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(54) **VARIABLE CYCLE INTAKE FOR REVERSE CORE ENGINE**

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(51) **Int. Cl.**

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F02C 7/042	(2006.01)
B64D 33/02	(2006.01)
F02C 7/055	(2006.01)
F02C 7/052	(2006.01)
F02K 3/077	(2006.01)
B64D 27/20	(2006.01)
F02C 3/10	(2006.01)

(52) **U.S. Cl.**

CPC ***F02C 7/057*** (2013.01); ***B64D 33/02*** (2013.01); ***F02C 7/042*** (2013.01); *B64D 27/20* (2013.01); *B64D 2033/0286* (2013.01); *F02C 3/10* (2013.01); *F02C 7/052* (2013.01); *F02C 7/055* (2013.01); *F02K 3/077* (2013.01); *F05D 2250/314* (2013.01)

(58) **Field of Classification Search**

CPC F02C 7/042; F02C 7/057; F02K 3/077; F02K 7/16; B64D 27/14; B64D 27/16; B64D 27/20; B64D 29/04; B64D 33/02; B64D 2033/0286

See application file for complete search history.

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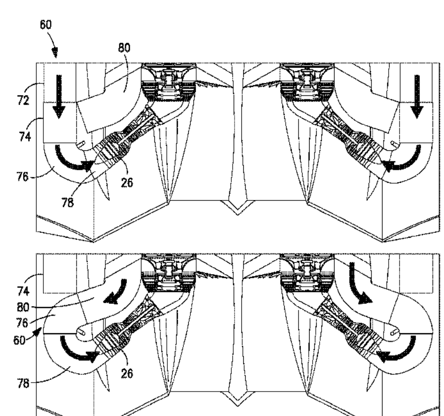
(57) **ABSTRACT**

A gas generator for a reverse core engine propulsion system has a variable cycle intake for the gas generator, which variable cycle intake includes a duct system. The duct system is configured for being selectively disposed in a first position and a second position, wherein free stream air is fed to the gas generator when in the first position, and fan stream air is fed to the gas generator when in the second position.

26 Claims, 7 Drawing Sheets



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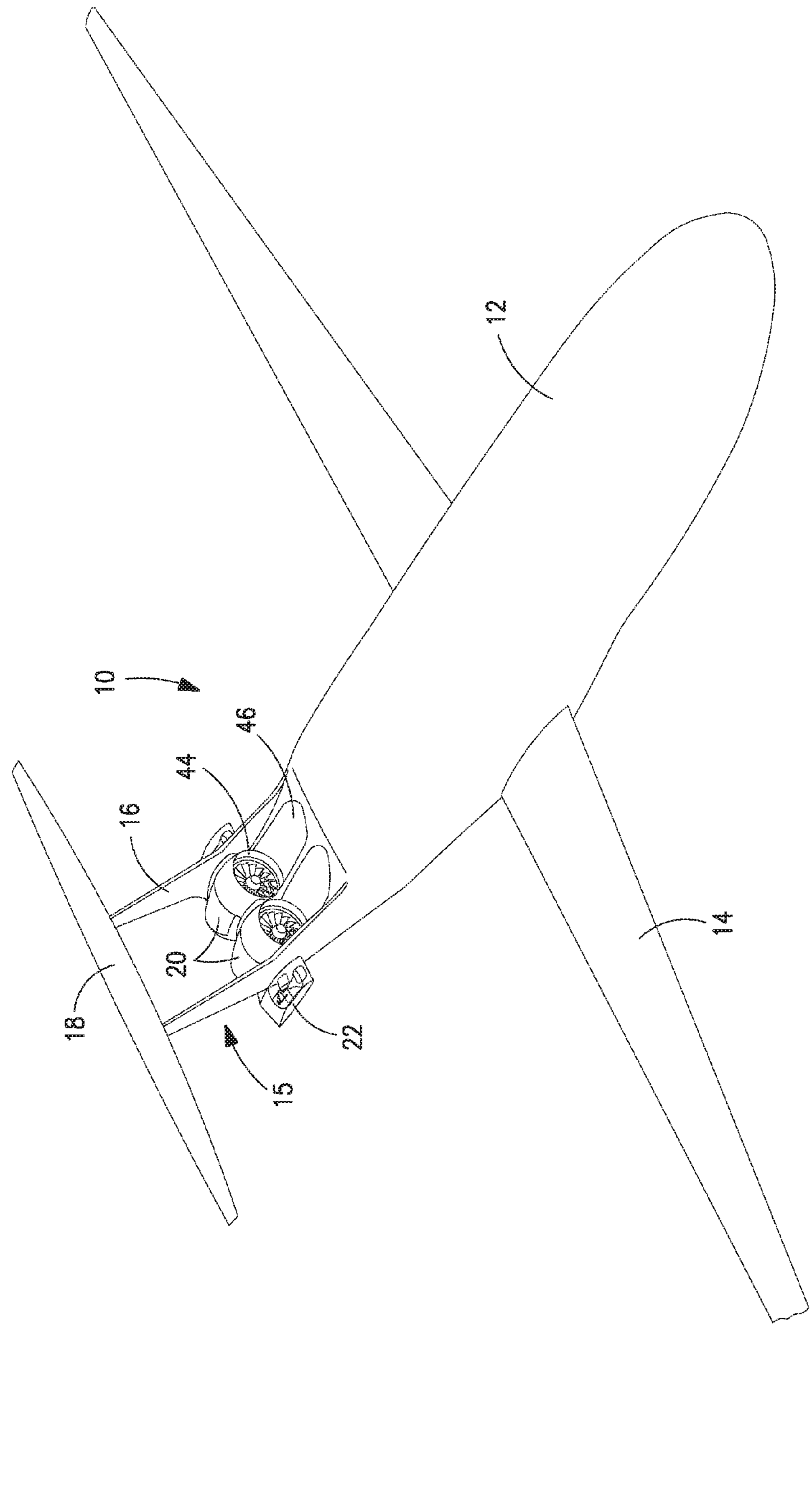

