently from the thrust-reverser cowl doors 16a, 16b, the core cowl doors 18a, 18b are each hinged or otherwise pivotally connected at their respective edges to a lower portion of a support part for rotation about a respective core cowl hinge line 32a, 32b. In the illustrated embodiment, the support part takes the form of a respective apron or bifurcation 20a, 20b fixed to, and extending downwardly from, the upper part of the nacelle 30 or the pylon.

It can be seen from Figure 3, that the core cowl hinge lines 32a, 32b are offset radially from the corresponding thrust-reverser hinge lines 24a, 24b. In particular, the core cowl hinge line 32a for the left hand core cowl door 18a is radially inwardly displaced from the thrust-reverser hinge line 24a whilst the core cowl hinge 32b for the right hand core cowl door 18b is radially inwardly displaced from the thrust-reverser hinge line 24b.

In addition, in the illustrated embodiment, the core cowl hinge lines 32a, 32b are laterally and/or angularly displaced from the corresponding thrust-reverser hinge lines 24a, 24b. That is to say, the left hand core cowl hinge line 32a is angularly offset (in an anticlockwise direction in the drawing) and/or laterally displaced from the centreline X of the engine by a greater amount than the left hand thrust-reverser hinge line 24a. Similarly, the right hand core cowl hinge line 32b is angularly offset (in a clockwise direction in the drawing) and/or laterally displaced from the centreline X of the engine by a greater amount than the right hand thrust-reverser hinge line 24b.

Furthermore, as best shown in Figure 11, while the left and right hand thrust-reverser hinge lines 24a, 24b extend generally parallel to the engine centreline X, the left and right core cowl hinge lines 32a, 32b do not.

The illustrated arrangement is, however, not intended to be limiting and the invention is equally applicable to arrangements having substantially any orientation of hinge lines

including, for example, arrangements in which the core cowl hinge lines 32a, 32b extend parallel to the corresponding thrust-reverser hinge lines 24a, 24b and/or to the engine centreline X, arrangements in which the core cowl hinge lines 32a, 32b are not angularly or laterally offset from the thrust-reverser hinge lines 24a, 24b and arrangements in which the thrust reverser hinge lines 24a, 24b and/or core cowl hinge lines 32a, 32b are not mutually parallel.

Again, the space 11 defined between each thrust-reverser cowl door 16a, 16b and the corresponding core cowl door 18a, 18b together form a generally annular channel comprising part of the bypass duct for the nacelle 30.

The left and right hand thrust-reverser cowl doors 16a, 16b are coupled at their lower interface 26 by a first latch (not shown) which, when released, permits each door to be rotated upwardly about its respective thrust-reverser hinge line 24a, 24b so as to permit access to the engine core cowl for maintenance purposes.

In addition, the left and right core cowl doors 18a, 18b are coupled at their lower interface 34 by a second latch (not shown) which, when released, permits each door to be rotated upwardly about its respective core cowl hinge line 32a, 32b so as to permit access to the engine core.

For the avoidance of doubt, the thrust-reverser section of the nacelle 30 differs from that of the nacelle 10 in that the core cowl doors 18a, 18b are not directly fixed to, or integral with, the thrust-reverser cowl doors 16a, 16b but, instead, are independently hinged to the nacelle 30 or to the pylon about respective core cowl hinge lines 32a, 32b that are radially and/or laterally offset from the thrust-reverser hinge lines 24a, 24b.

In addition, as best shown in Figure 3b, the nacelle 30 of the present invention is provided with connecting means in the form of a pair of elongate rods or struts 40 (hereafter termed link rods) for selectively connecting the left and right hand core cowl doors 18a, 18b to the corresponding thrust-reverser cowl doors 16a, 16b, as described below. In the illustrated embodiment, a first end 401 of each link rod 40 is pivotally connected to an inner surface of a respective one of the core cowl doors 18a, 18b by means of an articulation, such as a hinge or ball joint.

The second end 402 of each link rod includes an attachment means configured to connect to or engage with, preferably in an articulated manner, a suitably configured feature or

attachment point (not shown) disposed on an inner surface of a respective one of the thrust-reverser cowl doors 16a, 16b.

In the illustrated embodiment, each link rod 40 is extensible, that is to say capable of adopting a plurality of axial lengths. For example, the link rod may be arranged to extend between a first, reduced length position, and a second, extended length position. Preferably, but not essentially, the link rod 40 is configured to be lockable in one or both of the first and second positions.

The use of variable-length link rods 40 is not essential (i.e. fixed-length link rods may alternatively be employed) but advantageously enables dimensional tolerances between the inner and outer cowl doors to be absorbed as well as providing further improved access for the maintenance operator, as described below.

Figures 3a and 3b illustrate the nacelle 30 in a closed condition. In the closed condition of the nacelle 30, the link rods 40 are placed in a stowed position in which each link rod is fully retracted and lies adjacent the inner surface of the respective core cowl door 18a, 18b, extending generally parallel to the centreline X of the engine on either side of the lower interface 34 between the left and right hand core cowl doors 18a, 18b. As described above, the first end 401 of each link rod 40 is permanently fixed to the core cowl door inner surface by means of the articulation. On the other hand, the second, free end 402 of each link rod 40 is releasably connected to the respective core cowl door 18a, 18b by the attachment means. This arrangement reduces any adverse effect on the fluid flow through the engine caused by the presence of the link rods 40.

Referring now to Figures 4 and 5, these illustrate an opening sequence for the thrust-reverser section of the nacelle 30 which may be used, for example, during maintenance of the engine.

In a first step, shown in Figure 4a, the first latch (coupling the left and right hand thrust-reverser cowl doors 16a, 16b at their lower interface 26) is released by the maintenance operator and the thrust-reverser cowl doors 16a, 16b are each rotated, together or independently, about their respective thrust-reverser hinge line 24a, 24b to a first, partially open position. This initial opening of the thrust-reverser cowl doors 16a, 16b may be carried out manually or, advantageously, by means of a powered door opening system (PDOS) which may comprise an electrical or hydraulic actuator system.

The amount by which the thrust-reverser cowl doors 16a, 16b are initially opened may be selected as desired but should be sufficient for the maintenance operator to gain access to the second latch (coupling the left and right hand core cowl doors 18a, 18b) and the stowed maintenance rods 40.

In a second step, shown in Figure 4b, once the left and right thrust-reverser cowl doors 16a, 16b are in the partially open position as described above, the maintenance operator releases the second latch so as to uncouple the left and right core cowl doors 18a, 18b. The operator then releases the link rods 40 from their stowed position and attaches the second end 402 of each link rod to the attachment point (not shown) on the inner surface of the respective thrust-reverser cowl door 16a, 16b. Advantageously, the link rods 40 are configured such that they are substantially fully extended when initially coupled to the attachment point. The left and right core cowl doors 18a, 18b are thus coupled in an articulated manner to the corresponding thrust-reverser cowl door 16a, 16b by means of the link rods 40.

Referring next to Figure 5a, illustrating a third step in the opening sequence, the core cowl doors 18a, 18b are manually rotated outwardly, either independently or simultaneously, towards the stationary thrust-reverser cowl doors 16a, 16b, about the core cowl hinge lines 32a, 32b. This rotation of the core cowl doors 18a, 18b relative to the thrust-reverser cowl doors 16a, 16b causes the link rods to compress, i.e. to reduce in length.

Since the core cowl hinge lines 32a, 32b are radially inwardly offset from the thrust-reverser hinge lines 24a, 24b, and since the core cowl doors 18a, 18b have a reduced radius compared to the thrust-reverser cowl doors 16a, 18b, the core cowl doors 18a, 18b are able to rotate through a greater angle than the thrust-reverser cowl doors 16a, 16b and to "nest" within the cavity defined therein as shown in Figure 5b.

The maintenance operator continues to rotate the core cowl doors 18a, 18b towards the thrust-reverser cowl doors 16a, 16b until the link rods 40 are fully compressed and the "nested" condition of the core cowl and thrust-reverser doors has been achieved. It will be appreciated that, in this nested position, the spacing or perpendicular distance Yn between the core cowl door and the corresponding thrust reverser door is less than that Ys at the fully closed positon shown in Figure 3a. This position is hereafter termed the “intermediate position”. The link rods 40 are then locked in the fully contracted condition to prevent further variations in length.

In a fourth step in the opening sequence, illustrated in Figure 5b, the maintenance operator uses the PDOS system to rotate the thrust-reverser cowl doors 16a, 16b to the fully open position. During this step, the thrust-reverser cowl doors 16a, 16b and the corresponding core cowl doors 18a, 18b are rotated simultaneously, being connected by means of the link rods 40.

Once in the fully open position, the thrust-reverser cowl doors and core cowl doors are maintained in the open position by further supports, known as "hold open rods" (not shown), which are provided as a safety feature in the event of failure of the PDOS system.

The articulations at the connection points between each link rod and the respective core cowl door 18a, 18b and thrust-reverser cowl door 16a, 16b, enable the doors to rotate simultaneously about different hinge lines whilst being connected by a fixed-length rod. Where the thrust-reverser cowl hinge lines 24a, 24b and the core cowl hinge lines 32a, 32b are not parallel, the articulations allow for any movement of the attachment points forward or aft relative to each other.

Figure 5b shows the thrust-reverser cowl doors 16a, 16b in their fully open position with the core cowl doors 18a, 18b nested therein. It will be appreciated that, while the angle of rotation α of the thrust-reverser cowl doors 16a, 16b is no different to that of the known nacelle 10, the angle of rotation β of the core cowl doors 18a, 18b is increased, thereby increasing the available access Xb to the engine core compared with the nacelle 10.

This increase in access is illustrated in Figures 6 to 8. Figure 6 shows an overlay of a section through the thrust-reverser section of the known nacelle 10 and the nacelle 30 of the present invention in their open condition. It can be seen that the core cowl doors 18a, 18b of the nacelle according to the present invention are able to rotate through a considerably greater angle (β) than in the case of the known nacelle 10 (α). For example, the core cowl doors 18a, 18b of the nacelle 30 may be rotatable through an angle β of up to 58° compared with an angle α of less than 36° in the case of the known nacelle 10.

The shaded area Z represents the reduced accessibility available to maintenance personnel with the conventional C-Duct type thrust-reverser nacelle 10 when compared to the nacelle 30 of the present invention. The increased accessibility to the engine core provided by the present invention is extremely beneficial to the maintenance operator and can significantly reduce maintenance time on the engine.

Figure 7 shows a view of the section A-A in Figure 6 while Figure 8 shows a view of the section B-B. These Figures clearly show the improved access afforded by the present invention, represented by the shaded area Z, in comparison to the conventional C-Duct type thrust-reverser nacelle 10.

