US007730714B2

(12) **United States Patent**
Wood et al.

(10) **Patent No.: US 7,730,714 B2**
(45) **Date of Patent: Jun. 8, 2010**

(54) **TURBOFAN GAS TURBINE ENGINE WITH VARIABLE FAN OUTLET GUIDE VANES**

(75) Inventors: **Peter John Wood**, Loveland, OH (US); **Ruby Lasandra Zenon**, Sharonville, OH (US); **Donald George LaChapelle**, Cincinnati, OH (US); **Mark Joseph Mielke**, Blanchester, OH (US); **Carl Grant**, Cincinnati, OH (US)

(73) Assignee: **General Electric Company**, Schenectady, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1074 days.

(21) Appl. No.: **11/290,247**

(22) Filed: **Nov. 29, 2005**

(65) **Prior Publication Data**

US 2007/0119150 A1 May 31, 2007

(51) **Int. Cl.**
F02K 3/02 (2006.01)
F02K 1/38 (2006.01)

(52) **U.S. Cl.** **60/226.1**; 60/262; 60/226.3

(58) **Field of Classification Search** 60/226.1, 60/226.3, 262, 761
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,632,224	A	1/1972	Wright et al.	
4,069,661	A	1/1978	Rundell et al.	
4,137,708	A	2/1979	Aspinwall et al.	
4,275,560	A *	6/1981	Wright et al.	60/226.3
4,791,783	A *	12/1988	Neitzel	60/262
5,148,673	A	9/1992	Enderle	
5,311,735	A	5/1994	Orlando	
5,311,736	A *	5/1994	Lardellier	60/226.3
5,402,638	A *	4/1995	Johnson	60/204
5,404,713	A *	4/1995	Johnson	60/204
5,694,768	A	12/1997	Johnson et al.	
5,794,432	A	8/1998	Dunbar et al.	
5,806,303	A	9/1998	Johnson	
5,809,772	A	9/1998	Giffin, III et al.	
5,867,980	A	2/1999	Bartos	
6,045,325	A	4/2000	Horvath et al.	
6,438,941	B1	8/2002	Elliott et al.	
6,619,916	B1	9/2003	Capozzi et al.	
6,662,546	B1	12/2003	Giffin, III	
6,901,739	B2 *	6/2005	Christopherson	60/226.3
6,931,858	B2	8/2005	Venkataramani et al.	
7,246,484	B2 *	7/2007	Giffin et al.	60/268

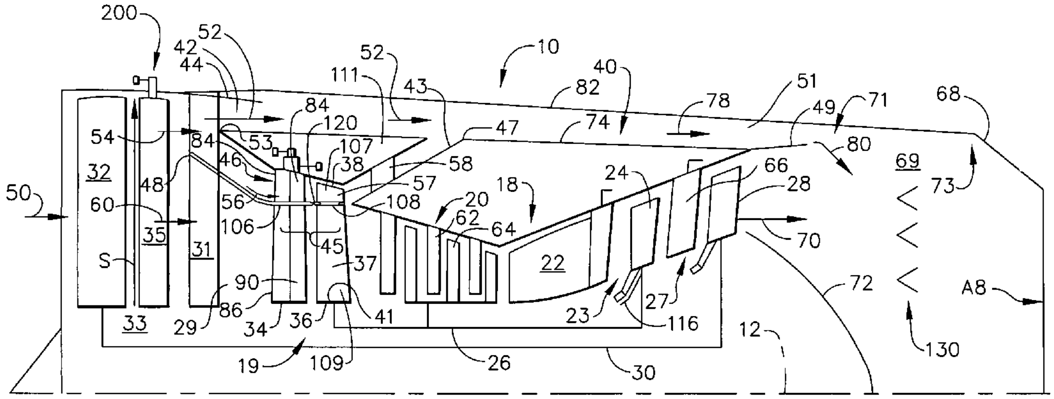
(Continued)

Primary Examiner—Michael Cuff
Assistant Examiner—Gerald L Sung
(74) *Attorney, Agent, or Firm*—William Scott Andes; Steven J. Rosen

(57) **ABSTRACT**

A turbofan gas turbine engine includes a forward fan section with a row of fan rotor blades, a core engine, and a fan bypass duct downstream of the forward fan section and radially outwardly of the core engine. The forward fan section has only a single stage of variable fan guide vanes which are variable fan outlet guide vanes downstream of the forward fan rotor blades. An exemplary embodiment of the engine includes an afterburner downstream of the fan bypass duct between the core engine and an exhaust nozzle. The variable fan outlet guide vanes are operable to pivot from a nominal OGV position at take-off to an open OGV position at a high flight Mach Number which may be in a range of between about 2.5-4+. Struts extend radially across a radially inwardly curved portion of a flowpath of the engine between the forward fan section and the core engine.

33 Claims, 5 Drawing Sheets



U.S. PATENT DOCUMENTS

2002/0148216	A1	10/2002	Brault et al.	
2005/0072158	A1	4/2005	Christopherson	
2005/0081509	A1 *	4/2005	Johnson	60/226.1
2006/0242941	A1 *	11/2006	Johnson	60/226.1

