



(51) International Patent Classification:

B64F 1/36 (2006.01) *F16L 59/153* (2006.01)
F16L 11/08 (2006.01) *F24F 13/02* (2006.01)

(21) International Application Number:

PCT/US2012/054717

(22) International Filing Date:

12 September 2012 (12.09.2012)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

13/232,023 14 September 2011 (14.09.2011) US

(71) Applicant (for all designated States except US):

ILLINOIS TOOL WORKS INC. [US/US]; 3600 West Lake Avenue, Glenview, Illinois 60026 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **LEADINGHAM,**

David Wayne [US/US]; c/o Illinois Tool Works Inc., 3600 West Lake Avenue, Glenview, Illinois 60026 (US). **HANSEN, Richard Lawrence** [US/US]; c/o Illinois Tool Works Inc., 3600 West Lake Avenue, Glenview, Illinois 60026 (US). **NEWELL, Ty Allen** [US/US]; c/o Illinois Tool Works Inc., 3600 West Lake Avenue, Glenview, Illinois 60026 (US).

(74) Agent: **HAUPTMAN, Benjamin J.**; Lowe Hauptman

Ham & Berner, LLP, 1700 Diagonal Road, Suite 300, Alexandria, Virginia 22314 (US).

(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

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

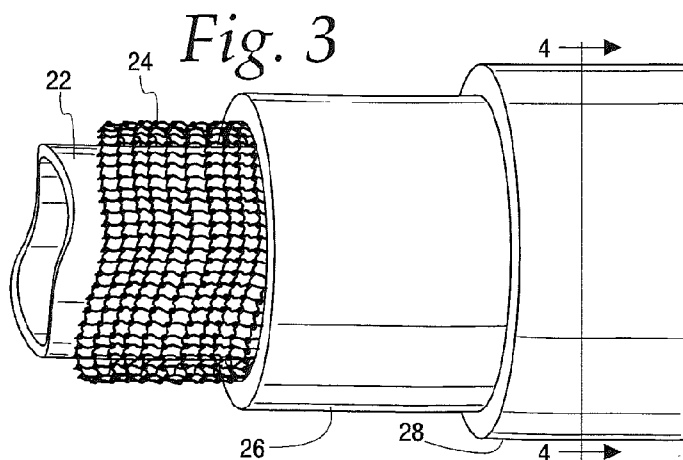
Declarations under Rule 4.17:

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

Published:

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

(54) Title: AIRCRAFT GROUND SUPPORT HOSE ASSEMBLY



(57) **Abstract:** An air delivery hose assembly (10) for use with aircraft ground support equipment (12) provides conditioned air to an on-ground aircraft (14). The hose assembly (10) includes an impermeable inner liner (22) which forms an air conduit, a stress layer (24) comprising a web of cord material which surrounds the inner liner (22), and an insulating layer (26) which surrounds the inner liner (22) and the stress layer (24) to thermally insulate air passing through the air hose. The stress layer (24) prevents air pressure in the conduit from expanding the inner liner (22) and compressing the insulating layer (26), and thereby from reducing the effectiveness of the insulating layer (26).



AIRCRAFT GROUND SUPPORT HOSE ASSEMBLY

Cross-Reference to Related Application

[001] This application claims priority to and the benefit of U.S. Non-Provisional Patent Application No. 13/232,023, filed September 14, 2011, the entire contents of which are incorporated herein by reference.

Background of the Invention

I. Field of the Invention.

[002] The present disclosure relates generally to an air supply hose assembly. In particular, the present disclosure is directed to an air supply hose assembly for supplying pre-cooled air to an on-ground aircraft.

II. Description of the Prior Art.

[003] Aircraft on the ground powered up for repair or replenishment often require conditioned air to cool the pilot and to maintain electronics and other support equipment at desired temperatures. Such conditioned air is typically supplied by a ground support cart which is positioned in close proximity to the aircraft. The ground support cart is connected to the aircraft by means of a flexible duct or hose.

[004] Conventional prior design flexible hose assemblies for ground support consist of an impermeable inner liner forming a conduit for the air, a closed cell insulation layer surrounding the inner liner to minimize warming of air passing through the conduit, and an outer liner to protect the insulation layer. Most of these current aircraft supply hose assemblies evolved from air supply hose assemblies used for civilian aircraft that operate at relatively low

pressures and small temperature ranges, and therefore have not been satisfactory for military aircraft which require substantially higher pressures and wider temperature ranges. When preconditioned air is forced from a ground support cart to a military aircraft through prior design air supply hose assemblies at higher pressures, the inner liner of the supply hose expands under the pressure and compresses the insulation, resulting in a loss of insulation efficiency and consequent increased warming of the conditioned air as it passes through the hose assembly.

