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(54) Title: A METHOD FOR CLEANING A TURBOFAN ENGINE AND APPARATUS FOR USE THEREOF

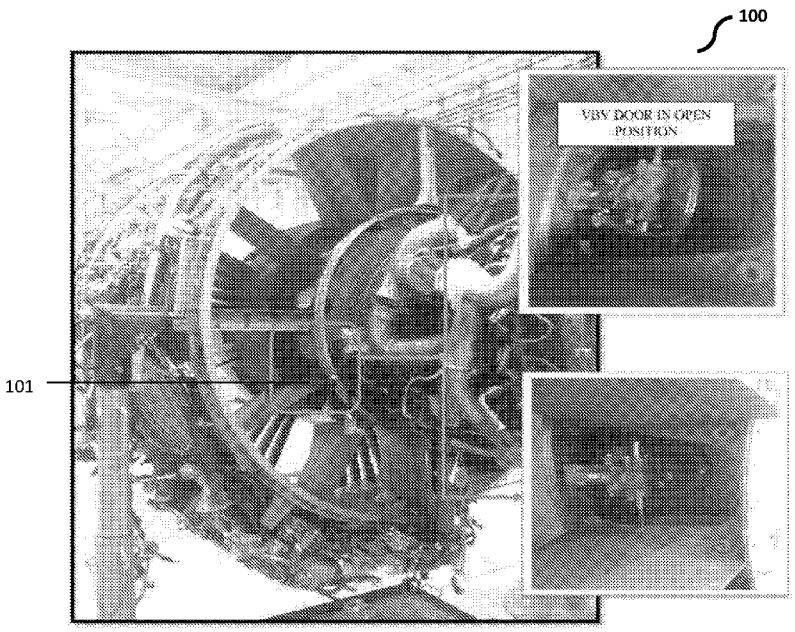

Figure 1

(57) Abstract: The present invention relates to a method and apparatus for cleaning a turbofan engine by means of dry ice pellets and a plurality of nozzles. The method comprises steps of setting up the emitting device, activating the turbofan engine, initiating the emitting device for cleaning the turbofan engine, halting the turbofan engine and repeating the steps for various settings and parameters. The apparatus comprises an emitting device, a plurality of nozzles, a conduit means, and a clamp.

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

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Published:

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

A METHOD FOR CLEANING A TURBOFAN ENGINE AND APPARATUS FOR USE THEREOF

TECHNICAL FIELD OF THE INVENTION

The invention relates to a method for cleaning a turbofan engine and a apparatus for use thereof. More particularly, a method and apparatus for cleaning the compressor of the turbofan engine.

BACKGROUND OF THE INVENTION

A turbofan engine is a gas turbine engine. A gas turbofan engine typically includes a fan section, a compressor section, a combustor section and a turbine section. Air entering the compressor section is compressed and delivered into the combustion section where it is mixed with fuel and ignited to generate a high-speed exhaust gas flow. The high-speed exhaust gas flow expands through the turbine section to drive the compressor and the fan section. The compressor section typically includes low and high pressure compressors, and the turbine section includes low and high pressure turbines.

In order to maximise operating efficiency and minimise carbon build-up in the turbofan engine, periodic cleaning of the turbofan engine is necessary. Although the turbofan engine works most efficiently at very high temperatures, the periodic cleaning of the turbofan engine is best done at room temperature. Cleaning of the turbofan engine herein does not refer to cosmetic cleaning of the engine exterior but instead the cleaning process applied to the interior components of the turbofan engine.

In addition, contamination of the turbofan engine by impurities such as insects, dust, dirt, etc causes rotation instability to the turbofan engine blades, consequently reducing compressor performance which substantially reduces the efficiency and power output of the turbofan engine. Further, there is an increase in the consumption of fuel required for creating thrust, causing an increased

thermic load on main components within the turbofan engine. The result is shortening of the lifespan of the turbofan engine, rise in fuel consumption and an increase in emission of CO_2, NO_x and other greenhouse gases.

Generally, cleaning of the turbofan engine involves use of water with detergents or certain solvents flowed through the engine to clean the turbine blades and the turbofan engine core. Traditionally, in order to carry out cleaning process of the turbofan engine, the engine has to be removed from the aeroplane, then applying cleaning mixtures during the engine overhaul. Naturally, such a procedure is undesirable due to the time and cost involved. Subsequently, as technology advances, cleaning of the engine on the wing of the aeroplane became feasible. The turbofan engine is first initiated, wherein the blades are rotated at low revolutions and the fluid sprayed at the suction end of the turbofan engine and flows through to the exhaust end of the turbofan engine. Conventional cleaning methods are not as effective because the denser cleaning mixture is partially centrifuged out into the bypass fan duct and therefore does not reach into critical gas-path components.

Another drawback of the conventional cleaning method using liquids was that the liquid lacked sufficient scrubbing action. Therefore, the method involved injecting a solid material into the engine such as ground pecan shells or corn cobs were implemented. However, the use of such materials did not solve the problem as significant damage were noticeable at the compressor blade surfaces and seals. Furthermore, these solid materials become stuck in the core of the turbofan engine, creating obstructions to rotation of the blades of the turbofan engine.

Fuel used in turbofan engine are often contaminated with sulfur, that when burned at high temperatures, emits sodium sulfate gas which causes sulfidation. Sulfidation is accelerated when the aeroplane operates near oceans, industrial complexes, cities, or volcanic regions. Sulfidation is a corrosive process that erodes the surfaces of compressor blades. Although at present, there is no way

of eliminating sulfidation, periodic cleaning of the turbofan engine has been proven to reduce and delay the sulfidation.