* cited by examiner

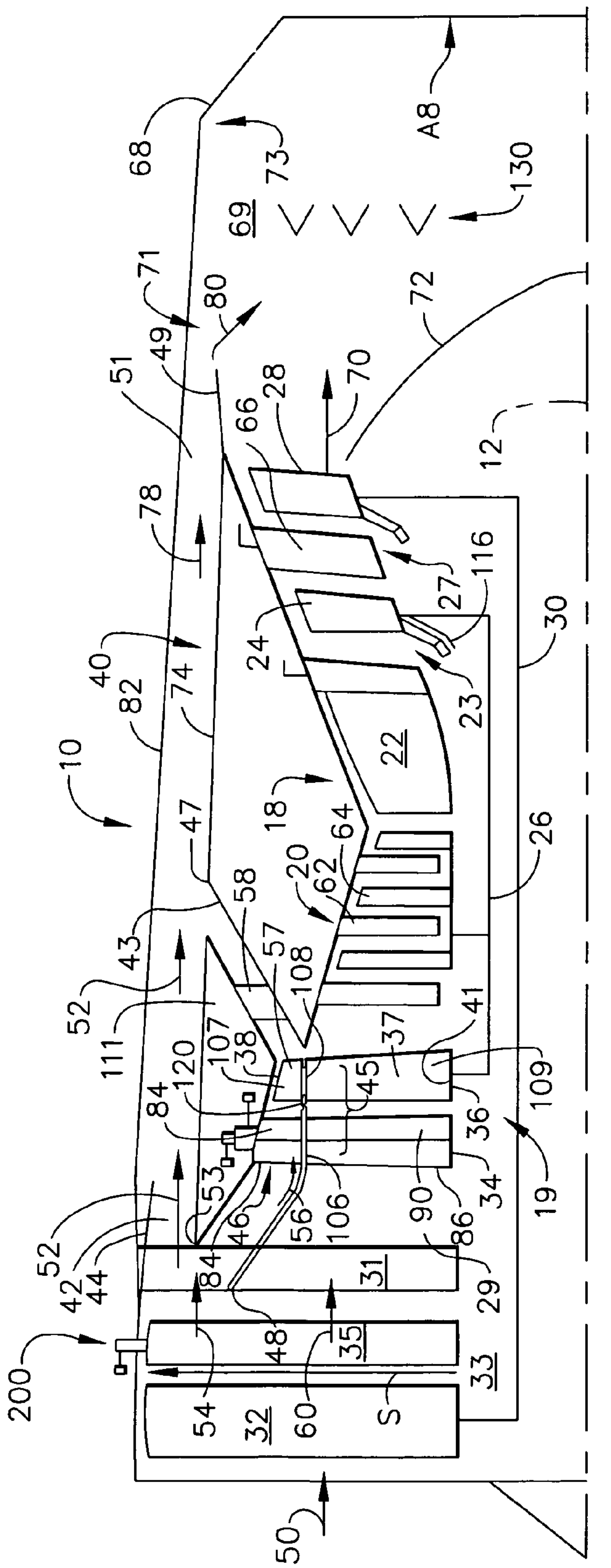

10
12
18
19
20
22
23
24
26
27
28
29
30
31
32
33
34
35
36
37
38
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
56
57
58
60
62
64
66
68
69
70
71
72
73
74
78
80
82
84
86
90
106
107
108
109
111
116
120
130
200
A8
S

FIG. 1

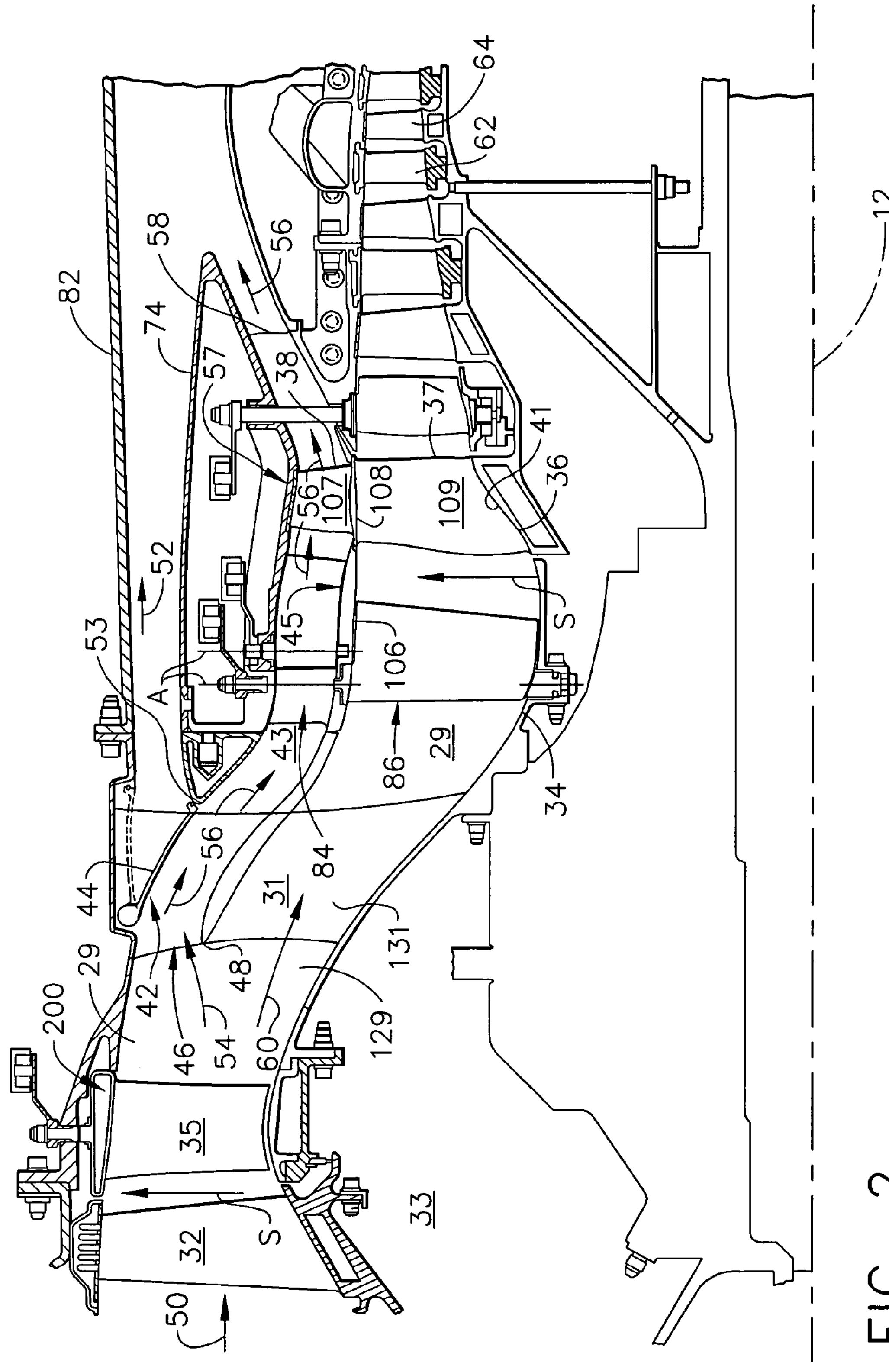

82
74
58
56
57
38
37
41
36
109
108
107
56
45
52
53
A
106
S
43
86
29
34
84
56
44
31
131
42
48
129
29
200
46
54
60
35
33
S
32
50
64
62
12

