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(54) **AXIAL FLOW POSITIVE DISPLACEMENT WORM COMPRESSOR**

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(22) Filed: **Feb. 2, 2006**

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(51) **Int. Cl.**
F02C 3/055 (2006.01)

(52) **U.S. Cl.** **60/39.45**; 418/48

(58) **Field of Classification Search** 60/39.45; 123/241, 249; 418/48, 51
See application file for complete search history.

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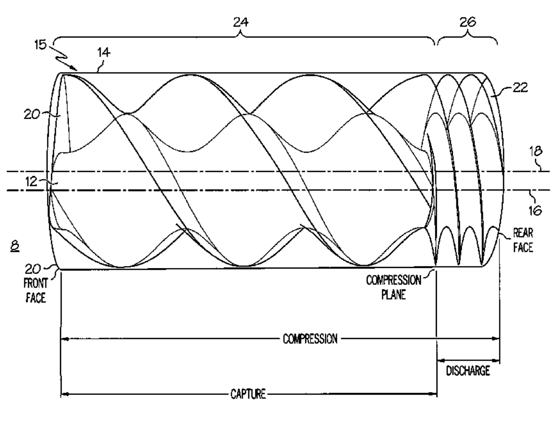
(57) **ABSTRACT**

An axial flow positive displacement compressor has an inlet axially spaced apart and upstream from an outlet. Inner and outer bodies have offset inner and outer axes extend from the inlet to the outlet through first and second sections of a compressor assembly in serial downstream flow relationship. At least one of the bodies is rotatable about its axis. The inner and outer bodies have intermeshed inner and outer helical blades wound about the inner and outer axes respectively. The inner and outer helical blades extend radially outwardly and inwardly respectively. The helical blades have first and second twist slopes in the first and second sections respectively. The first twist slopes are less than the second twist slopes. An engine including the compressor has in downstream serial flow relationship from the compressor a combustor and a high pressure turbine drivingly connected to the compressor by a high pressure shaft.

51 Claims, 9 Drawing Sheets



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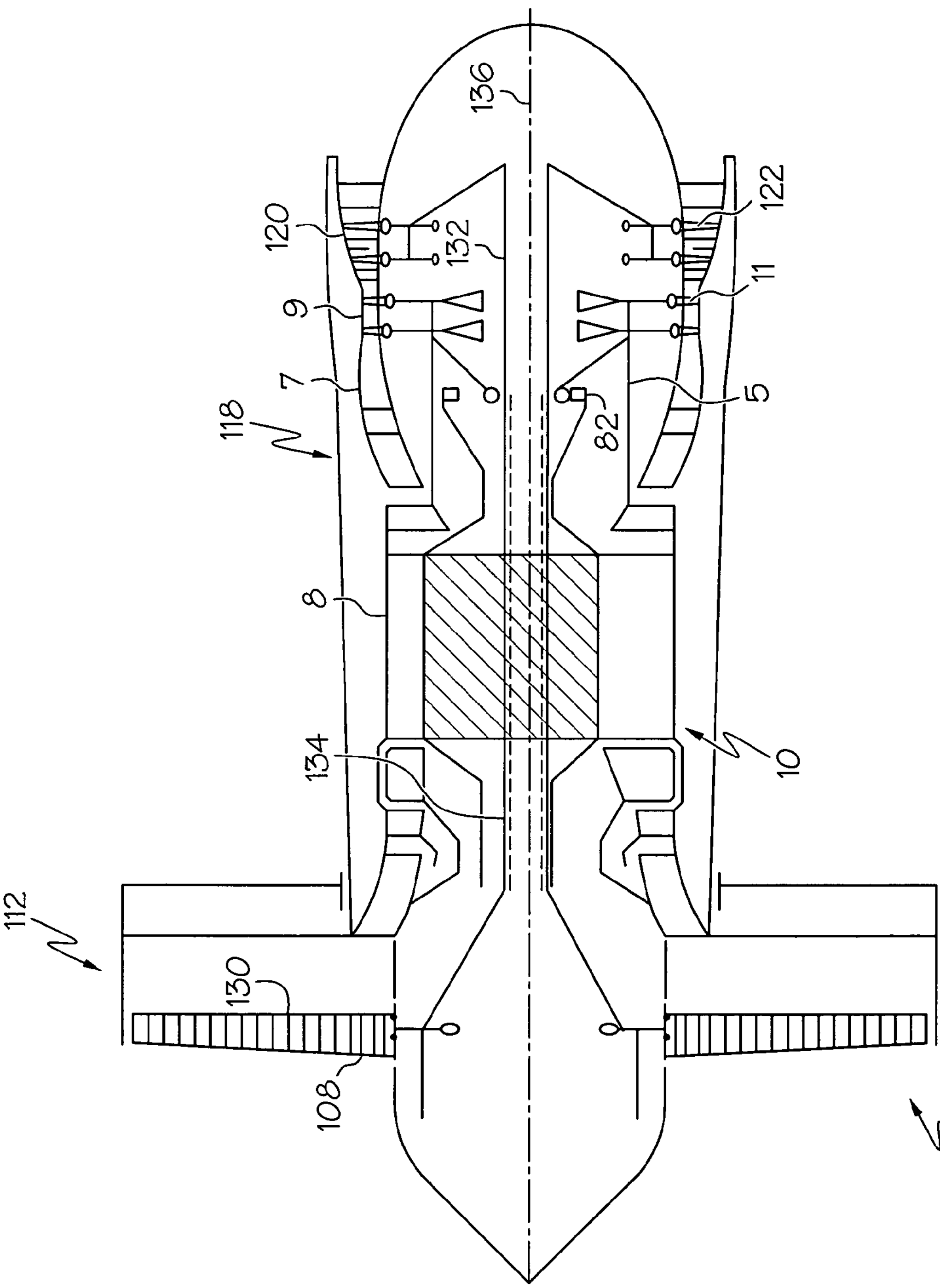