In view of the abovementioned shortcomings, several apparatuses and methods have been developed to provide improved ways of cleaning a turbofan engine and specifically an aeroplane jet engine.

United States patent number US 8,109,807 B2 discloses an apparatus for cleaning a jet engine using solid carbon dioxide. The apparatus further comprises at least two nozzles, which are flat in structure that rotates along with the engine to enlarge the spray area. The nozzles are design to directly in tact with fan section and the low pressure compressor (LPC) section which define the weaknesses of the processes. Also, the solid carbon dioxide used for the cleaning process mentioned herein disperses towards the turbofan and the low pressure compressor (LPC), but they do not effectively clean the blades in the high pressure compressor (HPC).

United States patent number US 7,815,743 B2 discloses a method for cleaning a turbofan engine comprising a plurality of nozzles arranged to atomize cleaning liquid in the air stream in an air inlet of the engine up-stream of a fan of the engine. The setup of the plurality of nozzles in a specific position and angle allows for more effective cleaning of the turbofan engine. However, the abovementioned nozzle setup is directed at the engine up-stream and does not effectively clean the entire turbofan engine sections.

SUMMARY OF THE PRESENT INVENTION

According to the present invention, described is a method for cleaning a turbofan engine comprising the steps of setting up at least an emitting device with at least a conduit for directing the flow of cleaning substances, activating the turbofan engine, initiating the emitting device for cleaning process of the turbofan engine and halting the turbofan engine and the emitting device. The method is characterized by the step of connecting at least a nozzle to the conduit for

discharging the cleaning substances towards inner parts of the turbofan engine, in which the nozzle comprises a detachable tip, connector plug and a coupling means for connection to the conduit.

The present invention further relates to an apparatus for cleaning a turbofan engine, comprising at least an emitting device for providing cleaning substances and at least a conduit for directing the flow of cleaning substances from the emitting device. The conduit is connected to at least a nozzle for discharging the cleaning substances towards the inner parts of the turbofan engine, in which the nozzle comprises a detachable tip, for connection to the conduit, capable of cleaning the inner parts of the turbofan engine.

It is an object of the present invention to provide a method and apparatus for cleaning a turbofan engine that is able to reduce fuel consumption of aeroplanes. It should be understood that the cleaner the turbofan engine, or more specifically the cleaner the high pressure compressor, HPC, the greater the mechanical energy output will be to generate power and reduce chemical energy consumption.

It is yet an object of the present invention to provide a method and apparatus for cleaning a turbofan engine that is able to clean the turbofan engine blades and to remove baked effect of the turbine blades due to the combustion processes.

It is a further object of the present invention to provide a method and apparatus for cleaning a turbofan engine that delays the deterioration period of the turbofan engine.

It is another object of the present invention to provide a method and apparatus for cleaning a turbofan engine that is capable of cleaning the blades of the turbofan engine at the High Pressure Compressor, HPC section.

It is further another object of the present invention to provide a method and apparatus for cleaning a turbofan engine using dry ice pellets.

It is yet further another object of the present invention to provide a method and apparatus for cleaning a turbofan engine that is environmentally friendly as the dry ice pellets sublimes and leaves no secondary waste after the cleaning processes.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a turbofan engine showing the location of variable bleed valve, VBV door according to the present invention.

Figure 2 illustrates a VBV nozzle for inserting into the VBV door pathway according to the present invention.

Figure 3 illustrates a BSI nozzle for inserting into the borescope port high pressure compressor, HPC.

Figure 4 illustrates a flowchart for a method for cleaning a turbofan engine according to the present invention.

Figure 5 illustrates a flowchart for a method for setting up the emitting device with the conduit according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The abovementioned and other features and objects of this invention will become more apparent and better understood by reference to the following detailed description. It should be understood that the detailed description made known below is not intended to be exhaustive or limit the invention to the precise form disclosed as the invention may assume various alternative forms. All the relevant modifications and alterations made to the present invention as covered in the detailed description should be construed to fall within the scope of the

appended claims. Therefore, the configuration of the invention is not limited to the configuration mentioned in the following description.

The present invention relates to a method and apparatus for cleaning a turbofan engine (100), more preferably a turbofan engine of an aeroplane. Common examples of a turbofan engine (100) are CFM56-5B4/3, CFM56-5B4/P, CFM56-5B46/P, CFM56-5B6/3, CFM Leap-1a26, Rolls-Royce Trent 700 and Rolls-Royce Trent 772b. It should be understood by the skilled addressee that these are just examples of turbofan engines and the present invention should not be limited to the use of these turbofan engines. As earlier described, a turbofan engine (100) comprises a fan blade, a low pressure compressor, LPC, a high pressure compressor, HPC, a combustion chamber, a high pressure turbine and a low pressure turbine. The method and apparatus for cleaning a turbofan engine (100) of the present invention herein described is focused at the HPC section of the turbofan engine. The cleaning substances are discharged to the HPC of the turbofan engine by means of a nozzle (200, 300).