FIG. 2

OGV OPERATION AT 40% SPAN

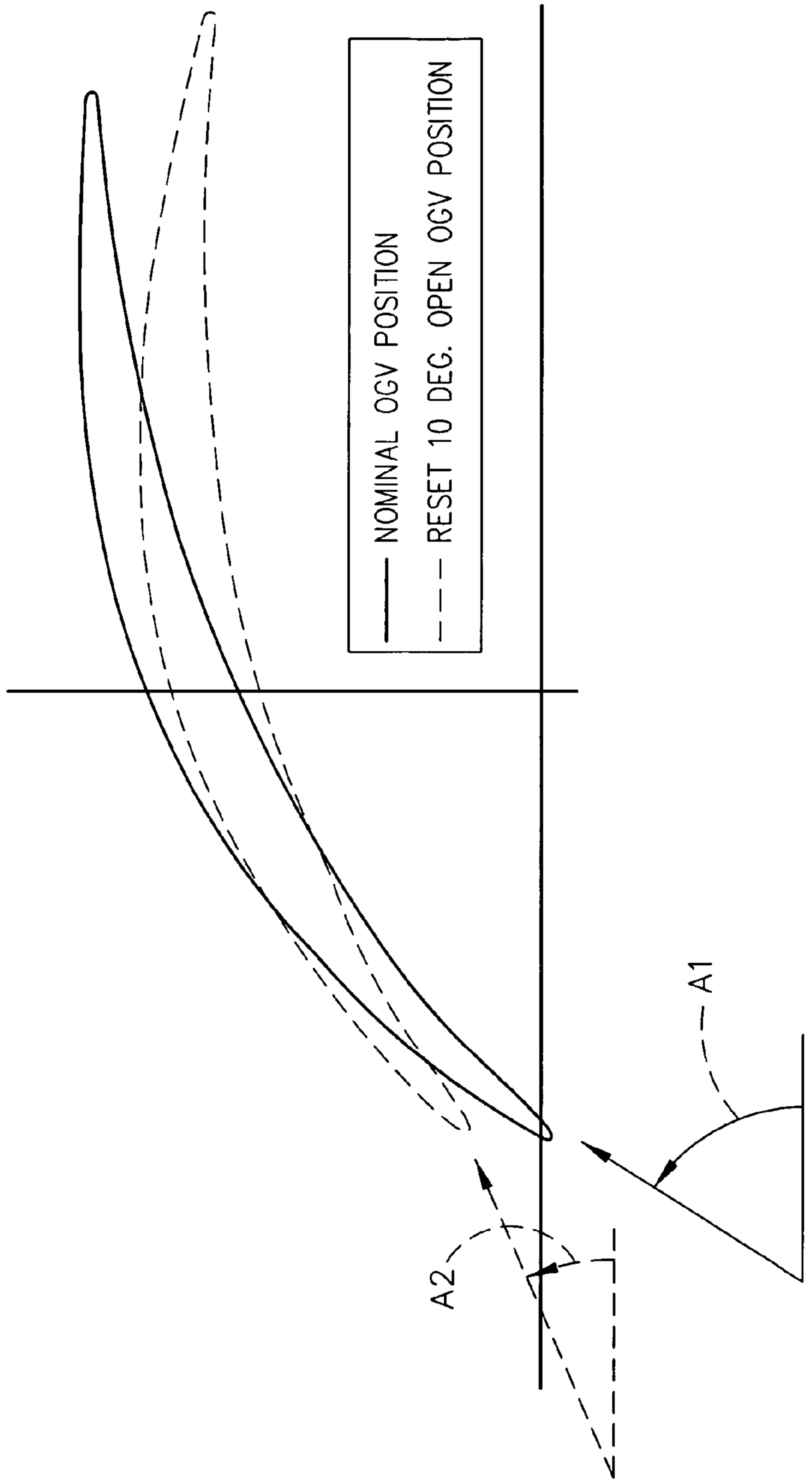


FIG. 3

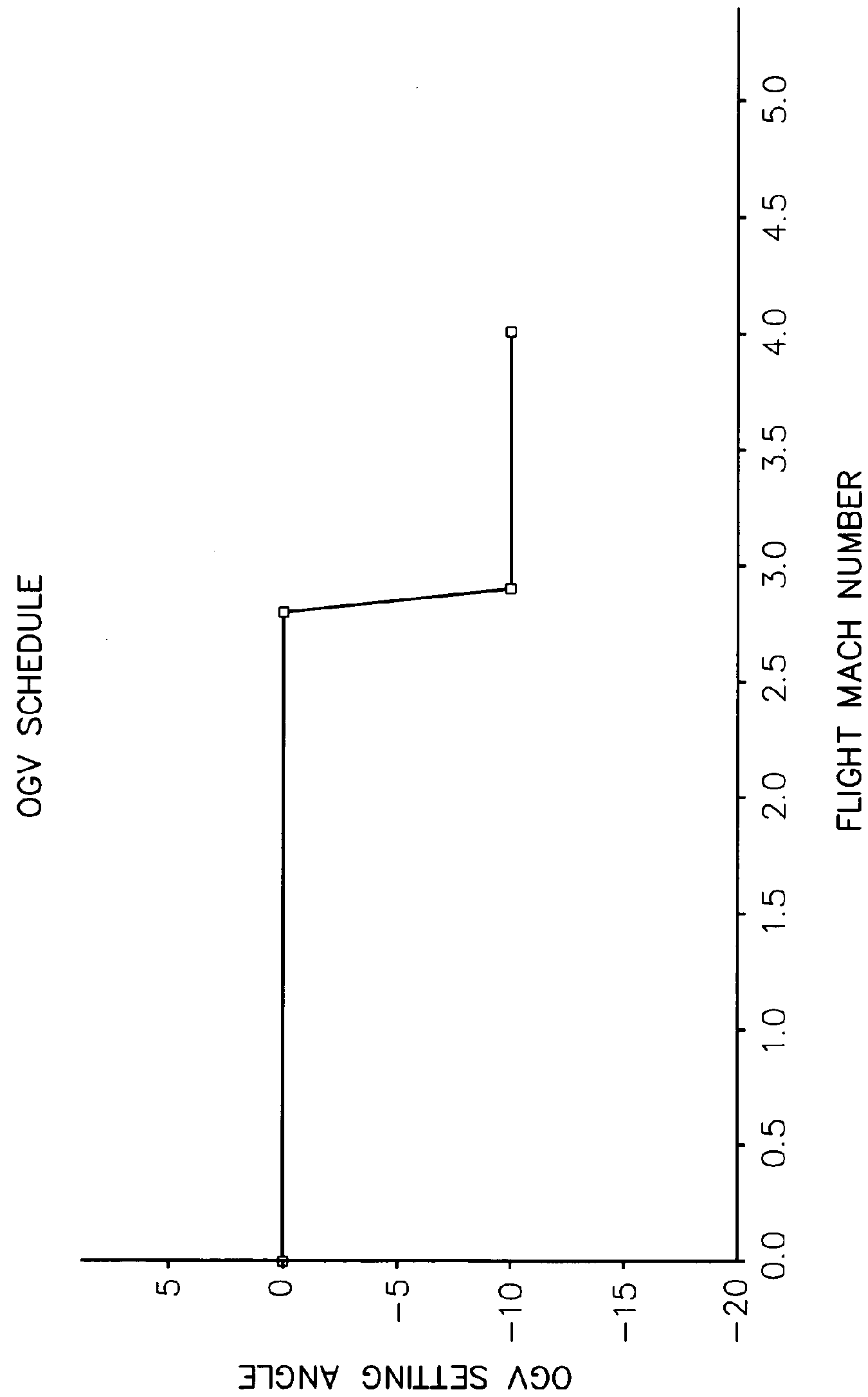

OGV SCHEDULE
OGV SETTING ANGLE
5
0
−5
−10
−15
−20
FLIGHT MACH NUMBER
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

FIG. 4

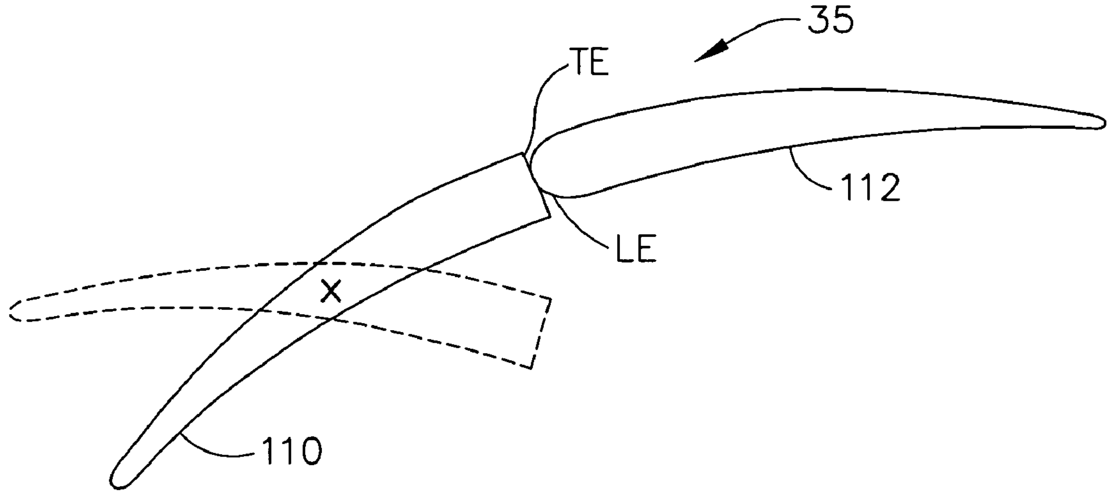


FIG. 5

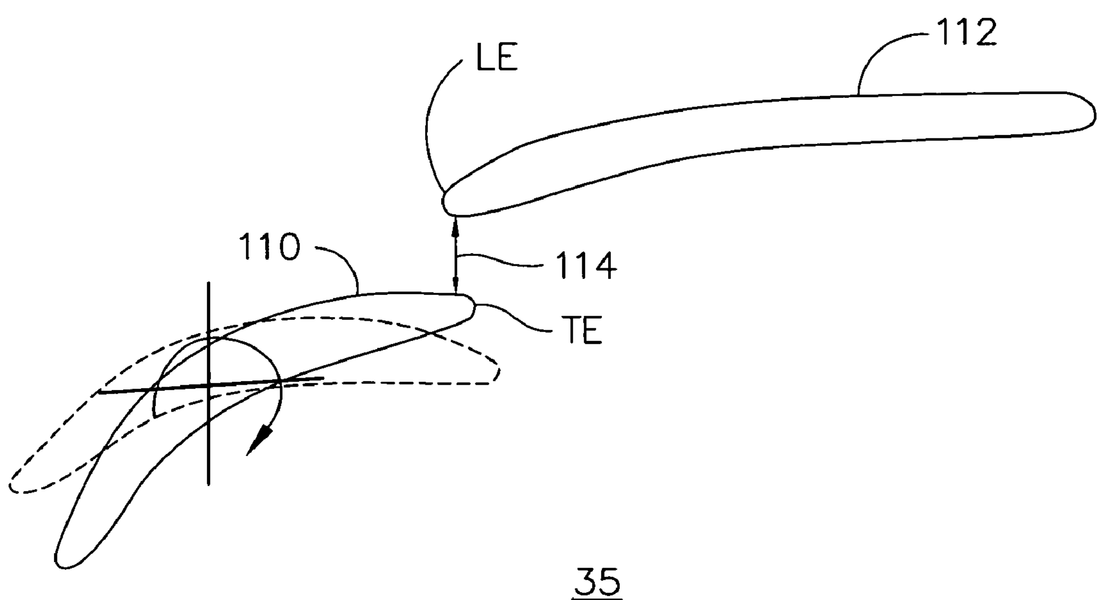


FIG. 6

TURBOFAN GAS TURBINE ENGINE WITH VARIABLE FAN OUTLET GUIDE VANES

The Government has rights to this invention pursuant to Contract No. NAS3-01135 awarded by the NASA.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to turbofan gas turbine engines and, more particularly, to such engines having guide vanes in the front fan section of the engine.