FIG. 1A

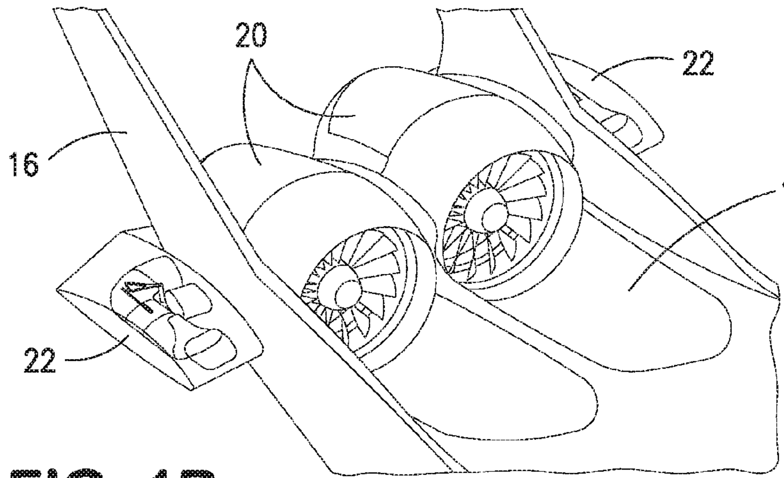

FIG. 1B

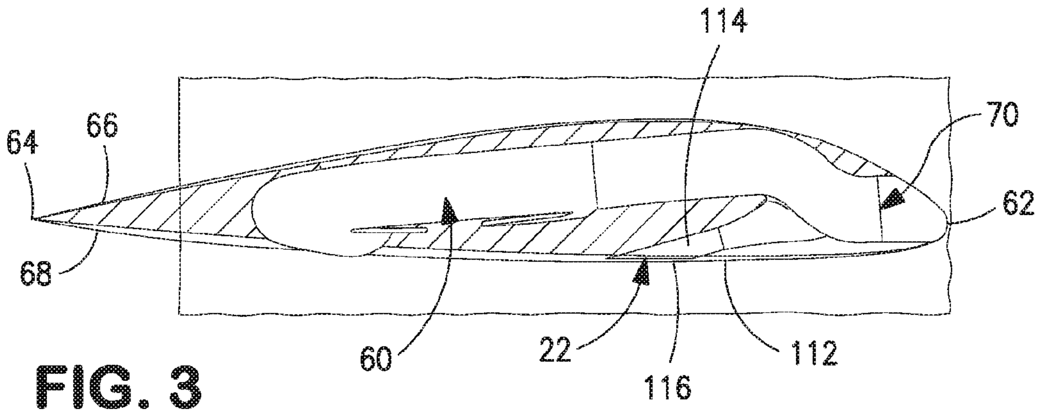

FIG. 3

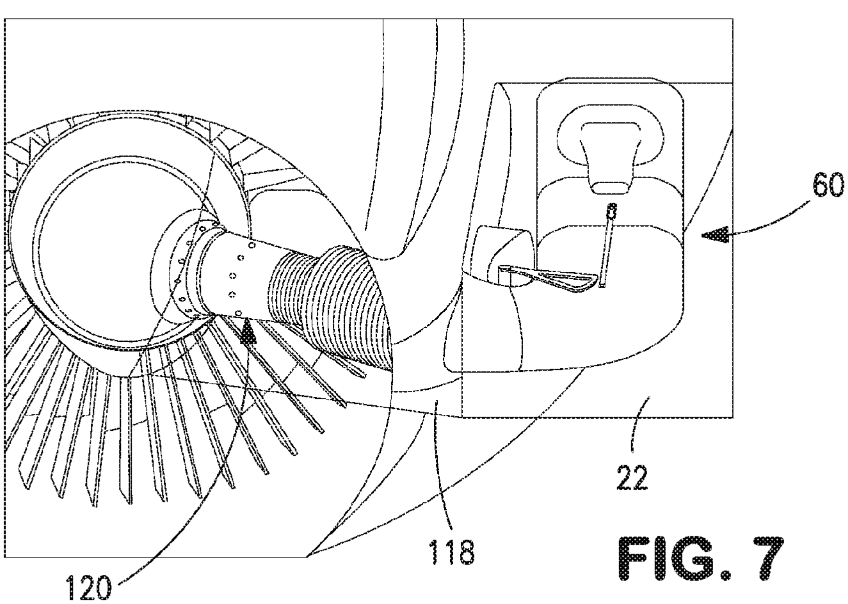

FIG. 7

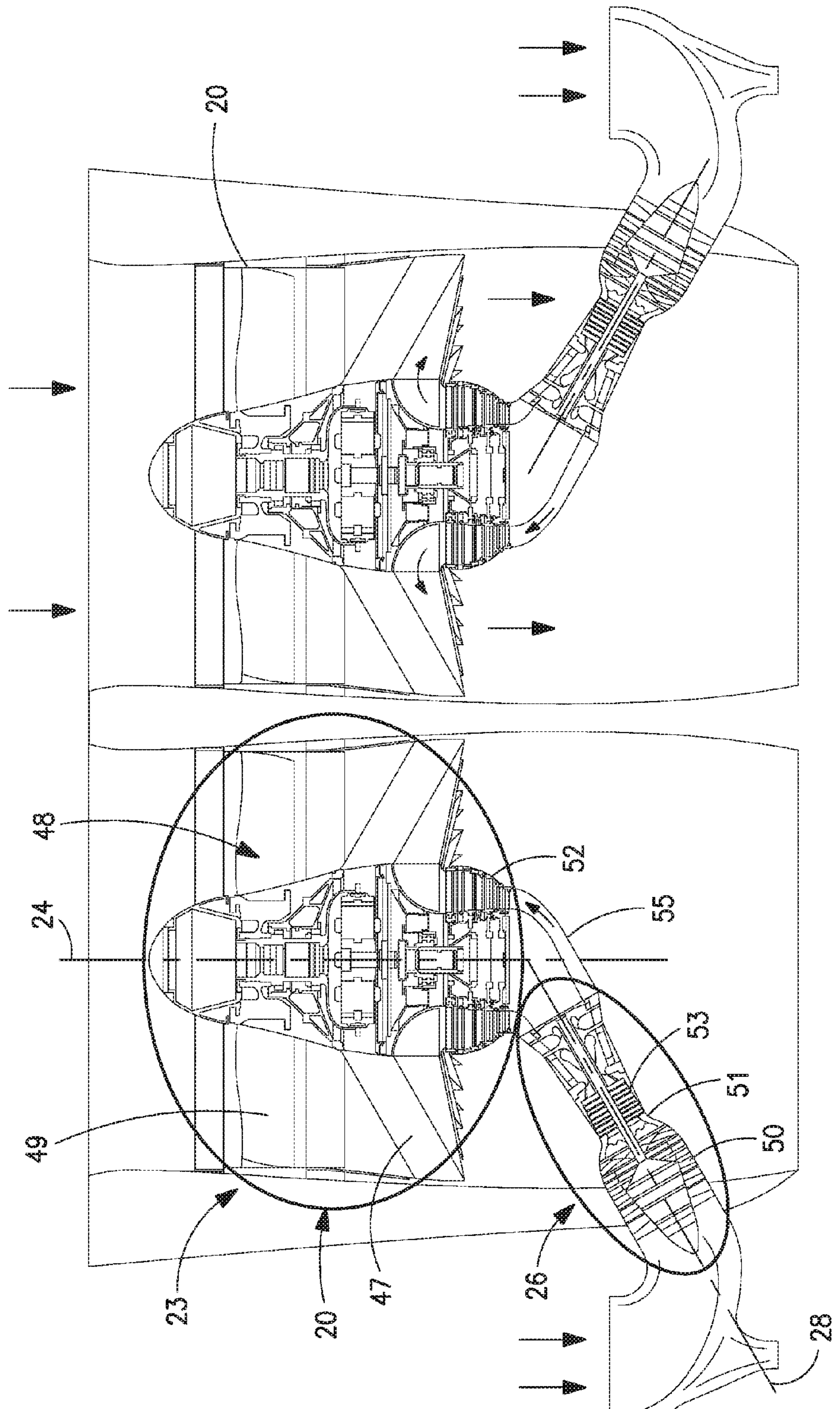