Figures 9 and 10 illustrate the closing procedure for the cowl doors 16a, 16b, 18a, 18b of the thrust-reverser section of the nacelle 30, which is the substantially the reverse of the opening sequence. For completeness, however, the steps are briefly outlined below.

In a first closing step, shown in Figure 9a, the maintenance operator unlocks and detaches the or each hold open rod and activates the PDOS system to lower the cowl door pairs 16a, 18a, 16b, 18b until the intermediate position is reached in which the thrust-reverser cowl doors 16a, 16b are almost closed but still provide sufficient access to the core cowl doors 18a, 18b for latching purposes.

In a second closing step, shown in Figure 9b, the link rods 40 are unlocked, allowing them to extend as the core cowl doors 18a, 18b are rotated from their nested position within the thrust reverser cowl doors 16a, 16b to the closed position with the thrust-reverser cowl doors 16a, 16b held stationary by the PDOS system.

In a third closing step, shown in Figure 10a, the link rods 40 are detached at their second ends 402 from the attachment points on the inner surface of the thrust-reverser cowl doors 16a, 16b and are returned to their stowed position within the core cowl 18a, 18b. The core cowl doors 18a, 18b are then fully closed and coupled or locked together at their lower interface 34 by means of the second latch. Advantageously, the design is such that if the link rods 40 are not correctly located in the stowed position, they will protrude through the split line between the core cowl doors 18a, 18b which will therefore not fully close.

The final closing step, illustrated in Figure 10b, involves the maintenance operator closing the thrust-reverser cowl doors 16a, 16b by means of the PDOS system and locking them together at their lower interface 26 by means of latching, such as by the first latch.

The precise form of link rod 40 and attachment means/attachment point for coupling the second end 402 thereof to the thrust-reverser cowl doors 16a, 16b is not essential and the skilled person will be eminently familiar with devices and configurations suitable to achieve the advantageous functionality described herein.

For example, in one embodiment, each link rod 40 comprises an elongated cylinder within which a cylindrical rod is slidably disposed. The free end of the cylindrical rod, constituting the first end 401 of the link rod 40, is coupled to the inner surface of the respective core cowl door 18a, 18b by means of the aforementioned articulation, whilst the free end of the cylinder, constituting the second end 402 of the link rod 40, is provided with a suitable attachment means for releasably engaging with the attachment point provided on the corresponding thrust-reverser cowl door 16a, 16b.

The link rod 40 may be biased towards the fully extended or the fully retracted position, as desired. This biasing force may be provided by resilient biasing means such as a spring. In one embodiment, a gas strut or compression strut is used for each link rod 40. Alternatively, or in addition, the length of the link rod 40 may be controlled by an actuator such as a hydraulic or pneumatic piston or an electric motor. Where the link rod 40 is power actuated, deployment and stowage thereof may also be controlled by actuators. Such an arrangement advantageously permits the control of the thrust-reverser opening and closing operations from a remote location, improving operational efficiency and safety.

As described above, the link rods 40 may be provided with latching or locking means (not shown), arranged to operate either manually or automatically at a pre-determined point or points along the stroke of the link rod 40, to maintain the link rod 40 at a predetermined length.

In the embodiment described above, the link rod 40 is able to be locked in its fully retracted condition so as to hold the core cowl doors 18a, 18b in the nested condition. Alternatively, or in addition, each link rod 40 may be lockable in both the fully retracted and fully extended conditions, and/or in various intermediate-length conditions.

It is noted that in some instances, for example where biasing means such as a spring or other biasing device is provided to bias the link rods 40 towards the fully retracted condition, such locking means may be unnecessary since the core cowl doors 18a, 18b will be urged towards the nested condition by the biasing force once the link rods 40 are coupled to the attachment points on the thrust-reverser cowl doors 16a, 16b.

Figure 11 shows the movement of the left hand link rod 40 from an initial position 40a to an end positon 40e during opening of the left hand thrust-reverser and core cowl doors 16a, 18a. The Figure clearly illustrates the trajectory 44t of the first end 401 of the link rod 40 (the articulation with the core cowl door 18a) and the trajectory 46t of the second end 402 of the

link rod 40 (the attachment point with the thrust-reverser door 16a) during the movement of the cowl doors to the fully open position. While the trajectory 44t is perpendicular to the core cowl hinge line 32a, and the trajectory 46t is perpendicular to the thrust-reverser hinge line 24a, they are not mutually parallel such that the orientation of the link rod 40 varies during opening. This change in orientation of the link rod 40 between the intermediate position and the fully open position of the cowl doors advantageously results in the core cowl door 18a, nesting further within the thrust-reverser cowl door 16a as the doors approach the fully open position, thereby permitting even greater access to the engine core 12.

Figures 12a and 12b demonstrate this further increased access. Figure 12a illustrates the cowl doors in the intermediate position, i.e. immediately after step three of the opening sequence. Reference D represents the increased access provided by the nesting of the core cowl door within the thrust-reverser door provided in comparison with the known nacelle 10 of Figure 1.

Figure 12b, on the other hand, illustrates the cowl doors in the fully open position, i.e. immediately after completion of the fourth step in the opening sequence. This Figure shows how a further increase in access (D + *x*) is provided by the change in orientation of the link rod 40 as the cowl doors move towards the fully open position which results in the core cowl door 18a nesting further within the thrust-reverser cowl door 16a. It will be appreciated that the right hand arrangement of cowl doors operates similarly.

It will be recognised by those skilled in the art that, when coupled by the respective link rod 40, the thrust-reverser cowl door 16a and the core cowl door 18a effectively form a four-bar linkage, with the two cowl doors 16a, 18a, the upper bifurcation 20a and the link rod 40 together forming the bars of the linkage and the thrust-reverser hinge 24a, the core cowl hinge 32a and the articulations at each end 401, 402 of the link rod 40 together forming the pivots of the linkage. This enables rotation of the core cowl door 18a relative to the thrust-reverser cowl door 16a even during final step of the opening sequence, i.e. as the cowl doors approach the fully open position, and contrasts with the known thrust-reverser arrangement of Figure 1 in which the core cowl door 18a and the thrust-reverser door 16a are integral or permanently joined and thus rotate as a unitary member at all times during opening.

Various modifications may be provided to the invention, the embodiments of which above are to be considered as illustrative and not restrictive. That is to say, the invention is not

limited to the specific embodiments provided, but only by the scope of the claims and statements of invention provided herein.

For example, while in the above embodiment each link rod 40 is permanently attached to the respective core cowl door 18a, 18b by means of the articulation, it is possible for the link rod 40 to be permanently attached to the respective thrust-reverser cowl door 16a, 16b. In this arrangement, the second step of the opening sequence would involve the maintenance operator releasing the second end of the link rod 40 from the thrust-reverser cowl door 16a, 16b and connecting it to a suitable attachment point provided on the core cowl door 18a, 18b.

On the other hand, it is envisaged that neither of the link rods 40 may be permanently connected to the cowl doors but may be fully detachable for storage elsewhere on the engine or nacelle. In this case, both ends 401, 402 of the link rod 40 may be provided with connection means for connection in an articulated manner to suitable attachment points on the thrust-reverser and core cowl doors 16a, 16b, 18a, 18b.

It will be appreciated that the present invention provides an advantageous improvement to a thrust-reverser section of a nacelle for a turbine engine. By providing independently pivotable inner and outer cowl doors in the thrust-reverser section of the nacelle, and by providing an articulated linkage between them, improved access to the engine core can be achieved.

Other advantages will be apparent to one skilled in the art. For example, nacelle maintainability is increased by improving accessibility to the engine even in cases where the opening angle α of the thrust-reverser cowl doors 16a, 16b is restricted by the proximity of the nacelle to the wing.

The invention may reduce nacelle weight by removal of the lower bifurcations 22a, 22b typical of a conventional C-duct type design, thereby also reducing the amount of “lost” bypass flow area. In addition, the invention removes the need for a separate opening system (PDOS) for the core cowl doors 18a, 18, which would otherwise be required for an independently hinged core cowl design.

In addition, the articulated nature of the linkage formed by the cowl doors and the link rods is such that if the PDOS is erroneously used to close the thrust-reverser cowl doors 16a, 16b without detachment of the link rod 40 during the third step of the closing sequence, no

structural damage will occur since the thrust-reverser cowl doors 16a, 16b will be completely closed before the core cowl doors 18a, 18b are completely closed.

While the embodiments provided above relate to the thrust-reverser section of a nacelle for a turbine engine, it will be appreciated by one skilled in the art that the invention is equally applicable to other sections of the nacelle, for example outer cowl and core cowl doors that are forward of the thrust-reverser section. Furthermore, it is envisaged that there are potentially other uses for the present invention with other engine types and for other vehicle applications.

CLAIMS

1. A nacelle for an engine, comprising:

an outer cowl door;

an inner cowl door; and

a connection device for selectively connecting the outer and inner cowl doors.

2. A nacelle as claimed in claim 1, wherein the outer and inner cowl doors are hinged to the nacelle for independent rotation relative thereto.

3. A nacelle as claimed in claim 1 or claim 2, wherein the outer cowl door is hinged for rotation about a first hinge line or axis and the inner cowl door is hinged for rotation about a second hinge line or axis, the first and second hinge lines or axes being offset from each other.

4. A nacelle as claimed in claim 3, wherein the first hinge line or axis is substantially parallel to the second hinge line or axis.

5. A nacelle as claimed in claim 3 or claim 4, wherein the first and second hinge lines or axes are substantially parallel to a central axis of the nacelle.

6. A nacelle as claimed in any preceding claim wherein the outer and inner cowl doors are independently movable between closed and respective fully open positions and wherein the perpendicular distance between the cowl doors in the fully open position thereof is less than the perpendicular distance between the cowl doors in the closed position thereof.

7. A nacelle as claimed in any preceding claim wherein the outer and inner cowl doors are rotatable between closed and respective fully open positions and wherein the angle of rotation of the inner cowl door between the closed and fully open positions thereof is greater than the angle of rotation of the outer cowl doors between the closed and fully open positions thereof.

8. A nacelle as claimed in claim 6 or claim 7, wherein in the fully open position of the outer and inner cowl doors, the inner cowl door is at least partially nested within the outer cowl door.

9. A nacelle as claimed in any of claims 6 to 8, wherein the connection device is arranged to maintain the inner cowl door at least partially nested within the outer cowl door when the cowl doors are in the fully open position.

10. A nacelle as claimed in any preceding claim, wherein the connection device is extensible and movable between a first, reduced length, position and a second, extended length, position.

