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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 June 2002 (27.06.2002)

PCT

(10) International Publication Number
WO 02/49913 A1

(51) International Patent Classification[7]: B64D 13/00, F16L 55/027

(21) International Application Number: PCT/GB01/05528

(22) International Filing Date:
14 December 2001 (14.12.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0031006.0 20 December 2000 (20.12.2000) GB

(71) Applicant *(for all designated States except US)*: **HONEYWELL NORMALAIR-GARRETT (HOLDINGS) LIMITED** [GB/GB]; Westland Works, Yeovil, Somerset BA20 2YD (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **ROOTS, Christopher, Francis** [GB/GB]; Bridge Cottage, Lufton, Yeovil, Somerset BA22 8SU (GB).

(74) Agent: **FORRESTER KETLEY & CO.**; Chamberlain House, Paradise Place, Birmingham B3 3HP (GB).

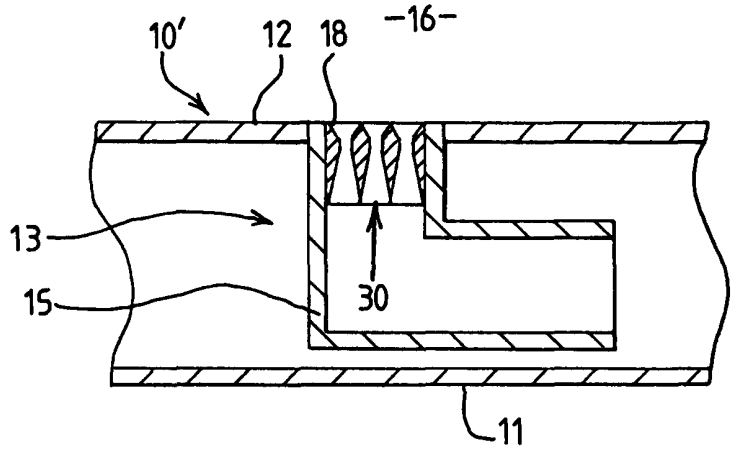
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: FLOW LIMITING APPARATUS



(57) Abstract: A flow limiting apparatus (10') for limiting the flow of bleed air from an engine includes a plurality of parallel air flow paths therethrough, each flow path being provided by a venturi device (32) having a throat (36) and associated diverging section (37).

WO 02/49913 A1

Title: Flow Limiting Apparatus

Description of Invention

This invention relates to an apparatus for limiting the flow of bleed air from an engine of an aircraft for use in the aircraft's sub-systems. For example such bleed air may be used for aircraft cabin air conditioning and pressurisation, or by an oxygen generating or concentrating apparatus, or for de-icing purposes.

It is desirable to use a flow limiting apparatus in such circumstances in order to maintain the air pressure and to enhance fuel efficiency.

Such a flow limiting apparatus typically includes a venturi device which has a converging section, a throat, and a diverging section. To achieve smooth fluid flow with a minimum of fluid turbulence, the length of the diverging section is dependant upon the diameter of the throat, with the diverging section being relatively long. For example, for a typical engine air bleed flow limiting apparatus in which the throat has a diameter of about 25mm, the diverging section may have a length of about 200mm, with a cone angle of the diverging section of about 14°.

Providing a flow limiting apparatus with a long diverging section, and thus long overall length is acceptable in many applications, where space permits, but particularly in some aircraft where space is at a premium, for example where the distance between an engine bleed port and an engine nacelle in an aircraft engine installation, is too short, it may not be possible to accommodate such a long length venturi device. In such circumstances, typically a flow limiting apparatus having a simple orifice has to be provided, resulting in unwanted turbulence, accordingly high fluid pressure losses, and attendant higher fuel consumption.

Another reason for minimising pressure losses due to the flow limiting apparatus is that where the bleed air is used for air conditioning, after

processing the bleed air, the bleed air is expanded by passing the bleed air through a turbine wheel. The greater the pressure of the bleed air, the greater the pressure and thus temperature drop can be achieved, resulting in greater and more efficient cooling of the bleed air.