Turbofan gas turbine engines with multiple bypasses and having variable cycle capability are being developed for improved speed and power. One particular application is for aircraft-like vehicles for space-launch operations. Such gas turbine engines are designed to accelerate the vehicle to high flight mach numbers (Mach 4+) at which point scramjet propulsion systems take over. It is highly desirable have a gas turbine engine that meets the broad range of operating conditions for such an application. The fan has to operate at a high fan pressure ratio at take-off and be windmilled at high flight mach numbers.

It is desirable to reduce frontal area of the engine, reduce weight of the engine, and minimize or eliminate airflow interruption going into the fan. The fan has to operate at a high fan pressure ratio at take-off. It is under these conditions where fan rotor and outlet guide vanes (OGVs) are most heavily loaded aerodynamically. An engine and fan section are needed to operate and operate efficiently at these conditions so as to be able to pass a required airflow through the fan stage into a ramburner to create the required thrust. For take-off operating conditions, the fan OGV has to be designed with high solidity and high loading, while at high flight mach numbers, the fan has to be windmilled. These two requirements have conflicting fan OGV designs. This approach results in an OGV design that at the high flight Mach numbers causes the OGV to operate choked which limits the amount of flow to the ramburner and hence lowers the amount of thrust that can be produced.

Thus, it is highly desirable to have a gas turbine engine that can operate from take-off to high mach number conditions including in ramburner mode without choking the OGV and being able to windmill the fan in ramburner mode and yet minimize weight, fan inlet frontal area, and fan inlet airflow interruption.

SUMMARY OF THE INVENTION

A turbofan gas turbine engine includes a forward fan section with at least one row of circumferentially spaced apart longitudinally forward fan rotor blades and a core engine located aft and downstream of the forward fan section. The core engine includes in downstream serial flow relationship a core compressor, a core combustor, and a high pressure turbine drivingly connected to the core compressor by a core engine shaft. A fan bypass duct located downstream of the forward fan section is disposed radially outwardly of the core engine. The forward fan section has only a single stage of variable fan guide vanes and the fan guide vanes are variable fan outlet guide vanes located downstream or aft of and adjacent to the forward fan rotor blades.

An exemplary embodiment of the turbofan gas turbine engine includes an exhaust duct downstream of and in fluid communication with the fan bypass duct and a low pressure turbine located aft and downstream of the core engine and

drivingly connected to the forward fan rotor blades by a low pressure shaft. An exhaust nozzle is disposed at a downstream end of the exhaust duct and an afterburner is disposed in the exhaust duct between the low pressure turbine and the exhaust nozzle. Struts may extend radially across a radially inwardly curved portion of a transition section of a flowpath of the engine extending axially between the forward fan section and the core engine. A forward variable area bypass injector may be located at an inlet to the fan bypass duct and a rear variable area bypass injector may be located at a fan bypass duct outlet from the fan bypass duct. The variable fan outlet guide vanes may be operable to pivot from a nominal OGV position at take-off to an open OGV position at a high flight Mach Number and the high flight Mach Number may be in a range of between about 2.5-4+. Applications are contemplated where the range may extend up to about a flight Mach Number equal to 4.9.

Another exemplary embodiment of the turbofan gas turbine engine has two inlets to the fan bypass duct, radially outer and inner inlets. An inner inlet duct extends from the inner inlet to the fan bypass duct and a supercharger is disposed in the inlet duct. The supercharger may include radially outwardly extending blade tips of rotor blades of the core driven fan.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and other features of the invention are explained in the following description, taken in connection with the accompanying drawings where:

FIG. **1** is a schematical cross-sectional view illustration of a aircraft variable cycle gas turbine engine with no fan inlet guide vane and a variable fan outlet guide vane.

FIG. **2** is a more detailed cross-sectional view illustration of a fan section in the engine illustrated in FIG. **1**.

FIG. **3** is a schematical cross-sectional view illustration taken through the variable fan outlet guide vane illustrated in FIG. **2** illustrating nominal and open positions of the variable outlet guide vanes.

FIG. **4** is a graphical illustration of an exemplary operation of the variable fan outlet guide vane illustrated in FIG. **3**.

FIG. **5** is an illustration of a first alternative embodiment of the variable fan outlet guide vane having a pivotal forward section with a trailing edge designed to seal flush against a leading edge of a fixed aft section of the variable fan outlet guide vane.

FIG. **6** is an illustration of a second alternative embodiment of the variable fan outlet guide vane having a gap between a trailing edge of a pivotal forward section and a leading edge of a fixed aft section of the variable fan outlet guide vane.

DETAILED DESCRIPTION OF THE INVENTION

Illustrated in FIG. **1** is an exemplary turbofan gas turbine engine **10** capable of operating in a fanjet, turbojet, and ramjet modes, or cycles from take-off up through about Mach 4 or higher (4+). Applications are contemplated where the range may extend up to about a flight Mach Number equal to 4.9. Disposed about a longitudinally extending axis or centerline **12** of the engine **10** is a forward fan section **33** and further downstream a core engine **18** (also called a gas generator). The core engine **18** includes, in a serial downstream axial flow relationship, an aft or core driven fan (CDF) **19**, a high pressure compressor **20**, a core combustor **22**, and a high pressure turbine (HPT) **23** having a row of high pressure turbine blades **24**. High pressure compressor blades **64** of the high pressure compressor **20** and the CDF **19** are fixedly interconnected in driving engagement to the high pressure turbine blades **24** by a larger diameter annular core engine shaft **26** which is disposed coaxially about the centerline **12** of the engine **10** forming a high pressure spool.

Pressurized air from the high pressure compressor **20** is mixed with fuel in the combustor **22** and ignited, thereby, generating combustion gases. Some work is extracted from these gases by the high pressure turbine blades **24** which drives the high pressure compressor **20**. The combustion gases are discharged from the core engine **18** into a low pressure turbine (LPT) **27** having a row of low pressure turbine rotor blades **28**. The low pressure turbine rotor blades **28** are fixedly attached to a smaller diameter annular low pressure shaft **30** disposed coaxially about the centerline **12** of the engine **10** within the core engine shaft **26** and drivingly attached to a row of circumferentially spaced apart longitudinally forward fan rotor blades **32** of the forward fan section **33**, thus, forming a low pressure spool.