11. A nacelle as claimed in claim 10, wherein the connection device is arranged to connect the inner cowl door to the outer cowl door such that movement of the connection device between the second position and the first position permits the inner cowl door to rotate relative to the outer cowl door such that the perpendicular distance between the cowl doors reduces.

12. A nacelle as claimed in any preceding claim, wherein the connection device is arranged to permit the outer and inner cowl doors to open simultaneously.

13. A nacelle as claimed in claim 10 or claim 11 wherein the connection device comprises means for locking the connection device in at least one of the first and second positions.

14. A nacelle as claimed in claim 13, wherein the means for locking is arranged to lock the connection device in a position between the first and second positions.

15. A nacelle as claimed in any preceding claim, wherein the connection device is pivotally connectable and/or connected at each end thereof to a respective one of the inner and outer cowl doors.

16. A nacelle as claimed in any preceding claim, wherein a first end of the connection device is connectable to one of the inner and outer cowl doors by means of a first articulation and wherein a second end of the connection device is connectable to the other of the inner and outer cowl doors by means of a second articulation.

17. A nacelle as claimed in claim 16, wherein the first end of the connection device is fixed to one of the inner and outer cowl doors by means of the first articulation, and wherein the second end of the connection device is detachably connectable to the other of the inner and outer cowl doors by means of an articulated attachment device.

18. A nacelle as claimed in claim 16 or claim 17, wherein the first and/or second articulation comprises one of a ball joint, rose joint or universal joint.

19. A nacelle as claimed in any preceding claim, wherein when the connection device connects the inner and outer cowl doors, the arrangement substantially defines an articulated, four-bar linkage comprising the cowl doors, the connection device and a portion of the nacelle.

20. A nacelle as claimed in any preceding claim, wherein the inner cowl door comprises a portion of a core cowl for at least partially surrounding a core of an engine housed in the nacelle.

21. A nacelle as claimed in any preceding claim, wherein the outer cowl door comprises a thrust-reverser portion of the nacelle.

22. A nacelle as claimed in any preceding claim, wherein the connection device is movable between a stowed position and a deployed position in which the connection device connects the outer and inner cowl doors.

23. A nacelle as claimed in any preceding claim, wherein the connection device is biased towards one of the first and second positions.

24. A nacelle as claimed in any preceding claim, comprising a first latch for latching the outer cowl door to a second, opposing outer cowl door in the closed position thereof.

25. A nacelle as claimed in any preceding claim, comprising a second latch for latching the inner cowl door to a second, opposing inner cowl door in the closed position thereof.

26. A thrust-reverser section for an engine nacelle, comprising:

an outer cowl door;

an inner cowl door; and

a connection device for selectively connecting the outer and inner cowl doors.

27. A thrust-reverser section as claimed in claim 26 comprising one or more of the features claimed in any of claims 2 to 25.

28. An engine for an aircraft comprising a nacelle or a thrust-reverser section as claimed in any preceding claim.

29. An aircraft or a vehicle comprising an engine, a nacelle or a thrust-reverser section as claimed in any preceding claim.

30. A method of accessing an engine housed in a nacelle having outer and inner cowl doors, the method comprising:

opening at least one outer cowl door by rotation through a first angle of rotation;

opening at least one inner cowl door by rotation through a second angle of rotation, that is greater than the first angle of rotation; and;

connecting the at least one outer cowl door to the at least one inner cowl door.

31. A method as claimed in claim 30, comprising carrying out the steps sequentially and in the order listed.

32. A method as claimed in claim 30 or claim 31, additionally comprising rotating the at least one outer cowl door and the at least one inner cowl door simultaneously.

33. A method as claimed in claim 30, comprising connecting the at least one outer cowl door to the at least one inner cowl door and then opening the cowl doors simultaneously.

34. A method as claimed in claim 30, comprising carrying out the opening and connecting steps simultaneously.

35. A method as claimed in any of claims 30 to 34, wherein opening the at least one outer cowl door comprises rotating the at least one outer cowl door about a first hinge line or axis and wherein opening the at least one inner cowl door comprises rotating the at least one inner cowl door about a second hinge line or axis, the first and second hinge lines or axes being offset from each other.

36. A method as claimed in claim 30, comprising:

unlatching the outer cowl door and rotating it through a first angle to a partially open position;

unlatching the inner cowl door and coupling a connection device between the inner cowl door and the outer cowl door;

opening the inner cowl door by rotation through a second angle that is greater than the first angle; and

rotating the outer cowl door to a fully open position whereby the connection device couples the movement of the outer cowl door with the inner cowl door, causing the cowl doors to open simultaneously.