FIG. 1

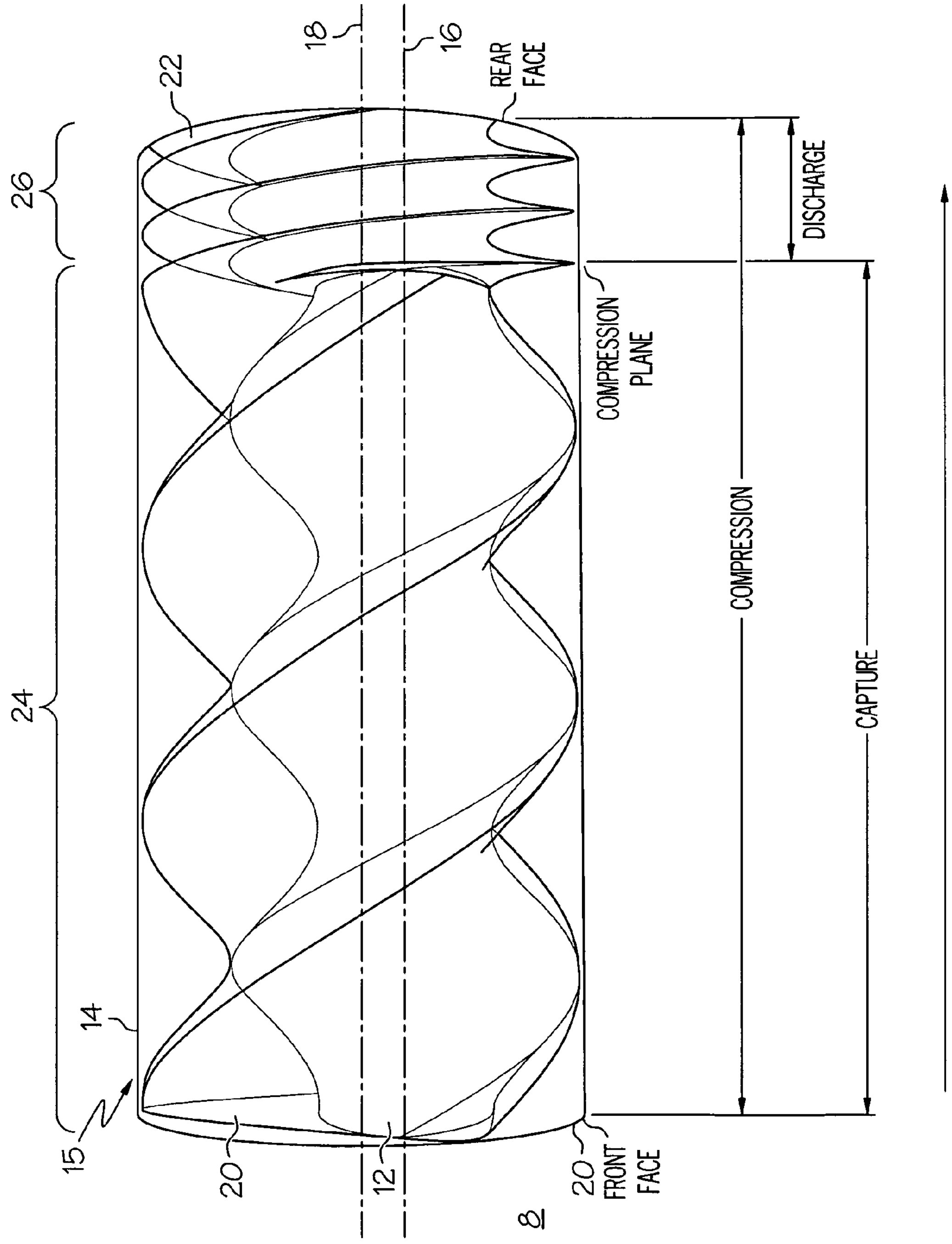

26
24
22
18
16
REAR FACE
DISCHARGE
COMPRESSION PLANE
COMPRESSION
CAPTURE
14
15
20
12
20
FRONT FACE
8

FIG. 2

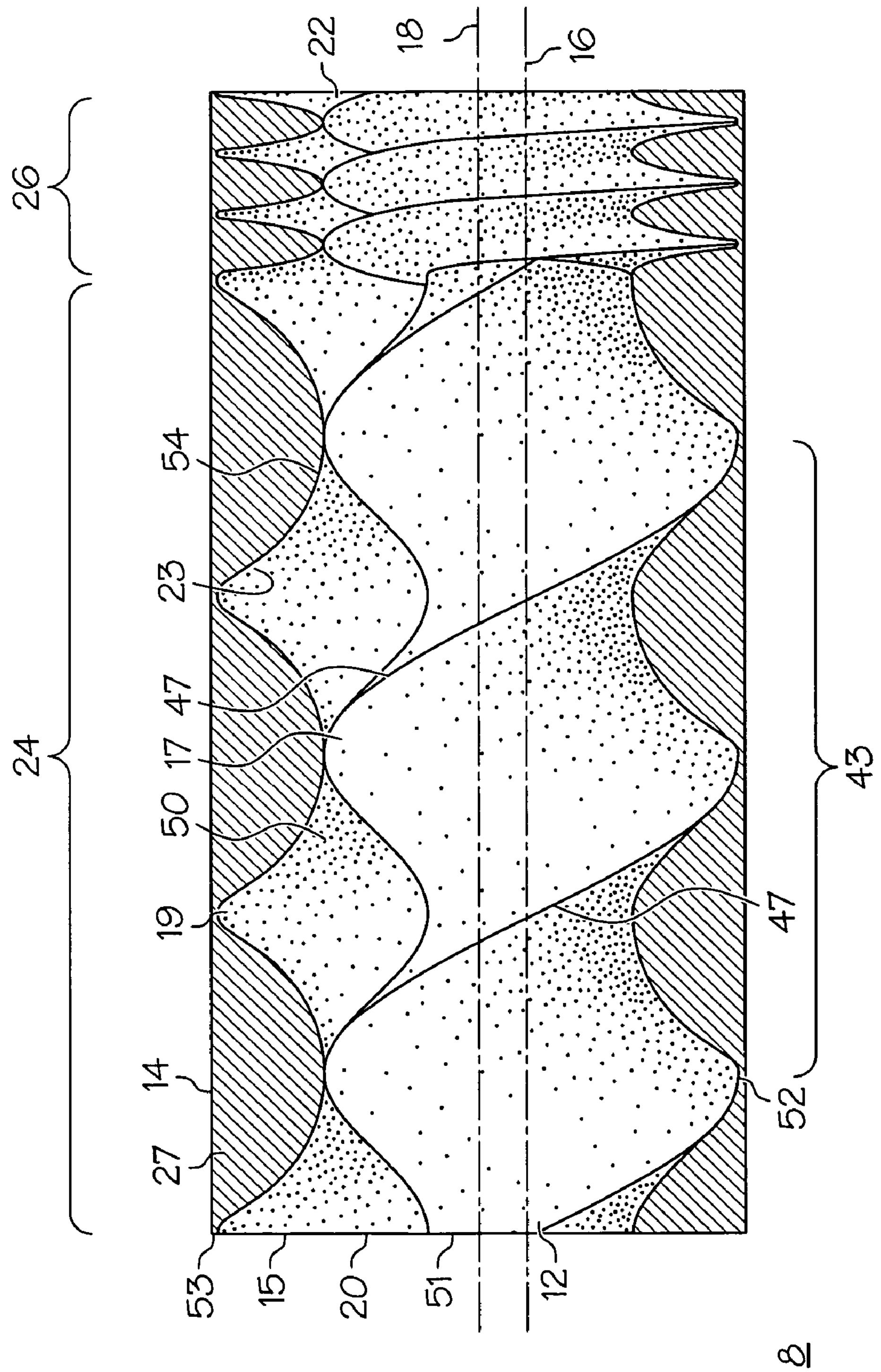
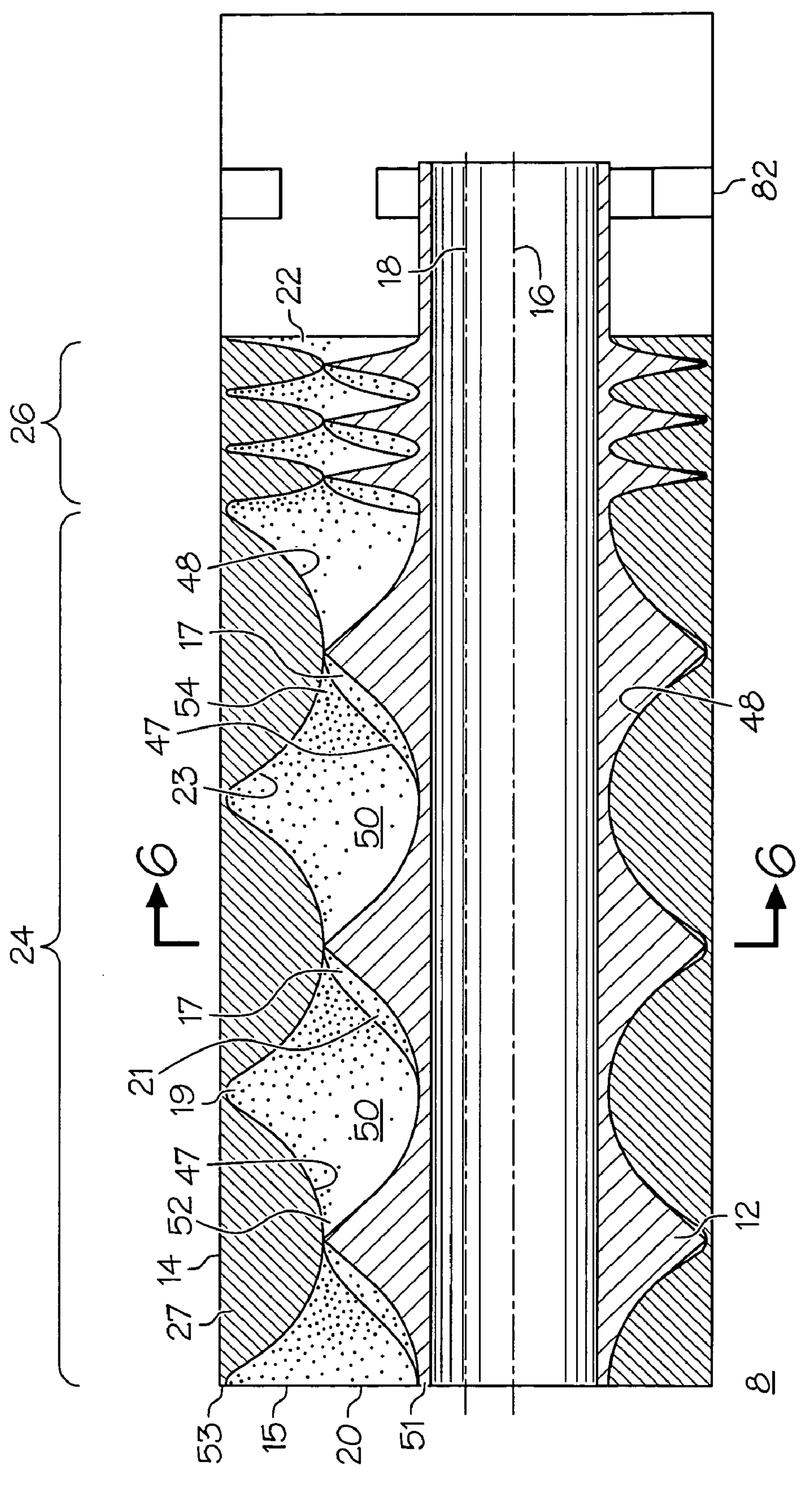