Referring to figure 1, the variable bleed valve, VBV is located after the low pressure compressor and at the start of the high pressure compressor. There is a VBV door (101) for inspection and maintenance purposes. The high pressure compressor section comprises a number of blades attached to a shaft. A borescope or similarly a boroscope is an optical device comprising rigid or flexible tube with an eyepiece on one end and is used for visual inspection work of the turbofan engine (100) where the area to be inspected is inaccessible by other means. The HPC comprises a plurality of borescope ports wherein the borescope may be inserted for inspection. There are a number of borescope ports at the HPC that has been categorized by stages, and the number varies depending on the engine models and their engine makers.

Referring now to Figures 2 and 3, illustrated are preferred embodiments of nozzles (200, 300) of the apparatus for cleaning a turbofan engine (100) according to the present invention. The present invention describes an apparatus for cleaning a turbofan engine comprising at least an emitting device

for providing cleaning substances and at least a conduit for directing the flow of cleaning substances form the emitting device. It is noted that the conduit is connected to at least a nozzle (200, 300) for discharging the cleaning substances towards the turbofan engine (100), in which the nozzle (200, 300) comprises a detachable tip (301) attached to a connector plug and a coupling means for connection to the conduit. The nozzle (200, 300) is capable of cleaning the inner parts of the turbofan engine (100). The inner parts of the turbofan engine are referring to any one or a combination of low pressure compressor, LPC and high pressure compressor, HPC.

The emitting device of the present invention is also known as a blasting device. Cleaning substance is inserted into the emitting device in for cleaning the turbofan engine. The cleaning substances are dry ice, more preferably dry ice in pellets form. The dry ice used for cleaning the turbofan engine have dimensions of less than 3mm, more preferably dimensions of less than 0.5mm. The emitting device comprises a scrambler for slicing dry ice. The scrambler is custom made based on the specification required for the cleaning of the turbofan engine. Smaller dimensions of dry ice gives improved cleaning properties. As the dry ice impacts the engine turbine blades, the dry ice removes the contaminations from the blades and sublimes, leaving behind no residue. The emitting device can be controlled and run remotely after the nozzles (200, 300) are set up at the correct locations. There is a setting on the remote control for which manual blast can be switched to automatic blasts.

As there are a few processes to be executed for the cleaning of the turbofan engine (100), there are two main types of nozzles (200, 300) that are being used throughout the cleaning processes, the first nozzle operated at the VBV door (101) pathway, herein now referred to as VBV nozzles (200) and the second nozzle operated at the borescope port HPC, herein now referred to as BSI nozzles (300). There is a conduit means connected to the emitting device and at the same time the VBV nozzles (200) or the BSI nozzles (300) are connected to the conduit through the rear tip (209, 309) of the nozzle.

Figure 2 illustrates the first nozzle (200) for discharging the cleaning substances that will be inserted through the VBV door (101) of the HPC. In order for the VBV nozzle (200) to be inserted through the VBV door (101) for discharge of the cleaning substances, at least a clamp is used to hold and support the VBV nozzle (200) to the turbofan engine (100) bracket. In one of the embodiment of the invention, the clamp acts as a lock to maintain the position of the nozzle. In addition, the VBV nozzle (200) for discharging the dry ice further comprises a flexible rotatable solid conduit (207) enabling a multi-directional flow of the cleaning substance. Optionally, the conduit can be in a fixed design instead of being flexible depending on the model of the turbofan engine. When the turbofan engine (100) is initiated and the cleaning substance discharged, the air pressure will push the dry ice through the HPC and cleans the blades through its paths.

Figure 3 illustrates the second nozzle (300) for discharging the cleaning substances is inserted through the boroscope port of the HPC. In order to achieve better cleaning results, the BSI nozzles (300) are inserted through a number of borescope port HPC. The BSI nozzles (300) comprises a rear tip (309), a coupling means (305), a one touch fitting, a connector plug (303) and an detachable tip (301). The connector plug (303) comprises a screw for adjusting and replacement of the tip (301). The rear tip (309) is for connection to the conduit means of the emitting device. It should be noted that the at least a nozzle (200, 300) has pre-determined indication showing the nozzle direction as well as labels to indicate the length. The BSI nozzle (300) is designed based on the diameter, thread size of the boroscope port and length of the blades of the turbofan engine.

Referring to Figure 4, illustrated are steps (400) of cleaning a turbofan engine (100) according to the present invention. The method comprises the steps of setting up at least an emitting device with at least a conduit for directing the flow of cleaning substances (410), activating the turbofan engine (100)(420), initiating the emitting device for cleaning process of the turbofan engine (100)(440), and halting the turbofan engine (100)(450) and the emitting device. The abovementioned steps are then repeated for various settings (460). The method

is characterized by the step of connecting at least a nozzle (200, 300) to the conduit for cleaning the inner parts of the turbofan engine (100) by discharging cleaning substances towards the turbofan engine (100) in which the nozzle (200,300) comprises a detachable tip (301), a connector plug (303) and a coupling means (305) for connection to the conduit. The at least a nozzle (200, 300) discharges cleaning substances to the HPC of the turbofan engine.