According to a first aspect of the invention we provide an apparatus for limiting the flow of bleed air from an engine, the apparatus includes a plurality of parallel fluid flow paths therethrough, each flow path being provided by a venturi device having a throat and associated diverging section.

Thus by providing a plurality of parallel fluid flow paths, with the diameter of each throat being smaller than that which would be required for a single venturi device whilst together providing at least an equivalent area for fluid flow as a single venturi device, it has been found that a desired limited air flow may be achieved through the apparatus, with a loss of pressure which is at least not substantially greater, and possibly less, than for an equivalent single venturi device. Importantly, the overall length of the apparatus may be made considerably shorter than for an equivalent single venturi device, whilst a cone angle of the diverging section may still be made to be about 14°.

Because the flow limiting apparatus may be made shorter than a conventional such apparatus, the apparatus may be situated where most convenient, e.g. either at or adjacent a port through which engine bleed air passes from the engine, or in ducting from the port.

Preferably the plurality of venturi devices are arranged in a generally circular array, with the throat of each venturi device centred generally on a circle, and the array may include a central venturi device, with the throat of the central venturi device centrally located of the circle.

Preferably each of the plurality of venturi devices includes a converging section.

The multiple venturi devices of the flow limiting apparatus may be contained within a generally cylindrical body.

If desired, the flow control apparatus may include means to monitor and/or regulate the flow of fluid through the apparatus.

To achieve this a fluid signal may be derived from the apparatus, and converted to an electrical signal using a suitable transducer, which electrical signal may be used to give an indication of fluid flow, or to regulate fluid flow.

The electrical signal may be used to operate a controller which is operative to regulate air flow through the apparatus.

Alternately, the monitoring and/or regulating means may be operated in response to an air signal.

Preferably, the air signal is derived from a plurality of or all of the fluid flow paths, for example by providing passages from the flow paths, in the region of the respective venturi device, and connecting the passages to so that the transducer receives a compound air signal.

Whereas it is previously known to monitor air flow through prior art devices in a similar manner to that described, by virtue of the invention, the overall length of the apparatus may again be minimised by virtue of the plurality of parallel venturis.

According to a second aspect of the invention we provide an engine installation including a chamber having therein, high pressure air, and an apparatus to limit the flow of bleed air from the chamber, for use, the apparatus providing a plurality of parallel fluid flow paths therethrough, each flow path being provided by a venturi device having a throat and associated diverging section.

The flow limiting apparatus may be positioned at or adjacent bleed port from the chamber, or in ducting extending from the port.

According to a third aspect of the invention we provide an aircraft having an engine installation according to the second aspect of the invention.

The aircraft may include a sub-system being one or more of the following, to which bleed air is fed for use, namely, an air conditioning sub-

system, a cabin air pressurisation sub-system, an oxygen generating or concentrating sub-system, and a de-icing sub-system.

According to a fourth aspect of the invention we provide a method of bleeding air from a high pressure port for subsequent use, including the step of passing the air through a flow control apparatus according to the first aspect of the invention.

The method may include deriving from at least one and preferably a plurality of the parallel air flow paths, an air signal, converting the air signal into an electrical signal, which may be used to give an indication of, or to operate a controller which is operated to regulate, air flow through the apparatus.

The invention will now be described with reference to the accompanying drawings in which:-

FIGURE 1 is an illustrative view of part of a prior art engine installation incorporating a prior art venturi device;

FIGURE 2 an illustrative view of part of a prior art, single venturi device;

FIGURE 3 is a view of an engine installation similar to figure 1 but incorporating a flow limiting apparatus in accordance with the invention;

FIGURE 4 is an end view of a flow limiting apparatus in accordance with the invention;

FIGURE 5 is a side cross-sectional view taken on the lines A-A of figure 4;

FIGURE 6a and 6b are respectively side and end views of a apparatus in accordance with the invention, with a flow monitor/control means.