The forward fan section **33** has only a single stage **200** of variable fan outlet guide vanes **35** extending radially across a flowpath **29** of the engine **10**. The single stage of variable fan outlet guide vanes **35** is located downstream or aft of and adjacent to the forward fan rotor blades **32** and they are the only guide vanes in forward fan section **33**. The term "adjacent" is used herein, for the purposes of this patent, to mean that there are no other rotor blade rows and/or stator vane rows between the named adjacent elements (i.e., between the forward row of fan rotor blades **32** and the variable fan outlet guide vanes **35**). There are no inlet guide vanes at all, neither fixed or variable, which is large weight savings for the engine.

The engine **10** is operable to accelerate a vehicle to high flight mach numbers (Mach 4+) at which point scramjet propulsion systems take over. In order for the engine to effectively meet the broad range of operating conditions for such an application, the forward fan section **33** has to operate at a high fan pressure ratio at take-off and be windmilled at high flight mach numbers. The single guide vane stage forward fan section **33** with only a single row or stage of variable fan outlet guide vanes **35** provides this capability.

The core engine shaft **26** also rotates a longitudinally aft row of circumferentially spaced apart core driven or aft fan rotor blades **36** having generally radially outwardly extending blade tips **38**. The aft fan rotor blades **36** are disposed longitudinally aft of the more longitudinally forward row of forward fan rotor blades **32**. A row of circumferentially spaced-apart aft fan stator vanes **34** is disposed longitudinally between the rows of the forward and aft fan rotor blades **32** and **36**, respectively, and longitudinally adjacent and in direct serial flow relationship with the row of the aft fan rotor blades **36**.

A fan bypass duct **40** radially located between an engine inner casing **74** and an engine outer casing **82** has a radially outer inlet **42** disposed longitudinally between the forward fan section **33** and the aft or core driven fan **19**. The outer inlet **42** includes a forward variable area bypass injector (VABI) exemplified by selector valve doors **44**. A radially inner inlet **46** to the fan bypass duct **40** is disposed longitudinally between the forward fan section **33** and the aft or core driven fan **19** and radially inwardly of the outer inlet **42**. An annular radially outer flow splitter **53** disposed between the radially outer and inner inlets **42** and **46**. The radially outer and inner inlets **42** and **46** provide two parallel bypass flowpaths, separated by the outer flow splitter **53**, into the fan bypass duct **40** from the forward fan. An inner inlet duct **43** extends from the inner inlet **46** to an inner inlet duct outlet **47** to the fan bypass duct **40** placing the inner inlet **46** in fluid communication with the fan bypass duct **40**. The inner inlet **46** includes an annular duct wall **45** with a radially inner flow splitter **48**.

The annular duct wall **45** includes a rotatable portion **108** or a shroud that is disposed radially between radially outer blade tip portions **107** and radially inner blade hub portions **109**, respectively, of blade airfoils **37** of the aft fan rotor blades **36**. The blade airfoil **37** extends from a blade base **41** to the blade tip **38** and the rotatable portion **108** is located at a location along a span S of the airfoil near the blade tip. The annular duct wall **45** also includes a non-rotatable portion **106** that is disposed between radially outer variable angle vanes **84** and radially inner variable angle vanes **86** which at least in part form the aft fan stator vanes **34**. A fan bypass duct outlet **51** is disposed longitudinally aft and downstream of the outer and inner inlets **42** and **46** and includes a rear variable area bypass injector (VABI) exemplified by rear doors **49**.

The engine or fan airflow **50** passes through the forward row of fan blades **32** and is then split into a core airflow portion **60** and bypass flow **54** by the radially inner flow splitter **48** at a forward end of the non-rotatable portion **106** supported by struts **31** extending radially across the flowpath **29**. The bypass flow **54** includes a radially outer bypass airflow portion **52** which passes through the outer inlet **42** of the fan bypass duct **40** and a radially inner bypass airflow portion **56** which passes through the inner inlet **46** of the fan bypass duct **40**, depending on the engine's operation. The blade tip **38** functions as a supercharger **57** that supercharges or further compresses the inner bypass airflow portion **56** of the bypass flow **54** which passes through the radially inner inlet **46** to the fan bypass duct **40**. At high power, the outer bypass airflow portion **52** is substantially zero and the inner bypass airflow portion **56** is at or near maximum. At part power as the inner bypass airflow portion **56** is decreased and the outer bypass airflow portion **52** increases in more or less direct proportion. When the front selector valve door **44** is closed, the fan airflow **50** is split between the core airflow portion **60** passing through the row of aft fan stator vanes **34** and the more aft row of fan blades **36** and the inner bypass airflow portion **56**. Note that the supercharger **57** disclosed herein is driven by the high pressure turbine **23** of the core engine **18** and that other superchargers in the radially inner inlet **46** to the fan bypass duct **40** driven by a low pressure turbine have been disclosed.

The inner bypass airflow portion **56** passes through the inner inlet **46** and past the outer variable angle vanes **84** and the blade tip portions **107** together which provide a supercharger means for compressing the inner bypass airflow portion **56** in the inner inlet duct **43**. The blade tip portions **107** compress or supercharge the inner bypass airflow portion **56**, and the outer variable angle vanes **84** provide control together, thus, providing variable and controllable supercharging of the inner bypass airflow portion **56**, which under certain operating conditions, may be essentially all of the bypass flow passing around the core engine **18** through the fan bypass duct **40** when the selector valve door **44** is in a fully closed position. A row of bypass stator vanes **58** are disposed in the inner inlet duct **43** to deswirl the inner bypass airflow portion **56** in the inner inlet duct **43** before the inner bypass airflow portion **56** is discharged into the fan bypass duct **40** to mix with the outer bypass airflow portion **52**.

The core airflow portion **60**, in serial flow, passes through the high pressure compressor stator vanes **62** and the high pressure compressor blades **64** of the high pressure compressor **20**; the combustor **22**; the row of high pressure turbine blades **24**; a row of low pressure turbine stator vanes **66**; and the row of low pressure turbine blades **28**. The core airflow portion **60** is discharged from the low pressure turbine **27** past the low pressure turbine rotor blades **28** between the engine inner casing **74** and a centerbody **72** at which point it is referred to as a core discharge airflow **70**. A total bypass airflow **78** including the outer and inner bypass airflow portions **52** and **56** combined flows through the fan bypass duct **40** to the VABI rear doors **49**. During turbofan and ram operation of the engine **10**, most of the total bypass airflow **78** is injected through the rear VABI into an upstream end **71** of an exhaust duct **69** as bypass discharge flow **80** and is mixed with the core discharge airflow **70**.