Figure 5 illustrated are steps (410) of setting up the emitting device with the conduit for cleaning of the turbofan engine (100) according to the present invention. There are two main procedures for the cleaning of the turbofan engine (100), one is the cleaning operation at the VBV door (101) pathway (415) and the other is the cleaning operation at the boroscope ports at the HPC (417). For the cleaning operation at the VBV door (101) pathway, the steps begin with the setting up the emitting device. The emitting device, also known as a blasting machine, is connected to at least a conduit means and a first nozzle (200) is connected to the conduit means (412). The conduit means herein may be referred to as a dry ice (or more particularly a solid form of CO_2) hose, whereas the nozzle may be referred to as VBV nozzle (200) which is the first nozzle (200). The VBV nozzle (200) is inserted into the VBV door (101) of the HPC of the turbofan engine before the cleaning process begins. Thereafter, a clamp attached to the turbofan engine (100) bracket beam is used to support the VBV nozzle (200) in place. Dry ice is inserted or poured into the emitting device (411). The amount of dry ice inserted or poured into the emitting device is in the range of 5 to 15 kg in weight, more preferably 10kg in weight. The turbofan engine (100) is then initiated at revolutions per minute, rpm, preferably in the range of 10 to 20 rpm, more preferably 15 rpm (420). The emitting device is then turned on for a few minutes (440), in the period of 2 to 4 minutes, preferably 3 minutes. As the emitting device is turned on, the dry ice will be sprayed onto the turbofan engine (100). The dry ice hits the engine turbine parts and blades and cleans the dirt and particles off from the blades, then sublimes without leaving behind residues. The emitting device is then turned off, turbofan engine (100) switched off (450), clamp dismantled and VBV nozzle (200) removed from the conduit means.

The cleaning operation at the borescope port HPC (417) is carried out after the cleaning operation at the VBV pathway and involves using of different nozzles, herein referred to as BSI nozzles (300), for different borescope port HPC stages. The dimensions and sizes of the BSI nozzles (300) varies depending on the model of the turbofan engine.

Upon commencement of the cleaning operation at the borescope port HPC, the second nozzle (300) or also known as the BSI nozzle (300) is connected to the conduit means (413, 416). A first BSI nozzle (300) is inserted into the stage 1 (STG1) boroscope port (417). The first BSI nozzle (300) is aligned to face a suction side of the blade of the HPC. Dry ice is inserted or poured into the emitting device (411). The emitting device is also commonly known as a hopper. The amount of dry ice inserted into the emitting device is in the range of 3 to 7 kg in weight, more preferably 5 kg in weight. The turbofan engine (100) is then initiated at revolutions per minute, rpm, preferably in the range of 10 to 20 rpm, more preferably 15 rpm (420). The emitting device is then turned on for a few minutes (440), in the period of 1 to 3 minutes, preferably 2 minutes. As the emitting device is turned on, the dry ice will be sprayed onto the turbofan engine (100), for cleaning the blades of the turbofan engine (100). The emitting device is then turned off, and the turbofan engine (100) is switched off (450). A second BSI nozzle (300) is then aligned to face subsequent blades of the HPC. The cleaning process is then repeated (460). To repeat the process for further cleaning, a third BSI nozzle is inserted into the stage 3 (STG3) boroscope port and a further BSI nozzle is inserted into a further stage of boroscope port. By implementing the repeating steps, each surface of the multi stages blades, vanes, and inner casing of the HPC will be thoroughly cleaned.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the scope of the following claims.

Claims

1. A method for cleaning a turbofan engine (100), comprising the steps of:

setting up at least an emitting device with at least a conduit for directing the flow of cleaning substances (410);

activating the turbofan engine (100)(420);

initiating the emitting device for cleaning process of the turbofan engine (100)(440); and

halting the turbofan engine and the emitting device (450);

the method is characterized by the step of connecting at least a nozzle (200,300) to the conduit for discharging the cleaning substances towards inner parts of the turbofan engine, in which the nozzle (200, 300) comprises a detachable tip (301), connector plug (303) and a coupling means (305) for connection to the conduit.

2. The method of claim 1, wherein the inner parts of the turbofan engine comprise any one or a combination of low pressure compressor, LPC and high pressure compressor, HPC.

3. The method of claim 2, wherein the step of setting up at least an emitting device with at least a conduit (410) further comprising the steps of:

inserting dry ice into the emitting device;

supporting the nozzle (200) by means of a clamp attached to the turbofan engine (100) bracket; and

inserting a first nozzle (200) for discharging the cleaning substances through the VBV door (101) of the HPC.

4. The method of claim 3, wherein the weight of dry ice inserted into the emitting device is in the range of 5 to 15 kg.

5. The method of claim 4, wherein the weight of dry ice inserted into the emitting device is preferably 10 kg.

6. The method of any one of claims 1 to 3, wherein the turbofan engine (100)(420) is activated at revolutions per minute, rpm, in the range of 10 to 20 rpm.

7. The method of claim 6, wherein the turbofan engine is activated at rpm of preferably 15 rpm.

8. The method of any one of claims 1 to 7, wherein the emitting device is initiated for a period of time of 2 to 4 minutes for cleaning the turbofan engine (440).

9. The method of claim 8, wherein the emitting device is initiated for a period of time, preferably 3 minutes for cleaning the turbofan engine (440).

10. The method of claim 2, wherein the step of setting up at least an emitting device with at least a conduit (410) further comprising the steps of:

inserting dry ice into the emitting device; and

inserting a second nozzle (200) for discharging the cleaning substances through boroscope ports of the HPC (417).

11. The method of claim 10, wherein the weight of dry ice inserted into the emitting device is in the range of 3 to 7 kg.

12. The method of claim 11, wherein the weight of dry ice inserted into the emitting device is preferably 5 kg.

13. The method of any one of claims 1, 2, 10 to 12, wherein the emitting device is initiated for a period of time of 1 to 3 minutes for cleaning the turbofan engine (440).