FIG. 2

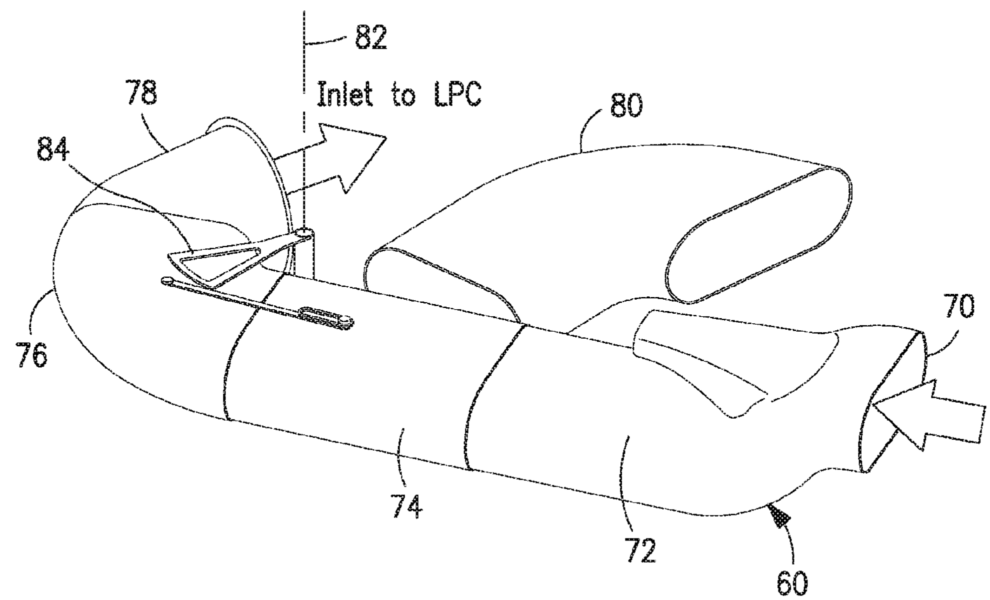
82
Inlet to LPC
78
80
84
70
76
74
72
60

FIG. 4

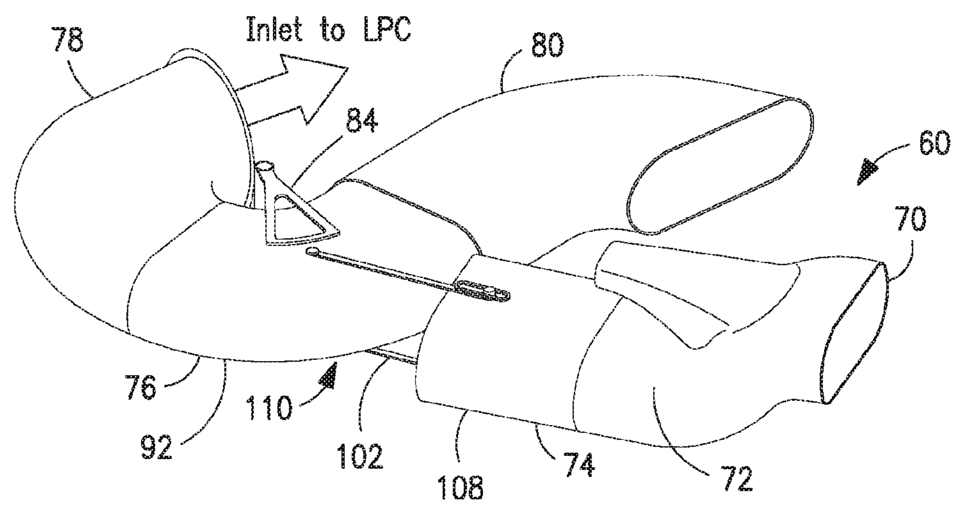
78
Inlet to LPC
80
84
60
70
76
110
92
102
108
74
72