FIGURE 7 is an illustrative view of an aircraft having an engine installation incorporating the invention.

Referring to figure 1, an engine installation 10 of an aircraft includes an outer engine casing 11, an inner engine casing 12, and a space 13 between the

inner 12 and outer 13 engine casings. Within the space 13 there is ducting 15 for engine air bled from a high air pressure chamber 16 of the engine installation 10, which air may be bled from the chamber 16 through a bleed port indicated at 18. To limit the flow of air through the port 18 there is provided a flow limiting apparatus 20 which in this case is a simple orifice 21, sized to restrict the air flow to a desired degree. However the simple orifice 21 results in considerable turbulence in the ducting 15, which is undesirable, and the flow limiting apparatus 20 of this figure, results in pressure losses which are greater than desirable.

In figure 2 there is shown a single venturi device 24 which may be used as a flow limiting apparatus in the place of the flow limiting apparatus 20 shown in figure 1, where space permits this. It can be seen that overall, the venturi device 24 is substantially longer than the flow limiting apparatus 20 of figure 1, and includes a converging section 25, a throat 26 through which the air is constrained to flow, and a diverging section 27 which is substantially conical in configuration and includes a cone angle of about 14°.

The venturi device 24 necessarily is long because the length of the diverging section 27 is related to the diameter d of the throat 26, and the cone angle is ideally of about 14°.

Thus where the bleed port 18 has a diameter D, so the inlet of converging section 25 has a diameter of about D, the throat 26 limits air flow, whilst minimal pressure losses are incurred due to the air flowing smoothly, generally without turbulence, along the diverging section 27.

It will be appreciated that in the figure 1 engine installation, the ducting 15 between the inner 12 and outer 13 engine casings is insufficiently long readily to accommodate the single venturi device 24 of figure 2 and thus the advantages of providing a venturi device, such as shown in figure 2, hithertofore, have not been realisable.

Referring now to figures 3, 4, 5 and 7 there is shown an engine installation 10' for an aircraft A, in accordance with the second aspect of the invention. Similar parts to those shown in figure 1 are indicated by the same reference numerals.

In the figure 3 installation 10', the simple orifice type of flow limiting apparatus 20 is replaced with a flow limiting apparatus 30 in accordance with the first aspect of the invention.

The flow limiting apparatus 30 of the invention provides a plurality of parallel air flow paths therethrough, in this example seven air flow paths, each air flow path including a venturi device 32 of substantially identical construction. Each venturi device 32 includes a converging section 35, a throat 36, and a diverging section 37. The diameters d' of the throats 36 are commensurately smaller than the diameter d of the single venturi device 24 of figure 2, the total cross-sectional area of the seven throats being about the same as the cross sectional area of a throat of a corresponding single venturi device 24, but the converging sections 35 and importantly diverging sections 37, are substantially shorter than the converging 25 and diverging 36 sections of the corresponding single venturi device 24. Moreover, the cone angles of each diverging section 37 of each venturi device 32 are maintained at about 14°.

Thus overall, the multiple venturi device flow limiting apparatus 30 is substantially shorter than a corresponding single venturi device 24, without there being any substantially greater pressure loss in the flowing air.

In this example, the multiple (seven) venturi devices 32 are housed in a circular body 38 which can be set in the bleed port 18 e.g. in the place of the simple orifice type flow limiting device 20 of figure 1. Thus six of the venturi devices 32 are arranged so as to be centred on a circle, with the seventh venturi device 32 located centrally of the body 38. Of course other arrangements are possible depending on the available space etc. Instead of providing the flow limiting apparatus 30 at or adjacent the bleed port 18, in another arrangement

the apparatus 30 may be positioned along the ducting 15 in another convenient location.