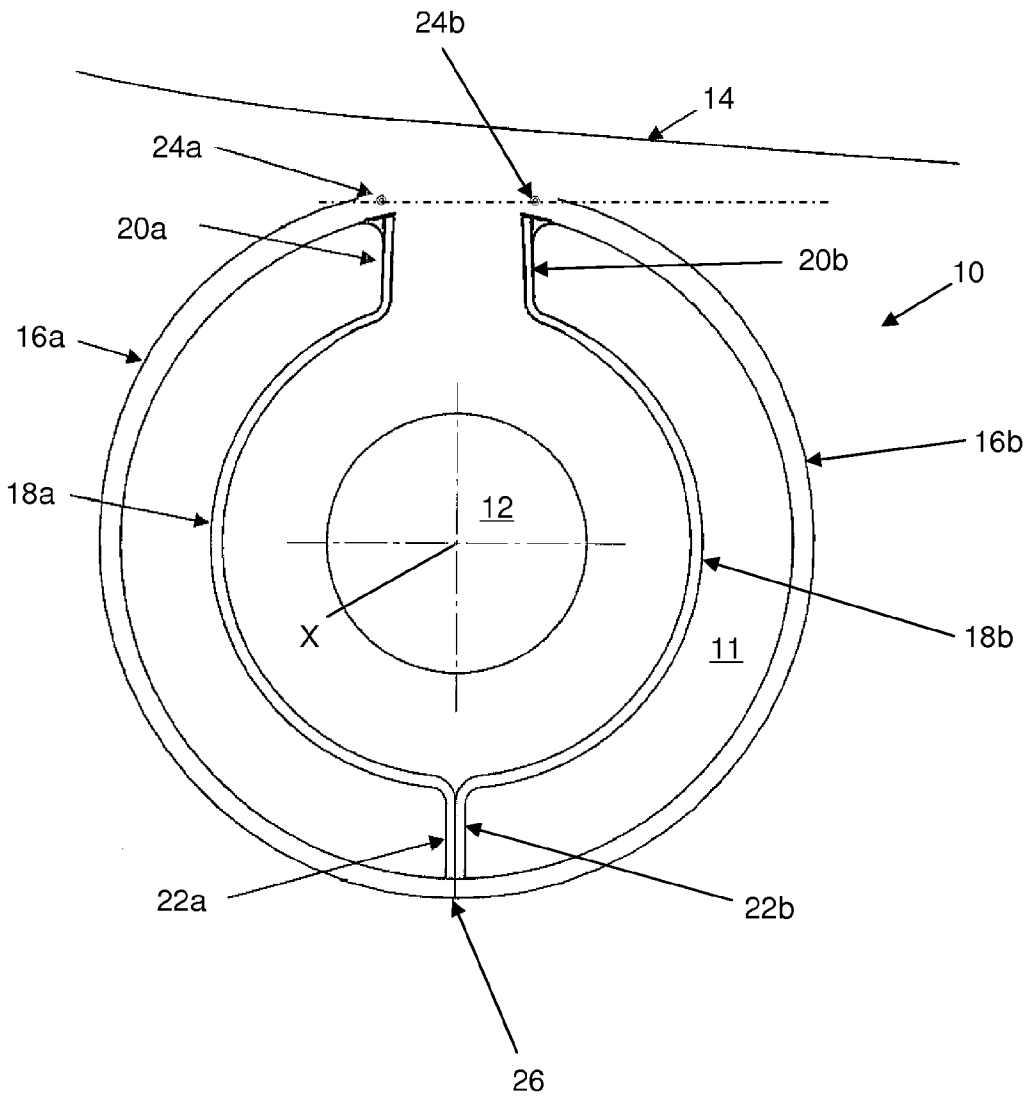


Figure 1

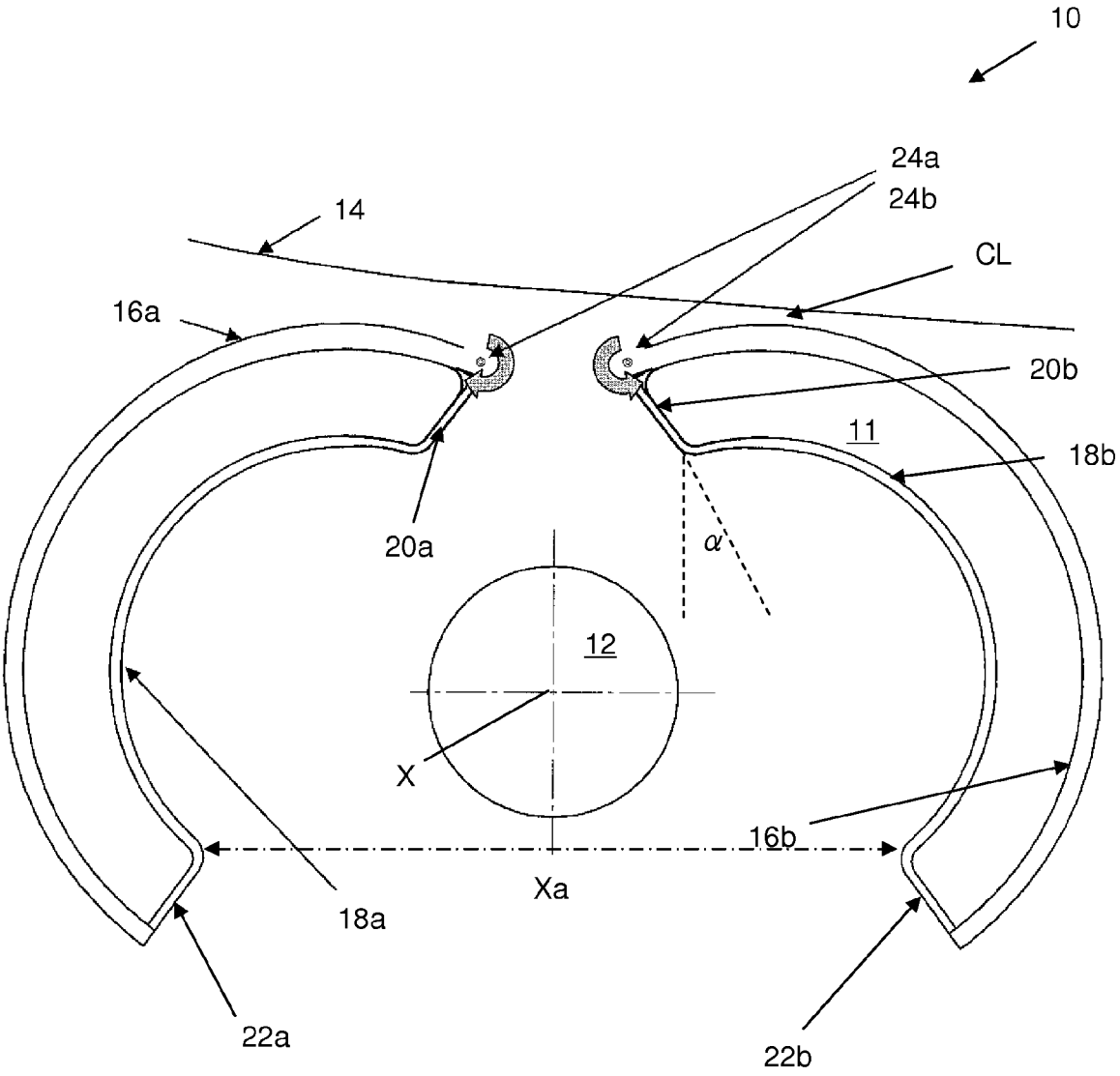


Figure 2

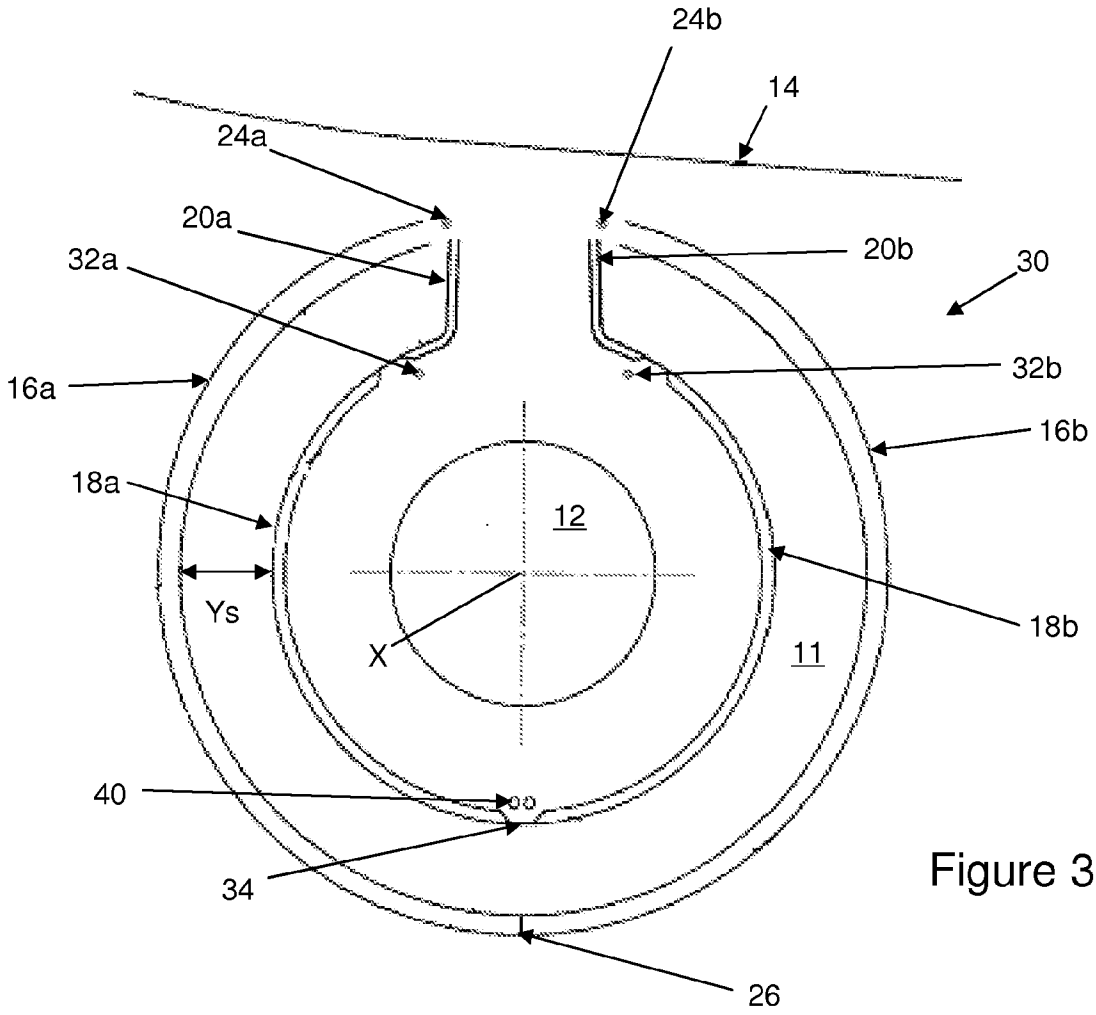


Figure 3a

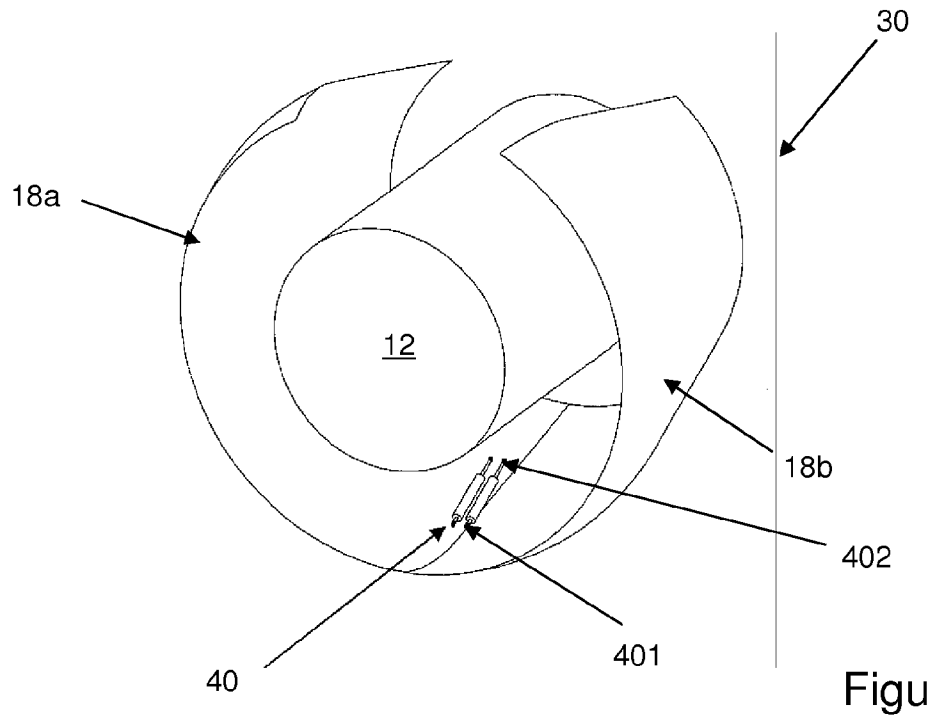