FIG. 3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53
15
20
51
8

FIG. 4

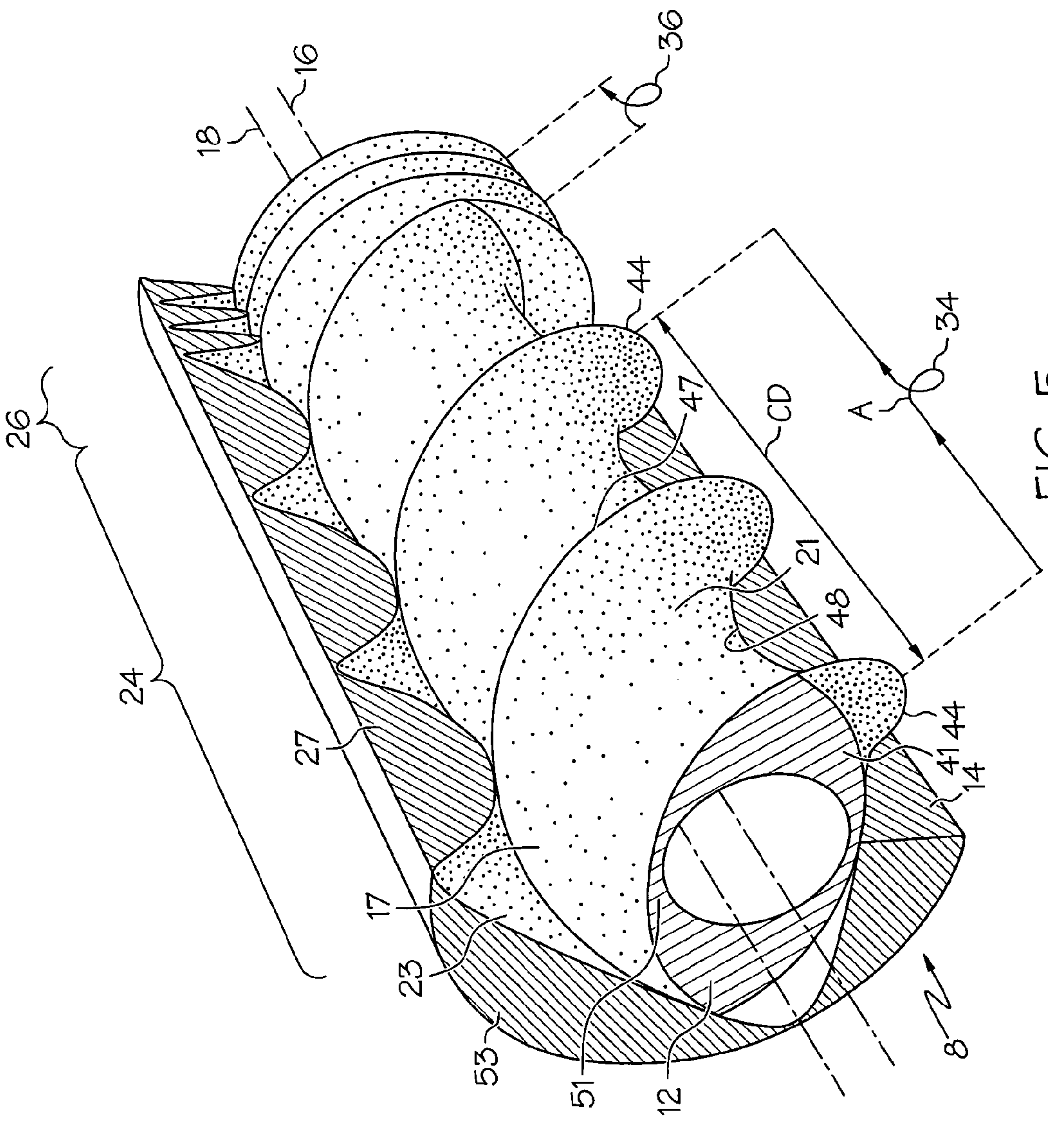

FIG. 5

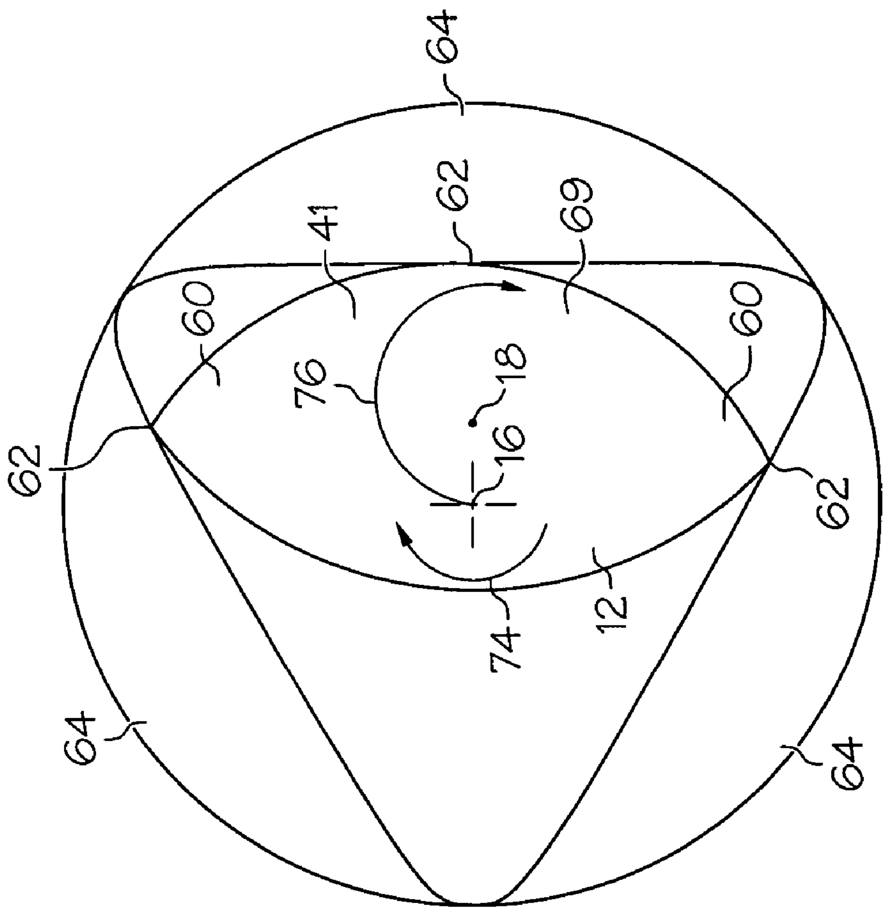

FIG. 6

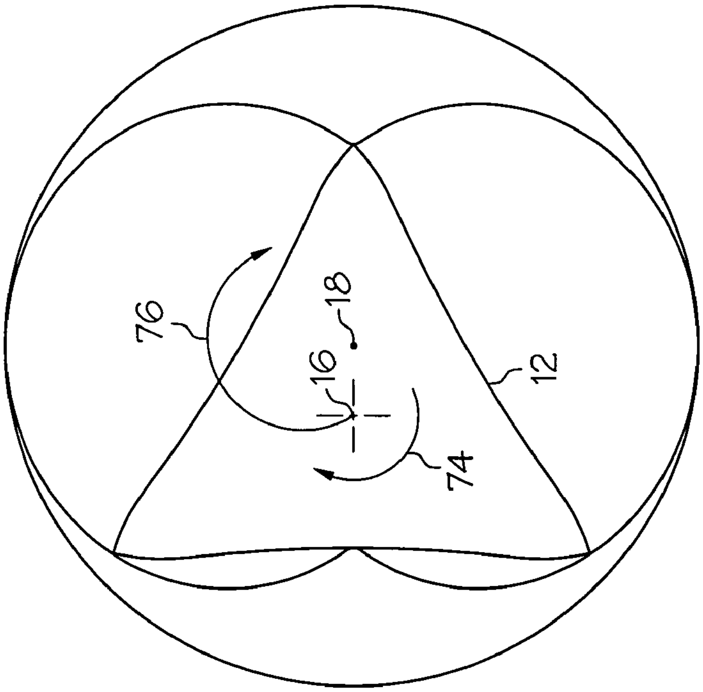

FIG. 8

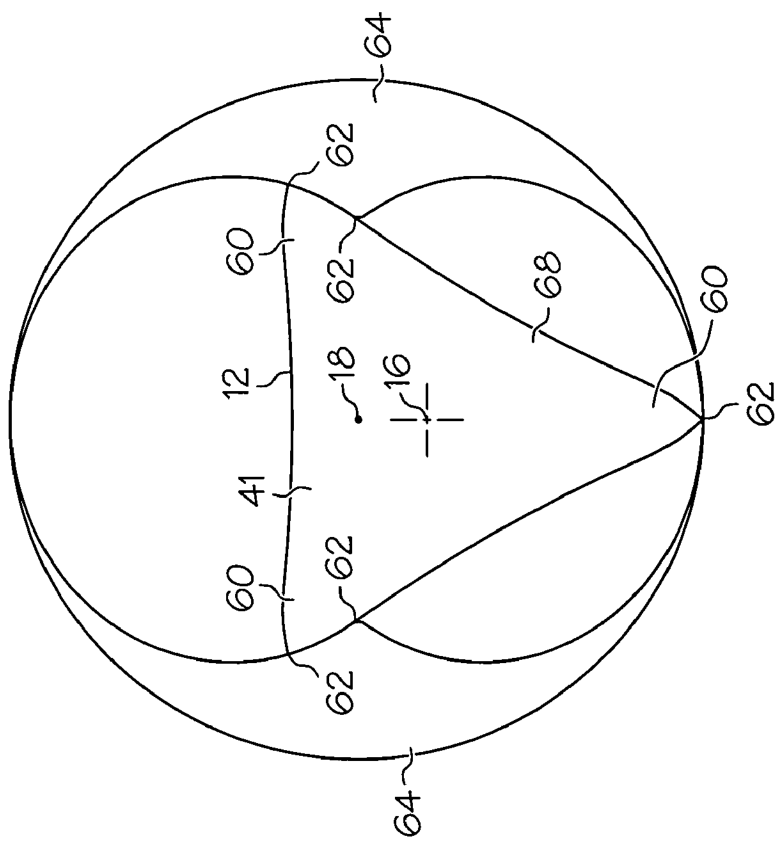

FIG. 7

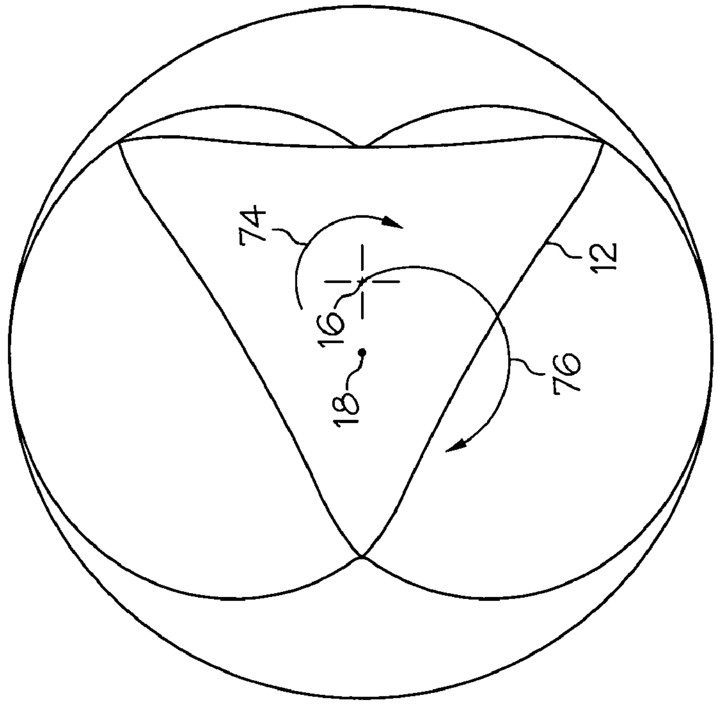

FIG. 10

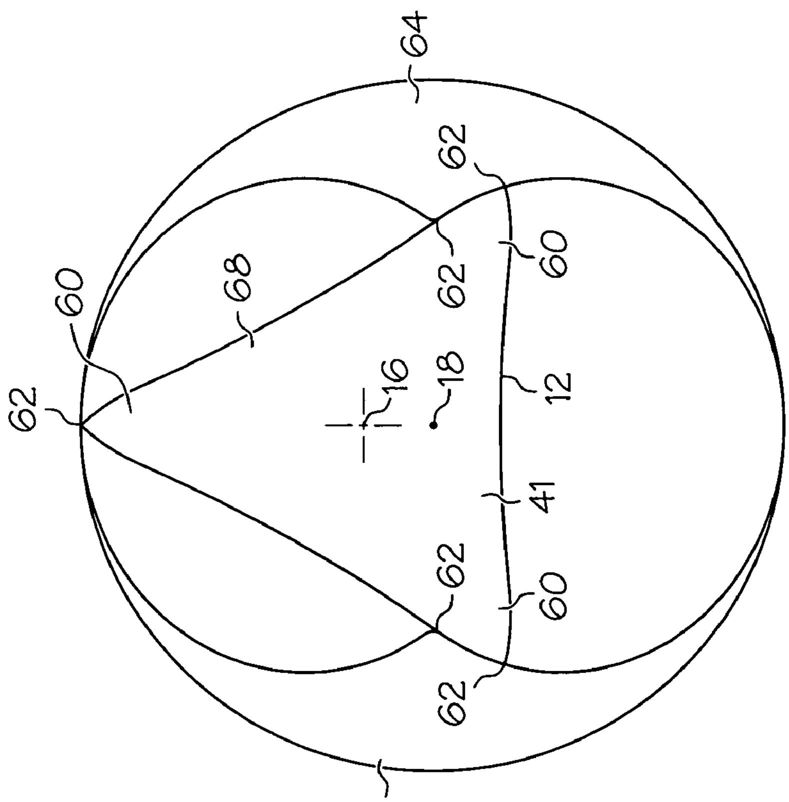

FIG. 9

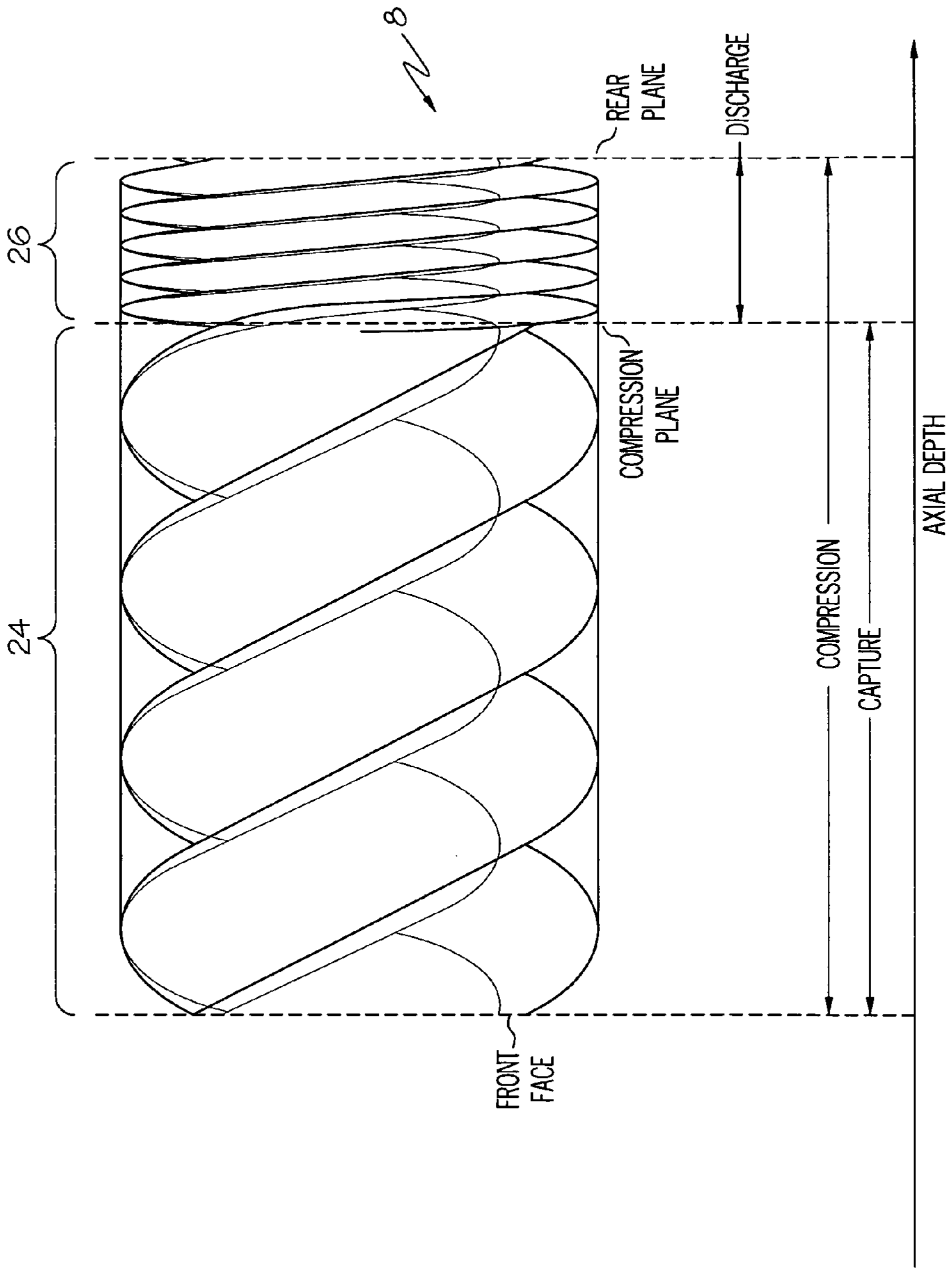
8
26
24
REAR PLANE
DISCHARGE
COMPRESSION PLANE
COMPRESSION
CAPTURE
AXIAL DEPTH
FRONT FACE

FIG. 11

AXIAL FLOW POSITIVE DISPLACEMENT WORM COMPRESSOR

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

The present invention relates generally to continuous axial flow compressors and, more particularly, to axial flow positive displacement compressors and worm and screw compressors.

Compressors are widely used in many applications such as in gas generators in gas turbine engines. Continuous axial flow compressors are utilized in a wide range of applications owing to a combination of desirable attributes such as high mass flow rate for a given frontal area, continuous near steady fluid flow, reasonable adiabatic efficiency, and the ability to operate free from aerodynamic stall and aeromechanical instability over a wide range of conditions. It is a goal of compressor and gas turbine manufacturers to have lightweight, compact, and highly efficient axial flow compressors. It is another goal to have as few parts as possible in the compressor to reduce the costs of manufacturing, installing, refurbishing, overhauling, and replacing the compressor. Therefore, it is desirable to have a compressor that improves on all of these characteristics.