An afterburner **130** is located aft and downstream of the core engine **18** in the vicinity of the upstream end **71** of the exhaust duct **69** and is operable to provide fuel for combustion with the mixed core discharge airflow **70** and the bypass discharge flow **80** in the exhaust duct **69** during thrust augmentation and ram mode operation of the engine **10**. The afterburner **130** provides virtually all of the fuel and ignition for combustion in the ram operating mode of the engine **10**. A variable throat area A**8** exhaust nozzle **68** is located downstream of the afterburner **130** at a downstream end **73** of the exhaust duct **69**.

Referring to FIG. **2**, the flowpath **29** is annular and has a transition section **129** extending axially between the forward fan section **33** and the core engine **18**. A portion **131** of the transition section **129** is radially inwardly curved in the axially aftwardly or downstream direction. The transition section **129** is sometimes referred to as a gooseneck. The struts **31** extend radially across the radially inwardly curved portion **131** of the transition section **129** of the flowpath **29**. The variable fan outlet guide vanes **35** are operable to pivot as illustrated by nominal and open OGV positions as illustrated in FIG. **3**.

The nominal OGV position is denoted by a solid line and the open OGV position is denoted by a broken line in FIG. **3**. The nominal OGV position is chosen to provide about 5 degrees of swirl coming out of the variable fan outlet guide vanes **35** which reduces loading of the variable fan outlet guide vanes **35**. The variable fan outlet guide vanes **35** have high solidity for better operability at take-off. The open OGV position is chosen to avoid choking of the variable fan outlet guide vanes **35** at high flight Mach Numbers which would limit the amount of airflow to a ram burner, illustrated herein as a afterburner **130** in FIG. **1** and, hence, lower the amount of thrust that can be produced.

The variable fan outlet guide vanes **35** are designed to pivot 10 degrees between the nominal and open OGV positions to accommodate first and second swirl angles A**1** and A**2**, respectively, as illustrated in FIG. **4**. The first and second swirl angles A**1** and A**2** are angles between the centerline **12** and flow vectors V**1** and V**2** at leading edges LE of the variable fan outlet guide vanes **35**. In the exemplary embodiment illustrated herein, the first and second swirl angles A**1** and A**2** are 51 degrees and 24 degrees respectively at 40% span of the variable fan outlet guide vanes **35** at take-off and flight Mach Number equal to 3.3. For a particular design, the variable fan outlet guide vanes **35** are set at the nominal setting which is designated at 0 degrees and then reset at vehicle flight mach number equal to about 2.9 to the open setting which is a change of −10 degrees as illustrated in FIG. **4**. The nominal and open OGV positions are designed to produce about + and −5 degrees of swirl respectively coming out of the variable fan outlet guide vanes **35** to ensure axial struts **31** downstream in the gooseneck or transition section **129** do not stall due to incidence effects.

Each of the variable fan outlet guide vanes **35** illustrated in FIGS. **1** and **2** pivot in its entirety between the nominal and open OGV positions. Two alternative embodiments of the variable fan outlet guide vanes **35** are illustrated in FIGS. **5** and **6** in cross-section at the 40% span of the variable fan outlet guide vanes **35**. Each of these variable fan outlet guide vanes **35** has a pivotal forward section **110** and a fixed aft section **112**. The nominal and the open OGV positions of the variable fan outlet guide vanes **35** are denoted by solid and broken lines respectively in FIGS. **5** and **6**. A trailing edge TE of the pivotal forward section **110** is designed to seal flush against a leading edge LE of the fixed aft section **112** so that no leakage can get through in the embodiment of the variable fan outlet guide vanes **35** illustrated in FIG. **5**.

A gap **114** is between the trailing edge TE of the pivotal forward section **110** and the leading edge LE of the fixed aft section **112** in the embodiment of the variable fan outlet guide vanes **35** illustrated in FIG. **6**. When the pivotal forward section **110** is closed, the nominal OGV position of the variable fan outlet guide vanes **35** denoted by a solid line, the forward and aft sections **110** and **112**, respectively, do not come together and a wake off the pivotal forward section **110** is directed slightly below on a pressure side **116** of the aft section **112**. When the pivotal forward section **110** is opened, the open OGV position of the variable fan outlet guide vanes **35** denoted by a broken line, the forward and aft sections **110** and **112**, respectively, are further apart, the gap **114** is larger and the wake off the pivotal forward section **110** is directed further away below and downstream on the pressure side **116** of the aft section **112**.

While there have been described herein what are considered to be preferred and exemplary embodiments of the present invention, other modifications of the invention shall be apparent to those skilled in the art from the teachings herein and, it is therefore, desired to be secured in the appended claims all such modifications as fall within the true spirit and scope of the invention.

Accordingly, what is desired to be secured by Letters Patent of the United States is the invention as defined and differentiated in the following claims.

What is claimed is:

1. A turbofan gas turbine engine comprising:

a forward fan section including at least one row of circumferentially spaced apart longitudinally forward fan rotor blades;

a core engine located aft and downstream of the forward fan section and including in downstream serial flow relationship a core compressor, a core combustor, and a high pressure turbine drivingly connected to the core compressor by a core engine shaft;

a fan bypass duct located downstream of the forward fan section and disposed radially outwardly of the core engine;

the forward fan section located axially forward and upstream of a radially outer inlet of the fan bypass duct;

an exhaust duct downstream of and in fluid communication with the core engine;

a fan bypass duct outlet from the fan bypass duct to the exhaust duct downstream of the core engine; and

the forward fan section having only a single stage of fan guide vanes and the fan guide vanes being variable fan outlet guide vanes located downstream of and adjacent to the forward fan rotor blades, for adjusting the flow into the fan duct.

2. A turbofan gas turbine engine as claimed in claim **1** further comprising:

a low pressure turbine located aft and downstream of the core engine and drivingly connected to the forward fan rotor blades by a low pressure shaft,

an exhaust nozzle disposed at a downstream end of the exhaust duct, and an afterburner disposed in the exhaust duct between the low pressure turbine and the exhaust nozzle.