14. The method of claim 13, wherein the emitting device is initiated for a period of time, preferably 2 minutes for cleaning the turbofan engine (440).

15. An apparatus for cleaning a turbofan engine (100), comprising:
at least an emitting device for providing cleaning substances; and
at least a conduit for directing the flow of cleaning substances from the emitting device;
characterized in that the conduit is connected to at least a nozzle (200, 300) for discharging the cleaning substances towards the inner parts of the turbofan engine (100), in which the nozzle (200, 300) comprises a detachable tip (301), for connection to the conduit, capable of cleaning the inner parts of the turbofan engine (100).

16. The apparatus of claim 15, wherein the inner parts of the turbofan engine (100) comprise any one or a combination of low pressure compressor, LPC and high pressure compressor, HPC.

17. The apparatus of claim 16, wherein the detachable tip (301) is attached to a connector plug (303) and a coupling means (305) for connection to the conduit.

18. The apparatus of claim 17, wherein the connector plug (303) is adjustable for replacement of the detachable tip (301).

19. The apparatus of claim 15, wherein the at least a nozzle (200, 300) discharges cleaning substances to the high pressure compressor, HPC of the turbofan engine (100).

20. The apparatus of claim 5, wherein the at least a nozzle is a first nozzle (200) inserted through the VBV door (101) for discharging the cleaning substances into the HPC.

21. The apparatus of claim 5, wherein the at least a nozzle is a second nozzle (300) inserted through the boroscope port for discharging the cleaning substances into the HPC.

22. The apparatus of any one of claims 15 or 20, wherein the apparatus further comprises a clamp that is attached to the turbofan engine (100) bracket for supporting the nozzle (200).

23. The apparatus of any one of claims 15 to 22, wherein the cleaning substances are dry ice.

24. The apparatus of claim 23, wherein the dry ice are in pellets form.

25. The apparatus of claim 24, wherein the dry ice pellets have dimensions of less than 3mm.

26. The apparatus of claim 25, wherein the dry ice pellets have dimensions of less than 0.5mm.

27. The apparatus of any one of claims 15 to 26, wherein the emitting device further comprises a scrambler for slicing the dry ice into pellets form.

28. The apparatus of any one of claims 15 to 27, wherein the emitting device is operated automatically through a remote control.