FIG. 5

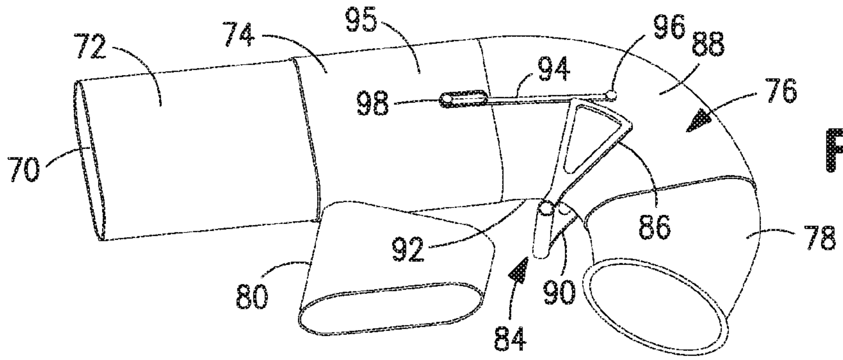

FIG. 6A

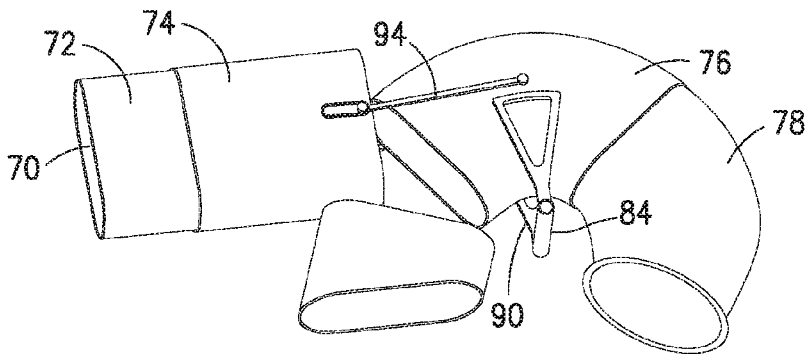

FIG. 6B

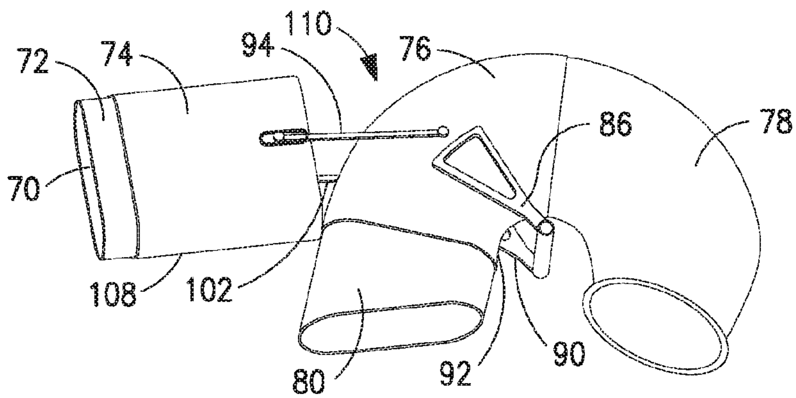

FIG. 6C

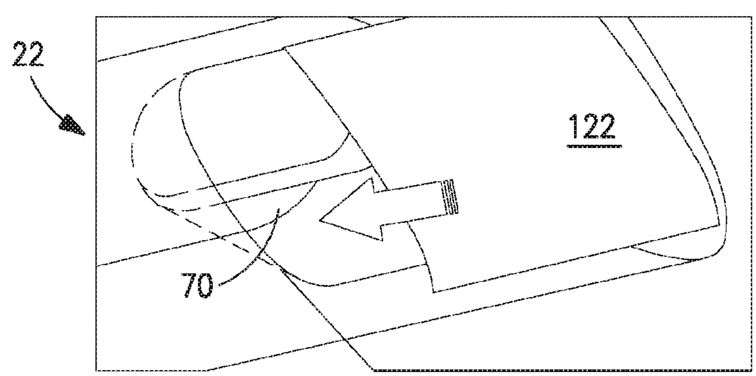

FIG. 12

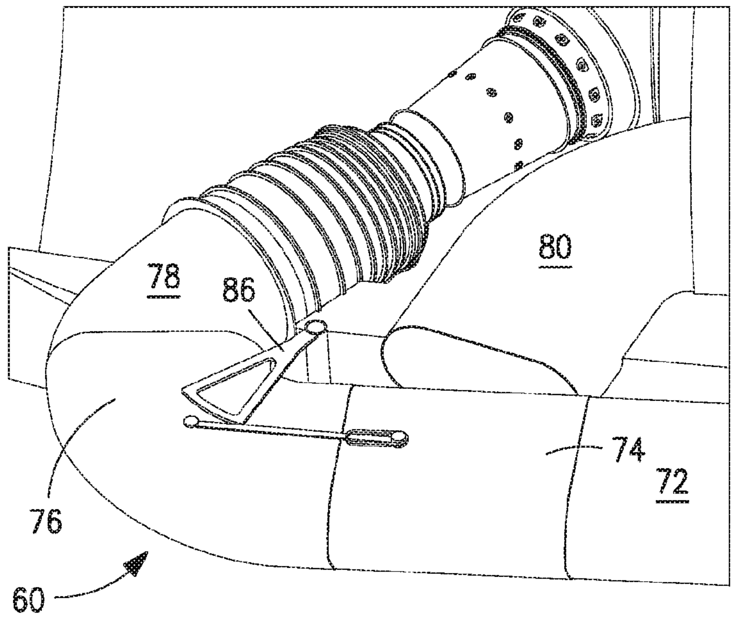

FIG. 8

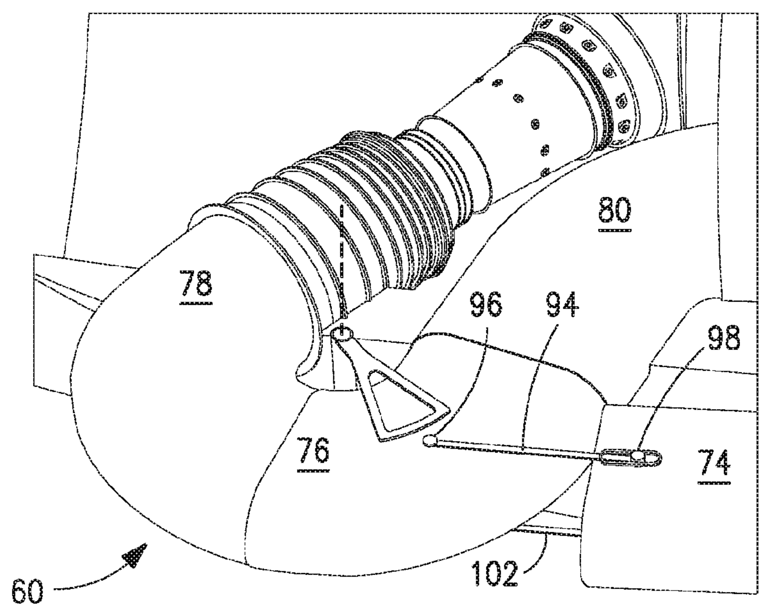

FIG. 9

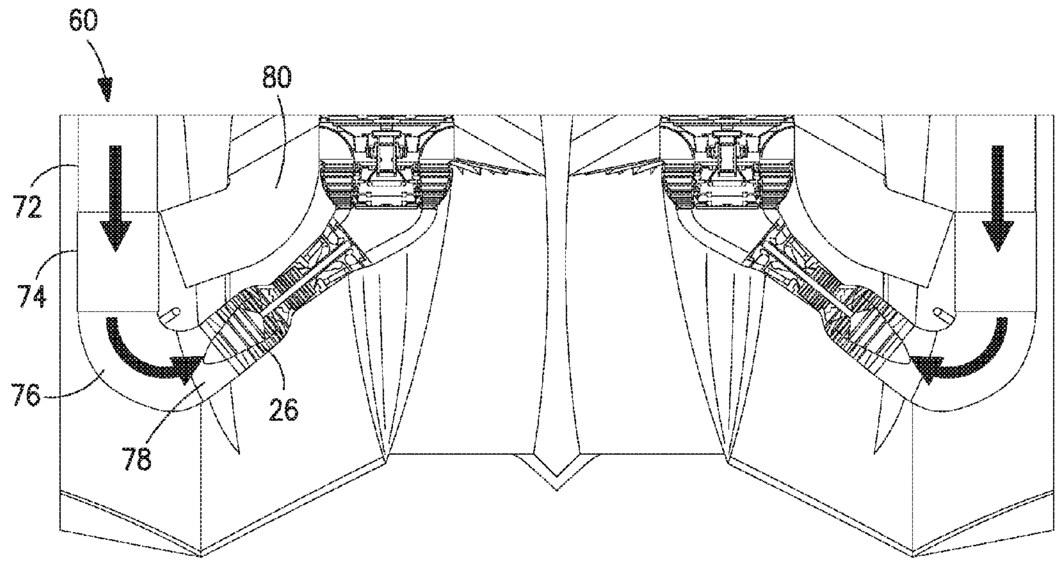

FIG. 10

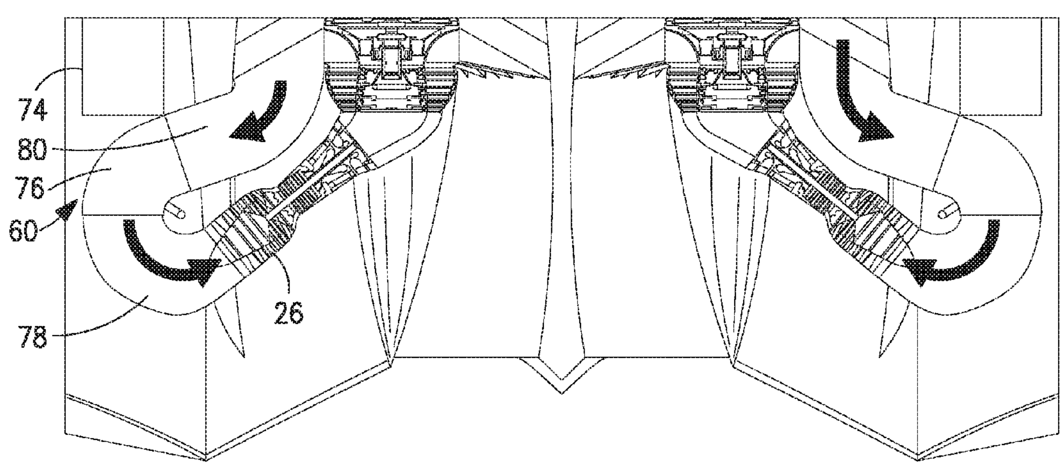

FIG. 11

VARIABLE CYCLE INTAKE FOR REVERSE CORE ENGINE

CROSS REFERENCE TO RELATED APPLICATION(S)

This application claims the benefit of provisional application Ser. No. 61/781,778, filed Mar. 14, 2013.

STATEMENT OF GOVERNMENT INTEREST

The Government of the United States of America may have rights in the present invention as a result of NASA Cooperative Agreement Contract No. NNX11AB35A and Sub-Contract No. MIT/PW Subaward No. 5710002937 awarded by NASA.

BACKGROUND

The present disclosure is directed to a variable cycle intake for a propulsion system having a reverse core engine, which variable cycle intake has a first position for supplying free stream air to an inlet of the engine and a second position for supplying fan stream air to the inlet of the engine.

Typical multi-spool turbofan engines include a nested core, in which a high pressure, or core, spool is nested inside a low pressure spool. Such a nested core engine includes, in axial sequence, a low pressure compressor, a high pressure compressor, a combustor section, a high pressure turbine, and a low pressure turbine. The high pressure compressor is connected to the high pressure turbine with a high pressure shaft that extends through the combustor section. The low pressure compressor is connected to the low pressure turbine with a low pressure shaft that extends through the high pressure shaft. Increases in efficiency of the turbofan allow for the core to be reduced in size, such as by having a smaller diameter. The low pressure shaft, however, cannot be reduced in diameter because the rotational speeds of the low pressure spool are limited by critical speed. The shaft critical speed is proportional to the shaft diameter and inversely proportional to the shaft length. Thus, decreasing the shaft diameter with reduced core sizes is not possible without reducing the shaft length if the same critical speed is desired. Thus, reductions in the core size yields compromises in the high pressure spool to accommodate low pressure spool shaft diameters. For example, the size and weight of high pressure spool rotor disk need to be increased to accommodate openings for larger low pressure shaft sizes. As such, there is a need for improving engine architectures to allow for, among other things, decreased core sizes resulting from more efficient turbofan engines.