In each case, air flowing through the multiple flow paths of the apparatus 30, i.e., through the throats 36 of the multiple venturi devices 32 may be fed for use in an aircraft sub-system such as an air-conditioning or air pressurisation sub-system, or an oxygen generator or concentrator, or even a de-icing sub-system. Particularly where the air is for use in air conditioning, the minimal loss of pressure sustained enables the air more effectively to be cooled before being fed into an aircraft cabin for example. Where the air is to be used by an oxygen generating or concentrating system, the minimal pressure losses enable oxygen to be produced, or oxygen concentration to be enhanced more effectively than with a simple orifice apparatus such as indicated at 20 in figure 1, where there is insufficient space to accommodate a single venturi device 24 of the kind shown in figure 2.

Referring now to figures 6a and 6b, a flow control apparatus 30 similar to that of figures 3 to 5 is shown, but modified. Similar parts to those indicated in figures 3 to 5 are labelled with the same reference numbers.

In this embodiment, an air signal is derived from the air flow apparatus 30, and fed along a line 40 to a transducer 41 which converts the air signal to an electrical signal on line 42. For example, the magnitude of or other characteristic of the electrical signal may depend on the pressure of the air of the air signal, but could depend on the air flow speed, where an air flow sensor is provided to generate the air signal.

The air signal is derived from respective passages 44 which connect with the fluid flow, in the regions of the venturis 32. In the example shown, a passage 44 is provided for each venturi 32, and the passages 32 are all connected, e.g. via a manifold 46 to the line 40 so that the air signal received by the transducer 41 is a compound signal.

In another example, the air signal may not be derived from all of the venturis 32, but only one of them, or from a plurality of them.

The electrical signal 42 is in this example, used to regulate the air flow through the apparatus 30. The signal is fed to a controller 50 which may include motive means, to turn a shaft 51 which is connected to a butterfly valve 52 in a bleed passage 55 downstream of the flow limiting apparatus 30. Of course, any alternative air flow regulating mans may be provided, and/or the electrical signal may be used for indicating air flow through the flow limiting apparatus 30, if desired.

Instead of using an electrical signal to operate a flow limiting apparatus 30, an air signal may be used, e.g. via Servo, to operate an actuator such as a piston and cylinder device, which operates a valve in the bleed passage 55, to regulate air flow.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof

CLAIMS

1. An apparatus for limiting the flow of bleed air from an engine, the apparatus including a plurality of parallel air flow paths therethrough, each flow path being provided by a venturi device having a throat and associated diverging section.

2. An apparatus according to claim1 characterised in that a cone angle of the diverging section of each of the plurality of venturi devices is about 14°.

3. An apparatus according to claim 1 or claim 2 characterised in that the plurality of venturi devices are arranged in a generally circular array.

4. An apparatus according to claim 3 characterised in that the throat of each venturi device is centred generally on a circle with there being a central venturi device, with the throat of the central venturi device centrally located of the circle.

5. An apparatus according to any one of the preceding claims characterised in that each of the plurality of venturi devices includes a converging section.

6. An apparatus according to any one of the preceding claims characterised in that the multiple venturi devices of the flow limiting apparatus are contained within a generally cylindrical body.

7. An apparatus according to any one of the proceeding claims characterised in that means are provided to monitor and/or regulate the flow of air through the apparatus.

8. An apparatus according to claim 7 characterised in that the monitoring and/or regulating means include a transducer to which an air signal derived from the apparatus is fed, the transducer converting the air signal into an electrical signal.

9. An apparatus according to claim 8 characterised in that the electrical signal operates a controller which regulates fluid flow through the apparatus.

10. An apparatus according to claim 7 characterised in that the monitoring and/or regulating means is operated in response to an air signal derived from the apparatus.

11. An apparatus according to claim 8 or claim 9 or claim 10 characterised in that the air signal is derived from a plurality of the fluid flow paths via passages from the flow paths in the regions of the respective venturi devices, the passages being connected so that the transducer receives a compound air signal.

12. An engine installation including a chamber having therein, high pressure air, and an apparatus to limit the flow of bleed air from the chamber for use, the apparatus providing a plurality of parallel fluid flow paths therethrough, each flow path being provided by a venturi device having a throat and associated diverging section.