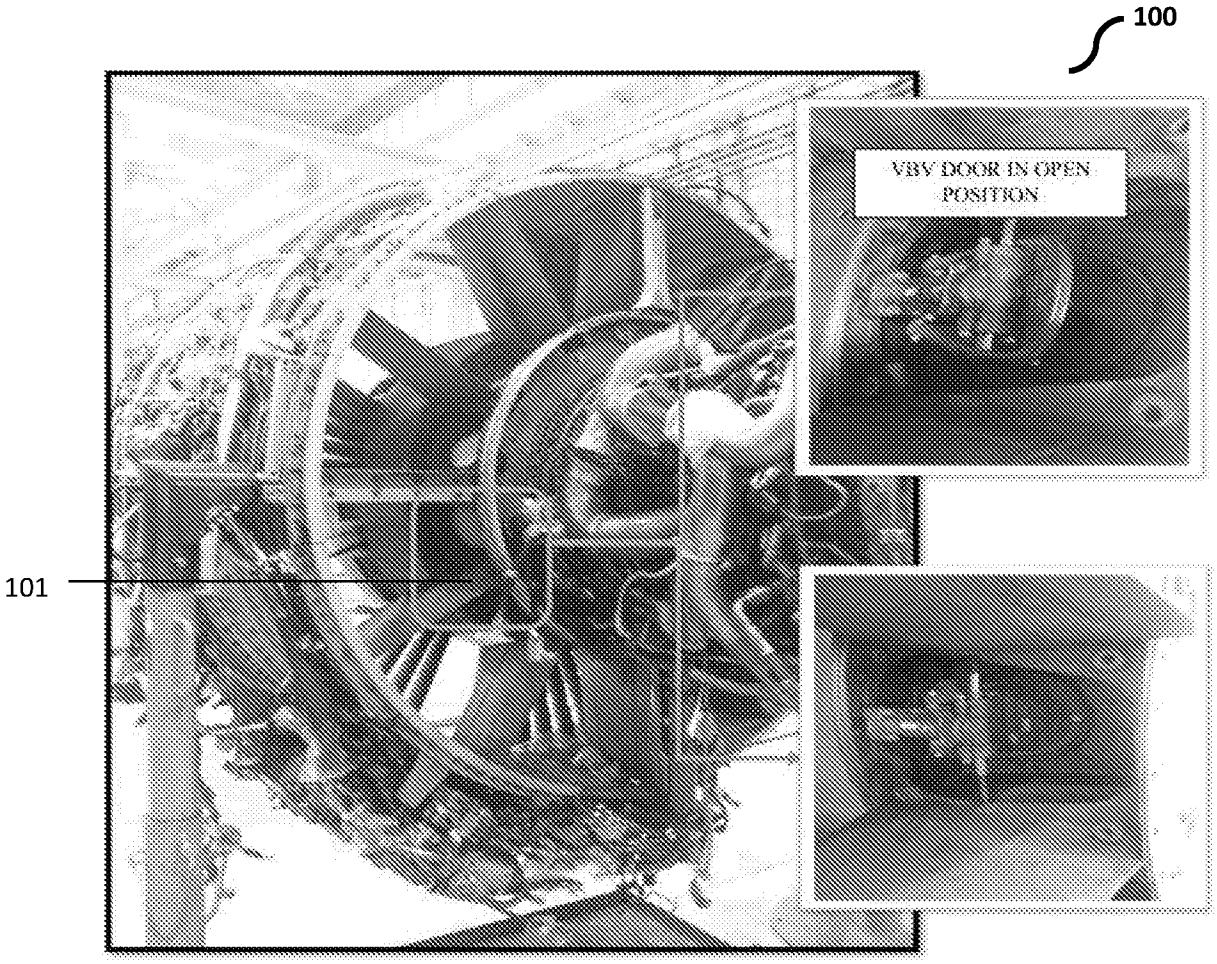

Figure 1

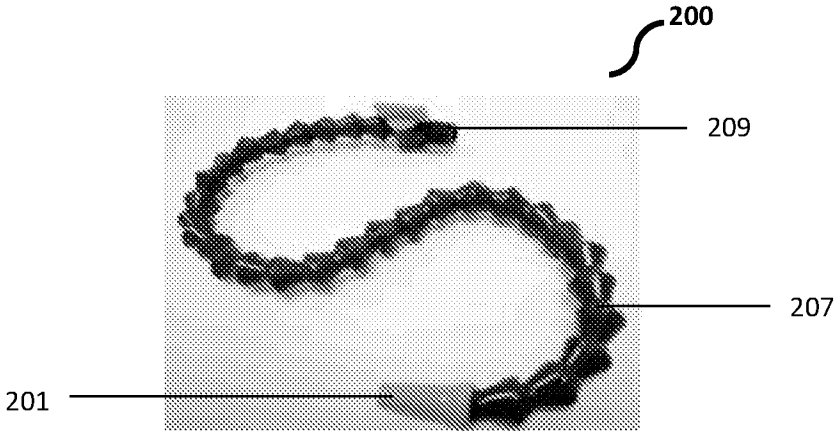

Figure 2

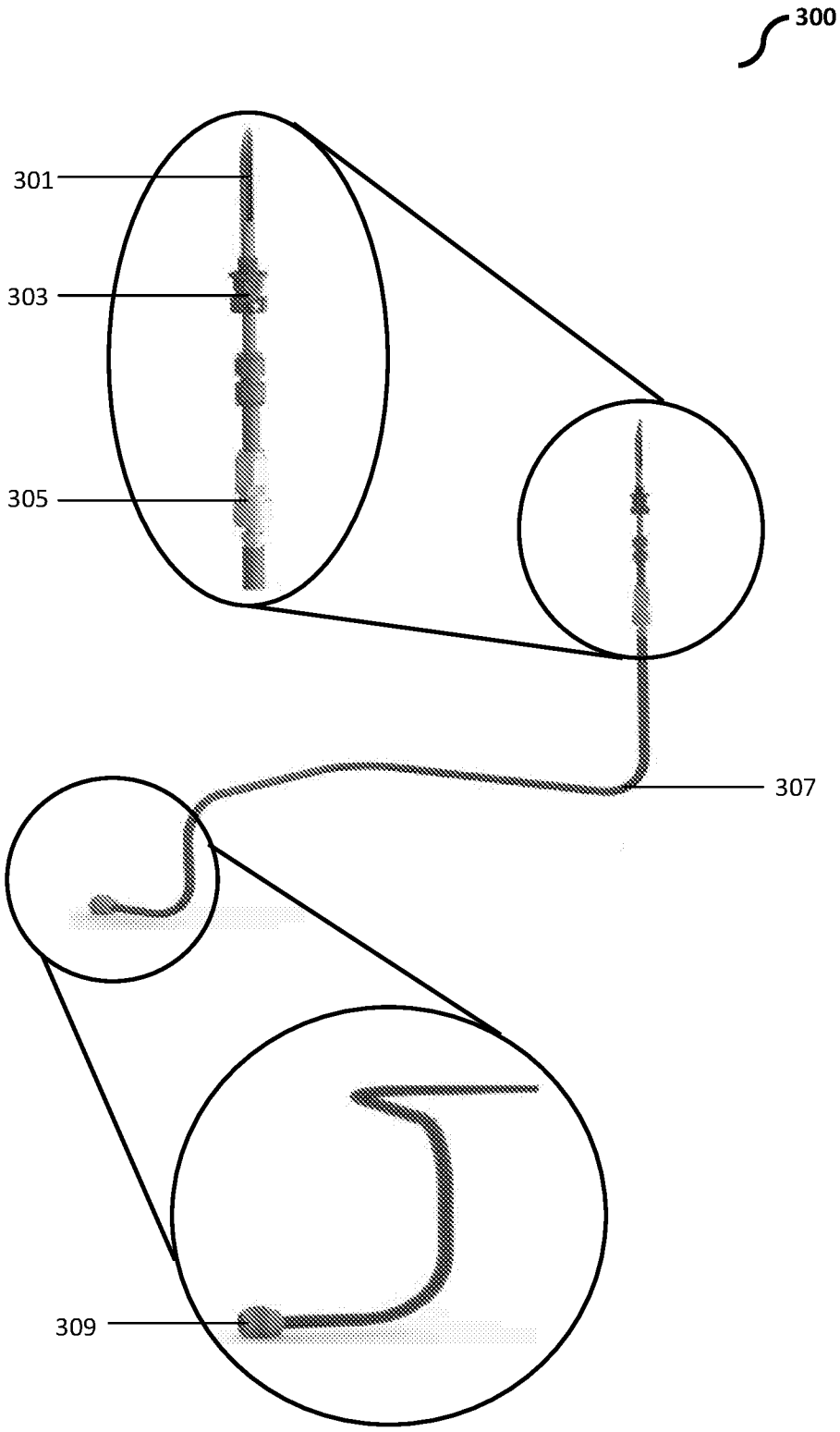

Figure 3

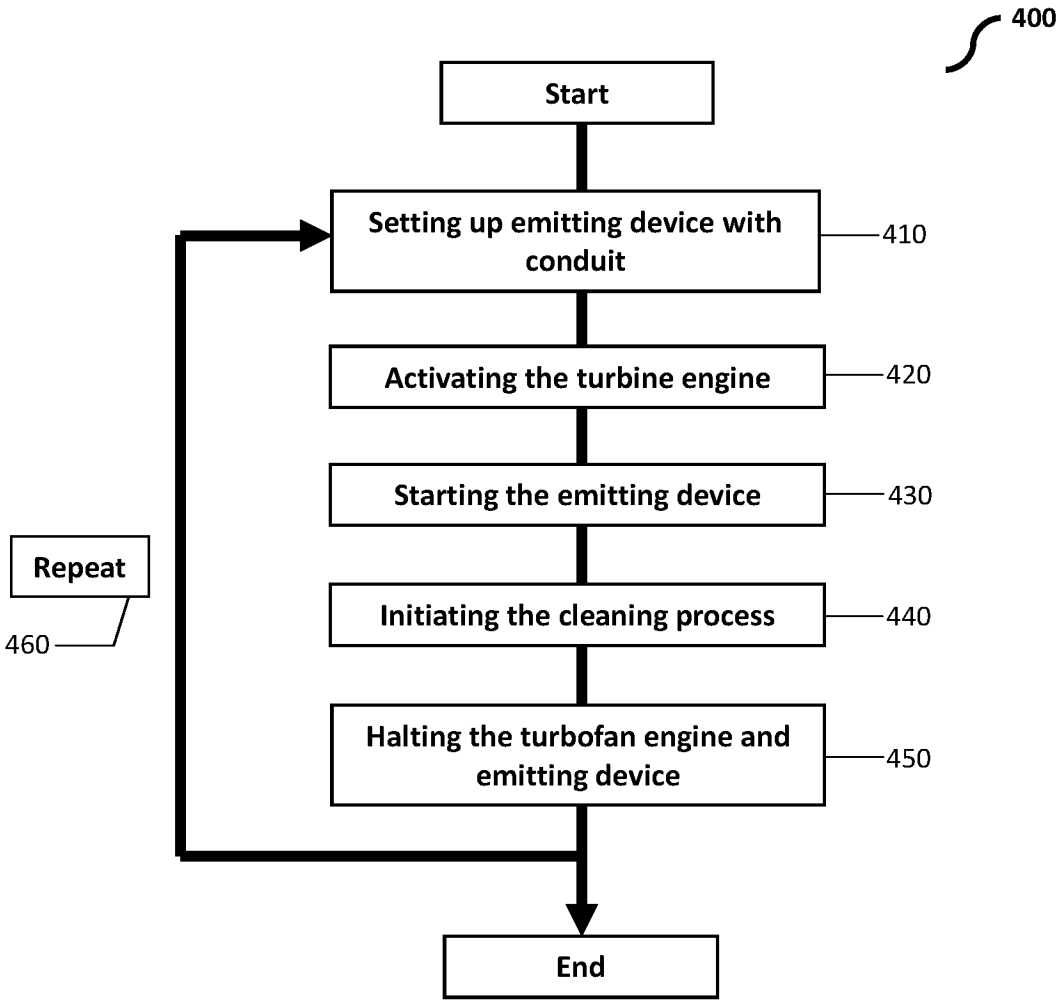
400
Start
Setting up emitting device with conduit
410
Activating the turbine engine
420
Starting the emitting device
430
Initiating the cleaning process
440
Halting the turbofan engine and emitting device
450
Repeat
460
End