There has been proposed a gas turbine engine comprising a fan drive gear system, a low spool connected to the fan drive gear system, and a high spool disposed aft of the low spool. The low spool comprises a rearward-flow low pressure compressor disposed aft of the fan drive gear systems, and a forward flow low pressure turbine disposed aft of the low pressure compressor. The high spool comprises a forward flow high pressure turbine disposed aft of the low pressure turbine, a combustor disposed of aft of the high pressure turbine, and a forward-flow high pressure compressor disposed aft of the combustor.

One issue faced by designers of these new engine architectures is incorporation of the new engine architecture into an aircraft.

SUMMARY

In accordance with the present disclosure, there is provided a gas generator for a reverse core propulsion system, which broadly comprises a variable cycle intake for the gas generator, said variable cycle intake comprising a duct system which is configured for being selectively disposed in a first position and a second position, wherein free stream air is fed to the gas generator when in the first position and fan stream air is fed to the gas generator when in a second position.

In another and alternative embodiment, the duct system includes a free stream air inlet, a duct extending from the free stream air inlet, a slidable duct, a curved duct segment, and an outlet duct section.

In another and alternative embodiment, the slidable duct moves between a first position where the slidable duct communicates with the curved duct segment and a second position where the slidable duct is out of communication with the curved duct segment.

In another and alternative embodiment, the slidable duct surrounds a portion of the duct extending from the free stream air inlet.

In another and alternative embodiment, the curved duct segment surrounds a portion of the outlet duct section.

In another and alternative embodiment, the outlet duct section supplies one of free stream air and fan stream air to the gas generator.

In another and alternative embodiment, the outlet duct section is connected to an inlet of the gas generator.

In another and alternative embodiment, the gas generator further comprises a fan stream air inlet duct.

In another and alternative embodiment, the curved duct segment is moved from a free air stream position in contact with the slidable duct and out of contact with the fan stream air inlet duct to a fan air stream position in contact with the fan stream air inlet duct and out of contact with the slidable duct.

In another and alternative embodiment, the gas generator further comprises an actuator to move the curved duct segment from the free air stream position to the fan stream air position and from the fan stream air position to the free air stream position.

In another and alternative embodiment, the actuator has a first arm connected to a first surface of the curved duct segment and a second arm connected to a second surface of the curved duct segment.

In another and alternative embodiment, the gas generator further comprises a first link connected to the first surface of the curved duct segment and to a first surface of the slidable duct and a second link connected to the second surface of the curved duct segment and to a second surface of the slidable duct to move the slidable duct as the curved duct segment moves.

In another and alternative embodiment, the gas generator further comprises a particle separator connected to the free stream air inlet.

In another and alternative embodiment, the gas generator further comprises a cover plate for covering the free stream air inlet when the variable cycle intake is in the second position.

Further in accordance with the present disclosure, there is provided an aircraft which broadly comprises a fuselage having a tail section; a pair of gas generators located in the tail section; each of the gas generators having a variable cycle intake for supplying one of free stream air and fan stream air to a respective one of the gas generators; and variable cycle intake comprising a duct system which feeds free stream air to the respective one of the gas generators when in a first position and which feeds fan stream air to the respective one of the gas generators when in a second position.

In another and alternative embodiment, the duct system includes a free stream air inlet, a duct extending from the free stream air inlet, a slidable duct, a curved duct segment, and an outlet duct section.

In another and alternative embodiment, the slidable duct moves between a first position where the slidable duct communicates with the curved duct segment and a second position where the slidable duct is out of communication with the curved duct segment.

In another and alternative embodiment, the slidable duct surrounds a portion of the duct extending from the free stream air inlet.

In another and alternative embodiment, the curved duct segment surrounds a portion of the outlet duct section.

In another and alternative embodiment, the outlet duct section supplies one of free stream air and fan stream air to the respective one of the gas generators.

In another and alternative embodiment, each of the gas generators comprises a reverse core engine and the outlet duct section is connected to an inlet of the respective one of the gas generator.

In another and alternative embodiment, the duct system further comprises a fan stream air inlet duct.

In another and alternative embodiment, the curved duct segment is moved from a free air stream position in contact with the slidable duct and out of contact with the fan stream air inlet duct to a fan air stream position in contact with the fan stream air inlet duct and out of contact with the slidable duct.

In another and alternative embodiment, the duct system further comprises an actuator to move the curved duct segment from the free air stream position to the fan stream air position and from the fan stream air position to the free air stream position.

In another and alternative embodiment, the actuator has a first arm connected to a first surface of the curved duct segment and a second arm connected to a second surface of the curved duct segment.

In another and alternative embodiment, the duct system further comprises a first link connected to the first surface of the curved duct segment and to a first surface of the slidable duct and a second link connected to the second surface of the curved duct segment and to a second surface of the slidable duct to move the slidable duct as the curved duct segment moves.

In another and alternative embodiment, the duct system further comprises a particle separator connected to the free stream air inlet.

In another and alternative embodiment, the duct system further comprises a cover plate for covering the free stream air inlet when the variable cycle intake is in the second position.

In another and alternative embodiment, the duct system is at least partially embedded within an aerodynamic fairing.

In another and alternative embodiment, the aircraft further comprises a pair of free turbines and a pair of fans fan driven by said free turbines, wherein said gas generators provide air for driving said pair of free turbines.

Other details of the variable cycle intake for reverse core engines are set forth in the following detailed description and the accompanying drawings wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a schematic representation of an aircraft having a propulsion system with two gas generators in the form of reverse core engines;

FIG. **1**B illustrates a portion of the tail section of the aircraft of FIG. **1**A;

FIG. **2** is a sectional view of the propulsion system for propelling the aircraft of FIG. **1**;

FIG. **3** is a sectional view of a fairing having the variable cycle intake embedded therein;

FIG. **4** is a schematic representation of the variable cycle intake in a first position where free stream air is supplied to a gas generator;

FIG. **5** is a schematic representation of the variable cycle intake of FIG. **4** in a second position where fan stream air is supplied to the gas generator;

FIGS. **6**A-**6**C are schematic representation of the variable cycle intake as it moves from the first position to the second position;

FIG. **7** is a rear view of the propulsion system showing the fairing blended into a bi fi wall;

FIG. **8** illustrates the variable cycle intake in the first position;

FIG. **9** illustrates the variable cycle intake in the second position;

FIG. **10** illustrates the flow through the variable cycle intake when in the first position;

FIG. **11** illustrates the flow through the variable cycle intake when in the second position; and

FIG. **12** illustrates a cover which can be slid over an air inlet of the variable cycle intake when not in use.