3. A turbofan gas turbine engine as claimed in claim **2** further comprising:

a flowpath of the engine,

a transition section of the flowpath extending axially between the forward fan section and the core engine, and

struts extending radially across a radially inwardly curved portion of the transition section.

4. A turbofan gas turbine engine as claimed in claim **3** further comprising a forward variable area bypass injector at an inlet to the fan bypass duct and a rear variable area bypass injector at the fan bypass duct outlet from the fan bypass duct.

5. A turbofan gas turbine engine as claimed in claim **4** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

6. A turbofan gas turbine engine as claimed in claim **5** wherein the high flight Mach Number is in a range of between about 2.5-4.9.

7. A turbofan gas turbine engine as claimed in claim **2** further comprising a forward variable area bypass injector at an inlet to the fan bypass duct and a rear variable area bypass injector at a fan bypass duct outlet from the fan bypass duct.

8. A turbofan gas turbine engine as claimed in claim **7** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

9. A turbofan gas turbine engine as claimed in claim **8** wherein the high flight Mach Number is in a range of between about 2.5-4.9.

10. A turbofan gas turbine engine as claimed in claim **2** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

11. A turbofan gas turbine engine as claimed in claim **1** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

12. A turbofan gas turbine engine as claimed in claim **11** wherein the high flight Mach Number is in a range of between about 2.5-4.9.

13. A turbofan gas turbine engine as claimed in claim **1** further comprising each of the variable fan outlet guide vanes having a pivotal forward section and a fixed aft section.

14. A turbofan gas turbine engine as claimed in claim **13** further comprising:

an exhaust duct downstream of and in fluid communication with the fan bypass duct and a low pressure turbine located aft and downstream of the core engine and drivingly connected to the forward fan rotor blades by a low pressure shaft,

an exhaust nozzle disposed at a downstream end of the exhaust duct, and

an afterburner disposed in the exhaust duct between the low pressure turbine and the exhaust nozzle.

15. A turbofan gas turbine engine as claimed in claim **14** further comprising:

a flowpath of the engine,

a transition section of the flowpath extending axially between the forward fan section and the core engine, and

struts extending radially across a radially inwardly curved portion of the transition section.

16. A turbofan gas turbine engine as claimed in claim **15** further comprising a forward variable area bypass injector at an inlet to the fan bypass duct and a rear variable area bypass injector at a fan bypass duct outlet from the fan bypass duct.

17. A turbofan gas turbine engine as claimed in claim **16** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

18. A turbofan gas turbine engine as claimed in claim **17** wherein the high flight Mach Number is in a range of between about 2.5-4.9.

19. A turbofan gas turbine engine comprising:

a forward fan section including at least one row of circumferentially spaced apart longitudinally forward fan rotor blades;

a core engine located aft and downstream of the forward fan section and comprising in downstream serial flow relationship an aft core driven fan, a compressor, a core combustor, and a high pressure turbine drivingly connected to the core driven fan and the core compressor by a core engine shaft;

a low pressure turbine located aft and downstream of the core engine and drivingly connected to the forward fan rotor blades by a low pressure shaft;

a fan bypass duct downstream of the forward fan section and disposed radially outwardly of the core engine;

the forward fan section located axially forward and upstream of a radially outer inlet of the fan bypass duct;

an exhaust duct downstream of and in fluid communication with the fan bypass duct and the low pressure turbine;

the fan bypass duct including radially outer and inner inlets from the forward fan section to the fan bypass duct;

an inner inlet duct extending from the inner inlet to the fan bypass duct and having a supercharger disposed in the inlet duct; and

the forward fan section having only a single stage of fan guide vanes and the fan guide vanes being variable fan outlet guide vanes located downstream of and adjacent to the forward fan rotor blades and axially between the forward fan rotor blades and the fan bypass duct for adjusting the flow into the fan duct.

20. A turbofan gas turbine engine as claimed in claim **19** further comprising an exhaust nozzle disposed at a downstream end of the exhaust duct and an afterburner disposed in the exhaust duct between the low pressure turbine and the exhaust nozzle.

21. A turbofan gas turbine engine as claimed in claim **20** further comprising:

a flowpath of the engine,

a transition section of the flowpath extending axially between the forward fan section and the core engine, and

struts extending radially across a radially inwardly curved portion of the transition section.

22. A turbofan gas turbine engine as claimed in claim **21** further comprising a forward variable area bypass injector at an inlet to the fan bypass duct and a rear variable area bypass injector at a fan bypass duct outlet from the fan bypass duct.

23. A turbofan gas turbine engine as claimed in claim **22** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

24. A turbofan gas turbine engine as claimed in claim **23** wherein the high flight Mach Number is in a range of between about 2.5-4.9.

25. A turbofan gas turbine engine as claimed in claim **20** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

26. A turbofan gas turbine engine as claimed in claim **19** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

27. A turbofan gas turbine engine as claimed in claim **26** wherein the high flight Mach Number is in a range of between about 2.5-4.9.

28. A turbofan gas turbine engine as claimed in claim **20** wherein the supercharger includes radially outwardly extending blade tips of rotor blades of the core driven fan.

29. A turbofan gas turbine engine as claimed in claim **28** further comprising:

a flowpath of the engine,

a transition section of the flowpath extending axially between the forward fan section and the core engine, and

struts extending radially across a radially inwardly curved portion of the transition section.

30. A turbofan gas turbine engine as claimed in claim **29** further comprising a forward variable area bypass injector at an inlet to the fan bypass duct and a rear variable area bypass injector at a fan bypass duct outlet from the fan bypass duct.

31. A turbofan gas turbine engine as claimed in claim **30** further comprising the variable fan outlet guide vanes being operable to pivot from a nominal outlet guide vane position at take-off to an open outlet guide vane position at a high flight Mach Number.

32. A turbofan gas turbine engine as claimed in claim **31** wherein the high flight Mach Number is in a range of between about 2.5-4.9.

33. A turbofan gas turbine engine as claimed in claim **32** further comprising each of the variable fan outlet guide vanes having a pivotal forward section and a fixed aft section.

* * * * *