Figure 3b

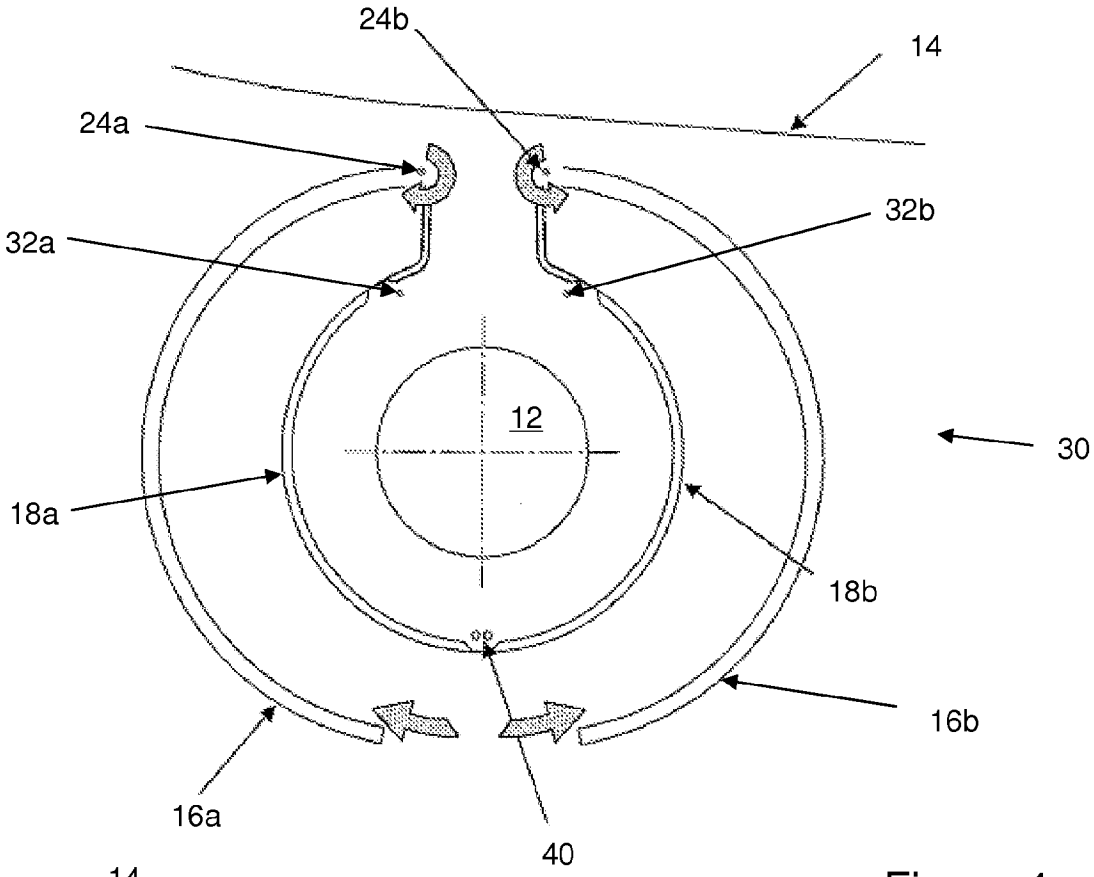


Figure 4a

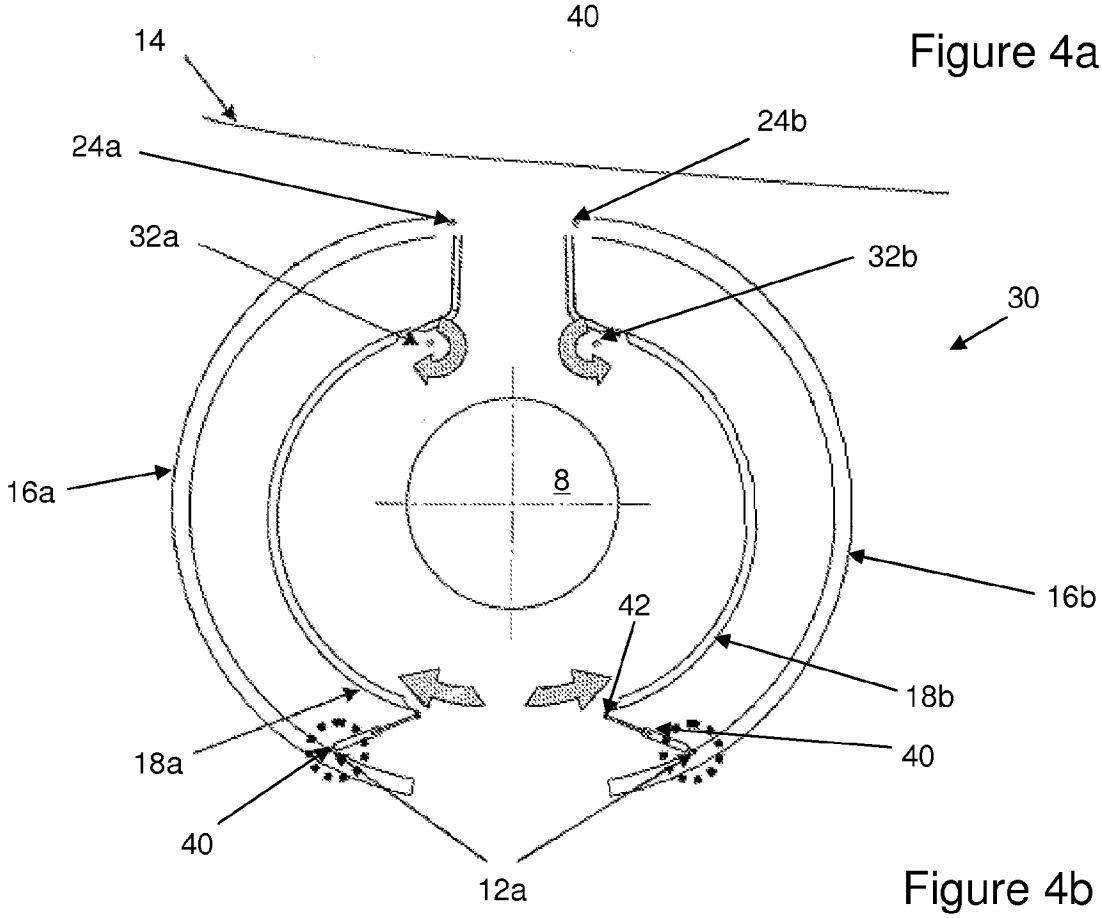


Figure 4b

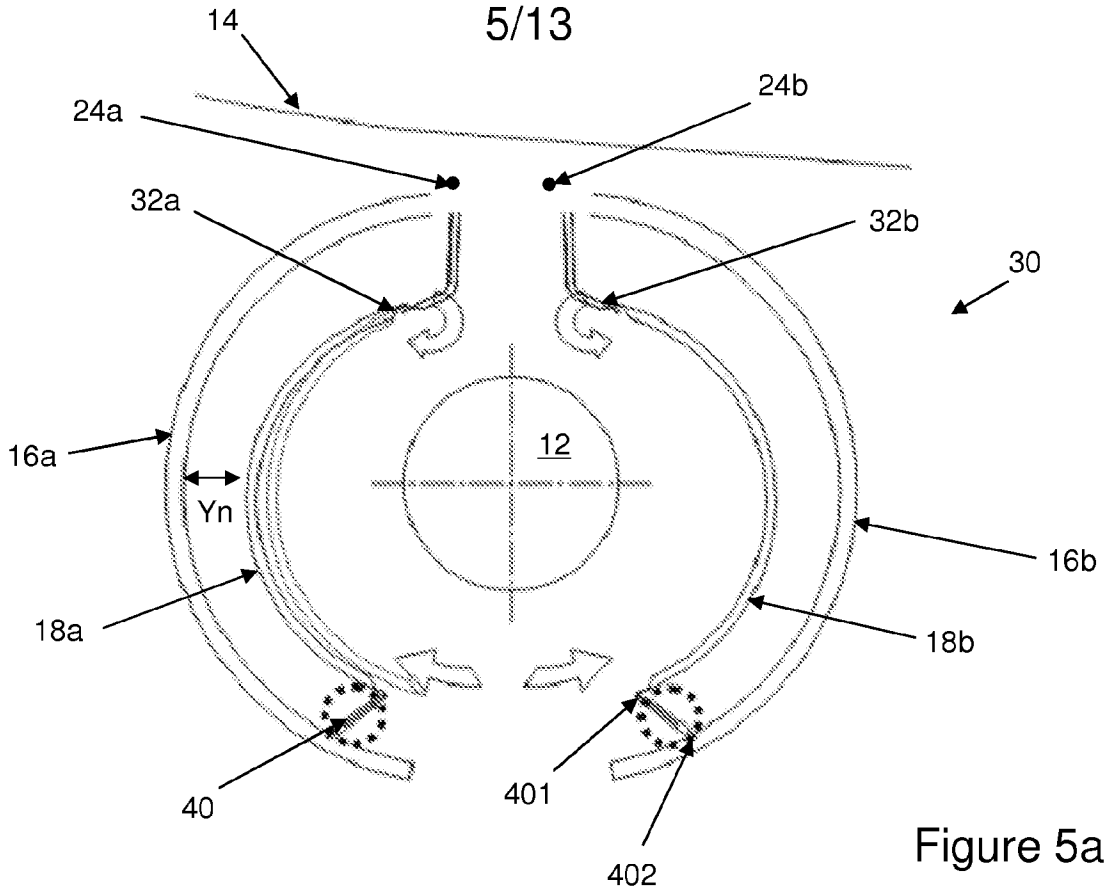


Figure 5a