13. An installation according to claim 12 characterised in that the flow limiting apparatus is positioned at or adjacent a bleed port from the chamber.

14. An installation according to claim 14 characterised in that the flow limiting apparatus is positioned in ducting extending from the bleed port.

15. An aircraft having an engine installation according to any one of claims 12 to 14.

16. An aircraft according to claim 15 characterised in that the aircraft includes at a sub-system being one or more of the following, to which bleed air is fed for use, namely, an air conditioning sub-system, a cabin air pressurisation sub-system, an oxygen generating or concentrating sub-system, and a de-icing sub-system.

17. A method of bleeding air from a high pressure port for subsequent use, including the step of passing air through a flow limiting apparatus according to any one of claims 1 to 11.

18. A method according to claim 17 characterised in that the method includes deriving from at least one of the plurality of parallel air flow paths of the flow control apparatus, an air signal, and using the air signal to give an indication of, and/or to operate a controller which is operative to regulate, air flow through the apparatus.

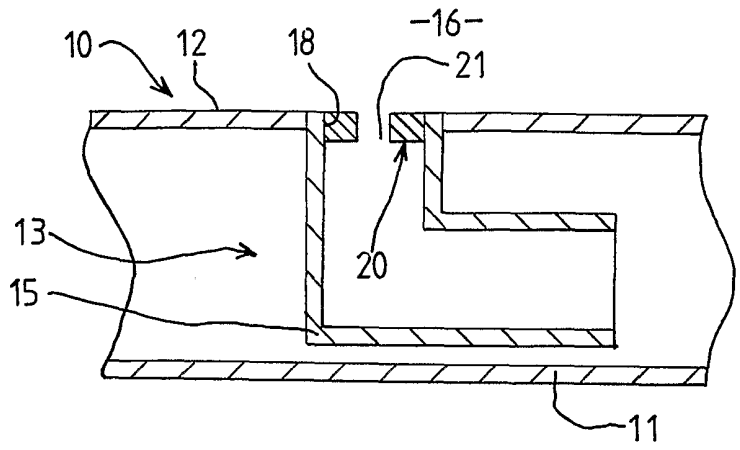


FIG 1
(PRIOR ART)

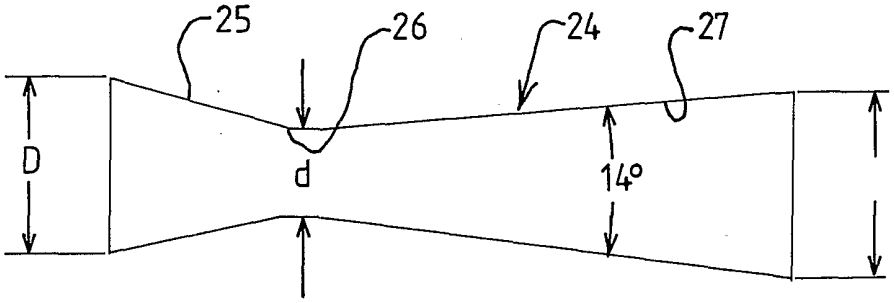


FIG 2 (PRIOR ART)