[005] Accordingly, it is a general object of the present disclosure to provide a ground support hose assembly which provides improved insulation efficiency at the higher conditioned air pressures required by military aircraft as well as lower pressure conditions of other Military and Commercial aircraft.

[006] It is a more specific object of the present disclosure to provide a ground support hose assembly which includes an inner stress layer that prevents the inner liner of the hose from expanding as a result of pressurized air in the conduit.

[007] It is a still more specific object of the present disclosure to provide a ground support hose assembly having a woven stress layer composed of high strength cording which prevents the inner liner of the hose assembly from expanding under pressure.

[008] These and other objects, features and advantages of this disclosure will be more clearly understood through a consideration of the following detailed description.

Summary of the Invention

[009] According to an embodiment of the present disclosure, there is provided a ground support hose assembly for providing conditioned air from aircraft ground support equipment to an aircraft. The hose includes an inner liner forming an air conduit, a stress layer surrounding the inner liner for preventing the inner liner from expanding when air is forced through the conduit, and an insulating layer covering the stress layer and the inner liner for insulating air in the conduit.

[0010] There is also provided an air hose assembly for coupling a ground support cart to an aircraft. The assembly includes a main section having two ends, each of which includes a connector. The main section includes an inner liner forming an air conduit, a stress layer surrounding the inner liner for preventing the inner liner from expanding as a result of air pressure in the conduit, and an insulating layer surrounding the stress layer and the inner liner for insulating air in the conduit.

Brief Description of the Drawings

[0011] The present disclosure will be more fully understood by reference to the following detailed description of one or more preferred embodiments

when read in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout the views and in which:

[0012] Figure 1 is a perspective view of an aircraft connected to a ground support cart by an air supply hose assembly constructed in accordance with the principles of the present disclosure.

[0013] Figure 2 is a perspective view of the air supply hose assembly shown in Figure 1.

[0014] Figure 3 is an enlarged perspective view of the central portion of the air supply hose assembly of Figure 2 partially broken away to show the component parts thereof.

[0015] Figure 4 is a cross-sectional view of the supply hose assembly of Figure 3 taken along line 4-4 of Figure 3.

[0016] Figure 5 is a simplified cross-sectional depiction of an aircraft support hose assembly of conventional design illustrating pressurized air expanding the inner liner and undesirably compressing the insulation layer of the assembly.

[0017] Figure 6 is a simplified cross-sectional depiction of an aircraft support hose assembly constructed in accordance with the present disclosure illustrating the effect of the stress layer in preventing pressurized air from

expanding the inner liner and compressing the insulation layer of the hose assembly.

[0018] Figure 7 is a plot of pressure vs. heat transfer coefficient of representative conventional ground support hose assemblies A and B of conventional design and a hose assembly C constructed according to the principles of the present disclosure.

[0019] Figure 8 is a table showing delivery air temperature change of conventional prior design hose assemblies A and B of conventional design and a hose assembly C constructed according to the principles of the present disclosure.

Description of the Preferred Embodiments

[0020] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the disclosure, its application or use.

[0021] Turning now to the drawings, Figure 1 illustrates a preconditioned aircraft ground support assembly 10 connected between a conventional ground cart 12, such as the model J03C manufactured by ITW Military GSE, and a high performance military aircraft 14. The air hose assembly 10 delivers conditioned air to aircraft 14 to avoid the need to operate the on board air conditioning system of the aircraft itself while the aircraft is parked, or to supplement the on-board air conditioning to provide additional cooling when

the aircraft is operating on the ground. Such conditioned air may provide cooling for avionics or personnel while the aircraft 14 is on the ground.

[0022] As shown in Figure 2, the illustrated ground support hose assembly 10 includes a first connector 16 at one end for connection to ground support cart 12, a center section 18, and a second connector 20 at its other end for connecting to aircraft 14. In further embodiments, the ground support hose assembly 10 may include any number and combination of reinforced sections and/or flat sections, depending on the design specifications for the desired assembly.