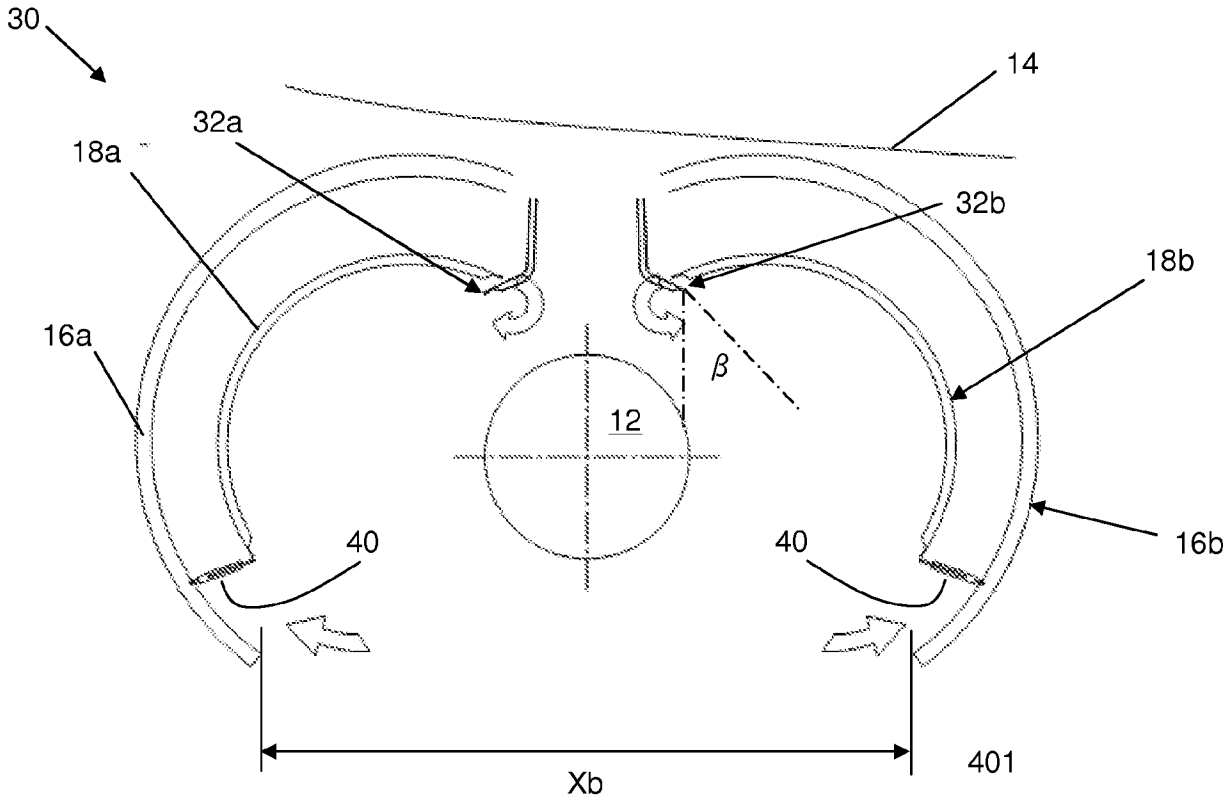


Figure 5b

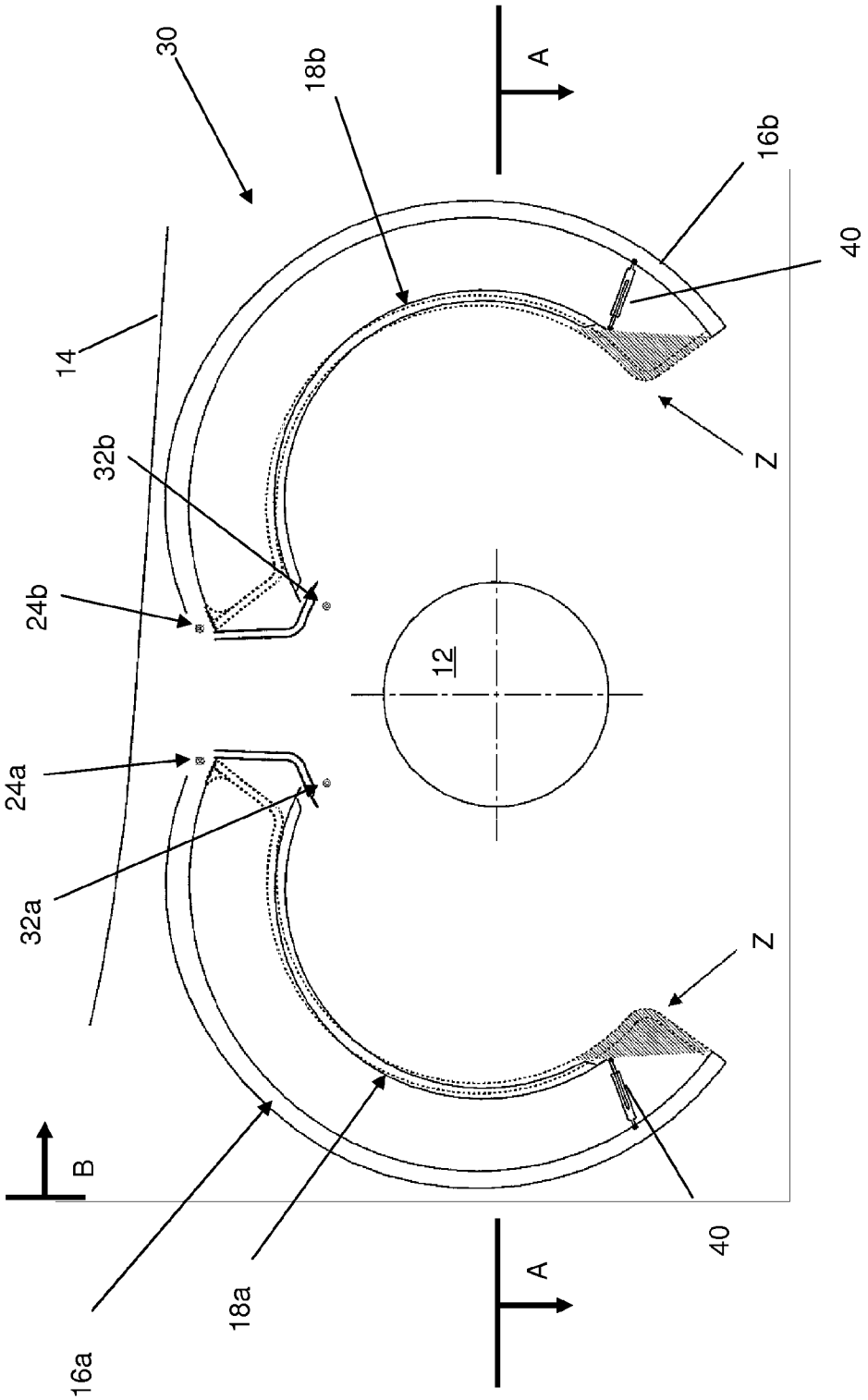


Figure 6

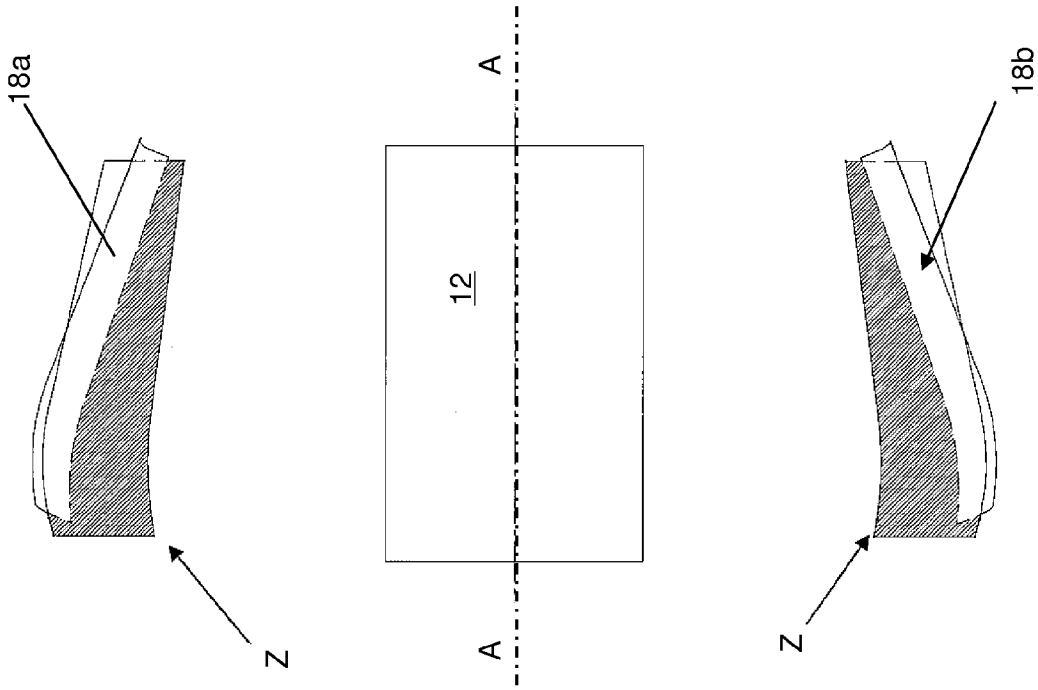
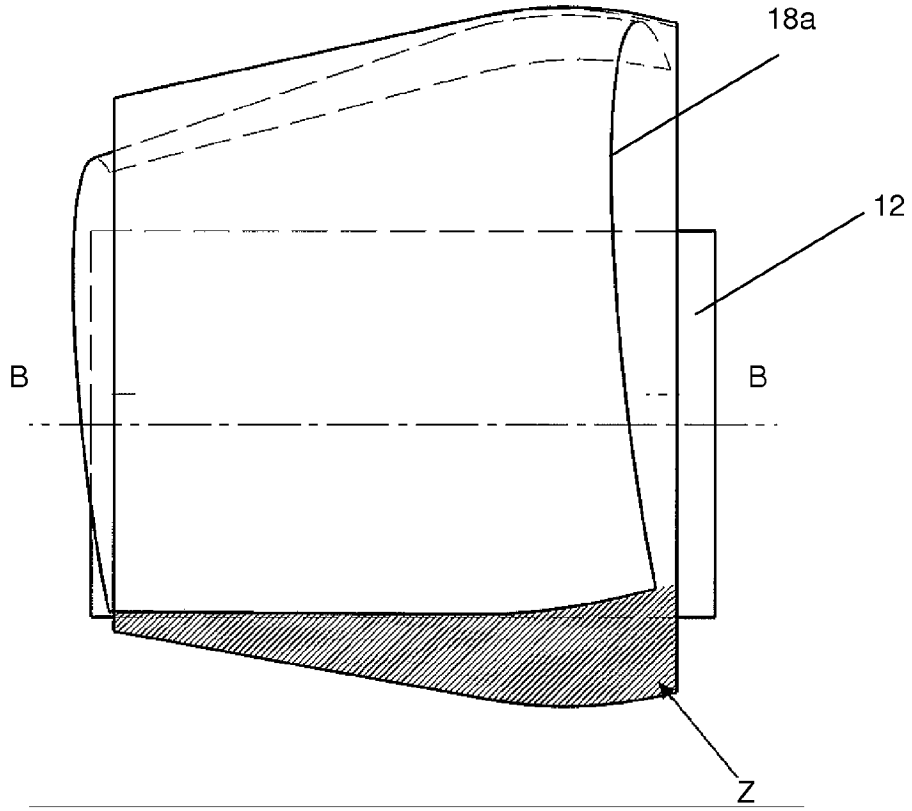