DETAILED DESCRIPTION

FIGS. **1**A and **1**B illustrate an aircraft **10** having a fuselage **12**, wings **14**, and a tail **15** having vertical tail surfaces **16** and a tail wing **18** mounted to the tail surfaces **16**. A propulsion system having a pair of propulsors **20**, which are gas turbine engines, is mounted to the fuselage **12** at the base of the tail **15**. The inlet **44** to each of the propulsors **20** includes a channel **46** in the fuselage **12** for delivering atmospheric air to the propulsors **20**. An aerodynamic fairing **22** may extend from each side of the fuselage **12** adjacent the tail **15**.

Referring now to FIG. **2**, each of the propulsors **20** may comprise a propulsor section **23** which has a free turbine **52**, a fan **48** having a plurality of fan blades **49** which is driven by the free turbine **52**, and a plurality of fan exit guide vanes **47**. The free turbine **52** and the fan **48** rotate about a central axis **24**. Each of the propulsors **20** further has a gas generator **26** which has a longitudinal axis or central axis **28** which is at an angle to the fan central axis **24**.

The illustrated gas generator **26** is a reverse core engine which includes a compressor section **50** having one or more stages such as a low pressure compressor and a high pressure compressor, a combustion section **51** having one or more combustors, and a turbine section **53** having one or more stages such as a low pressure turbine and a high pressure turbine. The low pressure compressor in the gas generator **26** is driven by a low pressure turbine via a low pressure spool and a high pressure compressor in the gas generator **26** is driven by a high pressure turbine via a high pressure spool. The gas generator **26** delivers combusted fluid to the free turbine **52**, for driving same, via a plenum **55** connected to the outlet of the gas generator **26**. The free turbine **52** drives the fan **48**.

Referring now to FIG. **3**, there is shown a variable cycle air intake **60** which is at least partially embedded within the aerodynamic fairing **22**. As can be seen from FIG. **3**, the aerodynamic fairing has a leading edge **62**, a trailing edge **64**, an upper aerodynamic surface **66**, and a lower aerodynamic surface **68**.

Referring now to FIGS. **4** and **5**, the variable cycle intake **60** has a duct system which includes a free stream air inlet **70**, a duct **72** extending from the air inlet **70**, a slidable duct section **74** which surrounds a portion of the duct **72** and which moves relative to the duct **72**, a curved duct segment **76**, and an outlet duct section **78** which connects to an inlet of a low pressure compressor section of the gas generator **26**.

The curved duct segment **76** overlaps and surrounds a portion of the outlet duct section **78**. The curved duct segment **76** is movable relative to the outlet duct section **78** between a first position (see FIG. **4**) and a second position (see FIG. **5**). In the first position, the curved duct segment **76** is in communication with the slidable duct section **74**. In the second position (see FIG. **5**), the curved duct segment **76** is in communication with a fan stream air inlet duct **80**.

As can be seen from FIGS. **4** and **5**, the curved duct segment **76** is rotated about an axis **82** by a U-shaped actuator **84**. As shown in FIGS. **6**A-**6**C, the U-shaped actuator **84** has a first arm **86** connected to a first surface **88** of the curved duct segment **76** and a second arm **90** connected to a second surface **92** of the curved duct segment **76**. The actuator **84** may be rotated about the axis **82** by a motor (not shown) or any other suitable power source.

An upper link **94** is connected at a first end **96** to the first surface **88** of the curved duct segment **76**. At a second end **98**, the upper link **94** is connected to a first surface **95** of the slidable duct section **74**. As shown in FIG. **5**, a lower link **102** is connected to at a first end to the second surface **92** of the curved duct segment **76**. At a second end, the lower link **102** is connected to a second surface **108** of the slidable duct section **74**.

Referring now to FIGS. **6**A-**6**C, as the actuator **84** rotates about the axis **82** towards the air inlet **70**, the rotation of the actuator causes the slidable duct section **74** to move from a first free stream air position to a second fan stream position. In the first free stream position the slidable duct section **74** is in contact with the curved duct segment **76**. In the second fan stream position, the duct **74** is out of contact with the curved duct segment **76**.

When moving from the first position to the second position, the slidable duct section **74** moves relative to the duct **72** by siding in a direction toward the air inlet **70** and assume the position shown in FIG. **5** and FIG. **6**C. As shown in FIGS. **6**B and **6**C, movement of the slidable duct section **74** creates a gap **110** which allows the curved duct segment **76** to rotate and come into fluid communication with the fan stream inlet duct **80**. When the curved duct segment **76** is in the position shown in FIG. **6**C, fan stream air is supplied to the inlet of the gas generator **26**.

When the actuator **84** rotates about the axis **82** away from the air inlet **70**, the rotation of the actuator causes the curved duct segment **76** to rotate into the position shown in FIG. **4** and causes the slidable duct section **74** to slide over the duct **72** and into the position shown in FIG. **4** where the slidable duct section **74** is in communication with the curved duct segment **76** and the curved duct segment is out of contact with the fan stream inlet duct **80**. In this position, free stream air is provided to the inlet of the gas generator **26**.

The variable cycle intake **60** may include a particle separator **112** (see FIG. **3**) which separates solid particles from the free air stream. The particle separator **112** may be provided with a first, upstream outlet that communicates with an internal channel **114** and a second downstream outlet **116** in the external lower aerodynamic surface **68**. Particles within the free air stream tend not to follow the curvature of the intake **30** and continue on straight into the particle separator **112**.

As shown in FIG. **7**, the aerodynamic fairing **22** may be blended into a bi-fi wall **118** surrounding the core **120** of the gas generator **26**.

FIGS. **8** and **10** illustrate the variable cycle intake **60** in a first position where free air stream may be provided to a low pressure compressor section of the gas generator **26**.