[0023] Figures 3 and 4 illustrate the center section 18 of the ground support hose assembly 10 in more detail. The center section 18 includes an impermeable inner liner 22, a stress layer 24 surrounding the inner liner, an insulation layer 26 surrounding the inner liner 22 and stress layer 24, and an outer scuff covering layer 28 surrounding the inner liner 22, stress layer 24 and insulation layer 26. The inner liner 22 can be fabricated from a variety of impermeable materials such as vinyl with a fabric scrim or mesh embedded therein. The diameter of the liner 22 depends on the air delivery requirements of the application, but generally ranges from 4 to 14 inches.

[0024] The stress layer 24 is adjacent to and envelops the impermeable liner 22. The stress layer 24 is preferably fabricated as an open weave of a high strength cord or rope material. The weave density is determined by various factors, including the material strength of the cord, the air pressure in

assembly 10, and the diameter of inner liner 22. Low pressure applications would use a lighter cord and a more open weave while higher pressure applications would require a thicker cord and a denser weave. The woven cord stress layer 24 adds strength to the hose assembly, while still allowing flexibility when the hose assembly is deflated. Moreover, stress layer 24 prevents inner liner 22 from expanding as a result of air pressure in assembly 10, thus preventing compression of insulating layer 26.

[0025] Insulation layer 26 surrounds and envelops the inner impermeable liner 22 and the woven stress layer 24. The thickness of insulation layer 26 is based on the amount of insulation required to minimize temperature increase from surrounding ambient air as cooled conditioned air passes through the ground support hose assembly. The insulation may be either an “open cell” or “closed cell” construction. Open cell insulation, such as open cell foam insulations and fibrous insulations (e.g., polyester batting) is used when it is important to be able to collapse or fold the hose and when moisture absorption in the insulation does not create difficulties. Closed cell insulation, such as closed cell foams, preferably in ½ inch thick polyethylene sheets, is used when moisture is expected that would cause problems for open cell insulations. In either case, the insulating layer 26 may or may not contain a reflective layer.

[0026] The outer covering 28 is primarily for protection from abrasion and adverse environmental conditions. The outer layer should be as thin as possible while providing the required protection and flexibility.

[0027] The current weaving method for stress layer 24 is a simple process. After the weaving process is completed, the inner liner 22 is pulled through the stress layer, and the insulation layer 26 is wrapped and glued around the stress layer. After this, the outer shell or outer covering 28 is wrapped around the insulation layer.

[0028] The resultant hose assembly 10 of the present disclosure is flexible, collapsible and of high strength. Most conventional aircraft supply hoses of conventional design have evolved from air supply hoses used for civilian aircraft that operate at lower pressures and less severe temperature ranges. Military requirements have introduced new pressure levels, such as those required, for example, by the F-35 fighter jet, thereby requiring new concepts in conditioned air supply hoses. As previously discussed, one such problem among conventional hose designs with higher pressure is that the insulation layer is crushed between the inner liner and the outer shell. Crushing the insulation layer reduces insulation resistance and decreases hose flexibility. As a result, the temperature loss in conventional prior design hoses at high ambient temperatures would require the ground conditioning cart to supply subfreezing air. The subject hose assembly of the present disclosure resolves this issue.

[0029] More particularly, as shown in Figure 5, without the stress layer 24 of the present disclosure, the inner liner 20 of a conventional aircraft support hose assembly expands to a diameter d_1 (30) under the pressure of

conditioned air. By contrast, and as shown by Figure 6, in a hose assembly constructed in accordance with the present disclosure, the inner liner 22 remains at its design diameter d_2 (32) under the pressure of conditioned air because expansion is prevented by stress layer 24. Consequently, the thickness of the insulation layer 26 is undesirably reduced to T_1 (34) in Figure 5, while the thickness of the insulation layer in Figure 6 remains at T_2 (36). Thus, as conditioned air is forced under pressure through a conventional hose assembly, the diameter of the inner liner expands to d_1 and the insulation layer is compressed to T_1 . However, as conditioned air is forced under pressure through a hose assembly of the present design, the diameter of the inner liner remains constant at d_2 , which leaves the thickness of the insulating layer constant at T_2 .

[0030] In practice, a typical non-military commercial aircraft may require conditioned air to be delivered at approximately 1 psig pressure. In contrast, a military fighter aircraft may require approximately 5 psig. Consequently, the internal liner of a conventional ground support hose when used to supply conditioned air to a military aircraft expands with the increased air pressure and crushes its insulation layer against its outer layer (see Figure 5). This crushing of the insulation layer results in loss of the R-factor of the insulation layer, causing the cool conditioned air passing through the hose assembly to pick up heat and the conditioning cart to have to work harder in order to meet the temperature requirements of the aircraft.