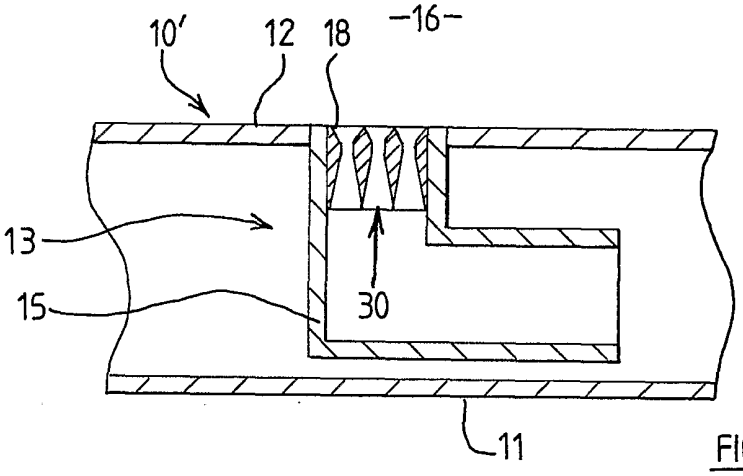


FIG 3

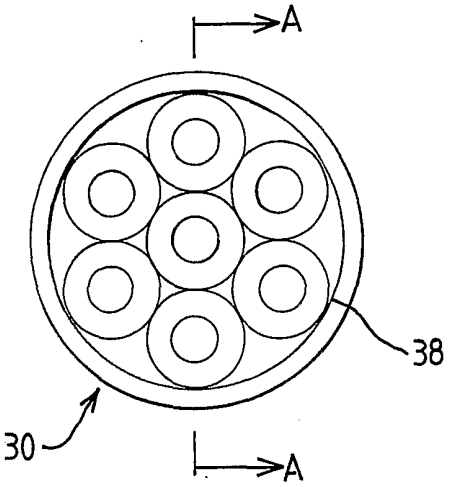


FIG 4

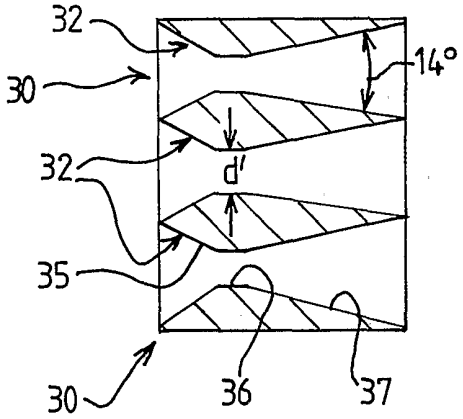


FIG 5

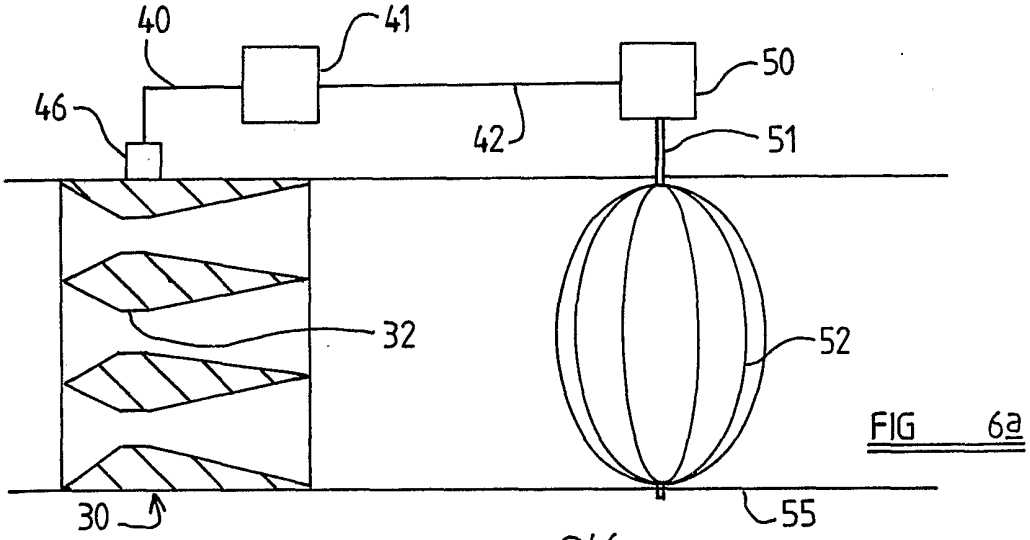


FIG 6a

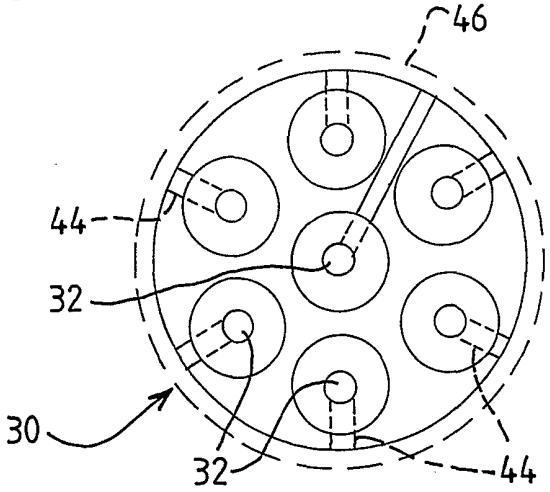


FIG 6b

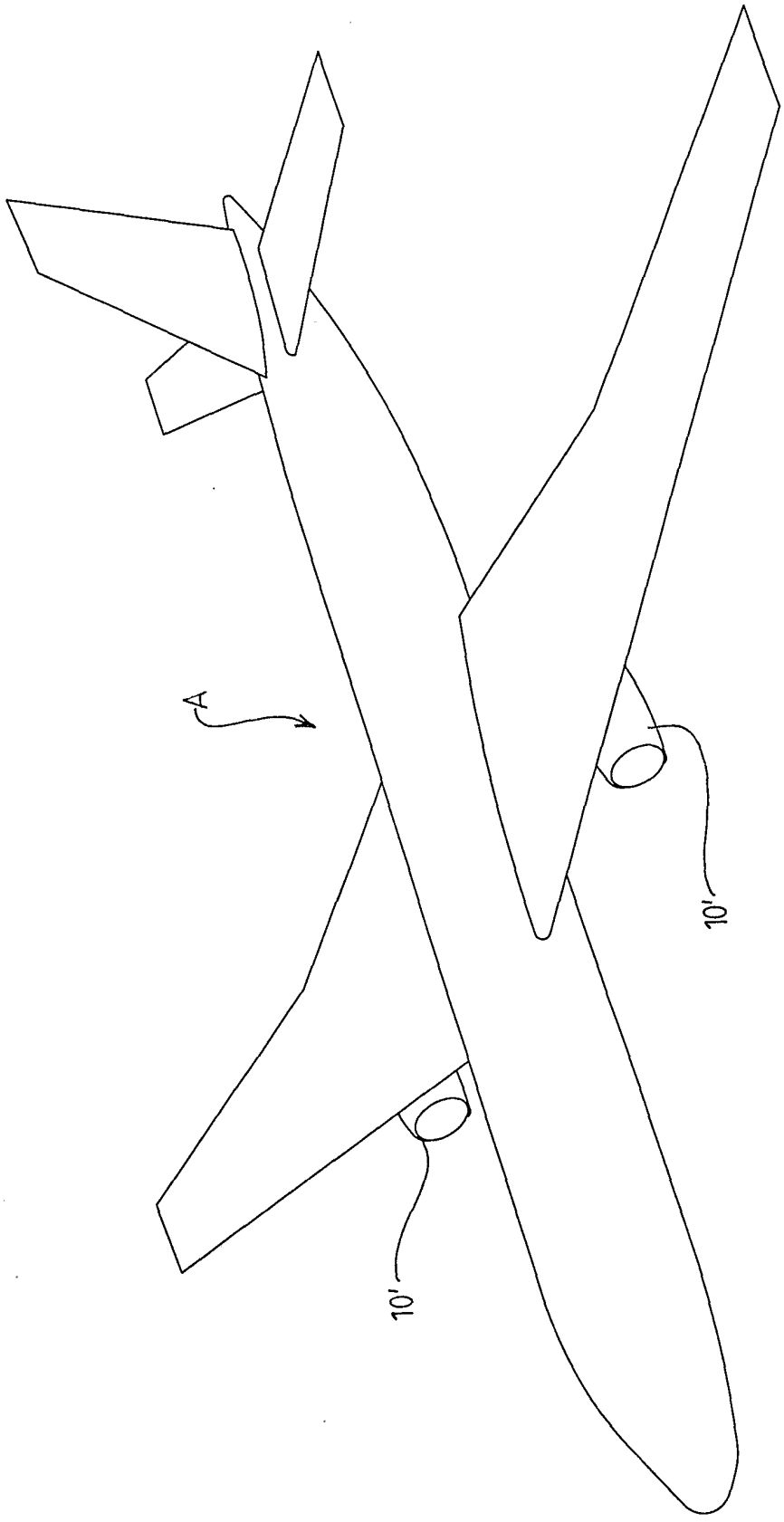


FIG 7

INTERNATIONAL SEARCH REPORT

Inte ›nal Application No
PCT/GB 01/05528

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B64D13/00 F16L55/027

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)
IPC 7 B64D F16L

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 710 392 A (WESTINGHOUSE ELECTRIC CORP) 31 March 1995 (1995-03-31) page 3, line 3-20; figures page 7, line 27-34	1-3,5,6
A	figure 2	4
X	US 4 030 523 A (CRAM ROBERT E ET AL) 21 June 1977 (1977-06-21) column 1, line 66 -column 2, line 67; figures	1,5,7, 12,14,17
X	DE 43 14 788 C (PETERSEN HUGO VERFAHRENSTECH) 18 August 1994 (1994-08-18) column 3, line 29-33; figure 3 column 5, line 33-56	1,3-6

-/--