FIGS. **9** and **11** illustrate the variable cycle intake **60** in a second position where fan air stream may be provided to the low pressure compressor section of the gas generator **26**.

As shown in FIG. **12**, a cover plate **122** may be provided within the fairing **22** to cover the free stream air inlet **70** when the variable cycle intake **60** is in the fan stream air position. An actuator (not shown) may be provided to slide the cover plate **122** over the air inlet **70**.

The primary benefit of the variable cycle intake **60** is the dual cycle capability that it provides.

There has been provided in accordance with the present disclosure a variable cycle intake for a reverse core engine. While the variable cycle intake has been described in the context of specific embodiments thereof, other unforeseen alternatives, modifications, and variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations which fall within the broad scope of the appended claims.

What is claimed is:

1. A gas generator for a reverse core propulsion system, comprising:
- a variable cycle intake for the gas generator; said variable cycle intake comprising a duct system; said duct system comprising
  - a free stream air inlet;
  - a straight duct extending from the free stream air inlet;
  - a slidable duct connected to the straight duct;
  - a fan stream air inlet duct;
  - a curved duct segment having an inlet end and an outlet end; and
  - an outlet duct section connecting the outlet end of the curved duct segment to the gas generator, said duct system being selectively disposed in a free air stream position and a fan air stream position, wherein a free stream air is fed to said gas generator by connecting said inlet end to said slidable duct when in said free air stream position and a fan stream air is fed to the gas generator by connecting said inlet end to said fan stream air inlet duct when in said fan air stream position.

2. The gas generator according to claim **1**, wherein said slidable duct moves between the free air stream position where said slidable duct connects with said inlet end of said curved duct segment and the fan air stream position where said slidable duct is disconnected from said inlet end of said curved duct segment.

3. The gas generator according to claim **2**, wherein said slidable duct surrounds a portion of said straight duct extending from the free stream air inlet.

4. The gas generator according to claim **1**, wherein said curved duct segment surrounds a portion of said outlet duct section.

5. The gas generator according to claim **1**, wherein said outlet duct section supplies one of the free stream air and the fan stream air to said gas generator.

6. The gas generator according to claim **5**, wherein said outlet duct section is connected to an inlet of said gas generator.

7. The gas generator according to claim **1**, wherein said curved duct segment is moved from the free air stream position in contact with said slidable duct and out of contact with said fan stream air inlet duct to the fan air stream position in contact with said fan stream air inlet duct and out of contact with said slidable duct.

8. The gas generator according to claim **7**, further comprising an actuator to move said curved duct segment from said free air stream position to said fan air stream position and from said fan air stream position to said free air stream position.

9. The gas generator according to claim **8**, wherein said actuator has a first arm connected to a first surface of said curved duct segment and a second arm connected to a second surface of said curved duct segment.

10. The gas generator according to claim **9**, further comprising a first link connected to said first surface of said curved duct segment and to a first surface of said slidable duct and a second link connected to said second surface of said curved duct segment and to a second surface of said slidable duct to move said slidable duct as said curved duct segment moves.

11. The gas generator according to claim **1**, further comprising a particle separator connected to said free stream air inlet.

12. The gas generator according to claim **1**, further comprising a cover plate covering said free stream air inlet when said variable cycle intake is in said fan air stream position.

13. An aircraft comprising:

a fuselage having a tail section;

a pair of gas generators located in said tail section; each of said gas generators having a variable cycle intake supplying one of a free stream air and a fan stream air to a respective one of said pair of gas generators; and

said variable cycle intake comprising a duct system, said duct system comprising

a free stream air inlet;

a straight duct extending from the free stream air inlet;

a slidable duct connected to the straight duct;

a fan stream air inlet duct;

a curved duct segment having an inlet end and an outlet end; and

an outlet duct section connecting the outlet end of the curved duct segment to the gas generator, said duct system feeds the free stream air to the respective one of said pair of gas generators by connecting said inlet end to said slidable duct when in a free air stream position and feeds the fan stream air to the respective one of said pair of gas generators by connecting said inlet end to said fan stream air inlet duct when in a fan air stream position.

14. The aircraft according to claim **13**, wherein said slidable duct moves between the free air stream position where said slidable duct connects with said inlet end of said curved duct segment and the fan air stream position where said slidable duct is disconnected from said inlet end of said curved duct segment.

15. The aircraft according to claim **14**, wherein said slidable duct surrounds a portion of said straight duct extending from the free stream air inlet.

16. The aircraft according to claim **13**, wherein said curved duct segment surrounds a portion of said outlet duct section.

17. The aircraft according to claim **13**, wherein said outlet duct section supplies one of the free stream air and the fan stream air to said respective one of said pair of gas generators.

18. The aircraft according to claim **17**, wherein each one of said pair of gas generators comprises a reverse core engine and said outlet duct section is connected to an inlet of said respective one of said gas generator.

19. The aircraft according to claim **13**, wherein said curved duct segment is moved from the free air stream position in contact with said slidable duct and out of contact with said fan stream air inlet duct to the fan air stream position in contact with said fan stream air inlet duct and out of contact with said slidable duct.

20. The aircraft according to claim **19**, wherein said duct system further comprises an actuator to move said curved duct segment from said free air stream position to said fan air stream position and from said fan air stream position to said free air stream position.

21. The aircraft according to claim **20**, wherein said actuator has a first arm connected to a first surface of said curved duct segment and a second arm connected to a second surface of said curved duct segment.

22. The aircraft according to claim **21**, wherein said duct system further comprises a first link connected to said first surface of said curved duct segment and to a first surface of said slidable duct and a second link connected to said second surface of said curved duct segment and to a second surface of said slidable duct to move said slidable duct as said curved duct segment moves.

23. The aircraft according to claim **13**, wherein said duct system further comprises a particle separator connected to said free stream air inlet.

24. The aircraft according to claim **13**, wherein said duct system further comprises a cover plate for covering said free stream air inlet when said variable cycle intake is in said second position.

25. The aircraft according to claim **13**, wherein said duct system is at least partially embedded within an aerodynamic fairing.

26. The aircraft according to claim **13**, further comprising a pair of free turbines and a pair of fans driven by said free turbines, wherein each one of said pair of gas generators provide air for driving a respective one of said pair of free turbines.

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