[0031] The advantage of the hose assembly of the present disclosure over conventional hose assemblies is further illustrated in Figures 7 and 8. Figure 7 is a plot of heat transfer data that compares a first exemplary hose assembly A of conventional construction and a second exemplary hose assembly B of conventional construction to a high performance hose assembly C constructed in accordance with the present disclosure. The hose assembly “U value”, or its overall heat transfer coefficient, is plotted against the hose pressure. As pressure increases, the A and B hose assemblies lose insulation value as indicated by the respective increasing U values. By contrast, the subject C hose assembly shows only a modest increase in U value at high pressure.

[0032] Referring now to Figure 8, the predicted delivery air temperature change is shown for a 30 foot long 8 inch diameter aircraft ground support hose assembly operating at 5.5 psig with a 50 PPM flow and a 140°F ambient temperature. The A and B hose assemblies provide increases in delivered air temperature of 19.8°F and 13.05°F, respectively. By contrast, the subject C hose assembly keeps the air temperature increase below 6°F at 5.97°F. Thus, the high performance hose assembly C of the present embodiment improves the cooling system’s efficiency, maximizes cooling capacity, and minimizes evaporator frosting.

[0033] The foregoing detailed description has been given for clearness of understanding only and no unnecessary limitations should be understood therefrom. Accordingly, while one or more particular embodiments of the

disclosure have been shown and described, it will be apparent to those skilled in the art that changes and modifications may be made therein without departing from the invention if its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the present disclosure.

What is claimed is:

[C1] 1. A ground support hose assembly for providing pre-conditioned air from aircraft ground support equipment to an aircraft, the hose assembly comprising:

an impermeable inner liner forming an air conduit;

a stress layer surrounding said inner liner for preventing said inner liner from expanding when the ground support equipment forces air under pressure through said air conduit; and

an insulation layer surrounding said stress layer and said inner liner for insulating pre-conditioned air as it flow through said air conduit.

[C2] 2. A ground support hose assembly as defined in claim 1 further including an outer layer surrounding said inner liner, said stress layer and said insulation layer for protecting said hose assembly.

[C3] 3. A ground support hose assembly as defined in claim 1 wherein said stress layer comprises a mesh formed of high strength cording.

[C4] 4. A ground support hose assembly for coupling a source of conditioned air to an aircraft, the assembly comprising:

a main section having two ends, each of said ends including a connector, and wherein said main section includes:

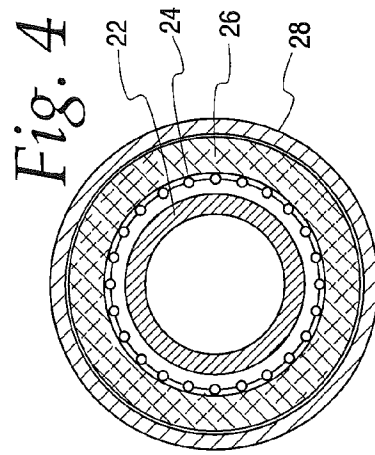
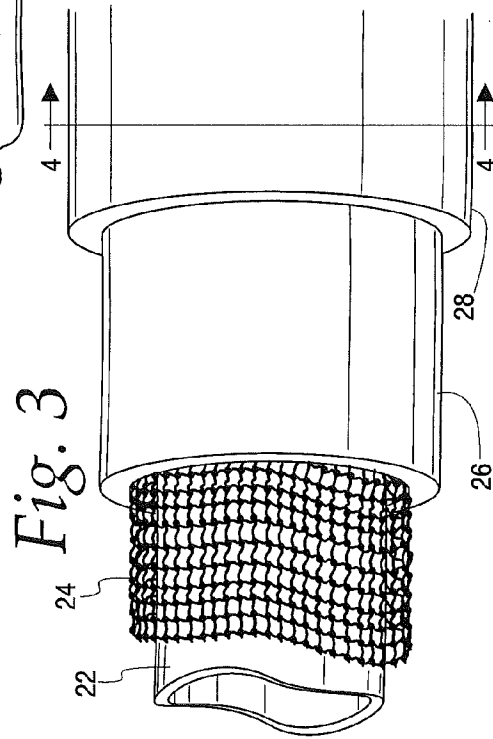
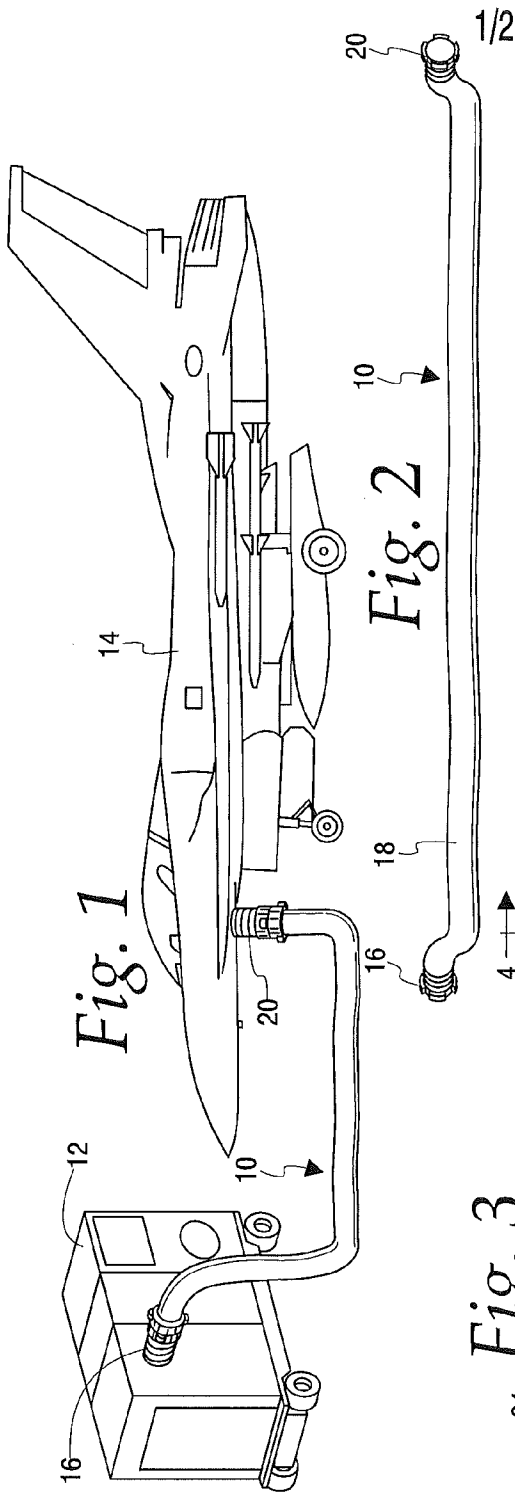
an impermeable inner liner forming an air conduit for said conditioned air;

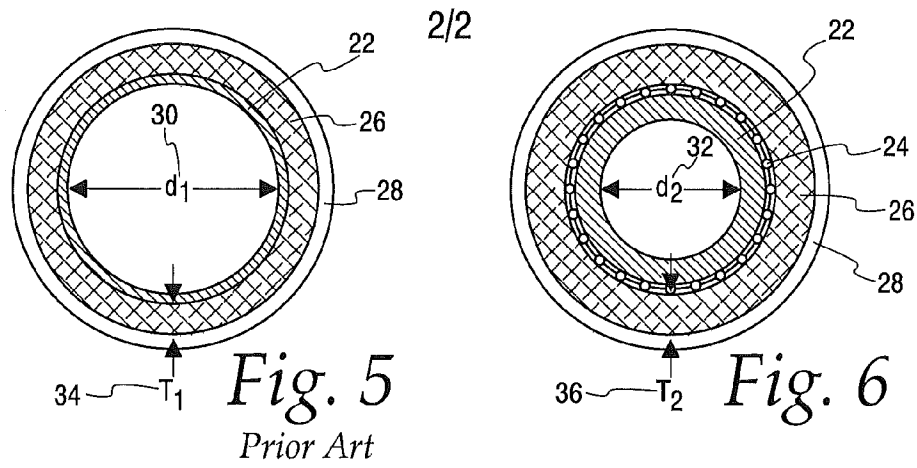
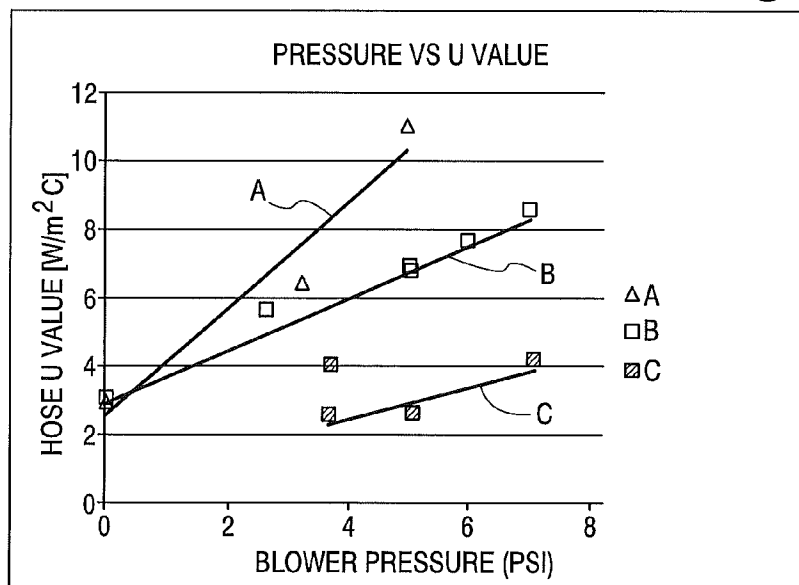
a stress layer surrounding said inner liner for preventing said inner liner from being expanded by conditioned air flowing under pressure in said air conduit; and