BRIEF DESCRIPTION OF THE INVENTION

A continuous axial flow positive displacement compressor also referred to as a worm compressor includes an inlet axially spaced apart and upstream from an outlet. The worm compressor includes a compressor assembly including inner and outer bodies extending from the inlet to the outlet. The inner and outer bodies have offset inner and outer axes, respectively. The compressor assembly has first and second sections in serial downstream flow relationship. Either or both bodies may be rotatable. In one embodiment of the compressor, the inner body is rotatable about the inner axis within the outer body. The outer body may be rotatably fixed or rotatable about the outer axis. The inner and outer bodies have intermeshed inner and outer helical blades wound about inner and outer axes, respectively. The inner and outer helical blades extend radially outwardly and inwardly, respectively.

The helical blades have first and second twist slopes in the first and second sections of the compressor assembly, respectively. A twist slope is defined as the amount of rotation of a cross-section of the helical element per unit distance along an axis. The first twist slopes are less than the second twist slopes. The helical blades in the first section have a sufficient number of turns to trap charges of gas in the first section during the compressor's operation. In one embodiment of the compressor, the number of turns is sufficient to mechanically trap the charges of gas. In another embodiment of the compressor, the number of turns is sufficient to dynamically trap the charges of gas. The helical blades in the second section have a sufficient number of turns to ensure that the leading edge of the charge is not exposed to the conditions downstream of the compressor until the trailing edge of the charge has crossed the compression plane, thereby completing the compression process.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view illustration of an exemplary aircraft gas turbine engine with a positive displacement continuous axial flow compressor.

FIG. **2** is a diagrammatic cross-sectional view illustration of the compressor illustrated in FIG. **1**.

FIG. **3** is a diagrammatic partially cut-away perspective view illustration of helical blade portions of inner and outer bodies of the compressor illustrated in FIG. **2**.

FIG. **4** is a diagrammatic cross-sectional view illustration of gearing between inner and outer bodies of the compressor illustrated in FIG. **3**.

FIG. **5** is a diagrammatic cut-away perspective view illustration of the helical blade portions of the inner and outer bodies of the compressor illustrated in FIG. **3**.

FIG. **6** is a diagrammatic cross-sectional view illustration of the inner and outer bodies taken through **6-6** in FIG. **4**.

FIGS. **7-10** are diagrammatic cross-sectional view illustrations of an alternate inner and outer body configuration at different relative angular positions.

FIG. **11** is a diagrammatic cross-sectional view illustration of the positive displacement continuous axial flow compressor with the inner and outer bodies illustrated in FIG. **7**.

DETAILED DESCRIPTION OF THE INVENTION

Illustrated in FIG. **1** is an exemplary embodiment of a continuous axial flow positive displacement compressor also referred to as a worm compressor **8** in a gas turbine engine **100**. The worm compressor **8** is part of a gas generator **10** used to power a low pressure turbine that produces work to drive a fan **108** in a fan section of the engine **100**. The gas generator **10** may be used to directly drive power consuming devices such as marine propulsion drives and electrical power generators or aircraft nozzles or fans. The exemplary embodiment of the gas turbine engine **100** illustrated in FIG. **1** is an aircraft gas turbine engine having a core engine **118** including the worm compressor **8** and gas generator **10** downstream of the fan section **112**.

The core engine **118** includes in downstream serial flow relationship the worm compressor **8**, a combustor **7**, and a high pressure turbine **9** (HPT) having high pressure turbine blades **11** drivingly connected to the worm compressor **8** by a high pressure shaft **5**. Combustion gases are discharged from the core engine **118** into a low pressure turbine (LPT) **120** having low pressure turbine rotor blades **122**. The low pressure turbine rotor blades **122** are drivingly attached to a row of circumferentially spaced apart fan rotor blades **130** of the fan **108** in the fan section **112** by a low pressure shaft **132** to form a low pressure spool **134** circumscribing an engine centerline **136**. The worm compressor **8** may be used in other applications including, but not limited to, ground based industrial and marine gas turbine engines.

Referring to FIGS. **2-5**, the worm compressor **8** includes a compressor assembly **15** having inner and outer bodies **12**, **14** extending from an inlet **20** to an outlet **22**. The inner body **12** is disposed within a cavity **19** of the outer body **14**. The inner and outer bodies **12**, **14** have inner and outer axes **16**, **18**, respectively. The compressor assembly **15** has first and second sections **24**, **26** in serial downstream flow relationship. The compressor assembly **15** provides continuous flow through the inlet **20** and the outlet **22** during operation of the worm compressor **8**. Individual charges of gas **50** are captured in and by the first section **24**. Compression of the charges **50** occurs as the charges **50** pass from the first section **24** to the second section **26**. Thus, an entire charge **50** undergoes compression while it is in both the first and second sections **24** and **26**, respectively.

Either or both bodies may be rotatable and, if both bodies are rotatable, they rotate in the same circumferential direction, i.e. either clockwise or counterclockwise, but at different rotational speeds determined by a fixed relationship. If only one body is rotatable, then the other body is fixed. In one embodiment of the generator, the inner body **12** is rotatable about the inner axis **16** within the outer body **14** and the outer body **14** may be rotatably fixed or rotatable about the outer axis **18**.

The inner and outer bodies **12**, **14** have intermeshed inner and outer helical elements wound about the inner and outer axes **16**, **18**, respectively. The elements are inner and outer helical blades **17**, **27** having inner and outer helical surfaces **21**, **23**, respectively. The inner helical blades **17** extend radially outwardly from a hollow inner hub **51** of the inner body **12** and the outer helical blades **27** extend radially inwardly from an outer shell **53** of the outer body **14**. An inner helical edge **47** along the inner helical blade **17** sealingly engages the outer helical surface **23** of the outer helical blade **27** as they rotate relative to each other. An outer helical edge **48** along the outer helical blade **27** sealingly engages the inner helical surface **21** of the inner helical blade **17** as they rotate relative to each other.

Illustrated in FIG. **4** is a longitudinal cross-section taken through the inner and outer bodies **12**, **14**. The inner and outer bodies **12**, **14** are illustrated in axial cross-section in FIG. **6**. The inner body **12** is illustrated herein as having two inner body lobes **60** which correspond to two inner helical blades **17** that form a football or pointed oval-shaped inner body cross-section **69**. The outer body **14** has three outer body lobes **64** which correspond to three outer helical blades **27** (illustrated in FIGS. **3** and **4**). Note that three sealing points **62** between the inner and outer bodies **12**, **14** are illustrated in FIG. **6** but that five periodically overlapping seals exist between the inner and outer helical blades **17**, **27** along the entire length of the inner and outer bodies **12**, **14**.

An alternative configuration of the inner and outer bodies **12**, **14** is illustrated in cross-section in FIGS. **7-10**. The inner body **12** is illustrated therein as having three inner body lobes **60** which correspond to three inner helical blades **17** which result in a triangularly-shaped inner body cross-section **68** as illustrated in FIG. **7**. The outer body **14** has two outer body lobes **64** which correspond to two outer helical blades **27**. In general, if the inner body **12** has N number of lobes the outer body **14** will have N+1 or N−1 lobes. Note that five sealing points **62** between the inner and outer bodies **12**, **14** are illustrated in FIG. **7**, corresponding to five periodically overlapping seals between the inner and outer helical blades **17**, **27** along the entire length of the inner and outer bodies **12**, **14**.