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

[X] Patent family members are listed in 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
13 February 2002	22/02/2002

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, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Salentiny, G

INTERNATIONAL SEARCH REPORT

Int al Application No
PCT/GB 01/05528

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 143 866 A (WESTINGHOUSE ELECTRIC CORP) 9 February 1973 (1973-02-09) the whole document	1,3-6, 12,13,17
A	US 4 559 275 A (MATT BERNHARD ET AL) 17 December 1985 (1985-12-17) the whole document	1-3
A	EP 0 507 725 A (UNITED TECHNOLOGIES CORP) 7 October 1992 (1992-10-07) the whole document	7-10,12, 14-18
A	EP 0 773 276 A (INST FRANCAIS DU PETROL) 14 May 1997 (1997-05-14) page 3, line 29	2
A	US 4 506 594 A (ROWLAND CHARLES M ET AL) 26 March 1985 (1985-03-26) the whole document	7,12,17

INTERNATIONAL SEARCH REPORT

Information on patent family members

Ir al Application No
PCT/GB 01/05528

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
FR 2710392	A	31-03-1995	BE	1009104 A3	05-11-1996
			FR	2710392 A1	31-03-1995
US 4030523	A	21-06-1977	NONE		
DE 4314788	C	18-08-1994	DE	4314788 C1	18-08-1994
			AT	184209 T	15-09-1999
			DE	59408710 D1	14-10-1999
			EP	0628335 A1	14-12-1994
			ES	2139685 T3	16-02-2000
FR 2143866	A	09-02-1973	FR	2143866 A1	09-02-1973
US 4559275	A	17-12-1985	CH	659864 A5	27-02-1987
			DE	3320753 A1	29-12-1983
			GB	2123981 A	08-02-1984
			JP	1671456 C	12-06-1992
			JP	3037650 B	06-06-1991
			JP	59009306 A	18-01-1984
EP 0507725	A	07-10-1992	US	5155991 A	20-10-1992
			DE	69201452 D1	30-03-1995
			DE	69201452 T2	14-06-1995
			EP	0507725 A1	07-10-1992
EP 0773276	A	14-05-1997	FR	2741086 A1	16-05-1997
			DE	69609390 D1	24-08-2000
			DE	69609390 T2	07-12-2000
			EP	0773276 A1	14-05-1997
			ES	2150649 T3	01-12-2000
			JP	9169983 A	30-06-1997
			TW	402580 B	21-08-2000
US 4506594	A	26-03-1985	EP	0087935 A2	07-09-1983