an insulation layer surrounding said stress layer and said inner liner for insulating conditioned air flowing in said air conduit.

[C5] 5. An air hose assembly as defined in claim 4 wherein said main section further includes an outer covering surrounding said insulation layer.

[C6] 6. An air hose assembly as defined in claim 4 wherein said stress layer comprises a mesh formed of high strength cording.



*Fig. 7**Fig. 8*

	P [PSI]	U [W/M ² C]	FLOW [PPM]	TAMB [°F]	TIN [°F]	TOUT [°F]	TOUT-TIN [°F]
C	5.5	3.14	50	140	40	45.97	5.97
B	5.5	7.15	50	140	40	53.05	13.05
A	5.5	11.27	50	140	40	59.80	19.80

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/054717

A. CLASSIFICATION OF SUBJECT MATTER
INV. B64F1/36 F16L11/08 F16L59/153 F24F13/02
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)
B64F F16L F24F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/214519 A1 (NOGUEIRA MANUEL [FR] ET AL) 28 October 2004 (2004-10-28) abstract; figures paragraphs [0024] - [0028] -----	1-6
X	EP 2 189 697 A1 (PARKER HANNIFIN CORP [US]) 26 May 2010 (2010-05-26) abstract; figures paragraphs [0001], [0002], [0017] - [0021], [0028] -----	1-6
X	FR 2 520 294 A1 (TUYAUX FLEXIBLES FORGE STE NLE [FR]) 29 July 1983 (1983-07-29) page 3, line 24 - page 4, line 12; figure 2 ----- -/-	1-6

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 November 2012

Date of mailing of the international search report

30/11/2012

Name and mailing address of the ISA/

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

Authorized officer

Untermann, Nils

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/054717

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 327 920 A1 (MAYR ANDREAS [CH]) 1 June 2011 (2011-06-01) abstract; figures paragraph [0014]; claim 1 -----	1-6
X	EP 0 084 088 A1 (FELTEN & GUILLEAUME ENERGIE [DE]) 27 July 1983 (1983-07-27) abstract; figures page 4, paragraph 3 - page 7, paragraph 1 -----	1-6
X	CH 680 815 A5 (BRUGG ROHRSYSTEM AG) 13 November 1992 (1992-11-13) abstract; figure 2 column 5, line 46 - column 6, line 8 -----	1-6
A	WO 2008/094372 A2 (HOBART BROTHERS CO [US]; KOIZUMI SCOTT TAKAYUKI [US]; PIETY BRIAN MICH) 7 August 2008 (2008-08-07) abstract; figures paragraphs [0026] - [0028]; figures 6-8 -----	1-6

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/054717

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004214519 A1	28-10-2004	DE 10351398 A1	13-05-2004
		FR 2846732 A1	07-05-2004
		US 2004214519 A1	28-10-2004
EP 2189697 A1	26-05-2010	EP 2189697 A1	26-05-2010
		US 2010126617 A1	27-05-2010
		US 2012227851 A1	13-09-2012
FR 2520294 A1	29-07-1983	NONE	
EP 2327920 A1	01-06-2011	NONE	
EP 0084088 A1	27-07-1983	DE 3200441 A1	04-08-1983
		EP 0084088 A1	27-07-1983
CH 680815 A5	13-11-1992	NONE	
WO 2008094372 A2	07-08-2008	CA 2677197 A1	07-08-2008
		CN 101622488 A	06-01-2010
		DE 112007003306 T5	10-12-2009
		US 2008185064 A1	07-08-2008
		US 2011209792 A1	01-09-2011
		WO 2008094372 A2	07-08-2008