Figure 7

Section A-A



Section B-B

Figure 8

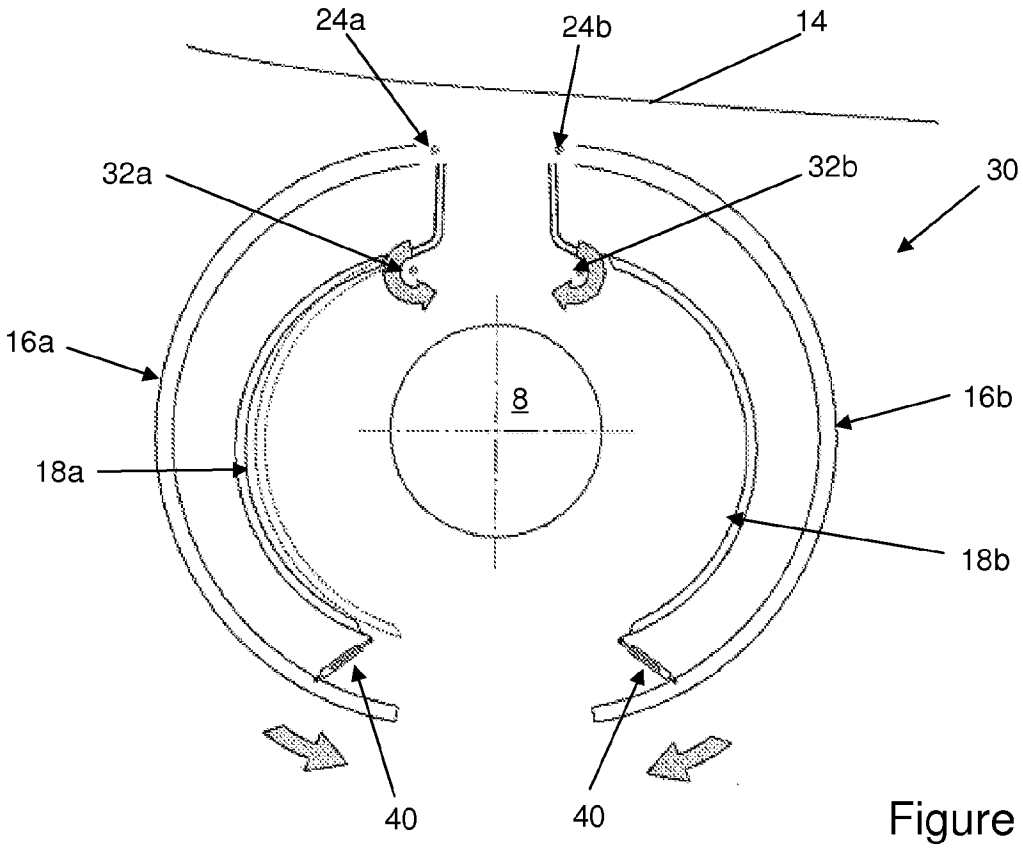


Figure 9a

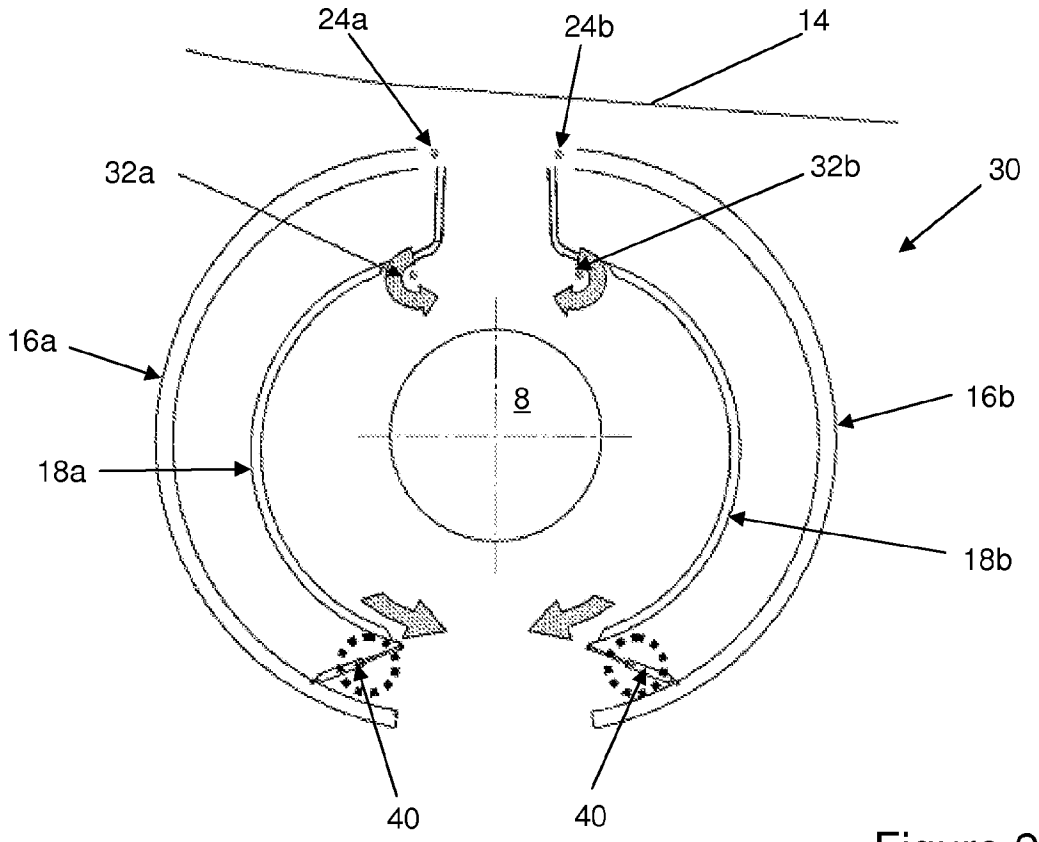


Figure 9b

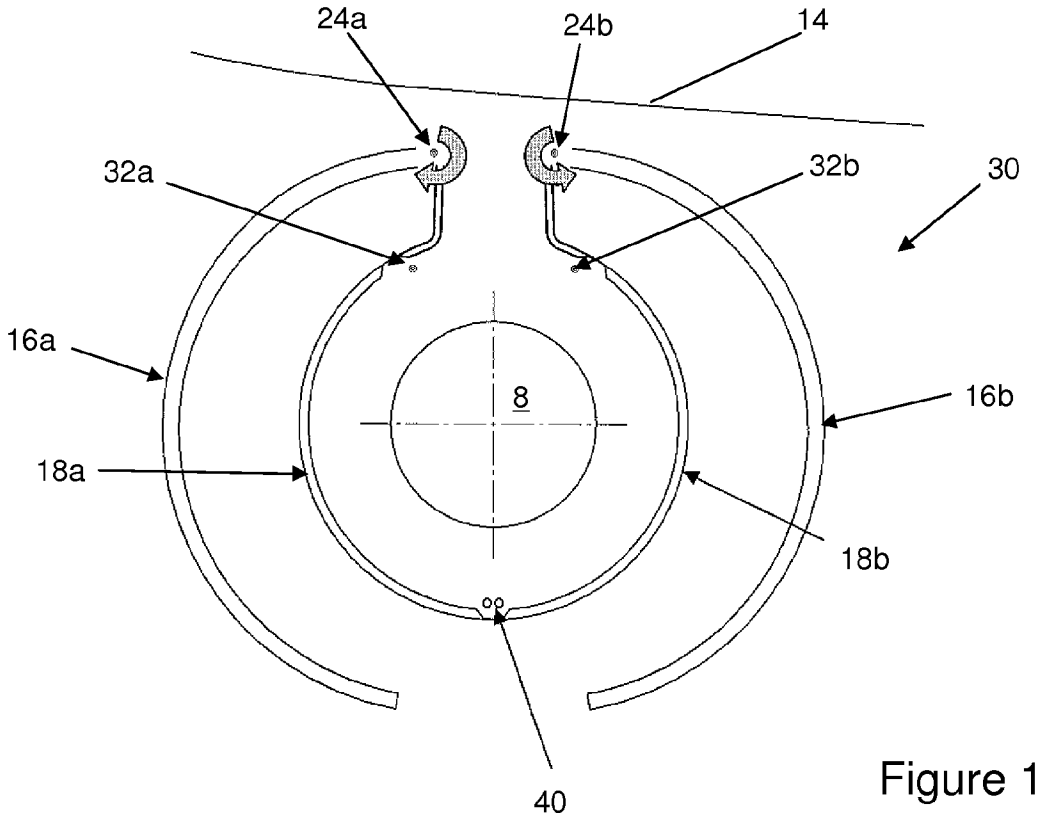


Figure 10a

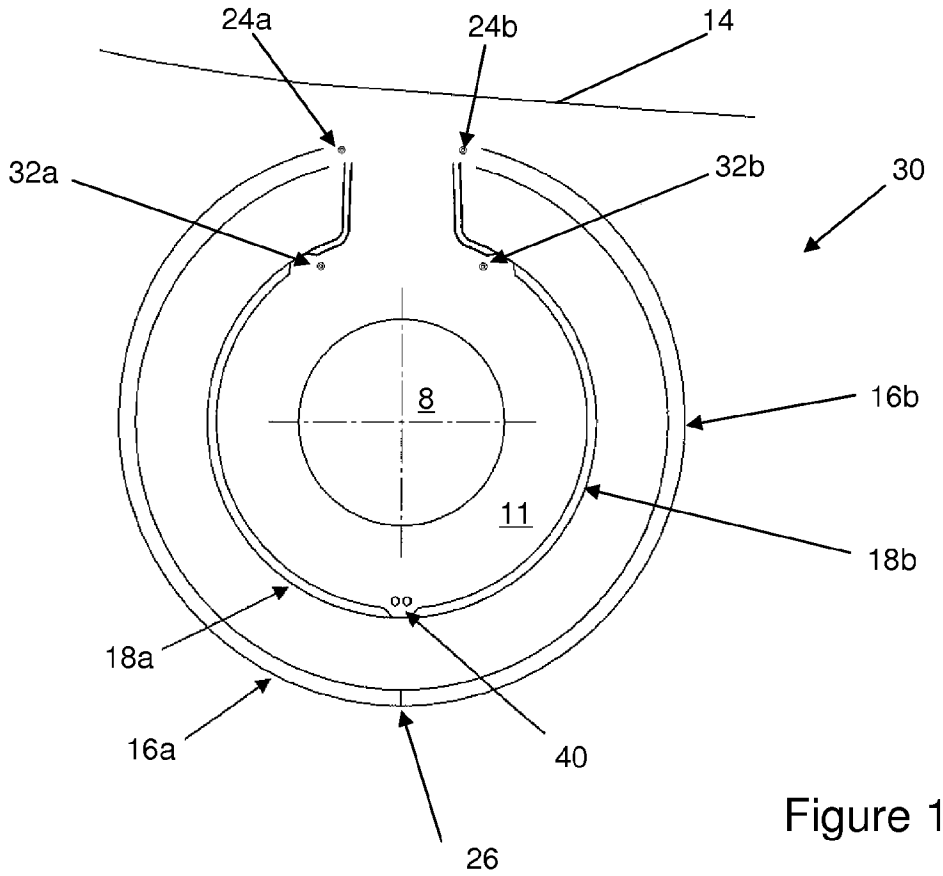


Figure 10b

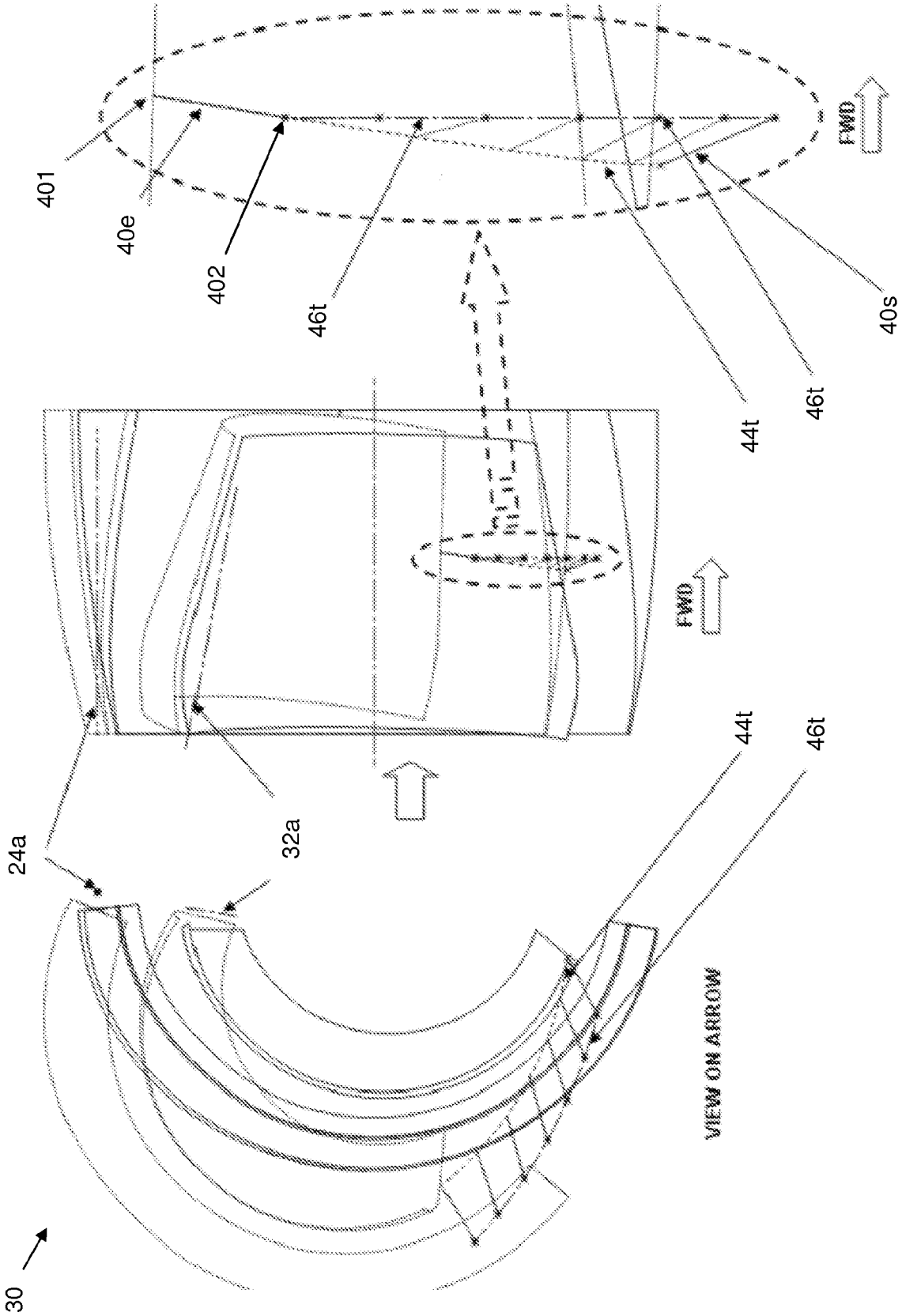

401
40e
402
46t
40s
44t
46t
FWD
FWD
24a
32a
44t
46t
VIEW ON ARROW
30

Figure 11

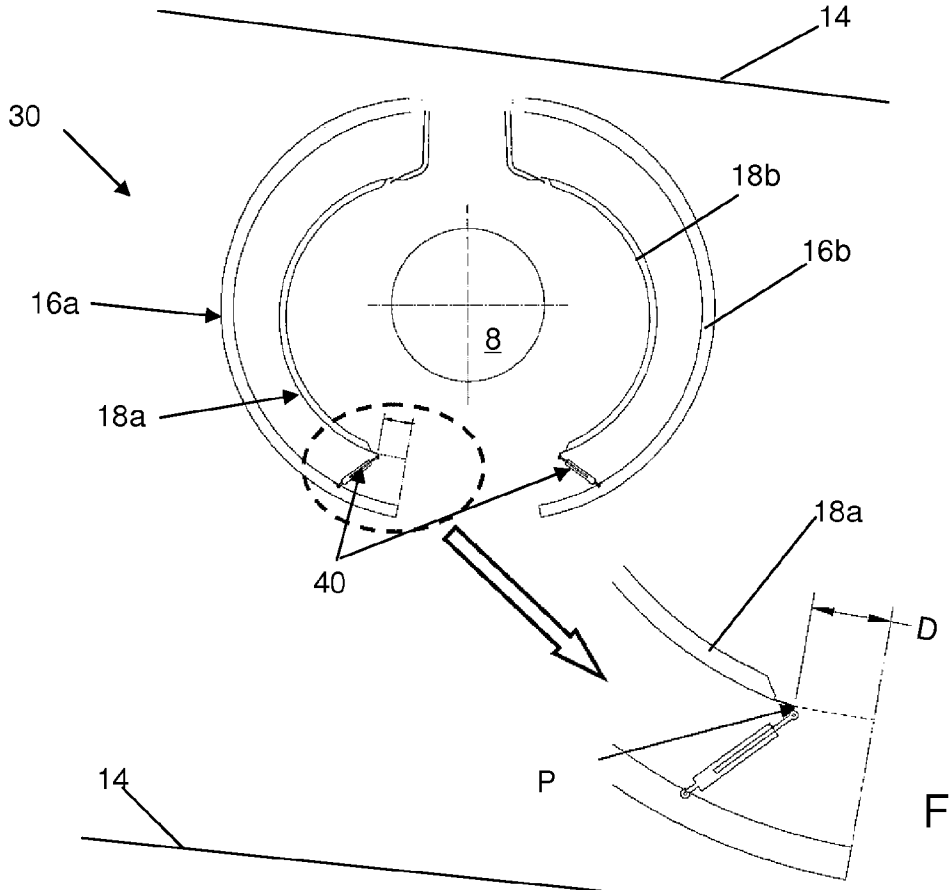


Figure 12a

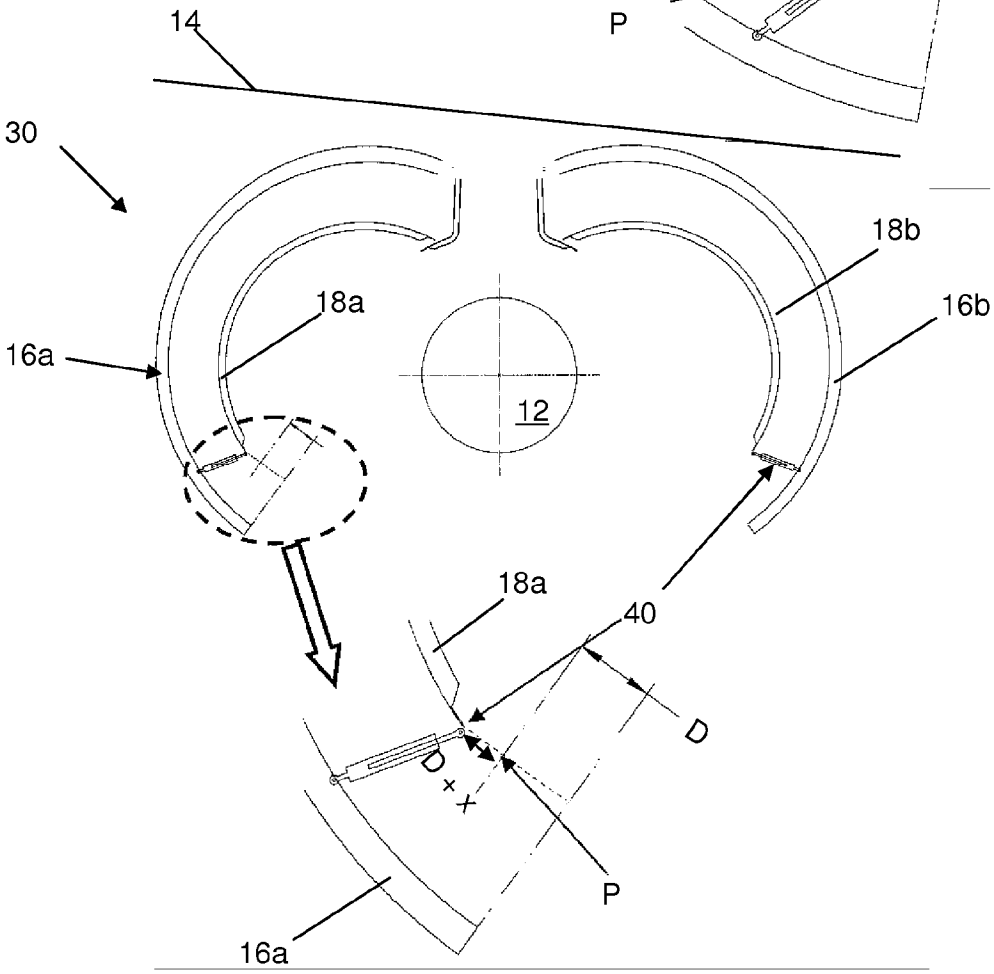


Figure 12b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/064197

A. CLASSIFICATION OF SUBJECT MATTER
INV. B64D29/08
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)
B64D

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 practical, 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	EP 0 393 259 A1 (BOEING CO [US]) 24 October 1990 (1990-10-24) the whole document	1-18, 20-31, 34,35

X	EP 0 155 887 A1 (SNECMA [FR]) 25 September 1985 (1985-09-25) figures 9a,9b,10a,10b	1-5,8, 26-30,35

X	FR 2 897 339 A1 (AIRCELLE SA [FR]) 17 August 2007 (2007-08-17) figures 1-6	1-3,7,8, 21,24-29

X	FR 2 920 177 A1 (AIRCELLE SA [FR]) 27 February 2009 (2009-02-27) figures 1-9	1-5,7, 10-13, 15-23, 26-33,35

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] 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 document 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	Date of mailing of the international search report
18 August 2011	25/08/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Wojski, Guadalupe