Figure 4

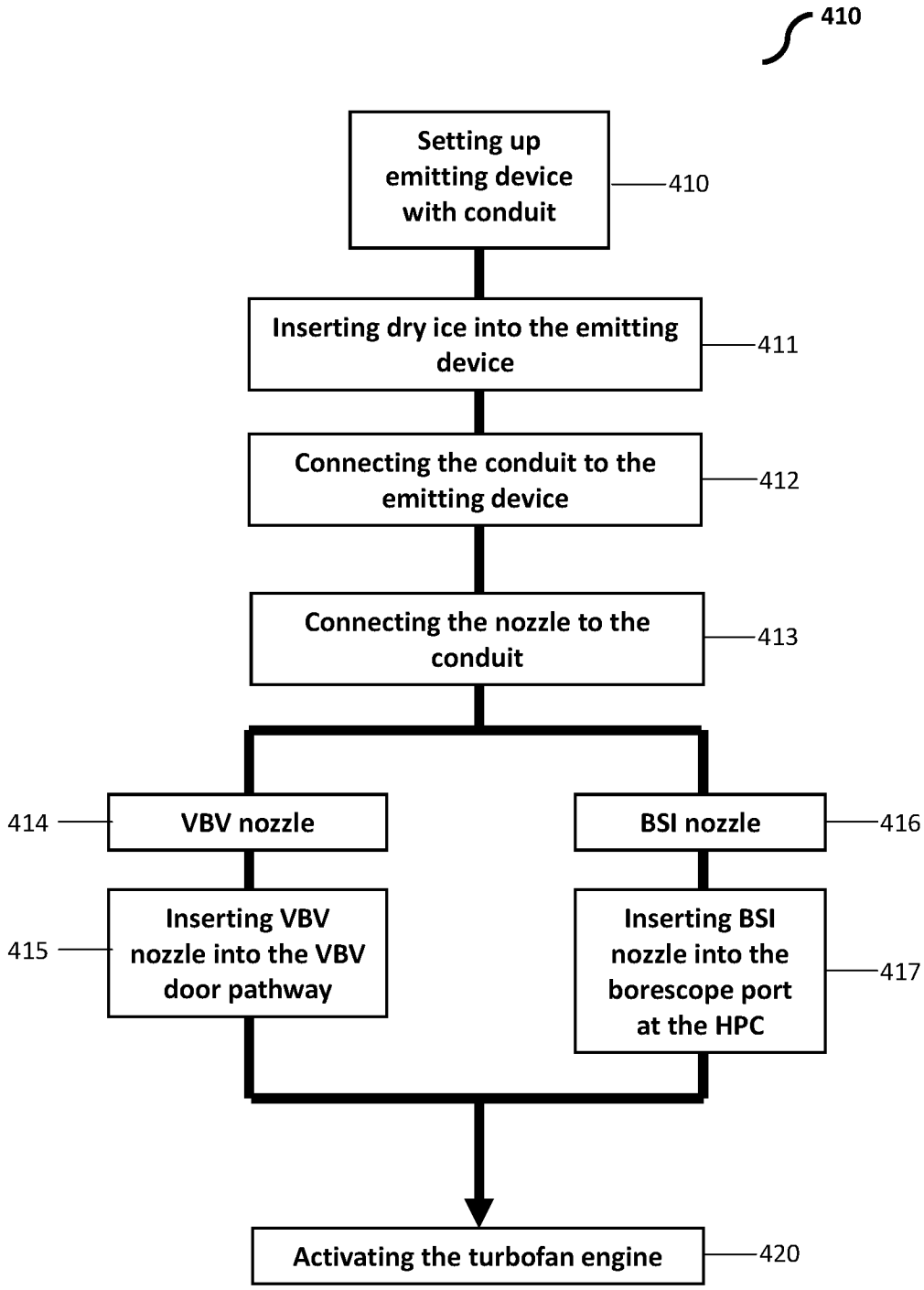
410
Setting up emitting device with conduit
410
Inserting dry ice into the emitting device
411
Connecting the conduit to the emitting device
412
Connecting the nozzle to the conduit
413
414
VBV nozzle
BSI nozzle
416
415
Inserting VBV nozzle into the VBV door pathway
Inserting BSI nozzle into the borescope port at the HPC
417
Activating the turbofan engine
420

Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2016/050055

A. CLASSIFICATION OF SUBJECT MATTER

B08B 9/00 (2006.01) F02B 77/04 (2006.01)

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)

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)

EPOQUE X-FULL: databases: TXPEA, TXPEB, TXPEC, TXPEE, TXPEF, TXPEH, TXPEI, TXPEP, TXPEPEA, TXPES, TXPUSE0A, TXPUSE1A, TXPUSEA, TXPUSEB, TXPWOEA, WPIAP, EPODOC; class marks: B08B, F01D, keywords: clean, wash, turbine, engine, compressor, nozzle, spray, blast, detach, replace, modular, decouple, disconnect, conduit, pipe, tube, and like terms. Espacenet and Google Patent searches: keywords: turbofan engine, compressor, turbine, clean, wash, nozzle, dry ice, online, and like terms. Espacenet, AusPat, PAMS NOSE, and INTESS applicant and inventor searches: Applicant name: AIIS SOLUTIONS; Inventor name: SHAHBUDIN.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[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

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"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

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Date of the actual completion of the international search	Date of mailing of the international search report
28 October 2016	28 October 2016
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Hong Yu AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262837946

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/MY2016/050055**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5273395 A (MCDERMOTT) 28 December 1993 Abstract, Figures, column 2, lines 43-57, column 3, line 30 - column 4, line 18	1-28
X	US 2004/0255422 A1 (REBACK ET AL.) 23 December 2004 Abstract, Figures, para. [0019]-[0022], claims	15-28
X	US 7531048 B2 (WOODCOCK ET AL.) 12 May 2009 Abstract, Figures, column 4, lines 43-51, column 7, lines 1-10, claims	15-28
A	US 5826602 A (CHEN) 27 October 1998 Abstract, claims, Figures	1-28

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/MY2016/050055**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 5273395 A	28 December 1993	US 5273395 A	28 Dec 1993
		US 5011540 A	30 Apr 1991
US 2004/0255422 A1	23 December 2004	US 2004255422 A1	23 Dec 2004
		US 7065955 B2	27 Jun 2006
		BR PI0402334 A	31 Jan 2006
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		JP 2005009494 A	13 Jan 2005
		SG 118274 A1	27 Jan 2006
		US 2007062201 A1	22 Mar 2007
		US 7373781 B2	20 May 2008
US 7531048 B2	12 May 2009	US 2009084411 A1	02 Apr 2009
		US 7531048 B2	12 May 2009
US 5826602 A	27 October 1998	US 5826602 A	27 Oct 1998

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.