Referring to FIG. **5**, the inner and outer helical blades **17**, **27** have constant first and second twist slopes **34**, **36** in the first and second sections **24**, **26**, respectively. A twist slope A is defined as the amount of rotation of a cross-section **41** of the helical element (such as the oval-shaped or triangularly-shaped inner body cross-sections **69**, **68** illustrated in FIGS. **6** and **7**, respectively) per distance along an axis such as the inner axis **16** as illustrated in FIG. **5**. Illustrated in FIG. **5** is 360 degrees of rotation of the inner body cross-section **41**. The twist slope A is also 360 degrees or 2Pi radians divided by an axial distance CD between two successive crests **44** along the same inner or outer helical edges **47**, **48** of the helical element such as the inner or outer helical blades **17**, **27** as illustrated in FIG. **5**. The axial distance CD is the distance required for one full turn **43** of the helix.

The twist slope A of the inner element in each of the sections is different from the twist slope A of the outer element. The ratio of the twist slope A of the outer body **14** to the twist slope A of the inner body **12** is equal to the ratio of the number of inner helical blades **17** blades on the inner body **12** to the number of outer helical blades **27** on the outer body **14**. The first twist slopes **34** in the first section **24** are less than the second twist slopes **36** in the second section **26**. The helical elements may also be described in terms of helical angle. The helical elements have constant first and second helical angles corresponding to the constant first and second twist slopes **34**, **36**, in the first and second sections **24**, **26**, respectively.

Referring again to FIGS. **3-5**, the inner helical blade **17** in the first section **24** has a sufficient number of turns **43** to trap the charges of gas **50** in the first section **24** without allowing the compression process to affect the inlet flow field during the compressor's operation. The trapped charges of gas **50** allow positive displacement compression so that higher pressures developed downstream cannot force gas back out the inlet **20**. In one embodiment of the gas generator, the number of turns **43** in the first section **24** is sufficient to mechanically trap the charges of gas **50**. In another embodiment of the gas generator **10**, the number of turns **43** in the first section **24** is sufficient to dynamically trap the charges of gas **50**. Mechanically trapped means that the charge **50** is trapped by being closed off from the inlet **20** at an upstream end **52** of the charge **50** before it passes into the second section **26** at a downstream end **54** of the charge **50**. Dynamically trapped means that though the downstream end **54** of the trapped charge may have passed into the second section **26**, the upstream end **52** of the charge has not yet completely closed. However, at its downstream end **54** by the time a pressure wave from the second section travels to the inlet **20**, relative rotation between the bodies will have closed off the charge of gas **50** at its upstream end **52**.

For the fixed outer body **14** embodiment, the inner body **12** is cranked relative to the outer axis **18** so that as it rotates about the inner axis **16**, the inner axis **16** orbits about the outer axis **18** as illustrated in FIGS. **7-10**. The inner body **12** is illustrated as having been rotated about the inner axis **16** from its position in FIG. **7** to its position in FIG. **8** and the inner axis **16** is illustrated as having orbited about the outer axis **18** about 90 degrees. The inner and outer bodies **12**, **14** are geared together so that they always rotate relative to each other at a fixed ratio as illustrated by gearing in gearbox **82** in FIGS. **1** and **4**.

The inner body **12** rotates about the inner axis **16** with an inner body rotational speed **74** equal to its orbital speed **76** divided by the number of inner body lobes. The number of inner lobes are equal the number of blades. If the inner body **12** rotates in the same direction as its orbital direction, a 2 lobed outer body configuration is used. If the inner body **12** rotates in an opposite orbital direction, a 4 lobed outer body configuration is used. In a first embodiment the inner and outer bodies **12**, **14** are both rotatable and the outer body **14** rotates about the outer axis **18** at 1.5 times the rotational speed that the inner body **12** rotates about the inner axis **16**. The outer body **14** rotates at a speed equal to the rotational speed of the inner body **12** times the number of lobes on the inner body divided by the number of lobes on the outer body **14**.

The twist slopes of the outer body **14** are equal to the twist slopes of the inner body **12** times the number of inner body lobes N divided by the number of outer body lobes M. For the configuration illustrated in FIGS. **7-10** having three inner lobes or inner helical blades **17** and two outer lobes or outer helical blades **27**, it takes 900 degrees of rotation of the outer body **14** and 600 degrees of rotation of the inner body **12** to mechanically capture one of the charges of gas **50**. The inner body twist slope is substantially increased going from the first section **24** to the second section **26** at an axial location designated a compression plane as indicated in FIG. **2**. A fairing section between the first and second sections may replace the compression plane if undesirable stress distributions are present. A further comparison between the configuration illustrated in FIGS. **7-10** having three inner lobes and two outer lobes to the configuration illustrated in FIG. **6** having two inner body lobes **60** and three outer body lobes **64** may be had by comparing FIG. **11** to FIG. **2**. Note the number of turns and degrees of rotation of the outer body **14** and the number of turns and degrees of rotation of the inner body **12** needed to capture one of the charges of gas **50** between the upstream and downstream ends **52**, **54** of the charge **50**. Also note the difference in twist slopes of the first and second sections **24**, **26**.

The continuous axial flow positive displacement compressor, referred to herein as a worm compressor **8**, may be used in a wide range of applications and provides high mass flow rate for a given frontal area, continuous near steady fluid flow, and reasonable efficiency over a wide range of operating conditions. It is light-weight and highly efficient and has far fewer parts as compared to other axial compressors which in turn reduces the costs of manufacturing, installing, refurbishing, overhauling, and replacing the compressor. The first embodiment provides a first mode of the compressor's operation disclosed herein in which the inner and outer bodies **12**, **14** both rotate about the inner and outer axes **16**, **18**, respectively. The first mode avoids introducing a centrifugal rotor whirl effect on a support of the compressor and core engine. In a second embodiment the outer body **14** remains static and the inner body **12** simultaneously orbits the outer body's geometric center which is the outer axis **18** and spins about the instantaneous inner body's geometric center which is the inner axis **16**. The second embodiment provides a second mode of the compressor's operation disclosed in which there is only a single rotor rotating potentially simplifying the mechanical design process.

The continuous axial flow positive displacement compressor, referred to herein as a worm compressor **8**, may be used in a wide range of applications and provides reasonably high mass flow rate for a given frontal area, continuous near steady fluid flow, and is expected to provide reasonable efficiency over a wide range of operating conditions. Because the worm compressor operates in a positive displacement mode, it will provide compression levels that are nearly independent of rotor speed over a wide operating range. In thermal engines and other applications, this feature provides a distinct advantage over conventional axial flow compressors, for which compression ratios are directly related to rotor speed. Positive displacement operation also reduces or eliminates aerodynamic stall effects which allows the compressor to be run off-design at compression ratios well above a conventional stall line with the only ill effect being degradation of adiabatic efficiency. The worm compressor is expected to be light-weight, highly efficient, and have far fewer parts than conventional axial compressors which in turn reduces the costs of manufacturing, installing, refurbishing, overhauling, and replacing the compressor.