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/064197

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 737 914 A (PORTE ALAIN [FR] ET AL) 14 April 1998 (1998-04-14) the whole document -----	1-3,30
X	EP 1 099 629 A1 (AEROSPATIALE MATRA AIRBUS SA [FR] AIRBUS FRANCE [FR]) 16 May 2001 (2001-05-16) figure 1 -----	1-5, 26-30
X	FR 2 907 759 A1 (AIRCELLE SA [FR]) 2 May 2008 (2008-05-02) figure 1 -----	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/064197

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0393259 A1	24-10-1990	US 5046689 A	10-09-1991
EP 0155887 A1	25-09-1985	DE 3560143 D1	04-06-1987
		FR 2560854 A1	13-09-1985
		US 4683717 A	04-08-1987
FR 2897339 A1	17-08-2007	AT 453568 T	15-01-2010
		CA 2642300 A1	23-08-2007
		CN 101384485 A	11-03-2009
		EP 1984248 A1	29-10-2008
		ES 2338066 T3	03-05-2010
		WO 2007093683 A1	23-08-2007
		US 2008315034 A1	25-12-2008
FR 2920177 A1	27-02-2009	CA 2696710 A1	26-02-2009
		CN 101784445 A	21-07-2010
		EP 2178758 A1	28-04-2010
		EP 2319762 A2	11-05-2011
		WO 2009024431 A1	26-02-2009
		US 2011038725 A1	17-02-2011
US 5737914 A	14-04-1998	FR 2731049 A1	30-08-1996
		GB 2298402 A	04-09-1996
EP 1099629 A1	16-05-2001	CA 2325870 A1	10-05-2001
		DE 60021244 D1	18-08-2005
		DE 60021244 T2	20-04-2006
		ES 2244398 T3	16-12-2005
		FR 2800707 A1	11-05-2001
		US 6666408 B1	23-12-2003
FR 2907759 A1	02-05-2008	AT 473163 T	15-07-2010
		CA 2666614 A1	08-05-2008
		CN 101528543 A	09-09-2009
		EP 2084062 A1	05-08-2009
		ES 2347894 T3	22-11-2010
		WO 2008053087 A1	08-05-2008
		US 2010284806 A1	11-11-2010