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. An axial flow positive displacement compressor comprising:

an inlet axially spaced apart and upstream from an outlet,

a compressor assembly including an inner body disposed within an outer body and the inner and outer bodies extending from the inlet to the outlet,

the inner and outer bodies having offset inner and outer axes respectively,

at least one of the inner and outer bodies being rotatable about a corresponding one of the inner and outer axes,

the inner and outer bodies having intermeshed inner and outer helical blades wound about the inner and outer axes respectively,

the inner and outer helical blades extending radially outwardly and inwardly respectively,

the inner helical blades extending radially outwardly from an inner hub of the inner body,

the compressor assembly having first and second sections in serial downstream flow relationship extending between the inlet and the outlet,

the inner and outer helical blades having first and second twist slopes in the first and second sections respectively, and

the first twist slopes being less than the second twist slopes.

2. A compressor as claimed in claim **1** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

3. A compressor as claimed in claim **2** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

4. A compressor as claimed in claim **2** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

5. A compressor as claimed in claim **1** further comprising the outer body being rotatable about the outer axis and the inner body and being rotatable about the inner axis.

6. A compressor as claimed in claim **5** further comprising the inner and outer bodies being geared together in a fixed gear ratio.

7. A compressor as claimed in claim **6** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

8. A compressor as claimed in claim **7** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

9. A compressor as claimed in claim **7** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

10. A compressor as claimed in claim **1** further comprising the outer body being rotatably fixed about the outer axis and the inner body being orbital about the outer axis.

11. A compressor as claimed in claim **10** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

12. A compressor as claimed in claim **11** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

13. A compressor as claimed in claim **12** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

14. A engine comprising:

in downstream serial flow relationship an axial flow positive displacement compressor, a combustor, and a high pressure turbine drivingly connected to the compressor by a high pressure shaft,

the compressor having an inlet axially spaced apart and upstream from an outlet,

a compressor assembly including an inner body disposed within an outer body and the inner and outer bodies extending from the inlet to the outlet,

the inner and outer bodies having offset inner and outer axes respectively,

at least one of the inner and outer bodies being rotatable about a corresponding one of the inner and outer axes,

the inner and outer bodies having intermeshed inner and outer helical blades wound about the inner and outer axes respectively,

the inner and outer helical blades extending radially outwardly and inwardly respectively,

the inner helical blades extending radially outwardly from an inner hub of the inner body,

the compressor assembly having first and second sections in serial downstream flow relationship extending between the inlet and the outlet,

the inner and outer helical blades having first and second twist slopes in the first and second sections respectively, and

the first twist slopes being less than the second twist slopes.

15. An engine as claimed in claim **14** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

16. An engine as claimed in claim **15** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

17. An engine as claimed in claim **15** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

18. An engine as claimed in claim **14** further comprising the outer body being rotatable about the outer axis and the inner body and being rotatable about the inner axis.

19. An engine as claimed in claim **18** further comprising the inner and outer bodies being geared together in a fixed gear ratio.

20. An engine as claimed in claim **19** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

21. An engine as claimed in claim **20** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

22. An engine as claimed in claim **20** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

23. An engine as claimed in claim **14** further comprising the outer body being rotatably fixed about the outer axis and the inner body being orbital about the outer axis.

24. An engine as claimed in claim **23** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

25. An engine as claimed in claim **24** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

26. An engine as claimed in claim **25** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

27. A gas turbine engine comprising:

a gas generator connected in work producing relationship to a power consuming device,

a core engine including in downstream serial flow relationship an axial flow positive displacement compressor, a combustor, and a high pressure turbine drivingly connected to the compressor by a high pressure shaft,

the compressor having an inlet axially spaced apart and upstream from an outlet,

a compressor assembly including an inner body disposed within an outer body and the inner and outer bodies extending from the inlet to the outlet,

the inner and outer bodies having offset inner and outer axes respectively,

at least one of the inner and outer bodies being rotatable about a corresponding one of the inner and outer axes,

the inner and outer bodies having intermeshed inner and outer helical blades wound about the inner and outer axes respectively,

the inner and outer helical blades extending radially outwardly and inwardly respectively,

the inner helical blades extending radially outwardly from an inner hub of the inner body,

the compressor assembly having first and second sections in serial downstream flow relationship extending between the inlet and the outlet,

the inner and outer helical blades having first and second twist slopes in the first and second sections respectively, and

the first twist slopes being less than the second twist slopes.

28. An engine as claimed in claim **27** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

29. An engine as claimed in claim **28** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

30. An engine as claimed in claim **28** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

31. An engine as claimed in claim **27** further comprising the outer body being rotatable about the outer axis and the inner body and being rotatable about the inner axis.

32. An engine as claimed in claim **31** further comprising the inner and outer bodies being geared together in a fixed gear ratio.

33. An engine as claimed in claim **32** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

34. An engine as claimed in claim **33** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

35. An engine as claimed in claim **33** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

36. An engine as claimed in claim **27** further comprising the outer body being rotatably fixed about the outer axis and the inner body being orbital about the outer axis.

37. An engine as claimed in claim **36** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

38. An engine as claimed in claim **37** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

39. An engine as claimed in claim **38** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

40. An aircraft gas turbine engine comprising:

a fan section and a core engine including a gas generator downstream of the fan section,

a low pressure turbine having at least one row of turbine rotor blades downstream of the gas generator,

the low pressure turbine drivingly attached to at least one row of circumferentially spaced apart fan rotor blades in the fan section by a low pressure shaft,

the core engine including in downstream serial flow relationship an axial flow positive displacement compressor, a combustor, and a high pressure turbine drivingly connected to the compressor by a high pressure shaft,

the compressor having an inlet axially spaced apart and upstream from an outlet,

a compressor assembly including an inner body disposed within an outer body and the inner and outer bodies extending from the inlet to the outlet,

the inner and outer bodies having offset inner and outer axes respectively,

at least one of the inner and outer bodies being rotatable about a corresponding one of the inner and outer axes,

the inner and outer bodies having intermeshed inner and outer helical blades wound about the inner and outer axes respectively,

the inner and outer helical blades extending radially outwardly and inwardly respectively,

the inner helical blades extending radially outwardly from an inner hub of the inner body,

the compressor assembly having first and second sections in serial downstream flow relationship extending between the inlet and the outlet,

the inner and outer helical blades having first and second twist slopes in the first and second sections respectively, and

the first twist slopes being less than the second twist slopes.

41. An engine as claimed in claim **40** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

42. An engine as claimed in claim **41** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

43. An engine as claimed in claim **41** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

44. An engine as claimed in claim **40** further comprising the inner and outer bodies being geared together in a fixed gear ratio.

45. An engine as claimed in claim **44** further comprising the outer body being rotatable about the outer axis and the inner body and being rotatable about the inner axis.

46. An engine as claimed in claim **45** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

47. An engine as claimed in claim **46** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

48. An engine as claimed in claim **44** further comprising the outer body being rotatably fixed about the outer axis and the inner body being orbital about the outer axis.

49. An engine as claimed in claim **48** further comprising the helical blades in the first section having a sufficient number of turns to trap charges of gas in the first section during the compressor's operation.

50. An engine as claimed in claim **49** further comprising the number of turns being sufficient to mechanically trap the charges of gas.

51. An engine as claimed in claim **49** further comprising the number of turns being sufficient to dynamically trap the charges of gas.

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